Artificial Intelligence (AI) and Ethical Artificial Intelligence (EAI) Medical Decision Support System, Medical Sapiens (MS)

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The concept of AI (Artificial Intelligence) is relatively new and is being used with increasing frequency. The importance of this concept has to do with the increased capacity of what we understand as intelligence. However, it is a delicate concept and easy to misuse and/or misinterpret. A good understanding of what AI is, what it is based on, or should be based on and its forms of practical operation is required.

First, I would like to discuss the difference between AI (Artificial Intelligence) and EAI (Ethical Artificial Intelligence). In general, AI is thought of as a program or machine capable of answering difficult questions by generating relationships related to the question within large relational databases. This leads to results where it is not always clear how they were obtained (what was the "reasoning" behind them). In the long term, this can lead to important problems due to misunderstanding and dependency. Here, we would ultimately be obeying a machine based on its eventual high predictive capacity. But, in this case, who is really the decision-maker and who is just the "decision-operator"?

This becomes a very delicate question, since the human being, by losing the ability to manage or administer the decision due to his inability to understand why it turned out that way, also loses his freedom of action. Some people call it the "freedom to make mistakes" although I prefer to define it as "reaching a dangerous degree of dependency." Even if we started with the hypothesis that the machine is never wrong, this assumption removes a significant degree of freedom in our decision-making process and robs human beings of this crucial process in our development (for the human species our development depends on making good decisions).

As a counterpoint, Ethical Artificial Intelligence (EAI) is defined as an AI in which the human being is capable, in general terms, of understanding the sequence of steps or the procedure carried out by the AI to reach the result. If this is the case, the AI enhances the capacity of natural intelligence in humans or other species.

Understanding the sequence of steps or procedures performed by the AI is achieved naturally, for example, in the Medical Sapiens (MS)[1] system. Since the MS system was

[1] MS (Medical Sapiens) is a decision support software for medical diagnoses, emergency triage and doctor specialty derivation.

built using multicriteria models (Analytic Hierarchy Process and Analytic Network Process) based on topological metrics in weighted environments (order topology) instead of statistical metrics (relational databases), it is a real EAI system. The MS system is described in more detail later.

It is important to note that I'm not detracting from the usefulness and importance of statistical metrics. In fact, there are analyses of this type within MS too (known as data analytics). The idea is not to replace one with the other, but to use each one in its proper capacity in such a way that it is always possible to follow the simulated or real reasoning process. It is also important to understand the basic capabilities of all types of intelligence that are present, or must be present, whether it is natural or artificial.

On the capabilities of an AI

There are three basic capabilities that all AI systems must have which are listed below in order of importance:

1. *Pattern Recognition Capability (recognition)*

One of the main characteristics of intelligence is the ability to recognize patterns; without this ability, no system can survive. In fact, our own brain begins to work very early on building out its capacity to do this.

2. *Feedback Capability (adaptability)*

Once there is the ability to recognize patterns, it is important to have feedback; that is, be able to receive new information and adapt to this new reality. This adaptability is very important to keep the system updated. However, it should be clarified that this ability should not be thought of as a replacement or substitute for the pattern recognition ability. In fact, feedback must always be used to slightly modify the pattern recognition capability so that its impact occurs progressively. The way in which the initial pattern is modified should be relatively slow as new information is added so that the suggested change can be verified. Making slow changes is the way to avoid abrupt (discontinuous) changes that may no longer reflect reality.

It should be noted that in decision modeling we accept inconsistency (to a maximum degree) so we can accept new information that may not be consistent with what exists. However, this degree of inconsistency is usually quite limited (in general, it should not exceed 10%) such that it allows change, but it is slow, acceptable and compatible with the existing patterns.

3. *Optimization capability (efficiency)*

Finally, the system must have the ability to optimize. Optimization is closely linked to improving the efficiency of the system. It means doing the same work in a smaller unit of time or space. While this ability is important to recognize, often the advancement of technology allows it to be achieved naturally (almost automatically).

Introducing the Medical Sapiens[2] (MS) system

Medical Sapiens (MS) is a web system designed to help a physician make a presumptive medical diagnosis, triage, or decide which specialist a patient needs. The physician using the system will collect and describe the patient's signs and symptoms and enter them into the system. The MS system includes patterns of many different diseases built from signs and symptoms, each with its own degree of importance and scale of intensity. Then, the most likely disease can be determined by the MS system by comparing the patient's pattern against all the disease profiles (weighted disease profiles) in its database.

