A Tool for Automatic Reasoning over Decision Documentation using gUFO

Bruno G. Carneiro[1], **Renata Guizzardi**[1,2]

[1]Ontology and Conceptual Modeling Research Group (NEMO)
Federal University of Espírito Santo (UFES)
Av. Fernando Ferrari, 514, 29075-910, Vitória, Brazil

[2]Industrial Engineering and Business Information Systems
University of Twente
P.O. Box 217 7500 AE Enschede, The Netherlands

guimaraescarneiro@gmail.com, r.guizzardi@utwente.nl

Abstract. *This paper proposes a method for Decision Making Documentation that is founded on a formal ontology. To do this, we first proposes an extension to DMO, a decision making ontology founded on a foundational ontology named UFO, to include concepts on on Value Proposition and Economic Preference. [Guizzardi et al. 2020] Finally, we propose a template whose slots represent concepts in the Extended DMO and should be filled with sentences in natural language representing instances of these concepts. The goal of the template is to represent the rationale in the selection alternative phase of the Decision Making. Once the slots are filled, they can be converted to an OWL ontology using gUFO, a lightweight implementation of the Unified Foundational Ontology (UFO), suitable for Semantic Web OWL 2 DL applications, to enable automatic reasoning over the document.*

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1. Introduction

Decision Theory is an interdisciplinary topic that has been investigated by biologists, social scientists, philosophers, computer scientists, and others. Speaking and making decisions are related elements of the human nature: *"Darwinian considerations suggest that language may have developed because it leads to improved decision making and survival, justifying the study of language's contribution to decision making."* [Losee 2001] Nowadays, decision-making is an essential part of the everyday life of any organization. In this context, decisions are generally documented in unstructured natural language. [Guizzardi et al. 2018] In Computer Science, the study of Decision Making is generally focused in to built Decision Support Systems (DSS). By our informal literature revision, even though there are many works using ontologies and natural language to support decision-making, most do not use Formal Ontologies and use the Natural Language only to data processing, not to documenting decisions.

According to the purpose for which the natural language is used, proposals can be classified into two groups. One group proposes the use of natural language before the decision is taken in order to assist this process [Demner-Fushman et al. 2009], [Gkatzia et al. 2016] and [Martínez et al. 2015]. The second group uses natural language after the decision is taken in order to explain this process [Goodall 2014]

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and [Papamichail and French 2003]. To handle natural language, different techniques are used like Natural Language Processing [Losee 2001] and Computing with Words [Martínez et al. 2015].

In our master dissertation, we propose that decisions are documented in a tool that provides slots to be filled by texts in natural language. Our work started by evolving a Decision Making Ontology [Guizzardi et al. 2018], by reusing some notions of existing ontologies on Value Proposition [Sales et al. 2017] and Economic Preference [Porello and Guizzardi 2018, Porello et al. 2020]. This first result is presented at [Guizzardi et al. 2020]. The slots provided by our tool will reflect the concepts of this extended Decision Making Ontology. Once the slots are filled, they will be instantiated as an OWL ontology using gUFO [Almeida et al. 2019] to enable reasoning over the decision documentation.

With this proposal, we aim at supporting documentation of a decision making in natural language by formally representing the rationale behind the decision process.

2. Research Goals

Our main goal is to provide computational support for decision documentation, allowing reasoning over the decision making process.

To achieve our main goal, we have established these secondary objectives:

- To propose a core ontology on the decision making process.
- To support reasoning over the decision making process by implementing the aforementioned ontology.
- To implement a computational tool to support ontology documentation, based on the implemented ontology.

3. Research in Progress

Our starting point is that the decision maker wants to move from a INITIAL SITUATION to a new, and most valuable, DESIRED SITUATION. To do that, he finds some ALTERNATIVES that are possible actions to be performed that could bring him from the INITIAL SITUATION to the DESIRED SITUATION. We have identified in the literature some phases for this process: "problem definition", "alternative discovery", "alternative selection" and "decision evaluation [Frisk et al. 2014]. In this work, we focus on the documentation of the "alternative selection" phase, because a precise documentation with verbalization in this phase can improve the general process, particularly impacting the "decision evaluation" phase.

Important challenges in this scenario are the complexity and uncertainty of the decision situation or the existence of multiple conflicting objectives [Martínez et al. 2015]. This work is founded on some fundamental assumptions about the decision maker. Many works assume that the decision maker is an *Economic Man*, i.e. a man that is (1) completely informed, (2) infinitely sensitive, (3) rational, and (4) able to order situations by some criterion that should be maximized. However, this is a perspective that exceeds actual human cognitive capabilities [Fjellman 1976].

