ARCHITECTURAL DESIGN SUPPORTED WITH AGENT BASED DESIGN SYSTEMS: CASE OF A PSYCHIATRIC HOSPITAL

(Paper)
Topic: (Architecture)
Author(s):
Derya Güleç Özer
Turkey, Yildiz Technical University, Department of Architecture
www.deryagulecozer.com, dgulec@yildiz.edu.tr

Abstract

This paper has been developed within the results of a project developed in the Interscalar Workshop (Systemic Operations), in İstanbul. The theme was Bakirkoy Psychiatric Hospital, and its 90 hectares of urban field and the intimate therapy room for design ideas and interventions. Multilevel investigations took place regarding the site for redevelopment and/or remodeling of the pschiatric healing space. Lately, there has been great move away from the panopticon layout and the oversized, out of sight asylum. The spatial performativities play an integrated role in the supercustomized re-modeling of the patients mind and body.
Classification of privacy between the scale intervals; isolation rooms, patient rooms, daytime living areas in the garden, outpatient clinics, to beyond the hospital complex and its environment in relationship with the city is observed. These spaces contains an increasing degree of public that would introduce dissimilarities, while spatial degrees of security and urgency emerges. Different spaces of qualitative/scalar graduation are meant to be potential areas in thresholds for interaction.
One of the projects developed in the workshop by the author namely, FIELD: Individuals Distribution; was focused on the design of the courtyard within the hospital on human/environment centered scale. The patients' daily routine through space captured by stop-motion is reinterpreted by expansion and contraction. The focus on the courtyard emphasizes the multiple engagement in variying degrees of socialization, the topographic model utilizes interior properties to re-contour the open field condition.
From the data derived from the analysis, agent based design model was developed. To achieve this, rule sets were formed namely: [1] Security (high, medium, low), [2] Sun position (summer,fall, winter, spring between 10 am-3 pm), [3] Circulation (purpose, meandering, stroll), [4] Speed (high, medium, low). Depending on either agents, doctor/nurse (Agent 1), patient (Agent 2); rule sets was used to develop different scenarios. Relationship between Agent1 to Agent2, and between agent to its environment is modelled with various scenarios and an alternative design model is proposed.
The design method was to discover three ecologies focusing on boundaries and interfaces in various scales from the individual to public. Internal and external characteristics of the ecologies were discussed through photographic documentation. Relational modeling techniques and rapid prototyping and manufacturing methods, working environment of the cnc milling and repetitive production was achieved.

email/address
dgulec@yildiz.edu.tr

Key words: Agent Based Design, Hospital Architecture, Movement Analysis

Main References:

[1] Derya G. Ozer, Sinan M. Şener, "User Accessibility Optimization Using Genetic Algoritm: aDA", ITU AZ Journal, 10:2, pg.212-230, 2013.
[2] Y. Ophir, "Collective Intelligence:An Agent-Based Approach to Programmatic Organization in Architecture", International Journal of Architectural Computing, Vol. 7, No: 3, pp. 479-499, 2009.
[3] Derya G. Ozer, Sinan M. Sener, Cagri Zaman, "Optimization of User Accessibility Using Genetic Algorithm", Proceedings of 15. Generative Art Conference, Lucca, Italy, 2012.

Architectural Design Supported With Agent Based Design Systems: Case Of A Psychiatric Hospital

Assoc. Prof. Dr. D. G. Ozer, MArch, MSc, PhD
Department of Architecture, Yildiz Technical University, İstanbul, TURKEY
www.deryagulecozer.com
e-mail: dgulec@yildiz.edu.tr

Premise

This paper has been developed within the results of a project developed in the Interscalar Workshop (Systemic Operations), in İstanbul. The theme was Bakirkoy Psychiatric Hospital, and its 90 hectares of urban field and the intimate therapy room for design ideas and interventions. Multilevel investigations took place regarding the site for redevelopment and/or remodeling of the pschiatric healing space. Lately, there has been great move away from the panopticon layout and the oversized, out of sight asylum. The spatial performativities play an integrated role in the supercustomized re-modeling of the patients mind and body.
Classification of privacy between the scale intervals; isolation rooms, patient rooms, daytime living areas in the garden, outpatient clinics, to beyond the hospital complex and its environment in relationship with the city is observed. These spaces contains an increasing degree of public that would introduce dissimilarities, while spatial degrees of security and urgency emerges. Different spaces of qualitative/scalar graduation are meant to be potential areas in thresholds for interaction.
One of the projects developed in the workshop by the author namely, FIELD: Individuals Distribution; was focused on the design of the courtyard within the hospital on human/environment centered scale. The patients' daily routine through space captured by stop-motion is reinterpreted by expansion and contraction. The focus on the courtyard emphasizes the multiple engagement in variying degrees of socialization, the topographic model utilizes interior properties to re-contour the open field condition.
From the data derived from the analysis, agent based design model was developed. To achieve this, rule sets were formed namely: 1) Security (high, medium, low), 2) Sun position (summer, fall, winter, spring between 10 am-3 pm), 3) Circulation (purpose, meandering, stroll), 4) Speed (high, medium, low). Depending on either agents, doctor/nurse (Agent 1), patient (Agent 2); rule sets was used to develop different scenarios. Relationship between Agent1 to Agent2, and between agent to its environment is modelled with various scenarios and an alternative design model is proposed.

