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# Agent-based Virtual Society Polygon for Simulation and Evaluation in Massive Mobile Services

Daniil V. Voloshin[a], Kseniia A. Puzyreva[a], Vladislav A. Karbovskii[a]*

[a]*ITMO University, Kronverkskiy pr. 49, 197101, Saint Petersburg, Russia*

**Abstract**

Since there are phenomena that are too perplex to be observed through using traditional techniques of scientific investigation, there are tools allowing reconstructing them in a simplified form. Agent-Based modeling has established itself as one of these tools. Though the major analytical principle remains the same – decomposition of the complex object into primitive particles, models themselves are fluctuating from the simple ones (e.g. spatial segregation models) to those able to propose reproduction of crowds, transport/pedestrian flows and other interactions by implementing sophisticated intelligent agent architectures. However, the utilization of agent-based modeling is not limited to satisfying sole scientific interest, but may be used for the resolution of applied issues as well. A polygon focused on performing both investigative and practical tasks has been introduced to simulate collective response to the changing environmental conditions (e.g. in the course of the natural disaster). The model originally designed to be incorporated into the mobile service computational infrastructure to constitute a massive mobile service for decision-making support is described throughout the paper. The potential use of the obtained simulation results in the analysis of emerging issues under conditions of social and infrastructural disorder is discussed with special reference to natural disasters. Further perspectives of implementation of present model in decision-making assistance are outlined as well.


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*Keywords:* Agent-based modeling, Virtual society, Evacuation behavior, Disaster studies, Collective behavior

* *Corresponding author. Tel.: +7-950-002-2288.*
*E-mail address: vladislav.k.work@gmail.com.*


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## 1. Introduction

Agent-based modeling (ABM) allows researcher to have a view at the phenomena (or its' specific state or element) that is otherwise difficult or at times impossible to observe. Moreover, when applied to social sciences, it helps one liberate himself from possible (ethic, technical etc.) constrains set upon the use of experimental methods when studying collective behavior and minimize the cost of aggregating information prior to decision-making in the spheres that relate to it – for instance, spatial design, urban development, interactive systems planning. Though ABM has proved its' effectiveness in answering "what if" questions, little effort has been made in recognizing how ABM could lend itself to finding a better answer to "what now" issues that occasionally emerge and demand for immediate supply of relevant and trustworthy information to assist decision-making. Both of the presented problems are to be reflected upon in this paper in light of the creation of the virtual social polygon intended to resolve them. Originally designed as a component for the massive mobile service (MMS), it is capable of performing multiple tasks, such as real-time aggregating and processing population dynamics data, assessing the effects that external factors have upon the community of city residents and evaluating the effectiveness of the possible implementation of decision-making support services.

## 2. Related Works

Agent-based modeling as a tool is constantly becoming more complex and, despite of being a relatively novel research method, it has already made its' way from introducing simplified spatial segregation models [1][2][3] in various modifications [4][5] to proposing sophisticated reproduction of pedestrian flows, crowds or even complete sets of interdependent interactions within urban systems by using intelligent agent architectures [6][7][8]. As a result of the models' increasing complexity, the scope of their application started to exceed the boundaries of computational science, going beyond the purely scientific interest, in order to resolve more actual problems. One of the most extensive trends in ABM implementation is modeling/reproducing human behavior in different situations and under certain conditions. This is reflected in such domains as Crowd dynamics [9][10], Traffic dynamics [11], Urban and Regional Planning [12][13], Collective intelligence [14], Social networks [15][16] etc. In specific cases models representing the behavior of groups of individuals are run along with dynamic physical models of environment or crisis events (e.g. natural disasters) that potentially alter the state of the society and stable functioning of distinct urban subsystems, thus introducing greater amount of uncertainty to the simulation. For instance, Chen et al (2008) [17] propose launching both types of models synchronously in order to test two different evacuation strategies against the virtual flood. Another attempt to produce a realistic model of crisis response was made by Epstein, Pankajaksahn and Hammond, 2011 [18] as they supplemented Agent-Based Modeling with Computational Fluid Dynamics in order to introduce a technique for evacuation planning in urban areas, aimed at mitigating accidents that involve massive emission of airborne particles.

Despite being well-suited for narrow tasks, all of the above-listed models (even those designed to simulate the flow of the disaster and collective response) lack features that are crucial for meeting the demands of the project in-question. First of all, since social polygon is considered a functional subsystem, it is expected to be customized in a way to be easily integrated into the mobile service computational infrastructure. Secondly, it shall be tailored to real-time processing of incoming data on population density and distribution. The final concern is the flexibility of the model – it is required to adequately reflect different modes of the system – the Emergency and the Routine one. Considering the specifications and restrictions given, a decision was made to build an agent-based model "from scratch" that would encompass all three characteristics.