Collaborative medical reasoning in Telemedicine

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Abstract - During medical practice, doctors use different aspects of reasoning for diagnosis and treatment. There is a particular process when several doctors are involved in taking a medical decision. In this paper we present an overview of different constraints in the process of conventional decision making and collaborative medical reasoning. General notions for an assisted decision cooperation system are introduced, bearing in mind general medical practices; without neglecting the physician's role.
Keywords – Collaborative reasoning, medical decision, diagnosis-treatment, CSCW.

I. INTRODUCTION

In medical practice, doctors are faced with the patient and his disease, giving him these clinical objectives: how to establish a diagnosis (Dx.), determine the extent of the disease, consider a prognosis and decide on the best treatment (Tto.), all the while providing good care. This is carried out by means of work to establish and assess clinical findings and the etiology of the disease, make diagnostic tests and confront differentials diagnoses. Before establishing any medical computing system it is necessary to make an analysis of the nature of the processes occurring in the medical activities. For that reason we will take an approach involving all the relationships and constraints included in medical procedures.

II. DEFINITIONS – MECHANISMS

A. Medical Diagnoses

Physicians use two aspects of reasoning, analysis and synthesis, to help solve the patient's disease problem. In this process, diagnoses will be improved when data collected from evaluation of the subject can be accommodated in syndromes. The diagnosis (Dx.) is simplified when a clinical problem adjusts clearly to a well-defined syndrome, because only a few diseases need to be considered in the different diagnoses [1].

The physician restores classes from generic and/or single types towards the diagnoses that he establishes. This process is derived from the generation of hypotheses, through thought inference that can be of the abductive, deductive or inductive type. These principles have been used for the creation of systems in the field of Artificial Intelligence, according to different typologies of the reasoning studied: formal, hypothetical, approximate, procedural, associative, qualitative, geometric, by generalization and abstraction, by classification, and by analogy. An example derived from this last type is case-based reasoning which has been studied for planning problems and diagnoses [2].

B. Diagnoses types

The following types of diagnoses are distinguished: Intuitive Dx., or evocative, based on professional experience, and Inductive Dx., or systematic where an analysis is given of a patient's symptoms or clinical signs in relation to etiology, pathogenesis, pathology, anatomy, physio-pathology and semiology [3].

Corroboration of the diagnoses hypothesis increases as the clinical encounter evolves; a re-interpretation of the data collected and selected for the patient disease is contrasted in a pragmatic way. This Dx. is made in different ways, ranging from clinical exploration and/or para-clinical exams, auxiliary hypotheses to different diagnoses (see Fig. 1). But this Dx. involving the simultaneous procedures mentioned above, coexists in parallel with another scenario, that of Tto., both depending on the point in time vector that is related to the different speed movements.

Uncertainty is always present in the doctor's diagnostic process [4] because he relies on theoretical and subjective probability, for instance, the value assigned to a variable in Bayes' theorem. Usually, the subjective variable is fixed according to information that may come from medical literature, statistics and experience, because with this knowledge uncertainty is reduced. An important fact in medical reasoning is that, generally, the physician does not evaluate the presence of clinical data in order to find many diseases, but, on the contrary, he evaluates the clinical data in order to find a single disease, that is, to establish a causality principle, looking for the significance of one item that can explain variable x or y simultaneously [5].

C. Clinical Decision making

In order to improve the process of clinical decision making, investigations have followed three fundamental paths: descriptive studies of the process of clinical decision making by clinical experts, studies that come from the computer science area, especially the field of artificial intelligence applied to the problems of clinical decision resolution, and studies that try to apply techniques to help decision analysis through data mining from the knowledge produced by physicians and their measurements.

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25OCT2001	N/A	-

Title and Subtitle Collaborative medical reasoning in Telemedicine	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Ecole Nationale Supérieure des Télécommunications de Bretagne, Brest, France.	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
Papers from the 23rd Annual International Conference of the IEEE ENgineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom., The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
4

Historically, medical assistance has involved three fields: (a) basic and applied science; (b) economics, since it is possible for any medical act to performed if the equipment and material are available; and (c.) law and politics, when fulfilling what the State and society impose, while being careful of patient confidence. Currently, the physician's performance with a patient has become confused concerning a Dx. and a treatment (Tto.). These are of course closely related to the problem of clinical decision making, in which several possible alternatives for action are generated: 1. first the physician must establish some immediate treatment, or 2. he can indicate the diagnostic tests to be carried out and postpone the therapeutic decision making until the results of these tests; or 3. he can wait without doing anything and see what it happens [6].

