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# Simulating Urban Life With Ethically Conscious Tourists

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Modern cities struggle against urban problems, for instance, overcrowding which solution could be found through computer-aided simulation. This contribution describes simulation of scenarios in urban life and focuses on their ethical aspects. For this purpose, this article examines multidisciplinary determinants of ethical behavior of tourists and utilizes own framework for experimentation and rapid prototyping to create prototypes of urban simulation. This contribution ends up with a discussion and an outlook.

*Keywords*: SocioFramework, ethically conscious tourists, agent-based urban simulation, multidisciplinary determinants, urban scenarios

## 1. Introduction

Technological innovations bring significant changes in the Urban Life (UL) and modern cities have to take up this challenge. New urban solutions must be invented and verified what demands significant number of experiments and tests. Is it possible? Yes, an effective solution relies on computer-aided Urban Simulation (US) that implements urban scenarios and can be used to simulate various urban experiments. The goal of this contribution is moreover elaborating on US focusing on ethical aspects of urban problems.

## 2. Related work

Related work studies ethical aspects of urban problems. For example, Chan [1] explores how the city design and the urban process produce new ethical categories, shape new moral identities and relations. Pavoni [2] discusses an ethico-political strategy of urbanization in the context of justice. Related work also describes different urban scenarios and social issues are its considerable factor [3–7].

Different scholars consider simulation to test supposed impacts of UL prior to their integration in the real life [8–14]. Nijholt [15] discusses urban smart technologies and urban games as well as elaborates on urban data to design games and playful applications in the context of urban design. Rosol et al. [16] describe design features and data in a game that improves planning of travel in an urban environment. Cristie&Berger [17] elaborate on public participatory games for urban exploration. Pumain&Reuillon [18, sec. 1.4] examine urban evolution and how to predict urban development.

Literature on UL identifies significant urban scenarios and concepts. Mora et al. [19] examine urban planning and focus on the Social Networks (SNs), a community of persons that constitute a network bound by social relationships. The scholars claim that the SNs are a remarkable source of "explicit and implicit information about social structure" because they define "almost any aspect of the daily life of citizens such as practices, preferences, pictures, etc.". Maretto et al. [20] describe urban dynamics. They overview three theoretical models of spatial urban segregation and how they evolve at time. Jin et al. [21] discuss rapid urban growth and point to aspects of social interaction and neighborhoods in China. Moreover, the scholars describe variables that influence social integration such as the relationship between the environment and behavior, population density and socio-demographic characteristics of social integration. Koens et al. [22, Tab. 1] describe urban problems of overtourism such as overcrowding, less availability of housing, loss of sense of community and security.

Social justice is an important aspect of modern UL. Bauriedl&Strüver [23] warn of the "digital divide" meaning that implementation of smart city strategies can lead to intensified social segregation. Wacquant [24, ch. 5] discusses urban marginalization in the suburbs and describes their problems such as poverty, isolation etc. Rosol et al. [25] study social justice in the context of smart cities and elaborate on its theoretical foundation.

This contribution studies urban ecosystems as a special case of urbanization and describes how to simulate them. Here are some definitions of ecosystems. Francis&Chadwick [26:3] define ecosystems following Pickett [27] as "a biotic community or assemblage and its physical environment as a specific place". According to Francis&Chadwick [26:51], ecosystems can be "viewed as complex adaptive systems" characterized by "multiple components that interact across a range of scales". For Douglas&James [28:10] an ecosystem is "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit"... "with inputs and outputs of energy and matter".

Previous work of Osherenko [29] also investigated simulations which findings can be used in this contribution. These simulations maintained a big number of interacting agents (10,000 agents) and presented implementations of 35 scenarios of social interaction that are similar to urban scenarios in this contribution such as "Culture and group size" or activities in a digital city including shopping, business, transportation, education, and social welfare, or culturally heterogeneous controversial scenarios [ibid., ch. 3].

