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REVIEW ARTICLE

The History and New Trends of Medical Informatics

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ABSTRACT

The breakthrough of the computer and information technologies in all the segments of the society, led to the needs for the computer and information technologies. The knowledge of information technology is now part of general literacy. The computer literacy does not require comprehensive and detailed knowledge of the electronics or programming.

Although with the electronic computer which is the invention of our age, the attempts of the construction of the first machine for the processing of the information reach far in the history of human civilization. The only and global function of a computer data processing can be naturally separated into the series of the other elementary operations, as for examples are: 'the follow-up of the data, their registration, reproduction, selection, sorting, and comparison' and so on.

The computers are being classified according to 'the purpose, type and computer size'. According to the purpose the computers it can be of the general and specific purposes. The computers for the general purpose serve for the commercial applications or any other application that is necessary.

If medical informatics is regarded as a scientific discipline dealing with theory and practice of information processes in medicine, comprising data communication by information and communication technologies (ICT), with computers as an especially important ICT, then it can be stated that the history medical informatics is connected with the beginnings of computer usage in medicine.

The medical informatics is the foundation for understanding and practice of the up-to-day medicine. Its basic tool is the computer, subject of studying and the means by which the aspects and achieve the new knowledge in the studying of a man, his health and disease, and functioning of the total health activities.

Current network system possesses the limited global performance in the organization of health care, and that is especially expressed in the clinical medicine, where the computer technology has not received the wanted applications yet.

In front of us lies the brilliant future of the medical informatics. It should expect that the application of terminal and personal computers with more simple manners of operation will enable routine use of computer technology by all health professionals in the fields of telemedicine, distance learning (DL) (web-based medical education), application of ICT, medical robotics, genomics, etc. The development of nature languages for communication with the computers and the identification of input voice will make the work simpler.

Regarding the future of medical informatics education there are numerous controversies. Everybody agrees that the medical informatics is very significant for the whole health care and for the needs for personnel. However, there is not yet the general agreement regarding the teaching programs, because the medical informatics is very involved and propulsive, what makes the performance of the stable education programs more difficult. There are also not general agreement in which year of studding should transfer the knowledge from medical informatics. The majority of the experts still agree that the priority should be given in later study years, since more and more students enroll the faculties with prior informatics illiteracy, and the comprehension of some medical informatics fields is not possible without prior clinical knowledge.

Keywords: Medical informatics, Information and communication technologies, Distance learning, History of medical informatics, New trends of medical informatics.

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INTRODUCTION

The breakthrough of the computer and information technologies in all the segments of the society, led to the needs for the computer and information technologies. The knowledge of information technology is now part of general literacy. The computer literacy does not require comprehensive and detailed knowledge of the electronics or programming.[1] This is especially important for the students of the biomedical faculties and for all profiles of the health care professionals. It is important to know how to keep medical records, retrieve information from medical files or internet.[2] The information technologies are now important factor in medical education.

The computer is the most important device for the automatic data processing.[3] A computer is a machine for data processing of the numeric and non-numeric nature. It is wrong to think that computer process only the numbers. In the practice the majority of the data are of non-numeric nature (for example, gathering of the surnames and names of the patients is being arranged according to the alphabetic order in a computer).

Looking conceptually, the computer consists from the processing units 'which has the arithmetic and logic capabilities', the mechanism for the input of data 'into processor unit' (input), of the mechanism for storage of the data 'in the course of processing' and the mechanism for the receiving of information 'which are being processed' (output).[4]

The electronic computer 'is defined as a machine in which the information can be stored and which that information automatically and with great speed process according to the definite rules' (programs).[3] Still more precise, the electronic computer 'is a machine which manages the data, so that gets stored, retrieval, delivers, receives, analyzes and synthesizes the data which serve for

the production of information'.[1] One of the frequent definitions of the electronic computer is that is a 'machine or device in which or by means of which the data are processed by means of the electronic structures'.[5] The science which study the computers is a science about the computers and all that what is in connection with automatic data processing.[6]

All the physical components from which the electronic computer is made we call the technical basis or hardware (means iron goods). That the electronic computer could work and it is necessary to be programmed by the series of the commands (instructions). The programs are called software (soft things, fine things). Programs are instruction that make computer work. The term 'firmware' is used for the computer programs which are permanently recorded in the nonchangeable hardware memory and the user, in the principle, cannot change them. The function of the firmware is to start work of hardware according to stored instructions for system initialization (for example; from where to start operative system boot).[7]

The architecture of the computer is basic characteristic of main components and software of computer.[8]

The world which surrounds us by everyday becomes more and more complex.[9]

The electronic computer is the mean by which we can more successfully solve the problems. The electronic computer is probably one of the most important inventions in the second half of the previous century. The expansive breakthrough of the computer technologies into all spheres of human work, characterizes the new wave of the great changes which often is called 'the computer revolution'.[1] The intensive development of the electronic technology in this century enabled the construction of such machines which besides the arithmetic operations can perform also more complex logic operations by means of which it is possible to quickly easily and reliable solve such tasks which up to the invention of the computer was impossible to solve by the standard way of processing. Practically is proved that the computers have extraordinary ability to process a great number of the data in short time period.[10-13]

The processing can be performed by the standard methods (manually), mechanically or electronically (by the computer). In the past, the pencils and papers were the basic tool for data processing. Generally one can say: the contemporary way of life demands the creation of the enormous quantities of data which is necessary to register and process. Therefore, the computers are the choice in our struggle that the expansion of the data and information be easier, clearer and more arranged.[15-17]

The personal computers (PC) today are widely used in all the segments of society. They are used into two fields: in the business bookkeeping and household accounting. It is true, that today are much more convent for use in the household bookkeeping, but is very wide also their application in the business bookkeeping, by which the segment of the health care is one from the most significant ('the PC are widely used individually, in network or as the intelligent terminals on the great systems').

