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Intelligent Systems in Technology of Precision Agriculture and Biosafety

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1. Introduction

The XXI century is based on developments of up-to-date intelligent systems and self-learning wireless distributed sensory networks for different purposes of the application to make the whole of space surrounding us sensory and motoric but also for the health and human life maintenance, the improvement of a production status, an output quality, and the product biosafety. A bedrock principle underlying precision agriculture is a wide application of intelligent systems for the control and the assistance of decision making in technological operations of an agricultural production [1, 2]. Precise positioning of agricultural machines using satellite systems gives an opportunity to produce an intelligent system of the agrarian production with dosed applying fertilizers but also chemical weed and pest killers depending on information patterns in a specific spot of the tillable field for the sensory control. Microsensory intelligent systems on a chip "electronic eye" (e-eye) with a LED technology of the data acquisition let form soil light-colour information patterns fast to get a maximal quantity of quality products, foods or biomatters (blood, saliva, sweat, urine, tears, etc.) for the ecological, personal and social biosafety as well as real-time monitoring the human health. The LED technology represents an optical microtomography of functional states of bioobjects on a chip of the type e-eye. The intelligent control in the agro-industrial production offers an opportunity to generate information electronic maps, e.g., the distribution of nutrients and organic fertilizers applied in soil, virtual maps of crop yield taking into account the technological preparation of land for growing crops and micronutrients carried-out from this one with early taken crops, electronic satellite maps of field, electronic maps of the quality, the information-microbial biosafety of foodstuffs, the human health, and ecological environmental conditions. The distributed wireless sensory systems and networks with a self-learning software make for the development of intelligent precision agriculture including the information pattern recognition of an agrotechnical technology, agricultural products and external ecological conditions in a space of multidimensional sensory data. The use of intelligent information CIMLS (Continuous Intelligent Management and Life Cycle Support) technology with developed intelligent systems of data superprotection maintains and controls the life cycle of all the agricultural production.

2. Intelligent sensory systems and networks of precision agriculture

2.1 LED technology in precision agriculture

The main principle of intelligent precision agriculture is the high-precision dosed fertilizer application in a specified small piece of the ground depending in a soil physical-chemical status (colour, structure, organics content, moisture, temperature) for an equal distribution of organic fertilizers and using controlled actuators, electronic, virtual and intellect-maps for the agro-industrial production, the foodstuff biosafety and the human life maintenance. The use of intelligent technologies in precision agriculture enables to achieve saving weed and pest killers, fertilizers, energy resources, ecological sustainability, raising the level of crop yield, the quality of fields, the biosafety of agricultural products, and the increased efficiency of the agricultural production. The most effective method for monitoring and the fast formation of soil information patterns consists in the estimation of its spectral reflectance as a set of optical parameters in the ultraviolet, visible and near infrared spectral ranges. The LED technology presented by us is intended for taking soil brightness coefficients in the broadband optical spectrum range (10^{11}–10^{15} Hz) using a set of light-emitting and light-sensitive microelements for the illumination of a controlled small piece of soil and for recording the reflected optical signal. A wide application of intelligent sensory systems for precision agriculture and the fast control of soil information patterns in every spot of a cultivated agricultural field underlie the LED technology of precision agriculture with the differentiated fertilization [1, 3].

2.2 Mobile microsensory system for precision agriculture

A mobile microsensory system "ISSE" developed by us with the LED technology for the light-colour information pattern recognition can analyze a soil state from within and apply fertilizers on different spots of a field just that dosage which is required in a defined soil spot. The registration of soil optical characteristics is realized by means of light-emitting microdiodes with the emission wavelength 405 nm (violet), 460 nm (blue), 505 nm (green), 530 nm (green), 570 nm (yellow), 620 nm (orange), 660 nm (red) but also in spectral points of the sensory control of the infrared radiation (760-2400 nm) and white light (integrated index) [3, 4]. Light-emitting microdiodes irradiate the given electromagnetic waves in the broadband frequency range, but photosensitive microdiodes register a quantitative change of the reflected radiation. The optimal spectrum width corresponds to the wavelength range of 400-800 nm, so the oscillation spectrum effect of H_2O molecules in soil begins to become apparent at the greater wavelength, and complementary errors are introduced in results of the diagnostics of a soil horizon. The multisensory system "ISSE" includes an electronic optical module for the formation and the registration of optical impulses consisting of the analog-digital transducer with a microcontroller and a pulse-shaping module (Fig. 1) but also for the comparison of obtained information sensory patterns with soil experimental characteristics on local field areas using a special self-learning software [3].

Light-emitting microdiodes are equispaced on a perimeter of circle in 20 mm over on the angle about 10° relative to the vertical line, so the placing height of these ones over a controlled surface is equal to 30 mm. Eight numbers in the binary-coded decimal notation in the range of 0…1000 corresponding to reflectivity factors of the radiation for each of eight spectrum lines are generated by the use of RS-232 or RS-485 interfaces. Then the value 1000
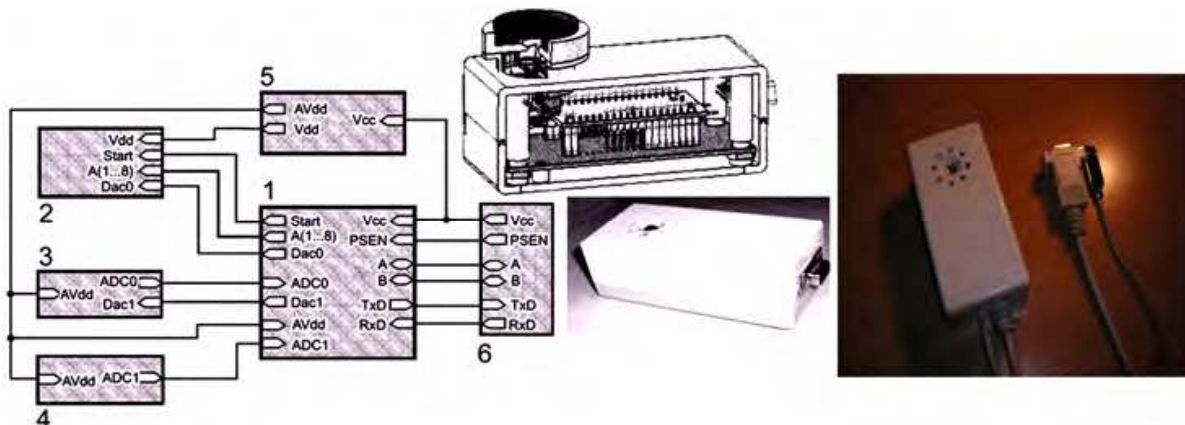
Fig. 1. Function circuit of the electron-optical module "ISSE" for a sensory system "CDOT": 1 – microcontroller for the control and information processing; 2 - light-emitting microdiodes control circuit; 3 - microphotodetector coupling; 4 – temperature monitoring circuit; 5 - secondary voltage source; 6 – COM-port connector

characterizes a reflection coefficient from a reference surface used for the calibration of the electronic optical module. The microprocessor-based device generating a soil sensory information pattern processes the output signal of the microphotodetector [4]. Using "ISSE" it is possible to analyze coefficients of absorption, refraction, light scattering, gradient change, and polarization but also coefficients of variation (intensity, amplitude, and phase) of the electromagnetic wave and a space-time field distribution. The obtained data of spectroscopic analysis enable to produce an information pattern of soil, agricultural products, foodstuff, and human biomatters. A gridded registrating unit periodic realizes the real-time satellite navigation and the control of soil parameters. The specifically developed software "ISSE" can be applied in an intelligent system "CDOT" (Control of Distribution of Organics and Temperature) on a chip "electronic eye" which is of interest in precision agriculture for the control of a soil humus-accumulative horizon at the depth of 20-30 to 180-200 mm. A small intelligent sensory "mole" ("CDOT") includes "ISSE" placed in the metal sheathing with the stone and sunlight protection. The optical beam output to a controlled soil surface is realized by the use of the sapphire transparent coating as the extra hard material, so "CDOT" can be attached, e.g., to a mini-tractor or any other agricultural units. "ISSE" explores the ground at the depth of 5-10 cm for the detection of organic substances, moisture, temperature, colour, granulometric composition and for the analysis of the fertile topsoil and using the GPS (Global Positioning System) navigation defines rapidly how much exactly fertilizers have to be applied with the micromechatronic system in the specific field place in process of optimal motion of the mini-tractor with an attached drawbar hitch (Fig. 2) [1, 3, 4].

The given depth of penetration of the multisensory system "CDOT" for topsoil copying is determined depending on structural features of the floor profile and on the location of the humus-accumulative horizon. The hydralift system of the mini-tractor is intended for the control of "CDOT" lifting and sinking actuators in soil. Positioning of the units is also based on data from ultrasonic, microwave, electrostatic sensory modules at the same time. The intelligent system "CDOT" fulfils data binding of a soil controlled information pattern to ground control points from a GPS receiver and stores obtained data in its memory for

postprocessing and the sensory information pattern recognition. Principal parameters of the mobile multisensory system "CDOT" developed by us for the control of soil in precision agriculture are presented in the table 1 [4].
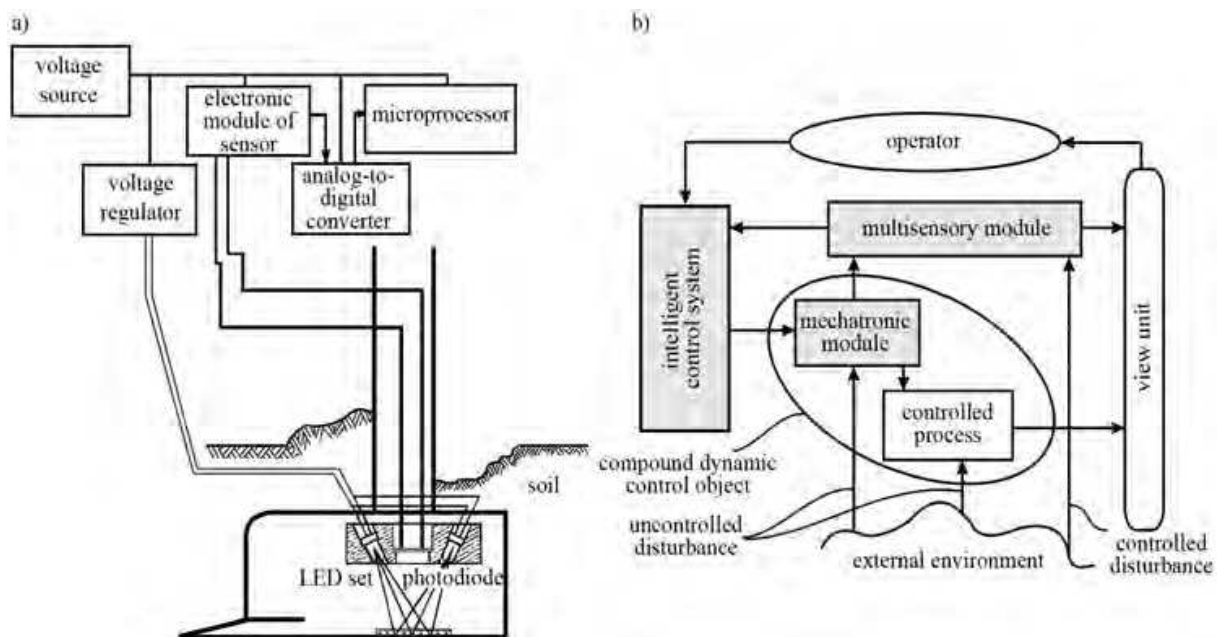

Fig. 2. Multisensory system "CDOT" for the light-colour soil control: (a) intelligent mechatronic system for precision agriculture; (b) block diagram of the intelligent sensory system

Technical characteristics of "CDOT"	Data description
controlled spectrum width	400-2400 nm
spatial resolution of agricultural unit location	2-5 m
spatial resolution for the control of soil	0,5 m
maximal output current of light-emitting microdiodes	40 mA
duration of information pattern generating	120 ms
space of time between impulses	5 ms
depth of taken measurements	8-15 cm
speed of the mini-tractor	2,83 m/s
control of organic matter content in the soil humic-accumulative horizon	0,1–6 %
control of soil moisture	0-20 %
control of temperature	3-50 ^{0}C

Table 1. Principal parameters of mobile multisensory system "CDOT"

Fundamental purposes of the developed intelligent multisensory system "CDOT" for precision agriculture is to ensure the processing quality optimization, in particular, for the control of the developed mechatronic mechanism of the agricultural unit and its positioning mechatronic system. The intelligent system analyses sensory processing information, carries

out the computation of optimal motion and changes a control criteria preliminary programming a movement pattern and maintaining the power-saving engine behaviour. Solar energy converters can be used as an auxiliary supply source or the alternative energy one of the intelligent mobile system "ISSE" for the optical control of the soil quality. A soil light-colour information pattern is taken into account in the process of dosing introduced fertilizers and considered as a control parameter according to the model of the plants inorganic nutrition:

$$F_{IF} = F - F_0, \tag{1}$$

where F_{IF} – cumulative dose of introduced fertilizers, F – plants nutrition level, F_0 – initial fertility of soil.

Metering microdevices of the mechatronic module are intended for the fertilizer application in soil or for the power feed of weed and pest killers with annular ultrasonic microactuators, so that acoustic vibrations of ones put a diaphragm mechanism in motion for the control of the metering microdevice-delivered material flow (Fig. 3) [1, 5].
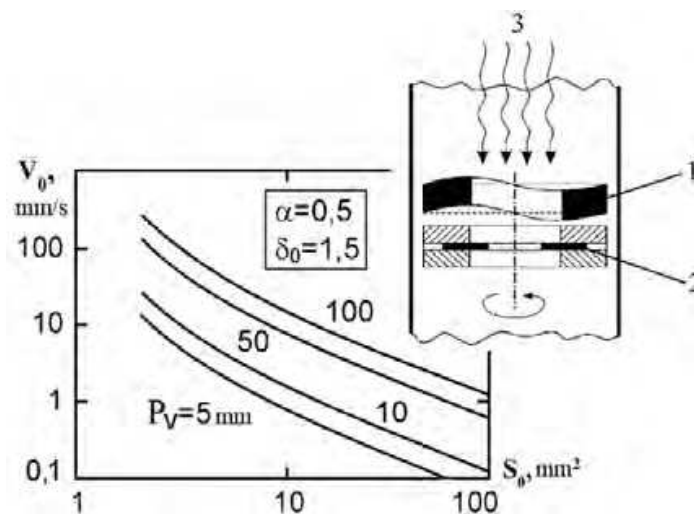

Fig. 3. Metering microdevice of the free-flowing material and the nomogram for its parameterization: 1 – electroacoustic element; 2 – diaphragm mechanism; 3 – flow of the dosed material

The intelligent system fulfils, e.g., dosing of introduced mineral fertilizers depending on the organics content in a field specified point by controlling impulse characteristics of a high-frequency generator which supplies the ultrasonic microactuator. The volumetric capacity P_v of the metering device with the presented design is equal to:

$$P_v = (S_0 - P_1 \cdot \delta_0 / 2,3) \cdot V_0, \tag{2}$$

where S_0, δ_0, V_0 – flow area, diameter of granules, flow velocity of dosed materials; P_1 – part of the metering hole perimeter formed by fixed edges relative to the material flow. The form of a hole produced by blades of the dosing unit is presented as an approximate circle, so P_1 can be written in this form:

$$P_1 = 2 \cdot \alpha \cdot (\pi \cdot S_0)^{-0,5}, \tag{3}$$

where $1 \geq \alpha \geq 0$ – coefficient characterizing the dosing performance degradation because of the reduction of the flow area. A value of the coefficient P_1 is taken into consideration on conditions that $P_1 > 0{,}025 \cdot S_0/\delta_0$ and for the considered dosing unit:

$$\alpha \geq 6 \cdot 10^{-3} \cdot \xi , \qquad (4)$$

where $\xi = D_0/\delta_0$, D_0 – diameter of the metering hole.

Nomographic charts in the form of the S_0-V_0 relation for different values of granules sizes δ_0 and the coefficient α were calculated for the metering device developed by us. The given dependences have a linear character for relatively low values α and δ_0, but these ones take the nonlinear form for $\alpha > 0{,}5$ and $\delta_0 > 0{,}5$ mm especially in and around small values of the sectional area of the metering hole. The increase in α and δ_0 requires rising in flow velocity of the dosed material to attain the same performance as for $\alpha = 0$.

2.3 Recognition of soil light-colour information patterns

Every soil information pattern is characterized by inhomogeneous agrochemical and agrophysical values. We investigated soil multicomponent information patterns using soil reference patterns with contrast colour tones in accordance with a triangle of the soil coloration. This one is produced from the assumption that soil humus colours in grey and dark-grey tones, iron compounds – in brown, reddish, yellowish ones, but many soil components (silicon dioxide, quartz, carbonates, and calcium sulphates) have a white colour. Light-colour information patterns were obtained as a set of values of brightness coefficients in this form:

$$R = I / I_0, \qquad (5)$$

where I, I_0 – light intensity reflected from a soil controlled sample and a standard white surface, respectively.

At the same time, a set of brightness coefficients in the soil humus-accumulative horizon defines its information light-colour pattern (Fig. 4). Histograms of a size distribution of soil particles and the soil microstructure registered by a method of scanning electron microscopy supplement a soil information pattern. We developed a special software for the data visualization of reflection indexes of the optical radiation, preprocessing, the data transmission [3, 5].

