Introduction in Medical Informatics

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Medical Informatics Term

The term medical informatics dates from the second half of the 1970s and was borrowed from the French expression informatique médicale. Before that time, other names were used such as medical computer science, medical information science, computers in medicine, health informatics, and more specialized terms such as nursing informatics, dental informatics, and so on.

Medical Informatics Term

The name ‘health informatics’ only came into use around 1973.

Health informatics is particularly focused on:

- Understanding the fundamental nature of these information and communication systems, and describing the principles which shape them,
- Developing interventions which can improve upon existing information and communication systems,
- Developing methods and principles which allow such interventions to be designed,
- Evaluating the impact of these interventions on the way individuals or organizations work, or on the outcome of the work.

Medical Informatics

Health Informatics or sometimes Medical Informatics is the intersection of *information science*, *medicine* and *health care*. It deals with the *resources, devices and methods* required to optimize the acquisition, storage, retrieval and use of information in health and biomedicine. Health informatics tools include not only computers but also *clinical guidelines*, *formal medical terminologies*, and *information* and *communication systems.*

Subdomains of (bio)medical or health informatics include: *clinical informatics, nursing informatics, imaging informatics, consumer health informatics, public health informatics, dental informatics, clinical research informatics, and bioinformatics, and pharmacy informatics.*

Medical Informatics

Aspects of the field

1. architectures for **electronic medical records (EMR)** and other **health information systems** used for billing, scheduling or research
2. **decision support systems (DSS)** in healthcare
3. **messaging standards** for the exchange of information between health care information systems (e.g., through the use of the **HL7 data exchange standard**) - these specifically define the means to exchange data, not the content
4. controlled **medical vocabularies** such as ***the Standardized Nomenclature of Medicine, Clinical Terms (SNOMED-CT), Logical Observation Identifiers Names and Codes (LOINC)*** or ***OpenGALEN Common Reference Model*** - used to allow a standard, accurate exchange of data content between systems and providers
5. use of hand-held or portable devices to assist providers with **data entry/retrieval** or **medical decision-making**

International Medical Informatics Association

IMIA or **the International Medical Informatics Association** is an independent organisation that plays a role in promoting and furthering the application of information science in modern society, particularly in the fields of healthcare, bioscience and medicine. It was established in 1967 as a technical committee of the International Federation for Information Processing **(IFIP**). It became an independent organisation in 1987 and was established under Swiss law in 1989.

Goals and objectives

1. *the promotion of informatics in health care and biomedical research*
2. *the advancement of international cooperation*
3. *the stimulation of research, development and education*
4. *the dissemination and exchange of information*

The European Federation for Medical Informatics (EFMI) was conceived at a meeting, assisted by the Regional Office for Europe of the World Health Organisation (WHO), in Copenhagen in September 1976.

Working Group EFMI:

- MCMS - MBDS, Case Mix and Severity of cases
- DPS - Data Protection and Security
- NURSIE - Nursing Informatics in Europe
- IPM - Information Planning and Modelling in Health Care
- EDU - Education in Health Informatics
- PCI - Primary Care Informatics
- NLU - Natural Language understanding
- OIMI - Organisational Impact in Medical Informatics
- MICIT - Medical Informatics in Transition Countries
- EVAL - Assessment of Health Information Systems
- EHR - Electronic Health Record
- MIP - Medical Imaging Processing
- CARDS - Cards in Health Care, social Security and Welfare

Ukrainian Association of COMPUTER MEDICINE

UACM was set up in August 1992 in Kharkiv, where the IVth World Congress of WFUPS (World Federation of Ukrainian Physicians Societies) was taking place.

UACM became a national member of International Medical Informatics Association (IMIA) in September 1993 (Kyoto, Japan).

Ukrainian Association of COMPUTER MEDICINE

This Council's terms of reference cover:

- elaboration and discussion of complex computerisation programmed in various fields of healthcare
- analysis and sharing of experience of computer technologies usage according to the situation in Ukraine
- consideration of foreign proposals dealing with introduction and selling of computer technologies in the field of medicine to Ukraine and making proposals to the Ministry of Healthcare of Ukraine to buy them
- progressive directions on elaborating and consideration of possible joint projects
- carrying out expert estimations for receiving state licences

Medical informatics concern with:

- Hospital information system
- Continuity of Care Record (CCR)
- Telehealth
- Telemedicine
- Consumer health informatics
- eHealth
- Bioinformatics
- Dental informatics
- Nursing informatics

E-Health

eHealth is a relatively recent term for health care practice which is supported by electronic processes and communication, some people would argue the term is interchangeable with *Health care informatics*. However, the term e-health encompasses a whole range of services that are at the edge of *medicine/healthcare* and *information technology*:

- **Electronic Medical Records**
- **Telemedicine**
- **Evidence Based Medicine**
- **Citizen-oriented Information Provision**
- **Specialist-oriented Information Provision**
- **Virtual healthcare teams**

Evidence-based medicine

Evidence-based medicine (**EBM**) is a medical movement based upon the application of the scientific method to medical practice, recognizing that many long-established medical traditions are not yet subjected to adequate scientific scrutiny. According to the Centre for Evidence-Based Medicine, ***"Evidence-based medicine is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients.“***

