

Tutorial On:

DECLARATIVE SPATIAL REASONING

THEORY | METHODS | APPLICATIONS

TUTORIAL PRESENTERS

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TUTORIAL SUMMARY

This tutorial will present computational visuo-spatial representation and reasoning from the viewpoint of the research areas of artificial intelligence, commonsense reasoning, and spatial cognition and computation. The key focus will be on declarative spatial reasoning: the ability to (declaratively) specify and solve real-world problems related to mixed geometric (i.e., quantitative) and qualitative visual and spatial representation and reasoning. The practical problems that we address and demonstrate in this context encompass both specialist and everyday commonsense reasoning instances identifiable in a range of cognitive technologies and spatial assistance systems where spatio-linguistic conceptualisation & background knowledge focussed visuo-spatial cognition and computation are central.

ABOUT THE TUTORIAL

Spatial thinking, conceptualisation, and the verbal and visual (e.g., gestural, iconic, diagrammatic) communication of commonsense as well as expert knowledge about the world –the space that we exist in— is one of the most important aspects of everyday human life. Philosophers, cognitive scientists, psychologists, linguists, psycholinguists, ontologists, information theorists, computer scientists, mathematicians, architects, and environmental psychologists have each investigated space through the perspective of the lenses afforded by their respective field of study.

This tutorial will present computational *visuo-spatial representation and reasoning* from the viewpoint of the research areas of *artificial intelligence*, *commonsense reasoning*, and *spatial cognition and computation*. The key focus will be on *declarative spatial reasoning* [3, 5, 16, 18]: the ability to (declaratively) specify and solve real-world problems related to geometric (i.e., quantitative) and qualitative visuo-spatial representation and reasoning. The practical problems that we address and demonstrate in this context encompass both specialist and everyday commonsense reasoning instances identifiable in a range of *cognitive technologies* and *spatial assistance systems* where spatio-linguistic conceptualisation & background knowledge focussed visuo-spatial cognition and computation are central [6].

Theoretical Foundations

On the theoretical front, the tutorial presents an intuitive overview of the formalisation of the declarative spatial reasoning approach; this will primarily encompass formalisations of *space* and *spatial reasoning* within constraint logic programming and answer-set programming. The tutorial will summarise past research on qualitative spatial reasoning, and explain the manner in which declarative spatial reasoning, and its manifestation by way of the CLP(QS) [5] and ASPMT(QS) [18] family of spatial reasoning systems, marks a clear departure from other (relational-algebraically based) spatial reasoning methods / tools by its use of the logic programming foundations for formalising the semantics of mixed quantitative and qualitative spatial representation and reasoning. The general concept of declarative spatial reasoning lends itself to re-interpretations and extensions with other perspectives such as diagrammatic representations; time permitting, this aspect will also be covered in the tutorial.

System Demonstrations

The tutorial will demonstrate CLP(QS) and ASPMT(QS), *declarative spatial reasoning systems* capable of modelling and reasoning about qualitative spatial relations pertaining to multiple spatial domains, i.e., one or more aspects of space such as topology, and intrinsic and extrinsic orientation, size, distance etc. We will especially highlight the capability to mix quantitative-qualitative spatial reasoning, and in the current form, basic quantification support offering the means to go back from qualitative relations to the domain of precise quantitative (geometric) information. With ASPMT(QS), the ability to handle spatio-temporal change and space-time histories as primitive objects will be emphasised.

The emphasis in declarative spatial reasoning (with CLP(QS) and ASPMT(QS)) is on the seamless integration of visuo-spatial (computational) problem-solving capabilities within large-scale hybrid AI systems, and cognitive (interaction) technologies. Currently, integration is achieved via the medium of *logic programming* — specifications in the form of (domain) *facts* and *rules* consisting of a mix of, for instance, background semantic or conceptual knowledge, spatio-temporal knowledge, and knowledge about action and dynamics.

Applications of Spatial Reasoning

Commonsense visuospatial reasoning using the declarative spatial reasoning method has demonstrated applicability in several domains, some recent examples being within *architectural design cognition and computation*, *cognitive vision*, *geospatial information systems*. The CLP(QS) system is also being designed as a pedagogical tool to be used as part of university based courses at the interface of Artificial Intelligence, Knowledge Representation and Reasoning, Cognitive Systems, and Spatial Informatics.

The proposed quarter-day tutorial will not have sufficient time to have a live hands-on session / walkthrough with the audience; however, we will spend sufficient time illustrating running examples. ¹ An exercise booklet with step-by-step instructions will be provided.

TUTORIAL AUDIENCE

- **target audience**

- interdisciplinary audience without topical background; some curiosity about KR helpful.
- interested in using tools for spatial reasoning in research and development
- educators wanting to learn about spatial reasoning tools and using them in their teaching activities

The general systems and all application related aspects will be demonstrated with working systems and precompiled examples. An exercise booklet with step-by-step instructions will be made available such that participants may execute the exercises in their personal time after the tutorial. Source-code level examples for exercises will be made available via a docker distribution (see below).

www: www.spatial-reasoning.com/

Demo system / Exercises / Code: <https://hub.docker.com/r/spatialreasoning/>

¹System and running examples will be accessible via <https://hub.docker.com/r/spatialreasoning/>.

Select References on Declarative Spatial Reasoning

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