Razonamiento Médico Diagnóstico

■ Ana I. Aguilera
email: aaguilef@uc.edu.ve
Departamento de Computación, FACYT, Universidad de Carabobo, Valencia, Venezuela

■ Alberto R. Subero
email: asubero@uc.edu.ve
Departamento de Computación, FACYT, Universidad de Carabobo, Valencia, Venezuela

Fecha de Recepción: 09 de junio de 2009
Fecha de Aceptación: 30 de septiembre de 2009

Resumen

El objetivo de este trabajo es presentar un análisis de la resolución de los problemas de diagnóstico en el campo médico. La especificación de métodos de solución de problemas médicos es un área de investigación importante debido a su gran aplicabilidad en sistemas médicos de uso corriente. La primera parte estudia el problema diagnóstico a diferentes niveles de resolución: Casos clásicos y casos complejos. Se presentan los puntos de vista colaborativos y dinámicos del proceso. La naturaleza misma del acto médico requiere la adopción de principios confiables a nivel de ingeniería basados en formalismos lógicos sólidos. En la segunda parte se hace una revisión de algunos de los métodos teóricos propuesto en la literatura sobre el tema. Este trabajo no presenta una arquitectura específica de desarrollo de sistemas de diagnóstico médico complejos pero presenta los elementos relevantes a ser tomados en cuenta en el desarrollo de tales sistemas. De la misma manera, este trabajo muestra que los enfoques basados en meta-razonadores son los más pertinentes en el desarrollo de dichos sistemas.

Palabras claves: Diagnostico médico, razonamiento médico, mecanismos de razonamiento.

Medical Diagnostic Reasoning

Abstract

The objective of this paper is to present an analysis of diagnostic problem-solving in the medical field. The specification of medical problem solving methods is an important research subject due to its great applicability in current medical applications. The first part studies the diagnostic problem solving approach at different resolution levels: classical and complex cases. A collaborative and dynamic point of view of the process is also presented. Various formal theories have been proposed in the literature to explain of medical reasoning; some of these approaches proposed are reviewed in the second part. The safety-critical nature of medical applications requires the adoption of reliable engineering principles with a solid foundation for their construction. This work does not present a specific architecture of development to complex medical diagnosis systems but the most important elements, that should be considered in the development of these systems, have been presented. In the same way, this work shows that meta-reasoning approaches are the most pertinent in these kinds of applications.

Keywords: Medical diagnosis, medical reasoning, reasoning mechanisms.

1. INTRODUCTION

The general objective of medical activity is to cure patients in an effective and efficient way. This global objective of medical work requires an appropriate administration of health systems which contributes to solving problems presented by patients. This resolution process involves two areas related to diagnosis (Dx) and treatment (Tto) over time (or evolution, in medical terms). In medical practice, the clinical objectives start when trying to efficiently establish a diagnosis of the patient's illness, to determine the illness behaviour, and to decide the best treatment. In general, doctors take into account: clinical findings, their etiology (Studying the causes of illness) probable differential diagnoses (if a not well-known illness is suspected), the realization of different complementary diagnostic tests and then, prognosis (the evolution of disease) and appropriate treatment. The positive final result toward curing the patient involves recommendations to the patient which make it possible to prevent a future recurrence of his/her current state. The tasks involved in the diagnosis process follow this cycle: observation–hypothesis generation – tests – Dx – Tto. These tasks involve a series of individual intellectual processes which are executed by the physician when making decisions about diagnosis, treatment, selection of tests, prognosis and the end of the cure cycle. These intellectual processes are known as medical reasoning. Formally, these are a set of intellectual operations that require the development of medical knowledge (semiology -studies signs of illness-, nosology- The systematic classification of illnesses by their distinctive characteristics-, and experience) and their use in practice to resolve the medical problem.

2. METODOLOGY

2.1. Medical Diagnostic Process.

In a wide sense, the word diagnosis means recognizing. In the medical sense, it has been attributed to the property of determining an illness by means of the signs observed (or the set of diagnostic signs) of an illness. It is the "art" of identifying an illness from its signs and its symptoms. When a physician meets a patient for the first time, an entire routine of information exchange begins between them which will allow the hypothesis to be made. At first, these hypotheses can be specific pathological entities or, conversely, syndromic entities (or syndromes) with respect to the general framework

of anato-physio-pathological explanations (because, initially, the illness is not identified).

