Dagstuhl Seminar 20172: Representing and Solving Spatial Problems

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Abstract

Everyday life takes place in space and time, and spatial experience lies at the heart of our existence. Understanding how we conceive of spatial relationships, and how we solve spatio-temporal problems, is therefore key to understanding human cognition. Spatial cognition research has advanced considerably over the past decades, with major successes particularly in computational implementations of knowledge representation and reasoning methods. Still, a range of key issues continue to pose major challenges. The goal of this seminar is to discuss the various options for the formalisation, implementation, and automated solution of spatial problems including the following issues: the identification and specification of relevant concepts as expressed in human language; the development of a module for automated understanding of domain descriptions; the use of spatial structures and affordances for direct spatial problem solving; and, the development of an efficient planning system capable of providing feasible solutions to spatial problems.

1 Topics to be Discussed

- 1: **Conceptualisation**. How do humans conceptualise and mentally represent spatial problems? What is the role of high-level spatio-temporal structures for perceiving spatial problems, for manipulating spatial configurations, and for commonsense spatial problem solving?
- 2: **Formalisation**. What would be a suitable formalism for commonsense problem solving that allows an accurate, flexible, and readable knowledge representation for spatio-temporal effects of actions performed by an intelligent agent?

- 3: **Description**. In contrast to the formal representation investigated on Item 2, the present topic deals with the development of human readable descriptions of the inputs, reasoning steps and solutions of spatial problems. In particular, we want to investigate whether (and to what extent) it would be possible to develop high-level representations or interfaces for dealing with natural language and/or diagrammatic constructions that allow specifying both the input knowledge and the output conclusions in terms of descriptions of spatial problems.

- 4: **Problem solving**. What are the commonsense problem-solving capabilities involving spatio-temporal features including temporal explanation and planning under physical/geometric qualitative or semi-quantitative constraints? This issue also includes the investigation of appropriate problem-solving algorithms and their potential applications to real-world domains that could be of interest to industry.

1.1 Expected outcomes

Apart from providing an appropriate forum for the discussion of new ideas on the issues described above, we intend to achieve the following results from this seminar:

- the creation of a multidisciplinary network of world-class researchers for fermenting further discussions and developments related to reasoning about spatial domains;

- the publication of a handbook about the seminar topics (with submission open to the community). Potentially, this handbook will receive contributions from joint collaborations created during the seminar. This initiative would consolidate the proposed multidisciplinary network;

- the organisation of possible future joint project proposals to be submitted to international funding agencies, which would guarantee the continuation of the collaborations built during the seminar.

2 Detailed schedule

Day 1

- 9:00–10:30: Plenary session: presentation and discussion of the seminar topics
- Introduction (15min each):
  1. Conceptualisation: Paulo Santos
  2. Formalisation: Pedro Cabalar
  3. Description: Thora Tenbrink
  4. Problem Solving: Christian Freksa

  Participants should position themselves with respect to these topics and, in particular, answer the following questions:
  - Which topics would you like to contribute to?
  - What are your visions for future research and developments?
  - What are the main challenges involved?
- 10:45–12:15: Preparation of break-out groups, and research questions, including (but not limited to):
  1. How do humans conceptualise and mentally represent spatial problems?
  2. What is the role of high-level spatio-temporal structures for perceiving spatial problems, for manipulating spatial configurations, and for commonsense spatial problem solving?
  3. What would be a suitable formalism for commonsense problem solving that allows an accurate, flexible and readable knowledge representation for spatio-temporal effects of actions performed by an intelligent agent?
  4. How to develop human readable descriptions of the inputs, reasoning steps and solutions of spatial problems?
  5. Whether (and to what extent) is it possible to develop high-level representations or interfaces for dealing with natural language and/or diagrammatic structures that allow specifying both the input knowledge and the output conclusions in terms of textual descriptions of spatial problems?
  6. Would it be possible (and desirable) to develop interfaces for dealing with spatial configurations including diagrammatic depictions and natural language descriptions to solve spatial puzzles in similar ways as humans do?

7. What are the commonsense problem solving capabilities involving spatio-temporal features including temporal explanation and planning under physical/geometric qualitative or semi-quantitative constraints?

- **12:15–14:00 Lunch Break**
- 14:00–15:30: Break-out group discussions
- 16:00–17:30: Plenary session/Summary of the day
  - Summary of the morning discussions
  - Definition of topics for the next day

Day 2

- 9:00–10:30: Plenary session: definition of the discussion topics for the day
- 10:45–12:15:Break-out group discussions
- **12:15–14:00 Lunch Break**
- 14:00–15:30: Break-out group discussions
- 16:00–17:30: Plenary session: Summary of the day

Day 3

- 9:00–10:30: Plenary session:
  1. discussion of the current status of concepts and approaches within and across the four main topics of the seminar
  2. future papers titles and abstracts
- 10:45–12:15: Break-out group discussions
- 13:00–17:00: Social event -
  - Traditional trip to Trier
  - visit the Gutenberg museum in Mainz

Day 4

- 9:00–10:30: Plenary session - the results of the first three days should be arranged and integrated in such a way that we have an outcome of the seminar that is of use.
- 10:45–12:15: Break-out group discussions
- **12:15–14:00 Lunch Break**

- 14:00–15:30: Break-out group discussions
- 16:00–17:30: Plenary session: Summary of the day discussions
  - Integrating the seminar discussions
  - Abstract submission

Day 5

- 10:00–12:00: Plenary session: plan for further collaborations
  1. Follow-up meeting (IJCAI workshop? AAAI Spring Symposium? Another Dagstuhl seminar?)
  2. Journal special issue – possible target: Spatial Reasoning and Computation Journal
  3. Handbook
  4. Joint publications

3 What the participants should do before the seminar

1. Send a one-page position paper on one of the seminar's topics, to be published in the seminar proceedings;
2. Indicate a primary and secondary topic of expertise / interest wrt the seminar agenda;
3. Formulate research questions to be addressed during the seminar;
4. Indicate what to expect from this seminar.
5. Describe one far reaching challenge for future research.