Development of Intelligent Technologies for Consumers Protection

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Abstract

Industry analysts expect that as regulations pertaining to testing of food and agricultural products continue to be adopted, the shift toward rapid-screening methods will continue. The overall product testing industry is growing steadily. The biosensor industry too is growing. Identification, assessment and conformity control of agricultural products, intellectual compatibility of measuring processes and functions of the "compensating stage" can be taken over by the cognition subject with its intellectual apparatus, which adds to the possibilities of applied investigation methods. The object's properties and registering results of the investigation object, which have to be fixed by means of different measuring devices, can be so significantly different that there can be no "essence" at all in the indications of the measuring device because the exploration object is always connected with a definite purpose of measuring process in a definite co-ordinates system. The advantage is, that not a set of the "crude" information, but complex of ready, qualitative knowledge is used, not a "bare", non-processed number information group, which rather misinforms, disorientates than informs or takes away uncertainty about features and peculiarities. Elaboration of metric time image is an attempt to find, understand and evaluate positive, valuable features of the explorable substratum. This image does not comprise neither space nor time, but includes only perceptual sensations - and without logically motivated conclusions (ready, completed esoteric knowledge). The research contains the fundamental scientific problem of elaboration of expert and Artificial Intelligence (AI) system in the field of agriculture is reflected. On the basis of results of experimental researches and modeling of "intellect of consumer" was developed new conformity method, based on principle of geometrical similarity of metrical images, also compact, low- cost electronic device "artificial tongue" for conformity control of agricultural products and legal protection of consumers interests and their rights. In article are discussed and reflected main results of elaborated intelligent technology and expert system for conformity assessment of agricultural products.

Key words: consumers' protection, intelligent technologies, quality conformity assessment.

Introduction

Research on an artificial tongue sensor for consumers protection has been acknowledged by the global scientific community. ETongue, ENose is a systems for automatic analysis and recognition (classification) of liquids or gases, including arrays of non-specific sensors, data collectors and data analysis tools. Electronic tongues are used for liquid samples analysis, whereas electronic noses - for gases. The result of artificial tongue and artificial nose can be the identification of the sample, an estimation of its concentration or its characteristic properties. This new technology has many advantages. Problems associated with human senses, like individual variability, impossibility of on-line monitoring, subjectivity, adaptation, infections, harmful exposure to hazardous compounds, mental state, are no concern of it. Synonyms of an electronic tongue: *artificial tongue*, taste sensor.Synonyms of an electronic nose: *artificial nose*, olfactory system (for example, Odor scanner Headspace HS100). The principle of e-nose or e-tongue systems can easily be compared to the human perception as strong similarities are observed. The electronic e-tongue or nose gives either a simple answer like "recognized", "good", or "bad" or a more sophisticated response such as an odor intensity or a molecule concentration The main difference e-tongue is that the system analyses a liquid matrix. So the sensors are immerged directly into the liquid or into others mediums. For years, engineers worldwide have been working to develop mechanical systems that can mimic the human senses of smell, sight, and taste. The quest began 30 years ago with the creation of mathematical algorithms that emulated the brain's method of processing information. Since then, *intelligent systems* that can sense, make decisions, "learn," and adapt have been successfully developed. Now, recent advances in technology have allowed these devices to become smaller, "smarter," and less expensive. Sales of artificial Ttngues, electronic noses and vision chip in 1998-2003 and principle of sensing modeling for artificial tongue can see on Fig.1, applied sensing methods - on Fig.2.

The electronic tongue or nose system performance is dependent on the quality of functioning of its pattern recognition block. Various techniques and methods can be used separately or together to perform the recognition of the samples. After measurement procedure the signals are transformed by a preprocessing block.

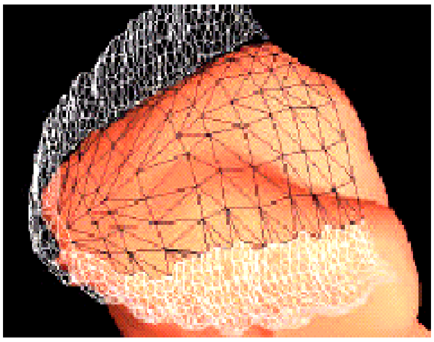
The results obtained are inputs for principal components analysis, cluster analysis or artificial neural network, also "Chernoff faces" pattern recognition method and algorithms (Moskvin, Spakovica 2004).

