Systems

PORTABLE DEVICE "FLORATEST" AS TOOL FOR ESTIMATING OF MEGALOPOLIS ECOLOGY STATE

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Abstract: Portable device "Floratest" for express-diagnostic of plant state, which is developed in the V.M. Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine, is considered. Party of this device is manufactured and transferred to organizations, worked in the agricultural sector, environmental protection area, mineral fertilizer production etc. for working out of methodical tools. Using of the device for estimating of megalopolis ecology state by means of evaluation of green plant state is described in the article. Together with Megalopolis Ecomonitoring and Biodiversity Research Center of National Academy of Sciences of Ukraine there were got results of experimental researches of influence detecting of heavy metals and harmful substances on the trees and plants in Kiev.

Keywords: Kautsky effect, chlorophyll, chlorophyll fluorescence induction, fluorescence, fluorometer, portable device, ecology.

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Introduction

Photosynthetic processes are the processes which supply energy to the cells of plants. Chlorophyll is the main pigment of the cells of plants. One of the main features of the molecular of chlorophyll is ability of fluorescence. The intensity of chlorophyll fluorescence depends on photosynthetic activity. After irradiation of leaf the intensity of chlorophyll fluorescent signal is increasing at first and then slowly reduces. This effect is called as effect of Kautsky [Kautsky, 1931] or effect of chlorophyll fluorescent induction (CFI). The form of this curve is very sensitive to adverse environment.

It gave possibility to develop in the V.M. Glushkov Institute of Cybernetics of NAS of Ukraine the portable device "Floratest" [Fedack, 2005, Palagin, 2007], which lets to estimate in several seconds the plant state after drought, frosts, pollution, herbicides etc. without plant damage. Like human cardiogram device builds CFI curve, which characterizes photosynthesis process, which is the base of plant vital activity.

Device "Floratest" description and application examples

Device and relevant diagnostic methods refer to the area of biological object researches by detecting their biophysical properties, particularly native chlorophyll fluorescent induction. Device is defined as smart biosensor with fragment plant as sensing element.

Express-diagnostic of plant state is carried out by functional features and is based on using of features of separate specific sections of IFC curve, which refer to separate areas of photosynthesis chains as diagnostic features. By IFC curve form it is easily to detect influence of one or another factor on the plant state.

Application areas of portable device "Floratest":

- express-estimating of plant vital activity after drought, frosts, sorts coupling, pesticide introduction;
- express-detection of optimal doses of chemical fertilizers and biological additives, what lets to optimize amount of fertilizers and additives and reduce nitrates content in vegetables and fruits;
- express-detection of level of pollution of water, soil and air by pesticides, heavy metals and superpoison;
- economy of energetic and water resources during man-made watering;
- developing of precision agriculture technology for increasing the quality of agricultural products;
- using of the device in the insurance agriculture to get predicted results of future yield;
- automation of researches in the plant physiology field.

Appearance of portable device "Floratest" is shown on the fig. 1.

Functional diagram of the device is shown on the fig. 2. Data processing unit and displaying unit are built on the base of microconverter ADuC812 and graphical display with resolution capability of 128*64 pixels. Microconverter is system-on-chip for data acquisition and processing, which includes analog-digital and digital-analog converters, reference supplies, temperature sensor, timers, power supply monitor, embedded industry standard 8052 microcontroller, external and internal data memory, program memory etc.