2.2. Diagnostic Approach in Classical Cases.

In classical cases, diagnostic approach is divided into four major steps, Figure 1:

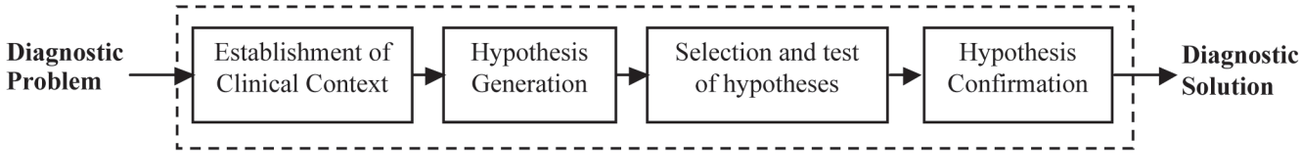

Figure 1: Diagnostic approach in classical cases

2.2.1. Definition of the clinical context (signs, symptoms, case history) established by means of questioning and by physical examination.

At the beginning of diagnostic activity, some standard information is collected: age, sex, race, summary of the present illness given by the patient, family medical history and relevant personal case history. This data can be indicated directly by the conscious patient or through the impressions of a relative of the unconscious patient. Data like age, sex, and race are very relevant, because this epidemiological information helps to direct the hypothesis to be studied. Clinical history is followed with questions about different functional systems of the body. The emphasis is put on all the systems related to the illness, for example, the case history of the respiratory and immunological system in the case of allergies and asthma. Subsequently, the physical exploration continues with a study of all systems: respiratory, neurological, abdominal, cardiovascular, etc. beginning with the vital signs: temperature, blood pressure, heart beat, and breathing rates.

The diagnosis is made using data collected at the moment of this structured observation of the patient. In this way, all symptoms and signs are noted, thus allowing a first approximation of a diagnosis at the following stage. Usually, the recognition of at least one determined clinical syndrome is established. A diagnosis starts from diverse reasons, resulting from a case of signs and symptoms, or from discovering a syndrome or from the observation of an abnormal medical image.

2.2.2. Hypothesis generation.

The application of medical knowledge (semiology, nosology, epidemiology, and experience) leads to a conceptual representation of the medical problem, which has been established in the definition of the context. The physician "generates" hypotheses as a part of his/her medical problem-solving task, that is, a disease or a more general category of diseases or any pathological problem. The goal of hypothesis generation is to create nonweighted hypotheses. Under ideal circumstances, the hypotheses can be described as a complete differential diagnosis, which consists of competent explanations for a given set of facts [1]. Every explanation includes a set of hypotheses and every set of hypotheses has to explain all the facts observed.

2.2.3. Selection and hypotheses test.

The selection of hypotheses is a process that enables hypotheses to be refuted and the remaining hypotheses to be weighed according to their relative importance. This weighting process can result from:

- Judgment of resemblance.
- Reflection based on etiological or physiopathological reasoning.
- Implementation of rules established by accumulated experience.
- Predefined algorithm.
- Probabilistic evaluation.

It is usual to test hypotheses by means of carrying out and using complementary tests. A complementary exploration must be justified by the prospective result,

that is: confirmation or refutation of a diagnostic hypothesis. These tests are justified by their utility in advancing the process of the diagnosis [2]. Hypothesis elimination may occur by negative, insufficient or absence of necessary evidence [1]. Physicians have access to many data sources thanks to both clinical and paraclinical noninvasive studies –such as clinical history, and invasive studies, such as blood tests or radiological studies with contrast-. According to the stage of the illness, certain types of tests can be used, ranging from detection to indicators of prognosis.

2.2.4. Hypothesis Confirmation.

Hypothesis confirmation may occur with positive, sufficient or necessary evidence [1]. The goal of this step is to validate a hypothesis as the diagnostic solution finding its causes and eliminating others diagnostic solutions:

Searching and establishing causes: etiological diagnosis. Once recognized, a syndrome must be confronted with its different possible causes. It is necessary to test the most probable cause, to confirm it or to invalidate it. This process is repeated several times (if necessary) until a satisfactory agreement is reached between the observed data and the nosological entity (defined by its cause and, if possible, its lesions and its mechanism –i.e. features of nosologically well-defined illness-) [2].

Elimination of "similar" illnesses: differential diagnosis. Once all the elements that allow a certain illness to be suspected, have been collected, it is necessary to begin the elimination of similar illnesses. This step, by convention, is called the differential diagnosis [2].