One of the main markets of the computer is the field of education, where they are used:

- For the education in the programming;
- As the assistance in the handling with estimates and data for the support to the special purposes in the frame of the general plan of the training;
- As the training means-teaching aids, constructed to lead the students through teaching material.

All the mentioned principles are valid also for the education in the field of health care and the medicine.

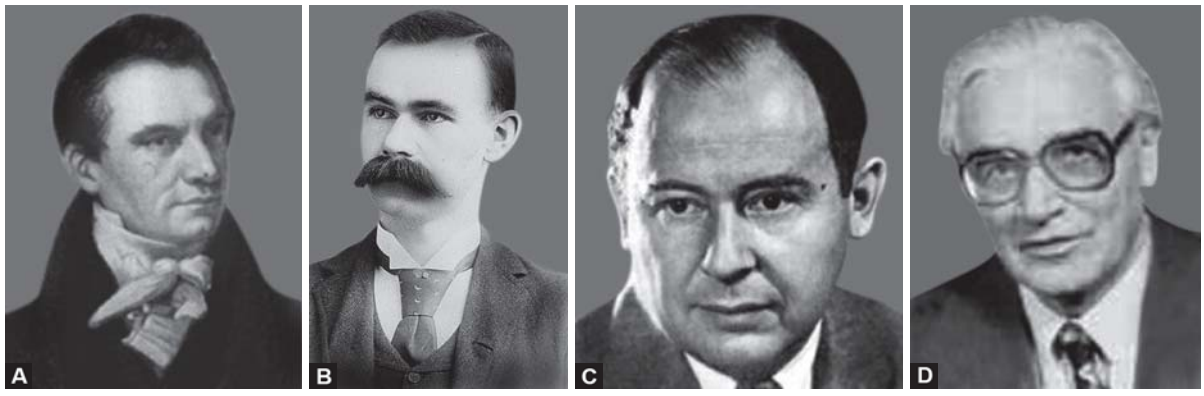
HISTORY OF THE COMPUTERS' DEVELOPMENT

Although with the electronic computer which is the invention of our age, the attempts of the construction of the first machine for the processing of the information reach far in the history of human civilization. The only and global function of a computer data processing can be naturally separated into the series of the other elementary operations, as for examples are: 'the follow-up of the data, their registration, reproduction, selection, sorting, and comparison' and so on.

The first actual calculating mechanism known to us is the abacus. It was built out of wood and beads. Its purpose is to be a calculating tool used primarily for performing arithmetic processes. It is thought to have been invented by the Babylonians sometime between 1,000 and 500 BC, although some pundits are of the opinion that it was actually invented the Chinese about 5000 years ago. In 1803, Joseph Marie Jacquard began work on an automatic loom that used punched cards to control the manufacturing process. A punch card is a piece of stiff paper that contains digital information represented by the presence of punched cards and was widely used throughout the 19th century for controlling textile looms. The punched card was used through the 20th century in unit record machines for input, processing and data storage. Early digital computers used punched cards as the primary medium for input of both computer programs and data absence of holes in predefined positions. On figures 1A to 2D is presented most important discoverers of hardware and software innovations in history of computer sciences.

THE DEVELOPMENT OF COMPUTERS

The first device for calculation is called Mark I ('automatic sequence controlled calculator') and was constructed by



Babagge Charles (1792-1871) | **Hollerith Herman (1860-1929)** | **Neumann John (1903-1957)** | **Zuse Konrad (1910-1995)**

Figs 1A to D: Pioneers of computer science technologies: Babagge, Hollerith, Neumann and Zuse

Atanasoff John (1903-1995) | **Kilby Jack (1923-2005)** | **Ritchie Dennis (1941-)** | **Gates Bill (1955-)**

Figs 2A to D: Most important researchers in computer science technologies: Atanasoff, Kilby, Ritchie and Gates

Howard Aiken, Harvard scientist. It was the first electromechanical computer which performed the operations without a man. In 1945, John von Neumann prepared a proposal for the EDVAC ('electronic discrete variable automatic computer') that described the logical design of a computer with a 'stored program', where the instructions to the machine would be stored in substantially the same fashion as the data (opposed to above Harvard architecture of Mark I). The second generation computers are computers built from transistors, designed between the mid-1950s and mid-1960s. The speed of the computer is significantly greater and moves in the multiplying about 20 microseconds. In this period are being introduced the symbolic program languages, as for example ALGOL and COBOL.

The third generation computers are built with small-scale integration integrated circuits, designed after the mid-1960s. Third generation computers use semiconductor memories in addition to, and later instead of, ferrite core memory. The two main types of semiconductor memory are read only memory (ROM) and read-and-write memories called random access memory (RAM). The computers of forth generation were built in 1971 on the principle so called very large scale integration (VLSI). Fifth generation computer are designed for artificial intelligence (AI) applications. Such systems are expected to be the next technology leap throughout. The sixth generation is beginning with many gains in parallel computing and started in 90s. One of the most dramatic changes in the sixth, the 21st century, generation will be the explosive growth of wide area networking. Network bandwidth has expanded tremendously in the last few years and will continue to improve for the next several years.

