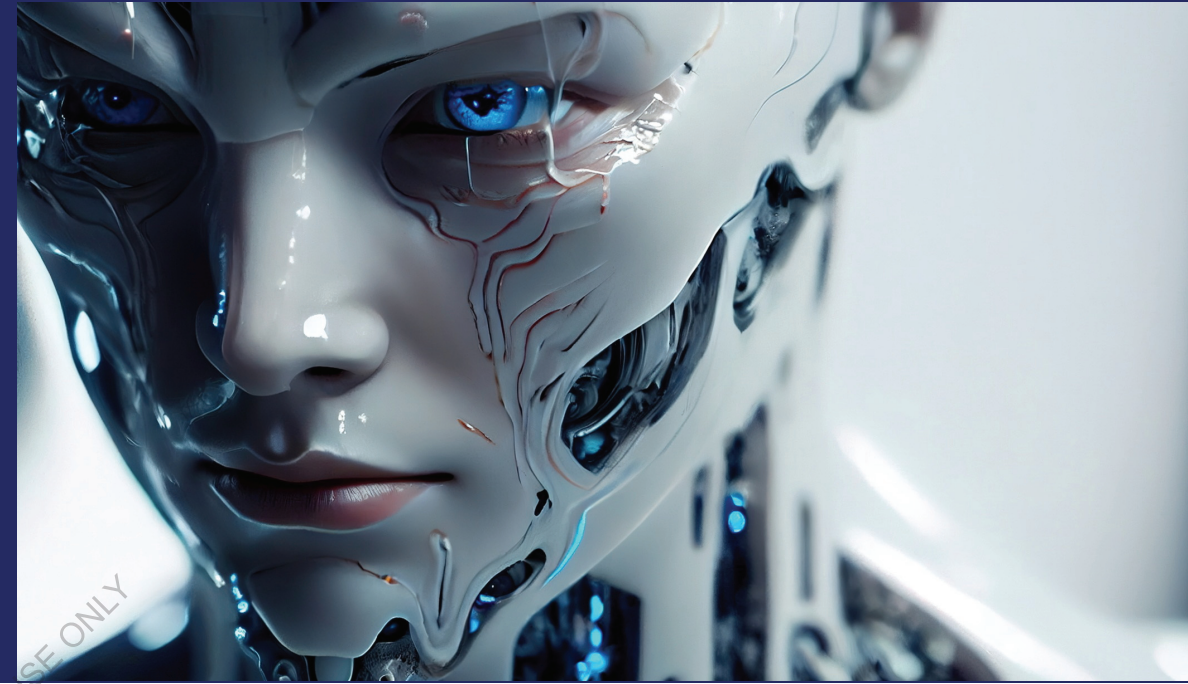
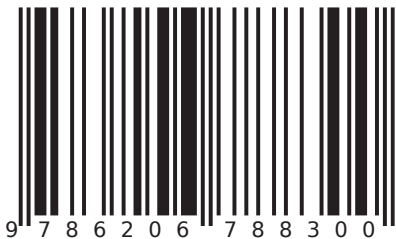




The objective of this book is to explore and analyze various aspects of smart systems and their applications in different domains. The work begins with an introduction to smart systems, providing an overview of their significance and impact. It then delves into a comprehensive examination of applications and potential future developments in building smart cities and smart systems. This study also focuses on smart home systems, examining their features and advantages for improving living areas. Additionally, it highlights the potential for a variety of applications by examining the implementation of smart systems through many modalities, including speech, images, videos, voice, and text. Furthermore, the study offers Python code for CNN, RNN and LSTM implementation as an example. The development of smart video system recognition is also covered, giving light on its future applications and technological breakthroughs. In summary, the goals of the author in this book are: to expand the body of knowledge in the area of smart systems, to offer insights into various use cases, and to provide a thorough understanding of the potential to solve problems in different fields.



Dr Alexander I. Iliev holds two patents in the Digital Audio Watermarking field. He has published a number of research papers in journals and international conference proceedings in the fields of DSP, Big Data Analytics, Smart Systems and Artificial Intelligence. He is affiliated to UC Berkeley, University of Miami, and University of Wisconsin.



Alexander I. Iliev

# Artificial Intelligence Smart Systems Design

Applied Use Cases | Part 1

**Alexander I. Iliev**

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# Artificial Intelligence Smart Systems Design

## Applied Use Cases

### *Part 1*

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## 1 Subject of the study

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Smart systems were designed originally to make autonomous decisions without human intervention. They now could sense, control, and analyze situations with high quality data processing and optimize desired outcomes.

The applications of smart systems highly evolved over the last few years, especially with the most recent advancements in machine learning and artificial intelligence. Smart systems became more and more self-learning entities that continually gather data from various sources, interpret patterns, and leverage their cognitive capabilities to optimize processes, enhance user experiences, and solve complex problems across diverse domains.

Unlike traditional systems, smart systems possess adaptability and context-awareness, enabling them to respond dynamically to changing conditions, learn from past experiences, and refine their operations over time.

These systems are characterized by their ability to sense and understand the surrounding environment, interpret vast amounts of information, and autonomously take appropriate actions based on predictive models and predefined objectives.

By integrating IoT devices, sensors, actuators, and cloud-based platforms, smart systems create a seamless ecosystem that facilitates real-time communication and data exchange, forming the backbone of the Internet of Things revolution.

Smart systems have the potential to revolutionize industries, including healthcare, transportation, agriculture, energy management, and manufacturing, ushering in an era of unprecedented efficiency, sustainability, and improved quality of life.

As smart systems become more pervasive, privacy and security concerns demand rigorous attention, necessitating robust data protection measures and resilient cybersecurity protocols to safeguard against potential threats.

To better understand the characteristics of the smart systems, we must first understand the characteristics of systems shown below:

- System element: it is a system component.
- Relation: a connection between two system entities.
- Objective: a list of actions the system can do in its surroundings to accomplish its goal.

- Environment: all that lies outside the system's perimeter.
- Interface: a component of the system that establishes a connection between itself and the surroundings.

There are some additional characteristics that smart systems may exhibit [107]:

*Communication Capability:* The elements must be able to interact to share information, communicate their capabilities, and provide information about their environment. Interoperability between the components of the system depends on communication. The definitions make extensive use of the terms "data," "information," "interaction," and "communication," which highlights the importance of interoperability between Smart System components or between system components and their surroundings.

*Embedded Knowledge:* The system must record information about the environment as well as human experience and skill. Knowledge in the context of smart systems can be perceived in several ways depending on the requirements of the system. For example, a knowledge base created by human experts, which is typical of Knowledge-based Systems (KBS), can be used as a model-driven resource by an inference engine. The alternative is that it might be a Machine Learning (ML) model that an element uses when it needs to process some input data or retrain the model using fresh training data (data-driven resource). Every choice made by the system must be supported by knowledge, regardless of how it is represented within it.

*Learning Capability:* Learning entails the use of various techniques and algorithms that enable the system's knowledge to be changed. This capacity allows for adaptive behavior, which helps one to successfully manage novel contexts or circumstances. The system updates its knowledge on its own and learns in an autonomous manner with little to no outside help.

*Reasoning Capability:* Smart Systems must be able to use their information to reason to make decisions. The system can use a variety of methods, including neural networks, fuzzy logic, evolutionary algorithms, expert systems, etc., to enable flexible data processing and make strategic decisions. The system's ability to reason also enables it to foresee future environmental conditions, enabling it to act before the changes become evident.

*Perception Capability:* The systemic perspective assumes the existence of an environment that Smart Systems engage with. Sensors (perception) are used to sense the state of the environment, and actuators (control) are utilized to conduct actions to affect that state,

to perform this interaction. Both "sensor" and "control" are words with a high level of importance for characterizing Smart Systems, according to the quantitative findings of this work. The surroundings and themselves must be continuously sensed or perceived by smart systems. Without sensors that can track and recognize changes in their surroundings, this would not be possible. Using the information gathered by the sensors, smart systems can characterize and analyze the surroundings.

*Control Capability:* Smart Systems are designed to help people or to give them the tools and mechanisms they need to better various elements of human life even though it could appear implicit for any human product. The first one is related to the Perception Capability because they are frequently designed to gather data from people via sensors. The second one is built on a high level of automation, which enables avoiding the need for user intervention to carry out specific tasks or make certain judgments. Actuators, which carry out decisions made by the system utilizing the resources at hand on the environment to change its state, provide the control capability.

*Self-Organization:* the actions performed by Smart Systems are not limited to the environment since they can also be used to act on the system elements in case self-organization is necessary.

*Context Awareness:* A system is self-aware if it considers the environment it operates in when carrying out its functions. A system must perceive its surroundings and have embedded knowledge that enables it to interpret its current condition to be context aware.

To protect sensitive data, stop unwanted access, and defend against harmful assaults, security in smart systems is crucial. Data encryption, robust authentication, secure communication protocols, and device security are just a few of the security measures that are put in place. For identifying and minimizing potential cyber threats, continuous monitoring, threat detection, and resilient design are essential. While following rules and standards provides a constant and high degree of security, ethical considerations and user knowledge play a role in encouraging responsible usage. Smart systems can run safely and shield both users and crucial infrastructures from hazards by taking care of these issues.

## 2 Objectives

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The objective of this book is to explore and analyze various aspects of Smart Systems and their applications in different domains. The study begins with an introduction to Smart Systems, providing an overview of their significance and impact. It then delves into a comprehensive examination of applications and potential future developments in building Smart Cities and Smart Systems.

This work also focuses on smart home systems, examining their features and advantages for improving living areas. Additionally, it highlights the potential for a variety of applications by examining the implementation of Smart Systems through many modalities, including speech, images, videos, voice, and text.

Furthermore, the study explores the potential and consequences of a modified deep learning neural network for face recognition. The development of smart video system recognition is also covered, giving light to its future applications and technological breakthroughs.

The study analyses smart healthcare systems during COVID-19, highlighting their integration with cloud computing FIWARE as a response to the global health issue. The goal is to comprehend how intelligent healthcare technologies may deliver effective and efficient medical services during challenging circumstances.

To determine strengths, limitations, and areas for improvement, the study assesses the present approaches used in the creation and application of Smart Systems.

Overall, the main goals of this study are to add to the body of knowledge already available on smart systems, offer insights into their various uses, and provide a thorough understanding of their potential to solve problems in other fields.

### 3 Tasks

---

To present this work, we will focus on the following tasks to fulfil the objectives and goals of this study:

**Literature Review:** Conduct a thorough assessment of the available literature on smart systems, smart cities, smart homes, speech, image, video, voice, and text recognition, face recognition using deep learning, and smart healthcare systems to compile pertinent research papers, articles, and publications. This action will aid in building a strong foundation and comprehension of the body of currently known information.

**Focus on data collection process and analysis:** Gather information on smart systems and the numerous domains in which they are used. Examine the gathered information to find patterns, problems, and prospective areas for methodological advancement.

**Understanding case studies:** To get practical insights into existing implementation, advantages, and obstacles, find and study real-world case studies of smart cities, smart home systems, and smart healthcare systems.

**Technology review:** Analyze and assess the various frameworks, technologies, and algorithms employed in the development of smart systems such as for face and video system recognition. Understand the best choice by contrasting their advantages and disadvantages.

**Deep learning and neural network advancements:** Understanding deep learning neural network models for increased efficiency and accuracy.

**Development of a Smart System process:** Understanding working prototypes of smart systems that can recognize and assess pertinent visual information.

**Ethical considerations:** Address the ethical issues around data privacy, security, and the proper use of smart systems, particularly in the context of healthcare and facial recognition applications.

**Meta-Analysis and Meta-Modelling:** To find common traits of Smart Systems, do a meta-analysis of the information and definitions acquired. To represent the components and connections of Smart Systems for multiple applications, create a meta-model.

**Conclusions and Recommendations:** Summarize the study's findings and offer practical suggestions for enhancing the application and use of smart systems across many sectors.

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## 4 Introduction to smart systems

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### Chapter abstract

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The capacity of a system to learn from new features and adapt to a new environment can be described as its smartness. According to this definition, smart systems are a class of systems that are capable of perception, decision-making, and action. Even though this field has been active for more than 30 years, recent developments are the result of factors like the COVID-19 pandemic and the Industrial Revolution 4.0. In this chapter, a definition of smart systems is provided, along with a discussion of some recent research in the smart systems area.

### 4.1 Introduction

---

Smart systems trace their origin to a field of research that envisioned devices and materials that could mimic human muscular and nervous systems. The main idea behind smart systems is to produce non-biological systems that will achieve optimum observed functionality, close to their biological counterparts, through the emulation of their capabilities and integrated design (Akhras, 2000) [1].

Smart systems consist of three parts. One is the sensor component which allows these systems to perceive their environment, two is the logical component which decides on the action to be performed and finally, the third is the actuators which then perform the actions which are decided by the logical part (Akhras, 2000) [1], (Romero, Guédria, Panetto, & Barafort, 2020) [2].

A diagram of a simple smart system is shown in Figure 1.1. Smart systems have been in development since the early 2000s, and their definition along with their applications has been changed through these years. From prosthetic body parts (e.g., artificial arm or eye) to aid devices till recently with the rise of the Internet of Things (IoT) smart homes (e.g., Amazon's Alexa) and smart cities that use the notion of smart systems in areas such as Smart-Autonomous Traffic handling. Moreover, these systems have been developed in the field of Human-Computer Interaction (HCI) to create prosthetic body parts such as prosthetic eyes or arms with the advancement of cognitive sciences Romero, M., Guédria, W., Panetto, H., & Barafort, B. (2020) [2].

This work aims to discuss the recent advances and areas in which these systems have been used by sifting through some research that has been done and published over the past few years. This work is organized as follows: in the second section a background of smart systems is discussed, in section 3 two examples of the development of smart devices to help people with visual and hearing disabilities are presented, section 3 discusses smart homes, smart buildings, and smart cities, and finally, in section 5 the research is concluded.

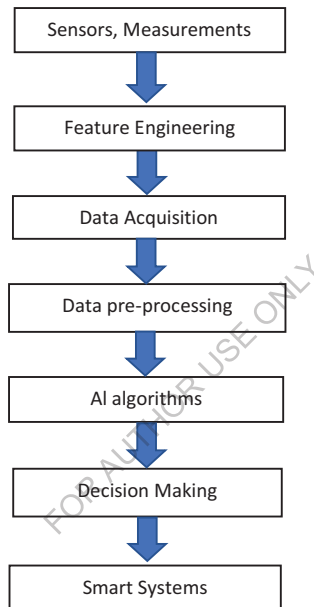


*Figure 1.1 A simplified block diagram for Smart Systems*

This section highlights several interesting research studies conducted in the field of smart systems, focusing on areas such as healthcare, communication, and environmental management. One study presents a guidance system for visually impaired individuals, employing sensors and actuators to assist with image captioning, face and emotion recognition, object detection, and text-to-speech conversion. Another study introduces a smart glove that interprets sign language through sensors and machine learning, achieving a 70% accuracy level. The section also discusses the applications of smart speakers, virtual assistants, and smart

wearable devices, emphasizing their use of AI technologies for natural language processing, voice recognition, and continuous learning. Additionally, the development of smart structures, including smart buildings and smart cities, is explored, highlighting advancements in health surveillance systems and adaptive garbage detection using object detection models.

FIWARE is an open-source platform that enables the development of intelligent solutions for smart systems. It provides a set of curated software components and APIs that facilitate the creation of applications in various industries, particularly in the context of smart cities. FIWARE allows for the integration of different technologies, such as IoT, AI, and machine learning, to build digital twins and enable data-driven decision-making. By utilizing FIWARE, developers can leverage real-time big data processing, predictive analytics, and efficient energy management, among other functionalities, to create innovative and sustainable smart systems that enhance the quality of urban life.

Smart home systems are an integral part of the growing trend towards home automation and the Internet of Things (IoT). These systems utilize advanced technologies, including sensors, internet connectivity, and intelligent algorithms, to enable the automation and control of various home devices and systems. The concept of a smart home revolves around creating an interconnected ecosystem where devices and appliances can communicate and interact with each other, providing convenience, comfort, and energy efficiency to homeowners.

The primary goal of smart home systems is to enhance the overall living experience by integrating and automating various functions within the home. These functions can include lighting, heating, ventilation, air conditioning (HVAC), security systems, entertainment systems, and appliances. By connecting these devices to a central hub or a cloud-based platform, homeowners can remotely monitor and control them through their smartphones, tablets, or voice assistants.

One of the key components of a smart home system is the presence of sensors and actuators throughout the house. Sensors, such as motion sensors, temperature sensors, and light sensors, collect data about the environment and occupancy within the home. This data is then processed by the intelligent algorithms of the system to make informed decisions and trigger appropriate actions. Actuators, such as smart switches, smart thermostats, and smart locks, receive commands from the system and carry out the desired actions, such as turning on/off lights, adjusting the temperature, or locking/unlocking doors.

The benefits of smart home systems are numerous. They provide homeowners with increased convenience and flexibility, as they can control various aspects of their homes from anywhere, at any time. For example, they can remotely turn on the lights, adjust the thermostat, or monitor security cameras while away from home. Smart home systems also contribute to energy efficiency by optimizing the use of resources. For instance, they can automatically adjust the temperature based on occupancy patterns or turn off lights when no one is in the room, leading to energy savings. Additionally, these systems enhance home security by integrating with security cameras, door locks, and alarm systems, providing real-time monitoring and alerts to homeowners.

The technology behind smart home systems is continuously evolving, with advancements in AI, machine learning, and natural language processing. AI-powered voice assistants, such as Amazon Alexa and Google Assistant, have become popular interfaces for controlling smart home devices through voice commands. Machine learning algorithms enable the system to learn user preferences and patterns, allowing for personalized automation and optimization of home functions.

Despite the numerous benefits, there are some challenges associated with smart home systems. Privacy and security concerns arise due to the collection and transmission of personal data. Therefore, robust security measures, such as encryption and authentication, are crucial to protect against cyber threats. Interoperability is another challenge, as devices from different manufacturers may use different protocols, requiring compatibility standards to ensure seamless integration within the system.

Smart home systems have revolutionized the way we interact with our homes. They offer convenience, energy efficiency, and enhanced security through the integration of devices, sensors, and intelligent algorithms. As technology continues to advance, smart home systems are expected to become even more sophisticated, offering personalized experiences and seamless connectivity within the broader IoT ecosystem.

Building smart systems through speech, images, videos, voice, and text involves leveraging advanced technologies to process and analyze different types of data for intelligent applications. These smart systems utilize techniques such as natural language processing, computer vision, and machine learning to extract valuable insights and enable automation in various domains.

Speech recognition is a key component of smart systems, enabling the conversion of spoken words into written text. This technology allows for voice commands and voice-controlled interactions with devices and applications. Natural language processing algorithms analyze the text to understand user intent and extract meaningful information for further processing.

Image and video analysis play a crucial role in smart systems, enabling the interpretation and understanding of visual content. Computer vision algorithms are used to identify objects, recognize faces, detect patterns, and extract relevant information from images and videos. This technology finds applications in surveillance, healthcare, autonomous vehicles, and augmented reality, among others.

Text analysis involves processing and understanding written text. Natural language processing algorithms analyze text to extract information, perform sentiment analysis, classify documents, and enable language translation. Text analysis is used in various applications, including chatbots, virtual assistants, content recommendation systems, and information retrieval.

Voice recognition technology is used to identify and differentiate between different voices, allowing for personalized user experiences in smart systems. This technology is often employed in virtual assistants and smart speakers to provide personalized responses and perform tasks based on individual preferences.

The integration of these technologies enables seamless interactions and automation in smart systems. For example, a voice command can be converted to text using speech recognition, analyzed using natural language processing to understand the user's intent, and then trigger appropriate actions based on the interpretation. Similarly, image and video analysis can be combined with other data sources to provide context-aware insights and enable intelligent decision-making.

Building smart systems through these modalities presents both opportunities and challenges. The availability of large datasets and advancements in machine learning algorithms have greatly improved the accuracy and capabilities of these systems. However, challenges remain, such as handling variations in speech and accents, accurately interpreting complex images and videos, and ensuring privacy and security when dealing with sensitive data.

Face recognition using a modified deep learning neural network is a powerful technology that enables the identification and verification of individuals based on their facial features. This technology has gained significant attention in various fields, including security, surveillance, authentication systems, and personalized user experiences. The use of deep learning neural networks allows for more accurate and robust face recognition compared to traditional methods.

The modified deep learning neural network for face recognition consists of multiple layers of artificial neurons that are trained using a large dataset of facial images. The network learns to extract discriminative features from the input images and maps them to a high-dimensional feature space. This feature space representation enables efficient comparison and matching of faces.

One of the key advancements in face recognition is the utilization of Convolutional Neural Networks (CNNs) as the underlying architecture for the deep learning model. CNNs are designed to effectively capture spatial dependencies in images by using convolutional and pooling layers. This allows the network to learn hierarchical representations of facial features, such as edges, textures, and facial landmarks. For more information and Python code example of CNNs please refer to Appendix A.

A modified neural network incorporates various techniques to enhance its performance. These techniques include data augmentation, which involves generating additional training samples by applying transformations such as rotation, scaling, and flipping to the original facial images. Data augmentation helps in increasing the diversity of the training dataset and improving the network's ability to generalize to unseen faces.

Another important aspect of face recognition is the preprocessing of facial images. This involves normalization techniques to account for variations in lighting conditions, pose, and facial expressions. Techniques like histogram equalization, normalization, and alignment are applied to ensure consistency and improve the accuracy of face recognition.

The training process of the modified deep learning neural network involves feeding a large dataset of labelled facial images into the network and optimizing the network's parameters using algorithms like backpropagation. The network learns to minimize the difference between the predicted outputs and the ground truth labels, enabling it to recognize faces accurately.

Once the network is trained, it can be used for face recognition tasks. During inference, a new facial image is fed into the network, and the network computes a feature representation for the input face. This feature representation is then compared with the stored representations of known individuals in a database. The similarity or distance between the feature vectors is calculated to determine the identity of the input face.

Face recognition using neural networks offers several advantages. It can handle variations in facial appearance, such as different poses, lighting conditions, and facial expressions. It is also robust to noise and can handle many individuals in the database. Moreover, the deep learning approach allows for end-to-end training, eliminating the need for manual feature engineering.

However, challenges remain in face recognition, such as handling occlusions, changes in appearance over time, and the potential for bias in the recognition process. Ongoing research aims to address these challenges and further improve the accuracy and reliability of face recognition systems.

## 4.2 Background

---

As discussed in the previous section, a smart system is a system that can mimic certain smart behavior by perceiving, processing, and then acting based on the perceived information. The smartness of the system hence can be defined in many ways. One of the common definitions of smartness is the ability to learn and adapt to a new environment based on new features (Brusa & Calà, 2014) [3]. Thus, this definition is used for this research to find and identify research that satisfies this definition of smartness.

## 4.3 Popular smart devices

---

With the rise of smart wearable devices in recent years, this field has been in the research spotlight for the past decade. There has been much research done on this field in many areas such as healthcare, surveillance, office assistance, and entertainment. In this section, a few of the more interesting research will be discussed.

### 4.3.1 Guidance system for visually impaired people

Patil et al. have designed a system to help visually impaired people (K. Patil, A. K., Kharat, A., P, C., Bidgar, S., & R, G. (2021) [4]. They have proposed a system of two parts. The first part is a collection of sensors which consists of a camera and a microphone, the second

part is a set of actuators which consists of a set of Bluetooth headsets, and finally, the third part is a processing unit that can be worn in a bag, this systems architecture is shown in Figure 1.2.

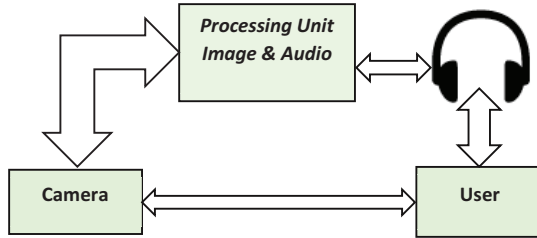


*Figure 1.2 A general schema of the implemented system. The camera performs as a sensor which then feeds information to the processing unit. The user then chooses the action based on the available actions which then is either performed by the sensors again or the processing unit (K. Patil, Kharat, P, Bidgar, & R, 2021) [4].*

Their proposed system gives the user 4 choices of action:

- Image captioning: Describing a proceeding of an ongoing scene/image to the visually impaired person.
- Face recognition / Emotion Recognition: Describing the perceived emotion of a captured facial image.
- Object Detection: Labeling different objects
- Text to Speech: Converting text into speech audio.

For each choice, they have implemented a different architecture of neural networks as shown in Figure 1.3. Technologies such as TensorFlow, OpenCV, Tesseract, and Pysstts x have been used to develop this system.

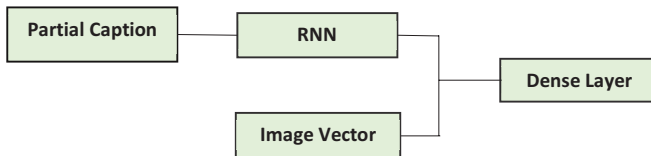


*Figure 1.3 Architectures of the machine learning Models: (a): proposed architecture for the scene (H S Anupama, 2021) [5]*

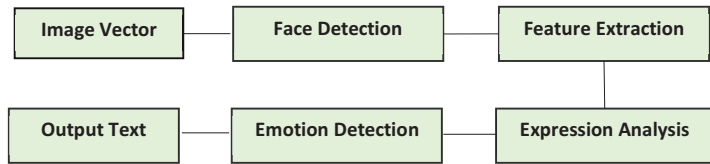


*Figure 1.4 Architectures of the machine learning Models: (b): Proposed architecture for facial emotion detection function (H S Anupama, 2021) [5].*

For more information and Python code example of RNNs please refer to Appendix B.