Evidence-based medicine

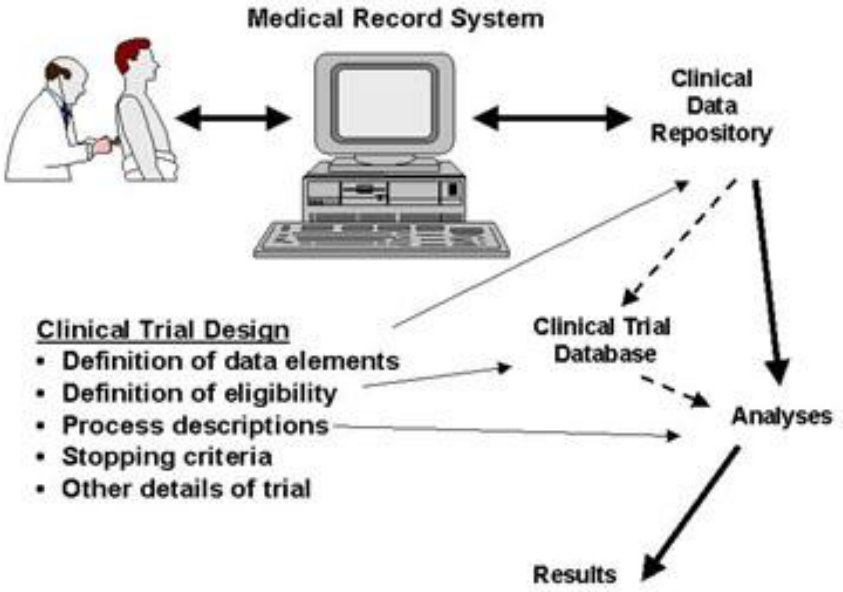
Practising evidence-based medicine implies not only clinical expertise, but expertise in retrieving, interpreting, and applying the results of scientific studies, and in communicating the risks and benefit of different courses of action to patients.

For all its problems, evidence-based medicine has very successfully demoted the ex cathedra statement of the "medical expert" to the least valid form of evidence, and all "experts" are now expected to be able to reference their pronouncements to the relevant literature. One way that physicians facilitate the integration of evidence-based medicine in daily practice is via participation in a journal club.

Electronic medical record

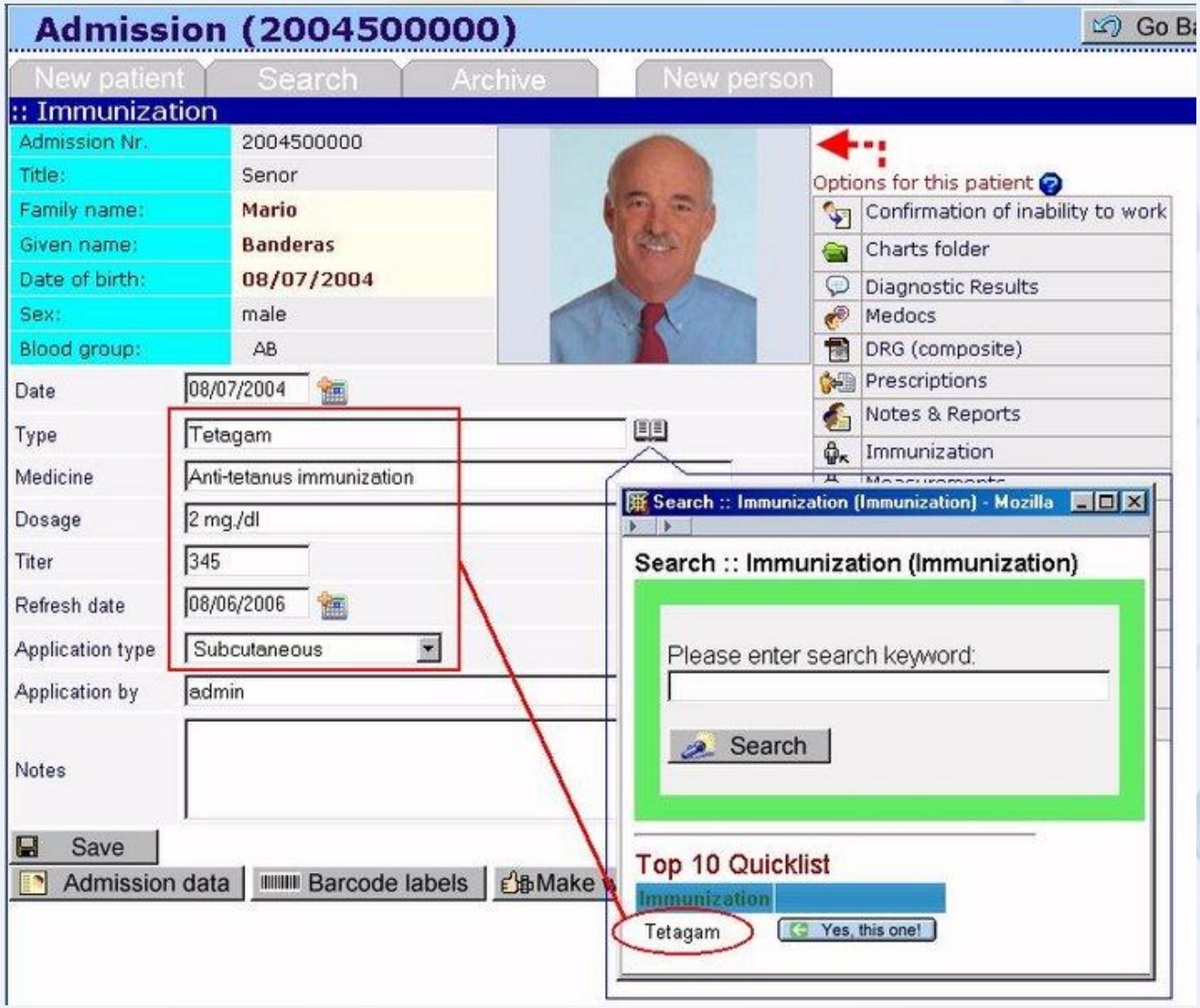
- **An electronic medical record (EMR)** is a computer-based patient medical record.
- **An EMR facilitates:**

