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Modeling Decisions for Artificial Intelligence

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Preface

This volume contains papers presented at the 15th International Conference on Modeling Decisions for Artificial Intelligence, MDAI 2018, held on Mallorca, Spain, October 15–18, 2018. This conference followed MDAI 2004 (Barcelona, Spain), MDAI 2005 (Tsukuba, Japan), MDAI 2006 (Tarragona, Spain), MDAI 2007 (Kitakyushu, Japan), MDAI 2008 (Sabadell, Spain), MDAI 2009 (Awaji Island, Japan), MDAI 2010 (Perpignan, France), MDAI 2011 (Changsha, China), MDAI 2012 (Girona, Spain), MDAI 2013 (Barcelona, Spain), MDAI 2014 (Tokyo, Japan), MDAI 2015 (Skövde, Sweden), MDAI 2016 (Sant Julià de Lòria, Andorra), and MDAI 2017 (Kitakyushu, Japan) with proceedings also published in the LNAI series (Vols. 3131, 3558, 3885, 4617, 5285, 5861, 6408, 6820, 7647, 8234, 8825, 9321, 9880, and 10571).

The aim of this conference was to provide a forum for researchers to discuss different facets of decision processes in a broad sense. This includes model building and all kinds of mathematical tools for data aggregation, information fusion, and decision making; tools to help make decisions related to data science problems (including e.g., statistical and machine learning algorithms as well as data visualization tools); and algorithms for data privacy and transparency-aware methods so that data processing procedures and the decisions made as a result of them are fair, transparent, and avoid unnecessary disclosure of sensitive information.

The MDAI conference included tracks on the topics of (i) data science, (ii) data privacy, (iii) aggregation functions, (iv) human decision making, and (v) graphs and (social) networks.

The organizers received 43 papers from 15 different countries, 24 of which are published in this volume. Each submission received at least two reviews from the Program Committee and a few external reviewers. We would like to express our gratitude to them for their work. This volume also includes some of the plenary talks.

The conference was supported by the research group Scopia (Soft Computing, processament d'imatges i agregació), the University of Balearic Islands (UIB), the European Society for Fuzzy Logic and Technology (EUSFLAT), the Catalan Association for Artificial Intelligence (ACIA), the Japan Society for Fuzzy Theory and Intelligent Informatics (SOFT), and the UNESCO Chair in Data Privacy.

July 2018

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Abstracts of Invited Talks

Consistency of Fuzzy Preference Relations

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In decision making the use of fuzzy preference relations to establish some degree of preference between any two alternatives is frequently adopted [3, 5, 12]. In order to design good decision making models some efforts on the characterization of consistency properties to avoid misleading solutions have been carried out [9, 14].

Transitivity has been a traditional requirement to characterize consistency in fuzzy contexts, i.e., when expert opinions are given by fuzzy preference relations. However, as it is pointed in [9] it is difficult to guarantee such consistency conditions in the process of decision making. In this work we present a type of consistency based on a t-norm and a t-conorm to guarantee consistency in the decision making process when fuzzy preference relations have been used. The proposed condition is quite general, which allows to include in it some of the definitions of consistency established by different authors.

Our objective is to obtain the degrees of preference $p_{i,j}$ with $i<j$ from the elemental preferences $p_{i,i+1}$ in such a way that the system is consistent, i.e.,

$$T(p_{ij}, p_{jk}) \leq p_{ik} \leq S(p_{ij}, p_{jk}) \qquad \forall i<j<k \tag{1}$$

where T is a t-norm and S is a t-conorm. An appropriate type of multidimensional aggregation function is introduced to calculate $p_{i,j}$, $i<j$, from $p_{i,i+1}$.

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Towards Distorted Statistics Based on Choquet Calculus

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In this study we discuss statistics with distorted probabilities by applying Choquet calculus which we call ‘distorted statistics’. To deal with distorted statistics, we consider distorted probability space on the non-negative real line. A (non-additive) distorted probability is derived from an ordinary additive probability by the monotone transformation with a generator. First, we explore some properties of Choquet integrals of non-negative, continuous and differentiable functions with respect to distorted probabilities. Next, we calculate elementary statistics such as the distorted mean and variance of a random variable for exponential and Gamma distributions. In addition, in the case of distorted exponential probability, we define its density function as the derivative of distorted exponential distribution function with respect to distorted Lebesgue measure.

Further, we deal with Choquet calculus of real-valued functions on the real line and explore their basic properties. Then, we consider distorted probability pace on the real line. We also calculate elementary distorted statistics for uniform and normal distributions. Finally, we compare distorted statistics with conventional skew statistics.