Estimation of Agricultural Product's Testing Industry

The fundamental purpose of a quality control program is to acquire dependable information on all the attributes of a product, which affect its quality. The methods used to measure quality can be subjective, as in taste tests or they can be objective, such as physical, chemical or microscopic analysis. Subjective methods are based on the opinions of the examiners and because they require the use of our various senses, they are often called sensory analysis. Quality management sys-

millions-$	1998	2003	AAGR %
Electronic nose	14	20	7.4
Vision chip	8	21	21.3
Artificial tongue	0	2	NA
Total	2	43	14

a.



b.

Fig.1 **Sales of Artificial Tongues, Electronic Noses and Vision chip in 1998-2003 (a.) and sensing modeling of artificial tongue , USA (b.)**

E-tongue	E-nose
•Potentiometric sensors •Measurements of conductivity •Voltamperom-metry •Optical sensors •Biosensors **•AFM-Resonanse (LUA)**	**•Conductivity sensors** •MOSFET (Metal-oxide-silicon field-effect-transistor) •CP (Conducting Polymer) **•Piezoelectric sensors** •QMB (Quartz Crystal Microbalance) •SAW (Surface Acoustic Wave) **•Optical sensors**

Fig.2 **Applied sensing methods**

tems (QMS) force operators to document what and how processes are done, then prove though records and audit that the process, however described, is consistent. QMS do not require specific or high quality standards, just that desired standards are met. QMS are also a convenient framework under which to introduce safety standards. The first types are legal standards - those which are commonly established by national governments and generally relate to safety. These standards are often mandatory and represent minimum standards of quality. The major purpose of these is to ensure that products are not adulterated or do not carry dangerous contamination. These might involve undesirable microorganisms, insects, pesticides or potentially toxic additives. They may even consider processing conditions to ensure that foods are not contaminated or unduly damaged. Few of us would argue the importance of standards genuinely related to food product safety.

In the most generic sense, quality refers to the combination of characteristics that are critical in establishing a product's consumer acceptability. In the food industry, this is usually an integrated measure of taste, purity, flavor, texture, color, appearance and workmanship. In a highly-competitive market, another criteria of quality can be 'value' or a consumer's perception of the worth of the product based upon the funds available for consumer's on all quality traceability stages of agricultural products– from environment to the home, Fig.3.

The measurement and evaluation of quality is a complicated affair. Most organizations employ professional technicians to carry out his task, but this has not always been the case. In the past, many companies assumed that the quality of their raw materials could be guaranteed simply by paying the highest prices. However, this did not prove to be very reliable and almost all firms now use various analytical methods for quality determinations. Recently in agriculture for quality control of agricultural products are even more often applied biosensors. The biosensors industry is new but growing. The market is comprised of four segments- medical, environmental, food, and military. Ninety percent of sales come from glucose-detecting biosensors for medical applications. The market is generating a need for pathogen detecting biosensors across all segments (Stephen M. Radke, 2002).

Quality control ensures that raw materials meet set standards, processing methods perform as designed, finished products meet company standards, and consumer confidence in the company remains high. Problems arise when there is disagreement on what is actually required to ensure safety. Another important area of standardization relates to the information presented to the consumer. In this case it is not the product itself, but rather its description that must conform to a particular standard. Much effort has been devoted to harmonizing labeling information and very large market segments do have common requirements. There may be some disputes arising out of a culturally-based philosophy regarding the role of food in the diet. Some societies traditionally confer great health benefits to certain foods while others may not. This may lead to health claims that are allowed in one country and not another. Industry standards are sometimes established by an organized industry association in order to establish a reliable identity for a particular product (Charles R. Hurburgh ,2003).