COMPUTER CLASSIFICATION

The computers are being classified according to 'the purpose, type and computer size'.[14] According to the purpose the computers can be of the general and specific purposes. The computers for the general purpose serve for the commercial applications or any other application that is necessary.

Some computers are built only for specific person such as monitor for vital function of patient in medicine or control satellite in space. It is usually not possible to modify the purpose of computer. According to the type the computers are divided onto 'analogs and digital'. The analogous computer 'works on the principle of the analogy of the different physical processes,' and is in the state to memorize the different sizes by means of the different values of the electric current strength in the individual points inside the computer.

The computers have also the third feature—they are programmable. According to this the computers have:[14]

- Possibility to manipulate with the data
- Possibility of the programming
- Possibility of the communication with the users, and
- Capability of the decision making.

MEDICAL INFORMATICS—DEFINITIONS AND CONCEPTS

If medical informatics is regarded as a scientific discipline dealing with theory and practice of information processes in medicine, comprising data communication by information and communication technologies (ICT), with computers as an especially important ICT, then it can be stated that the history medical informatics is connected with the beginnings of computer usage in medicine (Figs 3A to 5F).

Medical informatics has been emerging as a discipline in its own right over the past quarter century and there have been a number of notable attempts along the way to define the field in scientific and formal yet succinct terms.

Definition of Morris F Collen is: 'Medical informatics is the application of computer technology to all fields of medicine-medical care, medical teaching and medical research'.

Robert S Ledley (1926-) **Eugene Garfield (1925-)**

Figs 3A and B: Medical informatics researchers: Ledley and Garfield

Definition of Donald AB Lindberg is: 'Medical informatics attempts to provide the theoretical and scientific basis for the application of computer and automated information systems to biomedicine and health affairs... medical informatics studies biomedical information, data and knowledge—their storage, retrieval, and optimal use for problem-solving and decision-making'.

One of the most recent definitions of medical informatics, which stated the Association of American Medical Faculties (AAMC), sounds like: 'The medical informatics is the collection of knowledge and methods for organization and government of the information, which supports medical researches, education and patients care'.

THE POSITION OF MEDICAL INFORMATICS IN THE MEDICINE

The medical informatics is the foundation for understanding and practice of the up-to-day medicine. Its basic tool is the computer, subject of studying and the means by which the aspects and achievement in the new knowledge in studying of a man, his health and disease and functioning of the total health activities is performed. The theoretical nucleus of information and medical informatics science represents those theoretical and practical disciplines: information theory, system theory, decision theory, communication theory, structuring and information organization, forming of databases, informational documentation systems, classification theory, semiotics, organizational sciences, biostatistics, epidemiology, health politics, medical ethics, etc.

