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DECISION MAKING AND QUALITY-OF-INFORMATION

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RESUMO

Commonly, knowledge and belief are generally incomplete, contradictory, or error sensitive, being desirable to use formal tools to deal with these problems. Logic and Logic programs have emerged as attractive knowledge representation formalism and an approach to solving search problems. In the past few decades, many non-classical techniques for modeling the universe of discourse and reasoning procedures of intelligent systems have been proposed. A part from the need to treat the problem of uncertain information there exists a second need related to the problem of incomplete information. Logic Programming presents a powerful and attractive knowledge representation and reasoning formalism to solve search problems in environments with defective information. For example, Hommersom and Colleagues work is a good example of quality evaluation using logic. They used abduction and temporal logic for quality-checking of medical guidelines, proposing a method to diagnose potential problems in a timeline, regarding the fulfillment of general medical quality criteria at a meta-level characterization. They explored an approach which uses a relational translation to map the temporal logic formulas to first-order logic and a resolution-based theorem prover.

The objective is to built a quantification process of the Quality-of-Information (QoI) that stems from a logic program or theory during an evolutive process that aims to solve a problem in environments with incomplete information. In previous works, it is presented a model for group decision making with quality evaluation, along with the several stages of the decision making process in the context of a Group Decision Support System (GDSS) for VirtualECare.

In decision making processes [9, 11] it is necessary to search only the most promising search paths. Each path must be tested on their ability to adapt to changing environments, to make deductions and draw inferences, and to choose the most appropriate course of action from a wide range of alternatives. The optimal path in an ELP context is the logic program or theory that models the universe of discourse and maximizes its Quality-of-Information (QoI) factor. Let i $(i \in [1,m])$ represent the predicates whose extensions make an extended logic program that models the universe of discourse, as it is given above in terms of the predicates `itch`, `fever`, `and` `pain`, where j $(j \in [1,n])$ denote the attributes of those predicates. Let $x_j \in [min_j, max_j]$ be a value for attribute j. To each predicate is also associated a scoring function $V_{ij}[min_j, max_j] \rightarrow [0,1]$, that gives the score predicate i assigned to a value of attribute j in the range of its acceptable values, i.e. its domain (for simplicity, scores are kept in the interval $[0,1]$).

The `Quality-of-Information` (`QoI`) with respect to a generic predicate P can be analyzed in four situations and can be measure in the interval $[0,1]$, when the information is positive and negative, when the information is unknown but can be selected from one or more values, and when the information is unknown but can be derived from a set of values, but only one can be selected. If the information is known (positive) or false (negative) the (`QoI`) for the predicate term under consideration is 1. For situations where the value is `unknown` the `QoI` is given by:

$$QoI_P = \lim_{N\to\infty} \frac{1}{N} = 0(N >> 0)$$

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For situations when the information is unknown but can be derived from a set of values, $QoI_P = 1/Card$, where *Card* denotes the cardinality of the exception set for P, if the exception set is disjoint. If the exception set is not disjoint, the quality-of-information is given by:

$$QoI_P = \frac{1}{C_1^{Card} + \cdots + C_{Card}^{Card}}$$

where C_{Card}^{Card} is a card-combination subset, with *Card* elements. The next element of the model to be considered is the *relative importance* that a predicate assigns to each of its attributes under observation, i.e. w_{ij} stands for the relevance of attribute j for predicate i. It is also assumed that the weights of all predicates are normalized, that is:

$$\forall i \sum_{j=1}^{n} w_{ij} = 1, \text{ for all } i.$$

On the another hand, the predicate scoring function, when associated to a value $x=(x_1, \ldots, x_n)$ in a multi-dimensional space, it is defined in terms of its attribute domains in the form:

$$V^i(x) = \sum_{j=1}^{n} w^i{}_j * V^i{}_j(x_j)$$

Therefore, it is viable to measure the *QoI* that occurs as a result of invoking a logic program to prove a theorem (e.g. Theorem), by posting the $V_i(x)$ values into a multi-dimensional space and projecting it onto a two dimensional one.

The VirtualECare project embodies an intelligent multi-agent system aimed to monitor and interact with its users, targeted to elderly people and/or their relatives. The system is designed to have several services, beyond the health related ones. It will be connected not only to healthcare institutions, but also with user's relatives, leisure centers, training facilities and shops, just to name a few.

The VirtualECare GDSS is a knowledge-driven Decision Support Systems (DSS), that relies on a database (or knowledge base), and models representations of the world, following a proof-theoretical approach to computing, that addresses the truth value of a theorem to be proved in terms of the *QoI* of the terms that make the extension of a predicate or predicates under invocation.

Our approach of a VirtualECare GDSS follows Simon's empirical rationality. The *Intelligence* stage occurs continuously, as the GDSS interacts with other components of the VirtualECare system. Identified problems that call for an action triggers the formation of a group decision. This group formation is conducted in the pre-meeting phase, when a facilitator must choose the partakers. In order to form the "best" group he/she must evaluate the *QoI* on hand of possible participants, and not about the participants themselves, registered in the knowledge base system. The *Design* and *Choice* phases occur in the in-meeting stage. In the In-Meeting phase, the participants will be working in order to accomplish the meeting goals and to take de finest decisions. In order to accomplish this goal, the participants use a knowledge database and exchange information. Once again, the system must provide a measure of the *QoI* available.

Qualitative models and qualitative reasoning have been around in Artificial Intelligence research for some time, in particular due the growing need to offer support in decision-making processes. This area brings together research and evaluation projects in which healthcare decision-making plays a vital role. Indeed, decision making with healthcare implications spans a broad area, and is relevant at the national, regional local, and patient levels, and in the public and private spheres. The main focus of our studies in this field is decision-making at the patient level; although, as future work, we intend to study the problem at the organisational and societal levels. Our work addresses the problem of decision making, modeling it in terms of a multitude of scenarios, defined as logic programs or theories, being its selection based on its soundness, here measured in terms of their *QoIs* values.

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