The following conclusions result from undertaken experimental studies of the developed intelligent multisensory system "CDOT" [1-5]:

- reflection coefficients increase in the examined broadband wavelength range if the irradiation intensity goes up especially fast when the wavelength rises, but soil is lighter;
- the more soil fine particles, the higher the reflection coefficient which exponentially increases when sizes of soil particles reduce from 2500 μm to 25 μm, so large particles reflect less energy of the optical radiation because of a long space between ones;
- there are significant changes of the organics content for the mixture with light soil, and there are especially more significant differences of information patterns in the range of 620-660 nm in contrast to the one of 460-505 nm;

- there are a quite strong correlation dependence between the organics content in soil and moisture of this one, so moisture is generally retained in organic components of soil, but soil mineral ones don't absorb water (Fig. 5a);
- water makes changes in the reflection, and there is especially significant increased light scattering by soil particles in the visible spectrum, so a brightness coefficient falls slowly, but soil becomes darker if the water content increases (Fig. 5b);
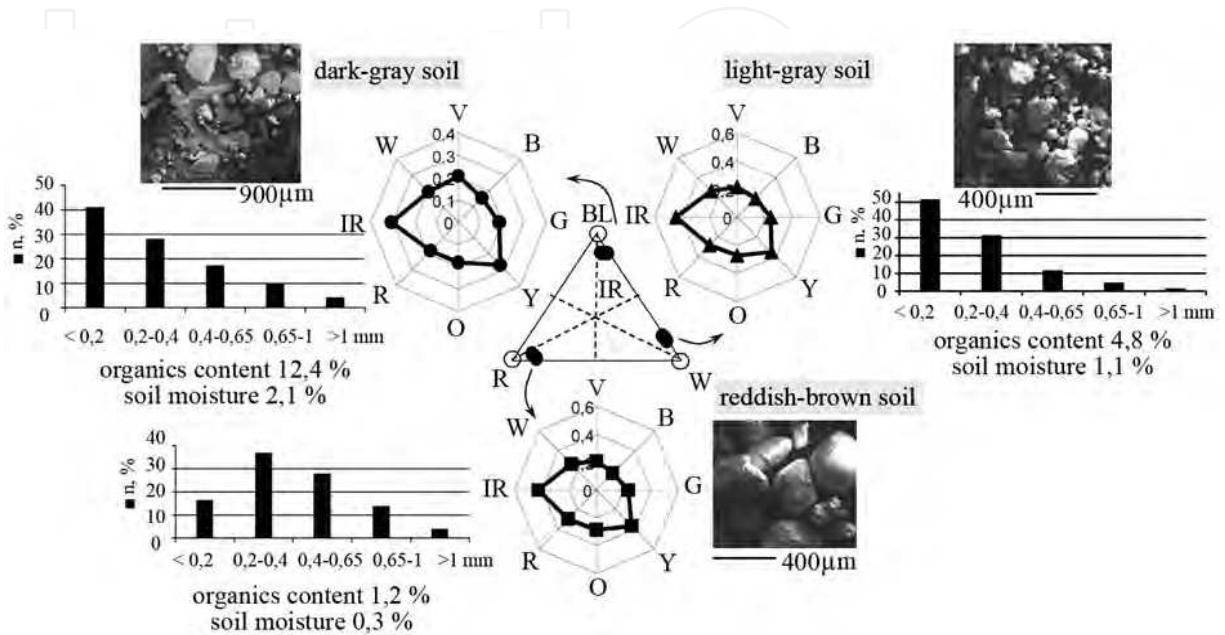

Fig. 4. Soil information patterns in the form of the triangle of the soil coloration: BL-black; W-white; R-red; reflected light: V-violet; B-blue; G-green; Y-yellow; O-orange; R-red; IR-infrared radiation
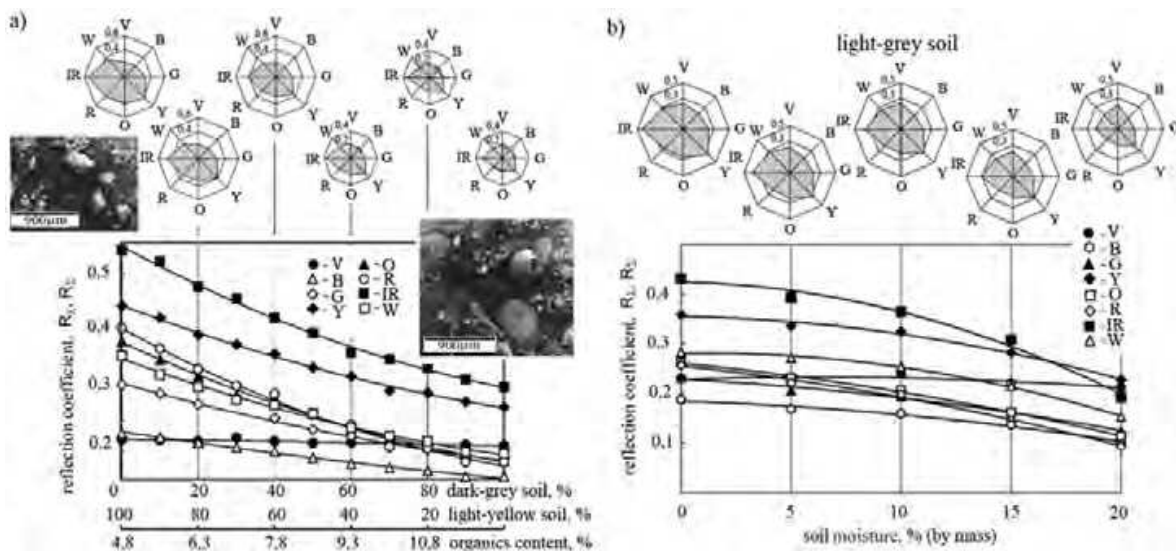
Fig. 5. Correlation of soil information patterns with the soil composition and moisture

- the ferric oxide content in soil considerably influences on reflection coefficients, so that there is the absorption with minimum energy in the range of 570-660 nm, but an absorption effect goes up if the organics content is more than 2 % (Fig. 6a,b);
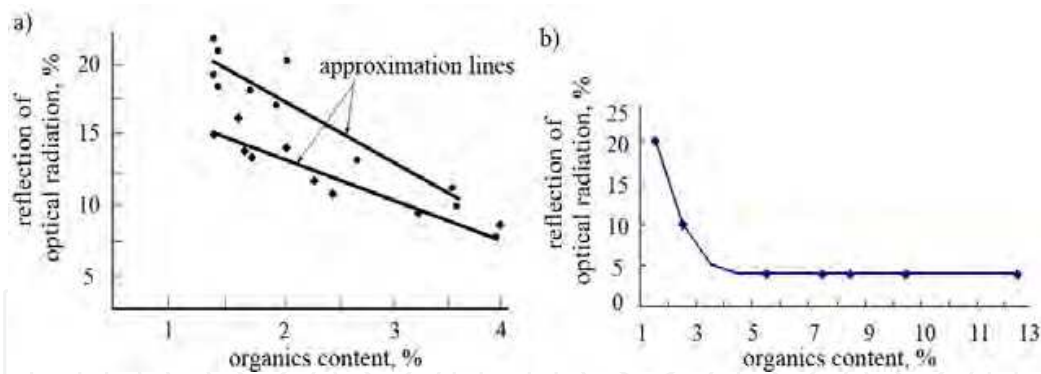
Fig. 6. Correlation of the organics content in soil and its reflection of the optical radiation: (a) well structured soil; (b) soil with a high content of sand

- using the self-learning intelligent system "ISSE" it is possible to determine the content of phosphorus and potassium in soil which is varied directly as the reflection coefficient, but the verification of an estimated model with experimental data of network outputs shows a high linear dependence.

The calculation of predictive models and special developed evaluation indicators in accordance with indexes of a soil physical state was used for the recognition of soil information patterns and for the comparison of ones with reference patterns in precision agriculture. Then algorithms of neural networks with the genetic optimization used by us enable to detect a set of basis information patterns of soil. These ones characterize not only the soil individual state (Fig. 7), but also its agrophysical state in general, increasing the level of crop yield, the quality and the biosafety of raising crops, foods, and a soil information-microbial state.
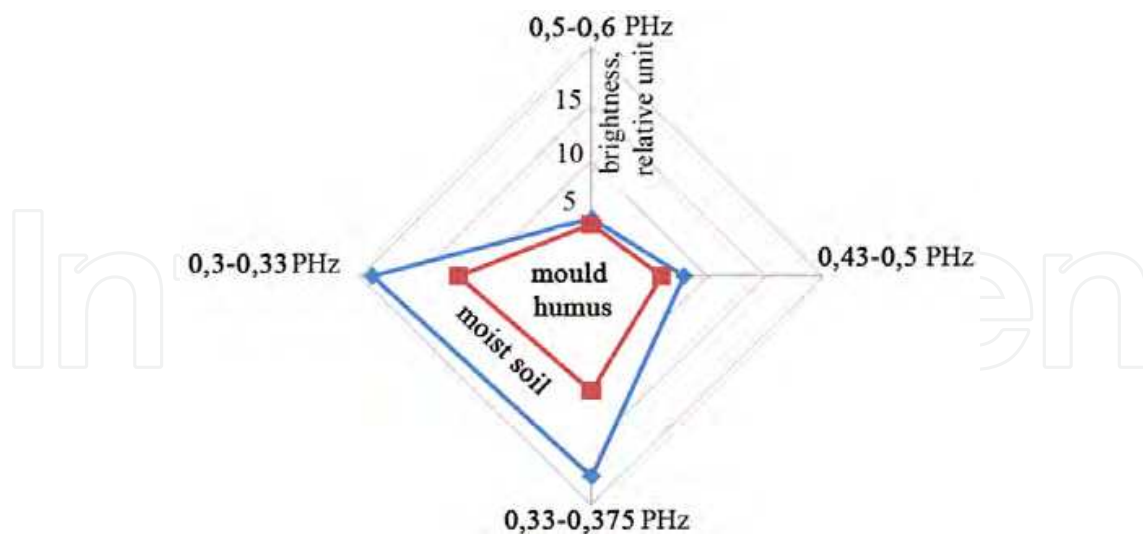

Fig. 7. Soil information patterns using "CDOT"

Sensory information processing and the control of agricultural operations in the intelligent system "CDOT" for precision agriculture is based on the self-learning ability of expert systems, e.g., by means of neural network modelling. Then the recognition of multiparameter information patterns generated by the output data transformation of

sensory modules occurs on the first network level. The experimental studies of the sensory pattern recognition are fulfilled using "CDOT" for the presented light-colour technology of the soil control underlying the operation of neural networks on the first level. A complex control parameter for the technological production process of an agricultural field is formed on the second level. The neural network on the third level enables to predict the value in a spot of the field based on generalized parameter changes to a point of time when the processing machine with its actuator is located at this one. To get reference colour patterns, a special palette is developed composed of 10×10 colour cells and primary polygraphic colours of the standard CMYK (C - cyan, M - magenta, Y - yellow, K - black) system are presented in corner palette cells, but all the other colour tones of ones can be got by primary colour mixing. Advantages of the used model of reference colour patterns consists in the precise identification of palette colours and soil colour tones, respectively, but also in the application for matching colours, e.g., Pantone (R). Surfaces of reflection coefficients for every colour of the optical radiation are produced using the developed palette (Fig. 8) [1, 5]. The minimum Euclidian distance is chosen as a decision rule for the nearest reference pattern (soil colour) in accordance with soil reflection coefficients registered by the sensory system "ISSE", but soil evaluation information is stored in the database of the intelligent system "CDOT".
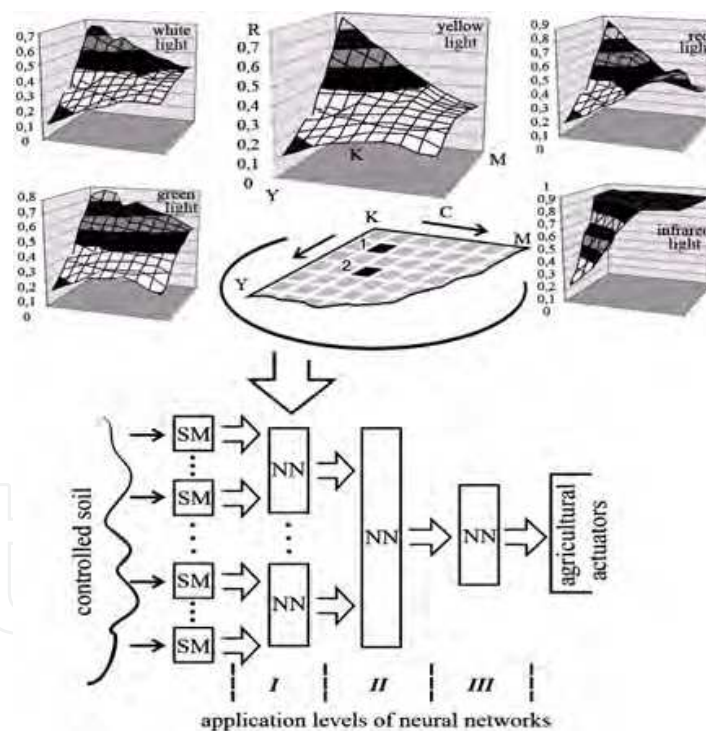

Fig. 8. Sensory modules and neural networks (NN) in precision agriculture with dependences of reflection coefficients for different wavelengths on the reference colour:
1 – dark-grey soil sample; 2 – light-grey one

2.4 Electronic virtual maps in precision agriculture

Having generated soil light-colour information patterns, the intelligent microsensory system "CDOT" can produce, e.g., electronic virtual maps of the fertility level of soil spots in some

spectral ranges including soil electronic maps of the organics content, moisture, temperature, granulometric composition, and colour. Forming electronic maps of a mineral fertilizers distribution on fields or virtual maps of planned crop yield using imaging data to estimate growth conditions and cropping are realized by dosed applying fertilizers in soil [1, 3, 5]. The optimal strategy of the agricultural production can be fast achieved by data overlapping of electronic virtual maps but also on the basis of current information about tillage, nutrients carry-over from soil with taken crops, characteristics of used agricultural units. Then it is possible to control operations of the agricultural machinery, to keep track of information how much fuel is consumed or whether fertilizers are applied. To produce electronic maps, we used a point krinning method for the estimation of the distributed random function in an arbitrary point as the linear combination of its values in initial ones. A variogram defines a form of the optimal interpolated hypersurface in the space between reference spots of the sensory control. According to the krinning method, the estimated value of the soil quality in the known spot p from a set of k neighbouring spots is calculated as weighed mean measured values in neighbouring spots in the form:

$$\psi_p = \sum_{i=1}^{k} W_i \cdot \psi_i, \tag{6}$$

where W_i – weighting coefficient of an index i of the soil quality in relation to the estimated spot p from a set of neighbouring spots.

The krinning method provides for solving a set of equations:

$$\sum_{j=1}^{k} W_j \cdot \gamma(\xi_{ij}) + \lambda = \gamma(\xi_{ip}),$$

$$\sum_{i=1}^{k} W_i = 1, \tag{7}$$

where $\gamma(\xi_{ij})$, $\gamma(\xi_{ip})$ – semivariogram values for the distance ξ_{ij} and ξ_{ip} between a points i and estimated points j, p, $i = \overline{1,k}$; λ – Lagrange factor.

Unknown weighting coefficients W_i are computed by solving a set of equations (7), but a value of the controlled variable in the spot p is calculated using the formula (6). The semivariogram on the area boundary of spots with the different agricultural background in precision agriculture has the sharp difference in values; therefore, the considered mathematical model shows the nugget-effect. Having estimated a value of the soil quality in an agricultural spot q in accord with controlled values k_1, $k_{2...}$ k_m of appropriate agricultural backgrounds m, the set of krinning equations for models with the nugget-effect can be presented as:

$$\beta_{1q} \cdot \sum_{j=1}^{k_1} W_{1j} \cdot \gamma(\xi_{ij}) + \beta_{2q} \cdot \sum_{j=1}^{k_2} W_{2j} \cdot \gamma(\xi_{ij}) + \ldots + \beta_{mq} \cdot \sum_{j=1}^{k_m} W_{mj} \cdot \gamma(\xi_{ij}) + \lambda = \gamma(\xi_{ip}),$$

$$\beta_{1q} \cdot \sum_{i=1}^{k_1} W_{1i} + \beta_{2q} \cdot \sum_{i=1}^{k_2} W_{2i} + \ldots + \beta_{mq} \cdot \sum_{i=1}^{k_m} W_{mi} = 1, \tag{8}$$

where $\beta_{iq} = \overline{\psi_i} / \overline{\psi_q}$, $j = \overline{1, m}$, $j \ne q$; $\overline{\psi_j}, \overline{\psi_q}$ – mean values of the soil quality in agricultural spots j, q determining a semivariogram jump ξ_{jq} on their area boundary $\delta_{jq} = (\overline{\psi_j} - \overline{\psi_q})^2 / 2$.

