Between Sense and Sensibility

Declarative narrativisation of mental models as a basis and benchmark for visuo-spatial cognition and computation focussed collaborative cognitive systems

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POSITION STATEMENT

What lies between '*sensing*' and '*sensibility*'? In other words, what kind of cognitive processes mediate sensing capability, and the formation of sensible impressions —e.g., abstractions, analogies, hypotheses and theory formation, beliefs and their revision, argument formation— in domain-specific problem solving, or in regular activities of everyday living, working and simply going around in the environment? How can knowledge and reasoning about such capabilities, as exhibited by humans in particular problem contexts, be used as a model and benchmark for the development of collaborative cognitive (interaction) systems concerned with human assistance, assurance, and empowerment?

We pose these questions in the context of a range of assistive technologies concerned with *visuo-spatial perception and cognition* tasks encompassing aspects such as commonsense, creativity, and the application of specialist domain knowledge and problem-solving thought processes [Bhatt et al., 2013a]. Assistive technologies being considered include: (a) human activity interpretation from sensor data; (b) high-level cognitive control for human-robot collaboration; (c) people-centred, function-driven, creative design in domains such as architecture & digital media creation, and (d) high-level qualitative analyses in spatio-temporal data-intensive geographic information systems

A. Compuational Narrativisation as a Benchmark

Narrativisation processes pertaining to space, actions, and change are ubiquitous [Bhatt, 2012, Tversky, 2004]. Humans, robots, and systems involving action and mutual (computer-human) interaction are embedded in *space*. Space, spatial configurations, and in effect, their perceptually grounded *mental models* [Johnson-Laird, 1983], declarative abstractions, or ad-hoc system-level representations undergo *change* — the notion of time, or change-based temporal progression, and therefore *spatio-temporal dynamics* and *spatio-temporal narrativisation* (processes) arise naturally.

The significance of *narratives* in everyday discourse, interpretation, interaction, belief formation, and decision-making has been acknowledged and studied in a range of scientific, humanistic, and artistic disciplines. Narrativisation of everyday perceptions by humans, and the significance of narratives, e.g., in communication and interaction, has been investigated under several frameworks, and through several interdisciplinary initiatives involving the arts, humanities, and social sciences, e.g., the narrative paradigm [Fisher, 1987], narrative analysis [Riessman, 1993], narratology [Herman et al., 2005, Meister, 2011, Prince, 1982], discourse analysis and computational narratology [Barthes and Duisit, 1975, Goguen, 2004, Lakoff and Narayanan, 2010, Mani, 2012, 2013]. Broadly, the study of narratives has attracted attention from several quarters, most prominently in disciplines such as literature, linguistics, anthropology, semiotics, cultural studies, geography, psychology, cognitive science, logic, and computer science.

We regard narratives, and high-level processes of narrativisation emanating therefrom, as a general underlying structure serving the crucial function of *perceptual sense-making* — i.e., as a link between problem-specific perceptual sensing and the (computational) formation of sensible impressions concerned with interpretation and analytical tasks. Given the nature of the visuo-spatial cognition tasks being considered, the particular form of the proposed narrative structure is that of cognitively inspired *computational model of narrativisation* involving high-level commonsense reasoning with *space, events, actions, change, and interaction*. In particular, the following capabilities are crucial:

1. Narrativising—based on modalities such as language, diagrams, visual abstractions, analogy, conceptual blending, and hypotheses— certain aspects of perceived reality, e.g., obtained via 2D or 3D perception sensors, from large-scale complex datasets representing spatio-temporal data etc
2. Achieving the narrativisation —or human-like perceptual sense-making— with a level of declarative abstraction,[1] analytical accuracy, and semantic & descriptive quality and expressibility that is comparable with, or even outperforming, expected human performance in specific problem contexts.