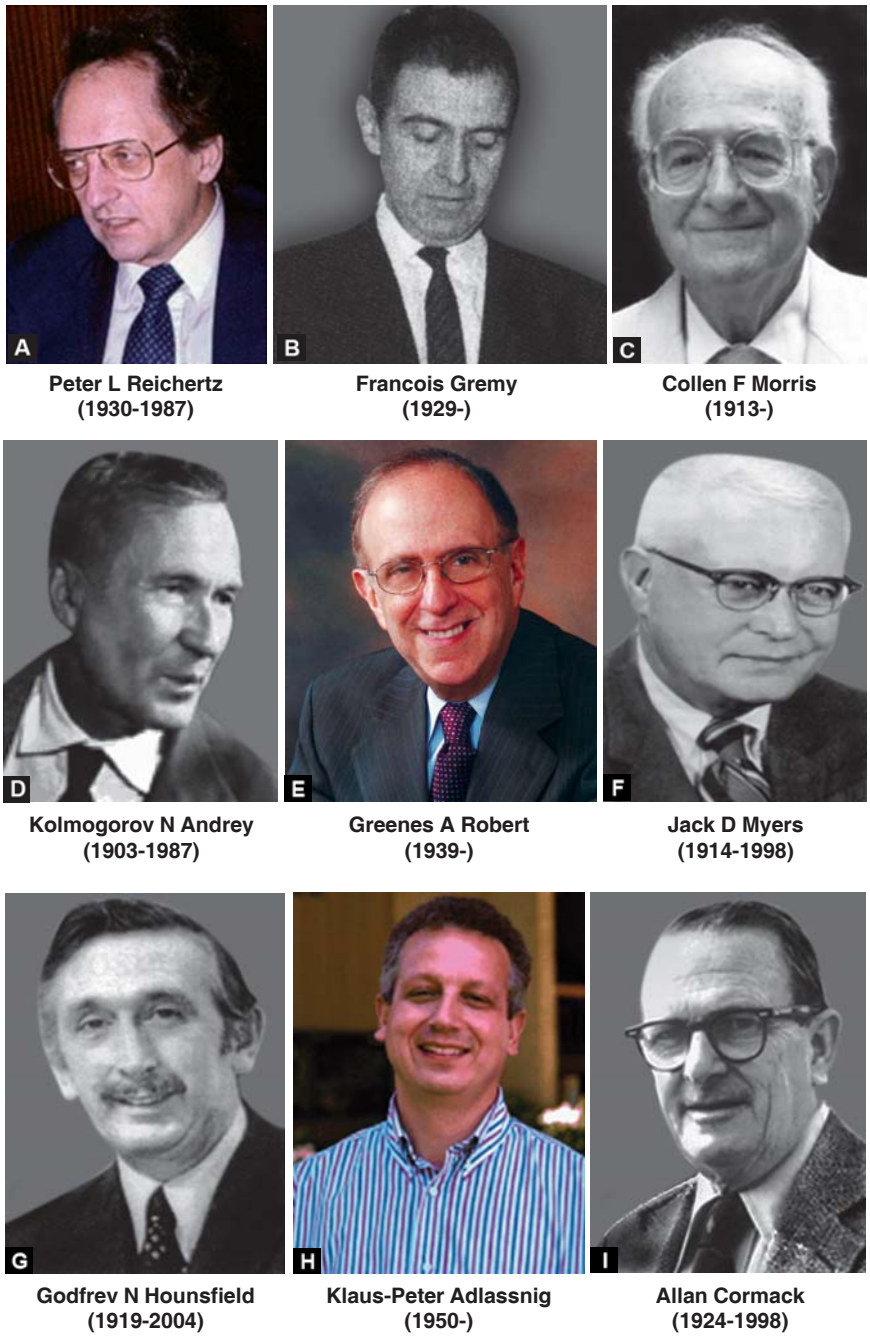
Methods of Medical Informatics

The medical aspects of the methodologies which they consider necessary for the creation of the medical informatics as scientific discipline are as follows:

- Tests evaluation data collecting method regarding to the objectivity, sensitivity, confidence and value
- Analysis of data informational contents
- Analysis and formal treatment of medical opinion and actions
- Evaluation of usefulness of medical decisions and actions
- Regulation of the theoretic concept of causative inter-relation between the objects and processes
- System analysis in health care: modeling and simulations.

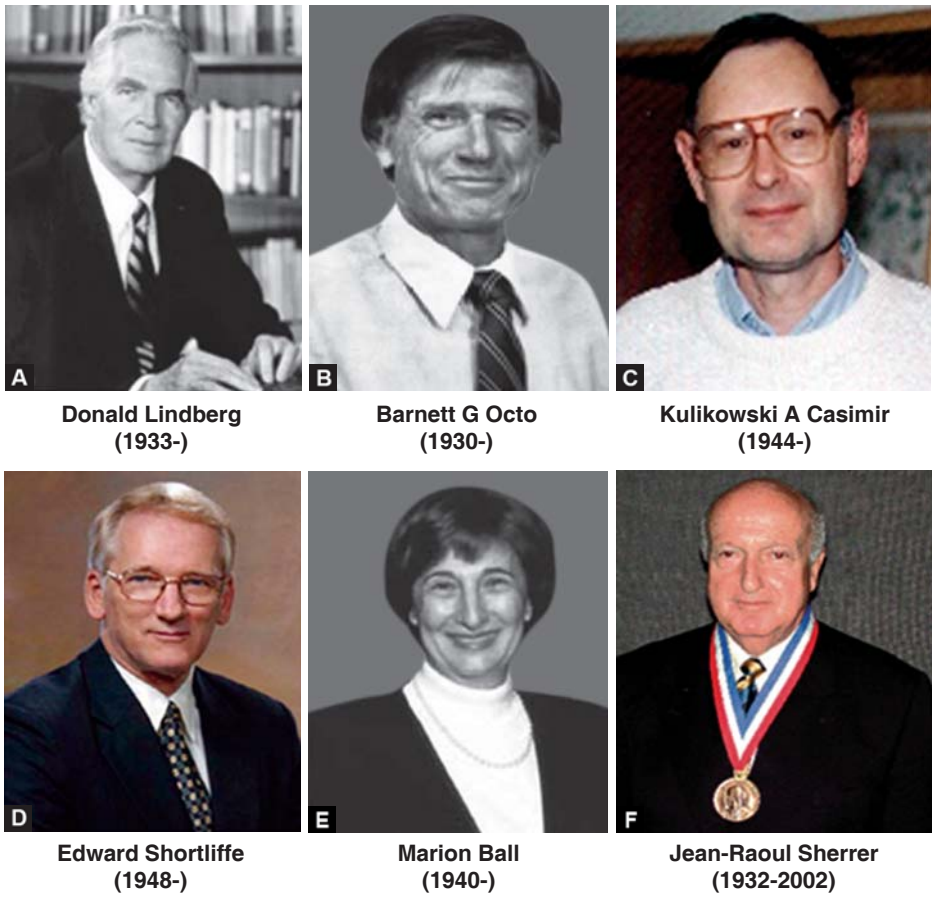
FIVE GENERATIONS IN DEVELOPMENT OF MEDICAL INFORMATICS

The first period from 1955 till 1965 mainly is characterized by experimenting, and the studying of the new technologies



Figs 4A to I: Medical statistics and informatics experts: Reichertz, Gremy, Collen, Kolmogorov, Greenes, Jack, Hounsfield, Adlassnig and Cormack

in the medicine. The pioneers of medical informatics are Joshua Lederberg and William S Yamamoto who early showed interest in automatic calculation in the 40s of the 20th century. The important work of Robert S Ledley, as the first medical professional working with the first computer of the pretransistor era SEAC on the development of new computing methods in the field of symbolic logics is described, leading later to his famous work with Lee B Lusted in automatic medical decision making. Another important step in medical informatics history was the development of BMDP software (biomedical programs) by Wilfrid J Dixon and collaborators, allowing the use of computers in biostatistics. As the first project in the field of computerized diagnostics, resulting from an incentive of Arthur E Rickli, Cesar A Caceres and Hubert V Pipberger developed a method for automatic analysis of electrocardiograms. The introduction of ARPANET, an early forerunner of internet, is noted as an important step for development of computerized medical applications. The history of the development of health information systems, computerization of clinical laboratories, computerized medical records, automated multiphase health screening is