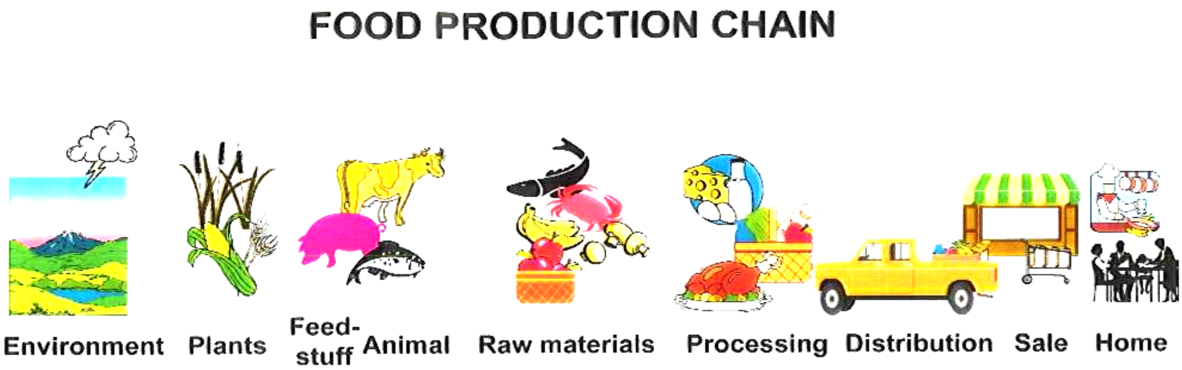


Fig.3 **Chain of agricultural and food production**

The processed food sector accounts for the largest number of tests, with over 52.2 million performed annually. This represents over 36% of total tests performed and is likely driven by the larger number of processing plants, which is 38% of all plants. Industry analysts expect that as regulations pertaining to pathogen testing continue to be adopted, the shift toward rapid-screening methods will continue. The overall food product testing industry is growing steadily. For example, the US food industry performed around 144.3 million microbiological tests. The dairy sector has the highest testing rate per processing plant, averaging over 630 tests per plant per week. The beef and poultry sectors perform the least number of tests per plant averaging 369 tests per plant per week. As a result, the beef and poultry sectors account for only 22.3% of all testing in the industry. The fruit and vegetable sector is currently the smallest of the four sectors accounting for only 9.7% of testing.

There is growing recognition of toxins as health risks, especially in grains and fish/seafood, which are two fast-growing food categories because consumers perceive them as healthful. Sales in the US for pathogen, pesticide and GMO products combined used by food processors are projected to increase from $149.5 million in 2000 to $239.4 million in 2005 at an AAGR (*average annual growth rate*) of 9.9%. The pathogen specific testing market is expected to grow for all segments at a *compounded annual growth rate* (CAGR) of 4.5% with a total market value of $563 million by 2003 (Evangelyn C. Alocilja, 2002).

Development of Intelligent Technologies for Consumers Protection

Intelligent techniques for measuring human sensory response to food texture have been undertaken since 1980s (Boyar and Kilcast, 1986a, 1986b; Moskvin, 1988a, Shmulevich et al., 1996; Sakamoto et al., 1989; Kohyama et al., 2000) to study relations between physiological and sensory testing of perception. Since the half of the eighties the technological mimic of the main functions of human olfaction became possible. Since that, an increasing number of researchers have dedicated their efforts to improve the original idea pursuing the fabrication of electronic tongue.

Practical applications, in a wide number of cases, appeared in the literature, and in the nineties some companies have introduced the electronic tongue technology to the market. Recently in food industry and in agriculture for quality control of agricultural products are even more often applied sensors. Much research was done in order to find new and more diverse sensors, and to date there are several companies offering ready-to-use electronic tongue (Moskvin,1996, 2002 a, b,2002a,b, 2003a,b), Fig.4.

