Chapter 7
Discussion

"…If the old perspective was a machine to viewing form in space, then the computer should be an instrument to view form in time. Just like when we look at the cloud we see the succession of iterations in time. We no longer look at objects, whether static or moving, rather at movement as it passes through the object. As architects we used to be obsessed with the cube and sphere, now we have become obsesses with a cloud, or a flock, with traffic jams, with behavior of a dog, with surface of water…We've stopped modeling form from outside, and generated it from inside instead. Obviously, a computer is used in this conceptual shift, a shift from Euclidean geometry to topology, from tectonics to textile, from crystalline space to the undulating field…"

(Spuybroek, 1999)

This thesis contributes to the understanding of the dynamic processes of the urban environment. These dynamics are caused by the interactions among people and various composed elements in space. We address these complex relationships from a detailed point of view, through micro-simulation modelling. Individual-based simulation in which we model behavior of an individual – agent – as it moves about the environment seems an appropriate way to study the phenomena of pedestrian interactions in an urban environment. We explore constructing a model that reveals the simple basis for the complexity of these interactions.

We started to develop a simulation model that consists of an environment in which the interaction occurs: various objects defined by characteristic parameters, and a number of individuals defined in terms of their behaviors and characteristics. Working with the notion of self-organization, the behavior structure of an agent is designed from the bottom up – from the less complex levels, reflex and reactive behaviors, to a more complex level, motivated behavior – in order to provide a foundation for additional behavior models that can be added to the simulation in the future. At this point, to explore the idea we use a **Mouse** that encapsulates only a few pedestrian behaviors.

Each mouse is autonomous and carries its own structure. The structure of a mouse consists of 1) an external perception system – specifically, an ability to 'see', 2) internal states of motivation, 3) a behavior production system that translates external perceptions and internal motivations into action in the simulated environment. By combining these three components, a mouse can independently move and act upon the environment. Its movement is based largely on its visual perception which continually changes along the course of movement and its internal states that can also be changed according to circumstances. The agent mouse's ability to adapt, we believe, can cause change – dynamics – in its behavior, making it difficult to predict.

The heart of the thesis is about describing pedestrian spatial behaviors for the simulation in a form that is computable and described in terms of local interactions – how an individual interacts with objects as well as other individuals. We brought together our "casual" knowledge (of how people interact with the built environment) supported by findings from theoretical and empirical studies as well as our own observations conducted before the model started to take shape. Two types of mice, aimless and purposive walkers, are used to demonstrate the two basic movements, which are 'wander' and 'walk through' as default, or reflex, behaviors. The actions of avoiding obstacles and avoiding collision are two types of reactive behavior. The last category includes behaviors associated with internal states of motivation, so that mice moving through space can be articulated as the search for objects – goals – of attraction whose attributes match the internal states of individuals. The repertoire of motivated behaviors can be expanded in the future along with the further development of the objects' attributes.

After we model individual behaviors at the level of motivated behavior, we use the model to demonstrate that pedestrian movement can be explained by space configurations and elements whose characters (qualities) correspond to individual internal states (Experiment 1). We then extend the framework, using the individual model as the base for a social action model. By adding more 'simple rules', the simulation demonstrates the idea that not only configuration of space and the distribution of attraction, but also the social environment have important consequences on pedestrian movement (Experiment 2). And, we demonstrated that some complex social behavior can be explained through social interactions among individuals.

For the purpose of learning, we developed this simulation as a game that allows users to create an environment to accommodate agent mice. Users arrange blocks and cheese to interact with various numbers of agent mice in different times of day, and we play the role of observer to see and understand how real urban environment, in some aspects, actually works. The capacity of a computer to store, transform, and convey information enables us to simulate such complex systems like pedestrian movement in urban environment. Moreover, it can also track and record the 'fluid data' of pedestrian paths and generate visualizations that reveal the value of the 'space'.

In the next steps of development, we plan to refine agent behaviors. We are looking for more motivated behaviors and the attributes of elements as well as more types of mouse to incorporate in the environment. More elements and attributes will yield more interactions, producing more complex behaviors, and revealing some clues of 'intelligence'. And, with these more complex – and we hope, realistic – behaviors, the mouse will soon be replaced with a pedestrian. Together with this refinement, the simulation model would be even more useful if we can enable general users to easily add and edit the behaviors so the users can test and demonstrate their own hypotheses about pedestrian behavior.

We have also left for future work the testing and validation of computational models against observed pedestrian behavior data. Although such testing and validation is clearly necessary for the full development of models of complex urban interactions, in this work we chose to focus instead on constructing a multi-level framework for simulations, as a proof-of-concept system rather than one with immediate predictive value. Thus, although the behavior of the simulated agent mice appear to resemble the actual behavior of pedestrians in real urban environments, we make no claim for the accuracy of these of these simulations. Rather, we chose to design and build a computational environment where it is possible to construct multi-level simulations of individual and emergent social patterns of behavior.

Finally, the quotation from architect Lars Spuybroek at the beginning of this chapter suggests an ultimate aim of this work: to help designers make better built environments, in which the creation of space and form may be driven directly by the behavioral patterns of people interacting in space with one another and with the physical elements of the environment.