1. ***access of patient data by clinical staff at any given location***
2. ***accurate and complete claims processing by insurance companies***
3. ***building automated checks for drug and allergy interactions***
4. ***clinical notes***
5. ***prescriptions***
6. ***scheduling***
7. ***sending to and viewing by labs***



The term has become expanded to include systems which keep track of other relevant medical information. The practice management system is the medical office functions which support and surround the electronic medical record.

A health information system's automatic immunization data entry in the patient's admission module



Telemedicine

The term **Telemedicine** is the delivery of medicine at a distance. The term is composed of the Greek word τελε (tele) meaning 'far', and medicine.

Definition

A more extensive definition is that it is ***the use of modern telecommunication and information technologies for the provision of clinical care to individuals located at a distance and to the transmission of information to provide that care***.

The terms **e-health** and **tele-health** are at times interchanged with **telemedicine.**

There are two basic forms of telemedicine in its current implementation: **live**, and **store-and-forward**. There is of course more to telemedicine, but this simplistic application is fast becoming ubiquitous.

Live telemedicine could be a telephone call, but more typically refers to **a videoconference link**. This requires the presence of both parties at the same time and a high-bandwidth, low-latency connection. At a minimum audio and video are involved, with remote tactile support sometimes also being present.

Telemedicine

- **Store-and-forward telemedicine** involves acquiring data, images and/or video and transmitting this material to a doctor or medical specialist at a convenient time for assessment offline. It does not require the presence of both parties at the same time, and the bandwidth of the connection need not be high. Latency is also not a problem.

- A proper Telemedicine interaction would involve store and forward followed by a live interaction. For this, time tables are created e.g. JJ Hospital shall be talking to BB Clinic at 11.00 Hrs to discuss patient ABC. Ideally these **Telemedicine Consultation Sessions (TCS)** should be done in the presence of the patient as well as the referring doctor on one side and the specialist on the other. For emergencies, initial links established by mobile telephones, requesting each other to come online immediately.

- Telemedicine is most useful when patients are extremely isolated (such as overwintering in Antarctica, remote communities in Australia, Africa and Alaska) or where specialist services are in very high demand.

- Medical specialties using telemedicine usually rely a great deal on **images** (still or moving) in the service delivery - assessment, diagnosis and management. Radiology services have been delivered by telemedicine for many years. Psychiatry, cardiology, ophthalmology, otolaryngology, dermatology and pathology are more recent users. Home care is often delivered by telemedicine.

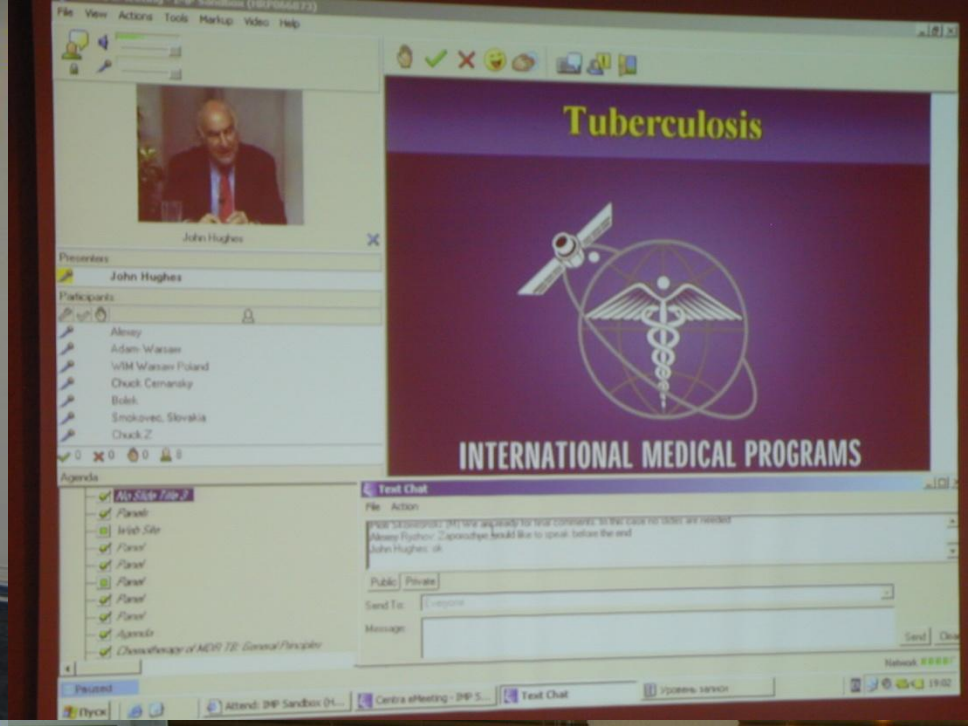
- **Telesurgery** may also be considered as a subset of telemedicine

