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An Analogical Model to Design Time in Clinical Objects

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Abstract - This paper proposes an object oriented model to implement medical Knowledge Base Systems (KBS). The model has two levels. The external level (type level) facilitates the implementation and the interoperability of the system. The internal level describes the objects which are combined with the composition (union) operator \oplus . A fuzzy vectorial space defines the evolution of the clinical objects involved in the system. Thus, the composition of the clinical picture objects is tuned by fuzzy functions whose values evolve with time. The model provides new tools to compare the evolution of objects and to implement analogical reasoning.

Index Terms - E-health, Medical Informatics, Modeling

I. INTRODUCTION

Modeling time in the evolution of clinical pictures for diagnosis, prognosis and therapy remains a great challenge due to the need to express the emerging properties of the clinical pictures, syndromes and signs in interaction. To efficiently compare the evolution of the structure and state of these objects we propose distances that rely on a gradient computed from a fuzzy vectorial space Figure 2. Our object model integrates time fuzzy functions to express the composition evolution of a disease without the need for fuzzification and defuzzification stages. In a previous work, we summarized the complexity of disease modeling: every patient is unique; most diseases are multifocal and are dynamic linear or cyclic processes, such as with a duodenal ulcer and psoriasis [1]; and treatments may result in unusual clinical aspects or produce iatrogenic diseases.

II. MATERIALS AND METHODS

Figure 1 shows the structure evolution of a disease and how an agent sorts the syndromes according to the gradient vector distances of their component signs and relevant attributes Figure 2. The attribute values (three to facilitate the representation) are normalized fuzzy functions on a $[-1, 1]$ interval that allow us to build a vector which defines the state of each component object at each time t . In turn, the component objects create a composite object and its corresponding resultant vector in the same manner.

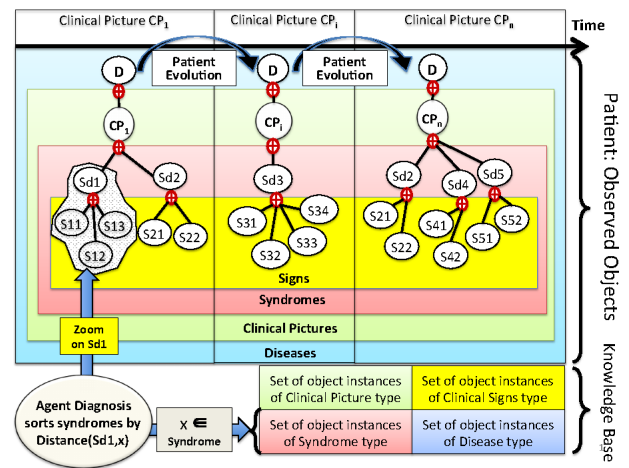


Figure 1: Evolution of a disease D composed of their clinical pictures CP, syndromes Sd and signs S

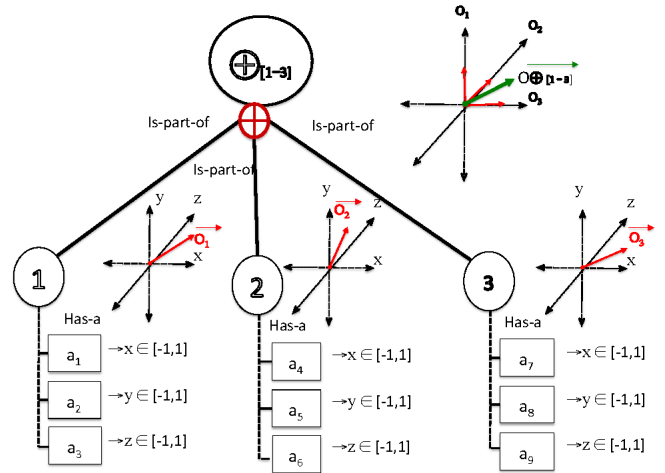


Figure 2: A fuzzy vectorial space defines a composition vector from its object components and their attributes

For brevity, we illustrate our model with a simple example: the diagnosis and prognosis of acute diarrhea. A compulsory initial sign (CS1) in Figure 3 can lead to several diagnoses Δ_1 to Δ_8 and their corresponding prognoses Π_1 to Π_8 and therapies (Figures 4, 5), depending on the clinical signs ES_1 to ES_6 , the history of risk (HR) and the signs of severity (SS) shown by the patient. The time evolution of the disease is compared according to the transitions of the