The design method was to discover three ecologies focusing on boundaries and interfaces in various scales from the individual to public. Internal and external characteristics of the ecologies were discussed through photographic documentation. Relational modeling techniques and rapid prototyping and manufacturing methods, working environment of the cnc milling and repetitive production was achieved.

1. Introduction

In recent years, advances in information and communication technologies provide new possibilities in computer-aided design [1]. The integration of agent-based models using genetic algorithms and artificial intelligence into the design process offers endless possibilities to designers [2,3,4]. Agent-based systems are used in the field of architectural design and building construction and they have also been integrated into large-scale urban planning models. These systems make it easy for designers to solve problems while providing time efficiency.

Agent-based simulation is important in terms of seeing users' behaviors, moves and motion in the facility [5]. Although simulation modeling is a method used by designers to express and develop their ideas; perspective drawings, three-dimensional physical modeling and three-dimensional computer modeling have been used in modeling and simulation of design and manufacturing processes. The rapid advancement in technology opened up new possibilities for more realistic and impressive design simulation capabilities using different, advanced computer techniques.

In this paper's theme, Bakirkoy Psychiatric Hospital is chosen to be focused within Interscalar Workshop. Working in teams, it was asked to respond with a system design in the multiple programatic combinatorics-choosing from a wide scope scales: the current and future site potentials down to the microscale landscape of the therapy space. The aim is to have an amalgamation of projects working in different scales, with prototypes and digital models, feeding in and out from other scales and projects, all working under the similar themes/consraints of the site-program. The site and the program reveal gradiencies of private/common, open/closed, secure/insecure, acute/emergent, specific/generic. Peculiarities like overhead planes every 15 min, dense pine woods of 30 hectares and a byzantium archeological site are undersized by the minute sensibilities of schizophrenia, bipolarities and disorderlies.

1.1 Scope, Aim and Method of the Study

Several problems occur during the post-production utilization process when the design process is completed without taking into account user movements in multi-user environment. The scope of this study will cover user movements in hospitals. To meet user needs, any problem or error that may occur in relation to the configuration of users and hospital settings/environment will be detected and corrected accordingly during the facility design process.

The aim of this study is to investigate the relationship between users and facility design in a virtual environment, under specific conditions, where human users will be represented by intelligent agents through the model we intend to design.

This study provided us with a platform where we have been able to think in multiple levels in order to observe intense systematic processes based on the key concept of interscale. The outline of the study has progressed in a set of guidelines that define the selected and focused ranges of motion by deciphering the concept of interscale as well as the theme of limitations. The theme that has taken its final shape as a result of many interviews with psychiatrists and mental health professionals in the field of psychiatry helped us reveal the security/privacy and interaction/isolation issues. [6]

Following the identification of user characteristics through agent-based modeling, the movement patterns of doctor, nurse and patient groups (selected as facility users) in designated times has been investigated [7]. The aim of this investigation was to design hospitals better equipped to meet patients' needs using the results obtained from situations that change depending on intelligent agents' behaviors representing the facility users; and to effectively detect problems and prevent them before they occur via agent-based pilot testing of the facility [8].

Mental health aims and objectives are as follows: restore the will to live and instil a sense of responsibility; reduce stigma and discrimination that affect thousands of people, families, and society in general; help individuals successfully integrate into and interact with society as well as other urban institutions. It is envisaged to increase the number of clinical services that are designed to address the above-mentioned issues. But, the crucial point here worth noticing is that whether there are any possibilities to transform the divisive/separative mechanisms into various communication interfaces without endangering security. How one can create safe limitations without building a wall or a fence? [6]

This study encourages a new way of thinking capable of bringing up for discussion an "out of chaos into reconciliation" notion in agent-based systems, instead of the notion of fixed limitations which separates these systems from their static values. Thinking through systems and diversities has led to a redefinition of the concept of limitation. Diversity is not a range of different things; it is the fact of knowledge, which models the mechanism, being reduced and aimed at the whole system without requiring static compositions. Each level where differences in scale may conceive interactions at threshold consists of security and urgency specifications. [6]

The busiest times of day in the hospital and the daily schedule and routines of doctors, nurses and patients, chosen as user agents, have been used as determinative factors in developing the model which was designed as part of this research. A user scenario, where each agent represents a human user, has been developed for different time intervals in different situations at various levels of security. Each agent has different travel/traffic patterns that match the prespecified user profiles and their prespecified goals. These patterns have been defined as purposive or goal-directed, meandering and random. Agent-behaviour patterns in different seasons, from 10.00am to 3.00pm have been considered fast, slow and moderate with high, moderate and low security levels.