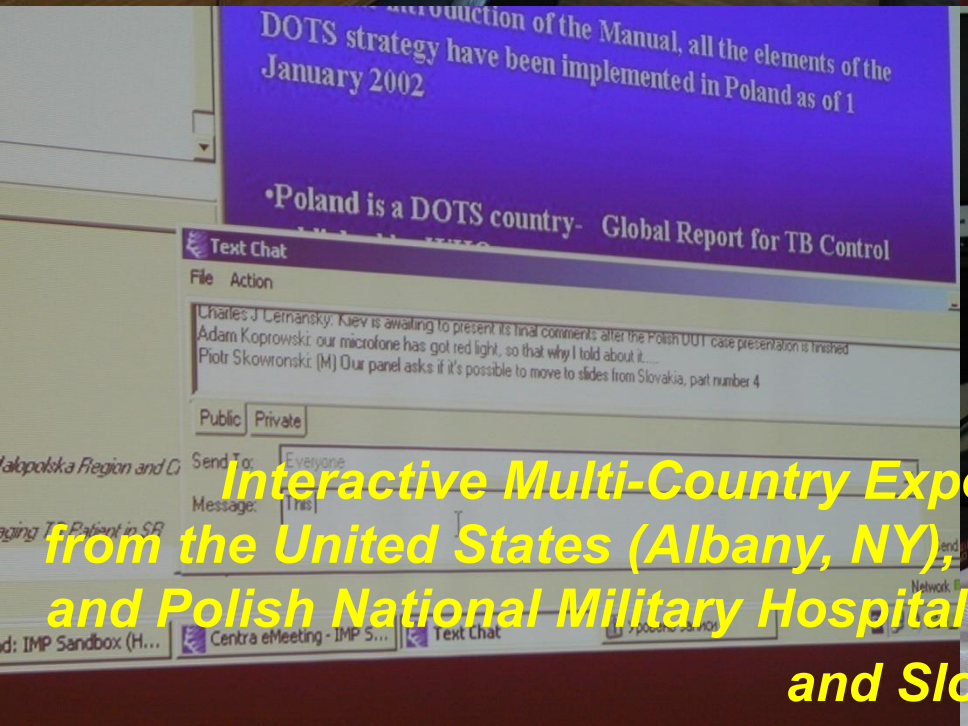
Telehealth

Telehealth is the delivery of health related services, enabled by the innovative use of technology, such as videoconferencing, without the need for travel.

Telehealth can refer to:

1. Transmission of medical images for diagnosis (referred to as store and forward telehealth)
2. Groups or individuals exchanging health services or education live via videoconference (real-time telehealth)
3. Health advice by telephone
4. Store and forward telehealth (for example teleradiology) is an established way of accessing a specialist opinion without needing to be in the same room. In most store and forward examples an immediate response is not critical.
5. Real time telehealth (for example telepsychiatry) uses videoconferencing and is an established way of health providers and consumers interacting face to face in real time more often, with whomever they need and on an ad-hoc basis.





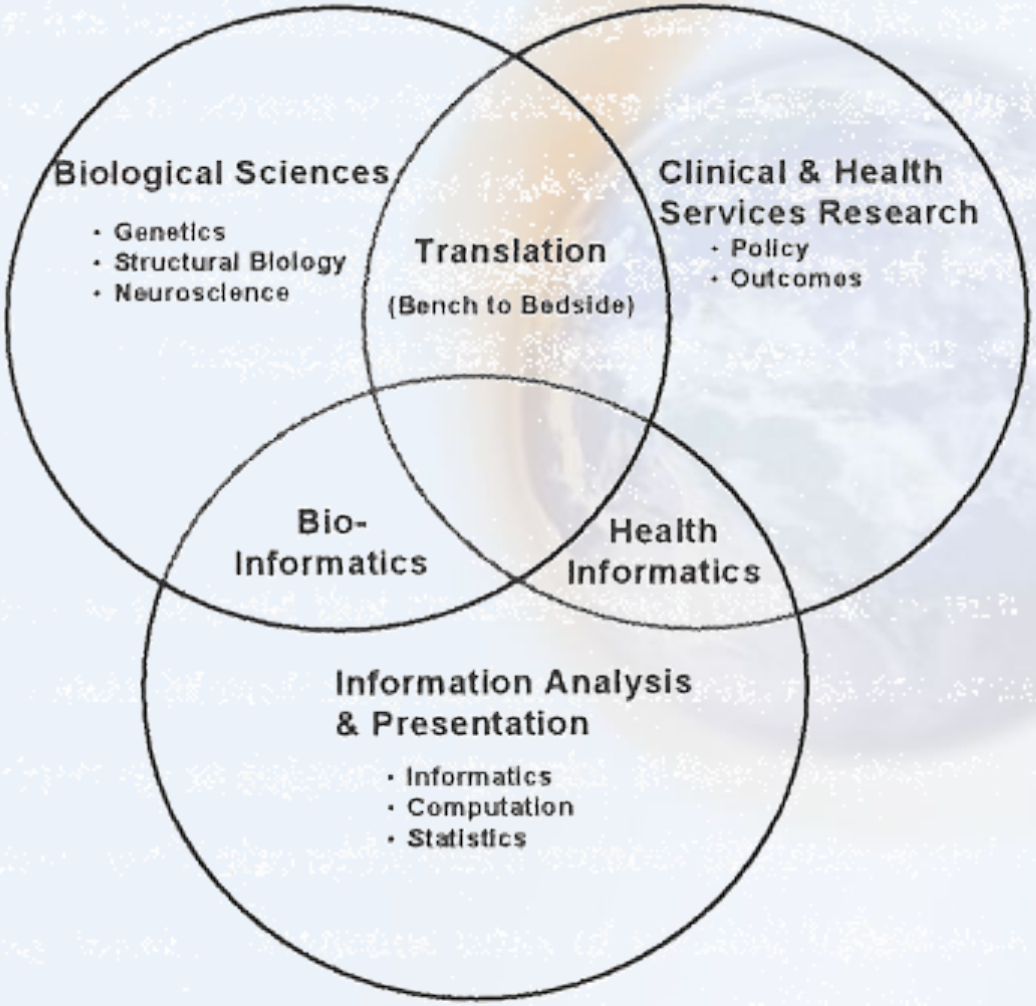
Interactive Multi-Country Experts' Forum on Tuberculosis from the United States (Albany, NY), Poland (Warsaw, Krakow, Rzeszow and Polish National Military Hospital), Ukraine (Kyiv and Zaporizhzhya) and Slovakia