Assessing the Risk of Default Propagation in Interconnected Sectorial Financial Networks

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Systemic risk of financial institutions and sectorial companies relies on their inter-dependencies. The inter-connectivity of the financial networks has proven to be crucial to understand the propagation of default, as it plays a central role to assess the impact of single default events in the full system. Here, we take advantage of complex network theory to shed light on the mechanisms behind default propagation. Using real data from the financial company BBVA, we extract the network of client-supplier transactions between more than 140,000 companies, and their economic flows. In this talk, we introduce a basic computational model, inspired by the probabilities of default contagion, that allow us to obtain the main statistics of default diffusion given the network structure at individual and system levels. Achieved results show the exposure of different sectors to the default cascades, therefore allowing for a quantification and ranking of sectors accordingly. As we will show, this information is relevant to propose countermeasures to default propagation in specific scenarios.

Decision Making Tools with Semantic Data to Improve Tourists' Experiences

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The offices of management of touristic destinations are interested in providing a more user-centered experience that takes into account the personal interests of each visitor or group of visitors. Tourism is a key element of economic wealth of many places, therefore, improving the tourism experience may have a great impact not only on the visitor but also in the place.

In this kind of field, the objects of analysis are usually touristic activities (such as parks, museums, events, shopping malls, routes, sports, etc). The amount of options available at each possible destination is usually very large. Their description includes numerical data but also categorical one, sometimes provided as a list of keywords. Exploiting the semantics of those words is crucial to understand the tourist's interests and needs.

We will present two decision aiding methods that use domain ontologies to interpret the meaning of the keywords and help the managers and visitors to improve the touristic experience on a certain place.

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Improving Spatial Reasoning in Intelligent Systems: Challenges

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Abstract. Here we tackle research on spatial thinking when facing two challenges: (i) describing scenes in natural language, and (ii) reasoning about perspectives for object recognition.

Regarding (i) addressing the following research questions is crucial: which kind of spatial features must intelligent systems use? Is location enough? And which kind of reference frames are suitable for communication? Deictic? Relative to the observer? Relative to the object? And what is the most salient object to describe? Intelligent systems must have common grounding with humans so that they can align representations and understand each other. Regarding (ii) addressing the following is decisive: how can we improve spatial perception in intelligent systems so that they can reason about object perspectives? Can tests done to people for measuring their spatial skills be used to model spatial logics?

On one side the challenge is to propose approaches to understand space and communicate about it as humans do. For that, intelligent systems (i.e. robots, tablets) can use computer vision and machine learning algorithms to analyse point clouds, recognise and describe scenes. On the other side the challenge is to propose approaches which solve spatial tests carried out to measure humans' intelligence and to apply these approaches in intelligent systems (i.e. computer games, robots) so that they can improve their spatial thinking, but also help improve humans' spatial thinking by providing them feedback.

Keywords: Qualitative spatial descriptors · Location · Spatial reasoning
Machine learning · Cognitive tests · Video games · Computer vision
Computational linguistics · Education · Spatial skills · Spatial cognition

Challenge I: Describing Scenes in Natural Language

Imagine the following scenario: It is 2056 and you have a robot at home to help you with your daily duties. One day you tell it: *Please, tidy the dining room*. To clarify, your robot asks back: *Should the new table be placed in front of the sofa or to the left*

The project *Cognitive Qualitative Descriptions and Applications* (CogQDA) funded by the University of Bremen is acknowledged. I also thank my collaborators in the described work.

of the armchair? And you answer: *Just leave it here on the left.* Or imagine another scenario in which you move to a new house and a decorator tutor application in your tablet helps you to arrange new furniture in a functional and fashionable way. Those situations would both involve spatial reasoning.

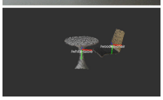
In the first scenario, your robot at home would need to understand the scene in order to talk about it, i.e. identifying the objects and their spatial locations in the living room. It also needs to identify that not all *left* locations are the same, but they depend on the reference frame used. In the second scenario, the decorator tutor would engage in human-computer interaction. It would need to produce natural language descriptions to provide the user with instructions, e.g. *if you locate the sofa on the corner, the room will look larger*, etc.

We envision a future where we humans communicate with automatic systems using language and these systems take decisions and interact with space accordingly. For that, these automatic systems need to describe the space using concepts that share a common reference frame with humans. But, how do we humans describe scenes i.e. in our home? What do we take as a reference to say where an object is located?

Qualitative spatial descriptors are based on reference systems which align with human perception and thus help establishing a more cognitive communication. Let us highlight that the spatial terms such as *in front of the sofa* and *to the left of the armchair* are qualitative and define a vague relation in space instead of a precise numerical location (e.g., [4]). The literature has studied the usefulness of using qualitative spatial descriptors in natural language: showing how people choose perspective and *relatum* to describe object arrangements in space [9] and showing how *salient* features are selected to describe objects depending on the context [5].

We outline here results of our experiments in cognitive scene description [2]: pieces of furniture in a 3D scene are detected and described according to its location using natural language based on qualitative spatial descriptors which are arranged according to reference frames and saliency determined after a cognitive study carried out to participants. Table 1 outlines some of our results.