Historically first instrument with artificial intellect in Latvia was built in Agricultural University at Jelgava 15 years ago under supervision of Prof. Gennady A. Moskvin. It was artificial tongue – device based on couple of electrodes and signal generating - signal recognition parts. For ages, the human tongue has been an important tool in assessing the quality of many products, food and agricultural products being good examples. While all others parts of production processes, includ-

Fig. 4 **"Artificial tongue" - Logicor-AT (Prof. G. Moskvin, LUA)** ing these of the food industry, were getting more and more automated, there was still no "objective" means for using the "subjective" information confined in the taste of products. This changed in 1988, when Gennady A. Moskvin introduced the new concept of an electronic tongue. The "Artificial Tongue" (AT) ES and AI device is an electronic intelligent instrument, which consists of data acquisition and data analysis systems.

Analysts expect that as regulations pertaining to food and agricultural products testing continue to be adopted, the shift toward rapid nonconformity assessment methods will continue. Normally such standards become effective because the majority of producers agree to them. They are seldom related to safety, but more to a characteristic quality which the industry feels is useful to establish credibility for the market. These standards are commonly referred to as commodity standards or standards of identity.

Many measuring devices usually consist of two functional knots: primary sensing element (measuring transducer) and registering device. Sensing element usually have electric exit signal and further processing measuring information is completed by using different electrical schemes, mainly, of an analogous type. As to functional opportunities, preciseness and signal stability, the processing of digital data has significant preferences. The presence of microcomputer in the measuring channel allows by use of special testing programs and errors back propagation algorithms to carry out identification experiment of measurable medium with help of intelligent complex making use of definite physical effects (Moskvin, 1996, 1998, 2002 d).

Automatic identification of the critical control points should be determined in all the stages of food production starting with the obtaining of raw materials or the production of component parts up to their marketing. Therefore, firstly, during the technological process a precise, safe, operative and objective information flow has to be established throughout all the production stages, Fig.3 (Moskvin, Spakovica, 1998a,b, 2000,2002,2003a-c). The solution of this problem is hindered by the lack of such measuring devices and suppliers which during testing, regulation and control of technological process parameters systematically, energetically, constructively, informatively, exploitatively and, what is most important, metrologically could be joined not only to the control systems but also to technical and measuring devices in real conditions. Just in such way can be explained the world tendency towards the "intellectualization" of measuring devices and sensors. In industrial production there are no analogous for such agricultural and food products properties as stochastic and not uniform flow of materials and informative resources, significant changes of their properties and quality in time, presence of inertia in the communications with a bionic system.

The above said does not allow applying the traditional methods and means in the control of technological processes and in the food production processes. The situation is worsened by the low technical level of the existing suppliers and devices used in agriculture and, in the first place, their preciseness and credibility. Theoretic investigations prove that sensors lag behind the development of food and other technologies therefore all over the world intensive financing is observed just in the field of technical progress.

The overall quality of a fruit is not linear combination of all measurable quality parameters. This presents major problem as to how these measurements should be combined into quality indices and grading decisions. The quality of fruit is combination of numerous parameters such as: firmness, acidity, aroma, color, color uniformity, bruises, scars, cuts, presence of soil, size, shape, insects diseases. The main sensible parameters are specific to the individual fruit. Thus, the concept of this work is to develop a system that can classify fruits based upon several of these parameters by using multi-sensors data acquisition (vision, taste, firmness, smell and weight).

Techniques and criteria for choosing training sets for the classifier were developed in such a way that only a middle training set (in total about 155 dates) was needed to achieve good conformity classification; 89% correct conformity classification for objects that were tested at different dates. A classifier that was trained 78% accuracy in the classification.

The main results of preliminary experimental research prove that quality and conformity assessment of agricultural products and raw materials can be determined by new conformity assessment method by use of intelligent sensor "artificial tongue", based on use principle *of geometrical similarity of metrical images* (Moskvin, Spakovica, 2002).