#### 4.3.2 Smart gloves for sign language interpretation

Anupama et al. designed a smart glove to help people with hearing problems interpret sign language to text. Their system uses three types of sensors: Flex sensors, contact sensors, and GY521 (gyroscope) sensors. Each sensor is responsible for recognizing different hand movements. Recognizing the bending of the fingers, contact between the fingers, and rotational movement of the fingers respectively (H S Anupama, 2021) [5]. By collecting sensor outputs and using them as input features and each letter as the label, they were able to train a K-Nearest Neighbor (KNN), a machine-learning model, to map every hand movement to a letter in the alphabet. With their approach, they were able to reach a 70% level of accuracy for their system. The architecture for this system is shown in Figure 1.4.

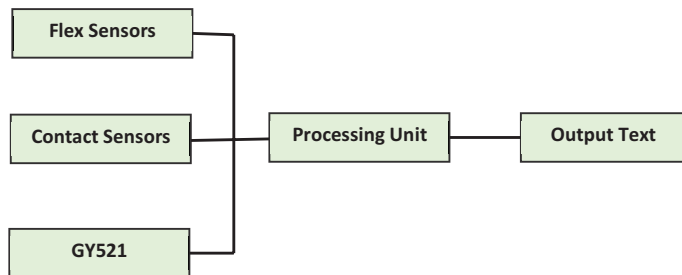


*Figure 1.5 The connection between sensors, processing unit, and the output screen that is proposed in (H S Anupama, 2021) [5]*

#### 4.3.3 Smart speakers

- **Natural Language Processing (NLP):** These devices use NLP to understand and interpret the voice command given. When a user gives a command, the device converts

the audio into text using automatic speech recognition. Then NLP algorithms analyse the text to determine the user's intent and extract the information

- **Voice Recognition:** AI-powered voice recognition is used to recognize and differentiate between different users' voices to personalize the experience.
- **Voice Commands and Tasks:** These devices can respond to voice commands to perform tasks like weather updates, news, briefing, general questions, set alarms or timers, play music, control smart home devices and much more.
- **Skills and Third-Party Integrations:** Smart speakers support third-party applications or services, often referred to as "skills" (Alexa) or "actions" (Google Assistant). These skills extend capabilities like ordering food, booking a ride, checking bank account balances, or controlling smart home devices.
- **Continuous Learning and Improvement:** This iterative learning process enables them to adapt to individual users and provide increasingly personalized and accurate responses.

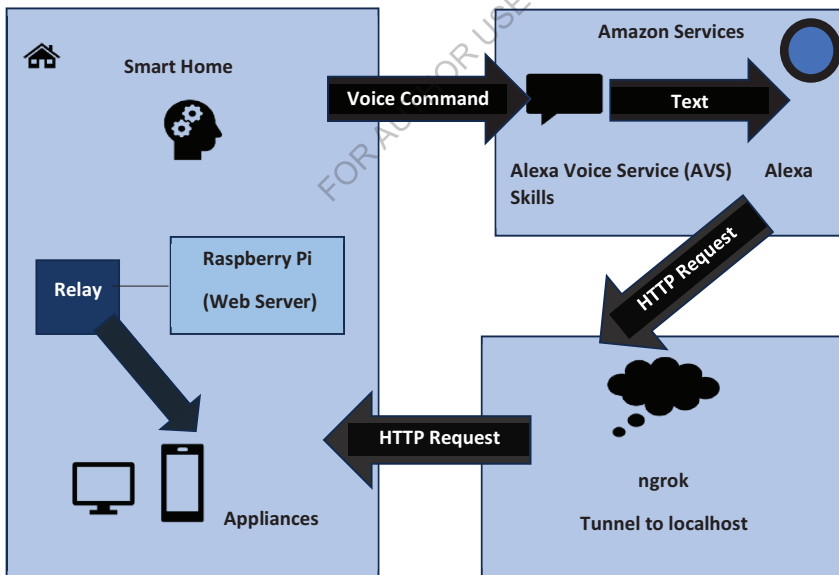


*Figure 1.6 Information architecture of user interaction with one of the main IPAs, Amazon Alexa [6]*

#### 4.3.4 Virtual assistants

AI functionality in virtual assistants like Apple's Siri, Google Assistant, Microsoft's Cortana, and Amazon's Alexa revolves around natural language processing, machine learning, and voice recognition technologies. These devices use AI algorithms to understand and interpret spoken or written commands from users and provide intelligent responses or perform tasks. They employ speech recognition to convert spoken words into text, natural language processing to comprehend user queries, and machine learning to improve their understanding over time. Through integration with various services and APIs, virtual assistants can perform tasks such as answering questions, setting reminders, playing music, controlling smart home devices, providing directions, and more. AI makes virtual assistants continually learn and adapt to user preferences, making them increasingly personalized and efficient in fulfilling user requests.

#### 4.3.5 Smart wearable devices

AI functionality in wearable devices, such as fitness trackers and smartwatches, improves their capability and provides personalized experiences for users. To deliver precise and timely insights regarding the user's health and fitness, these gadgets use AI algorithms to analyze sensor data from the user's heart rate, activity levels, and sleep habits. Activity detection, automatic exercise tracking, and sleep analysis are some of the AI-powered features. These devices can learn user behaviors and preferences using machine learning, providing individualized recommendations for fitness regimens, sleep quality enhancements, and health objectives. Additionally, AI provides intelligent notifications, contextual reminders, and adaptive coaching, which optimize the wearable device's performance as a health and wellness companion by customizing the user experience to individual needs.

#### 4.3.6 Smart structures

With the advancement of IoT in the past decade, the field of Smart Systems has a substantial advance as well in the branches of smart homes, smart buildings, and more recently smart cities. Since these structures can now be vastly connected as well as connected to the cloud or IoT hubs, such as AWS, they can use much more computational power than they used to (Gartner, 2022) [6]. By outsourcing the processing unit of a smart system, will have consisted of a sensor part and an actuator.

In this section, a few interesting and recently published papers regarding Smart Homes, Smart Buildings, and Smart Cities are discussed.

#### 4.3.7 Smart buildings

With the emergence of the COVID-19 pandemic, the need for surveillance of health standard measures also arose. Since the nature of this disease does not allow that much closeness, many developments have been done to reduce this contact, one of these is the development of a smart door that can detect whether a person has worn a face mask and make the decision on opening the door or not based on this detection (Baluprithviraj, Bharathi, Chendhuran, & Lokeshwaran, 2021) [7].

For this purpose, the researchers (Baluprithviraj, Bharathi, Chendhuran, & Lokeshwaran, 2021) [7] have trained a Multi-Task Cascaded Convolutional.

Neural Network (MTCNN) using the following features:

- Shape: a square is annotated by the location of faces
- Face Alignment, includes left-front front, left, right, and right-front.
- Eye centers which mask the Location of eyes
- The location of Masks with necessity details are annotated by a shape i.e., rectangles.
- Different types of masks are present in the market: i.e., man-made masks or without logos, and face masks covered by hand.
- Sealing Degree, the function of the face for recognition consists of four regions - eyes, nose, chin, and mouth.

Once this system detects a person without a face mask it will either close the door or add up to the number of people without a face mask to alert the owner of the property.

#### 4.3.8 Smart cities

Smart cities are a field of smart systems that focuses on developing systems for certain parts of city management that can act as smart and autonomous agents. One of these fields is traffic management. As cities become more and more crowded, the problem of littering and sanitation is becoming bolder. It is for this reason that Patel et al. have researched to detect an adaptive garbage detection system. Their system uses different object detection models such as EfficientDet D1, SSD ResNet50 V1, Faster R-CNN ResNet101 V1, CenterNet ResNet101 V1, and YOLOv5 for implementing real-time Garbage Detection System (Patel, et al., 2021)

[8]. Their system uses CCTV<sup>1</sup> footage as an input. For this task, they used the SpotGarbageGINI dataset (available on GitHub) which consists of 500 images of which 244 images were collected for this purpose. Then they used the 90%-5%-5% split for training, validation, and testing for their model. For their training, they used the five pre-trained models mentioned previously, and with 500 epochs of training, they reached 95% accuracy.

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## 5 A brief study of applications and future works in building smart cities and systems

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### Chapter abstract

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There have been significant advances in many research fields because of the development of big data, machine learning, and the Internet of Things. A review of the recent trends in building smart systems through speech, images, videos, and text for the purpose of building smart cities is presented in this study. A systematic overview of smart technologies and applications in smart systems is lacking, despite the rapid increase in research efforts over the past decade.

This review attempts to close this void. For this purpose, recent scientific research papers are selected to be examined further with the overview of the applications that have been used such as FIWARE with an example application that has used the digital twin method in the concept of smart cities and systems. We have attempted to address the key challenges to be faced in the coming years and identify potential future trends while emphasizing and highlighting future work availability.

### 5.1 Introduction

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Computers and smart systems have been around for quite some time in our lives and in our surroundings. In our decade, new technologies and initiatives are being born every day. To understand existing technologies and the surrounding developments much better, we need to keep an eye out for emerging trends. AI is one of the leading and most used technologies. AI is the ability of a machine to make decisions on its own. AI systems can be used to make decisions using a knowledge base is a store of information made up of facts, assumptions, and rules.

Despite research into autonomic models for managing computer resources, ranging from individual resources to a resource ensemble (e.g., multiple resources within a data center), research into integrating Artificial Intelligence (AI) and Machine Learning (ML) to improve resource autonomy and performance at scale continues to be a fundamental need in many

sectors (S. Gill, 2022) [9]. However, providing the ambient intelligence that is required to make decisions for smart behavior is still a challenging task (L. Silva, 2012) [10].

As online videos and digital evolution proliferate, the significance of video informatics and analytics has seen a marked rise. This growth has been evident in numerous areas, including digital marketing, security and video surveillance systems, healthcare infrastructures, talk show evaluations, scrutiny of influential groups on social media, and target monitoring (S. Al-Azani, 2022) [11]. This means that the future value of AI will be limited to the human creative capabilities, and lower investments in human-AI capabilities with inevitably result in lower value of the future AI systems (P. Radanliev, 2022) [12].

A key role of big data and a key foundation of its success is to discover new knowledge beyond the original use of data for learning, optimizing processes, and understanding the hidden rules of our world (A. Rapeaux, 2021) [13]. In this study, we try to provide a comprehensive overview of the scientific research in Smart Systems through FIWARE while briefly outlining the challenges and potential research directions in Smart environments such as smart cities.

## 5.2 Related works

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There have been significant amounts of research in the field of AI and Smart systems. Some researchers have focused on the technologies that have been used. Some of them focused on the environment and some focused on the leading companies and countries (L. Silva, 2012) [10] focused on the view of the state of the art of smart homes. They have looked at the research work related to smart homes from various viewpoints; first in the viewpoint of specific techniques such as smart homes that utilize computer vision-based techniques, smart homes that utilize audio-based techniques and then smart homes that utilize multimodal techniques. Then they looked at it from the viewpoint of specific applications of smart homes such as elder care and childcare applications, energy efficiency applications and finally in the research directions of multimedia retrieval for ubiquitous environments.

(P. Radanliev, 2022) [12] study was one of the researchers who focused on the countries and institutions. Their article conducts a statistical analysis of research data records on artificial intelligence by year, country, language, and organization. The results are clearly in favor of the USA on a national level, and English is clearly the dominant language for disseminating results.

On the other hand, (A. Ittoo, 2015) [14] has focused on the use of AI in Text Analytics. In their article, they provide a systematic review of the current state of the art in the application of text analytics in the industry.

In his work, (Sarker, 2022) [15] provided an in-depth perspective on "AI-based Modeling", detailing the foundational principles and potential capabilities of AI methodologies. These techniques are pivotal in crafting intelligent and smart systems for diverse real-world applications.

(Park, 2019) [16] focused on an integration of AI with smart systems and services with presenting to mitigate the existing challenges, which involves 18 novel and enhanced peer-reviewed papers from different dimensions of information technology research.

#### 5.2.1 Practical applications of AI based Smart Systems.

This section describes the main characteristics of Smart Cities and Smart Building with the scope of AI. Analysis is based on a review of the literature. An assessment has been conducted on smart buildings and smart cities by exploring the integration of smart buildings into smart cities, considering their applications, challenges, and upcoming trends.

##### a. Smart systems and smart cities

With the rapid development of urbanization, the burden on our cities is becoming heavier every day, full of challenges in the management of groundwater, waste, air and other resources considering pollution, health and hygiene, and traffic congestion. These challenges are forcing many urban planners around the world to look for smarter ways to deal with them and make cities sustainable and livable. The smart city concept has changed over time from "intelligent" to "digital" to "smart" and to "sustainably smart" or "smart sustainable"; many different definitions and main dimensions of a smart city have been identified (L. Silva, 2012) [10]. But to summarize, a smart city is an environment with ambient intelligence and automatic control functions that respond to the behavior of citizens and provide them with various options.

The standard approach to building smart cities is to computerize them. The set of sensors collects various types of data about the city's residents and utility consumption. A computer or device with computing power (such as a microcontroller) analyzes this data to determine

actions. They then react to these actions and events by controlling certain mechanisms built into the city (E. Hassan, 2017) [17].

**b. Smart city applications**

In a smart city, citizens collaborate to harness more solar energy, combine environmentally friendly modes of transport, and reduce energy use at home and work. Smart ideas demand education for everybody as a foundation for shared prosperity. A smart city sustains a high quality of life by protecting green areas and remaining a city that is open, exclusive, and collaborative (A. Ittoo, 2015) [14].

*Table 1. Smart City Components (R. Apanaviciene, Smart Building Integration into a Smart City (SBISC): Development of a New Evaluation Framework, 2020) [18]*

| Component of A Smart City | Related Aspect of Urban Life                  |
|---------------------------|-----------------------------------------------|
| Smart Economy             | Industry, Innovation and Competitiveness      |
| Smart People              | Education Creativity and Social Capital       |
| Smart Governance          | E-democracy, Participation, and Empowerment   |
| Smart Mobility            | Logistics and Infrastructures, Transportation |
| Smart Environment         | Efficiency and Sustainability, Resources      |
| Smart Living              | Security and Quality, Culture                 |

The components that have been the focus of smart city can be seen below:

**c. Smart infrastructure**

Digital technologies are becoming increasingly important in helping cities create the conditions for continued development. Buildings and urban infrastructure need to be planned more efficiently and sustainably. Cities also need to invest in electric and self-driving cars to keep their carbon footprint low. Rather, it is about intelligent technologies that enable energy-efficient and green infrastructure. For example, to reduce the need for electrical energy, smart lighting only emits light when someone walks by his smart lamp. Adjusting brightness levels and tracking daily usage are both important components of smart lights.

#### d. Air quality management

Smart cities are also implementing tools that can collect real-time pollution data and predict emissions. The ability to accurately predict air pollution allows cities to get to the bottom of their emissions problems and find strategic ways to limit the amount of air pollution they produce.

#### e. Traffic management

One of the biggest challenges in big cities is traffic optimization. However, finding a solution is not impossible. For example, Los Angeles, one of the busiest cities in the world, implements smart transportation solutions to manage traffic flow. Road-integrated sensors send real-time updates of traffic flow to a central traffic management platform. A central traffic management platform analyzes the data and automatically adjusts traffic lights to traffic conditions within seconds. At the same time, it uses historical data to predict where traffic will go. None of these processes require human intervention.

#### f. Smart parking

Cities are also using smart parking solutions that recognize when a vehicle has left its parking lot. Sensors are built into the floor and report the location of free parking spaces via a mobile app downloaded by the driver. Others use vehicle feedback to locate vents and guide waiting cars down a path of the least resistance. Smart parking is a reality today and does not require complex infrastructure or large investments, making this smart city application ideal for medium-sized smart city initiatives.

#### g. Smart waste management

Waste management solutions help optimize waste collection efficiency and reduce operating costs while successfully addressing the environmental issues associated with inefficient waste collection. These solutions have a level sensor in the waste container. When certain thresholds are reached, the truck driver's management platform receives notifications via smartphone. This message helps avoid half-empty drains by making the bin appear full (R. Apanaviciene, Smart Building Integration into a Smart City (SBISC): Development of a New Evaluation Framework, 2020) [18].

#### h. Energy management

FIWARE can be utilized to track and control energy use in homes and buildings. With the goal of optimizing energy consumption, predicting energy demands, and enabling smart grid integration for efficient energy distribution and management, AI algorithms may evaluate energy usage patterns, weather data, and occupancy information.

#### i. FIWARE smart applications

One of the biggest challenges in smart city projects is getting relevant context in one place, collected, and managed in different ways by different stakeholders. FIWARE uses a curated framework of open-source software platform components that can be used in combination with third-party components for faster, easier, and more cost-effective development of intelligent solutions (Park, 2019) [16].

The subsections below analyze the parts of technology most closely related to smart cities. An open data field showcasing the possibilities offered by FIWARE for developers interested in smart cities. The platform provides a robust set of APIs (application programming interfaces) that facilitate the development of intelligent applications for various industries.

#### j. FIWARE – Digital twins in autonomous driving application

Smart city solution providers face the challenge of developing effective vertical solutions that aim to solve specific problems, integrate different verticals in the city to achieve an overall smart city strategy, and use the city as a key driver of the data economy in the data economy. FIWARE platform can be utilized to build digital twins of automobiles or components used in autonomous driving systems. The properties and behaviors of the real-world items are captured by these digital twins, which serve as virtual representations of them. This is how the Digital Twins in Autonomous Driving Applications work:

- The performance of the vehicles or components in various scenarios can be predicted and analyzed by engineers utilizing digital twins in autonomous driving applications. Without driving the actual vehicles, which can be expensive and time-consuming, they can test and refine the behavior of the autonomous system.

- This allows for tracking, testing, and simulating the autonomous and can be connected to the actual vehicle or its sensors, it can update the virtual representation in real-time. It allows for tracking, testing, and simulating the autonomous

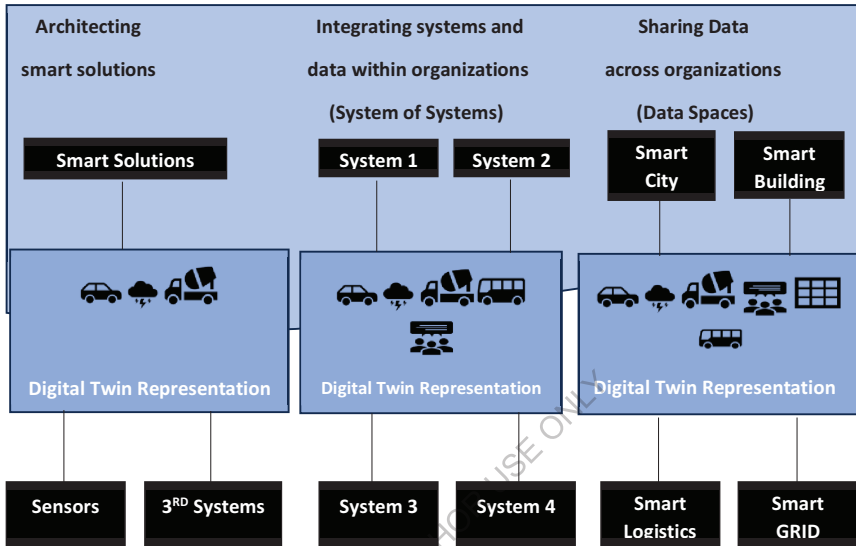


*Figure 2.1 FIWARE Digital Twin Structure (Petrova-Antonova, 2019) [19]*

Digital Twins contribute to safer and more resilient cities, helping city managers to identify and gather information describing the real world which can be processed to improve planning and effectiveness in the management of Smart City operations. In the concept of digital twins in autonomous driving scenarios, a physical car drives in a real environment. It will have a limited view of this environment based on information from its own sensors. This physical car has a digital twin. The digital twin is updated with the current sensor information of the actual car, but also has access to historical information and model of relevant aspects of the car. Additionally, digital twins can interact with other digital twins, not just digital twins of other cars, but also digital twins representing environments such as cars in the districts or intersections where all roads are connected. The sum of all this information is too large to send to the car in real-time, and the car may not have enough processing power (M. Bauer, 2021) [20].

A digital twin of a car can be developed in close conjunction with the physical car, but a digital twin of the environment must come from multiple independent sources and not necessarily in the context of creating the digital one. It's a more self-contained structure that doesn't need to be expanded to twin.

A car's digital twin can interact with other digital twins to access a wealth of information that is not limited to the car's sensors. This information can be used to better understand current conditions, predict future conditions, and recommend the best course of action accordingly. For example, the digital twin knows what's happening behind a curve, so it can choose the best route or recommend early braking if traffic ahead stops.

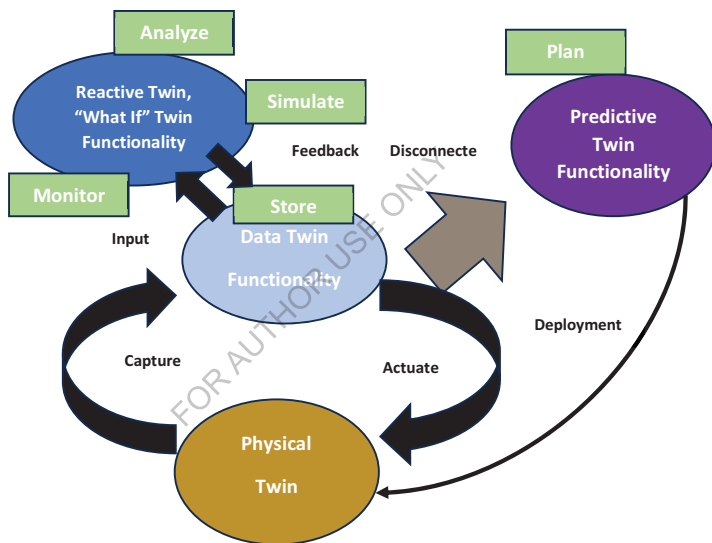


*Figure 2.2 Digital Twin Visualization (M. Bauer, 2021) [20]*

The digital twin concept has evolved and expanded its scope to include urban digital twins as a concept for smart city implementations. Leveraging the full context/digital twin representation of the city, a smart city governance system "or city operation center" can be developed. Developers can use real-time big data processing tools based on data from multiple sources to extract more valuable insights to support decision-making. Similarly, monitoring tools can be leveraged in this holistic context/digital twin representation of the city (M. Bauer, 2021) [20].

### 5.3 Challenges, future research directions

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Despite the dominant use of traditional machine learning approaches, an increasing trend of deep learning approaches for smart cities and systems is already observed and is expected to grow further (A. Sharma, 2022) [21]. The development of technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain and geospatial technology are key to the growth of smart cities around the world (T. Habuza, 2021) [22].

In cities, IoT is actively being used in three main areas: Transport and urban mobility, energy, and urban maintenance. In the area of transport and urban mobility, it provides traffic and parking information and facilitates the work of citizens. Mobility and assistance in finding a parking space for your private vehicle (Wang, 2015) [23]. On the energy front, cities save on electricity bills and improve energy efficiency. For example, streetlights can be connected to a smart network so that they can adjust their lighting to suit their current needs. In urban maintenance, governments can improve the condition of cities through comprehensive management of street furnishings and waste management.

AI offers numerous advantages to smart cities and its presence in these cities is growing. One of the primary and most valuable features of this technology is preventive maintenance (V. Despotovic, 2022) [24]. Thanks to AI, local governments can detect leaks and prevent incidents faster, so they can fix them faster. Traffic management and improved citizen safety on the road are other AI capabilities in smart cities. In addition to video surveillance functions, the use of AI-based security cameras is also increasing (X. Mei, 2022) [25] These are cameras that can recognize vehicle license plates to control access to cities and prevent entry of contaminated vehicles. With all these benefits, AI holds the key to developing smart cities. The same is true for other technologies, such as blockchain.

Blockchain technology is revolutionizing the world, and more and more cities are adopting it. It is a very useful technology for improving city services and city management. Transparency and security are essential, as these are services that involve many different processes and are frequently recorded and documented. Blockchain can be used to create a neutral, accessible, and secure information base for anti-corruption, creating the transparency needed in government.

Future research potential for smart building integration in smart cities can be extended by including interoperability and smart building performance predictions based on digital building and digital city modelling (M. Samonte, 2022) [26].

### Chapter abstract

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This work also presents a summary of a modern review of the latest and newest scientific trends in building Home Smart Systems. It is evident that the house prices may increase based on modern smart home improvements (Boutchaktchiev, 2017) [111], (Boutchaktchiev, 2021) [112]. The concept of a smart house has entered our lives, and technology now supports the processes that occur in our houses. Because of their ease, efficiency, and other characteristics, smart home systems have drawn the attention of users and intelligent device developers (J. Shen, 2018) [27].

Working on its specific developed platform, supported with AI system smart devices located at home and connected, it is a local network or microcontroller connected to parking, power, security, all the sensors in a house and even a swimming pool to provide robust comfortability, security, power consumption and management. A transformed AI smart home device can be added to any hospital, company, villa, or apartment. As a control panel to modify, update or just set new settings usually used a computer link, smart TV, or smartphone. Like the basic system, either the most complex one consists of multiple sensors and devices connected to the main system to control them by the user or via an AI system. Sensors, for example, are applied to control solar panels, house temp and power management: to generate electricity, power usage, and hot water usage control to provide better lifestyle and health care for their users. There are lots of advantages to using Smart Home systems:

- The owner can adjust the best temperature she or he needs in all rooms automatically.
- If we are talking about medical devices, it really can save lives to send emergency alerts to the right people.
- Solar panels are used to generate power and save regular electricity.
- Easy to be maintained, Arkin or moved to a new place.