MS has a semiological[3] clinical approach; thus, the doctors can easily follow the logic behind the profiles and input the data required by MS. It follows the ICD-10[4] classification for diagnoses and the Snomed (the international global standards for health terms) so the examining physician can easily describe the disease.

The MS system has approximately 5,000 signs and symptoms in its database, and each one has an associated absolute ratio scale, which results in 1,000 different disease profiles. Every disease has a profile of signs and symptoms, and their relative dominance (or importance in describing a disease) is given in an absolute ratio scale that has been derived through the AHP/ANP (Analytic Hierarchy/Network Process) via pairwise comparisons made by specialists (medical doctors) for each part of the body as well as MBE (medicine based on evidence).

To initially construct the MS system, the human body was divided topographically into 35 parts, and then different groups of specialists for each part of the body were gathered to build a model (structure and weights) and the absolute ratio scales for each terminal criterion (sign or symptom). Finally, all the models were grouped into a large network model (ANP model) since the human body is one big interrelated system.

For example, in the mouth, the part of the body that belongs to model 25 (the otorhinolaryngological model), there is a terminal criterion (a sign) called "color" which is one of the descriptors of tongue criterion that helps determine the diseases associated with the color of the tongue. Its absolute ratio scale is shown in Table 1.

[2] More information at: www.medicalsapiens.com
[3] The study of signs especially (semiotics). Webster dictionary
[4] ICD and Snomed are international classification of diseases. ICD-10 is the edition number 10.

Table 1
Intensity scale for color of tongue

INTENSITY NAME (color of tongue)	PRIORITY
Black	1.0000
White	0.8802
Cyanotic	0.5616
Erythematosus	0.2609
Yellow-whitish	0.0975

Therefore, if the color of the tongue is black, it is very helpful in making a diagnosis. However, if its color is yellow-whitish, it is not very helpful. It is important to note that the ratio scale associated with the criterion describes its capacity to make a diagnosis (not necessarily its degree of mortality or dangerousness).

In addition to the modeling process, it is possible to include all personal, family, work and socioeconomic antecedents, which serve as a basis for ruling out some diagnoses.

The input process

The information given to the MS is structured in a semiological way. This is the same process that physicians use when examining a patient; they first look for signs and symptoms. Therefore, physicians easily understand how to enter the MS data since it is the same way they were taught to determine signs and symptoms as they examine a patient. There is a cell for each possible symptom for all the diseases in the database. Each cell has intensity options that have associated priorities. The input format used by the physicians is almost 100% via mouse by clicking on the appropriate intensity shown in his/her patient. The physician only selects cells for the symptoms that appear in that particular patient.

There is one cell for each possible sign or symptom for every disease. As the physician observes a patient and notices a sign or symptom, they can easily find the symptom in the MS system due to the user-friendly way it is structured. Then, the physician rates the symptom's intensity on its associated scale (for example, color of tongue) by using the mouse to click the correct option as shown in Figure 1.

Figure 1 Example of template screen for otorhinolaryngological model during the physical exam.

The words in bold in Figure 1 indicate the line to be followed (by moving and clicking the mouse) to insert the doctor's finding (the tongue sign). Of course, the doctor only has to input the signs and symptoms that are displayed in the patient (abnormal signs or symptoms). The priorities of the signs and symptoms that are observed in the patient are then weighted and normalized by the MS system to form a profile of the patient's possible illness. To determine what the illness is, the profile is compared, one by one, against all known disease profiles that are stored in the MS database. The disease profile that it most closely matches (most similar in terms of compatibility) is most likely the illness the patient has.

For a computer, this process takes less than a second. To do this, the MS system uses the compatibility index G (Garuti´s index). The G compatibility index is based in set theory and vector algebra and is able to measure the similarity or closeness between two priority vectors in weighted environments in a very precise way. More information about this index can be found in *Measuring in Weighted Environments* (Garuti, 2016). Several papers have also been written about this index, the most recent being "Set Theory Justification of G-Compatibility Index (Generalization of Jaccard Index Working within Weighted Environment)" (Garuti, 2021).

Figure 2 graphically shows the matching process between the patient's symptoms and different disease profiles.