A main advantage of modelling on the basis of the nugget-effect consists in its applicability even if a number of experimental points are scarce, so it is conditioned, e.g., by small sizes of an investigated spot of the agricultural field. Fig. 9 shows the process of generating soil electronic maps by means of the developed software "ISIDP" for data processing of the sensory control of soil and the realization of precision agriculture. The half-dispersion of distances is determined in accordance with the accepted modelling algorithm and interpolated curve fitting by the approximation of neighbouring values, bilinear, bicubic, and cubic splines is realized using the developed application and for generating maps of isolines of distributed initial data. If grid-point data are initial ones, then these ones can be presented in the form of a matrix. The visualization of every contour curve for initial data is realised after the introduction of a matrix of distributed values (Fig. 9a,b) [5]. To improve visual perception of the electronic map, spot colour filling is fulfilled according to the chosen colour legend (Fig. 9c). The isolines obtained at this stage are only precise in nodal points, so the bivariate data interpolation is used (Fig. 9d).
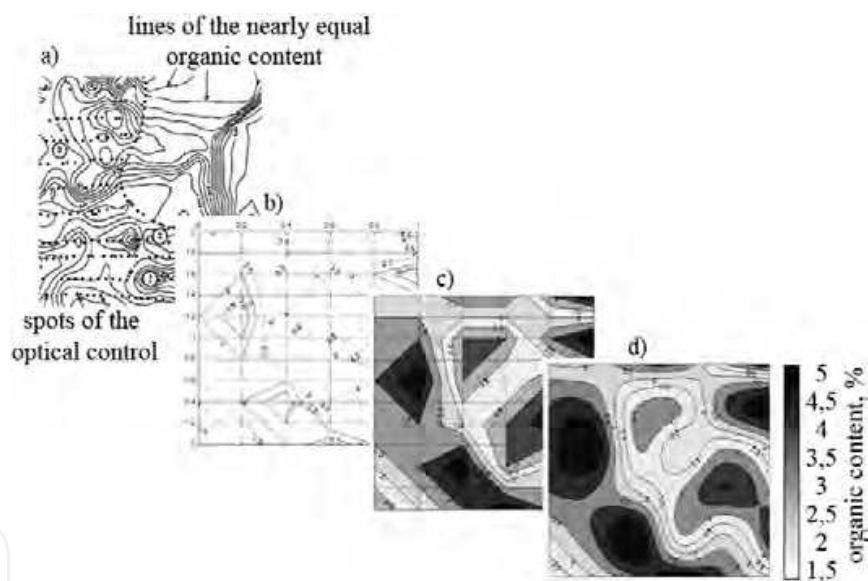

Fig. 9. Modelling soil electronic maps

The developed microsensory system "ISED" can be used for farm enterprises, individual entrepreneurs, agricultural holdings getting users exactly to know where fertilizers have to be introduced and what crops should be produced in a defined spot. "ISED" includes a multichannel sensor for the detection of organic substances in soil, a receiver of the satellite navigation system, data processing and logging controller but also a special software for this one (Fig. 10). The microsensory system "ISED" can send information automatically to a home computer or mobile devices (smartphone, communicator, iPad, etc.) of farmers, and satellite positioning enables "ISED" to be applied not with hectares, but with some hundred square metres accurate to 5 cm.
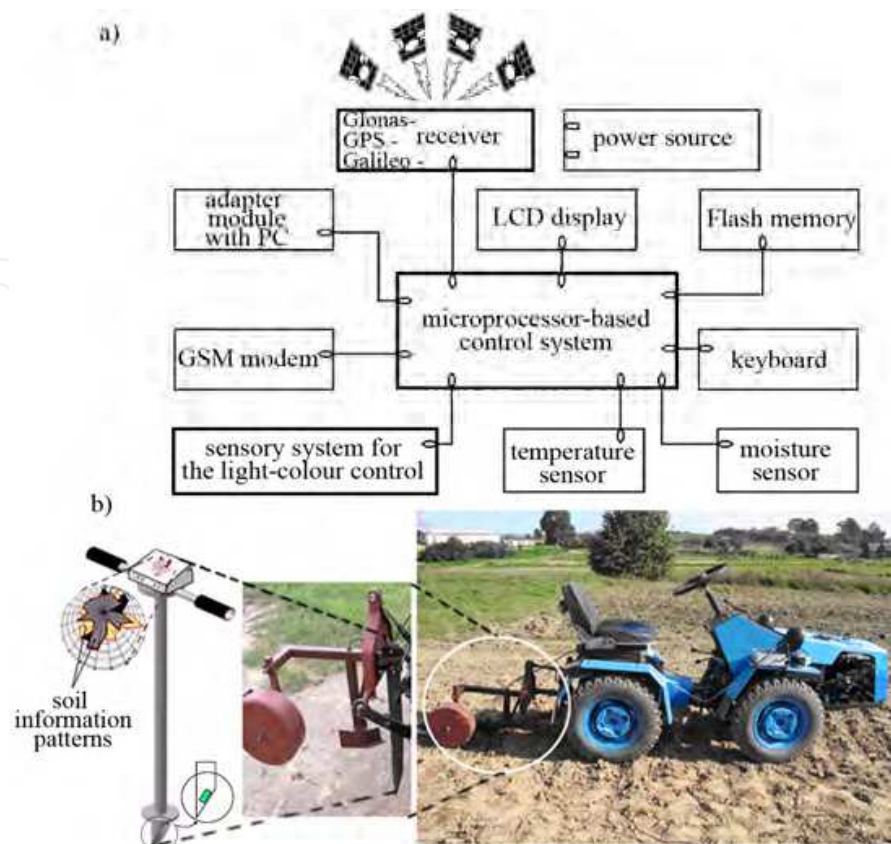
Fig. 10. (a) Structure chart of the laboratory portable multisensory system "ISED" and its design (b) for farming and individual entrepreneurs

2.5 Electronic intellect-maps for the maintenance of the human health and biosafety

The top priorities of society in the XXI century are striving for a maximal prolongation of life and the continuous maintenance of the human activity. An object of research of intelligent systems in precision agriculture for a personal and social biosafety is information patterns of farming cultures and foods produced from them. Genetic features, culture conditions, soil contamination, and a tilling technology generally determine the biochemical composition of food products during agrotechnical operations but also by the quality of crops for animals, intensity of the fertilizer application in soil, radiation levels, environmental ecological states, etc. However, fertilizers introduced in soil for raising the level of the crop yield contain a lot of chemical toxic substances which can be accumulated with time in plant and animal foods and cause the development of dangerous diseases and spreading of infectious ones exposing to danger the human health. Organic microelements in soil are distributed nonuniformly and accumulated in separate spots forming regions with active microbial communities. A number of microbes in soil determine the synthesis of high-molecular compounds and the storage of nutrients in soil but also the productive capacity of soil, an increase in productivity, information-microbial maps, etc. An intelligent system "ISMP" developed by us enables to generate electronic microbial maps of soil for intelligent precision agriculture and maintaining the personal and social biosafety (Fig. 11).
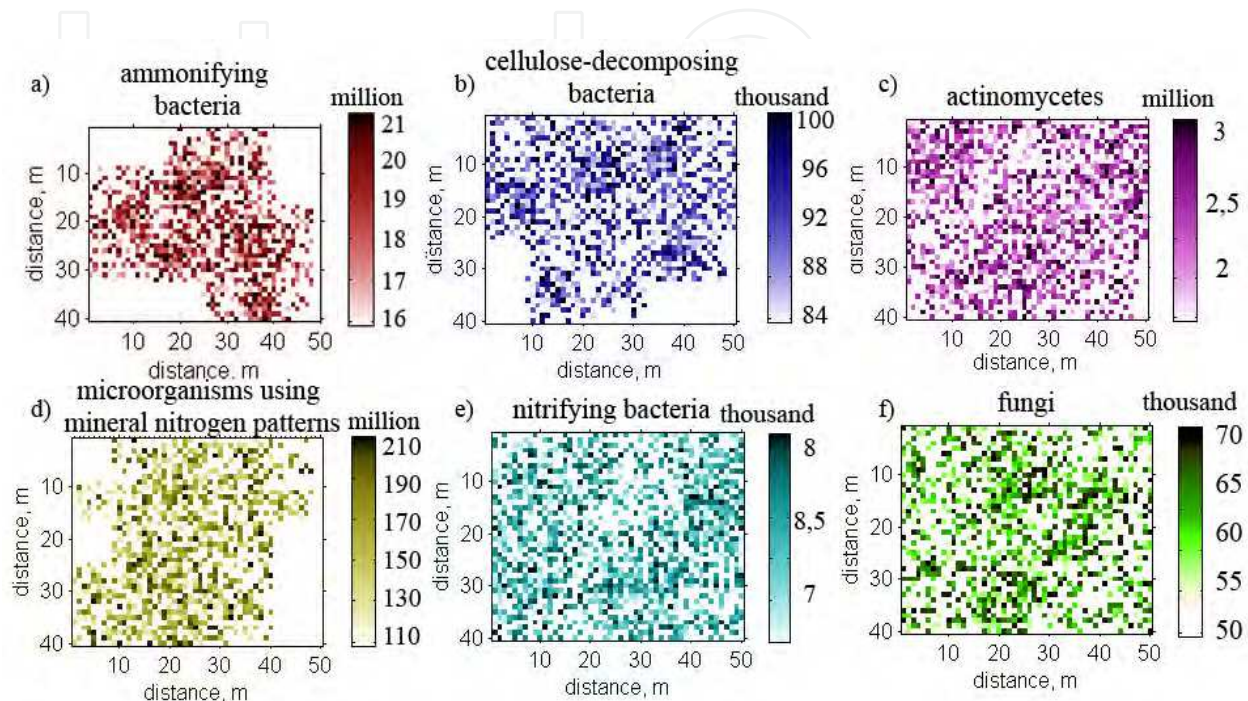
Fig. 11. Microbial maps of soil using the intelligent system "ISMP"

An increase in the number of microbial communities and their vitality in soil are determined especially by the humus level in soils, pH values and distances from pollution sources. There is a natural microbiological biosphere in soil which is not worked and used for the agricultural application. The active pesticide use in precision agriculture leads to the reduction of specified microbial communities in the next few years (Fig. 12). The pesticide application makes for the accumulation of toxic and dangerous substances in cultivated plants, animal and human organisms. There is need for using intelligent systems for the protection of human health and the control of microbial biosafety of consumed foods.

The developed intelligent system "ISLB" is intended for the control of the personal and social biosafety and the prevention of long-term general toxic influences on the human organism, e.g., of allergic, mutagenic, teratogenic or carcinogenic factors. It is quite enough

even very few toxins with the concentration which is below the level of the adopted standard for the biosafety in order to bring to nonspecific changes in the human biosystem. It is necessary to use the intelligent system "ISLB" for generating electronic intellect-maps of the biosafety of farming cultures but also soil virtual information-microbial and food maps therefore.
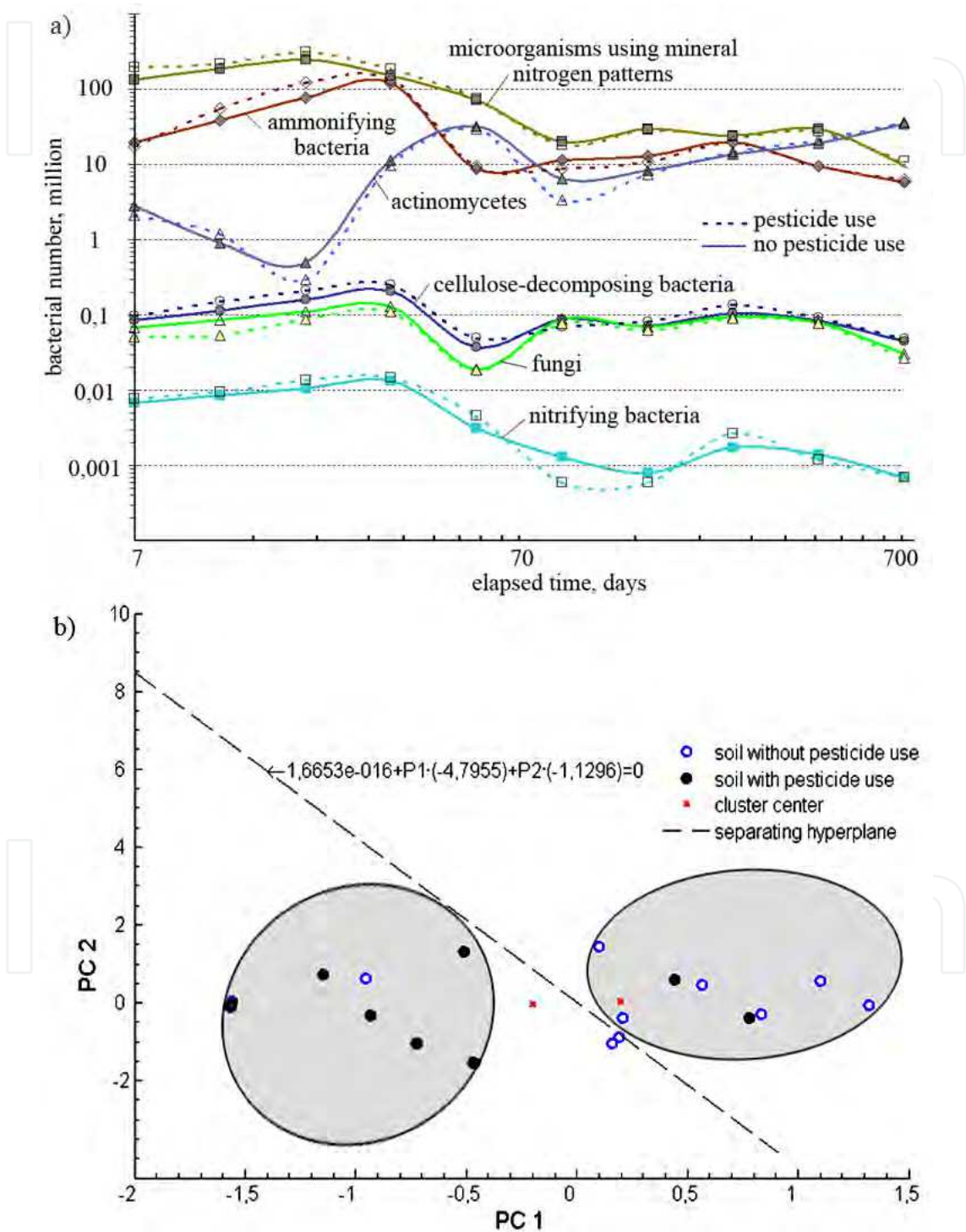

Fig. 12. (a) Changes of the number of microbial communities during some years. (b) Information patterns of soil carrying out agrotechnical methods

Sod-podzolic soils predominate in a structure of agricultural ones in the Republic of Belarus. The effective fertilizer application is possible only based on information patterns of fields with the analysis of their agrochemical data and the soil acidity. There are some results for the recognition of information patterns of soil in the Republic of Belarus in the figure 13. The high humus concentration defines the productive capacity of soil, an increased microbial amount and their enhanced vitality.
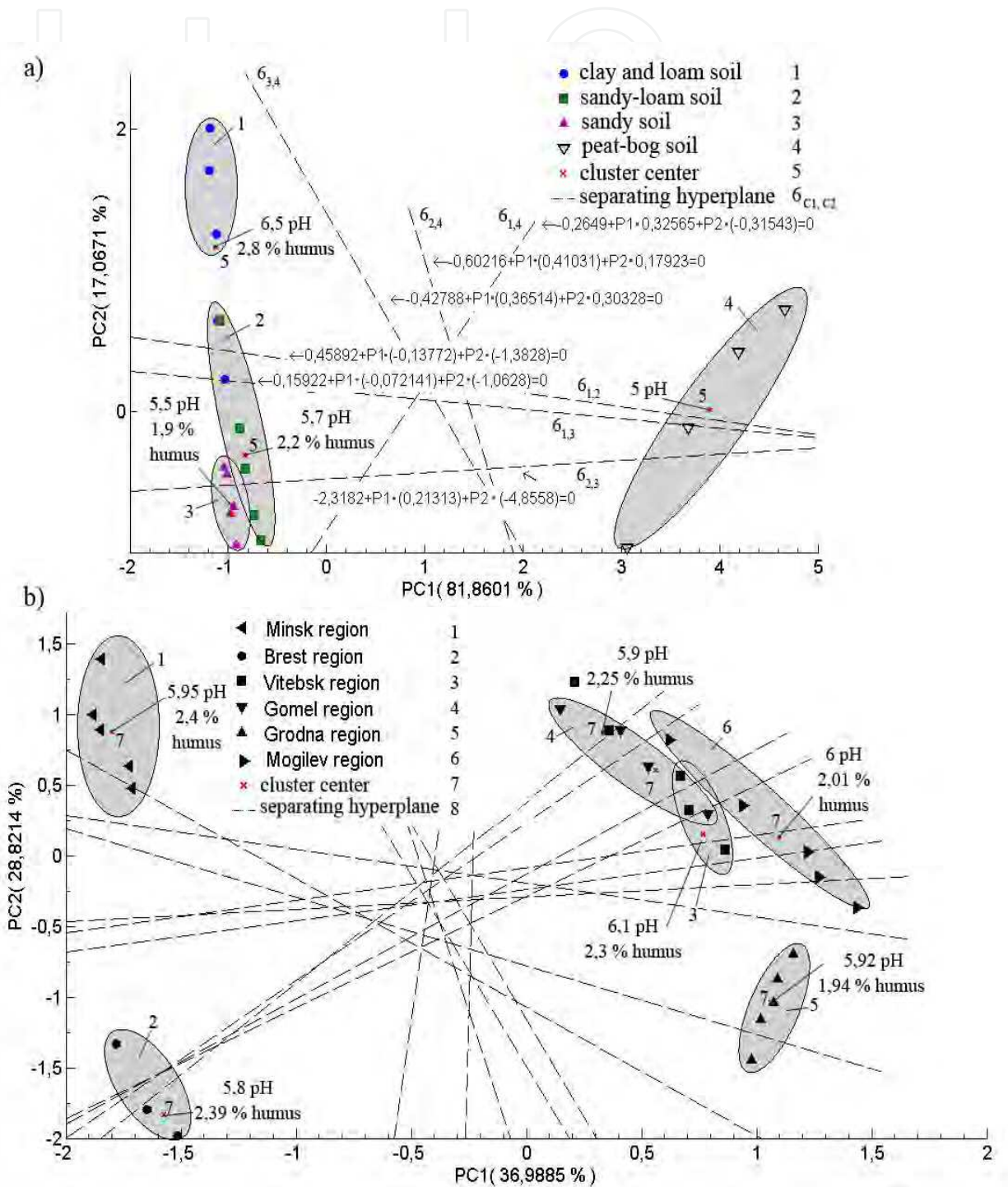

Fig. 13. (a) Information patterns of different types of soils using "ISLB". (b) Presented sensory patterns of sod-podzolic soils for main regions of the Republic of Belarus

3. LED technology for the analysis of biological fluids

3.1 Optical microtomography for the pattern recognition of biomatters

Human biological fluids (blood, saliva, sweat, urine, tears, etc.) are very sensitive to any external influences, but their information sensory pattern can be generated by means of our developed intelligent system "ISLB" with wireless mobile retransmitters. Using received sensory data of information patterns of biomatters it is possible to produce electronic virtual and intellect-maps of the quality of alimentary products or environmental conditions for the maintenance of the human health and the personal and social biosafety. The intelligent system "ISLB" can define spectral-response characteristics of biomatters, e.g., absorption, reflection, polarization factors, changes of intensity, phase, and amplitude of an electromagnetic wave in the broadband frequency range of 10^{11}-10^{15} Hz. "ISLB" is suited to be used for the individual application, e.g., in wristwatches, watch and mobile phones, smartphones, communicators, iPads, PDAs with an embedded software for the purpose of the continuous maintenance and monitoring of the human health, the prolongation of life and the improvement of the vital activity [6]. An important advantage of "ISLB" is the fast recognition of information patterns of biomatters, so there is no need for special conditions of its functioning and for a remote costly laboratory.