Figs 5A to F: Important medical informatics experts: Lindberg, Barnett, Kulikowski, Shortliffe, Ball and Sherrer

presented. The names as G Octo Barnett from the Massachusetts General Hospital, Wesley Clark and Charles Molnar from the Massachusetts Institute of Technology, William Hammond from the Duke University, Lawrence L Weed from the University of Vermont, Morris F Collen from the Kaiser Permanente Medical Care, and others are mentioned. The National Institute for Health care in USA (NIH) in 1960 founded the advisory committee for the computer application in the researchers (ACCR) with significant material investment of money (about 40 million dollars), induced the development in the field of automatization of the medical health care services, of modeling and simulation, equipment and instrumentarium, recognition of samples, training in biomedical of literature. That was the strong stimulus to the rapid development of the medical informatics, first of all in USA, and then in the whole world. In this period appeared also the first prototype of the (BIS) clinical information system in El Camino Hospital in California.

The second period from 1965 till 1975 characterizes the numerous invention activities of adequate solutions for the automatized data processing. By the end of the sixties West European countries were establishing the numerous hospital information systems. Firstly, medical equipment with built in computers were applied. The new biomedical engineer disciplines were developed; new diagnostic methods and therapeutic procedures based on the microprocessing technology were introduced. The development of medical informatics in Europe was presented, describing the pioneering role of Peter L Reichertz in Germany and Francois Gremy in France. First hospital information systems in Europe were implemented during the late sixties in Sweden (Danderyd and Karolinska Hospital), Great Britain (Kings Hospital in London) and Germany (Medizinische System Hannover). In 1979 the first Nobel prize in physiology and medicine was given for an achievement in medical informatics, the computer tomography—the laureates were Godfrey N Hounsfield and Allan M Cormack. Computer-assisted medical decision making started to develop significantly in the seventies in USA with the consultation system HELP of Homer R Warner and collaborators. In early seventies the development of artificial intelligence methods and expert systems was noted. In this connection, presented were the systems Dendral of Edward Feigenbaum, Bruce Buchanan, Joshua Lederberg and Carl Djerassi, Internist-I of Jack D

Myers and collaborators, Casnet of Casimir A Kulikowski and Sholom M Weiss, Mycin and Oncocin of Edward H Shortliffe and collaborators, Cardiag-2 of Klaus-Peter Adlassnig, Kardio of Ivan Bratko and collaborators.

The third period from 1975 till 1985 year is significant with the progress of computer technique development when it became cheaper, which lead to very intensive development of the information system at all the levels of health care system, from the primary to the quarterly level. The interest for education by health workers grew being engaged by medical informatics. The expert and scientific assemblies from the field of the medical informatics become with time more and more numerous and assembled a lot of experts of all profiles, including also the significant number of doctor who began to engage in the medical informatics professionally. Important congresses were organized: 11 world congresses on medical informatics organized by International Medical Informatics Association (IMIA), founded 1974 and 20 European congresses organized by European Federation of Medical Informatics (EFMI), founded in 1976. In this period appear the (software) packages on market, becoming the profitable venture with the significant commercial effects. Only in USA, during those years, they had 25 producers for the health care information systems with year turnover between 5 and 7 milliard dollars.

This period is characterized also by the appearance of PC at the world market with the perfected technical-technologic performances, especially by memory capacities, which enabled the powerful development of informatics in health care system. Besides, the intensive and mass application of PC opened the new possibilities—namely connecting computers from home ambulance directly to the informational systems in health care centers.

The installation of terminals was being intensified by patient beds (bed side terminal), when medical nurses for their current tasks, and patients—if they are able to—had possibilities of correcting wrongly taken data.

The fourth period from 1985 to 1995 was the new phase of medical informatics development. And further was the development of health care informatics intensified and was meeting high standards through new manner enabling processing and standardization of knowledge. Intensive researches on improvement of methods and technique of artificial intelligence was conducted, and included development and application of expert system in medical diagnostics and therapy. The artificial intelligence was being introduced as separate discipline of medical informatics, and began to be used by numerous expert systems in practice, about which we will speak later.

The hospital information systems, in this period, became more complex, more functional and more qualitative than the previous ones and supported greater number of hospital function. These systems were composed of more independent modules integrated by contemporary communications into unique system which supported all functions of a health care organization regardless to its size and complexity. Formerly built in information systems they integrated primary health care (ISPHC) and hospital information systems (HIS) into complex systems both on regional and national level. Such approach showed significant advantages in the development of BIS. Especially intensive connection of hospitals with private doctor surgeries by computer technologies was seen in USA.

In recent years, the clinical (department) information systems ('clinical departmental systems') with applications into HIS are being developed supporting connection of a patient and definite medical specialization, supporting decisions making in everyday medical work.