There is a partial list of sensors which are usually applied in houses nowadays: sensors of water level, hot and cold water, humidity, temperature, security, IR, gas, and earthquake. All these sensors are connected to an AI smart house system which helps with controlling and monitoring it. Humidity and temperature sensors can calibrate and check each room

temperature based on owner choice: somewhere in the room needs to open the window or turn on cooler or heater. Fire and gas sensors are usually located in kombi areas or kitchens to shut down the gas valve in case of gas leakage or switch on the water in case of fire. Cold and hot water sensors are usually located in the bathrooms, kitchens or in a water storage room where the system can measure the water pressure and control the pump depending on what level the house needs low or high. IR sensors are usually located in each room to detect movements and according to that save energy and switch on or off lightning. Earthquake sensors can help with early alarms for evacuation purposes.

Security sensors usually stand on all windows and external doors to provide information about locked or unlocked windows, garage or doors and full protection plus an emergency call to the police if the system sees that someone broke into the house without an invitation.

## 6.1 Different smart home systems

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### 6.1.1 Home health care system

Necklace, smart sport watch, sleep tracking bracelets or rings, or vital cam are existed to measure body temperature, blood heartbeats, pressure, oxygen, or body temperature are connected to the smart AI system where it can recognize a heart attack, any illness, health issue, to send emergency alerts-notifications to the primary phone number provided by the owner and call family members to request or claim rescue. Cameras can be applied to each room to cover every corner of a house. Cams can be placed in every room to be able to cover every corner of the house. Easy and comfortable wear, direct connection to the main system application through a smartphone or tablet gives fast access to health records and assists in recognizing health problems via doctor appointment. Plenty of smart systems can benefit from research performed in motor potential and the speed and power characteristics of athletes (Ignatova, Specificity of the motor potential for achieving Scholar Wellness, 2021) [108], (Ignatova, Affirming wellness culture through innovative methodology related to Blaze-pod trainer system, 2023) [109], (Ignatova & Iliev, Benchmarking for Development of Speed and Power Characteristics, 2022) [110].

### 6.1.2 Car parking and pools

The underground parking system operates a remote-control safety factor engineered to the highest Movable Floor swimming pool with an AI lifeguard. There is a very revolutionary solution in the world of outdoor and indoor pools available: the moveable floor. The floor can be set to different depths via the electronic control in the wall. The patio can be transformed into an outdoor pool and an indoor pool into a party room. The floor is pulled down by means of a cylinder and the private swimming pool is created (Swimming pool Miraqua — luxury spa resort in your house, n.d.) [28]. Then the covered mood floor is activated again, and the entire floor comes up and the room can be used for other purposes and the live video stream from our underwater cameras is automatically monitored by our “state-of-the-art” object recognition software (Smart Pool & Spa: Efficient, Convenient, Smart, 2021) [29].

### 6.1.3 Electricity generation, energy storage and management systems

An indiscrete system consists of smart rechargeable batteries, an inverter, and a controller to optimize the charging and discharging cycles of batteries. Energy stored in the batteries which is received from photovoltaic panels, as an alternative eco way to generate electricity where small wind turbines can be used. A storage system is a part of an energy management system. Energy management systems can handle energy storage, energy consumption of property, and energy generation, with various optimization and saving energy methods that can keep power and boost overall performance in the smart home. The system can collect data from integrated smart plugs and meters to generate weekly energy reports including consumption predictions and graph visualizations. Another feature that the system has is to provide uninterrupted continuous power to smart homes by responding to scheduled power outages or to unscheduled potential power outages by storing custom-determined power capacity values before outages. Systems can use the battery of an electric vehicle to sell or buy electricity or rechargeable batteries. Smart systems can control the sun rays entering the windows in the house. A shading system using AI takes the position of the sun into account to adjust the slats. That does a sustainable use and consumption of eco sun energy and saves cooling and heating energy depending on the year season. Preventing the room from heating during summertime as from outside it stays 90% of heat and we can save electricity to not to use air conditioning for cooling the room. The main reason for losing heat in wintertime is the

opened windows. When we turn on the energy management system during the night, we can save 18% on heating.

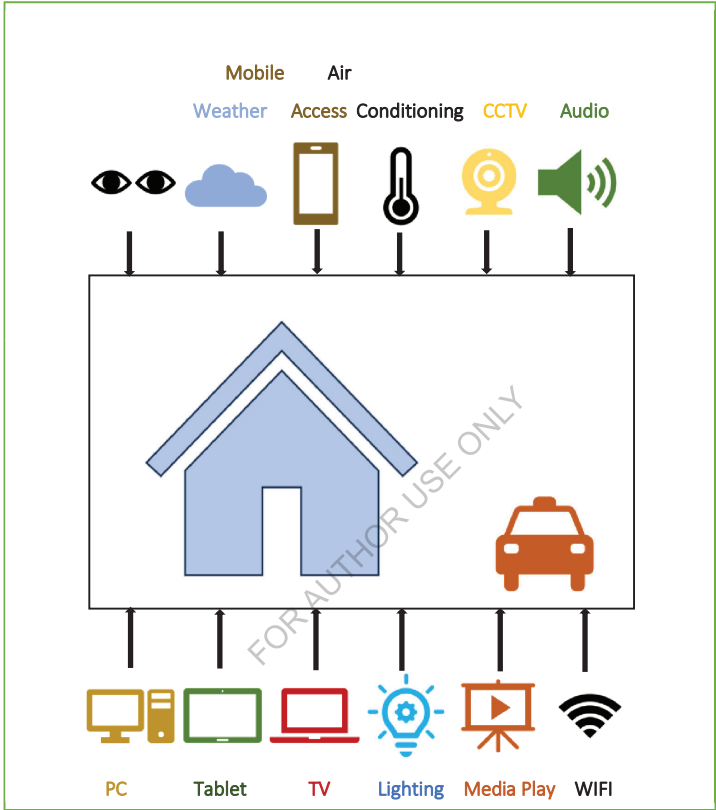


*Figure 3.1 Smart home system (Visioforce, 2021) [30]*

Let's look in detail at one of the modern energy-management smart-home systems. There are several subsidy programs and many laws, and rules in some countries to encourage of smart home integration like as supporting heating system optimization, deploying smart meters, and supporting building energy storage. Energy Performance of Building Directive 2010/31/ EU and European Standard EN 15232 (Parliamen, 2020) [31], which is in the same line as the Energy Roadmap 2050 (Foundation, 2020) [32], supports the smart-home technologies integration to decrease the amount of power demand. The control center is responsible for monitoring the proper units of different home appliances. There are some goals

of real-time collecting data by SHEMS, they are to adjust, correct, optimize, and predict consumption. Control center functions are here:

- Collect data from homeowners' commands, and grid utility through the communication system and different meters.
- Analyzing and monitoring consumption of energy for houses.
- Coordination between appliances and different resources to create the optimal working solution.

From power utilities smart meters receive a demand-response as an input to the SHEMS, system infrastructures can monitor many home features:

- Water
- Gas
- Heating
- Electrical consumption

Smart home devices fall into two categories: non-schedulable and schedulable loads. Non-schedulable loads pertain to devices without a predictable usage pattern, like printers, TVs, and hairdryers. On the other hand, schedulable loads relate to devices with a discernible operating pattern that can be managed by SHEMS, such as air conditioners and washing machines.

Plants wind and solar are the mature energy renewable sources in modern society. Some buildings today have or planning to install photovoltaic modules, micro wind turbines and thermal solar heaters. For smart homes can be provided solar energy instead of generating electricity, such as a solar water heater, solar dryer, and cooler. PV plants can be installed with low maintenance requirements that makes them more affordable. Remaining hot water from maintaining SWHs can be used as water for cooking or washing which will bring us to more energy saving and overall will increase the performance of whole the system. SHEMS has also energy storage, it is called energy-storage systems that handle energy storage. The most compatible storage types of energy in smart home applications are battery and fuel cells. The perfect match for these technologies is isolated houses in more remote areas. The process looks the following. Firstly, hydrogen fuel cells generate hydrogen using electricity during the charging phase. Secondly, during discharging, the hydrogen is used by the fuel cell to produce

electricity. Thirdly, fuel cells offer a highly clean storage setting with the ability to store additional hydrogen tanks.

Wind energy is cost-effective and efficient, especially for large-scale operations. However, the home-based wind micro-turbine market is quite niche. For micro wind turbines to operate effectively, they have certain specifications:

- A minimum wind speed of 2.7 m/s for basic power generation
- 25 m/s to achieve rated power
- 40 m/s for sustained power production.

Wind turbine technologies are very expensive and require constant maintenance if we compare them with a solar plant. Another promising alternative is biomass energy. Last researchers in that field consider the recommendation to look at biomass energy closer and use it for some types of buildings. The main function which can do biomass for people is heating as biomass-fueled generation systems are examined for many buildings. Examining the structure of the smart home, we find components like electricity sources, control hubs, intelligent meters, and communication devices, as depicted in Figure 3.2:

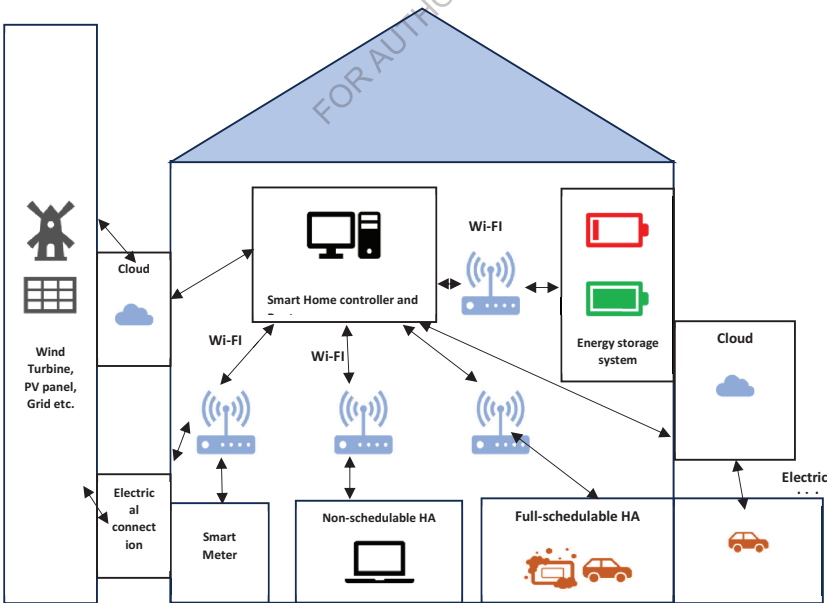


Figure 3.2 Infrastructure of SHEMS source (Arjun Valluri, 2010) [33]

Scheme-connected home devices, users, and grid operators via the internet to monitor and manage smart homes. The IoT and cloud computing have proven to be cheap, popular, and easy services for smart homes. IoT (Internet of things) schemes are compatible with many other communication protocols, such as Zigbee, Bluetooth, etc., as listed in Table 2. System security and privacy are critical challenges for such internet-based schemes. For small-scale residential buildings or ‘homes’, BEMS should deal with variable uncertain load behaviors according to the home occupants’ desires and requirements, which is known as SHEMS. SHEMS are defined as services that efficiently monitor and manage electricity generation, storage, and consumption in smart houses. Nazabal or SHEMS are defined from the electrical grid point of view as important tools that provide several benefits such as flattening the load curve, a reduction in peak demand and meeting the demand-side requirements.

*Table 2. IoT protocols features*

| Protocol                                                      | Advantages                                                                                        | Disadvantages                                                                                                                            |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 5G                                                            | Reliable with high speed and capable of managing a lot of devices simultaneously                  | Expensive with many problems related to security and privacy                                                                             |
| Z-Wave                                                        | Reliable, low data-transfer delay and without any interference with other communication schemes   | Limited ranges and needs special networking requirements                                                                                 |
| 6LoWPAN                                                       | A low-power consumer with a large data exchange capability                                        | Complicated with low data-transfer rate                                                                                                  |
| Zigbee                                                        | Low-power consumer, simple and cheap                                                              | Limited range and incompatible with other communication schemes                                                                          |
| Wireless<br>HART<br>Bluetooth                                 | Robust Low power consumer                                                                         | Insecure with low data-transfer rate. It can be interfered with by other IEEE 802.11 WLANs Limited range and low amount of data handling |
| Bluetooth<br>Low Energy<br>(BLE)<br>Narrowband<br>IoT(NB-IoT) | Simple, cheap with very low power-consuming rate Simple, cheap with very low power-consuming rate | Low speed with high data-transfer delay                                                                                                  |

|                                 |                                                                                  |                                      |
|---------------------------------|----------------------------------------------------------------------------------|--------------------------------------|
| Wi-Fi<br>(Wireless<br>Fidelity) | Devices can connect to the<br>internet and interact with one<br>other wirelessly | High speed with smooth data transfer |
|---------------------------------|----------------------------------------------------------------------------------|--------------------------------------|

Smart home systems can work with a batch of media such as images, voice and speech records, and videos and it can be used as a source of automation in several smart services. There is a synergy between Artificial Intelligence and Digital Signal Processing (DSP). After gaining, cleaning, and organizing multiple features from speech, we can develop feature vectors which consist of attributes, extracted through DSP, and then passed on to machine learning algorithms to complete specific smart tasks. Using speech, we can understand the following actions:

1. Who is talking,
2. What the person is saying,
3. What is the gender of a speaking person,
4. Define the emotional state of a person,
5. Define health-related issues in some cases.

Based on all those layers of information the decisions can be formed and automatically created in smart technologies. The system collects information about human behavior and activities on an everyday basis through one of the most natural ways of human communication – speech. Handling voice signals does not require a high level of computational complexity video then the image processing does. For example, innovative front-loader washing machines created by LG Electronics in the home appliances sector using ThinQ AI technology. LG AI DD washers can be managed using voice commands from a connected AI speaker as well as controlled and monitored with the ThinQ mobile app. The LMS (least mean squares algorithm) and ICA (independent component analysis) are deployed to filter out additive noise from speech signals captured in an authentic smart home setting. When assessing voice command recognition amidst various forms of additive disruptions such as television, vacuum cleaner, washing machine, dishwasher, and fan in this smart home scenario, the recognition success surpassed 95% in the chosen tests (R. Martinek, 2020) [34]. Speech recognition incorporated:

- Statistically-driven continuous speech recognition (Kumar, Dua, & Choudhary, 2014) [35], exploring varied methodologies (Arora & Singh, 2012) [36] in the speech recognition domain (Saksamudre, Shrishrimal, & Deshmukh, 2015) [37], including techniques like Mpeg-4 Audio to visual, feature extraction, acoustic models, and speech activity detectors.

- RASTA (SpecTrAl, RelAtive) approach,
- MFCC (Mel-frequency cepstral analysis),
- HMM (hidden Markov models) and ANN (artificial neural networks), such as feed-forward NN using the backpropagation technique and Radial Basis Function Neural Networks.

Examples include automatic speech recognition for aphasic patient therapy, DNN-HMM acoustic model utilization for phoneme identification, and feature combination in HMM/MLP and HMM/GMM speech recognition systems.

A pivotal component of speech signal processing also revolves around minimizing additive noise in speech signals, employing either single-channel or multichannel techniques. Single-channel strategies encompass:

1. Speech amplification, leveraging spectral subtraction-type algorithms,
2. Employment of intricate adaptive signal processing methods,
3. Model-oriented speech amplification,
4. Augmentation of additive noise elimination in speech processing via spectral subtraction,
5. Noise mitigation in speech signals.

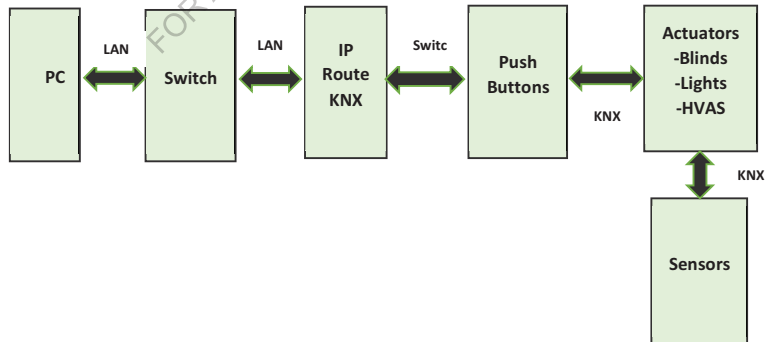


*Figure 3.3 Communication flow between computer and KNX technology using Switch and KNX Router (Weinzierl, 2014) [38]*

Multichannel techniques encompass:

1. LMS, the least mean square algorithm,
2. RLS, the recursive least squares method,
3. ICA, independent component analysis,
4. PCA or beamformer (BF) strategies, utilized for speech capture in noisy settings, including linearly constrained adaptive beamforming powered by a dependable algorithm.

For the execution of SHEMS automation, distinct modules from KNX technology were employed. KNX is tailored for intricate automation of smart buildings and homes, aligning with the European standard EN50090 (European Standard for Home and Building Systems) and the ISO/IEC 14543 standard. Given the preference of seniors, as well as disabled individuals, towards building voice-controlled automation to support independent living, the GHOST visualization software was developed and trialed for voice control features in SH. This software bridges the realm of individual voice recognition and KNX technologies. The interface between the voice-controlled computer and the KNX communication bus was facilitated using a Siemens KNX IP Router N146 module (5WG1 146-1AB01).

For the parameterization of distinct modules (like sensors, bus switches, and activators) of the KNX tech, the ETS5 SW tool was utilized. LabVIEW (Laboratory Virtual Instruments Engineering Workbench), a National Instruments product, facilitates programming via a distinct graphic programming language named "G". The app has a user interface loop, crucial for toggling the filter and detecting the position shift of the icon representing a person, which emulates the house segment where the user is. For instance, if the icon is positioned in the bathroom, activating lights or devices in other house sections isn't feasible (see Figure 3.3). If the position alters, an "UPDATE" alert activates in the filter loop, relaying the current coordinates of the simulated individual (icon), and the room they occupy is assessed. The data is then transformed into variables and clustered.

The "smart home" terminology is characterized by light toggling commands and blind operations applicable across all rooms, with specific commands designed for individual rooms (refer to Table 3). The application divides the "smart home" into five spaces: bathroom, bedroom, hallway, living area, and kitchen, where voice instructions are recognized. On app initiation, the icon representing a person is stationed in the hallway by default. Although voice

commands are received in this state, they aren't acted upon. For voice command execution, the user must position the icon in the designated room. For instance, to operate the blinds in a bedroom, the user would move the icon to this room, as shown in Figure 3.4. This mechanism averts unintended scenarios where a user, after moving the icon to the kitchen, attempts to control gadgets in other house areas.

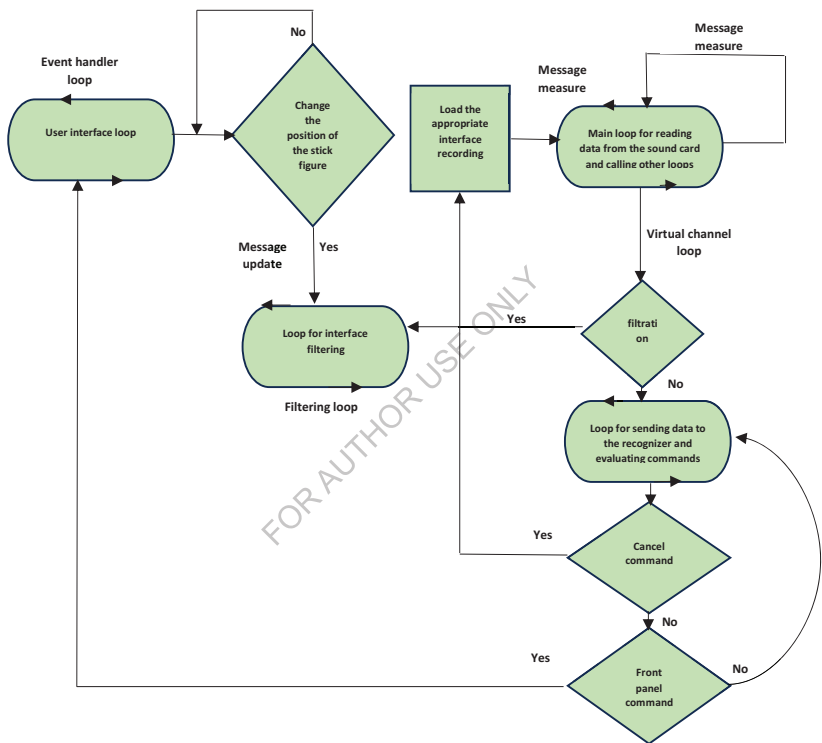


Figure 3.4 Block diagram for the “smart home” algorithm

Table 3. List of commands for voice control in a “smart” household

| Command                     | Room     |
|-----------------------------|----------|
| Light on                    | ALL      |
| Light off                   | ALL      |
| Turn on the washing machine | Bathroom |

|                              |                                  |
|------------------------------|----------------------------------|
| Turn off the washing machine | Bathroom                         |
| Dim up                       | Bathroom                         |
| Dim down                     | Bathroom                         |
| Turn on the vacuum cleaner   | Bathroom                         |
| Turn off the vacuum cleaner  | Bathroom                         |
| Turn on the dishwasher       | Kitchen                          |
| Turn off the dishwasher      | Kitchen                          |
| Fan On                       | Hall                             |
| Fan Off                      | Kitchen/hall/living room/bedroom |
| TURN ON THE TV               | Kitchen/hall/living room/bedroom |
| Turn off the TV              | Kitchen/hall/living room/bedroom |
| Blinds up                    | Kitchen/hall/living room/bedroom |
| Blinds down                  | Kitchen/hall/living room/bedroom |
| Blinds up left               | Kitchen/hall/living room/bedroom |
| Blinds upright               | Kitchen/hall/living room/bedroom |
| Blinds up middle             | Kitchen/hall/living room/bedroom |
| Blinds down left             | Kitchen/hall/living room/bedroom |
| Blinds downright             | Kitchen/hall/living room/bedroom |
| Blinds down middle           | Kitchen/hall/living room/bedroom |

In the case of interference from a vacuum cleaner (refer to Table 5), the preliminary success rate stood at a mere 1%, with only the "dim up" (5%) and "dim down" (3%) commands being identified. Post-filtration, the LMS algorithm saw an average success rate of 80%, while the ICA algorithm achieved an average of 86%. The "light off" command registered the poorest performance, garnering only a 27% success rate with the LMS filtration and 45% with the ICA approach.

*Table 4. Washing machine interference success rate result*

| LMA and ICA                  |            | Washing Machine maximum Volume |               |
|------------------------------|------------|--------------------------------|---------------|
| Command                      | Before [%] | LMS [%]                        | LMA & ICA [%] |
| Light on                     | 28         | 100                            | 100           |
| Light off                    | 21         | 45                             | 70            |
| Turn off the washing machine | 85         | 60                             | 78            |

In the presence of fan disruption (referenced in Table 6), the success rate prior to filtration stood at a mere 11%, with commands like "light on" (42%) and "light off" (24%) being the most detected. Upon filtration, the LMS algorithm exhibited an average success rate of 82%, while the ICA algorithm averaged at 91%. The lowest success rate was recorded for the "fan off" command again, where the filtration for the algorithm was only 18%, and 13% for the ICA method.

*Table 5. Vacuum cleaner interference success rate result*

| LMA and ICA                 |            | Vacuum Cleaner maximum Volume |               |
|-----------------------------|------------|-------------------------------|---------------|
| Command                     | Before [%] | LMS [%]                       | LMA & ICA [%] |
| Light on                    | 0          | 100                           | 100           |
| Light off                   | 0          | 27                            | 45            |
| Blinds down                 | 0          | 95                            | 100           |
| Blinds up                   | 0          | 93                            | 100           |
| Dim up                      | 5          | 100                           | 100           |
| Dim down                    | 3          | 100                           | 100           |
| Turn off the vacuum cleaner | 0          | 45                            | 60            |

*Table 6. Fan interference success rate result*

| LMA and ICA        |            | Fan maximum Volume |               |
|--------------------|------------|--------------------|---------------|
| Command            | Before [%] | LMS [%]            | LMA & ICA [%] |
| Light on           | 42         | 100                | 100           |
| Light off          | 24         | 28                 | 90            |
| Blinds down        | 2          | 100                | 100           |
| Blinds up          | 5          | 91                 | 100           |
| Blinds down left   | 3          | 88                 | 100           |
| Blinds downright   | 0          | 83                 | 100           |
| Blinds down middle | 0          | 100                | 100           |
| Blinds up left     | 6          | 95                 | 100           |
| Blinds upright     | 9          | 100                | 100           |
| Blinds up middle   | 15         | 100                | 100           |
| Fan off            | 18         | 18                 | 13            |

In scenarios with dishwasher noise, the initial average recognition rate stood at a mere 2%. The command “Turn off the dishwasher” was the most frequently identified; however, post-filtration, its recognition plummeted to zero. Both the LMS algorithm and the ICA approach achieved an average success rate of 85%. In contrast, amidst TV noise, the recognition rate before any filtration was 20%. The commands that were often detected include “blinds up middle” (42%), “blinds down left” (24%), “blinds down right” (21%), and “blinds down middle” (20%). This could be attributed to the recognizer's ability to discern these lengthy phrases during the television's dialogue pauses. After filtration, the LMS algorithm's average success rate was 84%, whereas the ICA's was 82%. The command “blinds down” recorded the lowest success after filtration as the recognizer often mistook it for variants like “blinds down the middle”, “blinds down right”, or “blinds down left”.