3.2 Blood

If using a mobile device (smartphone, communicator, iPad, PDA, wristwatch, watch or mobile phone, etc.) with the microsensory system "ISLB" an electromagnetic wave emitted by the microlight-emitting diode falls on the human skin surface, it is absorbed, scattered and reflected by this one. (Fig. 14) [1, 6].

The absorption of the radiation arises from the photons interaction with different chromophores, but scattering is because of changes of the reflection coefficient. There are some disturbances of the human biosystem, functioning its separate organs and biochemical processes because of the consumption of poor farming cultures, natural form foods or food products. Biochemical and spectral characteristics of blood are changed a lot and individually depending on cognitive and functional states of the human organism [6, 7]. The intelligent system "ISLB" with the developed software enables to maintain in a real time the personal and social biosafety and the human health. It is known that the hormone ghrelin is produced in stomach of a hunger man, at its maximum before eating, and then this one is reduced gradual during a meal. The satiation hormone PPY3-36 affecting hypothalamus is at its highest point after eating, and then this one is decreased in some following hours slowly [7]. The blood lipidic and carbohydrate composition is varied because of the nutritive absorption from food after a meal. An increase in the concentration of glucose in blood during eating results in ceasing neurons with sensing membrane channels to send signals and generating the hormone orexin which forces the human organism being awake, eating moderately and self-learning fast. It explains essential differences of information patterns for a man being hungry and sated (Fig. 15), excessive somnolence after a meal and the risk taking behaviour of a hunger man. In this case changes of a level of leukocytes, glucose and whole protein are defined more clearly in the table 2.
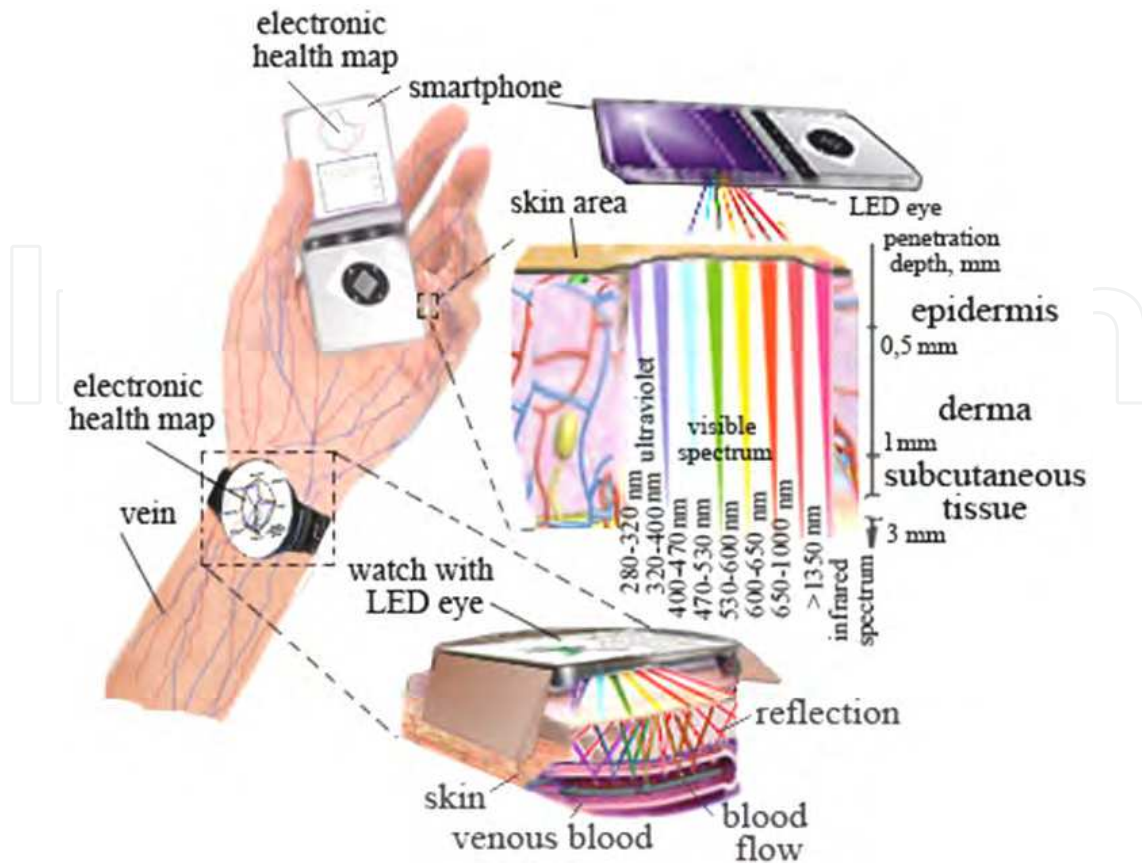
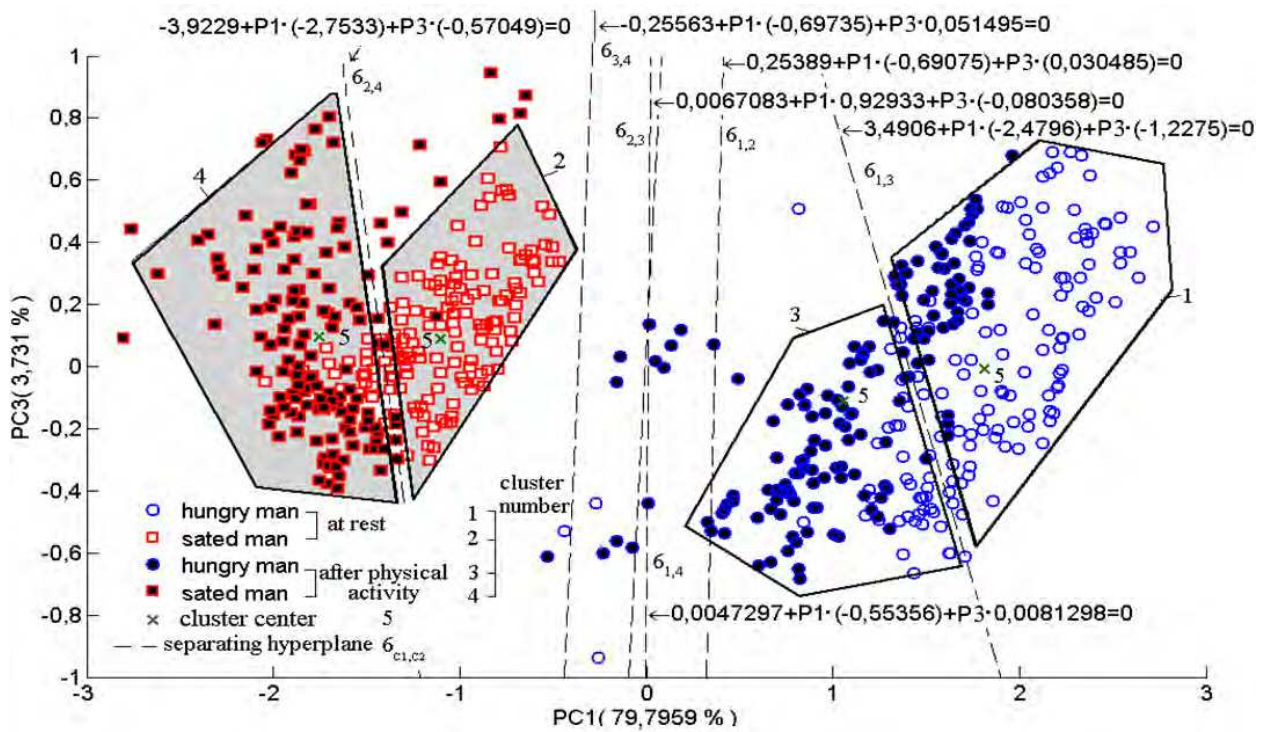Fig. 14. Intelligent system in the wristwatch or the smartphone for non-invasive measuring

Fig. 15. Non-invasive LED analysis of blood information patterns for the hungry man and the sated one at rest and after physical activity

Blood components	Healthy man (norm)	Hunger man	Sated man
leukocytes, $\cdot 10^9$ /l	4-9	4,3-11,3	5,8-13,4
glucose, mmole/l	3,3-5,5	2,4-4,3	4,3-5,7
whole protein, g/l	65-85	56-74	68-80

Table 2. Some most variable parameters of human blood during everyday life

The intensive glycolysis in human blood and the formation of adenosine triphosphoric acids are realized during a physical activity, so a man doesn't feel its being hungry, in danger or a state of the strong mental agitation. A short-time physical activity brings about the higher blood glucose level because of the amplifying glycogen mobilization, but this one determines low glucose content in human blood over a long period of time [7]. The physical activity of subjects not going in for sports can increase the insulin activity after eating and reduce the blood glucose level. The level of lactic acid rises from 1,1-1,5 mole/l to 5-20 mole/l, and the level of haemoglobin goes up from 7,5-10 mole/l to 13-15 mole/l (Table 3). Strong changes of blood information parameters are a result of intensive physical activities, human emotional states, humoral mechanisms, nutrition, and other factors therefore [8].

Values of blood parameters	Norm	Without physical activity	Short-timed physical activity	Long-timed physical activity
erythrocytes, $\cdot 10^{12}$/l	4-5	4,7	4,4	4,8
haemoglobin, %	13,8-18	15,5	14,3	15,7
hematocrit, %	40-48	44,6	38,2	40,7
reticulocytes, %	2-10	6,7	3,6	8,1
mean cell haemoglobin in erythrocyte , $\cdot 10^{-12}$g	24-33	27,3	29,6	35,3
mean corpuscular volume, μm^3	75-95	83,2	83,7	88

Table 3. Results of the clinical blood analysis during the human physical activity

There are explicit changes of blood information patterns in the right hand and the left one at rest and after clapping one's hands or stamping in the figures 16, 17.

It is connected with the variation of carbohydrate and protein metabolisms in blood, e.g., because of the increase of the lactic acid level, with the reduction of oxygen metabolism (Table 4). The lactic acid content in blood takes also place for a state of complete fatigue or unbalanced eating, for the lack of nourishment of animal proteins or vitamins. Then handclaps and stamping make it possible to improve human cognitive and motor skills, remove stress, influence positively on the blood hydrodynamic sanguimotion and enhance metabolic processes in the human organism.
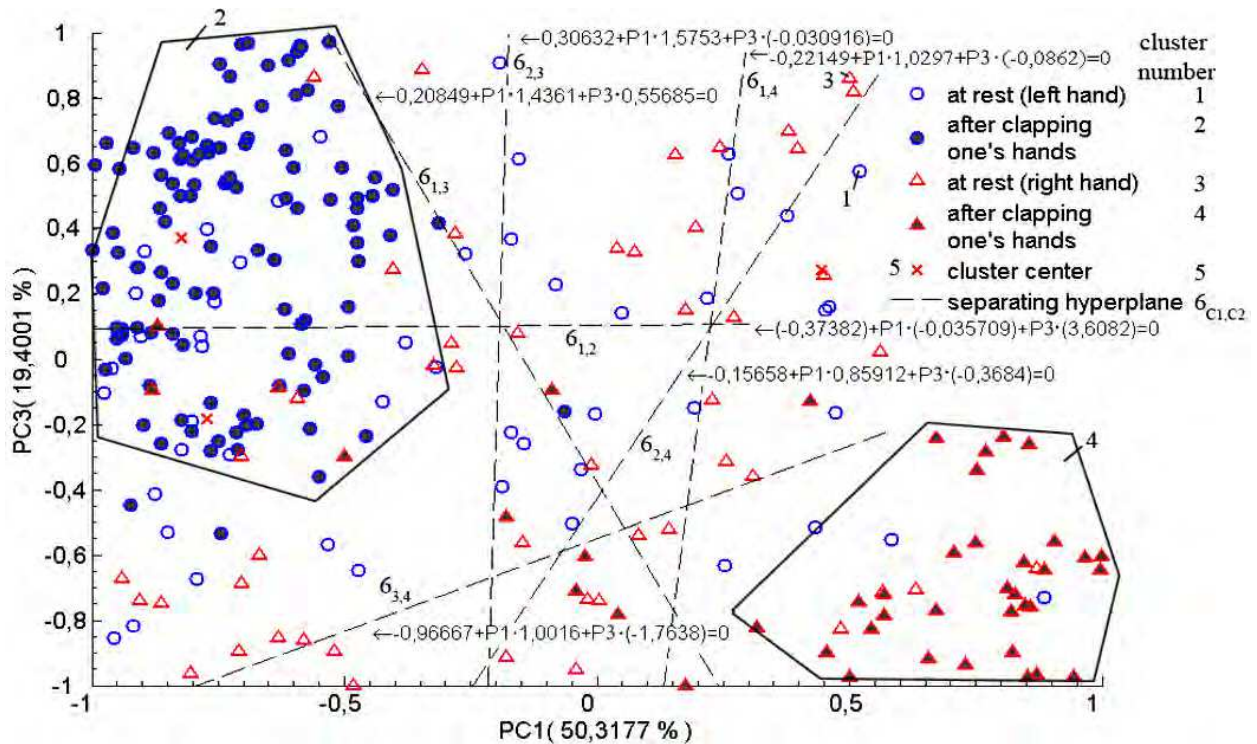
Fig. 16. Non-invasive LED analysis of blood information patterns of the right and left human hands of young men at a rest state and after making twenty handclaps
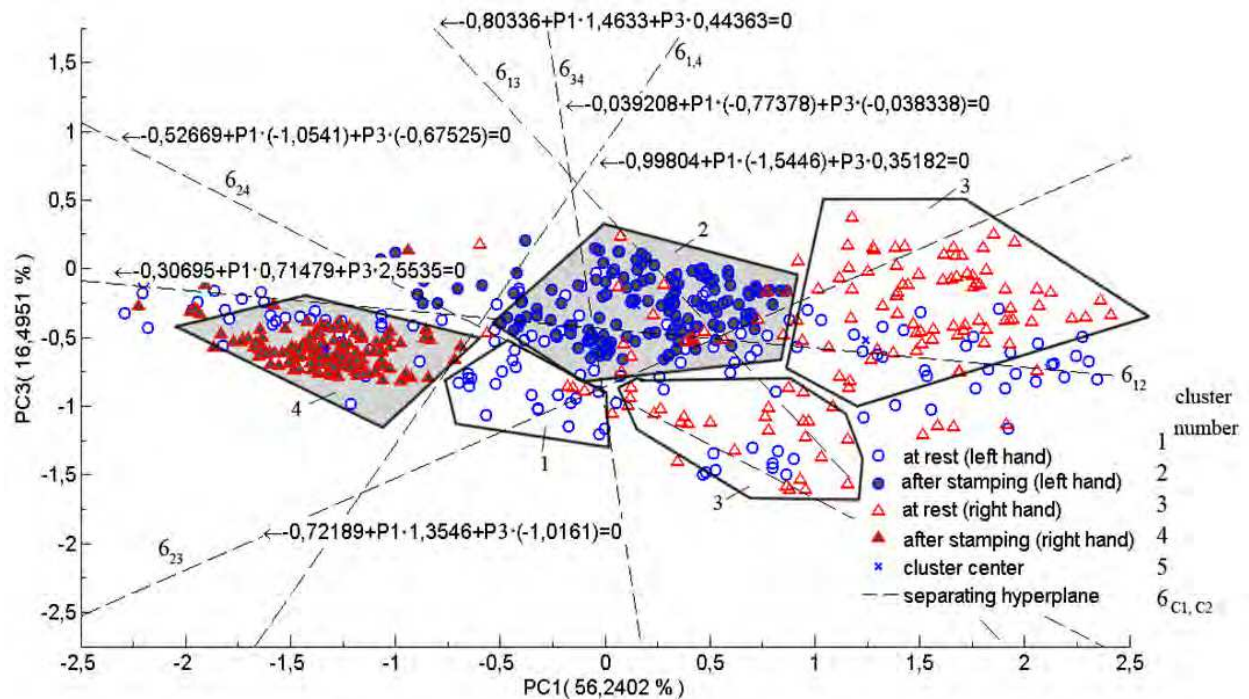