Reasoning arises from the understanding between two or more judgments before certain conclusions are reached. Partly from a theoretical or scientific statement, and partly from practice, norms or rules are established. Then, human reasoning is made possible by the interactions between the multiple abilities, aptitudes and interests.
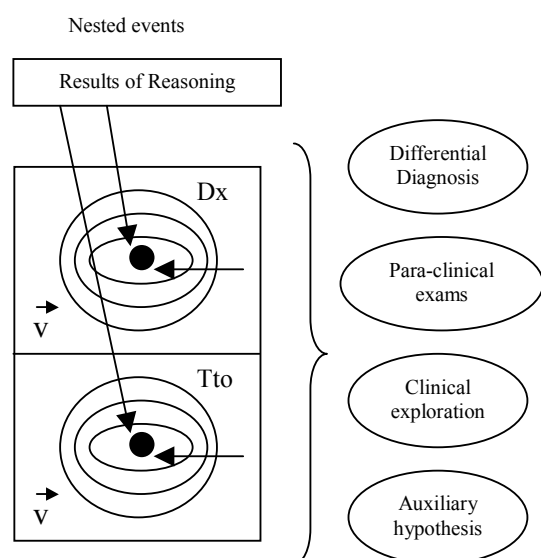

Fig. 1. Generation of Medical Decision Process

D. Reasoning - CSCW

Our judgments are based on the information available. Every day much medical information is generated and technological tools exists which can give us the possibility (among others) of managing this knowledge for lifelong learning skills. Telemedicine implies a combination of networking technological resources with health-care procedures. By the resources of telemedicine it is possible to collect knowledge from different sources of medical expertise, to interchange it, and to find a consensus through a discipline of communication technology and organisational process called "computer supported cooperative work (CSCW)". This system can establish a flexible organizational atmosphere and characterizes the

medical profession's interrelations in a synchronous or asynchronous way, with new technological skills [7], for example a graphical interface, refined and developed by tasks and requirements. The operating system in CSCW must support rather than supersede or interfere with the process of collaborative work, and it represents another possible application for the personal computer.

There are many challenges and limits to overcome for treating special cases of clinical problems, like the virtual atmosphere of CSCW. So it should first be pointed out that, in the decisive events of clinical problems, the cases of negative analysis can be omitted in order to find the correct rule by logic. This can be explained by our tendency to look for the confirmation of hypotheses and not evidence that might refute them [8]. Secondly, another disadvantage is the phenomenon of cognitive inflexibility and functional fixedness because sometimes experience is not permeable to new alternatives in the solution to problems, and it is clear that every day we formulate judgments and adjust our decisions. Thirdly, one of the most frequent difficulties is the over-interpretation of information to confirm an already existing hypothesis [9].

For CSCW, the design challenges plow through the analysis of cooperative activities and the user's opportunities for interventionism in design or modification of the system process. An important variable in CSCW is called conflict, which can be due to technological mediation, physical separation, time pressures, group size and participants' entrenched positions at each encounter, as much as to misunderstandings caused by opposing criteria. Thus certain strategies are considered in order to resolve conflict: clearly defined roles by means of approaches to achieve solutions while stimulating users to make concessions without reducing the situation to a "group-think" process, and a necessary third party or leader to introduce a resolution [10].

E. Diagnosis – Treatment

Physician must confront success from the Dx./Tto. pair in very often conflicting situations, for example the overcrowding of patients or treating patients in rural or underdeveloped places, and they must cover all situations, not forgetting the fundamental principle of "primum non nocere" and "ophélein mê bláptein", that is to say, first do no harm, and help not injure [6]. Heuristic systemic vision or general problems allow us to find intuitive ways or schemes to establish reasonable judgments.

Then, there are the following strategies between the diagnosis and the proposed treatment: define the context of the diagnosis (signs and symptoms), eliminate any alternative diagnosis by dealing with patient fears, give reasons in the context of a patient's belief system and his expectations of treatment, negotiate the plan to follow with the patient and ensure that it is understood, keep diagnostic options open and minimize the possibility of missing other critical diagnosis, play for time (temporal reasoning) by allowing signs and symptoms to develop in order to help

clarify the diagnosis, and plan for contingencies by providing appropriate if/then statements concerning situations requiring further action [11].

In diagnostic reasoning, individuality of thought and pattern recognition let expert physicians use their biomedical knowledge by means of rule and experience based learning. It is assumed that they have a great number of diagnostic skills because during their training causal knowledge is included by fusing information into clinical concepts. Experience is not characterized by standardization of judgment but individuality of thought. The heuristics are based on experts' clinical problem solving and approximate judgments [12].

There is no clear limit between clinical reasoning, problem-solving, human judgment, and elements of experience [13]. However, any medical act would have to imply the previous existence of a decision. Practice of clinical medicine also implies two types of reasoning: 1) Explanatory Reasoning (constructing a solution): this allows the physician to diagnose the patient's problem and to include/understand by hypothesis and analogy the etiology and physio-pathological mechanisms that cause it, and the anatomo-pathological bases that sustain it. 2) Executive Reasoning (symptom processing): physicians try to solve problems through therapeutic and prophylactic acts, to prevent possible complications and to maintain the health of an individual. Reasoning includes ignoring, excluding and re-interpreting data for establishing the hypothesis of a disease [4].

F. Medical Collaboration, Novices and Experts

The medical working day, involving specialist inter-consultations, case conferences and morning rounds in hospital centers, include information exchange and cognitive processes of the group type. These collaborative acts are important both for clinical decision making concerning diagnoses and treatment, and for the training of students and novice physicians, without forgetting that continuous, broad training expands the knowledge of experts. However, models of automated systems for medical diagnoses underestimate the distributed nature of clinical knowledge [14].

