Urban Form-making through Biased Agent Interaction (Demo Paper)

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B.2.2 [**Arithmetic and Logic Structures**]: Performance Analysis and Design Aids – *simulation* I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *multiagent systems*

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Algorithms, Design, Human Factors, Experimentation

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Multi-agent systems, Urban design, HCI, Player interaction

1. INTRODUCTION
The urban forms we find in our cities are usually a juxtaposition of several biases. For example, a Developer is biased to think of the city as a 'collection of numbers', an Infrastructure person is biased to think of the city as a 'connection between elements', and from a more political or sociological bias, the city might mean 'density'. Agents subscribing to these different biases constantly attempt to change the city-form in a collective fashion. What is interesting is that even in such a seemingly disjointed decision making scenario, we might expect non-convergent scenarios leading to constant change in urban patterns. However it is observed that cities over a timescale do exhibit organizations or coherent patterns. In this experiment we query this form of pattern or form making through a multi-agent framework and describe a urban game based on it.

2. DESCRIPTION
For our experiment we arbitrarily chose three formal typologies – 'Tall' developments, 'Connected' developments, 'Dense' developments. There are three kinds of agents and each agent is biased towards one kind of development through state transition (fig.2). Such state transitions are triggered in different degrees by three abstract paint elements {Pa, Pb, Pc} which metaphorically stands for resources for development (fig.1). The agents move around on a board (25x25 grid) constantly sensing their neighborhood and changing states. Every agent type has a *Preference Order* (PO) [1] which determines which paint element will affect or activate them more. The preference ordering of the three agents are as follows,

Agent		**Paint Elements**
Agent 1(Tall)	<-	Pa > Pb > Pc
Agent 2(Connected)	<-	Pb > Pc > Pa
Agent 3(Dense)	<-	Pc > Pa > Pb

We have arbitrarily fixed this preference ordering in order to create a top cycle [2] – so that there is no clear polarization of forms on the board.

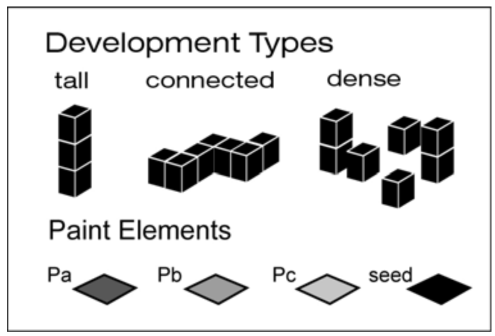

Figure 1

2.1 Agents
These are polymorphic automata, which sense neighborhood paint conditions as input and change their 'happiness' index based on it. The happiness index is a measure of the activation of the agent. The agents begin as 'mobile', roaming around the board. Based on their PO and KD, the paint elements affect their happiness index. They change their state and become 'static blocks' when their happiness index is higher than a particular threshold value. It is these static blocks that appear as form or pattern on the board. The static blocks constantly sense their neighborhood as well, updating their 'happiness' index. If the index falls below a threshold value the parked agents again change their state and become free and mobile agents (fig.2). Each of the agents has differing evaluation criteria that change dynamically based on their observed conditions. These agents not only have bounded rationality [3] in how they operate within their constraints and resources, but also change criteria on their present knowledge depth. Collectively they form a Multi-Agent System [4].

2.2 Paint
A *paint element* is an abstraction that changes the activation or happiness level in an agent. There are four kinds of paint elements and they activate different agents with different intensities. Once

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a paint element is used to affect an agent's state, it disappears from the board

Paint	**Agent Activation**
Pa (Blue)	-> Agent1 > Agent 2 > Agent 3
Pa (Orange)	-> Agent2 > Agent 3 > Agent 1
Pa (Green)	-> Agent3 > Agent 1 > Agent 2
Seed (Black)	-> Seed position for form making

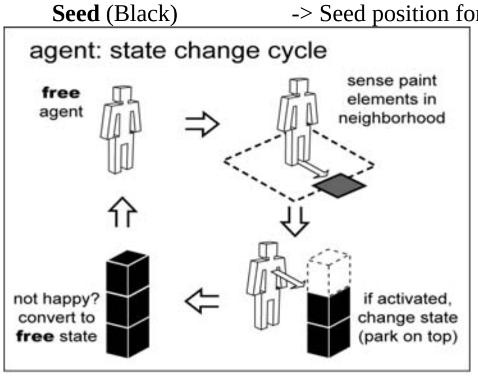

Figure 2

3. GAME PLAY

Based on the multi-agent framework we described above, we have developed a simple game where players compete to polarize the patterns on the board. As a narrative, we use the metaphor of a *City* and the players assume roles of Developers (they desire tall high-rise developments), Technocrats (they desire different parts of the city to be connected) and Socialists (they desire density). Players simultaneously paint the board with different colors to trigger their desired kind of developments.

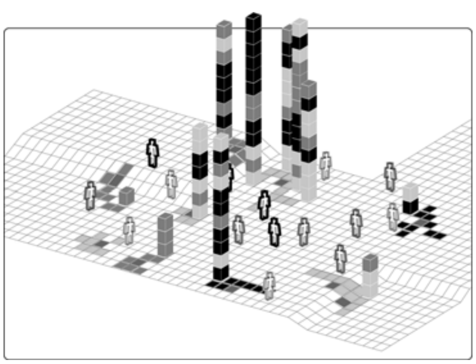

Figure 3: Screen capture of the game with 'Towers'

3.1 Players, Conditions, the World

This is a multiplayer game that captures the dynamic growth and change of a pattern (city) over time, by allowing the players to continuously superimpose their intensions via a simple painting interface. The players in this game simulation are playing in real time; there is no sequence in which the players take turns in play and the board reflects the changes immediately and represents the entire world for the players.

3.2 Game Play and Agent Behavior

The players interact in this world by placing bases (seed paint) and other paint elements using a remote controller (wii-motes) or by using a mouse. Bases are permanent assignments (colored black) that will define territories in which the three types of development may start to be constructed. The agents are finite in number, and initially distributed uniformly in the world. They are set to a default condition of randomly moving in the world until the players begin painting.

The agents start forming stacks or 'towers' (fig.3). A mixed-type tower (made up of mixed blocks) will be evaluated by the overall distribution, so that if the majority of blocks are blue (developer), the entire tower is said to be captured by the developer.

3.3 Scoring, Winning

The winning player will have accumulated the most points with the number of towers he captures. Whichever player polarized the entire development, therefore displaying greatest influence, will have the greatest index in this play of polarization

4. IMPLICATIONS / FUTURE WORK

This work is an attempt to find possible convergence among biased perspectives in a dynamic interactive environment. The results of our experiments are promising. We hope to further this framework to analyze and implement other models of multi-player negotiations where there are minimal or no resources of common interest. As further work it might be interesting to do a study on optimality conditions and have a game theoretic discussion incorporating ideas of 'utility' and 'negotiations'.

Furthermore this work attempts to create a game based framework for querying interleaved complexities observed in urban developments. What we observe as a city is usually the superposition of myriad layers of intentions and principles. If we were able to extract and observe how these principles interact and polarize developments, it would result in a powerful design tool in the urban design domain. This game models urban developments as an interactive evolutionary process, enabling multiple players to interact and collaboratively develop scenarios in dynamics. This is a leap from the conventional scenario making in urban planning. The formations in this game may be read as diagrams or genotypes for translation into more real situations. We plan to incorporate and implement the framework in actual design studios in the School of Planning and Architecture at MIT as further research.

5. REFERENCES

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