Fig. 17. Non-invasive LED analysis of blood information patterns of the right and left human hands at a rest state and after stamping during 10 sec

Values of blood parameters	Norm	At rest	After clapping one's hands and stamping
lactic acid, mmole/l	0,35-0,78	0,75	0,8
glucose, mmole/l	3,3-5,5	5,6	5,4
kreatine, mg/l	1-4	3,1	3,3
rest nitrogen, mmole/l	14-28	25	27
blood urea, mmole/l	2,5-8,3	6,5	6,8
creatinine, mmole/l	0,09-0,17	0,11	0,12
indican, mmole/l	0,7-5,4	4,1	4,2
total lipids g/l	3,5-8	4,3	4,5

Table 4. Results of the biochemical blood analysis before/after clapping and stamping

3.3 Saliva

The intelligent system "ISLB" can also analyse high-informative patterns of saliva for monitoring of the food, soil and human biosafety. Simplicity of saliva sampling gives an opportunity to monitor the human health and biosafety in real-time, e.g., for the recognition of physical and functional states of the human organism. There is a structure chart in the figure 18 with presented saliva basic components for intelligent monitoring systems.
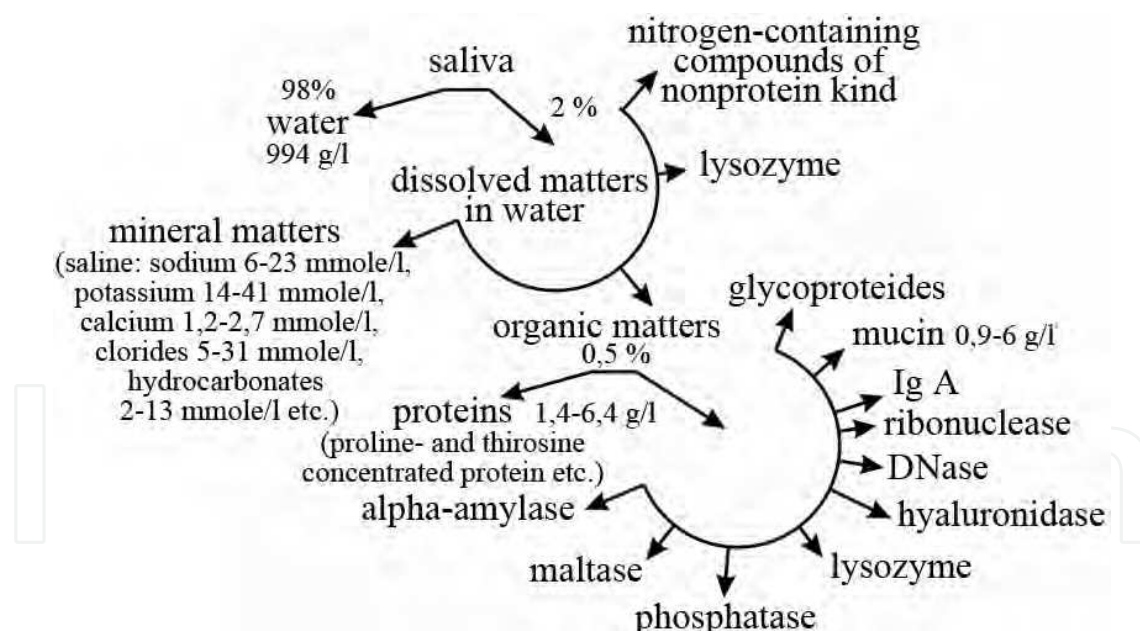

Fig. 18. Saliva structural pattern of a man

An information sensory pattern of saliva is changed under the influence of different physical activities but also depending on the state of being sated during a meal (saliva of the hungry man and the sated one) [8, 9]. Besides, a saliva pattern is changed considerable during the daily variation and defined by characteristics of the physical activity of different intensity as appears from the figure 19.
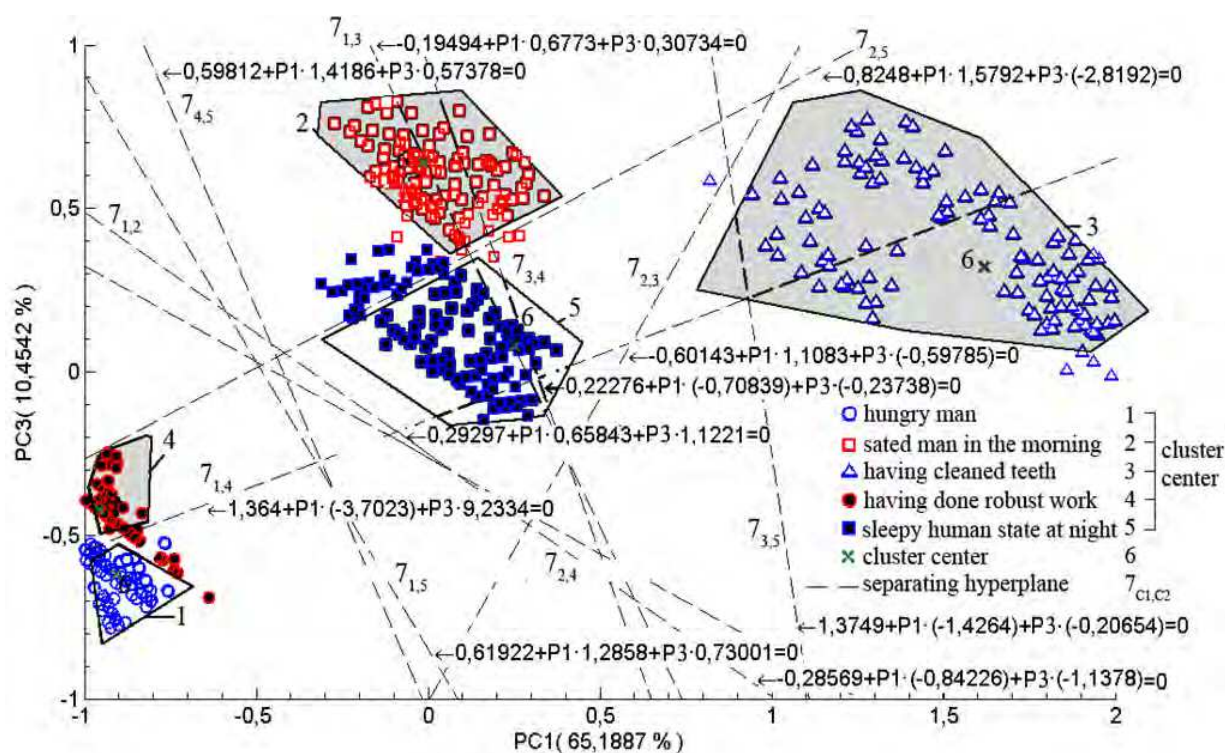
Fig. 19. Non-invasive LED analysis of saliva information patterns during the day

Ferments of the serous secretion of salivary glands suppress a microflora determining an antimicrobic function of covered coating produced by saliva of a hunger man. The saliva pH level (8,5 pH after breakfast) of a sated man exceeds greatly the saliva pH value for the hunger one (6,5-6,8 pH for awakening, 7 pH before a meal) and especially distinctly after carbonaceous eating because of the acid-produced activity of an oral cavity microflora changing saliva structural properties [9]. An information pattern after tooth brushing of toothpaste (9,4 pH) is distinctly different from other conditions of saliva taking and denotes the impossibility of immunorestoration as a result from a carbohydrate food intake (Fig. 20).

Saliva structural properties are impaired, and the application of such toothpastes will deteriorate biochemical saliva patterns in the future therefore. Toothpastes with a pH level being close to an initial saliva pattern with the normal pH level about 6-7,5 promote the recovery of saliva structural properties. Not only food, but also physical fatigue (5,5 pH) produces changes of saliva information patterns. At the same time, the saliva acidity is genetic individual for everyone and is varied according to the consumed nutrient composition. States of nervous excitement, mental or emotional strains produce an effect on saliva information patterns, so that there is the increase of a protein level in human saliva until 5 mg/ml, but its level doesn't exceed 2 mg/ml at rest.

The physical activity specifies the enhanced consumption of adenosine triphosphates in muscles, a strong oxygen need of human organism and an increase of lactic acid. A glycogen level is mainly consumed at the beginning of a physical work, but its consumption by organism is reduced during a continuous work. Saliva protein and enzymatic components characterize a human functional state during the physical activity therefore. There is the

decrease in a number of antibodies depending on the physical activity, e.g., the immunoglobulin secretion (IgA) is reduced over a long period of time especially after coffee and alcohol. A simultaneous exposure to different ecological factors is known to have direct and indirect profound effects on the human organism.
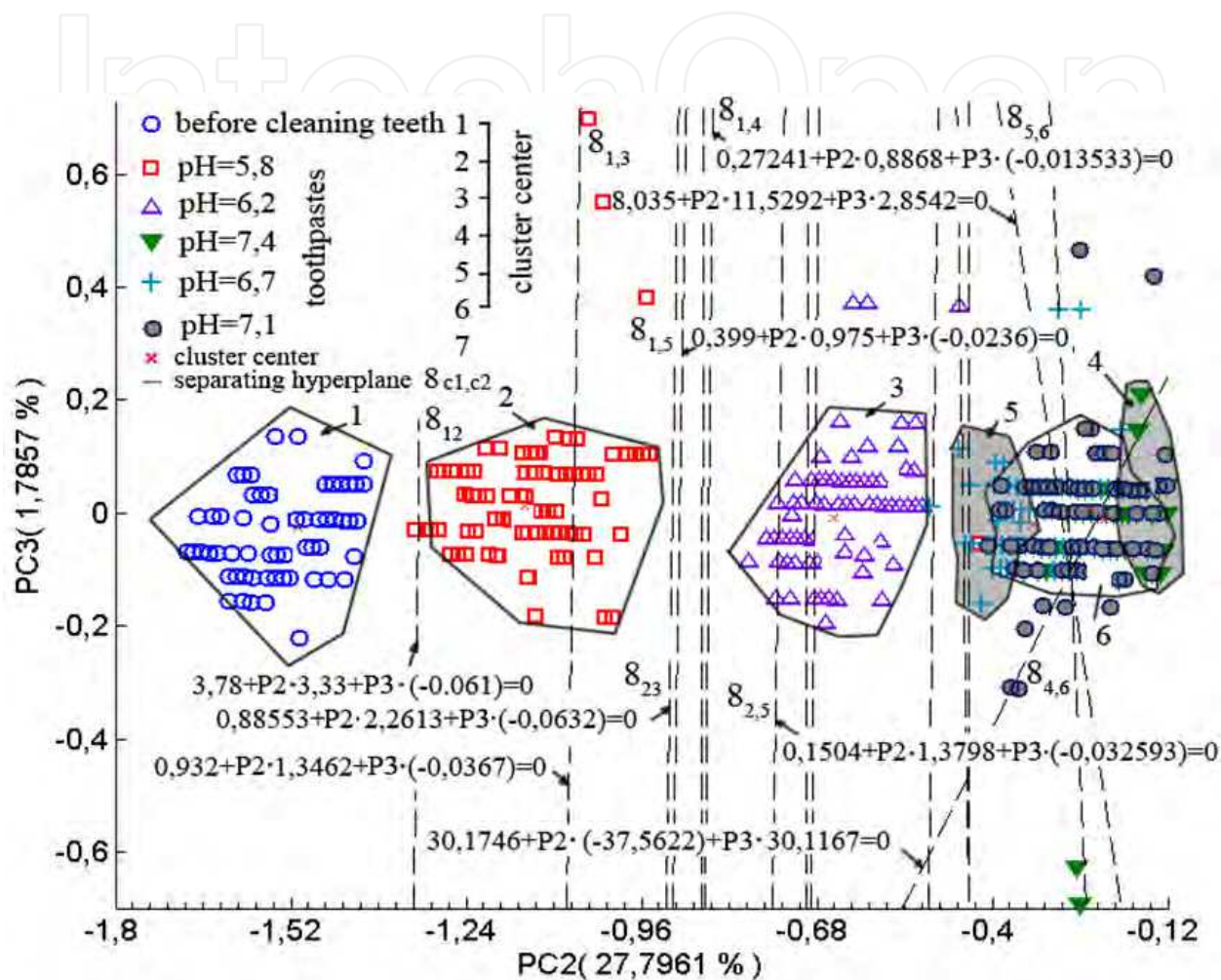

Fig. 20. Non-invasive LED analysis of saliva information patterns cleaning teeth

A geomagnetic factor connected with the Earth's magnetic field variability because of the increased solar activity has the strongest impact on the human health in particular [10]. The solar variability changes emotional and functional human states and brings to chronic diseases of nervous, circulatory and respiratory systems. There is a significant increase of the metal content (K, Mg, P, Pb, Cu, and Zn) and a reduced concentration of Na in saliva of men and women under the influence of the solar radiation exposure (Fig. 21) [10]. It means that the solar radiation taken during sunbathing enables to change saliva information patterns but also these ones for other human biomatters (blood, sweat, urine, tears, etc.).
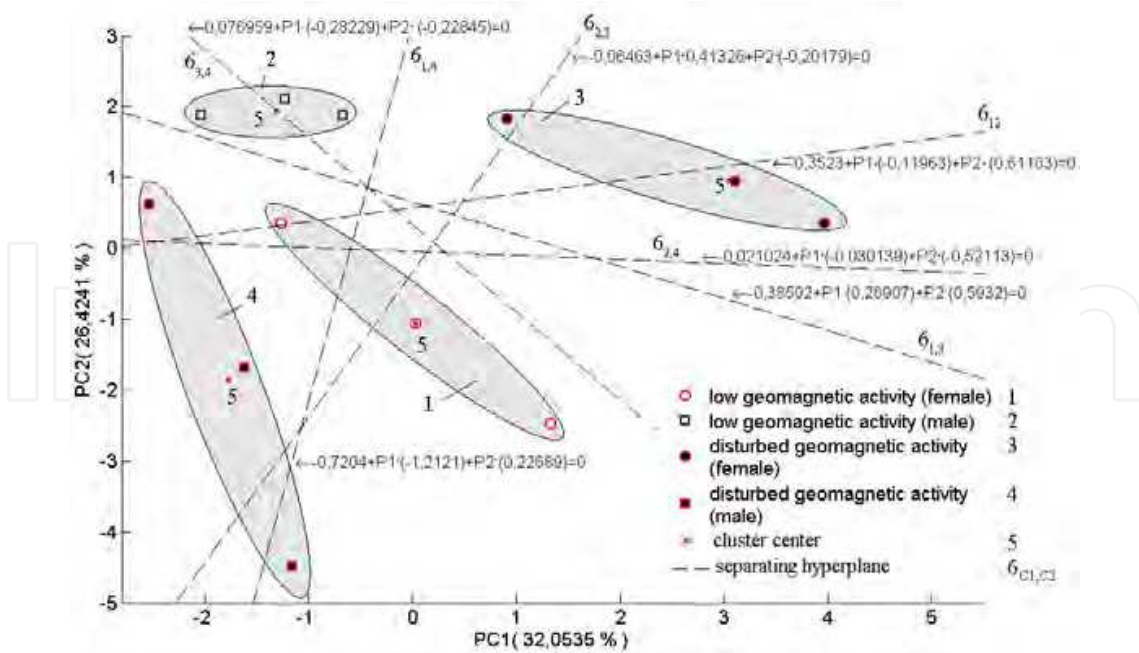
Fig. 21. Metal content in human saliva for low and disturbed geomagnetic activities

A self-learning intelligent system "ISCR" for monitoring and the recognition of a carcinoma in the broadband spectral range is developed by us which makes it possible to predict disturbances in the human organism caused by this one with the forecast precision about 80 % (Fig. 22) [8].
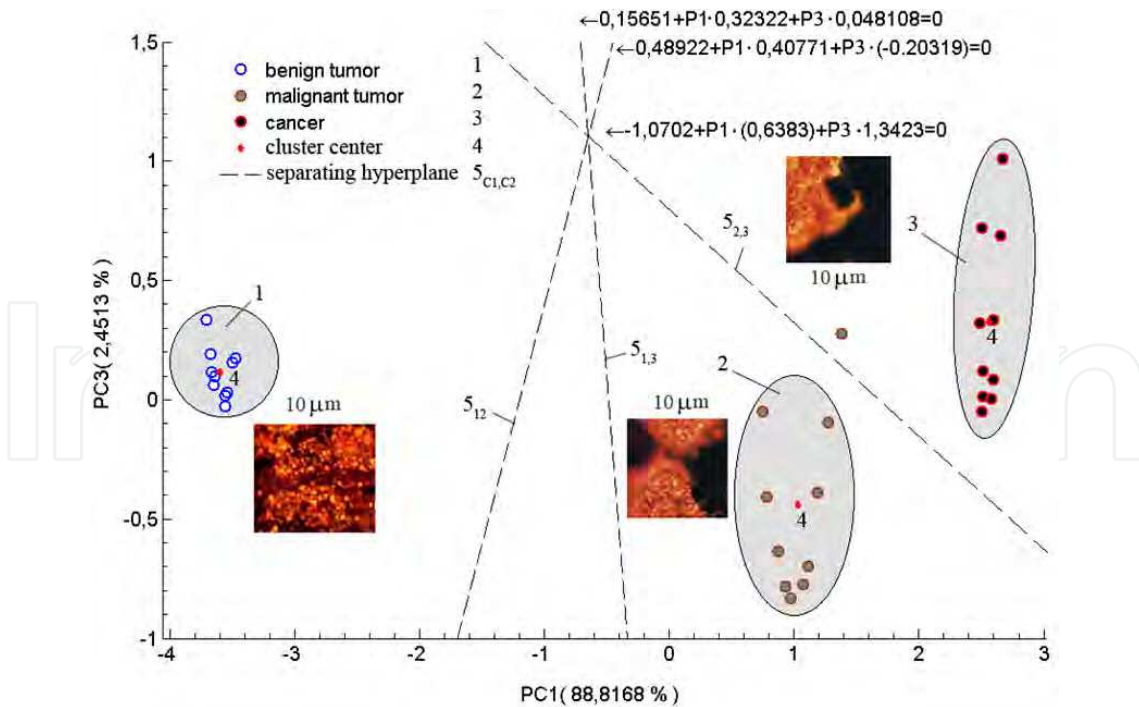