One of the most other applied industries is the medical field. One such product is the monitoring of patients which includes a quick reaction time of medical personnel when dealing with disabled people. The method uses a Raspberry Pi (RPI) based on Internet of Things (IoT) devices for patients with disabilities (Gregory, 2020) [39]. The device is activated via voice and is interpreting voices using a Support Vector Machine (SVM) and then generates alerts for medical personnel. The board comes with 1 GB memory and 1.2 GHz Quad core processing power. Scripts written in Python have been used to enable and control the voice recording part of the system as well as the communication part via liquid-crystal display (LCD) touchscreen. Raspberry Pi boards use a mini version of Linux called Raspbian and is running from a micro-SD card. Based on the card the user has different access times and speeds respectively. In this sense the system boots from the card onto the RPi device just as a plug-and-play device. The Fourier Transform is usually used when extracting and collecting the features. In this case, the Discrete Cosine Transform (DCT) was used to obtain the features.

This multiclass machine-learning algorithm used Support Vector Machine (SVM) as part of its core classification feeding voice waveform parameters into the input as can be shown. The signal is fed into a DCT block, and then frequency features from the DCT domain are fed into the SVM for classification. The dataset used was the Montreal Affective Voices (MAV). It contained a diverse set of voice samples containing emotions for both training and testing of the classifier. Nine emotional states were represented in 90 non-verbal voice samples: happiness, anger, sadness, surprise, disgust, fear, pain, pleasure, and neutral.

Maybe soon every home ought to have a Raspberry Pi computer. Aside from being relatively inexpensive, these sub-\$50 computers can accept analogue signals from sensors, are easy to maintain and use, and have a vast amount of community-based support. Given those features, the Raspberry Pi is becoming a hot piece of hardware when it comes to detecting images, objects, and specific people in a smart home. The older projects created image recognition models directly on the Pi, which took quite some time due to the limited processing power of the computer. For the latest project Edge Impulse, a machine learning object recognition service was used. That speeds up the “learning” part of the process because you can’t just plug a camera into a Raspberry Pi and expect it to just know what it sees. Instead, you must create models built to recognize specific things within a certain level of probability. More data and more processing power typically mean a higher probability of correctly identifying what’s on camera. The Raspberry Pi foundation itself highlighted face recognition on its hardware [39]. That project is a little more complex due to the introduction of a signal carried to a lock mechanism to the smart home: there are more opportunities, services, and affordable hardware than ever to build your own image or face recognition solutions. But there are reasons for a small set of smart homeowners to consider the DIY route. The Wyze cameras until the company’s ML partner was purchased by Apple last year. That one was the best of both worlds: on-device recognition models to keep your camera feed private and no subscription costs. In any case, DIY image, object, and person detection is a low-cost reality today. The harder part is getting information from such a project to other smart home devices. But even that landscape has become more accessible. A standard method of IoT sensor and device communication called MQTT debuted in 1999. It stands for Message Queuing Telemetry Transport and, as its name implies, is a messaging system of sorts. MQTT is an open standard for message communications between devices. In fact, MQTT is used by a few of the DIY smart home systems we’ve covered in the past. Home Assistant, Open HAB, and Node RED are a few that come to mind. You could even set up MQTT on your Raspberry Pi to bridge that image recognition project to other devices.

There are several areas that already use smart systems for core smart homes (Visioforce, 2021) [30]. The use of smart home systems leads to the development of old housing and infrastructure into advanced housing. This technology will enable AI to better understand the patterns of the owners to make their lives significantly easier and more comfortable. The smart housing market is expected to grow 21% annually until 2025. An advanced approach for processing voice signals, tailored for managing operational and

technical features in smart homes, was developed, and then subjected to specific filtering method tests. For the administration of various functions (like forced air circulation, irrigation, lighting, blinds, heating, and cooling) within smart home spaces (such as the living room, kitchen, dining area, and bedroom), a control program for KNX technology was devised utilizing the ETS 5 software.

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## 7 Building smart systems through speech, images, videos, voice, and text.

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### Chapter abstract

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Smart systems are most important and are very useful in today's modern Technology life and have been evolved into a huge advantage for the people in the present world. The world is turning into a technology-dependent nowadays. It is becoming more pervasive in the society. Here we discuss and compare about the smart systems through speech, image, videos, and text depending upon the input data and to see the smart systems that use images, texts, and audio as their main source to analyze and give the predicted output. Speech and text could perform embedding of vector data using the RNN model, whereas image and video might perform a CNN model depending on its data. In this study, we are about to see the smart systems that use images, texts, and audio as their main source to analyze and give the predicted output. These smart systems make the citizens' life simple. We also discuss a few examples from each source and a little basic explanation of how the process has been followed to get the final output. We will further know how the smart system detects the security system with intelligent face detection and recognition, smart video surveillance system based on edge computing and understanding of smart service systems through text mining. The aim is to establish common ground for understanding these smart systems through multiple disciplinary perspectives, which will motivate further research on modern smart systems.

### 7.1 Introduction

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In today's life, people spend their 80 percentage of their lives in office buildings, schools, hospitals, and homes. The Internet of things (IoT) provides us smart building solutions to meet our needs in our daily life and cheaper solutions than the old system such as closed-circuit television (CCTV). Many smart systems are created and being used everywhere all around the world. The slow rise of the systems is giving a big impact on the common citizens' life. There is a huge play of Artificial Intelligence in most of the smart systems that are being created and used out there. These smart systems need a proper source of input to perform its analysis for guiding and predicting the proper output. There are different sources of input that helps these smart systems. We are looking into the most important and common 3 input sources

namely Image, Text, and Audio. There are several Smart systems out there which are based on these 3 sources as their inputs and some smart systems are more popular and common in use nowadays because of our technology development. Face recognition is a technique which is achieved by some Machine Learning models and is used in many smart systems which is done by having the image as their main source of input. Likewise, Spam detection is another technique in which has Text is the main source of input and Voice Control like having Smart systems takes audio as their main source of input. These applications are used by us in our day-to-day life. There are still a lot more smart systems that are still in their developing stage and yet to come out to conquer the world. Here we will be discussing the face recognition IOT system using different components such as Raspberry Pi (Gregory, 2020) [39]. Moreover, The Internet of things (IoT) and computing on the edge nodes have been wider topics for research works that propose distributed video surveillance systems based on the concept of intelligence of the system.

Speech systems have been increasingly used throughout society. As per research, in 2017, 13% of all United States households had a smart speaker and today this percentage is increased to 55% by 2022. In general, a speech system is a technology that utilizes verbal speech to execute a specified command or action. Smart service systems are those service systems which connecting things and enabling intensive data and information interactions among people and organizations that improvise their decision-making and operations.

## 7.2 Smart systems using image

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### 7.2.1 Smart cameras for home monitoring

AI functionality in smart cameras for home monitoring revolutionizes the way we safeguard our homes. These cameras utilize AI algorithms to analyze video streams in real-time, enabling advanced features such as person detection, facial recognition, and object tracking. By leveraging deep learning techniques, smart cameras can distinguish between humans, pets, and other objects, minimizing false alarms and providing more accurate notifications. AI-powered features also include activity zone detection, which allows users to specify areas of interest for monitoring. Additionally, smart cameras can provide intelligent alerts, such as notifying users when a person is detected at the front door or when unusual activity is detected inside the house. The integration of AI in smart cameras enhances home

security, provides peace of mind, and enables users to actively monitor and protect their homes even when they are away.

### 7.2.2 Smart security camera

Smart security cameras with AI capabilities have improved event detection and analysis capabilities, enabling more sophisticated monitoring and security features. In order to recognize and categorize objects, people, and activities in real-time, these cameras make use of AI technologies like computer vision and deep learning. Facial recognition, object identification, and activity tracking are examples of AI-powered functionality. AI enables smart security cameras to recognize intrusions, differentiate between typical and suspicious behavior, and notify users right away. Advanced capabilities like person tracking, zone-based monitoring, and behavior analysis are also available from them, enabling preventative security measures. Smart security cameras with AI capabilities are much more effective at monitoring and securing homes, businesses, and public areas.

### 7.2.3 Autonomous vehicles

The core of autonomous cars' functioning and decision-making procedures is AI functionality. Autonomous vehicles can see their surroundings, analyze their environment, and make judgments in real time thanks to a combination of sensors, cameras, and AI algorithms. The vehicle can identify and recognize objects, such as other vehicles, pedestrians, and traffic signs, and understand their behavior and intent thanks to AI techniques including computer vision, machine learning, and deep learning. The vehicle can navigate, plan routes, and make difficult driving decisions because of the AI algorithms that interpret sensor data to produce a detailed depiction of the environment. With time, the AI system's performance and safety improve because of continual learning from data and experiences. In general, AI gives autonomous cars the capacity to comprehend and react.

### 7.2.4 Human face recognition

This technique is nothing but detecting and identifying a face from an image. These Face Recognition techniques are used in many smart systems. The below flowchart is from research where they used this face recognition method for an Attendance management system (M. Sujatha, 2019) [40].

This flowchart shows the outline of the technique and how it works starting from the camera and stepping into image enhancement, detecting the face using NI Vision Assistant which has the pattern matching algorithm because of the values of the histogram, extracting the features and finally finding the match of the acquired image with the face in the database and reporting to the attendance server (M. Sujatha, 2019) [40].

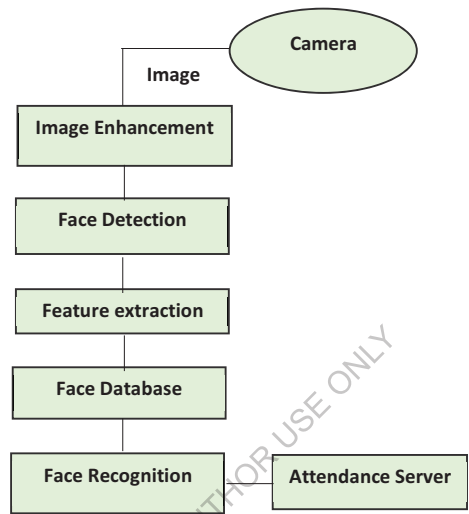


*Figure 4.1 Flow chart for Face Recognition (M. Sujatha, 2019) [40]*

This is a solid example of the usage of images through Face recognition in a smart system. There are many other smart systems that are built using images as a source for their smart systems. Images play a vital role in the current society and can be explored more in this area and make life simple and easy.

*Table 7. Report Generated after Detection (M. Sujatha, 2019) [40]*

| UID  | CID  | Name      | Contact | P/A |
|------|------|-----------|---------|-----|
| 1003 | 1588 | Praveen   | 942     | A   |
| 1004 | 1589 | Sanjay    | 718     | P   |
| 1009 | 1594 | Anirudh R | 962     | P   |
| 304  | 404  | ACB       | 972     | P   |
| 305  | 405  | ABC       | 982     | A   |
| 306  | 406  | ACB       | 992     | A   |

|     |     |      |     |   |
|-----|-----|------|-----|---|
| 307 | 407 | Rak  | 943 | A |
| 308 | 408 | Tra  | 805 | A |
| 309 | 409 | ADY  | 825 | A |
| 310 | 410 | XYZ  | 845 | A |
| 311 | 411 | KIIL | 865 | A |
| 312 | 412 | Bill | 895 | A |

### 7.2.5 Smart system using speech.

Smart systems built with speech as a source is not as popular as image and less compared to the image. But it is kind of similar with respect to some of the methods in image smart systems. There are applications out there for speech recognitions too like Voice search, Voice control, Translator, Helping the disabled, Voice Biometrics, and Hands-free Calling on mobile.

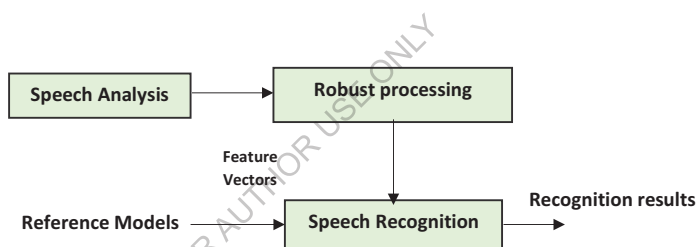


*Figure 4.2 Flow Chart of Speech Recognition System (Shingo Yoshizawa, 2016) [41]*

The flowchart shows the basic flow of how speech recognition is handled starting with the speech analysis using any deep learning architecture and giving us the output either in the same speech format or text format (Shingo Yoshizawa, 2016) [41]. Few examples of Smart systems using Speech follow.

### 7.2.6 Voice-activated TV remotes

Users benefit from ease and a hands-free experience thanks to AI technology in voice-activated TV remotes. These remote controls use artificial intelligence (AI) algorithms to recognize speech and understand natural language. By utilizing machine learning, these remotes may gradually learn and adjust to the voices and preferences of specific users, increasing accuracy and responsiveness. Using voice commands, consumers will soon be able

to operate a variety of TV tasks such as channel switching, volume control, content search, and even using smart TV applications. Voice-activated remotes powered by AI can also be integrated with virtual assistants like Alexa or Google Assistant, giving users the ability to control other smart home devices, check the weather, or receive personalized recommendations all with simple voice commands, improving the TV-viewing experience and allowing for more flexible use of the home's smart home technology.

### 7.2.7 Virtual assistants

Virtual assistants with AI capabilities can comprehend and react to user requests and commands, emulating human-like interactions. Natural language processing and machine learning techniques are used by virtual assistants like Amazon's Alexa, Apple's Siri, Google Assistant, and Microsoft's Cortana to understand spoken or written input. They can do things like setting reminders, giving weather updates, responding to trivia questions, managing smart home appliances, and even having casual chats. Virtual assistants gain better responses over time by continuously learning, adapting to user preferences, and honing their comprehension of context. By giving users current information and executing different activities with voice commands, virtual assistants can become more personalized and effective thanks to AI.

### 7.2.8 Voice-activated wearables

Hands-free and voice-controlled operations made possible by AI capability in voice-activated wearables redefine how we engage with technology. These wearables, which include smart earbuds, smart glasses, and smart helmets, integrate AI-powered virtual assistants like Siri, Google Assistant, or Alexa. This enables users to issue voice commands, ask questions, and get immediate answers. These assistants' artificial intelligence (AI) algorithms use natural language processing (NLP) to comprehend and translate user voice instructions. This enables seamless handling of a variety of tasks, including placing calls, sending messages, setting reminders, playing music, or obtaining directions. Voice-activated wearables offer a pleasant and intuitive user experience that boosts productivity, connectivity, and hands-free multitasking in a variety of daily tasks as they continue to progress in accuracy, context, and personalization.

Speech recognition can be facilitated using deep learning frameworks such as Deep Neural Networks, Convolutional Neural Networks, and Recurrent Neural Networks.

Additionally, numerous hybrid strategies exist to enhance accuracy in speech recognition, and these methods have gained significant popularity in contemporary times (Dokuz, 2020) [42]. Speech recognition is also used in smart home systems which is the most popular ongoing system which helps people in many ways. ASR in smart homes is the most impeccable thing which should be very accurate and proper. This ASR was a bit easy in this system because of the vocabulary. Usually, the vocabulary and grammar part will be very little because most of the words will be commanding (*McLoughlin, 2008*) [43].

The speech recognition accuracy decreases with an increase in the vocabulary size. Speech recognition is an upcoming system which needed more time to get evolved within itself before reaching out to the public. There are a few successful systems like this Voice search, ASR in the smart homes and Voice Translators.

#### a. Smart systems using text

There are many smart systems that are available outside based on text as their source. Some of the applications are customer care services, Risk Management, Business Intelligence, and Spam Filtering. Let's check out some examples:

#### b. Smart note

Voice commands can be used to interact naturally and without using your hands using voice-activated wearables. Artificial intelligence-powered voice recognition and natural language processing are features of these wearables, such as smart headphones and smart eyewear. The AI algorithms process and understand spoken commands, enabling users to carry out a variety of actions like placing calls, sending messages, setting reminders, playing music, or getting information just by speaking. With time, accuracy and comprehension of the AI system improve as it picks up on the user's voice and preferences. A seamless and simple user experience is provided by voice-activated wearables thanks to the additional capabilities of AI-powered voice assistants like Siri or Google Assistant, which can answer questions, provide personalized recommendations, and interface with other smart devices.

#### c. Chatbots

Chatbots with AI capabilities can interpret user inquiries and have natural-sounding conversations with users. Natural language processing (NLP) methods are used by chatbots to analyze and understand user inputs, glean context, and intent from the written word. AI-

driven chatbots may respond to a variety of user interactions, deliver pertinent data, and make individualized recommendations or solutions. Using machine learning techniques, they may continuously improve their responses by learning from previous interactions. Chatbots are useful tools for customer service, virtual assistants, and interactive conversational experiences since AI enables them to link with numerous systems and databases to retrieve real-time information. The use of AI in chatbots improves their capacity to comprehend, communicate with, and support users, resulting in more effective and gratifying engagements.

#### d. Spam filtering

Spam filtering is an important application that almost all organizations must be having with them to prevent themselves from cyber-crime and cyber-attacks.

Three approaches for spam filtering:

- Rule based
- Statistical
- Hybrid

There is a huge role played by Artificial Intelligence in this Spam filtering and detection applications. Some of the popular ML models that are used in this spam filtering are (Bhowmick, 2016) [44]:

- Naïve Bayes
- Random Forest
- K Nearest Neighbors
- Support Vector Machines

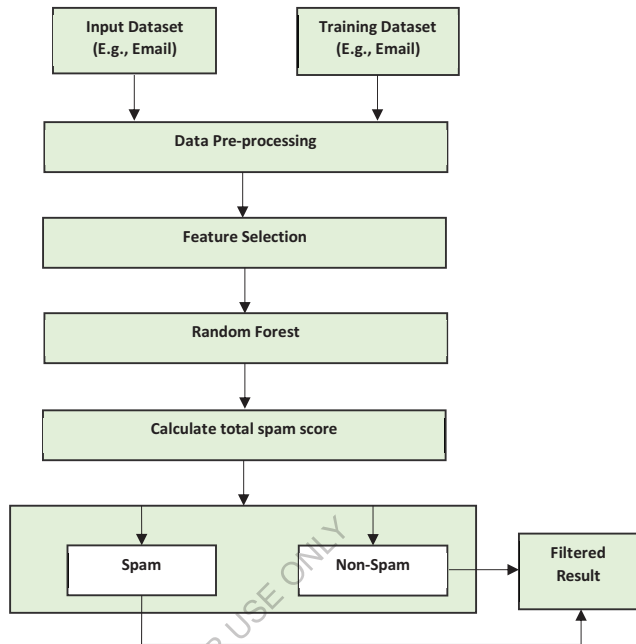


*Figure 4.4 Flow chart of the spam detection system (Kothapally, 2021) [45]*

From the above diagram, we can see how the text is used, modified, and processed to get the filtered result. From getting pre-processed, extracting the features, and finally running it through an ML model. This is the basic workflow of a Spam detection smart system which will fit for all the similar smart systems detecting spam using the text as source (Kothapally, 2021) [45].

Texts are used in several smart systems like preventing crime and detecting abusive language in the public platform and in many areas of technology. The above example of spam filtration is a concrete example that text is a main source for a smart system. All the large organizations who are providing mail services like Google, Microsoft have these smart systems in-built into the applications to segregate spam mail separately for the users.

### 7.3 Research methodology and previous related work

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The system is divided into two parts, hardware and secondly software design. In the hardware part, the role of the camera sensor is that it will detect and recognize the involvement of humans if the person is authorized or unauthorized in the system using the raspberry pi 3. However, in the software design part, the project will be interfaced with the HTML webserver and cloud storage platform on the system. Figure 4.6. shows the block diagram of the project (Lim, 2018) [46].

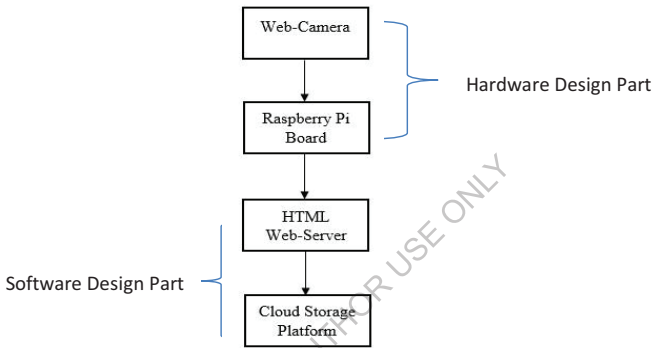


*Figure 4.5 Block diagram of the System (Lim, 2018) [46]*

The authorized person will be allowed to enter the building with the proper authorization by the system. However, A person entering without any authorization will be considered as an intruder. The captured image will be stored directly in the Dropbox cloud storage when the system detects the presence of a human.

Coming to the next phase of the topic about the development of video-surveillance systems is the VPU, developed by Intel. Focused on the parallel processing of neural networks. VPUs are highly oriented towards high-speed inference processing with low power consumption, being able to implement these types of devices in embedded systems, drones, or systems through external power supply. Intel has introduced three versions of devices with Myriad-1 and Myriad-2 has been discontinued and now Myriad-X being in the market. The VPU can be connected via USB (NCS2) or PCIe. This type of technology is becoming highly valuable in the development of smart systems by constructing an object classification system, or with the detection system on a Raspberry.

At the same time, speech systems are becoming more popular, with recent studies and estimations about adults and old age people who are likely to be interacting with the speech systems throughout later stages of life. There are a number of potential benefits to this technology, one challenge that it could create in the older adult’s usage of speech systems is the degree to which these systems can decipher their speech.

Now the conceptualization of smart systems is not easy given the variety of related studies and volume of applications. Thus, we try to rely on a text-mining method to develop our understanding of these systems. Text mining is a discovery of previously unknown knowledge from textual data. Text mining is used in a wide range of document types, such as technology trend analysis with patent data, customer understanding with customer opinion or feedback etc.

We try to rely upon web browsers like Google News platform service for data collection to ensure the quality, originality, text richness and regularity of the content. Figure 4.7. Will give a brief explanation of the overview of data analysis as discussed by (Lim, 2018) [46].

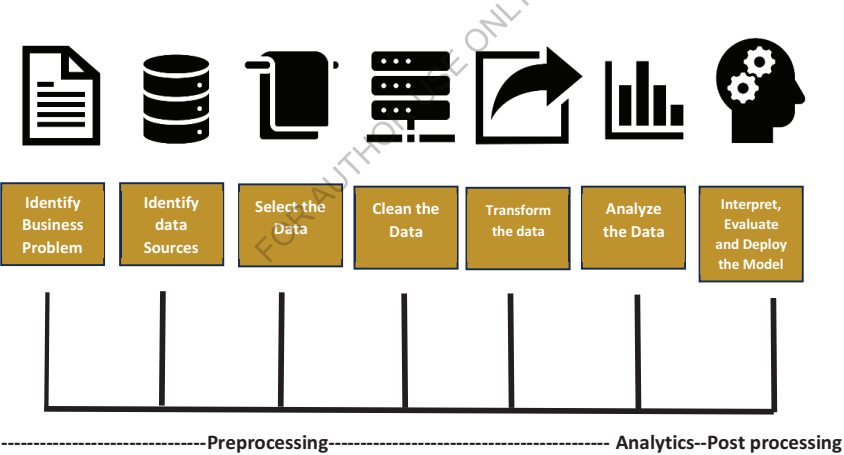


Figure 4.6 Overview of Data Analysis

The most important challenge in text mining is to identify meaningful data and word features in the context of the question. Figure 4.7 also illustrates the process of finding a core vector space in the scientific article data. There are totally three steps involved in the process. Firstly, cleaning the data, there are multiple ways to transform the data into numerical form and eliminate irrelevant data. Second, selecting the word features which may represent “smart

service systems” depends upon TF-IDF values which represent the importance of the word in the entire data set. Lastly, eliminating the data where the abstract or the information was missing or was a duplicate.

## 7.4 Results and discussion

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The video frame after clicking on the button of face recognition helps to recognize the human names which are registered on the data set and there is another person who is not recognized and does not store any information in the data set, automatically the system will display “Unknown”. Raspberry Pi can detect accurately with motion or the presence of humans in the system. The captured image will be stored in the Dropbox cloud storage and the image will only be stored if there is any movement in the front of the camera. EPFL dataset was used to find the possible real scenario in which there are overlaps, different people, as well as changes in the illumination.

This dataset contains two scenarios. Firstly, one is a laboratory which is a huge space in which there is a set of four people overlapping one another and changing their position in the image. The second scenario is a university corridor in which there are around eight people with little space. To check the system's precise state of the art, we compare the PR curve with different methods involved such as ACF which uses an RGB detector based on AdaBoost and aggregate features.

## 8 Face recognition using modified deep learning neural network

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### Chapter abstract

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Deep learning techniques, particularly convolutional neural networks (CNN), have shown significant achievements in facial recognition systems. While they excel with vast datasets, they struggle when trained with a limited number of samples. To learn about facial expressions from a smaller dataset, this document provides a modified deep learning neural network. CNNs, RELUs, and layers that are fully connected make up the proposed network. To double the complexity of the training set, Gaussian and Poisson noise are applied to each sample in the training dataset, thereby creating synthetic samples. These experiments demonstrate that CNNs show greater generalization power with augmented training datasets. An AT&T face database is used to train the network. The proposed approach successfully improves recognition rates based on limited training data.