Consumer health informatics

- **Consumer health informatics** is a relatively new discipline and has been defined by Eysenbach as follows:
- **Consumer health informatics** is the branch of medical informatics that analyses consumers' needs for information; studies and implements methods of making information accessible to consumers; and models and integrates consumers' preferences into medical information systems. (Eysenbach 2000)
- Consumer health informatics (CHI) provides patients and healthy consumers with the tools, skills and support they need to better manage their health decisions. **Examples for CHI tools** are **Web sites** providing **self-care information, Internet-based disease management tools, telemedicine, personal health records (PHRs), online support groups**, etc. In the age of the Internet, almost any health information system or communication tool has an interface for consumers.
- Healthcare providers are turning to consumer health informatics to provide patients not only with health advice but with an opportunity to manage certain aspects of their condition. One of the purposes of the aforementionned PHR is to involve patients in the management of their healthcare. Meanwhile, consumers are themselves looking for resources on the **Internet** or even starting their own.

Biomedical Informatics

Figure 1: Informatics Application and Research Areas



Biomedical Informatics is the interdisciplinary science that deals with biomedical information. Biomedical informatics is grounded in the principles of computer science, information science, cognitive science, social science, and engineering, as well as the clinical and basic sciences.

Bioinformatics

Bioinformatics or **computational biology** is the use of techniques from applied mathematics, informatics, statistics, and computer science to solve biological problems. Research in computational biology often overlaps with systems biology. Major research efforts in the field include **sequence alignment, gene finding, genome assembly, protein structure alignment, protein structure prediction, prediction of gene expression and protein-protein interactions, and the modeling of evolution**.

Information system

The term **information system** has the following meanings:

1. **A system**, whether automated or manual, that comprises people, machines, and/or methods organized to collect, process, transmit, and disseminate data that represent user information.
2. Any **telecommunications** and/or **computer related equipment** or **interconnected system** or **subsystems of equipment** that is used in the acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of voice and/or data, and includes software, firmware, and hardware

Information system

- **The simplest model** that describes **the Structure and Behaviour of an Information System** takes five objects**:**

- **For Structure**:

1. **Repositories**, hold data permanent or temporarily, such as buffers, RAM, hard disks, cache, etc.
2. **Interfaces**, exchange information with the non-digital world, such as keyboards, speakers, scanners, printers, etc.
3. **Channels**, connect repositories, such as buses, cables, wireless links, etc. A Network is a set of logical or physical channels.

- **For Behaviour**:

4. **Services**; provide value to users or to other services via messages interchange.
5. **Messages**; carries a meaning to users or services.

- **Source**: from book "Seguridad de la Informacion", 2004 ISBN 84-933336-7-0

Information technology

- ***Technology*** *is then the collection of tools plus the knowledge of how to develop and apply them in our environment.*
- *"The number of information systems, computing devices, data archives and other IT resources that are interconnected in complex, distributed systems is exploding. The resulting systems have the potential to transform both science and engineering research (e.g., with environmental and geological systems, remote observing systems, or embedded sensor systems for research on materials) and expectations about how we live, learn and work (e.g., with transportation and telecommunications networks, power generation and distribution systems, or distributed life long learning systems.)"*

- **Information Technology (IT)** or **Information and Communication(s) Technology (ICT)** is a broad subject concerned with technology and other aspects of managing and processing information, especially in large organizations.