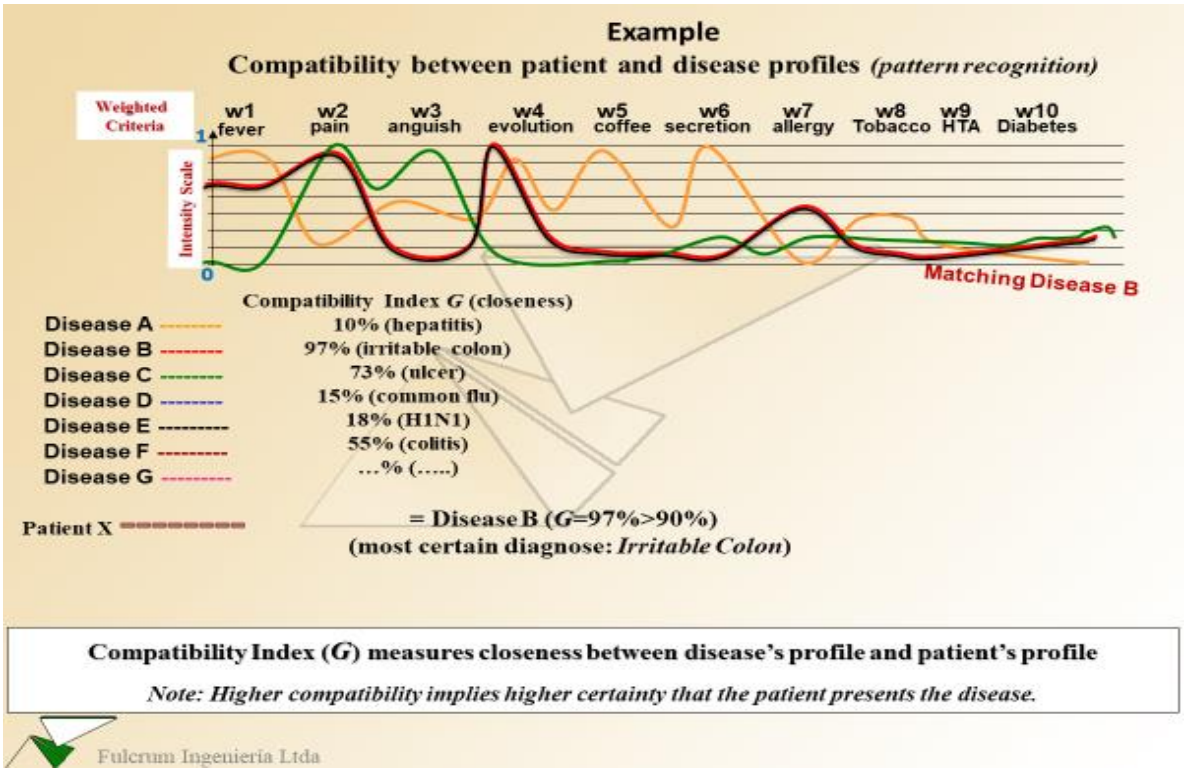

Figure 2 Matching process calculation in graphical terms

This process is called additive medicine in contrast to the classic differential medicine. With this process, all the possible diseases are always present during the diagnostic process. Every time a new symptom is added, MS reorders (re-prioritizes) all the diseases according to its new compatibility. This is an important factor since we know that diseases are intrinsically dynamic, they may change along the timeline, and it should be possible to follow that change without losing any possible diseases. Covid-19 is an example of why this process is important. In differential medicine, sometimes a disease may be overlooked because one relevant symptom isn't present; however, that symptom can appear later.

The output process

Once the pertinent information about a patient has been completed, the MS system displays the information structured in two blocks, anamnesis (patient interrogation) and patient examination. At this point, the doctor can request an MS opinion which is in the form of a prioritized list of diseases expressed in percentages of similarity (compatibility) between the profile of the patient's disease and the profiles of the diseases included in the MS database.

In addition, the output screen has a column where the doctor can find which signs and symptoms could increase the degree of similarity between the patient's profile and the

disease profiles. This provides a refinement tool for analyzing the signs of the disease and making a different diagnosis. This will help new doctors gain knowledge about the behavior of specific diseases. Also, MS can be used as a "learning tool" by students of semiology in the study of medicine.