### 8.1 Introduction

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Deep convolution networks have had a lot of success in the field of computer vision recently. Facial recognition has been extensively researched and most interesting application. Facial recognition is used in video surveillance, identity authentication, multimedia applications, home and office security, law enforcement and different human-computer interaction activities. The appearance of a person in an image is a result of the mutual effects of the illumination, pose, the 3-D structure of face, occlusion and background which are uncontrolled constraints that are encountered in real world applications (Vishwakarma V. , 2015) [50]. Different approaches have been proposed to deal with these technical hitches, like in illumination normalization techniques have been proposed and in (Vishwakarma V. P., 2016) [51] ANN based classifier is used to resolve this non-linearity.

CNN methods (Zhou, Naive-deep face recognition: Touching the limit of LFW benchmark or not?, 2015) [53], (Y. Sun X. W., Deeply learned face representations are sparse, selective, and robust, 2015) [54], (Y. Sun Y. C., Deep learning face representation by joint identification-verification, 2014) [55] have achieved the best three face recognition rates using the FRUE benchmark database LFW (Labelled Faces in the Wild) (G. Huang, 2007) [56].

The only problem with CNN is that it shows exceptionally great performance with large training datasets but fails for smaller ones. In such cases the use of deep learning is put off as the network will overfit severely with smaller training data (G. Hu X. P., 2016) [57].

Several academics have investigated the development of additional synthetic training data to address this issue (M. Jaderberg, 2014) [58], (Schoeler, 2015) [59], (A. Rozantsev, 2015) [60]. The key benefits of synthetic training data are the ability to generate the necessary number of training samples and the unrestricted control over the sample nuisance factor (G. Hu X. P., 2016) [57]. Data synthesis has also been applied to other recognition problems like, object detection (A. Rozantsev, 2015) [60], text recognition (M. Jaderberg, 2014) [58] and scene understanding (Schoeler, 2015) [59]. Data augmentation is another method which has been used to tackle the problem of training data (M. Paulin, 2014) [61], (Zisserman, 2015) [62]. It is very much like data synthesis, but easier to implement. It is more limited in, that available training images are distorted without influencing the semantic class labels. These include rotation, cropping, scaling, applying noise, etc (G. Hu X. P., 2016) [57], (Zur, 2017) [63].

In this experiment the number of training dataset is increased by Data Augmentation. This helps the CNN to work with smaller datasets. Face recognition system will show a very good result using augmented data. The only problem with CNN is that it shows exceptionally great performance with large training datasets but fails for smaller ones. In such cases the use of deep learning is put off as the network will overfit severely with smaller training data (G. Hu X. P., 2016) [57].

Several academics have investigated the development of additional synthetic training data to address this issue (M. Jaderberg, 2014) [58], (Schoeler, 2015) [59], (A. Rozantsev, 2015) [60]. The key benefits of synthetic training data are the ability to generate the necessary number of training samples and the unrestricted control over the sample nuisance factor (G. Hu X. P., 2016) [57]. Data synthesis has also been applied to other recognition problems like, object detection (A. Rozantsev, 2015) [60], text recognition (M. Jaderberg, 2014) [58] and scene understanding (Schoeler, 2015) [59]. Data augmentation is another method which has been used to tackle the problem of training data (M. Paulin, 2014) [61], (Zisserman, 2015) [62]. It is very much like data synthesis, but easier to implement. It is more limited in, that available training images are distorted without influencing the semantic class labels. These include rotation, cropping, scaling, applying noise, etc (G. Hu X. P., 2016) [57], (Zur, 2017) [63].

In this experiment the number of training dataset is increased by Data Augmentation. This helps the CNN to work with smaller datasets. Face recognition system will show a very good result using augmented data [50].

## 8.2 Related studies

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### 8.2.1 Deep learning

Deep learning techniques are a subset of machine learning techniques that help make sense of data like images, sounds, and text by learning several layers of representation and abstraction. Deep learning substitutes effective techniques for hierarchical feature extraction and unsupervised or semi-supervised feature learning (Bengio, 2012) [65].

Deep learning methods have been around for a long time now (G.E. Hinton and R.R. Salakhutdinov, 2006) [66], but the recent upswing was brought on by the ground-breaking work of (G.E. Hinton and R.R. Salakhutdinov, 2006) [66] in 2006. Deep learning has demonstrated exceptional performance in computer vision, speech recognition, and natural language processing over the past few years (Yann LeCun, 2015) [68]. Multilayered neural networks are the focus of deep learning today (G. Hu X. P., 2016) [67].

Feedforward neural networks, recurrent neural networks, and convolutional neural networks are the three types of deep neural architectures. The name "feedforward" refers to the way that feedforward networks transmit unstructured data from one end, known as input, to the other, known as output. The feedforward networks are regarded as universal function approximators because they can estimate any function  $f$  by constructing a mapping of  $y = f(x)$  and then learning the value of the parameter that best approximates  $f$  [20]. Recurrent neural networks use self-replicating components to describe dynamics over time (and space). RNNs are designed specifically for handling sequential data. They can save long-term dependencies and maintain a little amount of memory. RNNs are robust computational devices that can approximatively execute any program (Tsungnan Lin, 1996) [70]. A convolutional neural network produces a hierarchy of more complex features by applying alternately trainable filters and local neighborhood pooling operations to the input images. The input representation is downsampled and the input patterns are made larger by the pooling operations (Nguyen, 2017) [72]. CNNs are translation-invariant, a property shared by human visual cortex (Yann LeCun

and Yoshua Bengio, 1995) [71], as they make use of repeating local input patterns over time and place. Local input patterns are discretely sized small data slices, such as a collection of pixels in an image.

### 8.2.2 Face recognition

The efficiency of facial recognition algorithms has significantly improved in recent years. Face recognition is important because of its technological difficulties and diverse potential uses. Principal Component Analysis, often known as Eigenface, is the first widely used face recognition method (Pentland, 1991) [73]. It can be seen as a linear model with a single layer.

The single layer linear model Fisherface (Linear Discriminant Analysis) (A. Rozantsev, 2015) [60] is also one. Additionally using linear features was Laplacianface (Locality Preserving Projection) [74]. Then, other hand-crafted local nonlinear feature-based techniques appeared, including Fisher vectors, Local Binary Patterns (LBP), and Local Phase Quantization (LPQ) (Schoeler, 2015) (Chen, 2013) (Schoeler, 2015) [59, 75, and 59]. However, in unrestricted settings where the face photos encompass intra-personal variables such position, illumination, expression, and occlusion as revealed in Labeled Faces in the Wild (LFW) benchmark (G. Huang, 2007) [56], (Schmidhuber, 2015) [76], the performance of these hand-crafted characteristics significantly declined.

In the last few years, face identification in an unrestricted context has been successfully accomplished using deep learning techniques, particularly CNN. The main strength of CNNs is that each processing layer, right down to the pixel input, contains adjustable parameters that can be trained using data. As a result, supervised data-driven learning of features eliminates the need for hand-crafted feature design.

Features based on CNN learning are more resistant to intricate intra-personal variances (Schmidhuber, 2015) [76]. The three best face recognition rates in the FRUE benchmark database LFW (Labelled Faces in the Wild) were achieved by CNN algorithms (Zhou, Naive-deep face recognition: Touching the limit of LFW benchmark or not?, 2015) [53], (Y. Sun X. W., Deeply learned face representations are sparse, selective, and robust, 2015) [54], and (Y. Sun Y. C., Deep learning face representation by joint identification-verification, 2014) [55] (G. Huang, 2007) [56].

### 8.2.3 Data augmentation and synthesis

For some recognition issues, large training datasets are readily available. One such dataset is the CASIA Webface dataset (D. Yi, 2014) [77], which was semi-automatically acquired from IMDb and has 500,000 face photos. On the other hand, due to a variety of extrinsic constraints, there are numerous other recognition challenges for which it is difficult and possibly prohibitive to collect huge datasets. While the thermal infrared spectrum is perfect for nighttime and discreet face recognition tasks, sourcing vast quantities of labeled training data for thermal infrared imagery from the web is impractical (Schmidhuber, 2015) [76]. Because the networks will overfit badly when trained with datasets with fewer samples, the lack of large training sets is the obstacle preventing the implementation of deep learning in such problems (G. Hu Y. Y., 2015) [78].

Researchers (M. Jaderberg, 2014) (Schoeler, 2015) (A. Rozantsev, 2015) [58, 59, 60] have looked into the generation of additional synthetic training data as a solution to this issue. The major benefits of using synthetic training data are the ability to generate the necessary amount of training samples and the unrestricted control over sample nuisance [57]. That example, whereas data gathered from the internet may have limitations in terms of perspective and other variations, it is possible to synthesize photos with all desired variations in views, illumination, etc. Other recognition issues like object detection (A. Rozantsev, 2015) [60], word recognition [58], and scene understanding (Schoeler, 2015) [59] have also been addressed via data synthesis.

Another simple strategy that has been utilized to address the issue of a lack of training data is data augmentation (A. Rozantsev, 2015) [61], (Zisserman, 2015) [62]. Despite being simpler to construct, it is quite like data synthesis. It is more constrained in that the training images that are currently accessible are altered without changing the semantic class labels. Rotation, cropping, scaling, introducing noise, etc. are some of these (G. Hu X. P., 2016) [57], (Zur, 2017) [63].

The suggested method is based on adding noisy samples to the training datasets by applying Gaussian or Poisson noise to each sample in the training set. The finest aspect is that it is very straightforward, simple to use, and provides the best results.

### a. Proposed approach

This approach provides a modified method which will be beneficial when the training dataset is smaller for deep learning based facial recognition system. The number of training dataset is increased by data augmentation. The method is very easy and simple to use.

By applying Poisson and Gaussian noise on the original training samples additional images are created to double the size of training set. Face recognition rate is improved from 79% when trained the CNN on original training data to 95% when trained on augmented data on the standard AT&T face database [50]. This work experimentally demonstrates that the augmented training datasets improves the generalization power of CNNs. The modifies approach is shown in Fig. 5.1.

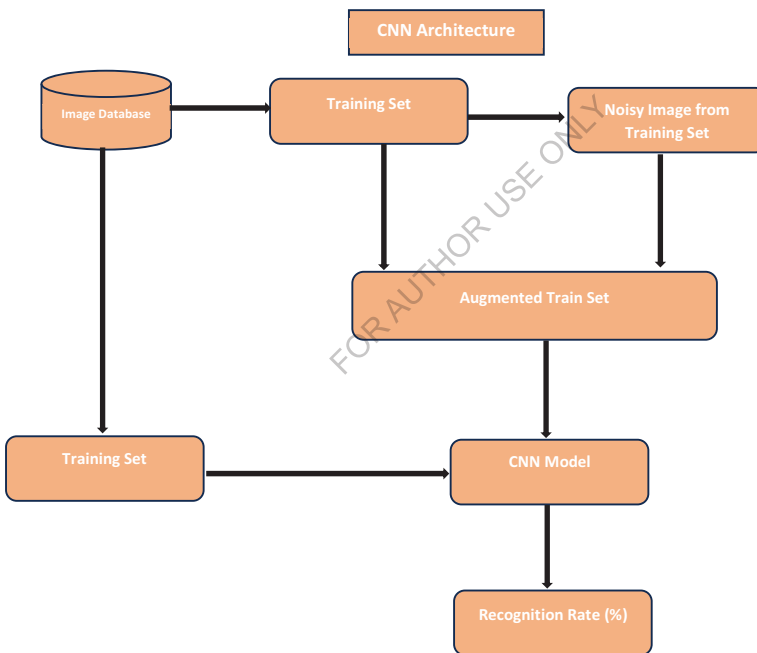


*Figure 5.1 Block Diagram of Proposed Approach [50]*

The Detailed Explanation of the approach:

- From an initial set of datasets first let us separate out the training dataset. Then the testing dataset is created from the remaining set.

- Synthetic images are then created by applying noise to the training samples. The noise applied could be anyone of the Poisson Noise or Gaussian Noise.
- Then the synthetically generated noisy samples are added to the training dataset which results in doubling the training data samples.
- The training dataset is then provided to CNN model for training.
- Testing dataset is then applied to this trained model.
- The percentage of success is calculated based on the number of correctly identified images with respect to the total number of testing images.

As was previously cited, training deep networks gives us more accurate learning, but they are unsuited to learning from small samples and need lots of training data.

In this experiment, a tiny training set from the AT&T face database is used and then images are synthetically created by adding noise to each training sample. The training set is then enhanced by adding these to the training data. The CNN is then instructed using the augmented training set. The model's ability to generalize is strengthened by the additional training dataset [50]. Table 9. Shows (image input layer is detailed in 1st row and indicates the  $\text{channel\_size} \times \text{size} \times \text{size}$ , Convolution layer is detailed in 2nd row and indicates  $\text{num\_of\_filters} \times \text{filter\_size} \times \text{filter\_size}$  and stride for convolution, Maxpooling layer is detailed in 3rd row and indicates  $\text{pool\_size} \times \text{pool\_size}$  and stride for the pooling region, Rectified Linear Units (RELU) is present in the 4th row, Fully connected layer is described in the 5th row and its dimensionality is specified by 40 classes/Labels, then we have a softmax layer in row 6 and classification layer in row 7.)

**Table 8. CNN Architecture**

| Layers                | Size                                          |
|-----------------------|-----------------------------------------------|
| Image Input Layer 1   | $112 \times 92$                               |
| Convolution Layer 2   | Industry, Innovation and Competitiveness      |
| Maxpooling Layer 3    | Education Creativity and Social Capital       |
| RELU Layer            | E-democracy, Participation, and Empowerment   |
| Fully Connected Layer | Logistics and Infrastructures, Transportation |
| Softmax Layer         | Efficiency and Sustainability, Resources      |
| Classification Layer  | Security and Quality, Culture                 |

This work uses a relatively straightforward CNN architecture. It can be seen in Fig 5.1. The *imageInputLayer* is utilized in this model to supply input, and the *convolutionlayer* is used

with a patch size of 5 5, stride of 5, and depth of 5. When using a 4 4 window size and a 4 stride, the *maxPoolingLayer* is used. A *fullyConnectedLayer* with 40 nodes is then applied after the *maxPoolingLayer* and before the *reluLayer*. Next comes a *softmaxLayer*, and finally is a *classificationLayer* [50].

## b. Experimental analysis and results

The purpose of the previously described method of using an enhanced training set produced by adding more data to the training set is acknowledged in this section. Experiments are carried out for this aim on the AT&T face database. Based on the network's percentage recognition rate for the testing set, the performance of the suggested approach has been assessed for this analysis. The dataset consists of 40 subjects, with 10 image samples of 112 X 92 each for each participant. Four image samples from everyone were utilized to create the training set, which allowed researchers to assess and compare the performance of the suggested strategy. MATLAB is the tool used for implementation. Two image noise functions are used.

The first one, known as Poisson noise, exhibits less distortion to the original image. The second one, known as Gaussian noise, contains more distortion. For Gaussian noise, 0 mean noise and 0.01 variance is set. Synthetic images are added to the training set and then the dataset is presented to CNN.

Learning rate of 0.001 for the CNN is used and terminated training after 80 epochs. Practically the dropout was hurting the little network's performance, so CNN is trained without the dropout. The batch size is kept as 30 and a momentum of 0.9.

CNN training is governed by the Softmax loss function. Section III provides a description of the CNN architecture. The trained model then recognizes the testing set, and the % recognition rate is used to gauge performance. Ten times of this entire process are done to determine the mean output.

The outcomes of alternative methods are contrasted with the mean performance. The performance indicator employed in this investigation was the percentage of recognition rate, which is the proportion of correct matches to all test photos. Table 10 lists the percentage recognition rates for several CNN techniques, both with and without noise.

Note that the recognition rates of the original/un-enhanced training sets are outperformed by the recognition rates achieved by the two augmented training sets.

*Table 9. Experimental results. (Comparison of %age recognition rate on AT&T face database with different approaches (with and without noise) for CNN.)*

| CNN<br>Approach for<br>Training | Number Of Images Per Subject for Training |       |       |       |       |       |       |       |
|---------------------------------|-------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                 | 1                                         | 2     | 3     | 4     | 5     | 6     | 7     | 8     |
| Without Noise                   | 41.75                                     | 61.34 | 78.57 | 79.29 | 86.30 | 88.56 | 89.92 | 90.88 |
| With Gaussian<br>noise          | 59.72                                     | 87.75 | 92.71 | 94.39 | 99.60 | 99.81 | 98.42 | 95.88 |
| With Poisson<br>noise           | 88.41                                     | 88.41 | 86.50 | 95.21 | 99.92 | 99.94 | 99.58 | 95.88 |

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## 9 Smart video system recognition

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### Chapter abstract

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The demands for security and monitoring systems are increasing, particularly for those focused on video surveillance, in terms of quality, dependability, and adaptability. Due to the presence of substantial illumination variations, noise, and changes in facial expressions, face detection and recognition from video sequences recorded from surveillance cameras are tough problems in such systems. The main goal of this work is to understand how video recognition by CNN works.

### 9.1 Introduction

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Safety-related applications use security and monitoring systems to regulate and prevent abnormal occurrences before they have a chance to cause irreparable harm to the nation's security, human lives, or facilities (A. Beghdadi, 2018) [79]. Also, there can be some issues while capturing the videos by this there are many chances of getting the video quality very low. In such systems, many phases of signal processing, including video capture, network transmission, and video compression, might have an impact on the quality of the captured video, leading to video distortions. Moreover, exterior constructions like stadiums, buildings, parking lots, roadways, etc. frequently use video surveillance systems (A. Beghdadi, 2018) (al, 2020)[79, 80]. Depending on the outdoor setting, natural degradations brought on by unfavorable weather, such as haze, fog, and smoke, sometimes significantly lower the visual quality of outdoor surveillance videos (al, 2020) [80].

These elements significantly lower the effectiveness of event/object detection and recognition, raising questions about safety and security. To assess the video in video surveillance systems, objective video quality assessment (VQA) metrics are essential (X. Qi, CNN based key frame extraction for face in video recognition, 2018) [81]. Quality before moving on to the visual tracking and detection procedures. For standard solutions and a testing procedure, Quality Assessment (QA) research heavily relies on subjective experiments (A. Beghdadi, 2018) [79]. All QA research ultimately aims to produce quality forecasts that are

consistent with the arbitrary judgment of human observers. It is necessary to have a dataset of films whose quality has been graded by human beings to calibrate VQA algorithms and evaluate their effectiveness. This is since recorded videos are susceptible to a variety of distortions that can occur at various points during the communication process. Based on where they are coming from, these video distortions can be divided into four groups: capture, processing (compression), delivery, and display (al, 2020) [80].

The most severe types of distortion are coding artifacts, which decrease the spatial and temporal resolution and become more obvious as the compression ratio rises (al, 2020) [80]. This is because the recorded videos are susceptible to a variety of distortions that can occur at various points during effective communication (al, 2020) [80]. Depending on where they come from, these visual distortions could be divided into four groups: capture, processing (compression), delivery, and display. The most severe types of distortion are coding artefacts, which decrease the spatial and temporal resolution and become more obvious as the compression ratio rises (X. Qi, CNN based key frame extraction for face in video recognition, 2018) [81].

In fact, video distortions are generally classified into four types based on their origin in the communication process starting from the capture and compression to the delivery and display. A few of the most common distortions for video surveillance systems are listed below (al, 2020) [80]:

**1. Coding artefacts:** They represent the most important categories of distortion. They impair the visual video quality by lowering temporal and spatial sharpness, and as the compression ratio rises, this effect becomes more obvious (al, 2020) [80].

**2. Noise:** Various types of noise during acquisition may have an impact on detecting the surveillance video. This is mostly caused by the sensitivity of camera sensors, which is especially true in low-light situations. The Additive White Gaussian Noise (AWGN), which is frequently considered to be the transmission, is a common simplistic model of image noise (al, 2020) [80].

**3. Blur:** The blur generated by optically defocus and the blur caused by object/camera motion can both happen throughout the surveillance procedure. These two distortions may affect object sharpness and detail visibility, which would make the processes of identification and recognition challenging (al, 2020) [80].

**4. Smoke:** Smoke in the air from a variety of sources, such as fires or smoke in stadiums or public areas, severely reduces sight and makes the video useless (al, 2020) [80].

**5. Haze:** Haze is a prevalent natural phenomenon in several areas. Whenever smoke and dust particles gather in extremely dry air, it frequently happens. Outdoor footage is deteriorated by suspended matter in the presence of the haze, rendering distant objects and landscapes invisible or difficult to perceive. Another sort of haze known as heat haze, an environmental condition that happens when a body like the ground is reflecting a lot of heat, can appear in some arid places. It results from the difference in temperature between the hot body and the cold air surrounding it (al, 2020) [80].

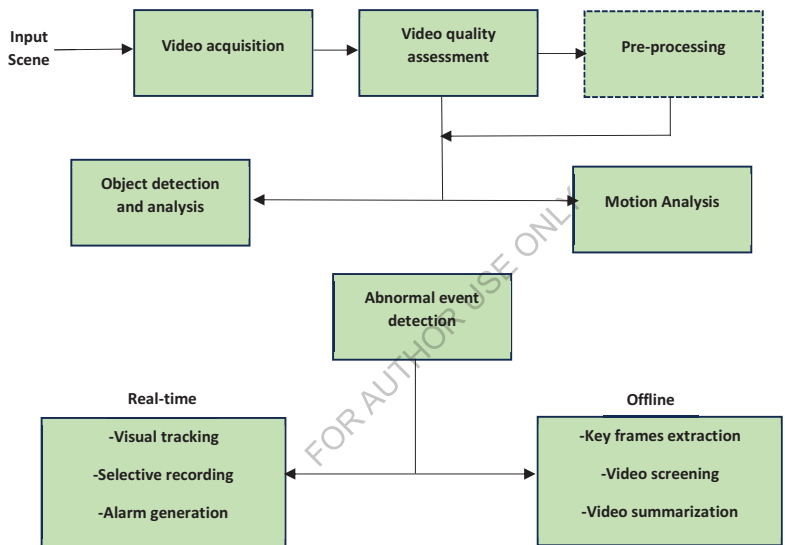


*Figure 6.1 Block diagram of video surveillance camera (A. Beghdadi, 2018) [79]*

It is a block diagram which consists of how a video camera works and how the functionality of this works. While giving the Input it assesses the quality of the video and then goes for preprocessing. The motion of the object or human activity is detected. To get the correct view it uses CNN and RNN to capture the great source and good quality of the object.

## 9.2 Related work

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### 9.2.1 Support vector machine classification

Deep learning-derived features turned out to be very effective for classifying images. Several researchers were motivated by this to use these trained characteristics for video classification (B. Lee, 2008) [82]. In this method, every video frame's feature set is extracted by running it through a cutting-edge deep learning model up until an intermediary fully connected layer (B. Lee, 2008) [82]. A well-known classifier, such as SVMs, is then used to classify the video utilizing the collective features for all the frames (B. Lee, 2008) [82].

### 9.2.2 Convolutional long short-term memory (LSTM)

A unique RNN called LSTM enables networks to learn lengthy dependencies. The employed a single LSTM layer, a Dropout layer, and some dropout in between (R. Miyoshi, 2019) [83]. This RNN is then provided with the feature extraction sequences from the previous stage along with the ground truth labels for training. This straightforward network beat all other approaches we considered in a comparable work study (R. Miyoshi, 2019) [83]. For more information and Python code example of LSTMs please refer to Appendix C.

*Methodology:* It has been shown that identification systems that rely on typical frontal face photos are more prone to mistake some background elements for faces. A visual front-end processor is needed to localize and extract the facial landmarks from the backgrounds in order to fix this issue [79]. Face detection in streaming video can be utilized for efficient security surveillance after that. In this section, we outline the architecture of our video frame extraction engine, which is built on CNN based FQA model and uses a performance framing selection method (A. Beghdadi, 2018) (al, 2020) [79, 80]. We will see the CNN layers one by one. Face recognition systems, extraction of features, and face recognition are the three basic processing steps that make up a traditional face recognition system. The system will extract the feature vectors after a face (al, 2020) [80]. Face detection and recognition are difficult research subjects in the fields of biometrics design and computer vision. In face recognition and visual monitoring systems, face detection is an essential first step (X. Qi, CNN based key frame extraction for face in video recognition, 2018) [81]. It has a variety of uses, including intelligent human-machine interface, information picture retrieval, video summarization, video

conferencing, and face recognition step (A. Beghdadi, 2018) (X. Qi, CNN based key frame extraction for face in video recognition, 2018) [79, 81]. Next, the extracted feature vectors are encoded and classified in the face recognition module which generates the verification or identification results. After the face tracking and identification module, the face quality assessment (FQA) module, and we combine them as the keyframe extraction (KFE) front-end of our system for the identification as shown in Fig 6.3 (X. Qi, CNN based key frame extraction for face in video recognition, 2018) [81].

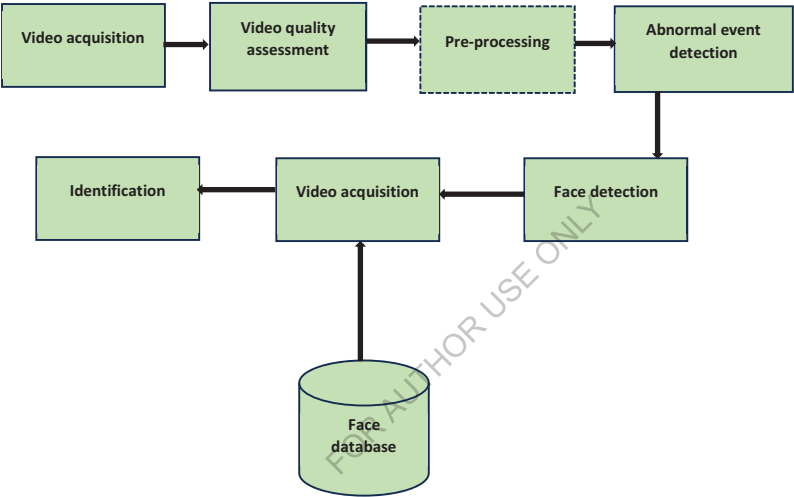


*Figure 6 2 Face Recognition (A. Beghdadi, 2018) [79]*

### 9.2.3 Convolutional layer

This is the layer where the filters are applied to an original image. In this layer, it can be found that most of the user-specified parameters are in the network. The most important feature of the Convolutional layer are the number of kernels and the size of kernels. The size is of the filters which is usually smaller than the actual image. It will capture the border.

