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.

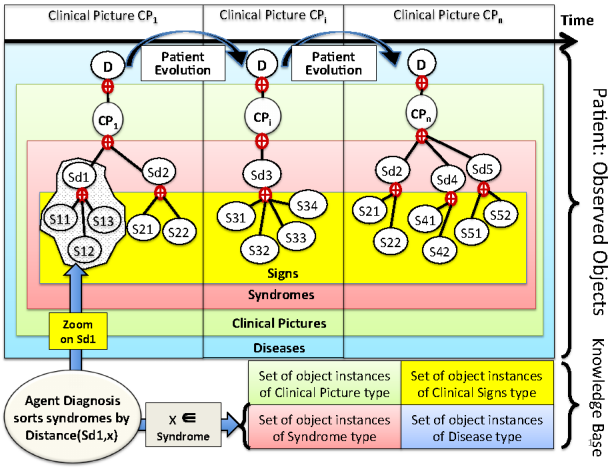


Figure 1: Evolution of a disease D composed of their clinical pictures CP, syndromes Sd and signs S

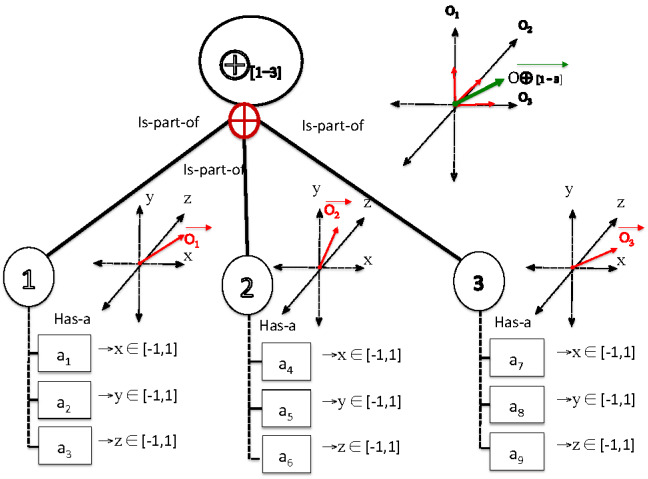
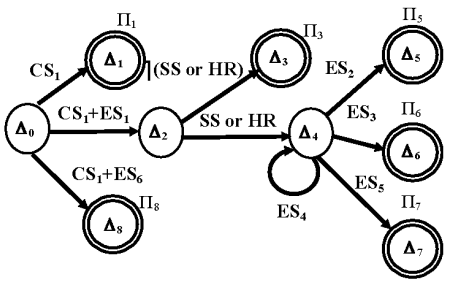


Figure 2: A fuzzy vectorial space defines a composition vector from its object components and their attributes

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



Compulsory Signs (CS), Evocative Signs (ES)	
CS_1	Recent frequent stool soft or liquid
ES_1	Nauseous state or vomiting, mucus, blood, abdominal pain (tenesmus) extracellular dehydration, fever, fatigue, muscle pain, infection, travel in tropical zone, recidivism, duration > 5 days
ES_2	Result of coproculture is positive et antibiogramme
ES_3	Result of Parasitology in stool +
ES_4	Colonic checkup : abdomen without preparation, colonoscopy
ES_5	Haemoculture
ES_6	Toxic Substances Research +
HR	**History of risk**: immunosuppression, Renal insufficiency, valvular disease, cirrhosis, diabetes, AIDS
SS	**Severity of Signs** : proctorrhagia, glairy mucus, temperature >= 38°5 C or hypothermia, bacteraemia, circulatory collapse

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	Π_5 to Π_8	Life-threatning
Δ_6	Parasitic severe diarrhea		
Δ_7	Septicemia (Gram negative germs)		
Δ_8	Toxic diarrhea		

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 hydratation, antikinetics opiates (codeine, diphenoxylate, loperamide), smectite + diet
Θ_3	Θ_3 Oral or I.V. hydratation, 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].

ACKNOWLEDGMENTS

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