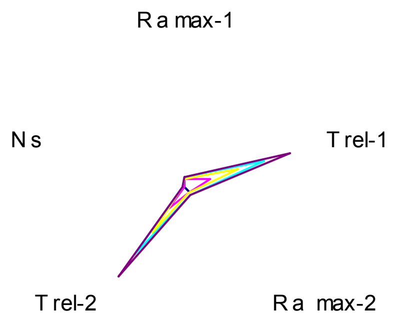
The multi - sensor system that utilizes an imaging system, an impact sensor, sensor of electroconductivity constant and alternating current, electronic chronometer for determination of relaxation time – **T** rel, an ultrasonic sensor, gauge for measuring an electrical resistance **R**a , force gauge, and an "artificial tongue" measurement device, Fig. 5.

Agricultural production peculiarities, conditions and specifics require elaborating simple, safe, inexpensive and precise conformity control electronic devices. Elaboration of such suppliers is the decisive factor in the quality of food and other products conformity control system operation.

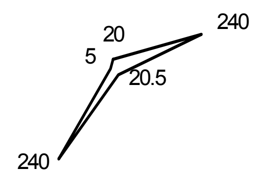
Intelligent sensors can essentially perfect the whole control system due to the increase of preciseness and a rational processing of signals received from the sensory element. Such existence problem of a measuring device and a sensor is the problem of a precise control of production processes, the problem of consumer's provision with qualitative food products, efficiency problem of any production. Therefore it is topical to design new generation conformity control measuring devices with the application of new fractal methods, which can effectively work under changing operation regime of equipment's, as well as adopt themselves to definite agricultural and food technology processes with not systemized parameters and not formalized requirements in real exploitation conditions.

One of the development directions can be the elaboration of rapid control law-cost conformity

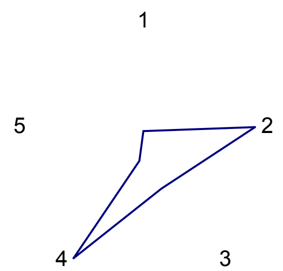
Generalized metrical image **"Bumbieris"**



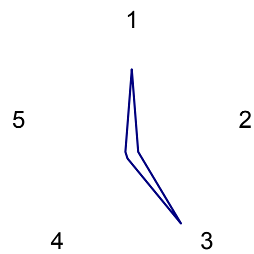
Generalized watch –fractal image**"Bumbieris"**



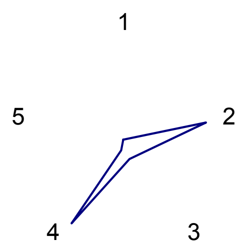
Watch – fractal **"Bumbieris – 2"**
(fruit is classified as sort 2)



Watch – fractal *"Bumbieris – 3"*
(fruit of bad quality, or is not classified as a fruit **"Bumbieris"**)



Watch – fractal *"Bumbieris – 24"*
(fruit is classified as sort 1)



Watch – fractal ***"Bumbieris – 45"***
(fruit is classified as sort 1)

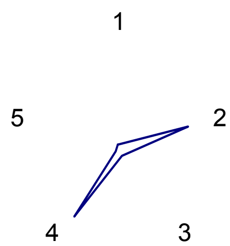


Fig.5 **Conformity assessment of the fruits by means of application of watch - fractal method**

control electronic devices with “Artificial Intelligence” (AI) elements, which continue the development of microprocessor technique technology. Such intellectual suppliers have “artificial tongue” sensible sensory elements in form of measurement transducer with digital or analogous electrical or other exit signal. AI “tongue” intelligent technology was designed as the synthesis of sensory elements with computing micro-devices.

Intelligent compatibility of measuring processes and functions of the “compensating stage” can be taken over by the cognition subject with its intellectual apparatus, which adds to the possibilities of applied investigation methods. In the elaboration of bionic intellectual measuring systems it has to be understood that such a system has to be open to man’s (expert’s, specialist’s) intellect, knowledge, practical experience (also not formalized and not systemized) and even to intuition (Moskvin G., 1998a,b).

These devices are already used in laboratories and in business (Moskvin G., Spakovica E. 2003a-c). Preliminary interrogations of consumers show positive relation of consumers and businessmen’s to application an intelligent devices “artificial tongue” for conformity control in area of agricultural production and business.