#### a. Pooling layer

The pooling layer is crucial in diminishing the spatial dimensions of the convolved attributes. It excels at drawing out predominant features that remain consistent regardless of rotation or position, aiding in the efficient training of the model. Within this context, there are

two kinds of pooling: max pooling and average pooling. Max pooling is the more commonly employed method. It not only acts as a noise suppressant but also discards the noisy activations and facilitates dimensionality reduction. On the other hand, Average Pooling mainly serves as a mechanism for noise suppression and reducing dimensions. Hence, it can be inferred that Max Pooling delivers superior outcomes compared to Average Pooling.

### b. Fully connected layer

The outcome of the convolution layers, which is compressed before being totally fed further into fully connected layers, serves as the inputs of the fully connected layer. According to the same, there seem to be several criteria that can be used to identify the image. Figure 6.4 displays the intricate layout of a typical face-tracking net and key-frame flowchart. Please keep in mind that network hyperparameters such as layers and neurons in each layer can vary vastly depending on the case. Here, colors represent random weights. The face identification process in this case has been fully repeated multiple times and enhanced with GPU acceleration.

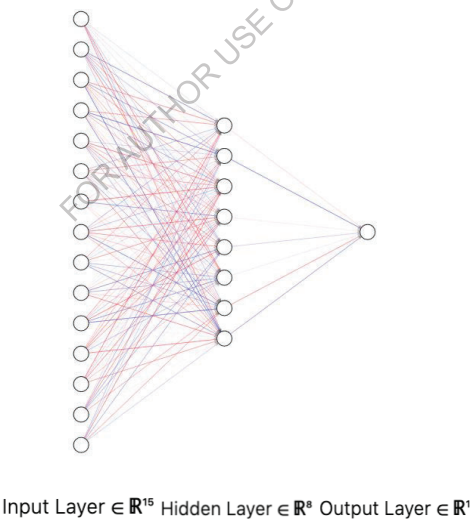


*Figure 6.3 Fully connected layer*

The face performance evaluation is then carried out on detected faces if the number of detected faces does not vary, indicating that the scenario is the same. This frame will be utilized as the image frames for the matching face if the evaluation of face quality reveals that the current face image is superior (X. Qi, CNN based key frame extraction for face in video

recognition, 2018) [81]. Every face in the frame is given this treatment. To analyze the accuracy of all identified human faces as the foundation of our key frame extraction (KFE) engine, we use a CNN-based face quality assessment (FQA) module. Keyframes are then extracted depending on the analysis result. Every face image in the training set is delivered to the FR rear during the CNN training phase to receive a recognition performance score that ranges from 0% to 100%. The facial image linked to its actual performance score is then sent to CNN for training. The training CNN is utilized to forecast the performance score of an incoming new face image, which is referred to as face clarity in this review study.

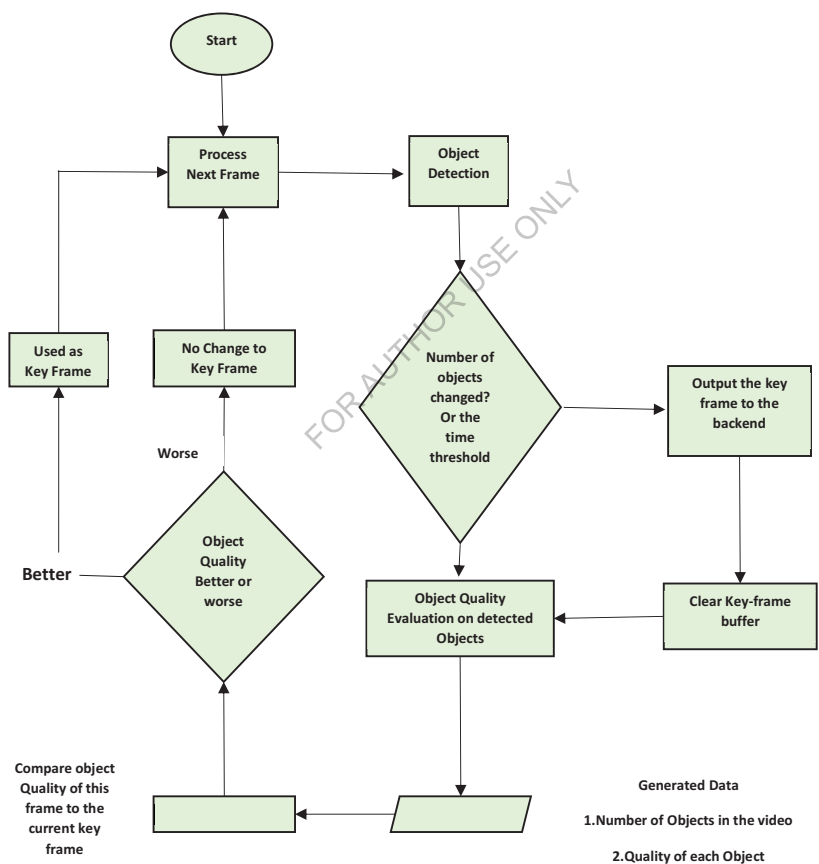


Figure 6.4 Flow chart key frame extracting (X. Qi, CNN-based key frame extraction for face in video recognition, 2018) [81]

## 10 Smart healthcare systems during COVID-19 and based on cloud computing FIWARE

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### Chapter abstract

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Since December 2019, the Coronavirus Disease (COVID-19) has been spreading fast across the globe, infecting 223 countries, and causing 6,615,258 fatalities (Muhammad Imad, 2022) [84]. To tackle the virus, healthcare professionals, governments, and organizations faced a significant problem in the early detection of infection. The epidemic increased society's reliance on online resources for work, study, and daily activities. The introduction of new work practices and the availability of services based on smart technologies revolutionized people's daily lives. One of the sectors of the economy that has suffered the most is tourism.

Every industry is evolving to produce better products and services for customer pleasure because of contemporary technical breakthroughs. The healthcare sector is one that is utilizing contemporary technology to alter the way patients are cared for and treated. The goal of the healthcare ecosystem in the modern day is not just disease management but also patients' well-being. Artificial intelligence is integrated into sensor-enabled IoT-based smart healthcare systems to orchestrate healthcare services and allow healthcare practitioners to track patients' daily activities in real-time and respond to their healthcare requirements promptly. In this research, we investigate various FIWARE-based countermeasures to the COVID-19 pandemic and a data communications paradigm based on the FIWARE platform and cloud technologies is discussed for trustworthy user medical information distribution.

### 10.1 Introduction

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Since 2019, the coronavirus disease (COVID-19) has been spreading globally. The disease's capacity and additional contributing elements, such as regional and population characteristics, determine the high infection rate. The disease has a high incidence of infection and spreads quickly across modern civilization, turning an epidemic into a pandemic. Unimportant enterprises had, to differing degrees, been shut down in several countries to stop

the disease's spread. In many nations today, the government has encouraged some businesses to resume operations, and output to secure citizens' livelihoods and restore economic progress. While the return to production is essential for socioeconomic advancement, it increases the chance of workplace cluster infections. Every government acts by putting into place preventative controls to manage its citizens, flattening the graph. All nations have developed or are implementing five prevention strategies to combat the COVID-19 outbreak: the mask policy, social segregation, quarantine, vaccine, and lockdown.

With the rapid rise in the field of Information technology, there have been multiple opportunities in which the Healthcare industry could benefit from various services. Technology plays a significant role in bringing positive changes in the healthcare domain. Recent developments in electronic health can be considered as one of the applications in the Healthcare systems in terms of communication and information technologies. This involves a wide range of information mainly patient medical records, information about employees and hospitals, and billing and payment details which leads to new recommendations such as e-prescription, e-billing, e-records, and telecommunication. Nowadays healthcare institutions are increasingly turning to remote patient monitoring (RPM) systems which reduce costs and expand their potential market as well as provide high-quality care services. Healthcare providers can cut hospitalization expenses by helping patients receive care at home. Patients can stay in a more comfortable setting while reducing inconveniences for themselves and their families. Since the COVID-19 incident, the market for health remote assistance has grown quickly, as seen by the rise in the number of businesses making medical sensors and equipment to provide aid in the event of emergencies or to provide psychological support. In this environment, telemedicine is gaining popularity. Cloud computing has been an emerging solution in the field of healthcare technology development systems due to its outstanding features. This paradigm makes use of the latest technologies such as smart mobile applications, sensors, robots, and Telehealth systems using the internet. The vital need for patient data access from any device across the world has become a necessity for early diagnosis and proper treatment that results in efficient medical services and improved patient experience. In this regard, the European Commission (EC) launched the Future Internet Public and Private Partnership (FI-PPP) program to accelerate the implementation of such technologies (M. Fazio, Exploiting the FIWARE cloud platform to develop a remote patient monitoring system, 2014) [85]. To promote the use of this new, advanced European Cloud platform, the EC developed FIWARE and pushed the FIWARE Accelerator Programme, investing 80 million euros. To support ICT Small and

Medium Enterprises (SMEs) interested in using FIWARE, the program has 16 Future Internet Accelerator Projects that cover a variety of issues (such as smart cities, multimedia, healthcare, agri-food, etc.). In this study, we will study the research that has been done so far regarding the smart healthcare system. Also focused on the FIWARE platform used widely nowadays to produce smart cities (including healthcare, agriculture, security, etc.). In addition, there are several technological applications that assisted in tracking and observing the virus's spread (Mustofa Abi Hamid, 2021) [86].

*Which preventive measure is therefore more effective?*

Here is where FIWARE played a crucial role. FIWARE is an Open-Source Platform component collection that has been carefully selected to hasten the creation of Smart Solutions. The FIWARE Foundation, in collaboration with its members and partners, drives the definition and Open-Source implementation of key open standards that make it possible to develop portable and interoperable smart solutions more quickly, easily, and affordably, avoiding vendor lock-in situations. At the same time, FIWARE is developed as a long-term and innovation-driven business ecosystem (FIWARE Foundation, 2022) [87].

## 10.2 Overview of FIWARE

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Technologies like big data, cloud computing, and the internet of things (IoT) will power the future internet. In this situation, the European Commission (EC) saw a chance to promote wider use of such systems in complete openness, preventing vendor lock-in and streamlining the creation of new services. The EC was also aware of the necessity to strike the correct balance between academic and industrial domains. To this goal, the EC launched the Future Internet Private Public Partnership (FI-PPP) program, which resulted in the de-construction of a brand-new, intricate European Cloud platform called FIWARE. The objective of FIWARE is to produce an ecosystem that is worldwide open, sustainable, and standard. A group of general-purpose platform functions known as Generic Enablers (GEs) are part of the FIWARE Reference Architecture and are accessible through Application Program Interfaces (APIs). Advanced web-based user interfaces, service delivery networks, application/service ecosystems, cloud hosting, data/context management, IoT service enablement, and security are all considered to be GEs. FIWARE allows software architecture to depend on an integrated set of general-purpose open-source platform functions. FIWARE is a good fit for the demands of

a rapid development strategy as it helps organizations to construct future Internet applications and systems more quickly.

### 10.3 Related work

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The researchers (M. Fazio, Exploiting the FIWARE cloud platform to develop a remote patient monitoring system, 2015) [85] have provided an e-health solution for remote patient monitoring (RPM). To provide high-quality healthcare services they have proposed an IoT and Cloud-based RPM system. They believe utilizing remote monitoring and communication systems can decrease the need for medical personnel to visit patients at home while also improving the effectiveness of identifying accidents or potential threats to patients. With the use of several health monitoring devices, as well as new, enticing information and technology services, home care facilities can enjoy widespread success. They have used FIWARE technology in their solution to store the data which helps them to reduce the time to design the solution and improves the modularity, scalability, and flexibility of the system.

Researchers have developed a system (S. Sotiriadis, 2016) [88] that helps to send generic enablers (GEs) to different physical places. This means the services are contained within cloud virtual machines (VMs) in OpenStack environments which allows for a seamless transition to a private cloud system from a public cloud service provider without the need for user involvement. They mainly focused on two things - the automatic migration requirements in FIWARE systems, and they have proposed the VM migration tool among OpenStack cloud platforms and second is the automatic shipment and deployment of FI-STAR services among service providers' infrastructures, which is known as the FIWARE cloud nodes and service consumer infrastructures (FI-STAR use cases).

The researchers (S. Sotiriadis, 2016) [88] developed an IoT-based solution in the healthcare domain concerning real-time and batch processing. They have utilized the cloud solutions from AWS and data is generated using an IoT device named Raspberry pi. With the help of AWS cloud resources and IoT technology, the proposed method could be beneficial for health professionals by carrying out a real-time analysis that helps to find out the abnormalities in the data collected from various subjects and act as early as possible to overcome the consequences related to a patient's health. Also, the long-term analysis using the massive

volume of data collected from different IoT devices could provide insights based on the study and identify patterns for future use. In (K. Shivkumar, 2022) [89], they focused on the application and worked on machine learning models that produce the diagnosis of skin cancer. The data of 10,000 training images from the Human Against Machine project was taken to diagnose skin cancer. They have chosen AWS services to implement the model. AWS Simple Storage services (S3) are used to store the datasets from which Sage Maker is training the CNN model and the trained model gets stored in the AWS Elastic file system (EFS).

The authors focused on creating a system (X. Aizaga-Villon, 2022) [91] that contains several networking tools and gathers information about patients through web applications. Their main objective is to deliver necessary care in a timely manner to patients remotely to the medical staff. They have used the FIWARE platform to manage hospital data and also to produce secure transmission between the cloud and infrastructure. Below is the Telemedicine application architecture used in (X. Aizaga-Villon, 2022) [91], which is a broad representation of the communication model. Users with various rights communicate with one another on a platform designed with React.js. JSON is used in the communication model to deliver messages between the components.

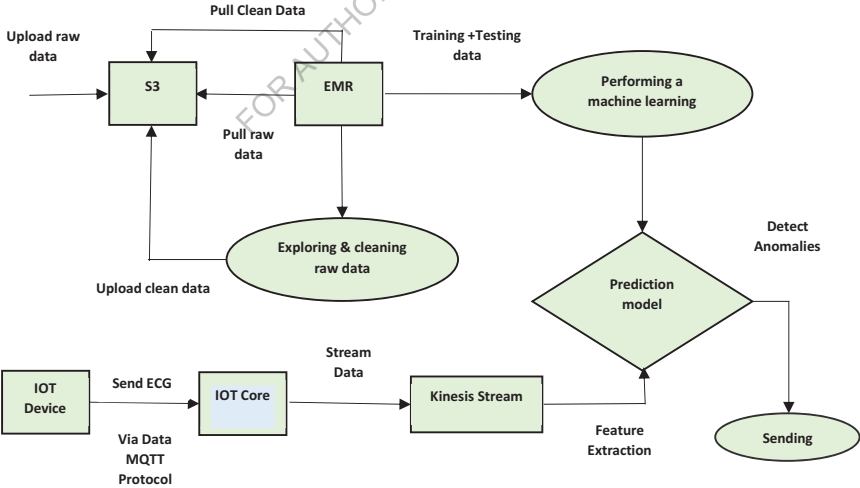


Figure 7.1 IoT-Cloud Solution Developed for ECG Dataset (N. C. Taher, 2019) [90]

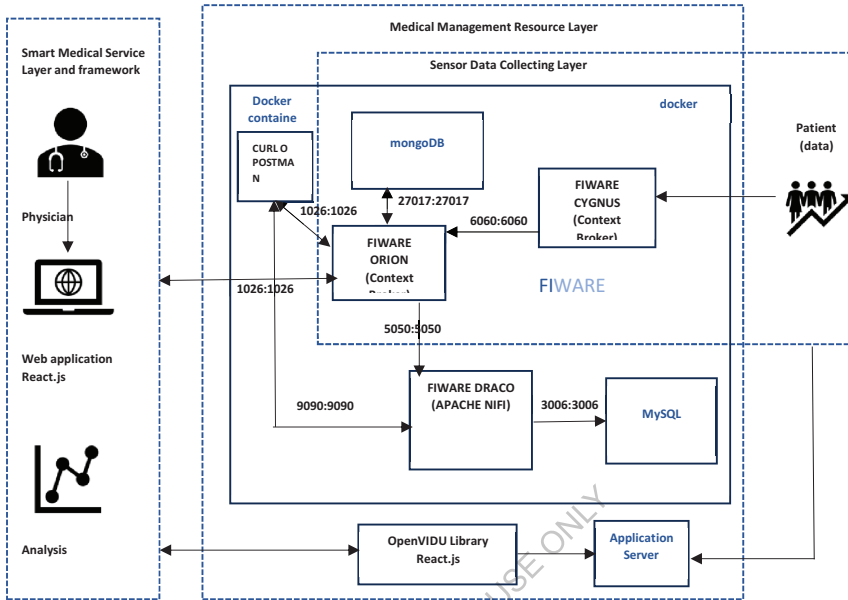


Figure 7.2 Telemedicine application architecture (X. Aizaga-Villon, 2022) [91]

In (Chakraborty, 2021) [92] the researchers discussed futuristic healthcare systems like remote patient monitoring and planning of the healthcare services between the members of the network. It offers a comprehensive structure that enables medical practitioners to offer top-notch medical treatment.

### 10.3.1 Methodology

To create a system for remote patient monitoring (RPM) we need to store the data globally and gather the information from the users/patients. Many are using the FIWARE platform to manage and store the data as it helps them to have secure and optimal communication between the infrastructure. The below steps are followed to create a smart healthcare system:

- 1. Information gathering:** There are so many tools/ applications available to gather information remotely. Sensors/ devices like to monitor BP, heart rate, pacemaker, etc. are used to collect the information without actual physical contact with the patient.

Also, there are applications that can collect the data. There are so many applications available easily and can be accessed through our smartphones.

2. **Storing and managing data:** Cloud computing platforms are used to store the data globally so that it can be accessed from any place and at any time. FIWARE platform is used to store the data publicly as it is free and secured. One can have secure and optimized communication between the infrastructures.
3. **Analysis and prediction of the data:** Artificial intelligence can help to analyze and predict/estimate the result. With the help of machine learning models, can predict the outcome of the disease a person is having and can be cured before it gets worse. From the stored raw data, extract the features from it and prepare it as the training dataset by labelling them. Further, this data can be used to build a model which can predict the disease.

### 10.3.2 FIWARE based use cases.

#### a. Dashram

Dashram aims to gather, synchronize, and display data pertinent to the COVID-19 situation. The Idra Generic Enabler undertakes the task of unifying open data portals and sources (either via APIs or web scraping) containing COVID-19 information, ensuring that these datasets align with European standards. Once these open datasets have been synchronized, they are channeled through the FIWARE Orion Context Broker, which facilitates visualization access using NGSiv2 REST APIs. The Dashram data display component offers a range of adaptable, sophisticated, yet intuitive charts and map-driven visuals, encompassing both 2D and 3D formats. Such visuals are crucial for empowering officials to base their actions on concrete evidence and for informing the public about the current spread of the virus and the overall pandemic status. (FIWARE, FIWARE4HEALTH, 2020) [93].

#### b. Eng-De4bios bio-surveillance system

The Digital Enabler, crafted by Engineering, is a data-centric, local cloud-based platform. Using this foundation, a Bio-surveillance system was developed to support governments grappling intensely with the challenges of COVID-19. Eng-DE4Bios enhances epidemic oversight by furnishing real-time data to medical professionals and COVID-19

emergency teams. By methodically accumulating all pertinent data, users are equipped with a comprehensive database that enables the execution of various epidemiological projections to illustrate the pandemic's trajectory. These projections can be incorporated into an application that facilitates automatic epidemic simulation and adjustment, allowing for scenario predictions when model parameters shift. With its data source agnosticism and commitment to an open data model for swift integration of varied data, EngDE4Bios offers significant adaptability.

#### c. HOPU

HOPU has introduced a novel indicator provider, entirely founded on the FIWARE CEF Broker and its IoT devices for crowds. This system aids in the recognition, forecasting, and tracking of crowd movements. It helps prevent the spread of COVID-19, aligning with the protocols of our current circumstances.

HOPU's indicator platform aids in the management and restoration of street activities by detecting crowds in open spaces, ensuring optimal resource security. These devices employ WiFi/BLE to identify individuals through their smartphone detection. They are GDPR-Ready, ensuring adherence to privacy and data storage regulations. HOPU's new service equips regions with functionalities such as people counting, tracking individuals and groups, popular routes, occupancy rates, frequently visited areas, and dwell time at locations. The system delivers real-time data, enabling the establishment of risk indicators and alerts for various local bodies, like the police or other urban authorities, to manage crowd situations effectively. (FIWARE, FIWARE4HEALTH, 2020).

#### d. OPENVIDU

OpenVidu is playing a role in mitigating the impacts of COVID-19 related to remote communication. Numerous organizations are transitioning from "free" or "freemium" platforms that might be susceptible to security and privacy issues to ensure that video calls are as secure and private as other communication methods. OpenVidu is fully customizable and configurable, and it can be deployed either on-premises or within the company's chosen cloud infrastructure. By adopting OpenVidu, organizations can be confident that their entire communication process is under their control, adhering to the standards and regulations set by the company.

From the time of its installation, OpenVidu not only offers a pre-installed video-call application but also allows for the creation of a bespoke application tailored to fit any organizational needs, ranging from specific login integrations with corporate LDAP or OAUTH2 to distinct roles and access regulations. OpenVidu functions as a FIWARE enabler. Additionally, OpenVidu can be integrated within FIWARE frameworks, delivering both video-call features and media processing capabilities. This allows for a range of media processes, including presence detection. An example use case within FIWARE is the remote access to smart camera video feeds, enabling security staff to operate from home and thus minimizing the risk of infection. (FIWARE, FIWARE4HEALTH, 2020) [93].

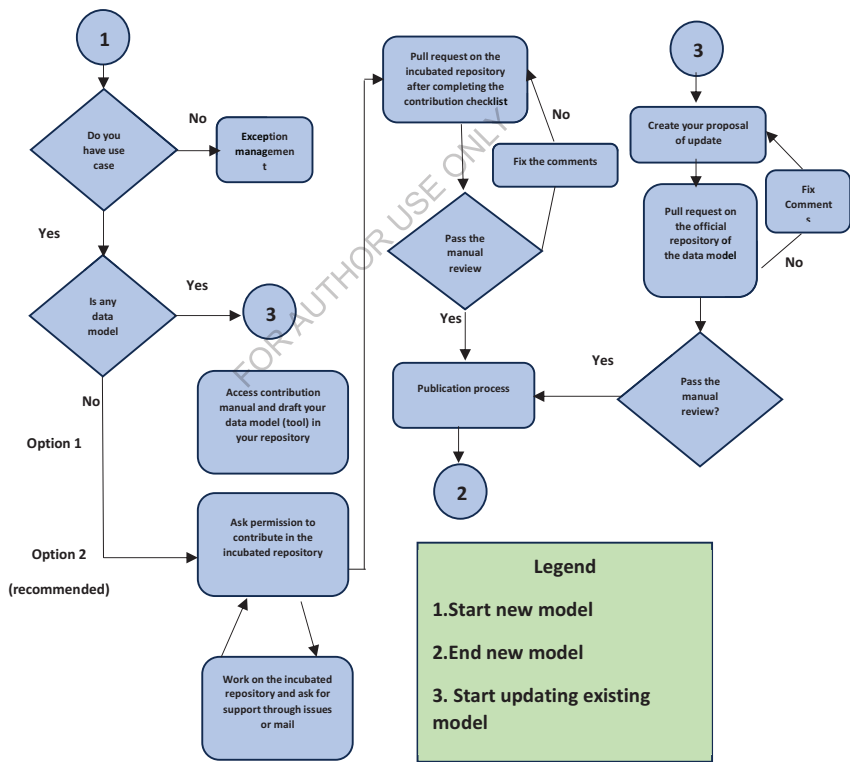


Figure 7.3 FIWARE architecture for smart health (K. Shivkumar, 2022) [89]

How Does FIWARE Smart Health Operate? FIWARE is built upon a smart data model concept that consists of three components: The schema, which is the technical blueprint of the model, outlines the technical data types and structures, and a document that provides a detailed explanation for human comprehension. Every data model is open to the public and comes without any royalty fees. The licensing structure grants users three specific privileges: *Free use, Free change, and Free sharing of the changes* (FIWARE Foundation, 2022) [87].

FOR AUTHOR USE ONLY

## 11 Analysis of current methodologies

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In this chapter, we will be covering, a few examples with code of some of the recent applications of smart systems. We will be analyzing their concept, the methods, the code used and the scope of improvement and future advancements of these approaches.