Table 1. Scene narrative generated by *QSn3D* [2] where there are oriented and non-oriented pieces of furniture.

Photo	Language description	Logic description
	**A.**The biggest object (a wooden-chair) as the most salient object: *In the background, there is a wooden-chair on the right (oriented to the left). The wooden-chair has a white-table in the front.*	is_categorized(object_0j, wooden-chair). location_wrt_observer(object_0j, right). distance_wrt_observer(object_0j, background). close_object(object_0j, object_1j). is_oriented(yes, object_0j, left). location_wrt_close_object(object_0j,object_1j, centre).
	**B.**The closest object to the observer (a white-table) as the most salient object: *In the foreground, there is a white-table in the centre. In the background, there is a wooden-chair on the right (oriented to the left).*	is_categorized(object_1j, white-table). location_wrt_observer(object_1j, centre). distance_wrt_observer(object_1j, foreground). close_object(object_1j, object_0j). is_oriented(no, object_1j, none).

A step further in this challenge is addressing human-machine interaction through dialogue, detecting changes in scenes and explaining them in a cognitive manner.

Challenge II: Spatial Reasoning About Object Perspectives

Pattern recognition and machine learning has demonstrated to be useful and effective in 3D object detection and recognition: a scene is discretised as a set of points floating in the air, called point clouds (see images in Table 1) and to recognize objects there, these points are put together again by learning different views of the object using machine learning methods [2]. Discretising space and then finding its continuity again is computationally very expensive and a challenge in AI and computer vision nowadays, as far as we are concerned.

So, in computer vision, pixels or cloud points do not automatically preserve space continuity. This contrast with situations, in real space, where if a change happens to an object side (dimension), it also affects the other dimensions automatically, preserving continuity. For example, when a cup handle breaks, we humans do not need to check from all perspectives to perceive the change in shape and depth, because we use continuity in space to infer that. The literature says that edge parallelism [6] is in our common sense from our childhood and that even young infants carry out physical reasoning taking into account continuity and solidity of objects [8].

Spatial reasoning is not an innate ability, since it has been shown that it can be trained [7] and showed a lasting performance [10]. Spatial reasoning skills correlate with success in Science, Technology, Engineering and Math (STEM) disciplines [11] and spatial ability has a unique role in the development of creativity or creative-thinking (measured by patents and publications) [3].

In cognitive science research, perceptual ability tests are carried out to people to measure how good are their spatial skills. And some of the problems intelligent systems must solve, are spatial problems which require spatial thinking such as inferring cross sections or canonical views of a 3D object, in order to recognize it. So, what can we learn from spatial cognition research that we can apply to computer vision and computer systems in general, so that the process of interacting with space is more 'intelligent or intuitive'?

Here we address that spatial thinking related to computer vision and to qualitative modelling leaded to the definition of a model for 3D object description which takes into account depth in the 3 canonical perspectives of the object at the same time [1] (see Fig. 1). Thus, it propagates changes in object volume, and it can also identify inconsistent descriptions. This model has been implemented in a video game which is being used at the moment in cognitive tests to see if the feedback provided is useful for people to improve their spatial reasoning skills. As future work, we intend to combine this cognitively-based knowledge approach with machine learning in order to improve object detection and reasoning about perspectives.

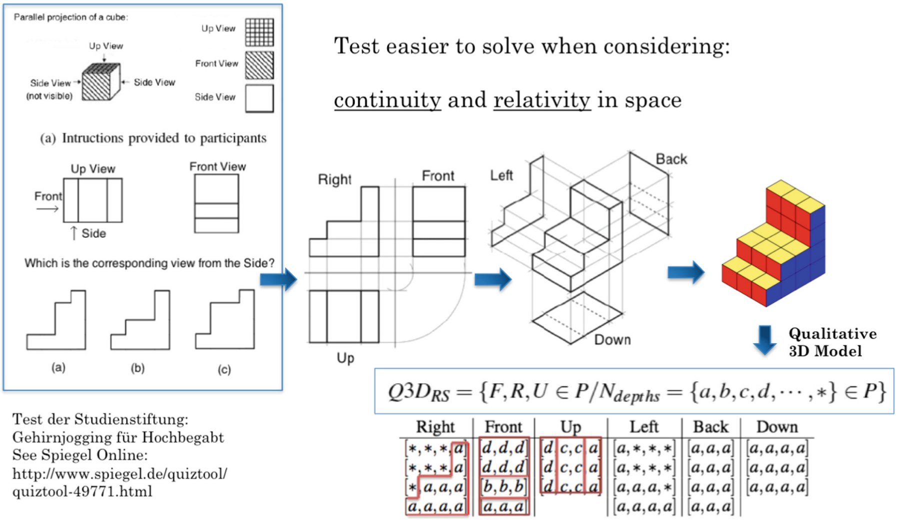


Fig. 1 Qualitative Descriptor for Reasoning about 3D perspectives.

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