## 3. Determinants

To believably simulate urban scenarios, this contribution discusses determinants of simulation and how these determinants are interpreted according to the Global Code of Ethics for Tourism (GCET) of the United Nations (`http://ethics.unwto.org`). Hence, this contribution reinterprets 10 agent-specific (related to a tourist or a resident) and 8 simulation-wide determinants in the ethical urban context extracted from 35 scenarios of social interaction (the references to the GCET are made only in most obvious cases).

Agent-specific determinants are:

(a) **Identity**. In UL, identity [30:72] is defined through different factors such as self-confidence and can influence, for instance, tourists' decision-making [9:175] [related to the Article 2[a] of GCET].
(b) **Emotions**. In many scenarios of social interaction, hence in scenarios of UL, emotions play a significant role and can influence the tourists' eye movements, body motions, haptics, physical appearance, speaking. Emotional model can be modeled using probabilistic Hidden Markov Models for affective behavior [29] following [31].
(c) **Personality**. To anticipate a general disposition of a tourist in UL, a personality dimension is necessary. The numerical model, called the BigFive model [32], can be used for this purpose.
(d) **Culture**. The culture dimension as a part of the tourist identity is indispensable for analysis of US and can be modeled as a synthetic culture [33]. The *Culture* determinant

[a] *Excerpt from Article 2 of GCET: Tourism as a vehicle for individual and collective fulfilment* Tourism, the activity most frequently associated with rest and relaxation, sport and access to culture and nature, should be planned and practised as a privileged means of *individual* and collective fulfilment; when practised with a sufficiently *open mind*, it is an irreplaceable factor of *self-education*, mutual tolerance and for learning about the legitimate differences between peoples and cultures and their diversity;

[related to the Article 1[b] of GCET].

(e) **Input/Output**. In some cases, simulation requires feedback from tourists or their input. For this purpose, a dialog system or the UNITY gaming engine `https://unity.com/de/solutions/edtech` can be used [related to the Article 1 of GCET].

(f) **Statistical engines**. Since UL relies on much data, statistical processing can be useful in US. For this purpose, the statistical toolkit WEKA [34] can be used (see also *Statistical processing* in the simulation-wide determinants).

(g) **NLP**. To react believably to tourists inputs, for example, to analyze ethical utterances, information processing can take into consideration NL processing [35:59]. Implementation of the NLP determinant is discussed in [36].

(h) **Space**. US can monitor positions of the population as in Jin et al. [21], for instance, to assure sustainability [related to the Article 3[c] of GCET]. To implement this determinant, US can extract the geographic position of tourists using GPS `https://github.com/googlemaps/google-maps-services-python` or `https://github.com/simondlevy/GooMPy`.

(i) **Social relationships**. Urban scenarios consider relationships between tourists in an urban environment what can be important, for example, in scenarios investigating influence of the group behavior or formation of SNs.

(j) **Context (agent-specic)**. The agent-specific context of US can define race, age, education, marital status, social class, religion, etc. For example, a multiethnic scenario of UL can consider avoiding building urban ghettos and social flashpoints.

(k) **Knowledge (agent-specific)**. The agent-specic knowledge are the facts about a particular matter. In the urban context, such knowledge can be knowledge of a tourist about specific problems of the residents, for instance, overcrowding.

(l) **Time (agent-specific)** US can consider well-being of individual tourists, for example, a jet lag and can be modeled in US in the *Time* determinant.

Simulation-wide determinants could be determined in the urban scenarios:

(a) **Explicit specifications**. To facilitate transparency in simulation development, US can define a specific scenario of UL using explicit specifications of the algorithms below such as the Alg. 4.1.

(b) **History**. US can maintain the urban history, for example, history of urban evolutions storing population of the urban area over time.

(c) **Space (simulation-wide)**. Some scenarios of UL consider geographical space such as the population density in Jin et al. [21] or to assure urban sustainability [related to the Article 3 of GCET]. To evaluate the density and, for instance, avoid overcrowding, US needs the simulation-wide space parameter.

(d) **Context (simulation-wide)**. The simulation-wide context denes circumstances in which US takes place. For example, US can be influenced by the weather conditions such as Japanese earthquakes.