The decision making process is a cognitive process, i.e. it is based on mental properties of the DECISION MAKER. To make a decision, the agent simulates in his mind

the possible consequences of his actions, and chooses one alternative based on these consequences. This simulation runs over the decision maker mental model of reality. This mental model defines the premises of the decision and the simulation defines a sequence of logic operations. This process consists of evaluating and comparing alternatives. In [Guizzardi et al. 2020], we included concepts on Value Proposition [Sales et al. 2017] and Economic Preference [Porello and Guizzardi 2018, Porello et al. 2020] to enable reasoning in the "alternative selection" phase. This ontology is the first result of this work.

By documenting the decision maker's reasoning over possible alternatives, we are interested in understanding how people actually make decisions. It is trivial to show that the decision maker has no total knowledge of his context and of the different end states that he can reach as a result of his actions. Therefore, the aforementioned Economic Man's properties (1) and (2) are discarded. Still, we keep properties (3) and (4). In this context, it is important to emphasize that to be rational does not means not having emotion, but to be able to reason over premises founded on emotions or values. Premises can be objective or subjective and are considered beliefs.

3.1. Performing an evaluation of the Decision Making Ontology

We aim at evaluating the core ontology on decision making presented in [Guizzardi et al. 2020], by comparing it with other works. So far, we have identified three related works:

The GRADE taxonomy [Papatheocharous et al. 2018] was created to establish the vocabulary for supporting decisions regarding architectural aspects of software-intensive systems. The main categories of this taxonomy are Goals, Roles, Assets, Decision and Environment.

The Strategic Decision Making (SDM) Ontology [Gómez et al. 2017] has been created with special focus in managing quality in Agile Software Development processes, although the authors claim it is general enough to be used in other contexts.

The Decision Making Ontology (DMO) [Kornyshova and Deneckere 2012] has been developed aiming at: clarifying the concepts of the domain of Decision Making, also supporting the specification of Decision Making requirements; and serving as basis of a specification of the components a DM method. To be more specific, it is part of an approach called MAke Decisions in Information Systems Engineering (MADISE).

We aim at extending our literature review to identify other relevant related initiatives.

3.2. Supporting reasoning over the decision making process

To enable the reasoning over the decision documentation, we aim at representing the Decision Making Ontology using gUFO [Almeida et al. 2019], a lightweight implementation of the Unified Foundational Ontology (UFO), suitable for Semantic Web OWL 2 DL applications.

gUFO is an OWL 2 DL ontology that is intended for reuse in the definition of UFO-based ontologies. It consists in instantiating and/or specializing the various classes, object properties and data properties defined in the ontology, inheriting from it the domain-independent distinctions of UFO.

To support reasoning, we aim at represent the Decision Making Ontology specializing the classes defined in gUFO.

To validate our approach, we intend to test many examples of decision documentations, using an OWL reasoner, checking if the model is able to identify the intended decision result.

3.3. Implementing the decision documentation supporting tool

Once all the above mentioned items are realized, we intend to implement a tool where the user can fill slots coming directly from the ontological concepts defined in the Decision Making Ontology. The tool will convert the documented decision into an OWL ontology based on gUFO and then calculate the final decision.

Documented decisions may be used by the decision-maker herself to justify and inform her future decisions. Moreover, when considering an organizational environment, documenting and further reusing the documented decisions may be an adopted practice to make sure that the organizational members act consistently, to guarantee the quality of the Decision Making process and to train newcomers joining the work. By using this tool, the user will be able to validate whether the data provided will actually imply the expected decision. On the other hand, future readers of this documentation will find it easier to understand the reasoning on which the decision was based since it will be formally documented.

4. Work Plan

The work plan to finalize our master dissertation is comprised of the following seven activities:

1. Evaluating the decision making ontology
2. Implementing the ontology based on gUFO
3. Generating examples to test the gUFO ontology
4. Implementing the decision documentation supporting tool
5. Evaluating the implemented tool
6. Writing the master dissertation
7. Defending the master dissertation

Table 1 details the work plan, scheduling its activities in the coming months, starting from November 2020 and going until July 2021.

Activity	Months								
	11/20	12/20	1/21	2/21	3/21	4/21	5/21	6/21	7/21
1	x	x							
2			x						
3			x						
4				x	x	x			
5							x	x	
6				x	x	x	x	x	x
7									x

Table 1. Work plan for the completion of the master thesis

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