Fig. 22. Information patterns of a carcinoma using non-invasive LED eye with "ISCR"

At the same time, intelligent systems equipped with "ISCR" can transfer information to mobile devices of users (mobile and watch phones, smartphones, communicators, wristwatches,

PDAs, iPads, etc.), and after that these data are processed to produce an electronic information map of diseases for an individual subject. The use of mobile systems with "ISCR" enables non-invasive to monitor human personal and social activities therefore (Fig. 23).
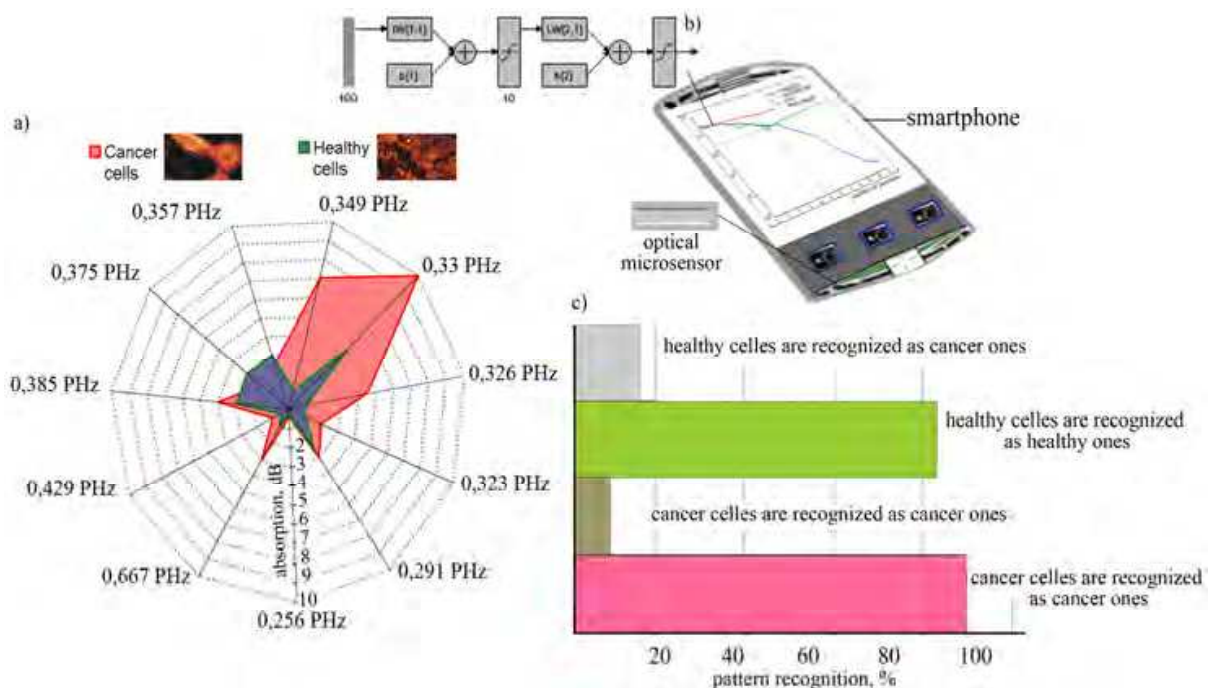

Fig. 23. Non-invasive recognition of information patterns of cells using the smartphone with LED eye

3.4 Sweat

The interest in sweat monitoring is increasing because of the sweat collection is convenient and non-invasive in comparison with traditional specimens (blood, urine, tears, etc.). The sweat chemical composition and the correlation of individual components depend on body perspiration (Table 5), the metabolism intensity, and the human health, emotional and functional states (Fig. 24) [11].

Values of sweat parameters	Biochemical information pattern of sweat	
	before taking a shower	after taking a shower
whole protein, g/l	0,8	0,38
albumens, g/l	0,41	0,11
urea, mmole/l	16,3	16,5
creatinine, μmole/l	52,5	35,9
ammonia, mmole/l	20,6	19,4
amino acids, mg/l	35	20,5
glucose, mmole/l	0,35	0,17
pH value	6,2	5,3

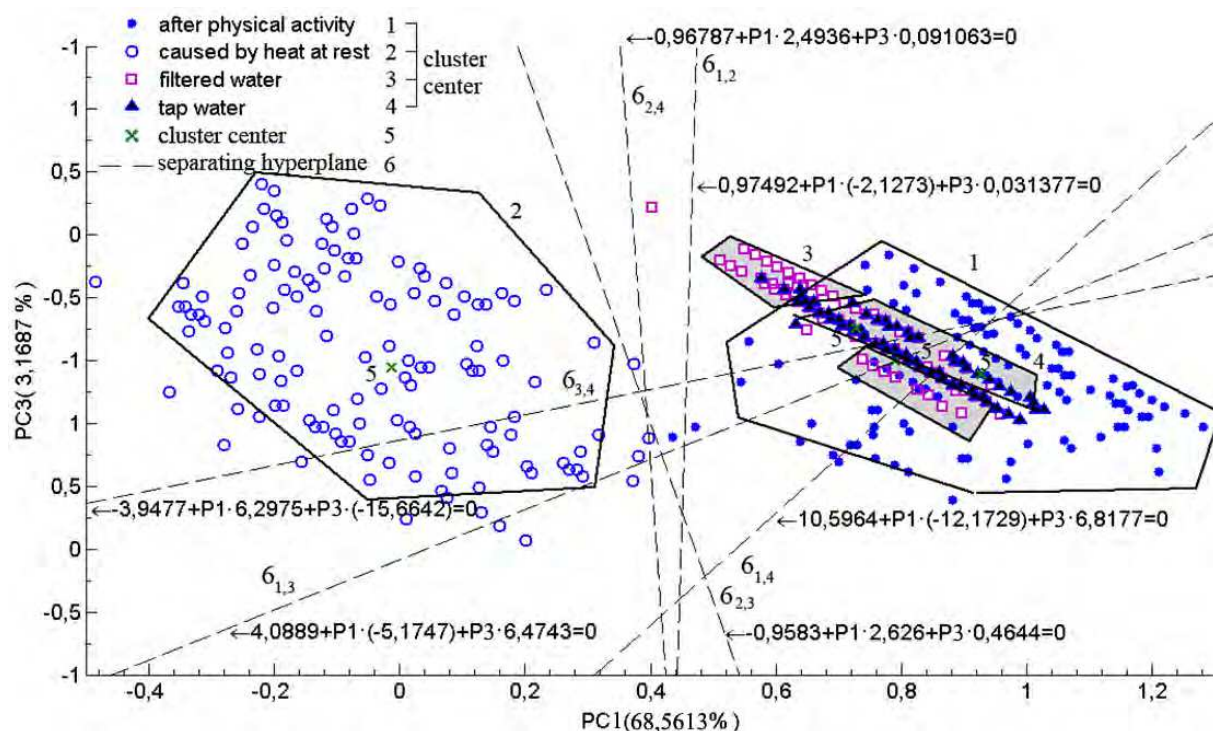Table 5. Results of the sweat biochemical analysis in the morning

Fig. 24. Non-invasive LED analysis of sweat information patterns depending on human functional states

The intelligent system "ISLB" can analyse sweat sensory patterns to recognize harmful and dangerous substances in the human organism. There are comparative estimating fluid parameters for sweat, tap water and filtered one in the table 6 which makes clear information patterns presented in the figure 24. It makes possible to use a sweat pattern for real-time monitoring of human emotions and an improvement of the emotional self-regulation. An emotion is worried feeling which motivates, regulates and orientates our perception, thinking, activity, can be super intellectual and generates new innovative ideas. "ISLB" controls, is trained in the host response to such and such but after that recognizes on the state of health (wet skin, temperature, etc.) whether a man is in good spirits or depressed. As soon as there is clammy sweat and temperature rises to 38,5°, it is indicative of preinfarction angina or worse than this one [8]. The intelligent system "ISLB" is able to predict the state of health and the quality of human life using sweat patterns.

Fluid parameters	Sweat (norm), mg	Tap water, mg/dm³	Filtered water, mg/dm³
pH	6,2	7,3 (7 pH - pure water)	7,1
Cu	0,006	0,006	not defined
Mn	0,006	0,1	0,1
Ca	8,7	56	1
Mg,	2,9	20,6	1,8
Fe	0,047	0,34	0,12
Na	134	120	12,72
Cl	161	0,7	0,2
K	39	180	53

Table 6. Comparison of a biochemical information pattern of sweat with some liquids

3.5 Urine

Human urine is a complex component biomatter consisting of organic components. Information patterns of urine describe general functional well-being, so urine passes through the human organism many times. Any changes of urine information patterns are connected with its pH level especially (Fig. 25). There is a low pH level (5-6,8 pH) of urine in the morning, but urine is getting neutral two hours later after eating, then alkaline (7-8,5 pH).
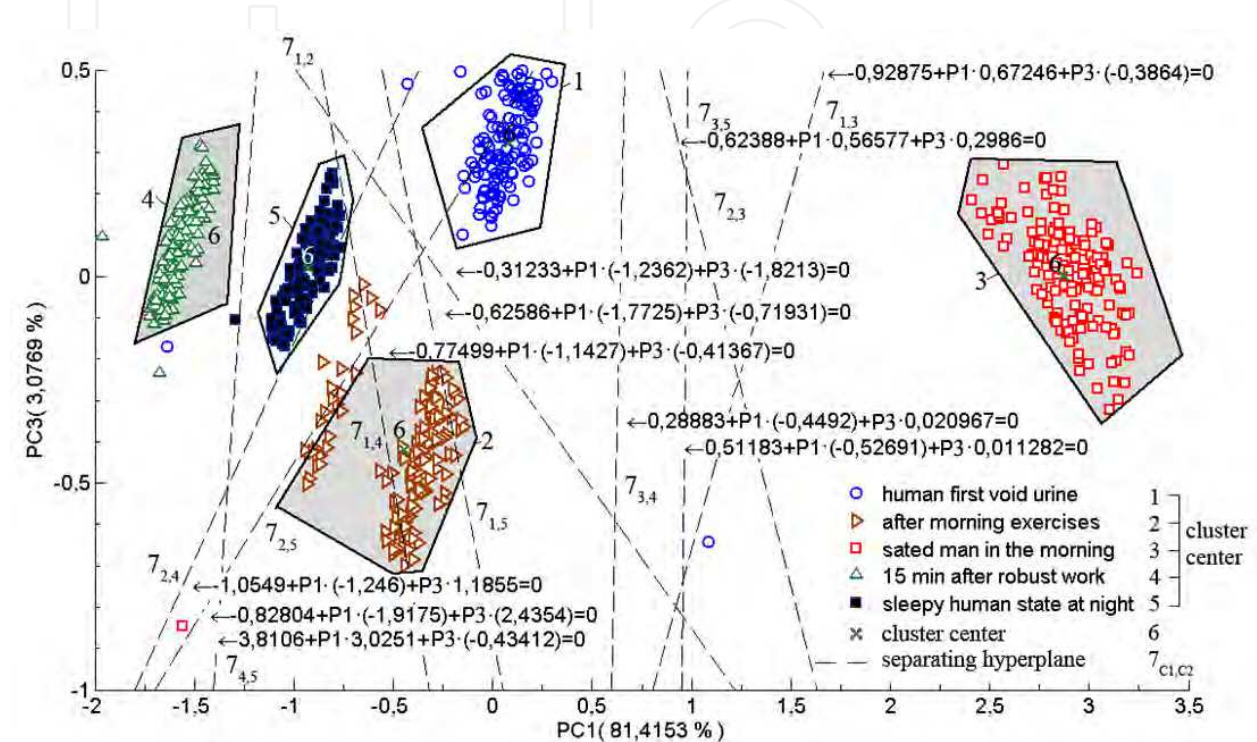

Fig. 25. Non-invasive LED analysis of information patterns of urine during the day

The pH level of urine remains to be equal to 6,6-6,8 pH by day. Ketone bodies are produced in the liver of a hunger man or after the long-term physical activity and characterize fat oxidation. There is also no glucose in urine of a healthy man, but it can be present because of the carbohydrate hypernutrition during a meal and physical activities [11, 12].

3.6 Tears

A lacrimal fluid is a multicomponent secreta which, e.g., total protein is a uniform dysbolism identifier in. This one is varied considerable depending on functioning states of the human health: there is total protein for a healthy man an average of 5,4 g/l but increases in case of, e.g., cornea inflammation to 7,8 g/l. The glucose content in tears correlates with its level in human blood, so that information lacrimal fluid enables to recognize patterns of emotional and functional states of the human organism. Moreover, it is possible to diagnose a human state and the health using for the analysis the alpha amylase activity in tears that catalyzes hydrolysis of starch and glycogen [13]. The concentration of amylase in a lacrimal fluid is in 4 times more than in blood. There is the amylase activity in tears of the healthy men in the range of 130-250 unit/l, but, e.g., acute pancreatitis emerges if this one is more 300 unit/l [14].

4. Intelligent systems in technology of biosafety

4.1 Intelligent system with virtual broadband polarized "electronic eye"

An intelligent mobile hardware and software microsensory system "ISPB" with a broadband polarized "electronic eye" is developed by us to recognize information patterns, e.g., of biomatters, soil, food products. The sensor intended for measuring the light polarization consists of a send-emitting module and a virtual polarizer with a self-learning software. If a polarized light penetrates, e.g., in a human biomatter (blood, saliva, sweat, urine, tears), then the plane of polarization is turned through angle depending on the concentration of individual components in a biological fluid. A refractive index of blood components strongly depends on the polarizability of protein structures in particular. The use of the virtual polarization also gives an opportunity to determine polluting and foreign surface layers on an investigated matter, produce information patterns of objects, e.g., food products for the personal and social biosafety (Fig. 26a) and for generating information patterns of the human functional state. Fig. 26b,c,d,e shows obtained average reflection factors of a scattered light and the polarized one for the investigated food products (soda, salt, water, milk) with the rotation of the plane of polarization (0°, 30°, 60°, 90°) in a direction to the plane of light incidence. If there are some surfaces with refractive indexes being different from a refractive index of an investigated matter, then the part of light is thrown back, but the rest of this one passes through the matter partially being reflected from it and after that goes out again. The reflection coefficient differs from the reflection factor of the investigated matter. Thus, the intelligent system "ISPB" makes it possible to determine refraction and reflection indexes for any light angles and any degrees of its polarization but also to carry out the research and the control of the quality of matters with impure substances, surface foreign or polluting films. "ISPB" is especially very important for the application in biotechnology, ecology, food industry, precision agriculture or for a personal and social biosafety [1, 2, 8].
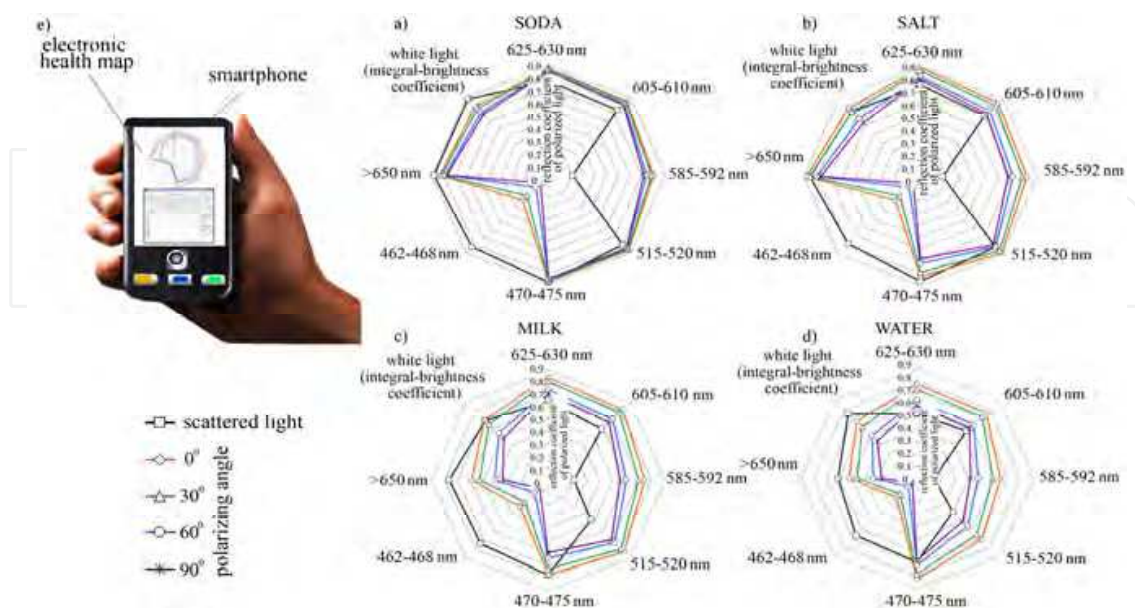

Fig. 26. Intelligent system "ISPB" with the virtual polarized "electronic eye" for the calculation of reflection coefficients of polarized light and forming information patterns

4.2 Recognition of food information patterns for the human biosafety

The developed intelligent system "ISSE" can be used for the recognition of information patterns of foods to maintain and control the human health and biosafety. Their physical and biochemical properties determine coefficients of the optical reflection and light scattering particularly, the quality and the biosecurity of produced food substances. There are optical reflection coefficients for light flour and dark one in the table 7. The flour is lighter, the one is more qualitative, so the reflection from lighter flour in the visible spectral range is higher for high quality one. The presented optical information patterns of different berries and foodstuffs (bread, butter, curds, flour, etc) in the figures 27, 28 can be applied as reference information for the detection of harmful or dangerous toxic components and the content of heavy metals which are accumulated in soil especially because of the nonuniform application of mineral fertilizers, microbial contamination and kept in harvested crops and produced foods [1, 3-5].