Fifth period from 1995 to present, development of medical informatics cannot be separated from development of computer technologies. With regard to this, we have to emphasize the fact once again, that the area of the medical informatics significantly grows wider than just the application of electronic computers, although the technical development of microprocessor and telecommunication technologies are significantly influenced by the development of the medical informatics and cannot be imagined without electronic computers. At the beginning the technical foundation ('hardware'), is necessary for support of informational systems development, and was unimproved and inadequate so that the beginning of applications in this region were modest and limited. In the meantime, however, accounting and computer technologies immensely advanced. For example, the appearance of electronic computers with network of terminals significantly influenced integration of informatics methods into medical segments in health care work sites, which was the basis for development of health care information systems in all segments of health care activities. Investment in huge material means of payment and adequate human potentials in this high specialized development resulted with significant improvements of hardware and software technologies, mostly in the domain of projecting on basis of high quality language of the fourth and fifth generation of computers. All this brought to the expansion the use of microprocessor technology in the diagnostic systems, and expansion of technology usage brought to wider use of microprocessor technologies and led to so called 'information revolution' of our time, resulting in application

of informatics methods in doctor surgery, building of informatics equipment, instrumentation and prostheses.

Behind us is five generations of computers, and already considerably is being done upon the sixth generation, of which hardware basis makes the 'biochip' as a foundation of microcomputers. This is completely new technique which, according to many, approaches to physiologic mechanism of neural synapsis in human brain. The contemporary informatics technology enables current realization of Lusted and other pioneers idea for medical computer application, especially in the domain of medical decisions making. By this the medical informatics becomes the basic discipline of nowadays medical science and practice.[19,20]

INFORMATION TECHNOLOGIES IN MEDICINE IN THE NEW MILLENIUM

Current network system possesses the limited global performance in the organization of health care, and that is especially expressed in the clinical medicine, where the computer technology has not received the wanted applications yet.

The appearance of the new initiative about the information technologies of the 21st century (IT2) urged specially the government of USA to take over the leadership and to build in the development program three key areas: (a) the final achievement of the computerization and processing (HECC), (b) the wide network diapason (LSN) and (c) initiation of inauguratory generation of internet (NGI).

The future prototype is development of quantum computers (QC) which will fall into the sphere of a technological development which reaches to artistic levels. The beginning speed is built in from 2 Qubit of multi-technologic method of hardware components designing. The high performances of storage system, the new system of software architecture for the initial 'petaflop' platform, the new iterative methods for solving of linear system, special languages, and modified computers are one of the characteristics of the new direction.[18,21]

Using the powerful supercomputer by molecular dynamic simulation solved the mystery about the fastest and the most efficacious enzyme in human organism acetylcholine esterase (AChE). The scientists from Huston University identified AChE in 152 picoseconds. Fluctuations of the substrate (ACh) enable the movement into active area outside. The researches illustrate that the enzyme by its movements selects the special substances or matters in the condensed milieu similar to that in vivid organisms.

The researchers NPACI have developed software for ectasia or gray-white mass of the cortical surface using the high resolution 3D with the data about human brain obtained from UCLA.

The methods of the dynamic programming were used for the defining of great number of contours of which the surface is gray and white mass, by using square resolution based on UCLA data.

Using the supercomputers, the psychiatrists are enabled to improve the continued monitoring (online) and to study the phenomenon of the forming of memory in human brain using the combination of two methods (EEG) and (IMRI). Microprocessor performances of supercomputers could soon enable usage of MRI scanners.

In this way usage of IMRI in psychiatry would be facilitated, monitoring the influence of drugs, and planning the operation in neurosurgery.

The new software for modeling the circulation and other body fluids is called 'NekTar'. This should enable the acceptance of the changes in the surgical practice for the treatment of the disease like arteriosclerosis. The precise models of circulations of body fluids would solve the complexity, not only of arteries, veins and valves which contain and transfer oxygen, but also the transport of the waste substances, as well as those which help heating and cooling of the body (Bracon University Research NCSA).

NRCAM immediately developed the computer models 3D for physiologic processes in the individual cells. The latest (recent) studies on 'virtual cell' about the dynamics of calcium in cell neuroblasts and cardiomyositis includes the modeling of diffusion processes in mitochondria, and the examination role of (Ca_2+) and in provoking Ca_2+ 'sparks' (shock) in the heart and analysis of structural changes in endoplasmic reticulum during the time of the activation of the egg.

The use of LSN is nowadays limited of the popular applications as 'e-mail' and (WWWG) World Wide Web browsers which have completely changed the manner of exploiting also of computer network.

The key of the development in the area, LSN includes the new components for use in the network, technologies in the domain LSN. Next several following lines illustrate future of LSN development in USA:

- There was increased efficacy of network line development technologies which were financed by the federal government as well as increased efficacy of federal network development.
- It became possible to intensify application of network improving the federal goals.

- Using inside agency collaboration in LSN and R&D. Discovery of the mechanisms for the co-operation in LSN and R&D between federal agencies, government laboratories, academies and industry.

The network system for biomedical researches is realized through implementation of quick 'interfaces' connections in the computer infrastructure so that the members of the teams for biomedical researches would have better approach. In this purpose the infrastructure Frederick Biomedical Supercomputing Center (FBSC) was used.

The development high performance parallel interface (HIPPI) and the optical channels is spread by new program about the use of systems based upon the interaction between the figure and voice for biomedical researches.