2.3. Diagnostic Approach in Complex Cases.

A significant number of diagnoses are considered as obvious. This happens because the nature of the illness in question is simple or because the physician's experience is significant. There are other less obvious cases for which it is not easy to establish a satisfactory diagnosis directly. There are many reasons for this: an insufficient number of available judgment elements; the illness has not evolved enough for certain signs to appear; or for a circumstantial nonschematizable cause. The diagnosis can involve great difficulties and requires a complex procedure. This procedure can implement several clinical maneuvers (exploration of various organs or systems, complementary tests and sometimes a further patient observation) which are repeated several times [2].The structure of the reasoning process for complex cases is not linear, Figure 2. It is a difficult process that involves a certain number of judgments and decisional nodes. Sometimes, it is necessary to retract many times. This approach can be summarized in two major steps:

2.3.1. Elaboration of the first diagnostic hypothesis.

This step is similar to the classical case in the establishment of the clinical context, the generation, selection and confirmation of hypotheses. When it is not possible to confirm a hypothesis, other hypotheses will be explored. In this case, a fresh clinical examination and complementary tests can be done again. This procedure can be repeated a certain number of times with a successive generation of hypotheses and re-examination procedures until a result is deemed satisfactory.

2.3.2. Stop (or continuation) of the process.

If the confrontation does not appear satisfactory and the comparison with the expected results is bad, the diagnosis is not retained. The process can begin again by studying the context and its evolution. This procedure can also be resumed a certain number of times until, finally, a diagnosis is retained (This point is also known as Closure of diagnosis) [2].This is the result of a judgment followed by a decision to retain a particular nosological entity or to recognize that it is momentarily impossible to progress towards a satisfactory diagnosis.

2.4. The Diagnostic Approach as a Collaborative and Dynamic Process.

All diagnoses are the result of a dynamic decision process in which several physicians may participate. The dynamics results from the fact that all processes involved in the resolution of a medical problem are valued in a sequence of steps (stages) over time, where each step is an element of information important for the following step [3].Medical practice imposes dynamism where several possibilities exist. The physician can establish a treatment without waiting any longer, can indicate the realization of diagnostic tests and wait for their result before taking a therapeutic decision, or do nothing at all except wait and observe the evolution of the patient over time, while offering palliative treatment, Figure 3. In the case of the diagnostic problem, the prognosis of the patient and his/her evaluation will

finally give the result. Establishing a treatment is not always accompanied by the absolute certainty of a diagnosis, therefore the real conclusion of a case and the making of clinical decisions will be shown via the change and the evolution present in the conditions of the patient.

Daily medical work (implying inter-consultation between specialists, case conferences, and hospital morning rounds) includes exchange and cognitive processes within groups. It is possible to observe different physicians (specialists and nonspecialists) working together on the same patient. The contribution of these exchanges to solving complex problems is becoming more and more essential. These acts of collaboration are important for clinical decision-making concerning diagnosis and treatment, as well as for the student training and junior physicians, without forgetting the continuous experience that helps to develop expert knowledge [4].There are several examples: it is possible to mention cases of multi-system illnesses whose physiopathology and the nature of origin make it necessary to examine the results of several diagnostic procedures; patients with chronic disorders such as diabetes mellitus, obstructive pulmonary illnesses, cardiological illnesses; or patients who receive palliative care at home. On the whole, the most current scenarios where it is possible to observe this collaborative scheme are [4]:

- *Inter-consultations:* This is a process where a physician needs specialized consultation with several other physicians. There are two possibilities for this process: 1) between specialists with the same specialty (consultation between radiologists who observe an image to decide on a diagnosis) and 2) between specialists with different specialties (an obstetrician who refers his/her patient to a cardiologist for a coronary problem).
- *Case Conferences and morning rounds:* There are cases where it is possible to find several physicians (specialist physicians interconnected with general practitioners) exchanging information on several medical cases in order to make patient evaluations, to work on the publication of cases, etc. These are considered as staff meetings. During the diagnostic process, there are multiple situations where it is possible to observe medical exchanges at different process levels. To mention some cases, we can cite, Figure 4:
- The exchange can begin from the moment of the establishment of the clinical context when, for example, the emergency physician receives a patient who is transferred to another internal service.
- In the process of hypothesis generation, when one colleague asks another about the differential diagnoses to establish.
- In the hypothesis selection, when a physician asks another colleague her/his opinion about which hypothesis should be retained and which not. In addition, in the application of diagnostic tests, when one physician asks a specialist for the application of a particular test.
- In hypothesis confirmation and establishment of the final diagnosis, when a physician requests the opinion of a colleague on this aspect.

