The New Navigators: from Professionals to Patients
R. Baud et al. (Eds.)
IOS Press, 2003

Criteria for Classification of Medical Information

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Abstract.

Medical information, which is the central notion in medical informatics, covers a large scale of structures and forms. Several classifications are possible and two criteria have been used in this paper: structural level and informational level. According to structural level we can distinguish three major areas: bioinformatics and neuroinformatics for molecular/cellular level, medical informatics for individual level and health informatics for community level and healthcare units. According to informational level the terms of data and knowledge are used and the representative information for each structural level is analysed also from this point of view: Finally, information transfer from living systems to computers is also seen through the structural point of view.

1. Introduction

As a typical interdisciplinary science, medical informatics borowed terms, tools and methods from other fields trying however to find its identity and to better define its object and methodology. A large palette of points view has been expressed along its short history.

In its early stage medical informatics was seen as a collection of computer applications in medicine [1]. Later, the concept of "medical information" has been introduced; however medical informatics was still considered as lacking "a prerequisite of the classical definition of a scientific discipline, namely an independent methodology" [2]. We will not present here the detailed evolution of the definition of medical informatics, mentioning the clarifications brought by the discussions of a Round Table in Heidelberg [3] and especially by a paper of van Bemmel [4] (including the comments on it published in the same volume).

The paper is a comprehensive synthesis of almost all views expressed until then and offers a systematic approach, scanning several points of view: level of complexity, discipline applications, methodology etc.

However, van Bemmel's classifications was mainly referring to work in medical informatics, especially research. Haux [5] is comparing several classifications, adding those of Hasman (processes in medicine and health care) and GMDS (sub fields of medical informatics).

In this paper we try to present additional criteria, referring especially to "medical information".

2. Medical Information

Most recent definitions of medical informatics (MI) use the notion of [medical] information:

- MI comprises the theoretical and practical aspects of information processing and communication, based on knowledge and experience derived from processes in medicine and health care [6]
- MI is the scientific field that deals with biomedical information, data and knowledge – their storage, retrival and optimal use for problem-solving and decision-making [7].
- MI is the discipline concerned with the systematic processing of data, information and knowledge in medicine and healthcare (Hasman, cited in [5]).

The authors have used the notion of medical information without an explicit definition, but subunderstood as the information (from *data* up to *knowledge*) used in biomedicine and healthcare. We can also notice that information processing is always present in definitions of MI.

This "definition" of biomedical information partially observes the classical rules (starting from *genus proximus*, with specific differences) and lets us approach its classification from various points of view. Two criteria will be discussed here.

2.1. First Criterion: Structural level

It is quite common in natural sciences to use the structural level of the studied object for a hierarchical approach. Such a criterion would yield a structure like in Table 1.

Table 1. Biomedical information classification using the structural level criterion

Structural level	Studied by:	Domain	Corresponding area of MI
molecular / sub cellular	molecular biology genetics	life sciences	bioinformatics
cell / tissue	cell biology		
organ	physiology		neuro informatics
system	brain theory	cognitive sciences	
body ('patient')	- paraclinical depts. (investigation) - clinical depts. (diagnosis, treatment)	medical sciences	medical informatics
- community level	public health	healthcare sciences	healthcare informatics
- healthcare activity	healthcare management		

We can distinguish here three main areas of medical informatics ('medical' is used here as a general attribute for all levels):

- **bioinformatics and neuroinformatics** – the youngest area, dealing with information at lower level in various structures of living matter from molecular and cellular up to physiological regulation mechanisms.
  - *Bioinformatics* is the result of the rapid progress of the Human Genom project and molecular biology. The enormous amount of data generated in the studies required appropriate structure for databases and specific software for sequence analysis, proteic interactions etc., including visualization tools [8].

- *Neuroinformatics* had an early development starting with studies on modeling and simulation of neural structures [9], which emphasized the fundamental difference between information processing in computers, where everything is controlled by one unit- the micro-processor, and in living neural structures where everything is distributed [10]. The studies in neuroinformatics, having deep interference with cognitive sciences, are expected to have a great impact on several areas of computer technology, distributed architecture [11], multiagent systems [12], and robotics. An adjacent field is **affective computing,** "computing that relates to, arises from, or deliberately influences emotions" [13], and we must accept that emotions are mainly generated by certain information and they also carry information.

- **medical informatics** – in the classical accepted sense MI is studying the information flow in call medical activities with a patient, starting from data acquisition and storage (including data under the form of biosignals or medical images), data processing, up to the use of knowledge bases for decision support and treatment [6]. Figure 1 represents the elementary cycle of medical information [14]: patient – physician – diagnosis – treatment – patient and a partial connection of this cycle to healthcare information flow cycle.