Application of telemedicine in preserving people health is actual. National Library of Medicine (NLM) supports the network connection between hospitals, clinics, doctor's surgeries, medical school, library, universities so that the users and the researchers could have the access to medical data. In the same time, the users could be connected from the far distant places, so that the patients could receive the treatment in real time including technologies for monitoring of anatomic photographs, analysis of X-ray (photographs), CAT scans computerized axial tomography, PAT scans tomography on basis of positron emission, D-basis for preservation, access and transfer of medical data about the patient, with the guarantee for accuracy and privacy of those data.

The USA federal government, together with other countries, created the funds for development of strong network which would represent the last word of the informational and communicational technologies.

Such a multimedia concept would be used at schools, work and at home. NGI initiative has the following three goals:

- The development would be directed to the next generation of internet with the improved performance and with expanded functionality as follows: reliability, security, resistance, servicing, new management and common 'bandwidth'.
- The development of NGI system for future technologies and their applications testing is planned to connect at least 100 pages hundred times (100×) with greater speeds than the internet from 1997, thousand times (1,000×) test system would connect[20] health stations with thousand times greater velocity than internet from 1997.
- The development and demonstration of following revolutionary technologies as well as technologies which collaborate closely: the digital libraries, distributed computers which guarantee the privacy and security, the telemetry operations, simulations, with special application in the basic sciences, crisis management, environment, the federal informational services, health care protection and production.

The medical programs will be used, for example in, supervision of teletraumas, at telemonograph and so on., aiming to improve the prices, quality, use, efficacy, security, health care protection, health education and the development of health care system. The new systems will be able to control, feel, govern (or rule) units from the distance, transfer the immense number of data with great correctness. Security and temporality without faults will take care about the secrecy of the medical data.

It is possible to examine brain function in the real time when the brain is in 'action' method (fMRI). The telemetry monitoring of activity of patient brain 'brain in action' is possible when patients are performing the cognitive or sensor motor tasks. Neurosurgeon, neurologist, psychiatrist and scientist could study the brain functions and establish the diagnosis, and finally treat brain diseases. With this technology, the neurosurgeon will be able to remove tumor for the wanted place, and in this way, avoid the special cognitive and sensor motor fibers (or threads) located close to tumor.

PERSPECTIVES OF THE DEVELOPMENT OF MEDICAL INFORMATICS

In front of us lies the brilliant future of the medical informatics. It should expect that the application of terminal and PC with more simple manners of operation will enable routine use of computer technology by all health professionals. The development of nature languages for communication with the computers and the identification of input voice will make the work simpler. The use of network systems and a great number of 'bed side terminals' will significantly make easier the communications among the health care personnel and optimize the diagnostics, care and treatment of patients. In accordance with that, it is anticipated that telemedicine technique as well as the technique of 'telecaring' will be further improved. This will open the great possibilities of establishing the diagnosis and granting the advices from distance, enabling patients to live in their natural encirclement conditions being under monitor control.

The health care informational systems will be a lot mightier with the synthesis of data base about the patient and the basis of medical knowledge with expert systems. In the framework of such a functional integration will be built in the dictionary of medical terms ('data dictionary'). In that way the new health care informational systems will

unite the complete history of the disease ('medical record') as well as the bases of knowledge into unique system which will be oriented to the support of medical work.[18] In the scope of hospital informational systems the progress is expected in the field of treatment and falling (away) of medical pictures. In the field of data protection new solutions are also expected. In the region countries of European community are intensively working on unique standards creation, classifications, nomenclatures and coding. In that manner, the conditions for integration of national health care informational systems and transportability of software will be created.

Summarizing the current problems we emphasize prioritized tasks which are looking for the solution:[1]

- Standards of coding of alphanumeric data and text
- Standards of coding of pictures and bio signals
- Integration of medical instrumentarium and equipment
- Basis of knowledge as well as systems for the support of decisions
- Multimedical working stations, communication networks and the system of falling (away)
- Modulation and integration of health care informational systems
- Regulation of rules and recommendations (medical, legal proceedings, ethical, economic and social ones); for the realization of these tasks high coordination of actions is necessary for all health professional persons, medical informaticians, of the informatics professional persons and politicians who are responsible for health care protections with the insurance of constant sources of financing.

EDUCATION IN MEDICAL INFORMATICS AND ITS PERSPECTIVES

It is realized at an early stage that there are needs for education in informatics of wide circle of health care personnel, and especially doctors. Still 1968 Toddo's commission for the medical education in Great Britain states that there is necessity for medical students to be educated in informatics, since the electronic computers will have very important role in the work of doctors in future. The development of the principle of medicoinformatic education has lived to see new strong stimulus after that the Association of American Medical Faculties (AAMC) have realized its ambitious program for education of doctors for XXI century. We will enumerate some of the more important conclusions of that program as follows:

- The medical faculties should determine some academic unit for the institutional leadership in the informatics and computers technologies application in general professional education of doctors and other medical personnel
- The students have to develop the skills about the computer application in taking care for patients, education and clinical researches
- The condition for acceptance at the medical faculty should be the elementary knowledge of handling with computer or even to possess PC
- Universities, faculties and adequate funds should support the basic researches in medical informatics.