- In particular, **IT** deals with the use of electronic computers and computer software to convert, store, protect, process, transmit, and retrieve information. For that reason, computer professionals are often called IT specialists, and the division of a company or university that deals with software technology is often called the **IT department**. Other names for the latter are **Information Services (IS)** or **Management Information Services (MIS).**

Database

- A database is an organized collection of data. The term originated within the computer industry, but its meaning has been broadened by popular use, to the extent that the European Database Directive (which creates intellectual property rights for databases) includes non-electronic databases within its definition.
- One possible definition is that *a database is a collection of records stored in a computer in a systematic way, such that a computer program can consult it to answer questions*. For better retrieval and sorting, each record is usually organized as *a set* of data elements (facts). The items retrieved in answer *to queries* become information that can be used to make decisions. The computer program used to manage and query a database is known as *a database management system (DBMS).* The properties and design of database systems are included in the study of information science.

Hospital information system

- Hospital information system (HIS) is a comprehensive, integrated information system designed to manage the administrative and clinical aspects of a hospital. This encompasses paper-based information processing as well as data processing machines.

- As an area of Medical Informatics the aim of an HIS is to achieve the best possible support of patient care and administration by electronic data processing.

- It can be composed of one or few software components with specialty specific extensions as well as of a large variety of sub-systems in medical specialties

Health Level 7

international healthcare standards

- "HL7" is a term used to refer to the all-volunteer, not-for-profit organization, *Health Level Seven*, Inc., that is involved in development of *international healthcare standards*. "HL7" is also used to refer to some of the specific standards created by the organization (i.e. HL7 v2.x, v3.0, HL7 RIM etc.).

- Health Level Seven is a Standards Developing Organization (SDO) that is accredited by the *American National Standards Institute* (ANSI). Founded in 1987 to produce a standard for *hospital information systems*, HL7 is currently the selected standard for the interfacing of clinical data in most institutions. HL7 and its members are dedicated to providing a comprehensive framework (and related standards) for *the exchange, integration, sharing and retrieval of electronic health information*. The standards, which support *clinical practice* and *the management*, *delivery*, and *evaluation of health services*, are the most commonly used in the world.

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Health Level 7

Areas of Interest

- In 1994, HL7 became accredited by ANSI.
- In the years since its founding, HL7 has expanded its influence well beyond traditional messaging protocols. Today HL7 standards development initiatives include:

- ***standardization of knowledge representation (Arden Syntax)***
- ***specification of components for context management (known as CCOW)***
- ***support for healthcare data interchange using object request brokers***
- ***standardization of XML document structures***
- ***specification of robust vocabulary definitions for use in clinical messages and documents***
- ***functional specifications for an electronic health record***
- ***work in the area of security, privacy, confidentiality, and accountability.***

Laboratory information system

- Laboratory information system (LIS), is a class of software which handles receiving, processing and storing information generated by laboratory processes. These systems often must interface with instruments and other information systems such as hospital information systems (HIS). An LIS is a highly configurable application which is customized to facilitate a wide variety of laboratory workflow models. Deciding on an LIS vendor is a major undertaking for all labs. Vendor selection, if done properly, should take months of research and planning. Installation takes from a few months to a few years depending on the complexity of the organization. These are complex software applications which comprise hundreds of tables and critical definitions to build, validate and maintain. There are as many variations of LISs as there types of lab work. Some vendors offer all components, others specialize in specific modules. Disciplines of laboratory science include hematology, chemistry, immunology, blood bank, surgical pathology, anatomical pathology, flow cytometry and microbiology. This article mainly covers clinical lab which encompasses hematology, chemistry and immunology.

Laboratory information system

- Basic Features
- Laboratory Information Systems commonly support the following features:

- Patient Check In
- Order Entry
- Specimen Processing
- Result(s) Entry
- Reporting
- Patient Demographics
- Physician Demographics

Laboratory information system

- **Additional Features**
- In addition LISs commonly support the following:

- Web based order entry
- Web based results inquiry
- Faxing and emailing of lab reports
- Custom report creation
- HL7 interfaces with reference labs and EMRs
- Preliminary reporting
- Final reporting
- Med tech worksheets
- Workload balancing
- Medicare Medical Necessity checking
- Billing
- Public health reporting
- Rule engines

Laboratory information system

- **Types**
- There are many laboratory disciplines requiring the support of computerized informatics. These include:

- Hematology
- Chemistry
- Immunology
- Blood bank donor center
- Blood bank transfusion
- Surgical Pathology
- Anatomical Pathology
- Microbiology
- Flow cytometry

Decision support system (DSS)

- **Decision support systems** are a class of **computerized information systems** that support decision making activities
- The concept of a decision support system (DSS) is extremely broad and its definitions vary depending upon the author's point of view (Druzdzel and Flynn 1999). A DSS can take many different forms and the term can be used in many different ways (Alter 1980).

- On the one hand, Finlay (1994) and others define a DSS broadly as **"a computer-based system that aids the process of decision making."** In a more precise way, Turban (1995) defines it as **"an interactive, flexible, and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilizes data, provides an easy-to-use interface, and allows for the decision maker's own insights."**

Decision support system (DSS)

Taxonomies

- Different authors propose different classifications. **At the user-level,** Hättenschwiler (1999) differentiates **passive, active, and cooperative DSS. A passive DSS** is a system that aids the process of decision making, but that cannot bring out explicit decision suggestions or solutions. **An active DSS** can bring out such decision suggestions or solutions. **A cooperative DSS** allows the decision maker (or its advisor) to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation. The system again improves, completes, and refines the suggestions of the decision maker and sends them back to her for validation. The whole process then starts again, until a consolidated solution is generated.