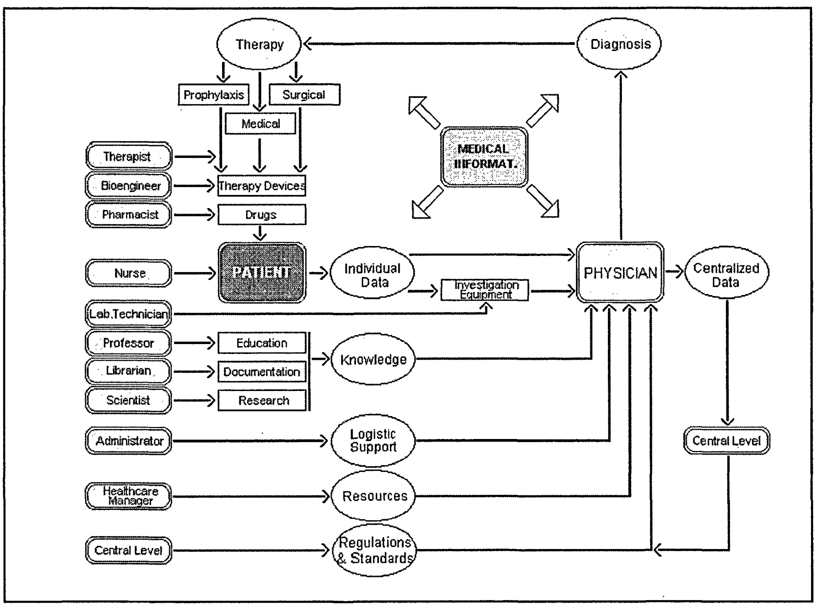

Figure 1. An example of an information flow in medical activities

- **health informatics** – the area studying information at community level. The object covers healthcare activity and public health; the emphasis falls on information systems in healthcare [15] starting from small units of primary care, like family doctor's office, to hospital information systems. It also includes up to national healthcare information networks [16].

2.2. Second Criterion: Informational level

It is now unanimously accepted that information, in a general sense, has a variable (increasing) value during processing [17]. It starts from a raw form, called *data*, which are in fact a set of specific facts, with no intrinsic meaning when standing alone. Data have individual character. The next step was called *information* – in a narrower sense here; it was defined by Drucker (cited in [18]) as "data endowed with relevance and purpose". The highest level was called *knowledge*; it is deeper and richer than information comprising a mix of contextual information, values, experiences and rules. Knowledge can be subdivided into *explicit knowledge* (general, formalized, easy to transfer) and ***tacit knowledge*** (personal experiences and skills, hard to communicate).

This criterion has been already considered in medical informatics; Hasman (cited in [5]) was even using it for MI definition. However these levels have been analyzed only in the "classical" area of MI, where data comprise all individual information about the patient (descriptive, numerical, signals, images) while knowledge is the general information used by the physician for interpreting the date (in diagnosis and treatment, fig. 1).

Let us extend the view over the other levels.

In bioinformatics data would refer to a particular molecule: DNA in genome analysis or a protein in proteome analysis. Knowledge would refer to all processing tools: sequence analysis, gene identification, computer simulations and visualization of molecular structure prediction and metabolic reconstruction.

In neuroinformatics data would be the input into a neural system while knowledge would comprise all rules for information processing and transfer.

In public health informatics data have an aggregated form as raw information about a community, while knowledge would comprise the set of health statistics indicators, their relations with other factors (natural, behavioral, social factors) including predictive methods.

In healthcare management informatics data refer to a particular healthcare unit while knowledge would comprise all organizational and managerial rules, legislation, financial resources and constrains, standards etc.

3. Biomedical information transfer

A typical feature in all areas of medical informatics is the structure of the communication channel: the information source is represented by a *biosystem* (the extension to healthcare system is somehow 'forced') while processing is performed by *a computer* (first step destination). We have to consider separately, for each structural level the *specific interface* for data acquisition.

Bioinformatics is using the results offered by specific laboratory equipment for cloning and sequencing, techniques which are not part of bioinformatics per se [8]. These results are collected in data files and analysed using centralized databases like NCBI, EBI or DDBJ.

The information handled in neuroinformatics at cellular level has still insufficiently developed devices for direct acquisition from the biological system. For *in vitro* studies a set of electrodes in direct contact with the living structure are used. The *in vivo* studies can collect only the overall results of the activities of several microstructures, with major difficulties in interpretation (like in EEG or functional NMR imaging). Preserving informational content in a contiguous structure requires a deep understanding of information support in each component, including biophysical processes at the interface. We expect that the 'bio-silicon' interfacing would become soon a major research topic, with very important medical applications, both in investigations and in treatment (advanced prostheses).

We shall also mention here the prospective for future development of human-computer interaction: human-centered interactive interfaces to mediate redistribution of cognitive tasks between people and machines [19]. The possible impact goes beyond medical applications aiming new architectures; the associative cognitive architecture would be able to capture the context-specificity of human judgment and the ability to integrate many pieces of information simultaneously [11].

The structure of table 1 reveals a missing area which would correspond to the term 'physiom' comprising other forms of information transfer within living matter, like intracellular signalling (secondary messengers) or humoral physiological regulation. Direct interfacing with these systems is much less available, explaining this gap.

4. Conclusions

The central concept in medical informatics is 'medical information'. As a generic term it covers the whole scale related to medicine, comprising also biological information and health information.

Such a large scale can be approached in various ways. We have used here the structural level for defining three major areas, each with its specific form of information: bio- and neuro-informatics for molecular/cellular level, medical informatics for individual level and health informatics for community level and healthcare management.

Prescribing information when transferred in a contiguous system raises new features to be deeper understood, concerning interfaces – specific for each level.

We estimate that this approach is useful in extending the systematization of biomedical information, taking into account all recent developments and trying to predict future areas of interest.

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