The instruction in medical informatics has been introduced at the numerous medical faculties all over the world. In Europe the medical informatics is the obliged subject in medical curricula in majority of universities. For example, in Germany all 27 medical faculties have tuition in medical informatics. In USA the teaching programs in the medical informatics exist in 37 medical faculties, universities or hospitals, and the instruction has been introduced also for dentistry, pharmacy faculties and the medical secondary schools for nurses. In these academic centers, methods for knowledge presentation, artificial intelligence, decision making analysis, the computers supported medical education, are being taught, governing with data bases and the clinic records systems. Regarding the experts profile, the most popular is the connection between internal medicine and medical informatics, in order to emphasize the importance of keeping up with the clinical practice in this field. The special place in the creation of education strategy of medical informatics development in the World and European scope, the contents recommendations and work methods, comes from this field have International Medical Informatics Association (IMIA) and the European Federation of Medical Informatics (EFMI) (Figs 6 to 8).[22-24]

IMIA was founded in 1967 as the Technical Committee of the International Federation of Information Processing TC4 (IFIP-TC4). In 1974 in Stockholm, during IFIP meeting, chaired by professor Francois Gremy, IMIA became the special interest group, and Jan Roukens, the Dutch representative in TC4 was elected as his first president. As the first chairman and moderator of TC4, Gremy is considered to be the first President of its renamed and refocused successor of IMIA. The role of IFIP-TC4 in bringing together early health informaticians cannot be underestimated.[19] As independent scientific and professional organization IMIA had scientific and other activities which it carries out through 19 various working groups: WG1-Health and Medical Informatics Education, WG2-Consumer Health Informatics, WG3-Intelligent Data Analysis and Data Mining, WG4-Security in Health Information Systems, WG5-Primary Health Care Informatics, WG6-Medical Concept Representation, WG7-Biomedical Pattern Recognition, WG8-Mental Health

Fig. 6: Izet Masic, Klaus Peter Adlassnig and Jacob Hofdijk, chairs of MIE 2009 Conference in Sarajevo (from left to right)

Fig. 7: Rolf Engelbrecht, John Mantas, Jan van Bemmel and Izet Masic, Medical Informatics Teachers at Universities in Chinua, Athens, Rotterdam and Sarajevo (from left to right)

Fig. 8: Dianne Withouse, Izet Masic, Arie Hasman, Kasimir Kulikowski, Jana Zvarova, George Mihalas, Marion Ball and Jan van Bemmel in Prague, April 2013, as panelist about medical informatics history, regarding 50 years of IMIA (from left to right)

Informatics, WG9-Health Informatics for Development, WG10-Health Information Systems, WG11-Dental Informatics, WG12-Biomedical Statistics and Information Processing, WG13-Organizational and Social Issues, WG15-Technology Assessment and Quality Development in Health Informatics, WG16-Standards in Health Care informatics, Telematics in Health Care, IGM-Informatics in Genomic Medicine, Human Factors Engineering for Healthcare Informatics, Open Source Health Informatics, SIG NI Nursing Informatics, Smart Homes and Ambient Assisted Living. Up to now the IMIA has organized the great number of scientific and expert meetings; every working group has its year scientific assemblies. The World Congresses of Medical Informatics (MEDINFO), which are being organized every third group of the medical informatics (MEDINFO), which IMIA organizes every third years, they were held by the following sequence: Stockholm (1974), Toronto (1977), Tokyo (1980), Amsterdam (1983), Washington (1986), Beijing/Singapore (1989), Geneva (1992), Vancouver (1995), Seul (1998), London (2001), San Francisco (2004), Brisbane (2007), Cape Town (2010). The following MEDINFO will be held in Copenhagen (2013), IMIA today amounts 40 countries, having full civil rights of members, among which is also Bosnia and Herzegovina (member from 1994) and 18 observed member countries.

EFMI has formed in 1976, and nowadays counts 31 member countries, among which is also Bosnia and Herzegovina, as official member country since 1994. EFMI has 16 working groups: CARDS-Cards in Health Care, Social Security and Welfare, EDU-Education in Health Informatics, EHR-Electronic Health Record, EVAL-Assessment of Health Information Systems, IDR-Informatics for Disabled people and Rehabilitation, IPAM-Information Planning and Modeling in Health Care, LIFOSS-Libre/Free and Open Source Software, MCMS-MBDS, Case Mix and Severity of cases, MICIT-Medical Informatics in Transition Countries, MIP-Medical Imaging Processing, NLU-Natural Language Understanding, NURSIE-Nursing Informatics in Europe, HOFMI-Human and Organizational Factors of Medical Informatics, PCI-Primary Care Informatics, SSE-Safety, Security and Ethics, TRA-Traceability.

Up-to-day EMFI organized 15 European congresses of medical informatics (MIE): Cambridge (1978), Berlin (1979), Oslo (1988), Glasgow (1990), Vienna (1991), Jerusalem (1993), Lisbon (1994), Copenhagen (1996), Thessaloniki (1997), Ljubljana (1999), Hannover (2000), Budapest (2002), St Malo (2003), Geneva (2005), Maastricht (2006), Gothenburg (2008), Sarajevo (2009), Oslo (2011), Pisa (2012). In 2014 MIE will be organized in Istanbul.

Regarding the future of medical informatics education there are numerous controversies. Everybody agrees that the medical informatics is very significant for the whole

health care and for the needs for personnel. However, there is not yet the general agreement regarding the teaching programs, because the medical informatics is very involved and propulsive, what makes the performance of the stable education programs more difficult. There are also not general agreement in which year of studying should transfer the knowledge from medical informatics. The majority of the experts still agree that the priority should be given in later study years, since more and more students enroll the faculties with prior informatics illiteracy, and the comprehension of some medical informatics fields is not possible without prior clinical knowledge.

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