Cognitively Biased Agent-Based Models

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Abstract. This speculative research proposal offers a user-centred perspective on Agent-Based Models for architectural/urban usability studies. As arbitrary decisions are typically made to model some variables over others, Agent-Based Models often miss the patterns and biases of human spatial behaviour long known in Spatial Cognition literature. When meaningful variables are included in the model, they are often assumed to be normally, or unimodally distributed. As a plethora of empirical studies have shown, human behaviour is neither logical, nor random, and very rarely optimal. This proposal presents the problem in detail and offers some avenues for further development, including the ideas for validation of the potential cognitively biased agent-based models.

Keywords: agent-based models, spatial cognition

The traditional approach to the majority of design disciplines has been (and still is) based on the designer's arbitrary decisions on the importance of particular factors for the outcome of the design process. Despite the fact this has been challenged by some design disciplines where user-centric approach has become commonplace (e.g. in Human-Computer Interaction), in urban design this tenet remains largely unquestioned. Agent-Based Models (ABM)—a tool often used to support urban planning—in their basic principle remain the illustration of this flaw.

Agent-Based Models often are the tool of choice for urban simulations, when the emphasis is put on the behaviour of city dwellers. Typically, the user is simulated at a very general level. Additionally, the choice of variables affecting agents' behaviour is usually top-down, i.e. arbitrary decisions are made on the significance of particular factors. Subsequently, the model is tested, and adjusted based on its fitness to the real world data. This approach has been identified as problematic, as it does not consider the bottom-up emergence of the city complexity phenomena from the human cognition [1]. Even though enriching ABM with simulated vision has proven to be beneficial, the major focus has been either on very generic, or too basic psychological characteristics (such as emotions) [2]. In each case, the process of emergence of those characteristics into the phenomena of spatial behaviour observed in empirical studies is mostly unknown.

Typically in ABM, logical movement choices (e.g. optimal shortest distance), and normal or unimodal distributions of the behaviour are assumed. In reality, although psychological characteristics tend to be normally distributed across populations, the behaviour resulting from those characteristics is rarely so. Human spatial behaviour is biased and therefore the distribution representing spatial choices in a specified situation is likely to be skewed. Intergroup, and intercultural differences have been shown to moderate those biases.

The aim of this project proposal is to inverse the process of designing Agent-Based Models by involving variables, importance of which has been empirically proven in the studies of Spatial Cognition. Examples of these include human preference for known path, or imprecise travel time

estimations for paths with more turns. Instead of making arbitrary decisions on the importance of specific variables, this importance can be assessed based on the existing knowledge base of Spatial Cognition.

Real-world case studies which put emphasis on spontaneous navigational behaviour will be selected for model validation. This might include road closure situations, sightseeing groups of tourists, or commuters traveling to rarely visited parts of the city. If similar datasets are available across cities, cross-cultural differences in real-life city navigational strategies can be investigated. The resulting ABM should also be tested against Space Syntax prediction (see [3] for considerable theoretical limitations of Space Syntax which can be tackled by ABM).

A study on traffic congestions using London taxi trips has already followed a similar framework [4], although it can be questioned to what extent their navigational strategies match those of less skilled commuters. In order to expand the use of the framework and foster the applicability of empirical findings from Spatial Cognition studies, more work is required on mapping the already known components of spatial behaviour [5] to its dynamic, socially-mediated, goal-driven manifestations in real-world environments.

The potential contribution of this work is a better understanding of not only how humans navigate the city on the everyday basis, but most importantly, what happens when a dynamic change occurs, requiring spontaneous navigational decisions from multiple commuters. The applications can include simulations of road closure/opening situations, emergency events, or the effect of dynamic road pricing system on driving behaviour. Substantial knowledge base in human Spatial Cognition allows for the development of user-centred agent-based models that represent empirically-informed behavioural patterns. The availability of rich city data makes it only now possible to test the laboratory-generated findings on a city-scale, in the real world.

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