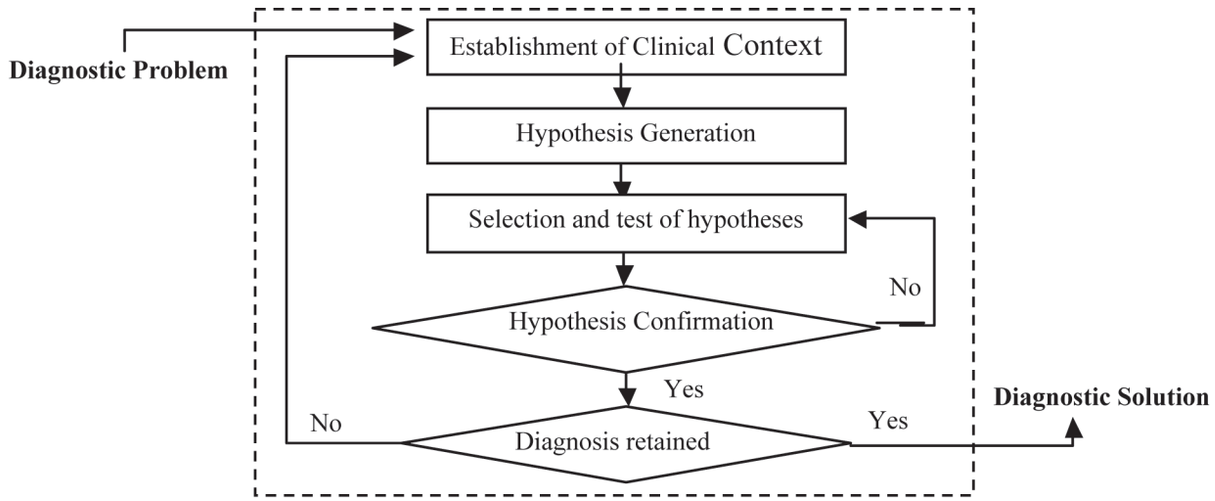

Figure 2: Diagnostic approach in complex cases

3. DIAGNOSTIC REASONING

Different types of knowledge are used to establish a medical diagnosis from the patient data. Some types of nosological knowledge are more important in certain forms of hypothesis generation than other types. This includes knowledge of signs, symptoms and findings (symptomatological knowledge), knowledge of clinical profiles of diseases and knowledge of causal relationships between symptomatological entities and clinical profiles of diseases (pathophysiological and pathoanatomical knowledge). The different types of disease knowledge are more closely related to the process of diagnostic reasoning. Thus, it is not possible to model disease knowledge independently from the process model of diagnostic reasoning and vice-versa. The diagnostic strategy of physicians is dependent (and based) on disease knowledge, just as knowledge is developed to support specific dynamic elements of the diagnostic process [5]..

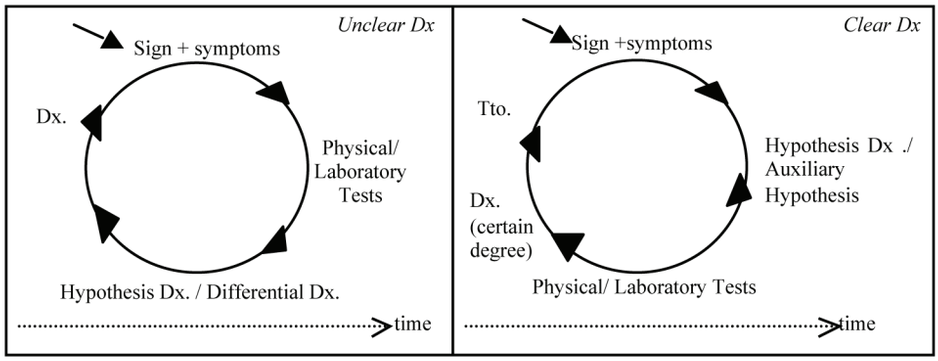

Figure 3: Evolutionary medical decision process

In the literature review about the medical diagnosis context, there are various analyses which attempt to explain the strategies of reasoning used to refine the case of the patient to a diagnostic solution. A strategy of medical reasoning is related to the way of making inferences between observations (signs, results of tests, etc.) and diseases. Thanks to these strategies, physicians make a decision concerning the steps to be taken in the current state of the case. This decision describes a choice between two actions (or more) and the path is based on the physician's knowledge.