Computational narratives not only provide a rich cognitive basis, but they also serve as a benchmark of functional performance in our development of computational cognitive assistance systems. We posit that computational narrativisation pertaining to space, actions, and change provides a useful model of *visual* and *spatio-temporal thinking* within a wide-range of problem-solving tasks and application areas (see B; B1-B5) where collaborative cognitive systems could serve an assistive and empowering function.

B. Narrativised Spatio-Temporal Thinking in Analytical and Creative Problem Solving

The ubiquity and diversity of visuo-spatial narrativisation is self-evident in a range of cognitive (interaction) systems and technologies that aim to assist and empower people in creative, specialist, and regular everyday living situations. Consider assistive technologies and systems concerning the problem domain and application areas in (B1–B5):

B1. *Perceptual Narratives and Human Activity Interpretation*
Perceptual narratives pertain to artificial sensor grounded visual, auditory, and haptic observations in the real world. Declarative models of perceptual narratives can be used for assistive tasks in the course of activities in everyday life and work (e.g., human activity interpretation, semantic model generation from video, ambient intelligence) [Bhatt et al., 2013b,c].

B2. *Narrative-based Control for Cognitive Robotics*
To the extent that a perceptual narrative, as in (A1), can help to make sense of a situation for an artificial agent (e.g., robot, system), it can also be the basis of future action. For instance, a robotic agent can identify abnormalities in a narrative, which may in turn affect subsequent (re)planning and sensing behaviour, and dialog with a user [Eppe and Bhatt, 2013, Suchan and Bhatt, 2014]

B3. *Narratives of User Experience for Spatial Design & Architecture*
Narratives of user experience pertain to human-grounded visuo-spatial and locomotive modalities. Consider this: you enter a Museum for the first time; as you go around, guided by the internal structure of the building, you form a narrative of user experience based on your visuo-spatial, locomotive, and affordance-based perceptions in the Museum. Architects concerned with designing this Museum are confronted with anticipating this sort of narrative of user experience, at a time when all that exists during the initial design conception phase is '*empty space*' [Bhatt et al., 2012, 2014].

B4. *Narratives for Creative Assistance in Digital and New Media Production*
We interpret creative assistance in digital media production as the capability of computational tools to support the creative skills of experts and artists at several stages within the media design and creation process. Consider the domain of film, animation, and comic book pre-production. Here, one may identify several forms of assistance at the production phase, e.g., virtual cinematography, storyboarding, and scene visualisation from scripts and automatic camera control in the animation domain. Professionals who may be assisted, in a film context, include: cinematographers, directors, script and screenplay writers, storyboarding artists [Bhatt and Flanagan, 2010].

[1] Declarative-ness signifies the existence of models that can be reasoned and queried upon, e.g., within a traditional declarative knowledge representation and reasoning framework such as logic programming, constraint logic programming, description logic based conceptual reasoning, answer-set programming, and specialised commonsense reasoners based on expressive action logics. Details of such underlying enabling methods are not reelvant for this position statement.

B5. *Geospatial Narratives and their Spatio-Temporal Dynamics*
Geospatial narratives attempt to make sense of massive quantities of micro and macro-level spatio-temporal data pertaining to environmental, socio-economic and demographic processes operating in a geospatial context [Bhatt and Wallgruen, 2011, 2014]. Such narratives pertain to spatio-temporal databases of precise measurements about environmental features, aerial imagery, sensor network databases with real-time information about natural and artificial processes and phenomena etc. Geospatial narratives typically span a temporal horizon encompassing generational change, but these could also pertain to the scale of everyday '*life in the city*', natural environmental processes etc. [Bhatt and Wallgruen, 2014]

In the backdrop of the problem domains in (B1–B5), we are investigating: (a) the conceptual and computational aspects of narrative-based visuo-spatial cognition, (b) declarative model of narrative knowledge, and its relationship with spatio-linguistically grounded behavioural and formal theories, (c) role of specialised knowledge representation and reasoning mechanisms as underlying methods for automating high-level narrativisation processes from the viewpoint of visuo-spatial *cognition and creativity*.

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Related Work

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