Problem-solving, Creativity and Spatial Reasoning: A ProSocrates 2017 Discussion

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Abstract

The ProSocrates 2017 Symposium aims to blend the topics of problem-solving, creativity and spatial reasoning. In this paper we will discuss the scientific interest of the topic blend. We will then describe the presented works, how they fit the Symposium theme and statistics about the 2nd Edition of ProSocrates. Finally, we will discuss how the topic mix looked like this year, possible future directions and an outlook for how the topics could be combined in the future.

1 Introduction

Problem-solving [Newell and Simon, 1972], human creative cognition [Finke et al., 1992, Boden, 2003], spatial cognition [Freksa, 2015], Qualitative modelling [Forbus, 2011] and computational creativity [Colton and Wiggins, 2012] are topics often treated separately, despite their major potential for synergies.

The ProSocrates Symposium aims to blend these topics and observe their interrelations. The ProSocrates Symposium had its first edition at the KogWis 2016 - Space and Cognition conference, and is now at its second edition, which was supported by the Hanse-Wissenschafstkolleg (HWK), Institute for Advanced Study[1].

This paper discusses the scientific interest and topics of ProSocrates (2), and summarizes the research papers and invited talks that were the content of ProSocrates 2017 (3). The way these papers represent the ProSocrates topics of interest and their interrelations this year is discussed in section 4.

2 Scientific interest and Topics

Problem-solving has been approached in different ways by AI and the study of human cognition. The ability to flexibly solve novel problems with little training is a fundamental component in human intelligence. For example, rescheduling a trip due to unexpected circumstances, playing Tangram/origami or finding a solution to an ill-structured problem [Newell and Simon, 1972] are well known tasks in human problem-solving. Commonsense reasoning, model building and the ability to creatively solve novel problems have an important role in the challenge of approaching general artificial intelligence.

Computational creativity focuses on building creative artificial systems capable of creative feats similar to those achieved by humans [Colton and Wiggins, 2012]. Through its applied nature, computational creativity is a great way of studying the type of algorithms and system implementations that can be used to approach artificially creative results, however the processes and representations in the field are rarely compared to those used by humans.

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[1] http://www.h-w-k.de/

Human creative cognition investigates the way humans solve a multiplicity of creative tasks [Mednick and Mednick, 1971], from the simple (coming up with an alternative use for an object) to the complex (solving insight problems)[Batchelder and Alexander, 2012], asking questions about process. However, no cognitive modeling universal set of tools exists for the pursuit of implementing computational approaches to test hypotheses in a unified manner.

Spatial cognition and reasoning [Freksa, 2015] is also known to contribute to the development of abstract thought, and to have a role in problem solving. Spatial cognition studies have shown that there is a strong link between success in Science, Technology, Engineering and Math (STEM) disciplines and spatial abilities [Newcombe, 2010]. Qualitative modeling [Forbus, 2011] concerns the representations and reasoning that people use to understand continuous aspects of the world. Qualitative representations are also thought to be closer to the cognitive domain, as showed by models for object sketch recognition [Forbus et al., 2011], for solving Raven's Progressive Matrices intelligence test [Lovett and Forbus, 2017], for solving oddity tasks [Lovett and Forbus, 2011], for 3D perspective descriptions matching [Falomir, 2015] and for paper folding reasoning [Falomir, 2016]. In the context of creativity, spatial descriptors and qualitative shape and colour descriptors and their similarity formulations were tools for object replacement and object composition in the theoretical approach presented by [Olteţeanu and Falomir, 2016] to solve Alternative Uses Test.

Cognitive Systems is a great intersection point for all these topics, bringing together the perspectives of human cognition, cognitive modeling and cognitive artificial intelligence. The interactions between (i) problem-solving and creativity in the context of cognitive systems [Olteţeanu, 2014, Olteţeanu and Falomir, 2015, Olteţeanu and Falomir, 2016, Olteţeanu et al., 2015, Olteţeanu, 2016, Olteţeanu, 2016, Olteţeanu et al., 2017] and between (ii) qualitative modelling and spatial cognition [Falomir, 2015, Falomir, 2016] were studied by the proposed guest editors in the last few years.

The focus of the ProSocrates Symposium and of the ensuing Special Issue is to bring the previous described disciplines together, by bringing in dialogue specialists from each of the fields. Authors of experimental, theoretical and computational work which combine perspectives from at least two of these 4 topics (problem-solving, spatial cognition/reasoning, cognitive systems and creativity) will be invited to submit contributions. The larger aim of integrating these topics is to produce theoretical tools, approaches and methodologies for creative and spatial problem solving in cognitive systems, in a manner that would benefit from such interdisciplinary bootstrapping.

3 Summary of works presented at ProSocrates'17

These ProSocrates'17 proceedings contains 6 accepted papers that were presented at the symposium. Each submitted paper was reviewed by two/three program committee members. Moreover, there were 6 invited talks whose abstracts are also included in these proceedings. A very short summary of these contributions follows, with the aim of observing the various topic blends in the next section.

3.1 Invited Talks

In his talk, *Reasoning at a Distance by Way of Conceptual Metaphors and Blends*, **Marco Schorlemmer** presented a mathematical model for expressing conceptual metaphor and blending; he then talked about modelling these in combination with the idea of "reasoning at a distance", from Barwise-Seligman theory of information flow.

In the talk *Symbolic models and computational properties of constructive reasoning in cognition and creativity*, **Tarek Besold** presented general principles of computational analogy, with a closer look at HDTP and cognitive plausibility.

In her talk, *Creating and rating harmonic colour palettes for a given style*, **Lledó Museros** presented a qualitative colour theory, the operations to create harmonic colour palettes and their classification as lifestyle.