(e) **Knowledge (simulation-wide)**. Knowledge can play a signicant role in US. This

[b] *Excerpt from Article 1 of GCET: Tourism's contribution to mutual understanding and respect between peoples and societies* The understanding and promotion of the ethical values common to humanity, with an attitude of tolerance and respect for the *diversity* of religious, philosophical and moral beliefs, are both the foundation and the consequence of responsible tourism; stakeholders in tourism development and tourists themselves should observe the social and *cultural traditions* and practices of all peoples, including those of minorities and indigenous peoples and to recognize their worth;

[c] *Excerpt from Article 3 of GCET: Tourism, a factor of sustainable development.* Nature tourism and ecotourism are recognized as being particularly conducive to enriching and enhancing the standing of tourism, provided they respect the natural heritage and local populations and are in keeping with the carrying capacity of the sites.

knowledge can mean not only facts about a particular urban environment, but knowledge of certain urban causalities, for example, that the residents of the urban area are concerned about overcrowding or loss of sense of community and security.

(f) **Time (simulation-wide)**. UL scenarios can analyze urban growth and dynamics and consider temporal issues. For example, tourists can consider touristic "rush hour" when most excursions take place and UL is overcrowded and can therefore decide to refuse from going on an excursion [related to the Article 3 of GCET]. To model urban time, US can use time zones.

(g) **Social network, topological issues**. US can maintain SNs, for example, to evaluate how social segregation influences UL. See [37, secs. 3.5, 6.4, 6.5].

(h) **Statistical processing**. US can process big amounts of information, for example, to perform urban analysis or urban planning and need therefore statistical processing.

## 4. Urban scenarios

This section discusses urban scenarios and concepts that can be implemented in US like urban monitoring, urban analysis, urban planning, urban evolution, urban dynamics, urban growth, urban ecosystem. The algorithms below present the simulation-wide *Explicit specifications* extending textual representation of UML sequence diagrams by adding special algorithmic notations like passing arguments in behaviors (`observer.register(population)`), returning values (prefix ->), loops (prefix ~) or conditional statements (prefix $), for example, the line `observer.$monitoring() -> ~` specifies the behavior `$monitoring` of the `observer` agent that is executed in a loop until the `$monitoring` condition is met.

(a) **Urban monitoring/Urban analysis** As an example of a monitoring scenario, a scenario from Jin et al. [21] is simulated.

**Algorithm 4.1.** *Urban monitoring/Analysis*

```
Urban_Monitoring/Analysis
{
  Simulation.inquire()->population;
  observer.register(population);
  //continuously observe the population
  observer.$monitoring(population) -> ~ {
    //send ping to and receive pong from the population
    population.ping()->Feedback {
      //get next feedback from the population
      population.pong(Simulation)->Feedback;
    }
  }
  Simulation.analyzeFeedbacks();
}
```

Alg. 4.1 shows the monitoring/analysis algorithm that extracts the monitored population (residents/tourists) from the simulation and defines the observer agent that monitors the simulation by sending in a loop ping messages and receiving feedbacks containing, for example, tourist's spatial position as answers to pong messages. After monitoring the feedbacks the simulation analyzes obtained feedbacks, for example, statistically.

(b) **Urban planning** Alg. 4.2 shows the monitoring algorithm that defines the observer agent that inquires spatial positions of the monitored agents (tourists/residents) in US and calculates the population density.

**Algorithm 4.2.** *Monitoring spatiality in the UL*

```
Urban_Spatiality
{
  Simulation.inquire()->population;
  observer.register(population);
  //continuously observe the population
  observer.$monitoring(population) -> ~ {
    //continously receive the population position
    observer.getPosition(population)->Position;
  }
  //calculate the urban density using the stored population positions
  observer.calculateDensity() -> Density;
  observer.doPlanning() -> UrbanPlan;
}
```

(c) **Urban evolution** Urban evolution considers history of urban growth. Alg. 4.3 compiles a history of observations of the urban area and forecasts future evolutions on the basis of this history.