Wavelength	Reflection coefficient	
	light flour	dark flour
405 (violet)	0,18	0,16-0,17
460 nm (blue)	0,84	0,72-0,76
505, 530 nm (green)	0,92	0,81-0,83
570 nm (yellow)	0,78-0,82	0,7-0,6
620 nm (orange)	0,87-0,82	0,81
660 nm (red)	0,87-0,93	0,85
405-650 (white colour)	0,77-0,81	0,7
760-2400 nm (infrared light)	0,89	0,86-0,87

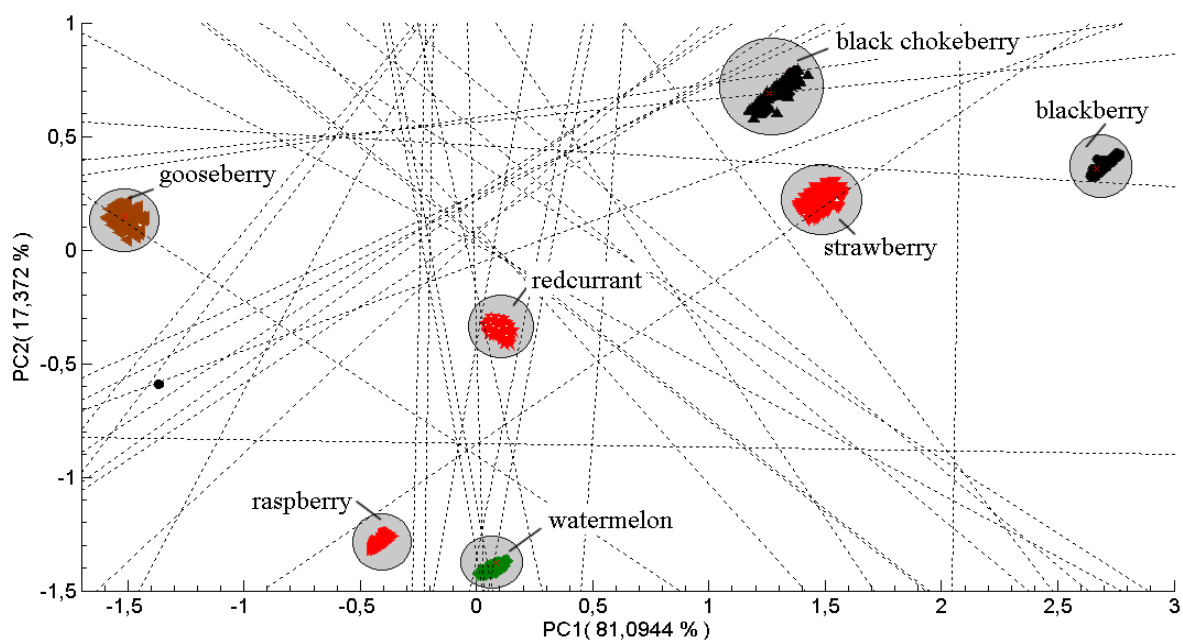Table 7. Comparison of reflection coefficients for different kinds of flour

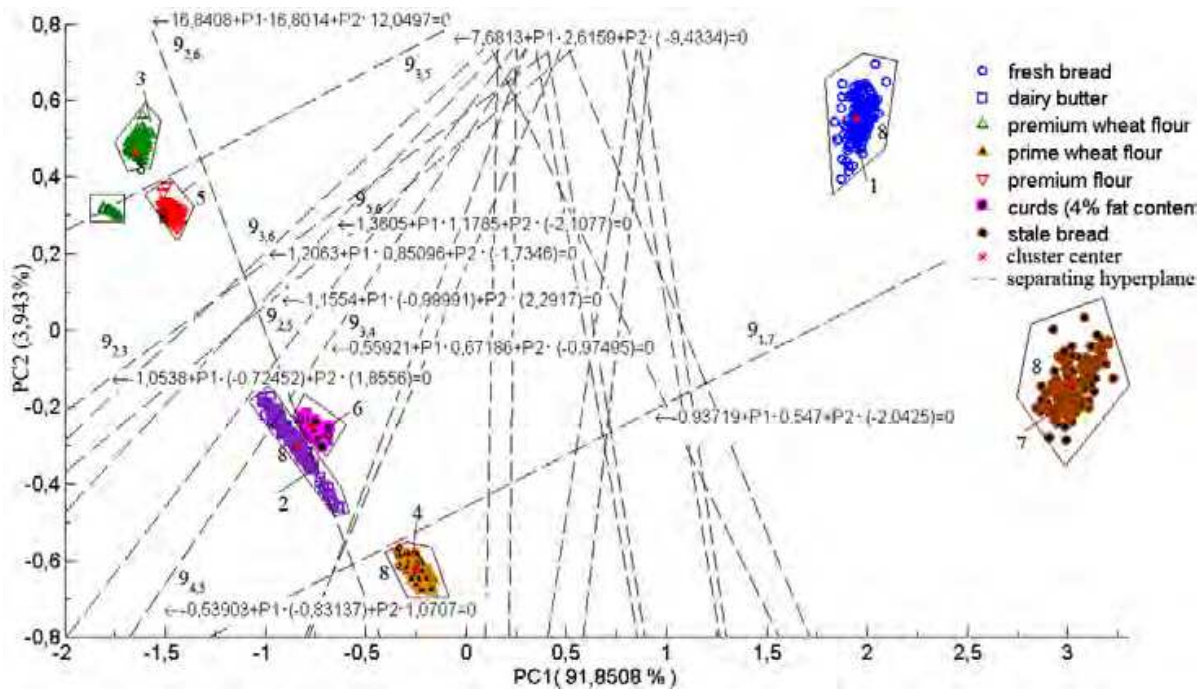Fig. 27. Noncontact LED e-eye for measuring information patterns of berries

Fig. 28. Noncontact LED e-eye for measuring information patterns of foods

Up-to-date techniques for the recognition of information sensory patterns of foods are rather labour-intensive, costly, extremely time-consuming and require highly skilled specialists. The intelligent microsensory system "ISLB" represents an unique microlaboratory on a chip of the type e-eye and is intended for solving important practical problems in intelligent precision agriculture, e.g., for the control of raised farming cultures (maize) and with the generation of sensory information patterns (Fig. 29).
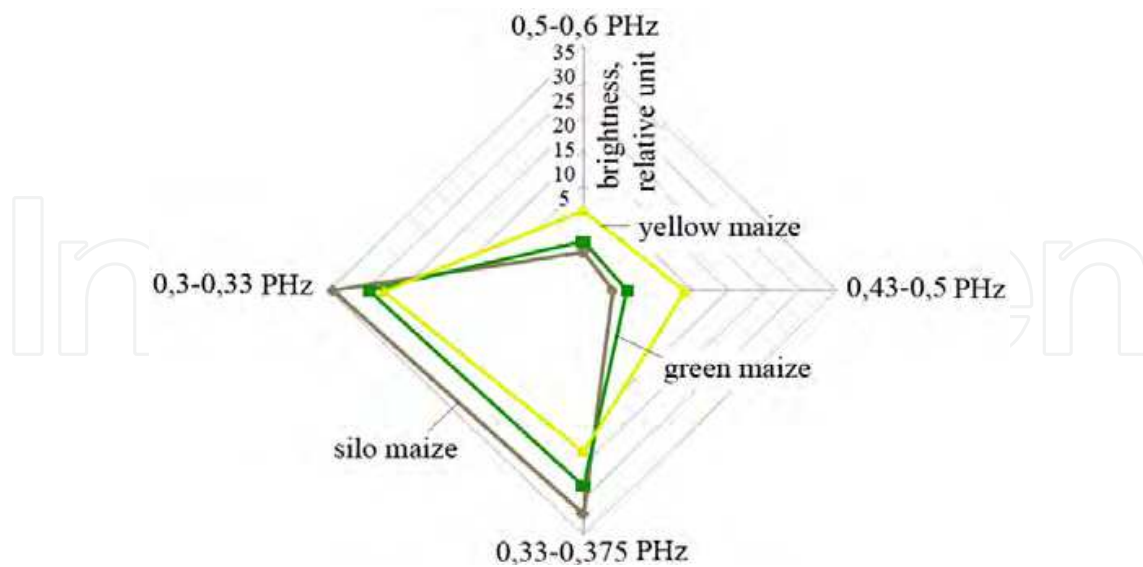
Fig. 29. Information patterns of maize using "ISLB"

Distinctive features of "ISLB" consist in the capability to function with the navigation satellite monitoring technology; therefore, "ISLB" can be presented as a mobile retransmitter and applied local with the use of pilotless vehicles or satellite mobile devices (Fig. 30) [8].
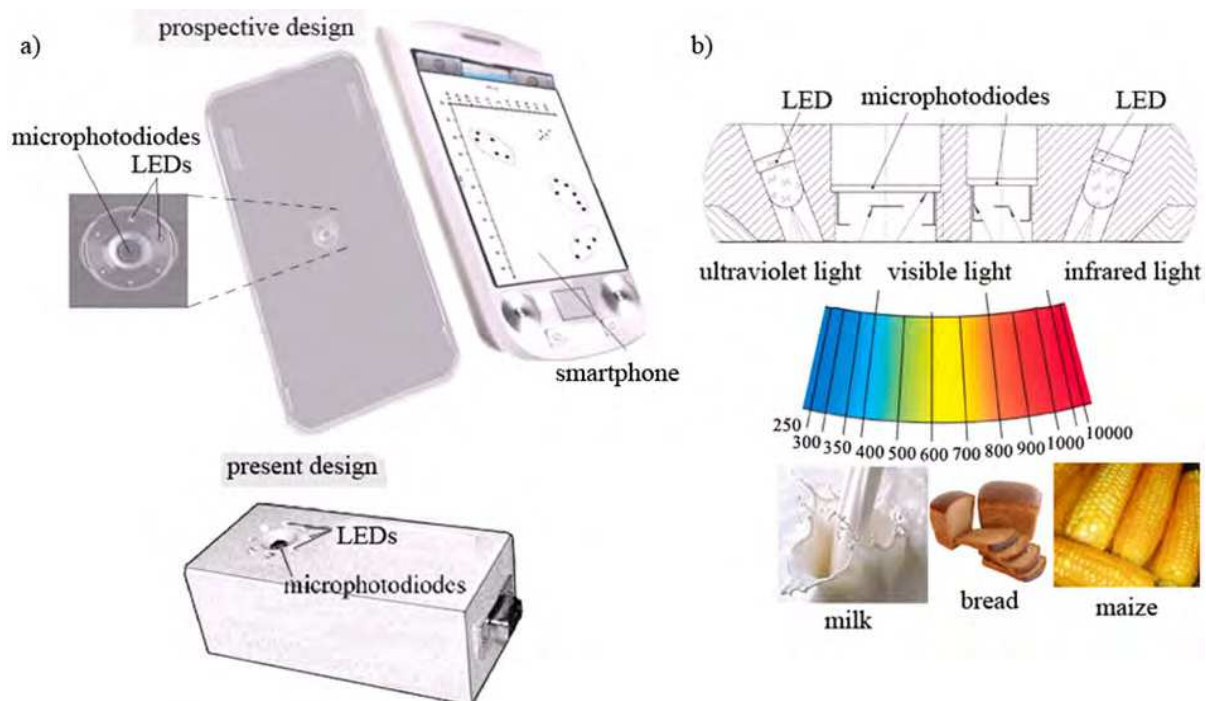
Fig. 30. (a) Design of the intelligent system "ISLB" with (b) the LED optical technology

After the registration of information patterns of biomatters (blood, saliva, sweat, urine, tears, etc.), food products or sensory patterns of soil a packet is generated, encrypted, cryptographic transformed, and antinoise encoded for the transfer to a server (Fig. 31). The transmission is realized through a socket defined at the client software or the server. Then information is conveyed to the server where the received data packet is decrypted and decoded, but data preprocessing, self-learning of the intelligent system based on expert judgements and previous obtained results are fulfilled. A high learning rate is achieved by means of the intelligent self-learning software "ISLB" based on multicore programming algorithms. Prediction results are transferred to the client software (watch and mobile phone, smartphone, communicator, iPad, PDA, wristwatch, etc.). There is displayed information on a screen with a full electronic intellect-map of functioning agricultural or farm enterprises during production steps of precision agriculture, an electronic map of the biosafety of raised cultures to control introduced fertilizers, toxic substances in soil or the level of crop yield. Moreover, an electronic virtual map of the human health with sensory information patterns of biomatters can be showed on the smartphone screen or other portable mobile devices. Intelligent client applications of Visial Studio with .NET Framework 3.5 ensure high adaptability and fast self-learning, but the data library Parallel Extensions gives an opportunity to accelerate data-handling and self-training procedures depending on a number of available system cores and SQL Server 2005 makes possible the development of Web-applications.

Owing to on-the-fly computing information patterns it is possible effective self-learning of the intelligent system "ISLB", the better opportunity to prevent the onset of human diseases at an early stage of their activity because of the consumption of poor food products or hazardous to the human health farming cultures which are raised in soils contaminated by dangerous viruses and bacteria. Thus, the scientific prognostication of the accumulation of

chemical and toxigenic substances in natural plant and animal foods and food products which endanger the human health and have harmful effects on human life is very important for the recognition of offending foods and non-specific changes in a biosystem state [8, 12].
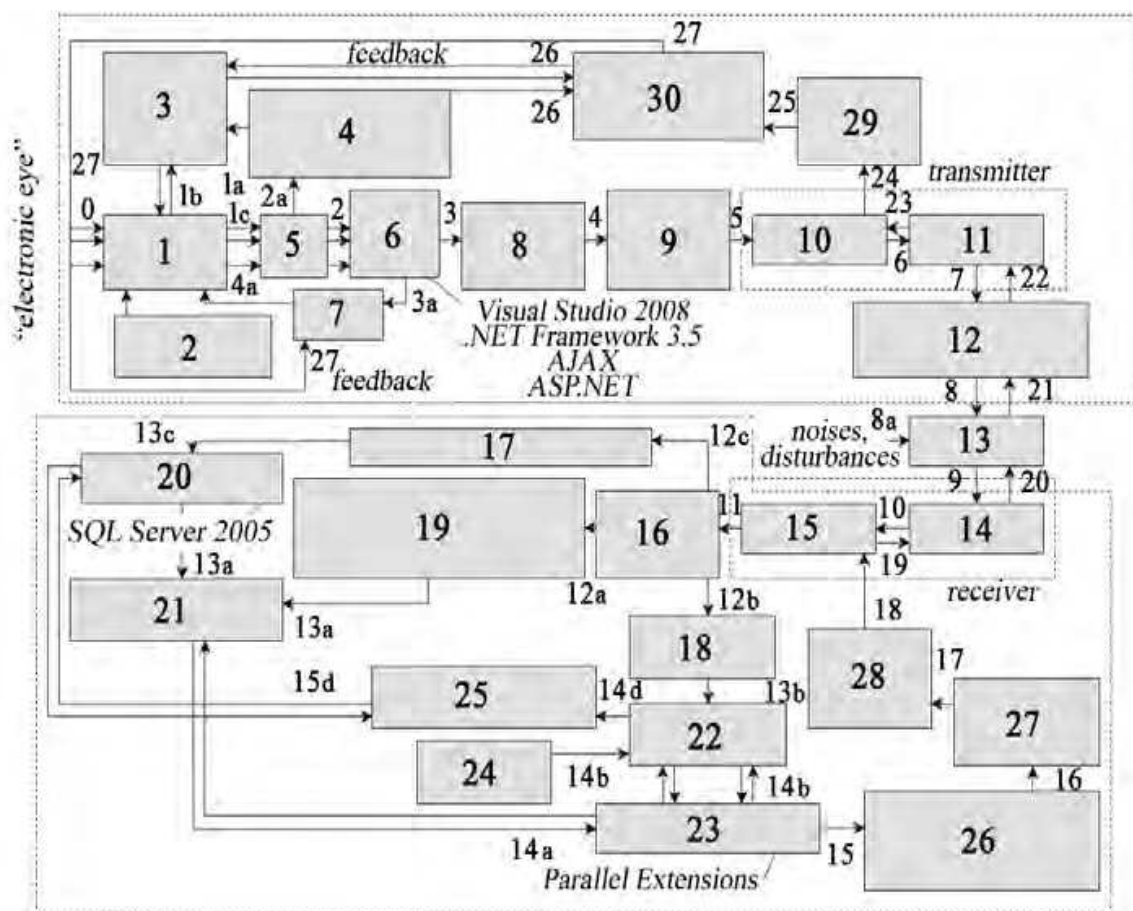