- **At the conceptual level**, Power (2002) differentiates **communication-driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS, and model-driven DSS.**

- **A model-driven DSS** emphasizes access to and manipulation of a statistical, financial, optimization, or simulation model. Model-driven DSS use data and parameters provided by DSS users to aid decision makers in analyzing a situation, but they are not necessarily data intensive. Dicodess is an example of an open source, model-driven DSS generator (Gachet 2004).
- **A communication-driven DSS** supports more than one person working on a shared task; examples include integrated tools like Microsoft's NetMeeting or Groove (Stanhope 2002).

Decision support system (DSS)

Taxonomies

- **A data-driven DSS** or **data-oriented DSS** emphasizes access to and manipulation of a time series of internal company data and, sometimes, external data.
- **A document-driven DSS** manages, retrieves and manipulates unstructured information in a variety of electronic formats.
- **A knowledge-driven DSS** provides specialized problem solving expertise stored as facts, rules, procedures, or in similar structures.
- **At the system level**, Power (1997) differentiates **enterprise-wide DSS** and **desktop DSS**. **Enterprise-wide DSS** are linked to large data warehouses and serve many managers in a company. **Desktop**, single-user DSS are small systems that reside on an individual manager's PC.

- When classifying DSS, it can be viewed as very broad or very narrow. Since it is difficult to classify DSS into only one classification, the taxonomy cannot exactly be pinpointed. However, if it is necessary, a DSS is certainly classified into precise, scientific organizational software that not only contributes, but also performs **decision making** steps in order to ease the pressure for its users. The fact is in a few words, DSS is an **organizational decision making software**

Clinical decision support system

- **Clinical (or Diagnostic) Decision Support Systems (CDSS)** are interactive computer programs, which directly assist physicians and other health professionals with decision making tasks.
- **For medical diagnosis**, there are scopes for ambiguities in inputs, like, history (patient's description of the diseased condition), physical examinations (especially in cases of uncooperative or less intelligent patients), laboratory tests (faulty methods or equipment).
- Moreover, for treatment, there are chances of drug reactions and specific allergies, and patients non-compliance of the therapy due to cost or time or adverse reactions.
- In all these areas, computers can be of immense help in facilitating the clinician to reach an accurate diagnosis faster. Another new branch of medicine **pharmacogenomics** is the product of breeding between information technology and biology, leading to individualized treatment.
- The basic components of a CDSS include **a dynamic (medical) knowledge base** and an **inferencing mechanism** (usually a set of rules derived from the experts and evidence-based medicine). It could be based on **Expert systems** or **artificial neural networks** or both **(Connectionist expert systems**)

Expert system

- **An expert system** is a class of computer programs developed by researchers in **artificial intelligence** during the 1970s and applied commercially throughout the 1980s. In essence, they are programs made up of a set of rules that analyze information (usually supplied by the user of the system) about a specific class of problems, as well as provide analysis of the problem(s), and, depending upon their design, recommend a course of user action in order to implement corrections.

- A related term is **wizard** (software). Like an expert system, a wizard is also an interactive computer program that helps a user solve a problem. Usually, the term wizard is used for programs that search **a database** for criteria entered by the user. Unfortunately, the distinction between these two definitions is not universal, and some rule-based programs are called wizards.

Types of problems solved by expert systems

- Typically, the problems to be solved are of the sort that would normally be tackled by a human "expert"—a medical or other professional, in most cases. Real experts in the **problem domain** (which will typically be very narrow, for instance "diagnosing skin diseases in human teenagers") are asked to provide "rules of thumb" on how they evaluate the problems, either explicitly with the aid of experienced system developers, or sometimes implicitly, by getting such experts to evaluate test cases and using computer programs to examine the test data and (in a strictly limited manner) derive rules from that. Generally expert systems are used for problems for which there is no single "correct" solution which can be encoded in a conventional algorithm — one would not write an expert system to find shortest paths through graphs, or sort data, as there are simply easier ways to do these tasks.

- Simple systems use simple true/false logic to evaluate data, but more sophisticated systems are capable of performing at least some evaluation taking into account real-world uncertainties, using such methods as **fuzzy logic**. Such sophistication is difficult to develop and still highly imperfect.