### 11.1 Smart car features with embedded systems

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The field of automobiles and autonomous vehicles has seen an immense growth in technological advancements. However, with an increase in the number of vehicles on the road, safety concerns have also risen dramatically. The number of accidents resulting in life-threatening injuries has reached an alarming level. It is imperative to introduce adequate safety measures in automobiles. To address this issue, this project (Das, Desai, Dhuri, Ail, & Kadam, 2021) aims to develop a prototype for a smart vehicle system that provides real-time location of the vehicle upon detection of a crash, alerting the police station and the user's relatives. Moreover, it also employs a drunk driver detection feature, a rain sensor automatic viper system, and a passenger safety panic button.

#### 11.1.1 Methodology

The project employs an Arduino Uno based approach with a combination of various sensors for the different features provided.

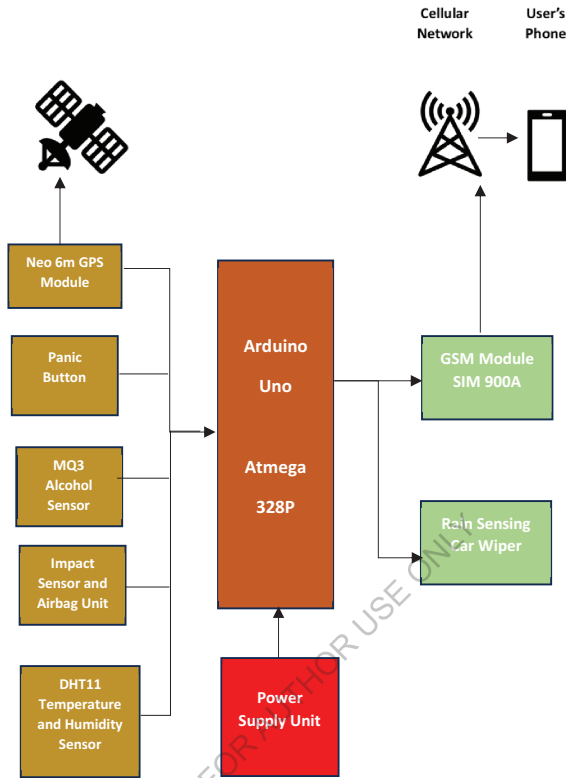


*Figure 8. Block Diagram of Proposed Smart Car System [99]*

### 11.1.2 Implementation

Accident Detection is enabled in this system using the SW420 sensor module. When the vehicle experiences a significant impact, it will quickly decelerate. An Impact Sensor can detect this change in velocity or vibration. When the impact is strong enough, the sensor triggers the airbag circuit and signals the Arduino to send an alert. The Arduino then uses the GPS module to determine the vehicle's location by communicating with GPS satellites. This location information, along with a Google Maps link, can be sent to a designated mobile number via SMS using the GSM module. The SW420 sensor module can output '1's or '0's depending on the presence of vibration, tilt, or external force. Its sensitivity can be controlled on the board.

The proposed system places an MQ-3 Ethanol Sensor on the car's steering or driver's seat belt to monitor the driver's breath alcohol level. If the level exceeds the predetermined limit, the Arduino triggers the GSM to alert the driver's designated safety number, such as a home number. Preventive measures may also include not starting the car engine until the alcohol level decreases. When the user exhales, the ethanol present in their breath is oxidized to acetic acid, and oxygen from the atmosphere is reduced at the cathode. The overall reaction is the oxidation of ethyl alcohol, which produces a charge flow measured to calculate the resistance, resulting in different levels of intoxication determined by the Arduino. To provide a sense of security for passengers, a panic button has been strategically placed throughout the vehicle. This button is used to raise an alert message via SMS whenever a passenger experiences feelings of terror or discomfort due to any reason. Multiple panic buttons can be placed at different locations in the vehicle for maximum coverage.

#### 11.1.3 Findings and future scope

The aim of this project was to present research ideas to the community, with the hope that they would be further developed and eventually scaled and deployed by the autonomous vehicle industry. While the sensors and equipment used in this prototype are low-cost and highly efficient, integrating these features with an existing vehicle's embedded system would require a more compact unit to be built. The development of more high-quality and accurate sensors would provide more desirable and reliable outputs.

### 11.2 HealthFog smart heart disease diagnosis

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Cloud computing enables the deployment of a multitude of applications over the Internet to provide services across various industries. However, cloud frameworks face a major bottleneck in terms of their scalability being limited, making them unsuitable for centralized IoT-based computer environments. Systems like surveillance systems and health monitoring systems encounter performance drops that are a major concern for latency-sensitive applications that need the computation of great volumes of data moved amid centralized databases and cloud data centers. To mitigate this issue, innovative solutions such as fog and edge computing have been proposed to bring resources nearer to users, providing low-latency

and better energy-consuming data processing in contrast to cloud domains. Nevertheless, existing fog models are not without limitations, often requiring trade-offs between accuracy and reduced response time or vice versa. To address this challenge, the group presented a novel structure [33] termed HealthFog. This integrates ensemble deep learning within Edge computing devices. HealthFog delivers healthcare as a fog service, using IoT devices to adeptly manage data from heart patients based on user preferences. This method introduces multiple operational modes that can be tailored to different fog computing situations and user requirements, guaranteeing the best service quality or prediction precision.

### 11.2.1 Methodology

HealthFog facilitates the integration of Edge-Fog-Cloud through software components that connect different hardware instruments. This integration is structured and streamlined, enabling end-to-end communication and data processing.

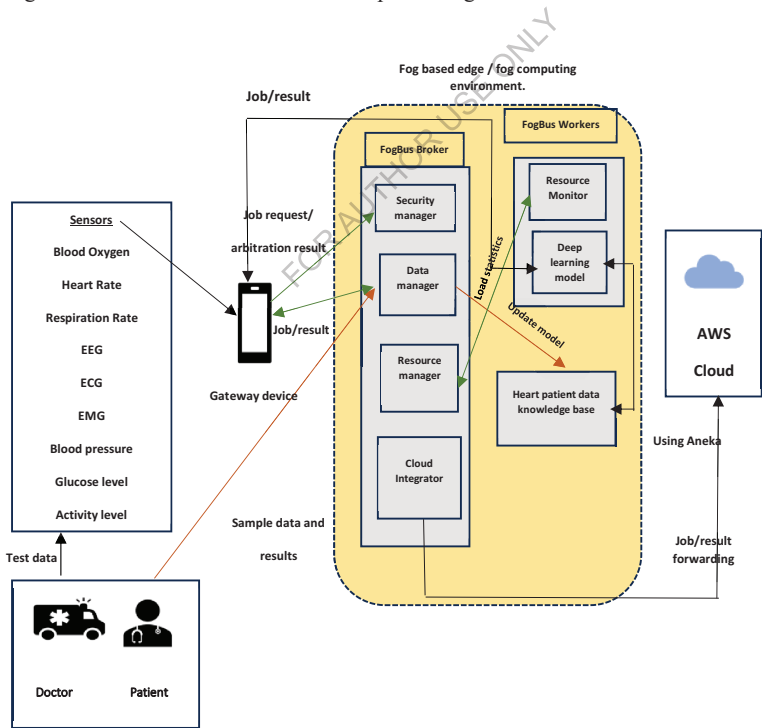


Figure 9. HealthFog System Architecture [102]

The system is composed of several core software elements, including:

**Data filtering and pre-processing:** In HealthFog, pre-processing is the first phase after data input, which involves using data analytics tools to filter the data and reduce it to a reduced proportion. By employing Principal Component Analysis (PCA) in conjunction with the Set Partitioning in Hierarchical Trees (SPIHT) algorithm, this objective is met. Subsequently, the data is encrypted leveraging the Singular Value Decomposition (SVD) method.

The aim of this initial processing phase is to pinpoint the pivotal components of data feature vectors influencing patients' health conditions. This refined data is then utilized to facilitate automated decisions, such as prescribing medicines and arranging medical consultations, anchored on the ongoing training data from healthcare providers and medical professionals. This pre-processed information is archived in a database for future retraining. This ensures the system's decision-making proficiency remains current and precise.

**Resource Manager:** The Resource Manager in HealthFog comprises two key modules, the workload manager, and the arbitration module. The workload manager maintains a queue of job requests and tasks for data processing and is responsible for handling most of the data that needs to be processed. On the other hand, the scheduling of the provisioned fog or cloud resources for processing the queued tasks managed by the workload manager is done by the arbitration module. The primary aim is to divide tasks among different devices to balance the workload and provide optimal performance. In pursuit of this objective, HealthFog empowers users with unparalleled flexibility, granting them the autonomy to craft bespoke load balancing and arbitration schemes that seamlessly align with their distinct application requirements. Overall, this dynamic and flexible Resource Manager module plays a critical role in optimizing data processing in HealthFog by efficiently distributing tasks among available resources.

**Deep learning Module:** The central function of the HealthFog's Deep Learning Module is to adeptly train a Neural Network to proficiently categorize data points. These points are drawn from feature vectors that are carefully processed from data collected via the Body Area Sensor Network. Guided by the directives of the Resource Manager, this module takes on the role of forecasting and producing outcomes using data retrieved from the Gateway devices. Leveraging its finely tuned training, the Neural Network adeptly discerns and classifies the health status of patients, ultimately recommending appropriate medical interventions. As such, the trained Neural Network stands as a vital cornerstone within the HealthFog framework, empowering it with cutting-edge capabilities for informed decision-making and optimal patient care.

**Assembling Module:** The assembling module, strategically positioned within the designated FogBus node, undertakes the pivotal role of receiving prediction results from diverse models and employing a sophisticated voting system to collectively determine the output class, which signifies the presence or absence of heart disease in a patient. Responsible for managing data distribution and result collection from other worker nodes, this module diligently orchestrates the aggregation of predictions from multiple models. By harnessing the collective intelligence of diverse models, the assembling module diligently endeavours to enhance the accuracy and reliability of the classification process, ultimately elevating the performance of the entire system to achieve refined outcomes.

### 11.2.2 Implementation

The HealthFog project's realization incorporated various programming languages for its different components. For the data pre-processing and ensemble deep learning segments, Python was selected. Specifically, the pre-processing segment adeptly standardizes data using its maximum and minimum values and organizes it based on the dataset's field parameters.

Within the ensemble deep learning segment, the Bagging Classifier from the Scikit-learn toolkit was harnessed to enable the voting mechanism. During its learning phase, the model disperses the data at random among its classifiers. In the diagnostic phase, the ensemble deep learning segment reviews every predicted category and delivers the one that dominates, drawing from the collective intelligence of its classifiers.

To refine the foundational model, the project adjusted several parameters, grounded in the dataset:

- I. Input layer size: 13 (corresponding to the number of features in the data)
- II. Output layer size: 2 (for binary classification indicating the presence or absence of heart disease in the patient)
- III. Hidden layers number: 3
- IV. Descriptions of layers: Fully connected layer comprising 20 nodes, another FC layer containing 20 nodes, and an FC layer with 10 nodes
- V. Optimizer: Adam
- VI. Activation function: ReLU
- VII. Learning rate: 0.0001

Using MIT's App Inventor, the mobile application was crafted and set up to communicate with the FogBus Broker node. During its operation, it saves data attributes to a

file in the Comma Separated Value (.csv) format and subsequently forwards this file to the Data Catalogue Module using HTTP POST. The Arbitration Module in the broker node selects the worker node for task execution based on the preset FogBus policy of selecting the worker with the lowest CPU load. The selected worker node receives the CSV file and analyzes it using the Ensemble Deep Learning code. The result is transmitted back to the Worker/Broker node, ensembled via the bagging strategy, and sent on to the gateway device (the Android application). The implementation code (Cloudslab, 2021) of the ensemble module is attached in Appendix B.

### 11.2.3 Findings and future scope

The HealthFog architecture is developed to provide healthcare services through IoT devices as a fog service, with the goal of optimizing prediction accuracy and ensuring high Quality of Service (QoS) for various user requirements and fog computing scenarios. The authors implemented and assessed the performance of the framework through the FogBus fog-integrated cloud system, measuring metrics such as power usage, network bandwidth, latency, jitter, accuracy, and processing duration.

The results demonstrate the effectiveness of the proposed HealthFog framework, offering low latency and high accuracy in heart disease analysis. The authors conclude that HealthFog is a promising approach for the efficient management of heart patient data using fog computing and can be adapted for other healthcare applications as well.

### 11.3 HealthEdge smart diabetes diagnosis

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Diabetes Mellitus, a major global mortality contributor, remains without a cure and can lead to severe medical issues if not addressed. As such, proactive steps are vital to either avert or forecast diabetes onset. Although machine learning techniques for predicting diabetes have been explored and reviewed in academic circles, a holistic diabetes prediction system is yet to be established. In this study (Hennebellea, Materwalab, & Ismail, 2023), the researchers introduce an AI-blockchain architecture that predicts diabetes based on associated risk factors. Integrated with IoT-Edge-Cloud Computing and blockchain, this system aggregates risk factor information from patients across various medical facilities, ensuring both the security and confidentiality of user details.

### 11.3.1 Methodology

Data on diabetes risk factors is collected through various sensors and medical devices, such as those measuring heart rate, hypertension, obesity, sleep duration, glucose, cholesterol level, physical activity, and serum uric acid, using IoT devices. As these devices have limited computing capabilities, data is transmitted to edge servers through a mobile application for transformation. Edge servers transform the data into a structured format consisting of timestamps, user/patient IDs, and risk factor values before sending it to the cloud. The collected data is preprocessed to remove missing values and then used for hyperparameter tuning to find optimal parameters for training a machine learning model. These parameters are used to create a prediction model. Edge servers utilize the developed model for predicting diabetes type.

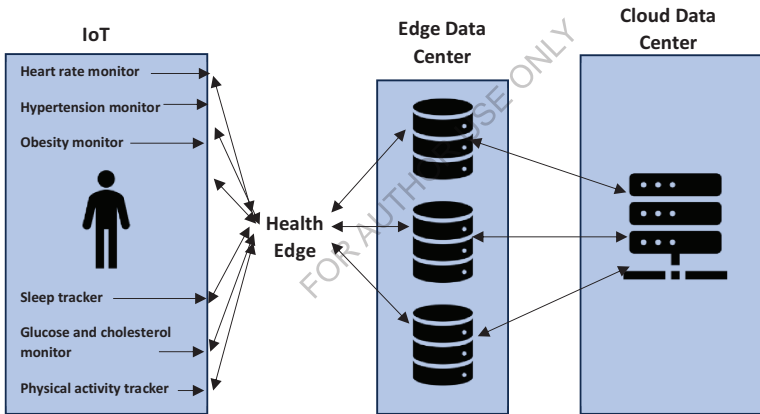


*Figure 10. HealthEdge System Architecture [102]*

### 11.3.2 Implementation

In this project, the performance of two frequently used machine learning algorithms, Random Forest, and Logistic Regression, was evaluated for diabetes prediction using two publicly available datasets. The first dataset was the PIMA Indian dataset, obtained from the National Institute of Diabetes and Digestive and Kidney Diseases, which holds the health information of female patients of PIMA Indian heritage that are at least 21 years of age. The

second dataset, the Sylhet dataset, includes health information of patients from the Sylhet Diabetes Hospital in Sylhet, Bangladesh, which was collected through direct questionnaires approved by a doctor.

This project aimed to evaluate the performance of two commonly used machine learning algorithms, Random Forest, and Logistic Regression, for diabetes prediction using two publicly available datasets.

To prepare the datasets, observations with missing values for at least one feature were removed, and values were normalized across the observations. For the PIMA Indian dataset, observations with missing data for skin thickness, BMI, and blood pressure features were removed. The pre-processed PIMA Indian dataset contains 532 observations, with 177 (33.3%) diabetic and 355 (66.7%) non-diabetic cases. The pre-processed Sylhet dataset contains 520 observations, with 230 (61.5%) diabetic and 200 (38.5%) non-diabetic cases. Hyperparameter tuning was performed using Python's GridSearchCV library to develop efficient diabetes prediction models for each machine learning algorithm under study.

Random Forest and Logistic Regression algorithms were evaluated considering both the inclusion and exclusion of features, before and after data balancing. 10-fold cross-validation was used to test the machine learning models. The performance of each algorithm for the PIMA Indian and Sylhet datasets was assessed based on accuracy, recall, precision, F-measure, and Area under the Curve. Some key parts of the code (INDUCE-Lab, 2021) for the implementation is attached to Appendix C.

### 11.3.3 Findings and future scope

The study conducted numerical experiments and comparative analysis of the two most popular machine learning algorithms, Random Forest (RF) and Logistic Regression (LR), on two real-life diabetes datasets. The findings revealed that on average, RF outperformed LR in predicting diabetes by 6% in terms of accuracy. For future scope, more diverse datasets can be added to the evaluation with a combination of other ML approaches as well.

### 11.4 Smart context aware system with emotion recognition

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Through our ability to be sympathetic and think visually, humans can make reasonable assumptions about other people's emotional states. This ability has prompted research into developing automated emotional intelligence systems that enable machines to detect human emotions. The utilization of computer technology for the purpose of recognizing human

emotions is gaining popularity in the development of responsive systems such as educational environments, healthcare systems, and other real-world applications. The enhancement of overall health has been a significant research area, and this work provides a theoretical foundation for emotional recognition and management within intelligent healthcare contexts. The researchers [37] have taken an innovative approach to develop a user-friendly system that captures emotional situations to create a supportive and sensitive environment that prioritizes emotional well-being for users. This system engages with users by discerning and distinguishing emotions through visual or vocal cues, taking into consideration the surrounding context. It suggests music and recommends mood color treatments through the services installed on users' IoT devices and only displays pleasant mood activating services.

### 11.4.1 Methodology

The authors propose a system where they combine the emotion recognized from a facial emotion recognition module and a speech emotion recognition to determine the emotional state of the user. Depending on the output, using a recommender system they would play appropriate music and switch on the appropriate lights to stimulate the evocation of a healthy emotion.

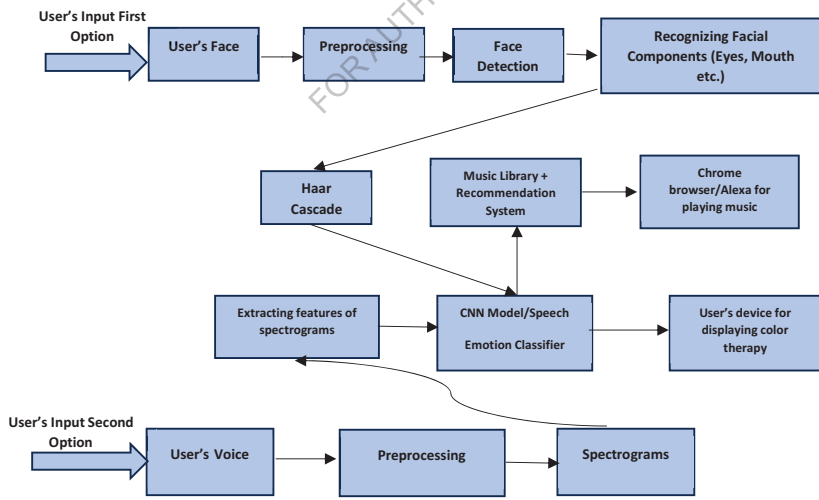


Figure 11. Proposed System Architecture [104]

### 11.4.2 Implementation

The objective of the FER (Facial Emotion Recognition) model was to achieve the highest possible accuracy in generalization. The model consists of several layers with predefined dimensions and specifications. Initially, the input layer handles the identified face. The OpenCV library facilitates face detection, with the image undergoing pre-trained filters from Haar Cascades before entering the input layer. Next, the image data generator segments the 48x48 gray-scale training and validation image datasets into batches of 64. In the third step, the VGG-16 model serves as the basis for transfer learning and pre-training. The trainable attribute of the layers is labeled as False, and a preferred output layer, 'block5 conv1', is frozen to stabilize the transfer learning model. This facilitates a preliminary training or "acclimatization" of the sequential model's layers to the provided data, allowing for modifications in weights during training but at a diminished learning rate. In the fourth phase, the genuine training process employs Sequential, and the model's layers encompass GlobalAverage-Pooling2D, Flatten, Dense, Dropout, and Softmax. To conclude, training guidelines are established by determining specific hyperparameters and constants like batch size, image dimensions, optimizers, learning rate, and training cycles. The loss function used is categorical cross entropy  $H(p, q)$  which is using:  $p^i$  - the truth label,  $q^i$  - the softmax probability for the  $i^{th}$  class, and  $n$  - the number of classes or 4.

For the Speech Emotion Recognition module, to achieve the best generalization accuracy, a sixteen-class classification model was developed. The model was evaluated based on test and generalization accuracy for two sets of male and female voices, with eight classes each.

To achieve the goal of classifying RGB images into 16 emotion classes, a custom neural network class was created, with the images being separated into fixed batches of 16 and sorted by emotion class. The core sequential model was defined with a pre-training parameter of an image data generator. Convolution 1-D Layers and Dense Layers were used in the core model.

For facilitating multi-class classification, a Conv1D Model was employed, integrating a 'SELU' activation function and culminating with a 'softmax' activation function, using the 'Adam' optimizer for adjustments. Once the foundational framework was set up, further measures were initiated to ensure a streamlined training process with improved overall accuracy. Here are potential layers to consider:

- Conv1D (256, input shape = (66,1))
- Activation ('SELU')

- Batch Normalization
- Dropout (0.4)
- Flatten
- Dense
- Activation('SELU')
- Batch Normalization
- Dropout (0.4)
- Dense (16)

To ensure a smooth learning process, the training utilized the 'Adam' Optimizer with a learning rate of 0.001 for 65 epochs. Initial recalls with patience of 10 were implemented to await decent accuracy and minimize the loss function. If the learning worsened, the training was stopped. A dedicated class was developed for exporting the model with optimal outcomes, which was the highest accuracy achieved during the training. The class also tracked whether the subsequent epoch had a higher accuracy than the previous one. Code snippets from the implementation can be found in Appendix D in [38].

#### 11.4.3 Findings and future scope

This research presents a comprehensive structure that includes all essential functions and interfaces for sentiment identification and control. The primary objective is to detect the user's emotions by analyzing facial expressions or speech. Three stages make up this algorithm. During the phase of image processing, the facial area and activity aspects are obtained using the Haar Cascade method. In the realm of emotion recognition sensitive to speech, the algorithm operates in two primary phases: extracting features (such as Mel scale, pitch, frequency, chroma, and Fourier transform) and classification through deep learning techniques.

Subsequently, the system decides to steer the user's emotions towards a positive condition by employing sounds and color/light manipulation. Finally, on the output side, the IoT devices change color to a variety of shades to enhance the user's mood. For example, the color spectra for a person feeling angry are lightened to soft colors, while bright colors are used to uplift the mood of someone who is feeling sad and drive them towards a pleasant state of mind.

While recent studies in ambient intelligence systems, visual deception detectors, and threat-identification security frameworks are encouraging, it's clear that there's a substantial path to tread in fully adopting a user-focused methodology. Such systems ought to integrate automated analysis of facial emotions, body language, and speech-related emotions to recognize situations with potential risks. AI systems developed to make an environment genuinely intelligent require them to fulfil the following requirements: 1) understand the ways, partialities, and requirements of the individual user; 2) augment user abilities and ease by offering novel automated service performance; 3) integrate IoT-enabled elements such as smart color blinds, smart home technology, and autonomous robots; and 4) provide an organized approach to examine, make decisions, and respond to the smart and welcoming environment.

### 11.5 DAGER: Deep age, gender, and emotion recognition

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The objective of this research (Dehghan, Ortiz, Shu, & Masood, 2017) was to provide a comprehensive overview of Sighthound's automatic system for detecting age, gender, and emotions. The system's core components include a set of deep convolutional neural networks that not only deliver top-of-the-line performance on various competitive benchmarks but also require minimal computational resources. The team gathered large, labelled datasets utilizing a semi-supervised approach to decrease the time and effort required for annotation, which provided the foundation for our cutting-edge deep networks. The system's capabilities were evaluated on several public benchmarks, and exceptional results were obtained.

#### 11.5.1 Methodology

Data was gathered from various sources and tagged for various objectives. For facial recognition, more than 4 million images of over 40,000 individuals are collected. Every image was tagged with its respective gender designation, and a portion of the data also had emotion annotations. A semi-automated technique was used to filter out irrelevant images with the help of human annotators. Subsequently, the images were pre-processed to extract and align the faces. Finally, the aligned images are used for training the exclusive deep network.

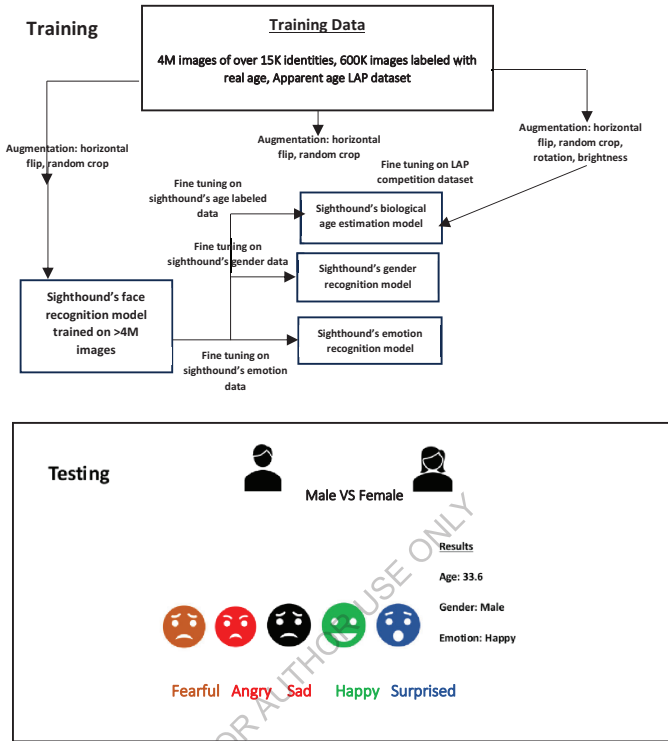


Figure 12: System Pipeline Overview [106]

### 11.5.2 Implementation

The subsequent paragraphs detail the various stages involved in the training process of the models.