3.1. Diagnostic reasoning approaches.

Resolving diagnostic problems and the diagnostic process implemented imply various methods or procedures. These methods include various resolution strategies. In daily practice, physicians use several methods or steps (called reasoning), among which we can mention, Figure 4: etiological reasoning, probabilistic reasoning, hypothetico-deductive reasoning, algorithm-aided reasoning, physiopathological reasoning, case based reasoning, descriptive reasoning, temporal reasoning, and uncertain reasoning. This list is not exhaustive; it lists only some forms of reasoning related to the medical field and its representation. These approaches are valid under the certain particular characteristics of each model (its constraints) but perfectly applicable as will be shown afterwards. The traditional development approaches of medical systems fail due to that only one, two or three approaches are implemented but in the real practices, all these approaches are used and combined in the complex problem solving. Consequently, the challenge of these systems is in the use of metareasoners able to select the correct approach or to decide the best combination of approaches to obtain the best results.

3.1.1. Etiological (called causal) reasoning.

Uses the deterministic principle. All causes have an effect, so it is possible to say that highlighting the cause allows us to explain the effect, and acting on the effect also means acting on the cause.

This approach establishes communication between clinical facts and a physiopathological model according to a cause-effect relation. Its interest lies in its capacity to explain why. It provides a conceptual framework for assembling the acquired facts (and the future facts) and a criterion of coherence in the validation of the hypothesis. It provides a framework for explaining and discussing between clinicians. In causal reasoning [6], the force of the links between the stimulus and the response must be estimated: credibility, effect of a change in the response on the stimulus, congruity,

duration and amplitude of the response to the stimulus, respect of chronology [7]. Etiological reasoning is based on the causes of a fact, a situation and a phenomenon in order to draw consequences. It does not take into account the intimate mechanism of the disorders and it remains in the preliminary phases of physiopathological knowledge. It is inoperative for diseases that do not correspond directly to a clinical table. It only functions correctly under the condition that a causal hypothesis is taken [2]. It is essential in two cases:

- To make an etiological diagnosis. This is the description phase of the cause or causes of disease.
- In order to decide the given treatment with curative objectives.

3.2.1. Probabilistic reasoning.

At the origin of statistical methods, it is essential for any study of populations in epidemiology, prevention, and diagnosis. Statistical methods also base clinical epidemiology on studies of patient populations. It provides instruments for the studies, indicating those that occur by chance at the time of the implementation of a study or experimentation. Commonly this approach is evoked at the outset of an epidemic period in a community. Probabilistic reasoning describes the clinician's conviction of the association between the signs observed and the diagnostic hypotheses, given the prevalence of diseases and the prevalence of the signs for each one of them. The probabilistic approach to diagnosis is characterized by the ill-defined and semi-quantitative expression of probabilities, using terms such as "common, possible, frequent, and rare" [7].

The use of probabilistic reasoning has experienced a significant theoretical development these last few decades [8].The probability theory of diseases has also been developed considerably. The post-test probability of a disease (after doing a diagnostic test) can be given by starting from the pre-test or initial (before the test) probability. Bayes' theorem and metrological data of the tests (sensitivity, specificity) are frequently used. This method is based on [2]:

- On the one hand, frequencies of certain diseases in given patient groups (which make it possible to determine a probability pre-test).
- On the other hand, a Bayesian revision, i.e. applying Bayes theorem to calculate the so-called post-test probabilities from initial and conditional probabilities.

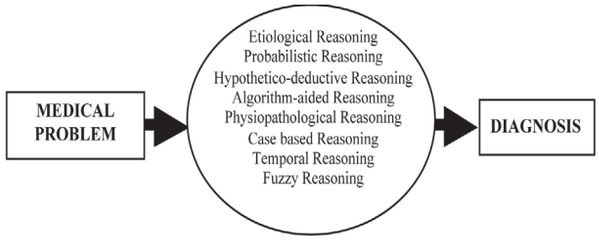

Figure 4: Medical Reasoning Types

This approach presents some limitations. Since the Bayesian approach is based on three assumptions:

- The hypotheses are mutually exclusive (diseases are excluded mutually which is not always the case - the same patient can present several diseases-).
- The hypotheses are exhaustive (all the diseases are listed).
- There is a conditional independence between the observed signs when the hypothesis is verified (for a given disease, the signs must be independent, which is not always the case - two different clinical signs may be statistically dependent).

These assumptions are rarely verified when a real problem is tackled. The method also requires the estimation of all the a priori probabilities, which is often difficult. Constraints on probability values (particularly, the fact that the sum of the probabilities of the various hypotheses is equal to one) make it very difficult to develop the knowledge base of such a system. The tendency is the realization of subsystems which allow the number of well-known probabilities to be limited.