Fig. 1. Appearance of portable device "Floratest"

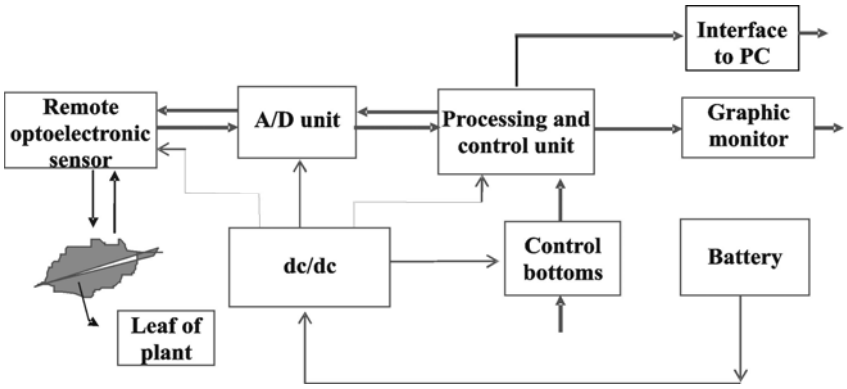

Fig. 2. Functional diagram of portable device "Floratest"

Remote optical sensor is built as "reflection diagram" on the base of four light-emitting diodes and one photodetector. "Reflection diagram" means that light-emitting diodes and photodetector are situated from the same side of researched leaf. To research chlorophyll fluorescence in the red spectral region the filter is placed on the input of photodetector. Emission intensity of light-emitting diodes and photodetector sensitivity can be changed during measuring process. Integrated algorithm of device work is shown on the fig. 3.