It is important to state that the doctor is ultimately the one who decides the diagnosis of the patient's disease. However, the MS system helps provide the doctor with an important set of possible diseases in a prioritized form. Before using the MS system, the doctor may not have known about the existence of a particular disease or been familiar enough with it to recognize that disease pattern.

Other features of the Medical Sapiens (MS) system

- MS is compatible with integration in any clinical record system.
- MS is an agile system, with an ability to add new diseases, new presentations or evolutions of existing diseases.
- MS requires no more than 5 or 6 minutes for the doctor to fill in the necessary data once he/she is trained.

On the relationship between the capabilities of the Medical Sapiens (MS) system and EAI

Regarding the relationship of the Medical Sapiens system (a medical decision support system) with EAI, MS meets the first and most important condition, pattern recognition ability. Pattern recognition is one of the main characteristics of the MS medical decision support system. The second capability, feedback, is currently being done manually. However, one of the short-term goals is to automate the process of updating the disease patterns in the system with the new information gathered during the process of comparing the initial diagnosis with the final (discharge) diagnosis and analyzing the closeness or compatibility between any two patterns. It should be noted that constructing new patterns of diseases that have not been known to exist or that were previously not included in the system is possible in the same way.

We conclude that the MS system fully complies with the first two capabilities that are most important for any AI system. The last capability of optimization represents a continuous process that must be done in parallel with the natural growth of the system. For example, a new database administrator might accelerate the process or find a new way to input data that makes it easier for the patient or doctor to enter the initial data in the MS system. This new way to input data is currently being worked on; we are programming a graphical way to describe where the pain is located on a human body as specifically as possible using software with zoom capability, which makes it easier for the patient, a nurse or a doctor to pinpoint the location of his/her pain.

A simplified version of the three capabilities of the medical decision support system (Medical Sapiens) is shown in Figure 3.

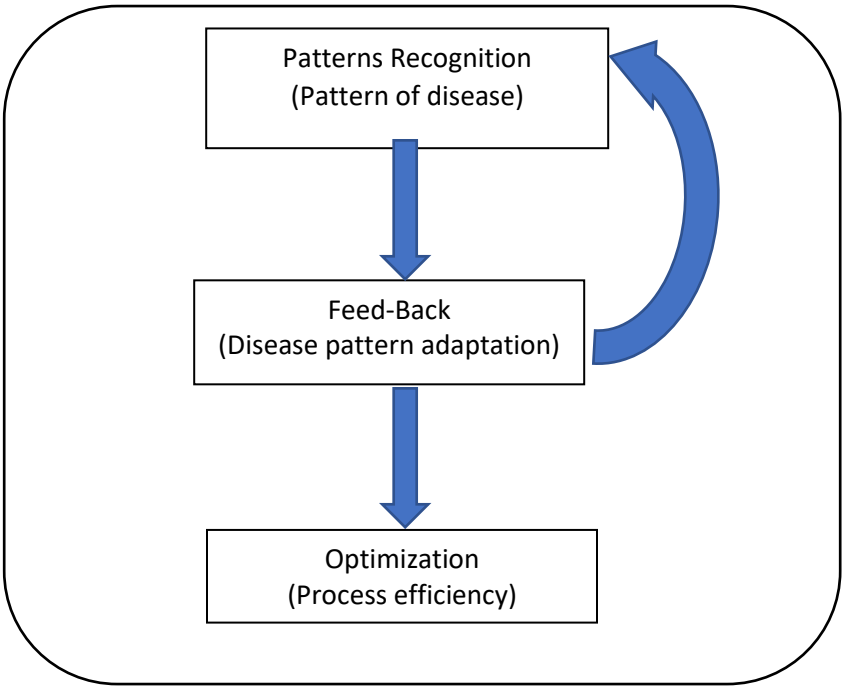

Figure 3 Process conceptualization of the three AEI capabilities

Conclusion

The use of the AHP/ANP to construct medical decision models in combination with the G compatibility index (used for pattern recognition in weighted environments) has shown a capacity to greatly assist doctors. It can especially help new doctors and general practitioners learn better diagnostic practices. It shortens the time to reach a final diagnosis, ask for specific exams, and direct the patient to the correct specialist. Also, MS can speed up learning about rare diseases, new presentations of old diseases, or the popup of new diseases such as Covid-19.

Furthermore, the way that MS was built allows the clinician to continually maintain control over the system, and to follow and understand why the results at any step were delivered by MS, which is a main requirement of an EAI.

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