The probabilistic formal approach is more satisfactory at the conceptual level but it requires a rigorous definition of the diseases (concept of golden rules). It requires one to know or consider the prior and conditional probabilities in order to calculate posterior probabilities. The validity of calculations relies on strong hypotheses applied to each medical recruitment: mutually exclusive diseases, independent conditional probabilities, exhaustiveness of the diseases and the signs [7].

3.1.3. Hypothetico-deductive reasoning.

This approach mainly involves hypotheses suggestion (For this reason, it is called "hypothetical"). From hypotheses, one deduces directly verifiable consequences of the present reality (For this reason

it is called “deductive”). Finally, these consequences are confronted with the facts in order to verify whether the hypothesis is sustainable or not [7]. In the medical context, this means proposing a hypothesis from the knowledge of the patient, and then, studying his case from the different tests done. This method is fundamental in the diagnostic step of the general practitioner. It gives him/her the possibility of effectively making a clinical judgment without accumulating a jumble of details of secondary importance.

This global method, i.e., the confrontation of the present reality with clinical patterns present in its memory, is frequently conducted in general practice [9].The observed clinical pattern has to be compared with the physician’s mental models, or “stereotypes” of diseases (which were the subject of the choice made between the diagnostic hypotheses). When the comparison is difficult because the observed pattern is not sufficient or not complete, the expert initially supplements his process by searching for other signs of clinical tests, and then, if necessary, by the implementation of complementary tests (which will allow the missing elements to be found but also, could indicate other additional tests). For this reason, it is necessary to reduce the field of application of tests and explorations to those which are the most “promising” i.e. to favor a hypothesis and within its framework to apply the most effective one. Nevertheless, favoring a hypothesis can result from a resemblance judgment (i.e. what appears the most “resembling” is favored), from a reflection based on etiological or physiopathological reasoning, from the implementation of rules established by accumulated experience or from an algorithm or a probabilistic evaluation, etc. [2].

3.1.4. Algorithm-aided Reasoning.

These procedures call on empirically established rules thanks to the knowledge of experts. Chains of thoughts are elaborated from a given symptom or situation [10]The path can follow a series of branches on a “tree”. The algorithm or decision tree uses a binary branch to guide the physician through various paths, proceeding by successive path elimination until he/she reaches a diagnosis. For example, a jaundiced patient who answers a series of questions logically leads to other questions; the clinical search for symptoms or technical investigations depends on a pre-established similar algorithmic process [2].

This method is also known as the deterministic or categorical method. It is based on standard “if... then...” production rules. The condition is a fragment of semantically significant information observed in the patient and the action is a specific predetermined consequence triggered by the condition. The application is vast, from diagnosis to treatment and prognosis. It is likely that several rules are activated in parallel and in competition, according to their strength and to their relevance. These rules or heuristics are well applied in the repeated clear-cut situations that are frequent in daily practice [7]. In principle, this approach is used by decision-aid systems. However, it presents some disadvantages:

The risk of fixed production system of approaches (an inventory of problems and algorithms for its resolution) is real, since none of these methods favours the essential procedure which is critical and clear reasoning leading to optimal result.

- They encourage a certain form of intellectual resignation because they accentuate the application of clinical practice recommendations.
- This method leads to clinical algorithms that realistically represent clinical decision and precision. But this requires paths to be followed strictly, becoming rapidly complicated in complex problems and it does not take uncertainty into account.
- Algorithms can be erroneous (constructed by only one individual or not validated), ambiguous and dependent on the context in which they have been elaborated. Most algorithms are therefore unusable for patients whose complaints are multiple or when facing complex clinical problems or interacting.

3.1.5. Physiopathological Reasoning.

This is the implementation of the set of contributions of clinical disciplines (macro-biopathology) and fundamental biology (micro-biopathology with the basic physicochemical disciplines) combined in order to understand the mechanism of pathological disorders [2].This only works correctly if a physiopathological hypothesis and/or a speculation is not taken for demonstrated reality (which is not, unfortunately always the case).

Within this framework of a diagnostic process, physiopathological reasoning cannot replace the clinical factual stages, almost always essential for the recognition of syndromes and the consecutive orientation of the diagnoses.

The exclusive or prevalent use of physiopathological reasoning can tend to neglect the reference to the firmly established nosology owing to the bases of taxonomic science, with the advantage of having been criticized by the scientific community.

3.1.6. Case based reasoning.

This reasoning approach considers medical experience based on past cases [11], [12]. It is founded on the principle of case analogy. Its objective is to solve a new problem (i.e. a new case) by comparing it to other similar situations and using information and knowledge related to this situation. An important aspect of this reasoning approach is its ability to learn: when the case considered is solved successfully, the experience can be retained to solve further similar problems [7].