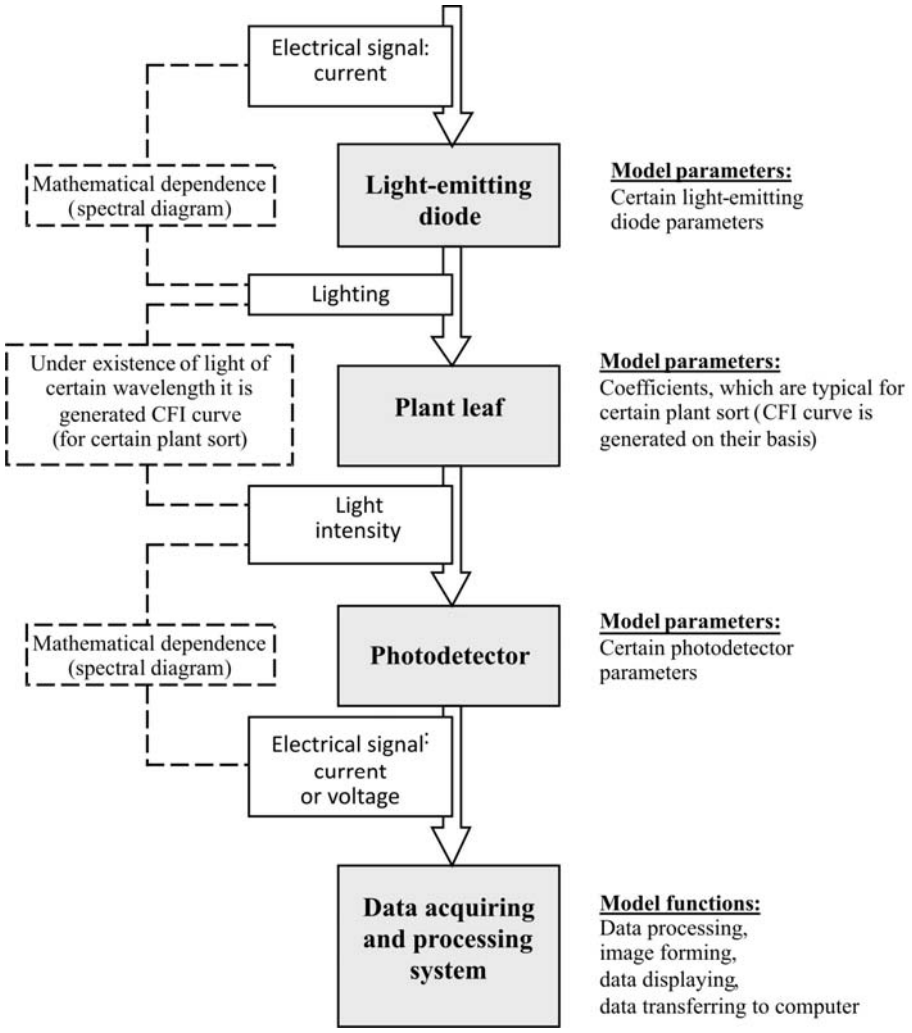

Fig. 3. Integrated algorithm of device work

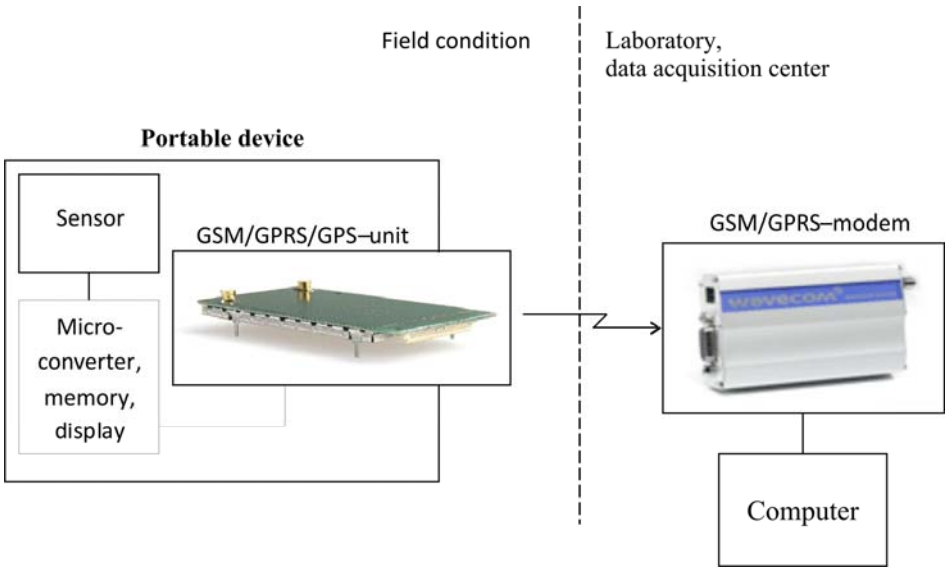

Fig. 4. Data acquiring, processing and transmitting system on the base of portable device with radio channel

Today it is not enough to acquire and save measurement result in the portable device memory. It is urgent to transmit measurement results from places of measurement to laboratories or centers of operative estimation of condition and necessary decision making. For data transmitting from measuring channel to receiving point it is proposed to use mobile communication by means of midget GSM-unit with GPS-subsystem, which is embedded in the portable device, and GSM-modem, which is connected to computer or work station. During such measurements the transmissions of a small amount of data are required, so it is reasonable to use GPRS standard. Data acquiring, processing and transmitting system on the base of portable device with radio channel is shown on the fig. 4.

Application of device "Floratest" for estimating of megalopolis ecology state

In 2008 together with Megalopolis Ecomonitoring and Biodiversity Research Center of National Academy of Sciences of Ukraine experimental researches of portable device "Floratest" were carried out to detect influence of heavy metals and harmful substances (e.g. lead, sodium, chlorine etc.) in leaf and soil on the plants state in Kiev. Today long-term phytomonitoring methods are used. They consist of visual observations and chemical analysis of soils and plant fragments and needs complicated equipments and lasts more than one week.