In general, it considerably allows, on one hand, to improve scientific knowledge’s basis of informative service and quality conformity control programs and on other hand, to implement practically Latvian laws “Conformity Control” and “Consumers Protection”, which guaranteed legal protection of interests and rights of each consumer.

The research of “consumer intellect” models are carried out by means of synthesis of the non-traditional conformity assessment imagining method *based on principle of geometrical similarity of metrical images* in different areas of identification, classification and conformity assessment of agricultural products by using of rapid control intelligent instruments.

Application of “Chernoff faces” Pattern Recognition Method and Algorithm for the Assessment of Conformity of Agricultural Products

The concept concerns the roles of marketing ethics in transactions between producers, marketers and poor consumers. Therefore we describe our research results looking from point of view some problems and obstacles faced by poor consumers. For protection of their interests and rights we have developed technical decisions by use of new “watch-fractal” method for quality nonconformity assessment of agricultural products, raw materials and goods, which was developed on the basis of “Chernoff faces” images deviation analysis principle, Fig.3.

Subsequently, the real “organisms” of AI systems can be expressed by means of the accepted

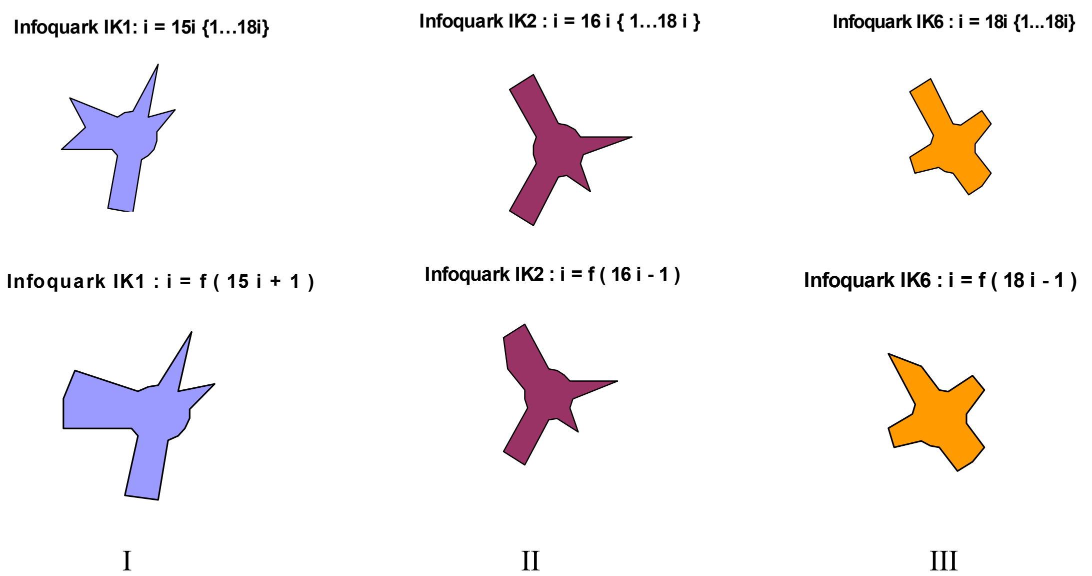


Fig. 6 **Conformity assessment of agricultural products on the principle of geometrical similarity (I – III - images for three trials IK1, IK2, IK6).**

conditioned standard of the perceptual model (experts knowledge). Besides, the most significant AI "biological" features remain. It can be said also in other way: real AI organisms are "the projections of the initial AI organism" designed by experts-theoreticians, models on in reality existing organic reason forms. Internal motivation of biological systems to self-organizing, reasonable by anti - chaos theory, can be used for the control of their quality, that is for definition of conformity of biological system or physical mediums to parameters of an optimality, which is determined to quality of agricultural products.