Experience makes it possible to shorten the path of any analytical mechanism of pathological case recognition which can be mentally posed by the physician. The physician's memory about cases similar to the case with which he/she is confronted will reinforce his/her convictions with the hypothesis (or the hypotheses) selected and with the initial quantity of hypotheses established. Moreover, the limitation of the number of the primary hypotheses can be explained by the personal consideration of the physician of the possible number of hypotheses that he/she is able to work with at successive stages. Thus, with the smallest possible number of hypotheses he/she is faced with, work is made less complicated and it will be more practical to find an answer quickly.

The limitations of this approach are associated with the subjective interpretations relative to: similarity criteria (when a case is similar to another one); the number of cases that are required (directly related to experience); the criteria needed to classify or to group cases together, to mention just a few.

3.1.7. Descriptive reasoning.

Generally, this reasoning approach implies the explanation or the fundamental relations of a phenomenon, a question or an observation. Descriptive reasoning identifies concepts or variables: What, Where, and Who. In the medical context, it allows clinical and paraclinical data to be collected which will permit a certain number of useful activities for taking care of the patient. The observation and detailed collection of symptoms and signs, allowing the development of semiology and the study of the lesions and their evolutions remain the basis for describing diseases and establishing medical knowledge. This can be useful for the prognosis and the monitoring of the evolution. This method can recognize neither the causes nor the mechanisms of the diseases, nor, therefore, the possible means of action on them [2].

3.1.8. Temporal reasoning.

This approach is able to establish a temporal order and to make inferences from it, to constitute qualitative operations suitable for structuring space. In clinical practice, the diagnostic process is essentially a temporal process [13].It takes into account the history of the disease treated with reference to its natural history [14]. Diagnostic hypotheses are founded on frequencies of appearance but especially on an immediate medical utility. The chronology of the frequency of the appearance of signs and symptoms, in a particular order, is extremely important. Physicians reason with data and events. Time is of primary importance in medicine. It plays a principal role in medical decision-making (clinical diagnosis and planning of therapy) and in medical data modeling and controlling (for example, representation of patient medical registers, including pathologies and past therapies, and control data).

The limitations of this approach involve the subjective variables relative to the granularity of the considered time and the mechanisms of maintenance of this time [15].

3.1.9 Fuzzy reasoning.

This type of reasoning has the capacity to make inferences with elements defined in a vague, imprecise, and uncertain manner [16].The processing of these elements can also be defined in a vague way, like the final results. The difficulty of decision-making, particularly in medicine and public health, results from the situation of uncertainty, owing to several reasons [7]:

- Uncertainty about knowledge: certain knowledge has a statistical nature (frequency of diseases or signs). It is associated naturally with a risk of error. Another type of knowledge imperfection is incompleteness, for lack of exploration or insufficiency of conceptualization (physiopathology);
- Uncertainty about the facts: the description of the patient's actual state is never perfect, either for lack of means or time (urgency), or for lack of measurement or bad interpretation of a symptom, a sign or a result.
- The uncertainty of the language: the fuzziness and the ambiguity of the concepts handled

disturb the treatment and the transmission of information.

The difficulty of this approach lies in the interpretation subjectivity of the values, as well as in the confidence in the methods used.

3.2. Medical reasoning and inductive, deductive, adductive, and analogical reasoning.

It is taken for granted that different *reasoning forms* can be identified, such as inductive, deductive, adductive, and analogical reasoning. Logic and mathematics have systematized these types of reasoning [17].

Inductive Reasoning: goes from the particular to the general. It envisages a precise case in order to reach the implications it generates at a general level. It makes generalizations based on specific examples to formulate general rules and it produces valid inferences with a certain degree of credibility or probability. Inductive reasoning is applied to the process of reasoning (which, as a general principle, is true because special cases are also true).

Deductive Reasoning: goes from the general to the particular. It draws conclusions from a law, a principle, a general rule and applies them to a particular case. Deductive reasoning applies to the process to conclude that something is true because it is a special case of a general principle.

Abductive Reasoning: is the method usually used to infer explanations resulting from causal links represented by logical implications i.e. this reasoning is a way of inferring causes from effects.

Analogical Reasoning: establishes an unusual relationship between two fields and shows the resemblances between them. It is the process of making inferences based on parallels between two entities or domains. The first step in analogical reasoning involves the intuitive recognition that if two things are parallel, then what is true of one must also be true of the other.