During these collaborative actions, quality or final product decisions are influenced by the pre-discussion distribution of problem-relevant information/knowledge among team members and by each team member's awareness of the other participants' knowledge and talents (see Fig. 2). Help between physicians (novices-experts) is required when diagnosis-treatment is problematic and when certain measurements are difficult to interpret. A collaborative system in CSCW will assist with these problems, obtaining and giving more information from knowledge sources to resolve any inter-consultation dilemma. It will fulfil the physician's need to work with a progressive unfolding of information over time.

Patient history information at group level has different levels of relevance since each individual may have a personal way of looking at the problem and possible solutions. Because the group tendency is to discuss information that is shared rather than unshared, a suggestion is made to first discuss problem-relevant information before making any resolutions; at the level of knowledge acquisition by each member of the group, called the "meta-knowledge base" [14]. This is useful for the medical information of the case discussed, in relation to the declared expertise and investigations made by other participant members. In this way, the discussion contributes to the training and experience of students and young physicians, giving keys to clinical decisions made about all the medically-raised information.

It is also considered that this meta-knowledge increases if there are group norms encouraging users to participate voluntarily and to solicit information. A physician's reputation is relevant and it strongly influences group opinions, mainly those of novices. This is tremendously important to bear in mind in order to improve the process of information exchange, and to see its application in teaching rounds or case conference [14].

Pertinent information and experience appear to be related and essential to a physician's competence. Expert knowledge is not processed from a single fragment of information but in the form of hierarchies made up of broad concepts divided into smaller concepts and facts which are then themselves divided into specific categories. By means of this organization, experts can recover information effectively.
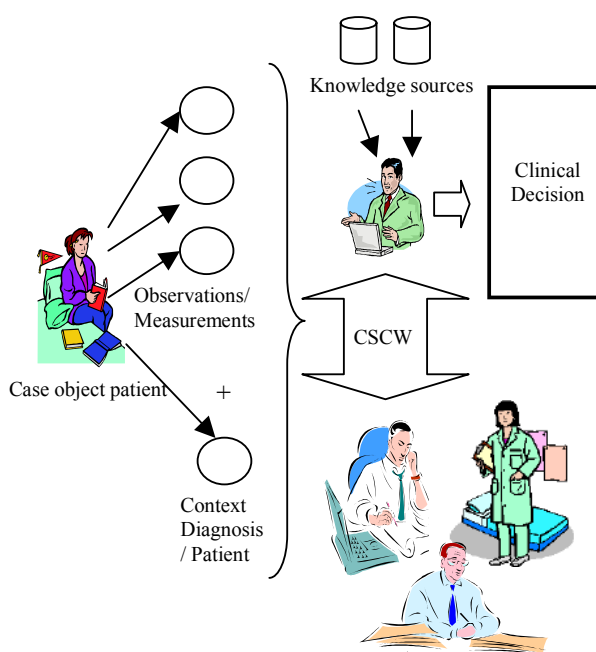

Fig. 2. Collaborative Medical Decision

Social processes are important in the university hospital because general or local knowledge representation from each agent is individual, and has undergone modifications according to hierarchical communication processes. These

include educative induction and deduction, on a scale including confidence, status and credibility existing between beginners and experts. It is difficult to include all the local, ecological and clinical conditions of a physician's reasoning, which include the results of the communication-social processes between doctor and patient, in an expert system for diagnosis assisted by computer and in patient history databases. Physicians have therefore underestimated these technological resources, because in the physician-patient relationship there are the concepts of clinical experience as well as the formulation of hypotheses for possible diagnoses which the technology does not possess [15].

As a consequence of much medical research in the scientific world, a cooperative movement called "Evidence Based Medicine" has come into existence. It looks for effectiveness in medical activity by supplying information to aid in the decision process, supporting it with the results of controlled and credible analysis from multi-center studies making decisions about new protocols, therapeutic ones being among them.

Regarding the development and processing of huge amounts of data that may take place in the collaborative medical decision, data mining seems important for knowledge discovery and seems of interest for data information patterns, with goals like the prediction of unknown values of a database and pattern description for user interpretation [16], improving the quality of decision making. There are three stages for data mining: 1) different sources of data must be integrated so that they represent all the components of the organization, 2) the information bases must be analyzed and 3) the conclusions obtained must be transformed into comprehensible rules to make decision making possible.

III. CONCLUSION

Since there are many aspects to the Diagnosis/Treatment process made by a physician, collaborative medical reasoning is important for giving clues to decision making, for constructing a solution and processing symptoms. With this aim in view, the design is centered on the user, who can use an interface as a tool for assisted-decision cooperative systems in telemedicine. It may allow physicians to obtain the knowledge produced (meta-knowledge base) in medical meetings (novice and expert physician interchange) by means of a graphical interface using visual communication language in electronic documents, adding information using an electronic pen, thus allowing empirical data to become available. The knowledge produced is structured in an expert database. Data mining is important in the development of the collaborative process of medical decision making and, eventually, it will be valuable in the prediction of unknown values in the data stored in databases and patterns extractable from the data for user interpretation.

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