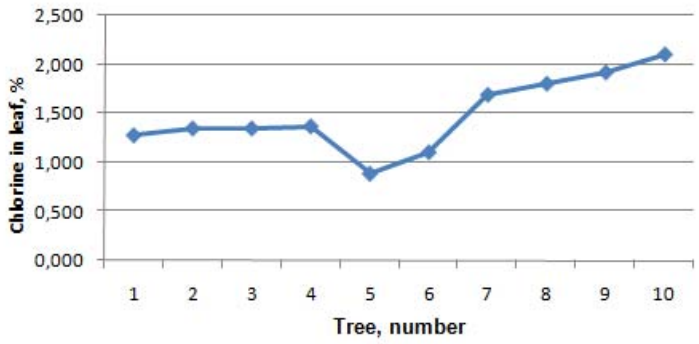

Fig. 5. Chlorine content in researched trees' leaf

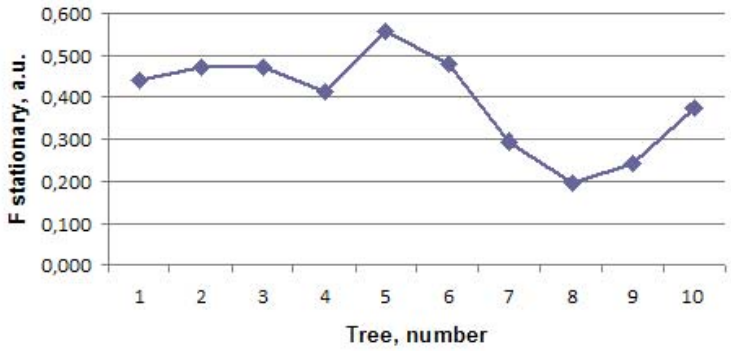

Fig. 6. Readouts of portable device "Floratest" for researched trees

Long duration and complexity of existing methods of heavy metals and harmful substances detecting in alive plants and necessity to involve skilled specialists to perform these researches set necessary conditions to develop special diagnostic methods and tools for this aim. Preliminary researches indicate that portable device "Floratest" can be used for detecting of heavy metals and harmful substances influence on state of plants by measuring of CFI curve. The form of CFI curve changes versus level of harmful substances influence.

Joint researches were carried out in Kiev green regions by means of common phytomonitoring methods and portable device "Floratest". After processing of research result there were built dependences for searching correlations between chlorine content in trees' leaf, which are got by common phytomonitoring methods (fig. 5), and readouts of portable device "Floratest" (fig. 6).

Even one can see some dependence between chlorine content in trees' leaf and readouts of portable device "Floratest" (stationary region of IFC curve) on figs. 5, 6. Calculations, made by mathematical methods, show certain correlations between these values. Such researches were made for other harmful substances, such as sodium, magnesium.

It is easily to concede that IFC curve form expresses not only contents of separate harmful substance, but general state of tree versus influence level of harmful substances. It is possible to convert IFC curve in a

description as a set of objects with features which values are integer numbers. The received description may be used by the system for inductive finding of regularities - Confor [Gladun et al, 2008], which permits to find common features of IFC curves for the trees which are under influence of equal oppresive factors. The found regularities may be used for automatic selection of harmful substances using the form of IFC curve.

Using VLCAD for designing "Floratest"

Let remember, that only by paying attention to the design process of computer devices it will be possible to reach a high level of competitiveness of scientific developments, what lets in the future to take up notable place on the world market. It is easily to see, that most devices have the same structure, to be exact, they consist of sensor, measuring channel, data processor, interface and additional subsystems. That's why process of designing could be easily formalized. [Palagin et al, 2009]