Internal intention of bionics systems to motivation and to structure it is important internal engine of process of search of an optimality of biological system. Such biological system itself continuously forms individual metric co-ordinates "space - time", selected space - measure and required "speed" of time for the conformity control, obtaining of needed

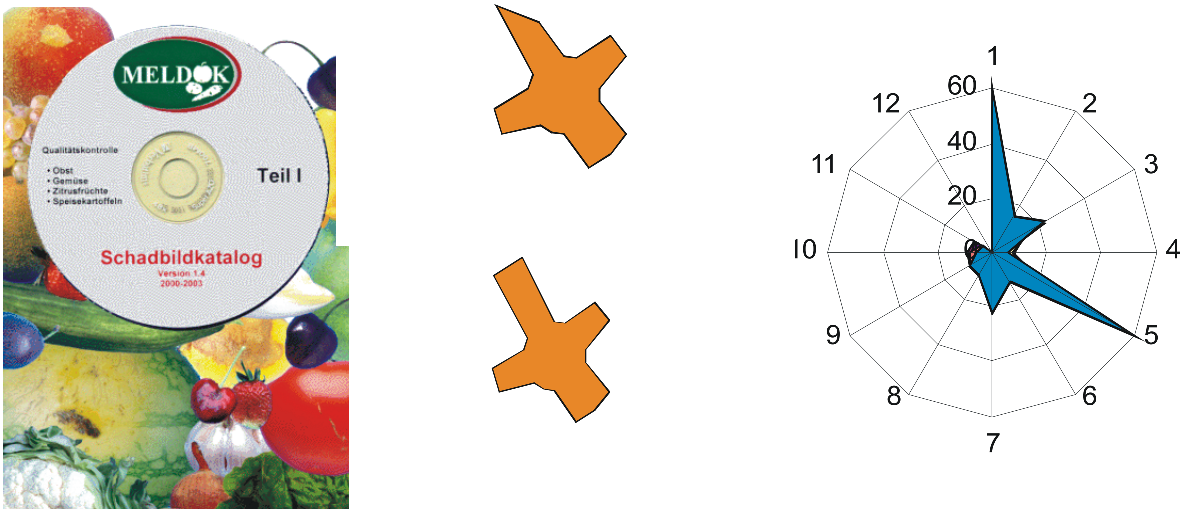


Fig.7 **Electronic CD ("Schadbildkatalog" , BMVEL -Germany) (a) and watch - fractals (b, c) (LUA) methods for the assessment of quality deviations of agricultural products**