Artificial neural network

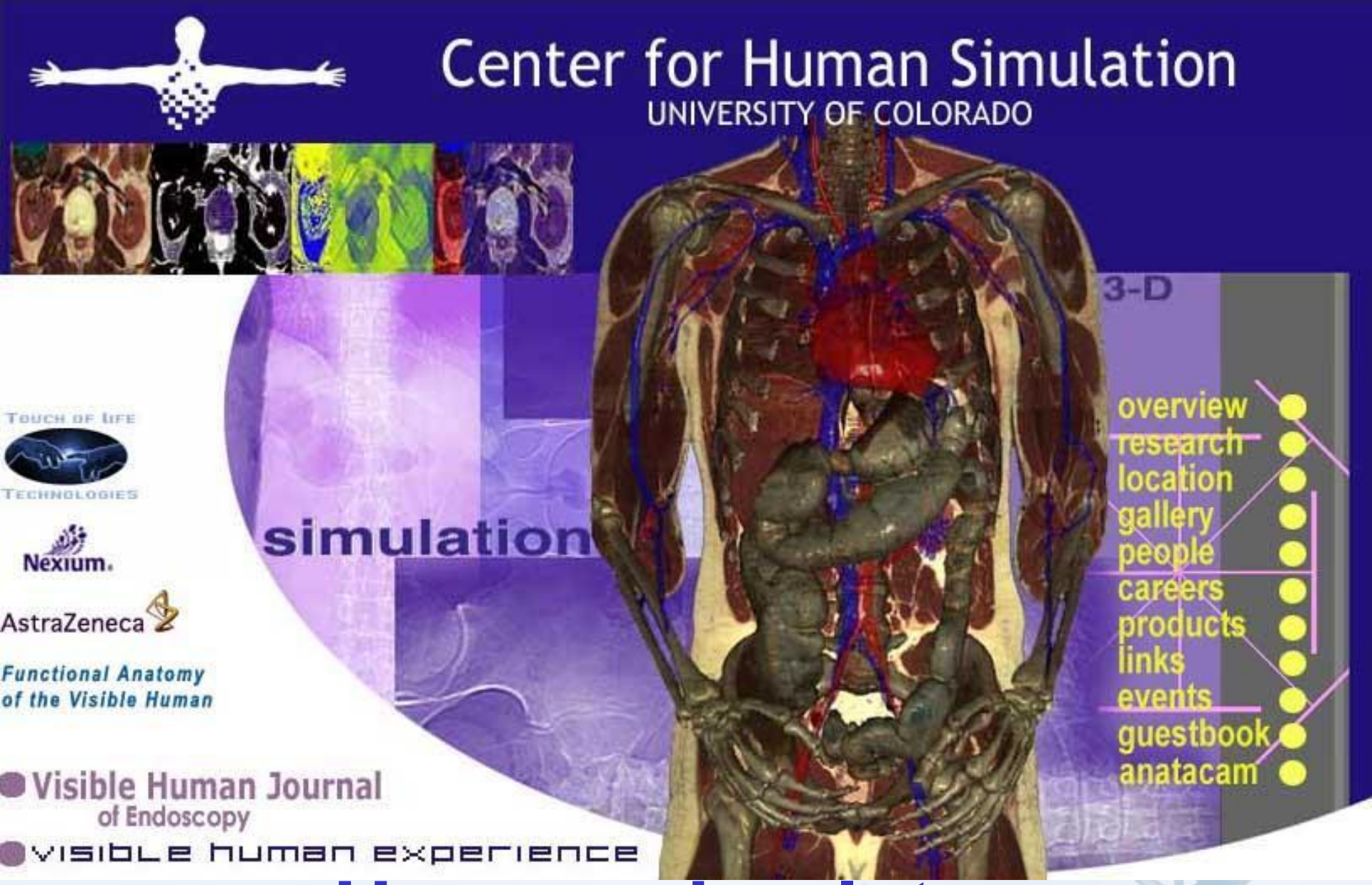
- **An artificial neural network** (ANN), also called **a simulated neural network** (SNN) (but the term neural network (NN) is grounded in biology and refers to very real, highly complex plexus), is an interconnected group of artificial neurons that uses a mathematical or computational model for information processing based on a connectionist approach to computation. There is no precise agreed definition among researchers as to what a neural network is, but most would agree that it involves a network of simple processing elements (neurons) which can exhibit complex global behaviour, determined by the connections between the processing elements and element parameters. Since anything approaching a full appreciation of neuronal function remains a distant dream, and since the factors producing global output result from many non-linear, modulating, and poorly understood real-time feedback signals within a single neuron, the greatly simplified artificial networks (where 'neurons' are modeled as input/output nodes) are perceived as academic research tools rather than even a distant representation of brain function. The original inspiration for the technique was from examination of the central nervous system and the neurons (and their axons, dendrites and synapses) which constitute one of its most significant information processing elements (see Neuroscience). In a neural network model, simple nodes (called variously "neurons", "neurodes", "PEs" ("processing elements") or "units") are connected together to form a network of nodes — hence the term "neural network". The term also includes implementations purely in software that may run on general purpose computers.

Artificial neural network

Real life applications

- The tasks to which **artificial neural networks** are applied tend to fall within the following broad categories:

1. **Function approximation**, or **regression analysis**, including **time series prediction** and **modelling**.
2. **Classification, including pattern** and **sequence recognition**, **novelty detection** and **sequential decision making**.
3. **Data processing**, **including filtering**, **clustering, blind source separation** and **compression**.
4. Application areas include **system identification** and **control** (vehicle control, process control), **game-playing and decision making** (backgammon, chess, racing), **pattern recognition** (radar systems, face identification, object recognition and more), **sequence recognition** (gesture, speech, handwritten text recognition), **medical diagnosis**, **financial applications, data mining** (or knowledge discovery in databases, "KDD"), and **visualisation**



Human simulators

for Medical Education

Real-Time Visually and Haptically Accurate Surgical Simulation

http://www.uchsc.edu/sm/chs/research/pics/KneCutLg.mpg

Real-Time Visually and Haptically Accurate Surgical Simulation

The major goal of the Center is to develop simulators that provide interactions with computerized anatomy in virtual space.

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