**Data Collection:** Gathering labelled data is crucial in the training of deep neural networks (DNNs). This project aimed to create labelled data for three distinct purposes: recognizing age, gender, and emotion. Labelling data for certain tasks, such as accurately estimating an individual's age, is more complex than other classification or detection problems due to the high potential for human error. As such, annotating faces with their precise real age is challenging. Nonetheless, the team managed to accumulate a substantial dataset of faces that includes age, gender, and emotion labels.

**Data Pre-processing:** To prepare the input data for the deep neural networks (DNNs), various pre-processing steps were carried out on each image. These steps include detecting the face, identifying facial landmarks, and aligning the face. In instances where an image has multiple faces, only the most centered one is selected. The resulting aligned faces are then cropped and resized to a standardized size. Unlike some previous studies that did not perform face alignment, this step played a crucial role in achieving the final accuracy results.

**Training:** In this phase, the team trained a DNN for facial recognition, using more than 4 million images of over 40,000 individuals. This model is efficient and achieves exceptional performance on the LFW dataset. This model formed the basis for the facial attribute recognition engine. To achieve optimal speed and accuracy, the team designed a separate, highly optimized deep network architecture for each specific task. Unlike recent works that attempted to create a network to perform all tasks simultaneously, the team opted for separate networks for each task, resulting in faster and more portable models. Although each task's network architecture differs, all networks are trained initially for facial recognition using a set of over 4 million images. The gender and age detection components' code [40] is available in Appendix E.

### 11.5.3 Findings and future scope

The novel deep architecture deployed refers to the deep convolutional neural networks that were designed for the specific tasks of age, gender, and emotion recognition, using the large dataset that was collected in-house. This architecture proved to be highly effective, surpassing the performance of both commercial and academic algorithms on multiple benchmarks. These benchmarks are used to evaluate the accuracy and efficiency of different models in solving specific tasks and are widely used in the field of computer vision and machine learning. The outstanding performance of the novel deep architecture in comparison to other algorithms is a testament to the effectiveness of the approach taken by the team in designing and implementing their system. The results obtained from these benchmarks show that the system is capable of accurately and efficiently recognizing age, gender, and emotion from facial images, making it a valuable tool for a range of applications, from security and surveillance to marketing and entertainment.

## 12 Contribution of this work

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The accomplishment of the tasks described in this study will result in a more thorough and in-depth understanding of smart systems and the applications they have across a variety of fields. The study intends to synthesize current knowledge and identify new trends and difficulties in the field of Smart Systems by performing an extensive literature review, collecting pertinent data, and analyzing case studies. Furthermore, an analysis of the technologies and algorithms utilized in face recognition, video system recognition, and other modalities will reveal the most recent innovations as well as possible areas for advancement.

Examining the potential of smart systems to solve real-world problems is one of the study's main goals. The study seeks to illustrate the useful applications and advantages of these technologies by understanding prototypes of smart systems and developing and modifying deep learning neural networks for face recognition. Smart Healthcare System integration with cloud computing FIWARE will demonstrate how cutting-edge approaches can improve the effectiveness and efficiency of healthcare services, especially in emergency situations like the COVID-19 pandemic.

Additionally, the examination of the present methodology will highlight the benefits and drawbacks of current strategies, opening the door to the discovery of best practices and new research prospects. A thorough grasp of the common traits of Smart Systems will be provided by the meta-analysis and meta-modelling, allowing for a better comprehension of their fundamental principles and more informed decision-making when it comes to their implementation.

The study seeks to advance a responsible and ethical approach to the creation and implementation of Smart Systems by addressing ethical issues relating to data privacy, security, and responsible use. The study's conclusions, combined with the suggested adjustments and new initiatives, will be helpful information for academics, professionals, businesses, and legislators. The knowledge gathered from this study will help the technology of smart systems progress, resulting in more effective, environmentally friendly, and user-centered solutions in areas like smart cities, smart manufacturing, and smart healthcare.

The study covers various topics related to smart systems, machine learning models, digital twin technology, smart home systems, speech and face recognition, data analysis, video surveillance, IoT-cloud solutions, and smart health applications.

It explores the design, implementation, and evaluation of these technologies and their architectures. The figures in the study likely illustrate the different components and workflows of these systems. For instance, it discusses the integration of sensors, processing units, and output screens in smart systems. It also covers the proposed architectures for machine learning models, particularly for scene understanding and facial emotion detection functions.

The study delves into digital twin technology, which involves creating virtual representations of physical objects or systems to monitor and analyze their behavior. Furthermore, it discusses smart home systems and their infrastructure, including communication flows between computers and technologies like KNX routers and switches. The study also examines various algorithms and approaches for speech and face recognition, including flow charts and block diagrams to visualize these systems' functionalities.

It explores data analysis and visualization techniques to gain insights and make informed decisions. In addition, the study touches upon video surveillance camera technology and the use of convolutional neural networks (CNNs) for key frame extraction in face recognition from video.

It also addresses the application of IoT-cloud solutions in healthcare and telemedicine, including architectures for smart health applications. The study presents proposed system architectures for specific use cases, such as the HealthFog system and the HealthEdge system.

In summary, this book delves into a broad spectrum of subjects tied to advanced technologies and their utilization in different fields, offering perspectives on the creation and execution of intelligent systems and machine learning frameworks. As a result, if the goals in this study are successfully completed, we will have a better understanding of smart systems and be able to contribute practically to their development, use, and ethical considerations. The findings from the research have the potential to spur innovation, guide policy choices, and open the door for further developments around Smart Systems, which will ultimately have a positive effect on a variety of domains and societal well-being.

## 13 Conclusion

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Smart systems are a paradigm shift in technology that has the power to reshape entire sectors, enhance quality of life, and tackle some of society's most difficult problems. These cutting-edge technologies also use artificial intelligence, machine learning, and real-time data processing to display intelligent behaviors, make independent judgments, and adapt to shifting settings without overt human involvement.

Businesses, governments, and researchers from all over the world are paying close attention to the study and application of smart systems. Smart systems are used in a variety of industries, including smart manufacturing, smart transportation, smart cities, and smart healthcare. They are essential tools for overcoming today's challenges because of their capacity to improve user experiences, streamline processes, and address complicated issues.

But there are things to think about before smart systems are widely used and implemented. Given that these systems manage enormous volumes of sensitive data and can make autonomous decisions, it is imperative to ensure data privacy, security, and ethical use. Gaining the trust of users and stakeholders requires striking a balance between technological innovation and ethical deployment.

Smart system research and development are continual processes, and to realize their full potential, constant exploration and innovation are required. Smart systems will probably spread much farther as technology advances, impacting many areas of our lives, including healthcare, transportation, energy management, and education.

It will take teamwork and interdisciplinary efforts to fully realize the promise of smart systems. To address problems, share knowledge, and create standards that support interoperability and responsible usage of these systems, researchers, legislators, and industry stakeholders must collaborate.

Hence, it is crucial to remember that while these gadgets can be useful, we must do our research because not all smart devices on the market are controlled by the same software. We need to decide which characteristics are most important and start there.

Future research will focus on examining a larger number of publications from many disciplines that address smart systems.

It's also important to develop a final conceptualization of smart systems that can apply to most fields. In addition, formal representations of concepts related to smart systems should be used, such as ontologies or meta-models. Based on the traits described in this research, the authors will create suitable prototypes of smart systems for various uses. Because the qualities detailed in this work were created using only atomic data and were entirely data-driven, additional qualitative analysis of the articles gathered might be done to identify more complicated or emergent traits.

Face recognition using a modified deep learning neural network is a highly effective technology for identifying and verifying individuals based on their facial features. With advancements in deep learning and neural network architectures, face recognition systems continue to evolve, offering enhanced accuracy, robustness, and applicability in various domains. In the beginning of this study, a short history and definition of smart systems were given. Then two research that has been done in the field of smart devices to help people with visual and hearing disabilities was discussed. Later in the work, a few research that has been done in the field of smart homes, smart buildings, and smart cities were explained and reviewed.

This study concentrated on papers and studies that dealt with smart systems and presented current problems, opportunities, and solutions.

As a result, academics can develop new techniques or enhance ones that already exist to address the issues and resolve practical issues in a variety of application sectors. More than anything else in human history, AI will have a significant impact on the world. A new wave of economic growth is being fueled by AI technology, which is also bringing solutions to some of the world's most difficult problems. the biggest problem facing humanity. Artificial intelligence has the potential to revolutionize a wide range of sectors, including information technology, telecommunications, transportation, traffic management, healthcare, education, criminal justice, defense, banking, and agriculture. My research has shown that using all the features suggested by the city smart domain in smart buildings and vice versa is the most crucial issue for the full integration of smart buildings into smart city platforms. For the surrounding system, building technology and intelligent construction are triggered.

The overall goal of this work was to present a comprehensive overview of AI-based modelling that can be used as a reference manual by decision-makers in a variety of real-world situations and application domains, in addition to scientists and industry specialists. The video streaming was successfully developed at a low cost and easily maintained. The face detection

and recognition were basically with a web server where the video streaming was transmitted from the camera to the server. Therefore, it had a better performance and was much more secure. Here the work did not provide much deeper knowledge and information on each topic as each area of smart systems has wide research and it consist of more details. However, text analysis is done based on data and the existing structure of smart systems. Lastly, for any future work, we can have upgraded system algorithms for face recognition using machine learning models and deep learning methods. These images, texts and audio are the sources which are available everywhere around us and building a smart system based on these 3 sources will be a huge advantage for the country's development and for the betterment of citizen's common day-to-day life. There are smart systems that use other than these sources also like Videos. These smart systems are also still in the development stages and only a few systems are available like traffic signal jumping, Speed detecting for vehicles, movement identification and so on. The future work of this research will be exploring many more sources of smart systems and doing some practical demonstrations with it.

In the field of computer vision, especially the challenging face recognition problem, deep convolutional neural networks have demonstrated excellent performance. CNN models perform exceptionally well when trained on large datasets, however, they are unsuitable for learning from datasets with few samples. This paper offers a novel method that augments the training dataset with artificially generated samples by including Gaussian or Poisson noise. This method addresses the issue of learning face representation from a smaller dataset. In fact, this strengthens the resilience against overfitting the model and increases the generalization capability of CNNs. On the typical AT&T face database, a 95.21% recognition rate is attained using the suggested technique for limited training data, and 99.92% for five training samples [50].

An essential technique for identifying people in situations involving video surveillance or the analysis of vast amounts of video information is face recognition. In this study, we reviewed CNN-based feature extraction and how it is important. The future study in terms of attention-based networks and the implications in video analysis is still ongoing. Also, more research about suspicious behavior and getting good-quality pictures is still ongoing.

FIWARE creates new possibilities and openings at a very large scale to create useful projects to improve and create a smart healthcare system. FIWARE is renowned for its capacity and quickness to respond to pressing issues and the demands of society, businesses, and government agencies. To help automate data exchange, there is a growing demand for ready-

to-use solutions based on open source and open standards concepts. This has once more become clear with the ongoing COVID-19 outbreak. Open-source principles have led to the development of more sharing tools that enable interested parties to access pre-existing solutions and build on top of widely used "off-the-shelf" solutions. The FIWARE4Health pamphlet highlights the way the FIWARE Community members are leading the charge to strengthen and secure the health sector, not least in the event of a pandemic. It also emphasizes how healthcare administrators and other relevant parties can use open-source technologies to improve patient tracking, help contain viruses, and create a strong healthcare system [87]. In this study, we observe how Cloud computing and IoT are used to create smart healthcare systems. Nowadays medical staff/ doctors can remotely monitor the health of the patients through the data they are receiving remotely from the devices used to measure the parameters (Blood Pressure. Also, by analyzing the data stored in the cloud/ FIWARE, predicting the possibility/ early detections, and treating them before getting the patient's worsening condition. In this context, FIWARE is very helpful as it is an open platform, and anyone can use the data to create a new and improved system.

The future of smart systems is undoubtedly promising. As technology continues to advance, smart systems will become more intuitive and efficient in assisting individuals with their daily lives. One of the most significant developments in smart systems is the integration of artificial intelligence and machine learning algorithms, which will enable them to learn and adapt to users' behaviors and preferences.

Smart systems will also become more interconnected, allowing different devices and systems to communicate with each other seamlessly. This connectivity will allow for greater automation, enabling smart systems to perform routine tasks and streamline processes.

Moreover, the rise of the Internet of Things (IoT) will play a vital role in the development of smart systems. As more devices become connected to the internet, they will be able to collect and analyze vast amounts of data, which can be used to optimize processes and improve user experiences. For example, smart home devices can learn a user's daily routine and adjust the thermostat or lighting, accordingly, improving comfort and energy efficiency.

In addition to improving daily life, smart systems have significant potential to make a positive impact in areas such as healthcare, transportation, and the environment. Smart healthcare systems can track patient data in real time and provide personalized treatment plans, while smart transportation systems can optimize traffic flow and reduce emissions. Smart

environmental systems can monitor and manage energy consumption, helping to reduce waste and mitigate the effects of climate change.

Overall, the future of smart systems is exciting, and we can expect to see significant advancements in the coming years. These advancements will not only improve our daily lives but also have the potential to make a significant positive impact on society.

One area of particular interest is emotion recognition. Emotion recognition technology involves using computer algorithms and machine learning techniques to analyze human emotions based on facial expressions, speech patterns, and other biometric data.

Currently, the state of emotion recognition technology is still in its early stages, but there have been significant advancements in recent years. Facial recognition technology is becoming more accurate at identifying emotions in real time, and speech recognition technology can analyze tone and intonation to detect emotions in spoken language.

Several industries have started to adopt emotion recognition technology, including healthcare, marketing, and entertainment. In healthcare, emotion recognition technology can be used to monitor and detect changes in patients' emotional states, particularly in cases of mental health disorders such as depression and anxiety.

In marketing, emotion recognition technology can be used to analyze consumer responses to advertising and products. By detecting emotional responses, marketers can tailor their advertising strategies to better appeal to their target audience.

In the entertainment industry, emotion recognition technology is being used to enhance virtual reality and video game experiences. By analyzing user emotions, these systems can adjust the game's difficulty level, storylines, and character interactions to provide a more immersive and personalized experience.

However, there are still challenges that need to be addressed in emotion recognition technology. One challenge is the potential for biases in the algorithms used to analyze emotions. Another challenge is the need for more diverse and representative datasets to train these algorithms accurately.

Despite these challenges, the future of smart systems and emotion recognition is promising. As technology continues to advance and become more integrated into our daily lives, emotion recognition technology has the potential to revolutionize how we interact with the world around us.

## 14. APPENDIX A

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### 14.1 Convolutional Neural Networks (CNN)

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At a high level, a CNN is a type of deep learning architecture specifically designed for image data. It's inspired by the human visual system, and it's great for tasks like image classification, object detection, and more.

The CNN works by learning image features in a hierarchical manner. The earlier layers might capture low-level features like edges, while deeper layers might capture more abstract and higher-level features.

*Key Components:*

1. **Convolutional Layer:** This is where the magic happens. Instead of connecting each neuron to every neuron in the previous layer (like in fully connected layers), in convolutional layers, neurons are connected only to a small subset of the previous layer. This structure is great for identifying local patterns like edges.
2. **Pooling Layer:** This layer is responsible for reducing the spatial size of the representation, helping to decrease the computational power required and also adding a bit of translation invariance.
3. **Fully Connected Layer:** After several convolutional and pooling layers, the high-level reasoning in the neural network occurs in the fully connected layers. It's a regular neural network layer.
4. **BatchNorm Layer:** Normalizes the activations of the current layer at each batch, i.e. applies a transformation that maintains the mean activation close to 0 and the activation standard deviation close to 1. This helps in faster and more stable convergence.
5. **Dropout Layer:** During training, a certain fraction of input units is set to 0 at each update, aiding in avoiding overfitting.

*Python Code Example for CNN for image recognition using TensorFlow and Keras with CIFAR10 dataset:*

```
8 import tensorflow as tf
9 from tensorflow.keras import layers, models, datasets
10
11 # Load CIFAR10 dataset
12 (train_images, train_labels), (test_images, test_labels) = \
13     datasets.cifar10.load_data()
14
15 # Normalize pixel values between 0 and 1
16 train_images, test_images = train_images / 255.0, test_images / 255.0
17
18 # Define the CNN architecture
19 model = models.Sequential()
20 model.add(layers.Conv2D(32, (3, 3), activation='relu', \
21     input_shape=(32, 32, 3)))
22 model.add(layers.BatchNormalization())
23 model.add(layers.MaxPooling2D((2, 2)))
24 model.add(layers.Conv2D(64, (3, 3), activation='relu'))
25 model.add(layers.BatchNormalization())
26 model.add(layers.MaxPooling2D((2, 2)))
27 model.add(layers.Conv2D(64, (3, 3), activation='relu'))
28 model.add(layers.BatchNormalization())
29
30 # Flatten the 3D output to 1D, and then add a few dense layers
31 model.add(layers.Flatten())
32 model.add(layers.Dense(64, activation='relu'))
33 model.add(layers.Dropout(0.5))
34 model.add(layers.Dense(10)) # 10 classes for CIFAR10
35
36 # Compile and train the model
37 model.compile(optimizer='adam',
38     loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
39     metrics=['accuracy'])
40
41 history = model.fit(train_images, train_labels, epochs=10, \
42     validation_data=(test_images, test_labels))
43
44 # Evaluate the model
45 test_loss, test_acc = model.evaluate(test_images, test_labels, verbose=2)
46 print("\nTest accuracy:", test_acc)
```

*Code explanation:*

- We first load the CIFAR10 dataset using `'datasets.cifar10.load_data()'`. CIFAR10 is a dataset of 60,000 32x32 color images in 10 classes, with 6,000 images per class.
- Next, we define our CNN model. It's a sequence of layers. We start with convolutional layers and then add pooling layers. After some convolutional layers, we flatten the output and pass it to dense layers (fully connected layers). Between the dense layers, we add a dropout layer with a rate of 0.5, meaning it drops out 50% of the input units randomly to prevent overfitting.

- After defining the model, we compile it. We use the Adam optimizer, and since our labels are integers (not one-hot encoded), we use ‘**SparseCategoricalCrossentropy**’ as our loss function.
- We train the model for 10 epochs. One epoch is when the entire dataset is passed both forward and backwards through the neural network once.
- Finally, we evaluate the model on the test dataset and print the accuracy.

*Important note: This is a very basic CNN model for CIFAR10 and might not achieve the best accuracy. Hyperparameters (like number of layers, number of filters, kernel size, etc.) can be tweaked for better performance. Always ensure to modify and experiment with the code to get a better understanding and improve the performance!*

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## 15. APPENDIX B

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### 15.1 Recurrent Neural Networks (RNN)

---

RNNs are a type of neural network designed specifically for sequential data. Think of tasks like language translation, time-series forecasting, and speech recognition — anything where the sequence of the input data matters. A key feature of RNNs is their 'memory'. An RNN processes sequences by iterating through the sequence elements and maintaining a 'state', which contains information relative to what it has seen so far.

However, traditional RNNs have certain issues. Among the most notable are the vanishing and exploding gradient problems.

#### **Vanishing & Exploding Gradients:**

During training, deep neural networks learn by adjusting their weights using a gradient-based optimization algorithm. The 'gradient' is a value that indicates the direction and rate of change for the weights.

1. **Vanishing Gradient:** In RNNs, when gradients are passed back through time (during backpropagation), they can become very small, effectively causing the network to stop learning. This means that the RNN might struggle to "remember" information from earlier time steps.
2. **Exploding Gradient:** Conversely, the gradients can also become very large, leading the model weights to update so drastically that the model becomes unstable and fails to learn meaningful patterns.

To overcome these challenges, variants of RNNs such as LSTM (Long Short-Term Memory) and GRU (Gated Recurrent Unit) have been introduced.

#### **Python Code example showing the use of RNNs in the field of Text Generation**

For this demonstration, we'll build a simple RNN to generate text, a common application for RNNs.

### *Python Code for a simple RNN using TensorFlow:*

```
8 import tensorflow as tf
9 from tensorflow.keras.layers import Embedding, SimpleRNN, Dense
10 from tensorflow.keras.preprocessing.text import Tokenizer
11 from tensorflow.keras.preprocessing.sequence import pad_sequences
12
13 # Sample data: sentences
14 sentences = ["I love neural networks",
15             "Deep learning is amazing",
16             "RNNs are great for sequences"]
17
18 # Tokenize sentences
19 tokenizer = Tokenizer(num_words=100, oov_token='<OOV>')
20 tokenizer.fit_on_texts(sentences)
21 sequences = tokenizer.texts_to_sequences(sentences)
22 padded_sequences = pad_sequences(sequences, padding='post')
23
24 # Simple RNN model
25 model = tf.keras.Sequential([
26     Embedding(100, 64, input_length=padded_sequences.shape[1]),
27     SimpleRNN(64, return_sequences=True),
28     SimpleRNN(64),
29     Dense(64, activation='relu'),
30     Dense(100, activation='softmax')
31 ])
32
33 model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', \
34              metrics=['accuracy'])
35 print(model.summary())
36
37 # Train the model
38 # Here, we're using the same sequences as both input and target,
39 # shifted by one position
40 X = padded_sequences[:, :-1]
41 y = padded_sequences[:, 1:]
42 model.fit(X, y, epochs=100)
```

#### *Code explanation:*

- We start with a sample dataset of three sentences.
- The ‘Tokenizer’ is used to convert these sentences into sequences of numbers.
- We use ‘Embedding’ to convert each token into a vector. This allows our model to understand the semantic meaning of each word.
- The ‘SimpleRNN’ layers process the sequences. The first RNN layer returns sequences, which are then processed by the next RNN layer.
- The final ‘Dense’ layers are typical neural network layers used to produce the output.

This model, once trained, can be used to generate new text based on the input sentences. However, note that this is a very basic model for illustrative purposes and might not produce meaningful text.

*Important note: This code serves as a starting point. For practical purposes, you might need a larger dataset, adjustments to model architecture, hyperparameter tuning, and other modifications. Always consider the requirements of your specific problem and adjust the code accordingly.*

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## 16. APPENDIX C

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### 16.1 Long Short-Term Memory (LSTM) Networks:

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LSTM is a special kind of Recurrent Neural Network (RNN) designed to overcome the limitations of vanilla RNNs. Remember when we talked about vanishing and exploding gradients in RNNs? LSTMs are the solution!

LSTMs, just like RNNs, work with sequential data. However, they're specifically designed to "remember" long-term dependencies in the data, which basic RNNs struggle with.

#### **Differences between LSTMs and vanilla RNNs:**

1. **Architecture:** LSTMs have a more complex structure with three gates: input, forget, and output gates. These gates determine what information should be stored, discarded, or output at each time step. This structure helps LSTMs decide what to "remember" and what to "forget".
2. **Long-term dependencies:** LSTMs are particularly good at learning and remembering over long sequences and are less susceptible to the vanishing gradient problem.
3. **Training:** LSTMs tend to be more stable during training due to their internal structure which helps mitigate the vanishing and exploding gradient issues.

#### **Example Use of LSTMs: Text Generation (Similar to the RNN example)**

### Python Code for a simple LSTM using TensorFlow:

```
8 import tensorflow as tf
9 from tensorflow.keras.layers import Embedding, LSTM, Dense
10 from tensorflow.keras.preprocessing.text import Tokenizer
11 from tensorflow.keras.preprocessing.sequence import pad_sequences
12
13 # Sample data: sentences
14 sentences = ["I love deep learning",
15             "Neural networks are powerful",
16             "LSTMs handle long sequences"]
17
18 # Tokenize sentences
19 tokenizer = Tokenizer(num_words=100, oov_token='<OOV>')
20 tokenizer.fit_on_texts(sentences)
21 sequences = tokenizer.texts_to_sequences(sentences)
22 padded_sequences = pad_sequences(sequences, padding='post')
23
24 # LSTM model
25 model = tf.keras.Sequential([
26     Embedding(100, 64, input_length=padded_sequences.shape[1]),
27     LSTM(64, return_sequences=True),
28     LSTM(64),
29     Dense(64, activation='relu'),
30     Dense(100, activation='softmax')
31 ])
32
33 model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', \
34              metrics=['accuracy'])
35 print(model.summary())
36
37 # Train the model
38 X = padded_sequences[:, :-1]
39 y = padded_sequences[:, 1:]
40 model.fit(X, y, epochs=100)
```

#### Code explanation:

- As with the RNN example, we start with tokenizing our sample sentences into number sequences.
- The **Embedding** layer transforms word tokens into vectors.
- Next, we use **LSTM** layers instead of the **SimpleRNN** layers. Notice the architecture remains quite similar. The key difference is inside the LSTM layer, where the gating mechanisms (input, forget, and output gates) reside. These gates ensure that the LSTM can capture and preserve long-term dependencies in the sequence.
- Lastly, **Dense** layers produce our output.

Upon training, this model can be used for text generation. The LSTM, given its ability to capture long-term dependencies, should be more proficient at generating coherent sequences compared to the simpler RNN.

*Important note: This code provides a foundational understanding. For actual deployment or more complex applications, you might need a bigger dataset, more complex architecture, hyperparameter tuning, and other adjustments. Always keep in mind the unique requirements of your problem and adjust the code accordingly!*

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