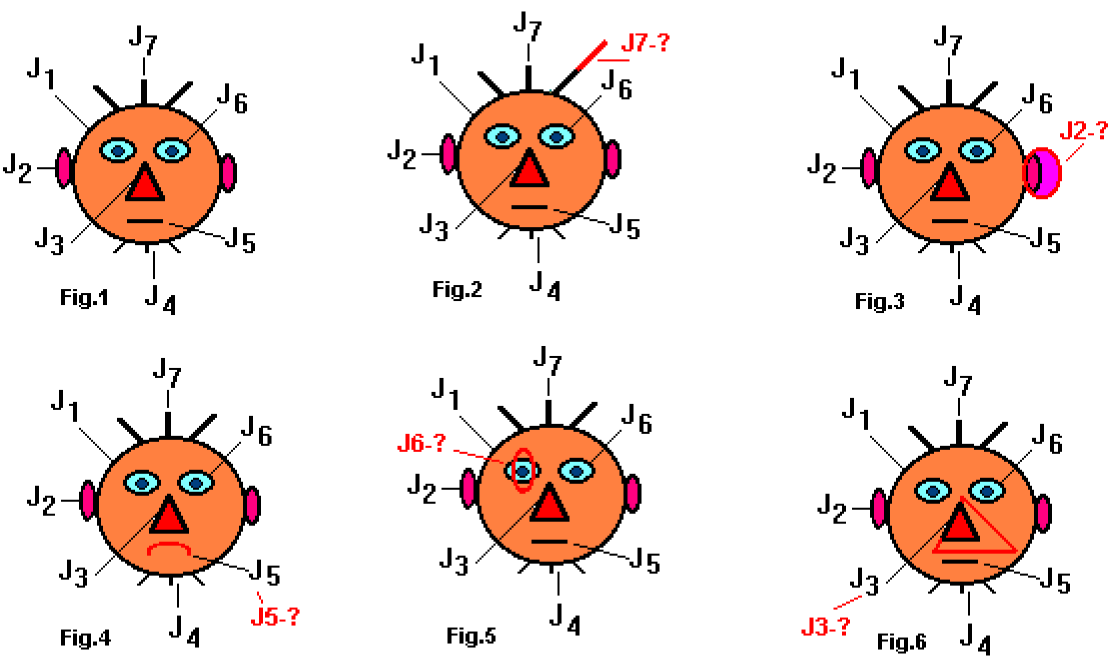


Fig.8 **"Chernoff faces" pattern recognition method for conformity assessment** useful information, for the modification and its processing by means of application of "artificial" or "natural" intellectual tools. Such motivation makes the identification process all embracing, core-aimed. This process never is local, but is global. Harmony degree of a external test influence on the researched biological medium can be estimated by methods of functional systems according to preservation of afferent principle. In bionic systems such harmonious approach in strategy of measurement and assessment of useful medium's properties allows to allocate such set of key test signals, which does not contradict to preservation of afferent principle (Moskvin, 2002 a, b).

Bionic approach in the modeling of intelligent AT measuring systems allows to examine two types of intelligent control models (Moskvin, 1996). For the elaboration of the first type models it is sufficient to study in isolation only "inner" parameters and processes of the object under exploration without taking into consideration the impact of outer medium factors and, in relation with it, "behaviour" changes of the structure intended for synthesis. The modeling of this type can be useful for a preliminary metric image identification and conformation of the object under exploration. The further use of the model depends only on the success of the acquired model's theoretic and technical continuation (Moskvin, 1996, 1998 a).

"Behaviour" factor analysis of the object of interest has to be considered at the basis of the second type of bionic models. Further on "reference" functions of the influence factors are determined and feedback algorithm is synthesized in the form of ANN "self-learning" programs. The basic contours of models technical realization are formed in complete agreement of the existing notions, data, levels of knowledge about the investigation process or object with the exploration task and aim.

Technological and informative revolution in all production spheres, especially in computing- and research-comprising technology branches determined application of local (divided intellect) systems in functioning structures and further development of local microcomputers. Subsequently, in the automation leading part belongs to intellectualization of measuring devices (Moskvin, 1991,1993,1996).

"Chernoff Faces" recognition algorithm can be divided into four different areas: *Face detection.* The goal of face detection is to identify and locate Chernoff faces in images at different nose, eyes, mouth, hair, ear positions, scales, orientations and other conditions. (Fig.8.)

Main steps to recognition of *Chernoff faces: face localization, face verification* (face verification is concerned with validating a claimed identity of faces and either accepting or rejecting the identity claim), *face recognition* (the goal of face recognition is to identify a "person" based on the real face geometrical deviation from standard face.

This face image has to be compared with all the registered "persons"(standard of agricultural product), respectively with their standard images, *elaborated on principle of geometrical similarity of metrical images*. Therefore, face recognition is computationally expensive regarding the number of registered "persons".

Conclusions

1. The overall product testing industry is growing steadily. In agriculture for quality control of agricultural products are even more often applied biosensors. The biosensors industry is new but growing.
2. Technological and informative revolution in computing technology branches determined the application of divided intellect systems and a further development of local microcomputers for conformity assessment of agricultural products. In a highly-competitive market, another criteria of quality can be 'value' or a consumer's perception of the worth of the product based upon the funds available for it. In the most generic sense, quality refers to the combination of characteristics that are critical in establishing a product's consumer acceptability.
3. Main preferences of watch-fractal *metrical images methods* is very easy possibility to detection of all deviations from standard images and easy possibility operatively to find namely those quality parameters, which have influences on quality deviations of product.
4. On the basis of results of experimental researches and modeling method "of intellect of the consumer " we has developed a new method *based on principle of geometrical similarity of metrical images* and compact, low - cost electronic AI devices "artificial tongue" for conformity assessment of agricultural products, goods and raw materials. Preliminary interrogations of

consumers show positive relation of consumers and businessmen's to new possibility for protection their rights and interests.

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