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RE-THINKING THE REGION: SYSTEMATIC EVALUATION OF RESIDENTIAL LOCATION CHOICE UNDER DISASTER RISK

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Introduction

The growing attention on the resilience and sustainability in the built environment requires both an enhanced understanding of the existing building stock (Christodoulou et al., 2017), and people's interactions with it. These kinds of systems, where one can observe many interactive parts and from it an arising macroscopic behavior, are called complex systems (Portugali and Stolk, 2016). Agent-Based Models (ABM) embody this notion by simulating behaviour of autonomous individuals (i.e. agents), that perceive their context and interact with each other (Parker et al., 2003). These models are also commonly applied within the field of residential choice and mobility (Huang et al., 2014). They investigate the relationship between the existing housing supply and the specific demands of the agents (i.e. households) to explain location decision-making and arising spatial patterns. However, environmental impacts are rarely included in such models (Acheampong and Silva, 2015). An aspect of these impacts is the disaster risk, which is also not considered in any commonly used residential choice model (Valeckaite, 2018). This abstract presents an agent-based modelling approach to formulation of the problem of large scale relocation schemes and a computational framework, which allows simulating disaggregate residential location choice behaviour with explicit risk representation and monitoring an aggregate measure of improvement or lack thereof. The purpose of the proposed computational framework is to potentially enhance the strategic planning capabilities of public planning organizations in situations, where a regional scale housing stock upgrading is required due to risk exposure.

Model overview and implementation

This research centres on a point in time, when people are faced with a location- and building-related risk. Specifically, we model households' choices relating to whether to move and which location and property to move to. This is represented as a discrete choice model, based on the notion of regret (see e.g. Chorus, 2016). Thus, agents of the model are the households, which can relocate to discrete locations (parcels and houses), connected by a network (roads): the collection of these elements is our case-study agent-based model.

The inputs of the model are processed datasets. From built environment perspective, the inputs are a combination of open governmental data and proprietary building stock datasets, enriched with the information relating to the building risk (Christodoulou et al., 2017). The properties of the households are synthesized using several aggregate spatial and non-spatial statistical datasets. The population synthesizing procedure is repeated a thousand times and each of the synthesized sets work as alternative model input.

The time in the model is represented by abstract time unit, step. During each of them households evaluate viable (i.e. affordable, sufficient in size) building options, of which the best one is bid upon. The bid is always won by the household with the largest capital. Consequently, the households then move to a new location, vacating their old building and adding it to the evaluation pool for the next step. The system attributes are collected after each successful bid and the process repeats until none of the households can relocate.

The framework showcases 7 optimization criteria. They are simultaneously, but not equally weighted in the decision procedure (more in Chorus, 2016). The criteria relate to: (1) household preferences (distances to subjective points of interests, dependent on the household composition); (2) building properties (e.g. building floor area, price, risk); and (3) location properties (accessibility to amenities).

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The model adapts through time, because agents can alter properties of the building stock, e.g. by investing in upgrades. This can permanently reduce the building collapse risk, increasing the property value, but reducing of the households financial resources.

From the point of the decision maker, the model allows interventions in the system by either introducing changes to the input data or programmatically introducing changes (e.g. disaster events), if they can be represented in the optimization criteria.

The proposed model is implemented in a procedural and object-oriented manner, utilizing Python programming language libraries.

Results

This residential location choice model is implemented on a real case study in an earthquake prone area in the Netherlands. This showcase covers around 1400 building nodes and 1000 households. To test the robustness and usability of the framework we implement series of financial incentives targeting either specific income groups or subsidies for structurally upgrading the properties.

All of the model runs display a convergence after an average of 20 model time steps. The parallel runs on a system with no interventions show an improvement of 1%-10% per aggregated optimization criteria. Moreover, the runs with interventions show the expected aggregate level behavior. More specifically, we observe consistent global compromising behavior given same criteria and the same intervention. On aggregate criteria level the alternatives perform additional 1%-8% better than the reference run with no interventions. However, whilst inspecting the data spatially and focusing on the subsidy target groups (fig. 1), the differences are more pronounced.

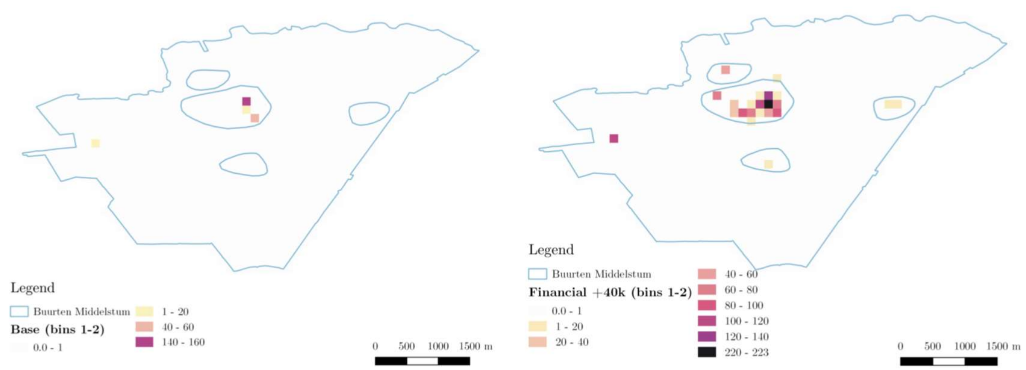

Figure 1. Relocation patterns of the households in the 2 lowest income groups, given a base (reference) run (left) and an intervention with 40k subsidy to these groups (right). Darker color indicates more movement.

Conclusion, discussion and future work

In this abstract we presented a general overview and preliminary results of a residential location choice model, given a disaster situation. The disaster risk aspect is represented as a property of the building stock, which can be improved if a household invests a part of their capital. Modelling this system as an agent-based model showcases the possibilities of inspecting their behaviour both from a spatial and group perspective, allowing us to create a flexible laboratory for the public planning organizations to test their spatial or financial policies.

However, we are conscious of the limitations of the current state of the model. which still requires calibration and extensive validation in several areas, such as real-estate market, risk models and mechanisms explicitly representing life-cycle events and transaction. The current spatial extents cover only a small subset of the area, thus, the code should be further optimized to explore broader regions. Nonetheless, we see this as a step towards a tool for educating, allowing to interactively determine the scenarios and explore the complexity of the data.

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