3.3. Diagnostic Process as an inferential process.

It is possible to establish a relationship between the inferential processes of deduction, induction, abduction, and analogy [18],[19] and the diagnostic processes studied, Figure 5. The resolution of a medical problem can be considered as a resolution process in several steps as was shown in Figure 1 and Figure 2. Each step can carry out a different inferential process. This relationship is showed in the follow steps:

1) After defining the patient's clinical context, physicians begin the process of hypothesis generation; this is recognized as an abductive process. The consequences (effects) observed in the patient allow a series of possible explanations for his/her problem to be obtained. These relations can be established according to the mechanisms discussed previously (etiological, probabilistic, descriptive, etc). This hypothesis generation can also be the product of an analogical process in which a certain similarity between the present case and past cases is established. Finally, the result of this step is one or several hypotheses to be tested.
2) The hypotheses retained in the previous step are ordered in a decreasing order (from the most probable to least probable one). For a given hypothesis, the effects expected in the patient are considered if this hypothesis is certain. This involves a deductive process and the result is a set of facts to be verified.
3) After applying all the tests and consultations, a conclusion that comes from these verified facts is established, and this process is induction. If the conclusion is "sufficiently" valid, from the physician's point of view, it is retained, but if not, the previous step must be repeated. It is important to indicate that

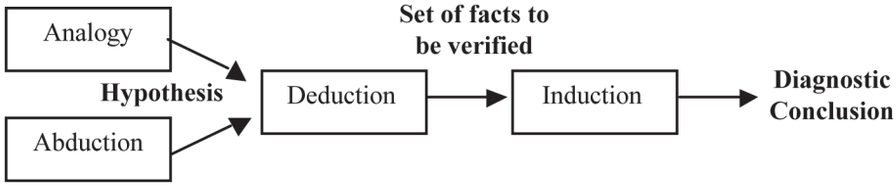

Figure 5: Inferential processes in diagnosis

this process is not linear, in any of its steps. As new findings are discovered or new information appears, these are incorporated into the set of facts. This allows the scheme to be continued or any step to be missed out, generating new hypotheses.

4. CONCLUSIONS

In this paper, an analysis of diagnostic problem-solving in the medical field is presented. There are many application areas in the field of medical computer sciences that are interested in this type of analysis, like for example, medical decision support systems, diagnostic aid, expert systems, telemedical systems, and collaborative work and problem-solving, to mention a few.

The first part presents the diagnosis and its stages. This subject is approached from three angles: the diagnostic problem in classical cases, in complex cases, and the collaborative and dynamical case, in which several experts take part. It is important to indicate that this classification is not exclusive, that is, a case, considered as complex at one time, can be later considered as a classical one. Similarly, a case requiring the intervention of several experts at one moment may be later considered and treated by only one physician. There are many variables that come into play, as has been shown by this study. The problems of dealing with biological systems, which are highly complex, variable, and dynamic such as medical problems, make it difficult to establish a unique and invariable formulation. This part of the study is completed with a description of the mental processes that are called upon by physicians responsible for the diagnostic task. Some restrictions that come into play, and which also make the treatment of the problem more complex, are mentioned and finally, the knowledge sources used are described.

The second part presents an overview of different research efforts in medical reasoning. This study is not exhaustive but it shows an overview of the different approaches that appear in the medical and computer science literature on the subject. The reasoning approaches described are: etiological, probabilistic, hypothetico-deductive, algorithm-aided, physiopathological, case based, descriptive, temporal, and fuzzy reasoning. We notice that a wide range of models exists. These models have tried to solve the problem from different perspectives, some more general than others and some more complex than others. Diverse areas like mathematics, medicine, and computer science have supported these models. We must not forget that man has tried to model his reality and the result is a variety of models valid within their limitations and their scopes for which they have been defined. This means that according to the constraints for which they were designed, they are perfectly valid. The study is followed by a logical point of view of the reasoning problem, as a result of inferential processes. For this, we used in the classical mechanisms of inference as a basis: deduction, induction, abduction, and analogy. The relation between these inferential processes and the diagnostic process studied in the first part allows us to establish an inferential scheme of the diagnostic problem. .

Finally, we observe that the literature has progressed from the early systems, which were mostly application dependent, to more general approaches which, even when applied to the resolution of real problems, have a more generalizable value and inherent soundness. An important role in this direction is that of research efforts in areas integrating several mechanisms of reasoning, metareasoning, data and information fusion, and the new generation of hybrid knowledge-based systems. All of these use appropriate technology for the computer-based resolution of complex, real-life problems like those encountered in medical domains.

Acknowledgment: Authors are grateful to FONACIT, Venezuela, under Project No G-2005000278.

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