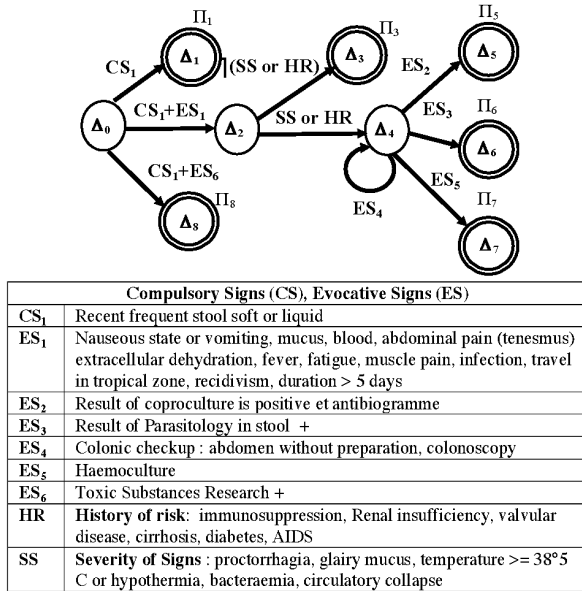


Figure 3: Automaton of acute diarrhea diagnosis (Δ_0, Δ_2 and Δ_4 are intermediate states)

| Diagnosis | | Prognosis | |
|------------|----------------------------------------|------------|------------------|
| Δ_0 | Acute diarrhea | | |
| Δ_1 | Viral diarrhea | Π_1 | Mild |
| Δ_2 | Diarrhea with invasive germ | | |
| Δ_3 | Mild bacterial diarrhea | Π_3 | Curable |
| Δ_4 | Bacterial or parasitic severe diarrhea | | |
| Δ_5 | Bacterial severe diarrhea | | |
| Δ_6 | Parasitic severe diarrhea | Π_5 to | Life-threatening |
| Δ_7 | Septicemia (Gram negative germs) | | |
| Δ_8 | Toxic diarrhea | Π_8 | |

Figure 4: Diagnoses $\Delta_0 - \Delta_8$ and Prognosis $\Pi_1 - \Pi_8$

automaton and the relevant signs that could occur as shown in Figure 3. The temporal analogical reasoning is implemented by computing a resulting gradient distance vector with the component objects as shown in Figures 1 and 2.

III. DISCUSSION-CONCLUSION

Although rule-based models have been widely used to build diagnosis KBS in the medical domain, they failed to model deep knowledge [2], to represent causality, time, object structure evolution and threshold incertitude in evaluating attributes and some contradictory rules [3]. A fuzzy rule approach is not well suited to implement a clinical object model where semantic capability is required to consistently express the structure evolution of a disease as in Figure 1. Also, most fuzzy rule approaches need a fuzzification step to represent scattered chunks of knowledge and a defuzzification step to allow the rules to be triggered by an inference engine [4] [5]. Our object model provides disease representations which are very close to a practitioner's

| Therapy | |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Θ_1 | Oral hydration, antikinetics opiates (codeine, diphenoxylate, loperamide), smectite + diet |
| Θ_3 | Θ_3 Oral or I.V. hydration, chelating agent of toxins (colestyramine), stool culture, antibiotic assay and targeted antibiotic treatment |
| Θ_5 | hospitalisation, Θ_3 + correction of hypovolaemia (plasma+albumin), I.V., antibiotic treatment. Clostridium difficile (Vanomycine) |
| Θ_6 | idem as Θ_5 + parasitic research, antiparasitic : metronidazole ou Tinidazole and then Tiliquinol |
| Θ_7 | idem as Θ_5 + blood culture + I.V. antibiotic treatment |
| Θ_8 | Tox screen + chelating agent of the drug |

Figure 5: Therapies Θ_1, Θ_3 and $\Theta_5 - \Theta_8$

way of thinking and to the medical semiology. This work is in progress and we are currently building a multi-agent platform to implement all the model features, with agents specialized in the different clinical steps: diagnosis, prognosis and therapy inspired by our previous works[1, 6].

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