Fig. 31. Functional diagram of "ISLB": 1 – registration of information patterns; 2 –information sensory patterns of biomatters (blood, saliva, sweat, urine, tears, etc.), food products, crops or soil; 3 – authentication and identification of biometric patterns; 4 – generating biometric patterns (micro-nanostructure of investigated matters); 5 – drivers of sensory devices; 6 – sensory data acquisition; 7 – periodicity of the control; 8 – forming the data packet for the transfer to the server; 9 – encoding and cryptography of the data packet; 10 – antinoise coding; 11 – modulator; 12 – data transfer using the socket determined at the client software or the server; 13 – transmission channel; 14 – demodulator; 15 – antinoise decoding; 16 – deciphering the data packet transferred to the server; 17 – expert evaluation (statistical analysis); 18 – data pre-processing; 19 – using optimization criterions to define temporal information patterns on the basis of the minimization of intercluster centroid distances; 20 – database of stored reference patterns; 21 – calculation of distance functions in a multidimensional space; 22 – self-learning the intelligent system; 23 – multicore paralleling of data processing; 24 – neural networks, genetic algorithms; 25 – calculation of reference bioinformation patterns; 26 – generating prediction results (statistical probability, error of bioinformation pattern recognition); 27 – intelligent system of decision making for the transfer to the client software; 28 – encoding and cryptography of the data packet; 29 – deciphering the data packet transferred to the server; 30 – data transmission of decisions taken by intelligent system

4.3 E-eye with SAW retransmitter for wireless sensory networks

The hardware and software complex on a chip of the type "electronic eye" developed by us can be technically improved using retransmitters on surface acoustic waves (SAWs) with the RFID technology of real-time monitoring for the individual human biosafety (Fig. 32a,b) [1].
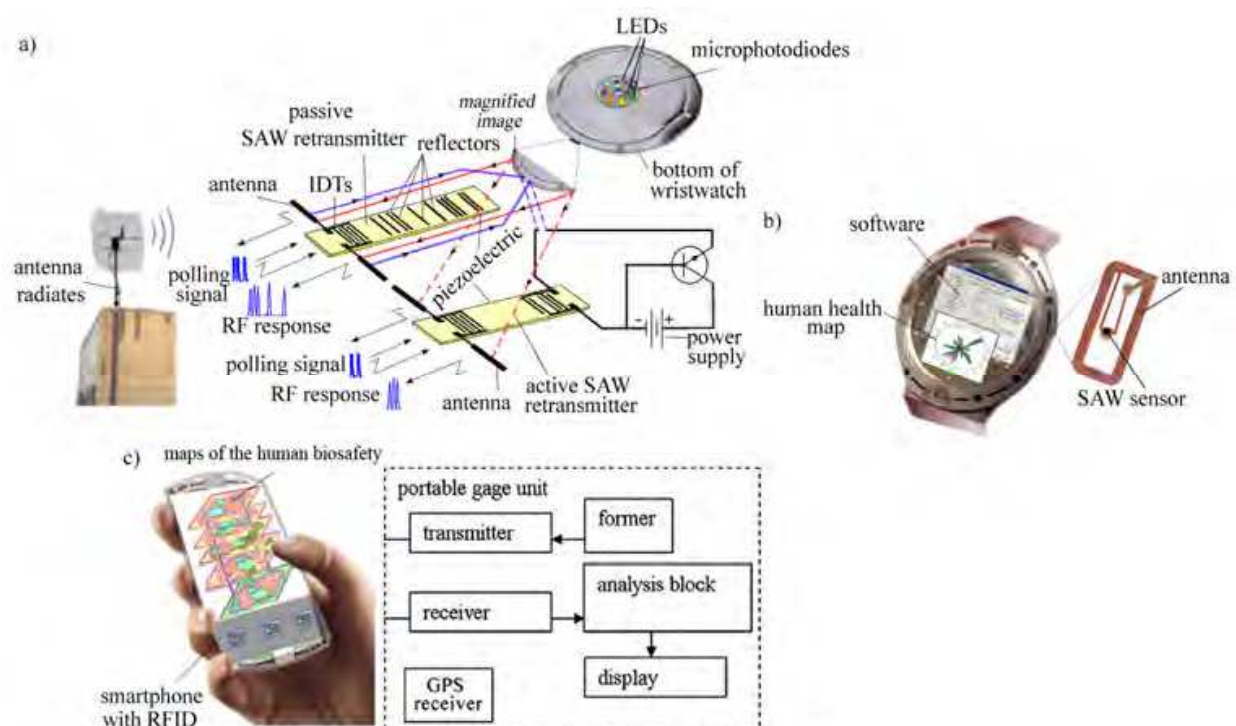

Fig. 32. (a) Wireless active (passive) SAW sensory micro-nanosystem with the LED technology e-eye. (b) Intelligent wristwatch with the RFID technology and LED e-eye. (c) Smartphone with the RFID technology for data processing from the wristwatch

The wireless SAW micro-nanosensory system consists of an antenna, interdigital transducers (IDTs) and a set of reflecting electrodes located on a piezoelectric crystal. If the antenna of the SAW sensor picks up a radio-frequency electromagnetic wave, then a received electromagnetic signal is transmitted to IDTs which are in the form of plane parallel electrodes on a substrate surface and are connected with each other through common buses and after that to a special control unit starting the optical information read-out. An outcoming time-lagged signal of spectral reflection characteristics enhances an alternating electromagnetic field which has the significant impact on an anisotropic dielectric and harmonic mechanical oscillations, tensions, strains caused by the inverse piezoelectric effect and emerged in the SAW sensor substrate. Electric charges with unlike signs are produced on the crystal surface which conditions the onset of an electric potential between IDT electrodes and the electrostatic field. There is a field with the elliptically polarized component determining an arising acoustic wave as a result of the superposition of the source field and the complementary subfield. The acoustic wave after the reflection effects on IDTs and brings to the distribution of electric charges due to the direct piezoelectric effect between IDT electrodes and to the generation of an electromagnetic signal. The SAW velocity and frequency this one are changed depending on different conditions of the propagation medium. The SAW propagates from IDTs in the direction of

reflectors but then backwards to IDTs where is transformed into an electromagnetic signal emitted by the antenna to a rider. Thank to the low SAW velocity it is possible to get long time delays and prevent echo signals, but the sampling time exceeds 10^{-5} s, so the system can be used in driving objects (agriculture machines, portable devices of farmers, etc.). The intelligent system enables to extract the initial signal containing spectral reflection characteristics from the investigated biomatter. The principal advantages of the developed system on a chip e-eye with wireless passive SAW retransmitters are low-power consumption, high reliability and low cost and unlimited operation life. The intelligent LED microsensory system with the wireless active SAW extra has an energy source and semiconductor microcircuitries for the signal multiplication and the increase in operating distances, but the working life of such devices decreases. The identification of active SAW retransmitters can be realized by changing distances between two IDTs. The readout distance of the active SAW retransmitter with the power source (10 W) can achieve up to 50 km therefore [1, 2, 15]. The basic future tendency of mobile technologies requires the development of intelligent sensory systems and networks which are able to adapt to different conditions of real-time monitoring of the individual human biosafety flexible. If agrotechnical machines, farm enterprises with portable mobile analyzers and mobile devices are equipped with "CDOT" developed by us, then agriculture will be more precise and economic, but the food biosafety of countries will be improved (Fig. 33a,b). Information patterns of soil are presented in the form of electronic and virtual maps, e.g., an electronic map of applied nutrients and organic fertilizers, of the level of crop yield, of the yield of soil for last years or an information-microbial state of soil. The human biosafety is better controlled by intelligent systems using an electronic satellite map of field, electronic maps of the biosafety of crops, plant and animal foods along with electronic intellect-maps for precision agriculture [3, 4, 8].
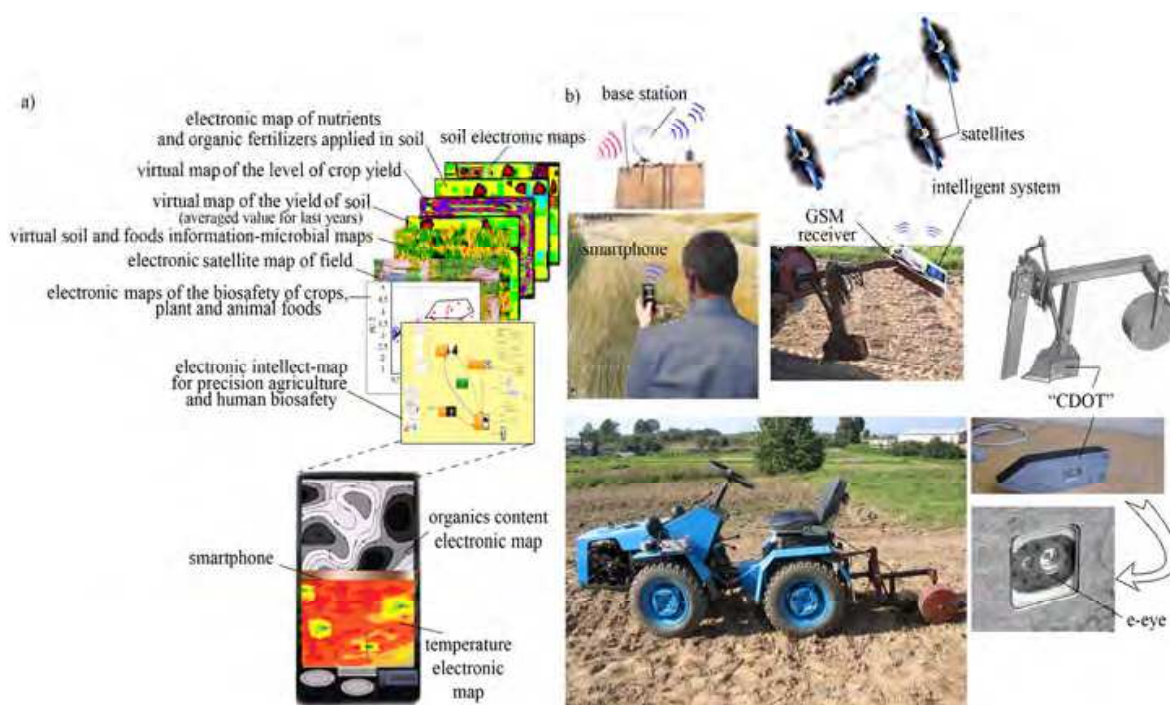

Fig. 33. (a) Intellect-map and virtual electronic ones for precison agriculture and the human biosafety. (b) Intelligent sensory system on a chip e-eye for the pattern recognition of soil

4.4 Data security for precision agriculture and biosafety

To ensure the confidentiality of information and the data integrity during processing and transferring in wireless self-learning intelligent sensory systems and networks, an antinoise coding, the superencryption using a private key generated from biometric data, an individual cryptographic data protection with an intelligent technique of the personal authentication superprotection patented by us are used in the sensory systems "CDOT" and "ISLB" for the recognition of the falsification, the imitation and an unauthorized use of synthetic biometric data by means of the analysis of additional micro-nanoinformation patterns of investigated biomatters (Fig. 34a,b,c) [1, 3-5, 16, 17].

A mobile application with a quick response (QR) encoding technique for mobile and watch phones, smartphones, communicators, PDAs, iPads on the Android virtual platform is developed to protect information patterns of bioobjects. A photo taken with the scanning device, e.g., with an embedded microcamera is QR encoded parallel completely, stored in a database including its QR code and divided into spectra (RGB) which are also QR encoded in a transducer separately. More precise QR code can be generated by the analysis and the comparison between the completely QR encoded pattern and the spectral ones. To read QR code, the obtained QR codes of spectral images and the base QR code of the photo are compared to produce the precise image pattern (Fig. 34).
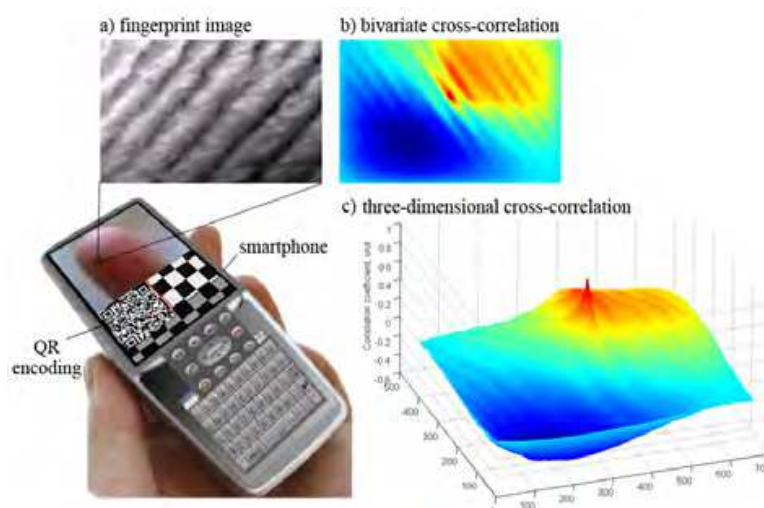

Fig. 34. Android virtual platform with QR encoding information patterns of bioobjects and the superprotection technology of biometric data: (a) nanostructure of the fingerprint; (b) bivariate / three-dimensional (c) cross-correlation function between the fingerprint and the imaged reference one

Intelligent precision agriculture requires a wide use of CIMLS-technologies for the continuous information support with an information security system at all the life-cycle stages of the agricultural production, services sectors and all the levels of personal and social activities in the process of mathematical and software modelling of perspectives and consequences of managerial and technological decision making [1, 18]. Then functioning systems are equipped with an intelligent interface and integral sensory micro-nanosystems for sensing and the adaptive control, with the wireless identification of objects, products, managerial decisions, services, etc. These principles are realized in accordance with International Standard requirements at the same time regulating an electronic data interchange with the nanotechnological biosafety and the information security. The CIMLS-

technology presents distributed data storage in a network computer system including many services and subdivisions of farm enterprises. There is a unified system of rules, the data representation, storage, coding, and communication in the CIMLS-technology. A main principle of CIMLS is the fact that information generated at any stages of the life cycle is stored in CIMLS and is made accessible to every participant of this stage and other ones in concordance with available access permissions to these data. It enables to avoid duplication, unauthorized data substitution, falsification, imitation, changing, and errors of the control system, to abridge the labour, cut time and finances. Actions of government officials are opened to public scrutiny, so there is an integrated logistic control process with the intelligent system of decision-, provision-, decree-, law making. Information in the CIMLS-technology is generated, transformed, encoded, stored, and transmitted using intelligent softwares, e.g., Agro, ADAMIS, ADMOS with a "electronic description" of all the life-cycle objects, and human embellishment or information hiding is eliminated, minimized completely and identified [18].

We developed mathematical models of a controlled process of the complex agricultural production for intelligent precision agriculture, but also the intelligent system "ISAG" is developed for the control of farm enterprises. One of the important directions of precision agriculture is the improvement of control algorithms, the use of steering functions including the nonlinear constraint, the acceleration of a controlled variable, information about characteristics of the controllable system, actuators, sensors, etc.

5. Conclusion

The intelligent microsensory systems presented in this chapter are intended for the recognition of optical information patterns of a technology, a product or environment external conditions in the space of multidimensional sensory data on the basis of the LED technology e-eye. These ones enable to solve important practical problems in an agro-industrial complex, e.g., in intelligent precision agriculture and for the control of the biosafety of farm products, soils, plant, and animal foods. The developed intelligent system "ISLB" can inform users about probable homeostatic threats and recognize timely any changes in functioning the human organism by means of self-learning on optical data of biomatters, e.g., using systems on a chip of the type "electronic eye". The application of the intelligent systems developed by us in mobile retransmitters (smartphones, watch and mobile phones, communicators, iPads, PDAs, wristwatches, etc.) enables the fast and individual monitoring of the human biosafety, to detect whether there is the departure from the norm and quality standards in the production process, give other important information about the quality of the agricultural production and environmental conditions. At the same time, the developed microsensory systems can function not only using satellite technologies, but also local in mobile retransmitters or in pilotless vehicles. It makes possible to produce electronic and virtual maps of soil, crop yield, foods, information-microbial patterns, intellect-maps for the maintenance of intelligent precision agriculture with the CIMLS-technology. The intelligent systems with the LED e-eye can be used in micro-nanoelectronics, biotechnology, agriculture, medicine, food industry, computer and communication systems and networks.

6. References

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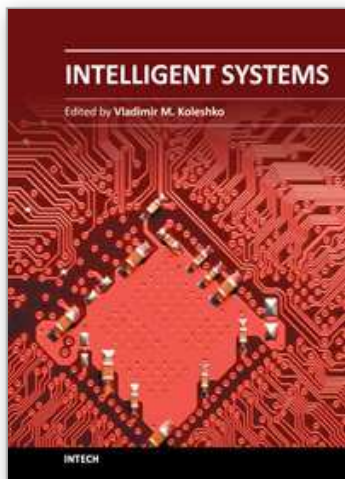
This book is dedicated to intelligent systems of broad-spectrum application, such as personal and social biosafety or use of intelligent sensory micro-nanosystems such as "e-nose", "e-tongue" and "e-eye". In addition to that, effective acquiring information, knowledge management and improved knowledge transfer in any media, as well as modeling its information content using meta-and hyper heuristics and semantic reasoning all benefit from the systems covered in this book. Intelligent systems can also be applied in education and generating the intelligent distributed eLearning architecture, as well as in a large number of technical fields, such as industrial design, manufacturing and utilization, e.g., in precision agriculture, cartography, electric power distribution systems, intelligent building management systems, drilling operations etc. Furthermore, decision making using fuzzy logic models, computational recognition of comprehension uncertainty and the joint synthesis of goals and means of intelligent behavior biosystems, as well as diagnostic and human support in the healthcare environment have also been made easier.

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