Ken Forbus discussed ideas for using the Companion cognitive architecture to create software collaborators that support creative work, in his talk *Creative Support Companions: Some Ideas.*

In the talk *Modeling visual problem-solving as analogical reasoning*, **Andrew Lovett** presented a computational model that uses analogical reasoning for visual problem-solving (i.e. Ravens Progressive Matrices test).

Bipin Indurkhya gave a talk titled *Thinking Like A Child: The Role of Surface Similarities in Stimulating Creativity.* In his talk, he presented examples of puzzles, research on creative problem solving, and two of recent empirical studies to demonstrate how surface similarities can stimulate creative thinking and to designing creativity-support systems.

3.2 Research Papers and talks

In the paper *Towards finer-grained interaction with a Poetry Generator*, **Hugo Gonçalo Oliveira et al.** reported on a recent effort towards providing alternative ways of using PoeTryMe to meet user suggestions, including a co-creative interface.

In the paper *Towards the Recognition of Sketches by Learning Common Qualitative Representations*, **Wael Zakaria et. al** reported on building a hybrid technique, in which aspects of machine learning, computer vision, and qualitative representations are mixed to produce a classifier for sketches of four types of objects.

Juan Purcalla Arrufi and Alexandra Kirsch submitted the paper *Using Stories to Create Qualitative Representations of Motion*. In this, they described a method to create new qualitative representations of motion from any qualitative spatial representation by using a story-based approach.

In the paper titled *Investigating Representational Dynamics in Problem Solving*, **Benjamin Angerer and Cornell Schreiber** presented a new spatial transformation and problem solving task of iterated cross-folding and outline an analysis of the task domain. In this task, subjects are asked to repeatedly mentally cross-fold a sheet of paper, and to predict the resulting sheet geometry. The authors discuss how subjects can approach the task domain with a variety of representational forms.

In the paper titled *An Approach to Compose Shapes Described Qualitatively: A Proof-of-Concept*, **Albert Pich and Zoe Falomir** presented a proof-of-concept towards solving spatial reasoning tests which deal with object composition, such as those used in measuring human spatial skills. This approach describes the connections between the objects and the shape of the final provided composition.

Two further talks were presented by the Symposium organizers, on state of the art of their research.

Ana-Maria Olteţeanu described how computational creative problem solving systems can be used to generate creativity test queries, in her talk *Generating queries with multi-parameter control for creativity tests*.

Zoe Falomir in her talk *3D Perspective Reasoning and Paper Folding Reasoning using Computer Games* explained how qualitative models can reason to solve spatial tests (i.e. perspective taking in object description or paper folding) and how the logics behind these models can be embedded in computer games to provide feedback to players so that they can: (i) understand the space transformations involved in the tests and (ii) practice to improve their spatial cognition skills.

4 Discussion - topic mix and future outlook

In this ProSocrates edition, all three of the main topics, Problem solving, Creativity and Spatial reasoning were present, together with some interdisciplinary research at the intersection of various pairs. Here is how the various talks and research papers represented the fields.

The talks by Forcus and Besold, with their focus on creative companions and computational analogy, represented the Creativity topic. The papers of Purcalla Arrufi&Kirsch and Zakaria et al represented mostly the topic of Spatial Reasoning.

The rest of the talks and papers were interdisciplinary, representing some intersection of two of the fields. Indurkhya, Anger&Schreiber and Olteţeanu presented talks at the intersection of Problem Solving and Creativity. Lovett, Falomir and Pitch represented the Problem Solving and Spatial Reasoning intersection. The talks by Museros and Schorlemmer situated themselves at the Spatial Reasoning - Creativity intersection. This outline of the content of talks for ProSocrates 2017 can be observed in the Venn diagram in Figure 1.

The fact that ProSocrates 2017 managed to promote and attract interdisciplinary papers between the three fields counts as a success for the organizers. We hope this trend to continue for the next edition, and perhaps ProSocrates 2018 will also start seeing some points in the middle of the Venn diagram, at the intersection between all three fields.

5 Epilog

The main focus of ProSocrates 2017 and the presented papers is to promote research in and between three possibly synergistic fields. This aims to encourage new research and collaborations, at the intersections of three fields which are very important for the general society.

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[2]HWK: `http://www.h-w-k.de/`

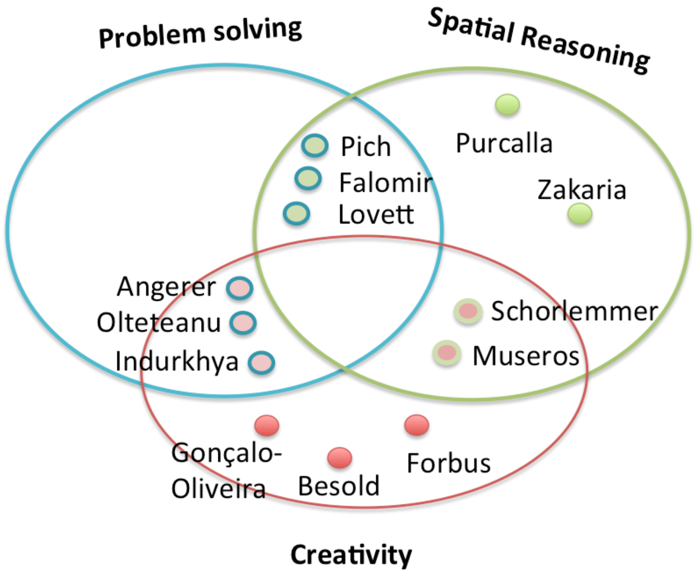

Figure 1: Outline of the contents of the talks distributed in a Venn diagram including Problem-Solving, Spatial Reasoning and Creativity.

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