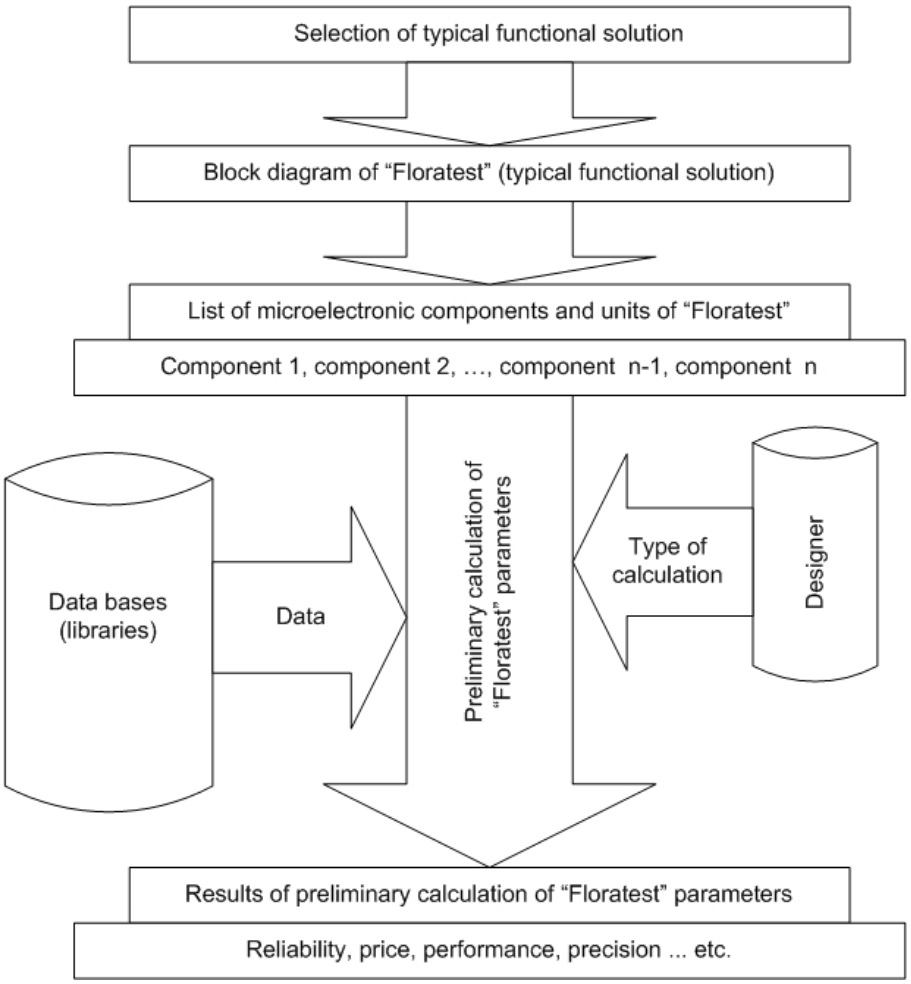

Fig. 7. Designing of "Floratest" by means of virtual laboratory

To solve this problem within the bounds of international Ukrainian-Bulgarian project it is began developing of virtual laboratory for computer-aided design for computer device designing (VLCAD) [Palagin et al, 2007]. The VLCAD is being created on the virtual methods of design [Galelyuka, 2008]. For VLCAD creating it is used the methodology of system integration [Palagin and Kurgaev, 2003] concerning base methods and tools, on which it is created.

In the process of designing of “Floratest” the VLCAD was used to:

- check possibility of creating of new modifications of "Floratest" on basis of developed sensors without involving specialists in circuit technology and instrument engineering at the stage of EFT-project;
- avoid expensive actual tests on the stage of device creating by replacing with virtual methods of designing and testing;
- calculate parameters (reliability, price etc.) of new device;
- prepare set of design documentations on designed device.

The sheme of using the virtual laboratory for designing of "Floratest” is shown on the fig. 7.

Conclusion

On basis of preliminary researches there were shown that using of portable device "Floratest" let to detect in express mode the worsening of photosynthetic apparatus of plant by measuring fluorescence of native chlorophyll on the early stages.

Satiation of ecological monitoring centers and institution of agrarian sector by such devices let to diagnose general state of live plants and environment influence on them, acquire data about that, how plants survive drought or frosts, and determine optimal dose of fertilizers or herbicides.

Using VLCAD the design process has been facilitated. The possibility to convert IFC curve in a description as a set of objects with features which values are integer numbers allows implementing the intellectualized components in the design process as well as in the real usage of the “Floratest”.

Acknowledgements

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