**Algorithm 4.3.** *Urban evolution*

```
Urban_Evolution
{
  //continuously observe an urban environment to compose the urban history
  observer.$monitoring() -> ~ {
    //extract an observation of urban life
    urban_environment.record()->observation;
  }
  //analyze extracted observations and forecast the urban evolution
  urban_environment.analyze(observations) -> urban_history;
  urban_environment.forecast(urban_history) -> urban_evolution;
}
```

(d) **Urban growth/Urban dynamics** Urban growth/urban dynamics can be seen as a case of an urban evolution spread for a short period of time (Alg. 4.4).

**Algorithm 4.4.** *Urban growth/urban dynamics*

```
Urban_Evolution
{
  //continuously observe an urban environment to compose a short urban history
  observer.$monitoring() -> ~ {
    //continuously record observations to compile the urban history
    urban_environment.record()->observation;
  }
  //analyze stored observations to explain urban growth and dynamics
  urban_environment.analyze(observations) -> urban_growth_dynamics;
}
```

(e) **Urban ecosystem** The SF models the urban ecosystem by defining its information flows between its components. For instance, an ecosystem consisting of four components: biotic complex, physical complex, social complex, built complex defined by Francis&Chadwick [26:15] (Alg. 4.5).

**Algorithm 4.5.** *Setting up the ecosystem*

```
Urban_Ecosystem
{
  biotic_complex:physical_complex.strongly_connected();
  biotic_complex:social_complex.strongly_connected();
  biotic_complex:built_complex.strongly_connected();
  physical_complex:social_complex.strongly_connected();
  physical_complex:built_complex.strongly_connected();
  social_complex:built_complex.strongly_connected();
//further steps of urban simulation
}
```

Alg. 4.5 shows the simulation algorithm of the urban ecosystem, for example, consisting of connection between the biotic complex and the physical complex components. Each of the components can be extended further to simulate the biotic complex or the physical complex.

## 5. Implementation

SocioFramework (SF) [37, ch. 5], own statistical framework for experimentation and rapid prototyping, is used to generate prototypes of US and for statistical processing. The SF was invented to implement simulations of social interaction and is utilized in this contribution to generate prototypes of US. The SF creates a simulation prototype as a Multi-Agent System (MAS) where the MAS represents a prototype of US and an agent in this MAS is a tourist or a resident. The MAS implementation relies on the JADE Multiagent environment [38] and the statistical WEKA toolkit [34]. Some statistics: It was possible to build US with 10,000 agents that exchange 20,000 interaction messages and run US with 1,000 agents maintaining 2,000 interaction messages [29].

A MAS in JADE can be monitored and debugged using two standard JADE agents, *Sniffer* and *Introspector*. Moreover, a MAS in JADE can be adapted dynamically and augmented with agents in run-time [37, sec. 6.6.2], for example, while evaluating social justice in US.

Agents in JADE communicate with each other using messages and maintain behaviors to handle particular events. To generate US behaving according to a certain algorithm, the SF uses the text of the *Explicit specifications* determinant to create particular behaviors as Java classes. For instance, the SF uses Alg. 4.1 to generate US and among other things resolves the line `observer.$monitoring()` into the behavior `$monitoring` run by the agent `observer`.

## 6. Discussion and future work

This contribution showed an approach to experiment with UL and to prototype US. For this purpose, different urban scenarios were studied and a computer-aided ethically conscious realizations of some multidisciplinary determinants were discussed. Moreover, this article described US implementing common urban scenarios.

In future, other scenarios of ethical urban behavior will be explored, for instance, a UL scenario that mitigates urban problems in Koens et al. [22, Tab. 1]. Simulation can mitigate urban problems in another scenario where responsible tourists can be reminded on the local traditions of the residents either by mobile robots or intelligent apps in mobile phones. To avoid overwhelming the residents by overtourism, other scenarios can be useful: a scenario in which tourists can be conducted to such locations as a food store or a restaurant by intelligent computer-aided guides or in which tourists are informed about geographical distance to a particular place. A practical impact of this contribution can result in installation of a mobile service that facilitates composition of SNs of psychologically compatible tourists, for example, to reduce spatial distribution of tourists' flows in the host city.

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