2. Intelligent Agents and Agent Learning Systems

2.1 Definition of Agent

There are several different definitions for the term "agent". According to Jennings and Wooldridge, agent is a software-based computer system operating without the direct intervention of humans, and having some kind of control over their actions. According to Janca and Gilbert, agents act on the behalf of users translating their requests into operational actions, but they present some limitations [9,10]. Nwana defines agent as referring to a component of software and/or hardware which is capable of acting exactingly in order to accomplish tasks on behalf of its user [11]. A large variety of agents exists including interface agents, simple reflex agents, mobile agents, knowledge-based agents, heterogeneous agents, curious agents, goal-based agents, cognitive agents, learning agents, situated agents.

Agents observe through sensors and acts upon an environment using effectors. The overall goal of Artificial intelligence, which is defined as an area of computer science that aims to analyse natural intelligence and abilities displayed by humans so as to design human-like behavioural patterns, is to design agent programs [10]. Before we design an agent program, we must have a pretty good idea of the possible percepts and actions, what goals or performance measure the agent is

supposed to achieve, and what sort of environment it will operate in [12]. Simple reflex agent can be described as follows [10]: A simple reflex agent finds a rule whose condition matches the current situation and does the action associated with the rule. When doing this, it uses the information on how its world evolved and how its actions can affect the world.

The two groups in this study consisted of a group of doctors-nurses (agent 1) and a group of patients (agent 2), interacting with each other. The site chosen for this study, Bakırköy Psychiatric Hospital, also offers multiple interaction opportunities for the study's aims and scope [6].

2.2 Characteristics of Intelligent Agents

Agents have three key characteristics. They are flexible, autonomous and intelligent [10]. But the most important feature of an agent is its autonomy. An agent is able to learn from its experience and use this information in its future actions. In some cases, no learning ability is required. In light of the above, it can be concluded that agents are computer systems capable of flexible and autonomous actions in order to achieve the predesigned goals in environments they are embedded. The most important feature of agents that separates them from other autonomous systems is their "flexibility" in dealing with situations. What we mean by flexibility is, essentially, agent/agents' ability to interact with other agents and humans, and their proactivity since they exhibit goal-oriented behaviour. The emergence of robotics and its efforts for the integration of visual and auditory perceptions into computer systems has resulted in a new approach where artificial intelligence is expected to perceive its environment, act upon it and learn by observing and perceiving its environment [1]. An intelligent agent is a computer system that is capable of taking flexible and autonomous actions in environments it is situated. The flexibility concepts mentioned here involves reflex, and being proactive and social [10].

Since different decisions might be made in environments bearing different characteristics, agents also should be able to act according to circumstances and take decisions that suit the situation. Although goal-oriented actions hold importance in a stable environment; in a dynamic environment, on the other hand, agents' ability to adapt to changes and exhibit behaviours as a reaction to these changes becomes crucial [10].

It is known that agents are defined as programs that can operate independently to reach a specific purpose in complete interaction with other agents and the systems they are embedded in. But, they are also expected to gain the ability to work collaboratively on tasks they are given. While agents can either be stable or dynamic, stable agents mostly work within a fixed-instruction computer.

Each agent has its own environment consisting of other agents and a physical world enabling them to interact with each other, take action together and to produce results by observing its own as well as other agents' situation and the environment they are situated in. An agent is capable of deciding on its own when to change and by whom it will be changed.

Although patients (the second agent group in this study) can act independently under a variety of circumstances, their actions may still be controlled by agent 1 depending on their disease state (behaviours that may endanger security considering they are mental health patients) or disease severity. But agent 1, comprising a group of doctors-nurses, acts independently from agent 2.

2.3 Intelligent Agents and their Environments

Each agent is situated in an environment consisting of other agents and the physical world. It interacts with the physical world in order to be able to act, imports data from the environment it is embedded in and generates an outcome that impact its environment. This interaction is mostly

continuous and it never stops. An agent does not possess a full impact on the environment it is situated in yet it can bring a certain impact on its environment [10].

Agent environments contain a certain gradation of interscale privacy, including seclusion room, patient room, common area, inner court, outdoor backyard and polyclinics, and beyond that, the hospital complex itself and its areas of differences that involve the hospital complex's relationship with the physical environment and the city, gradually turning into the gradations of publicness. These scale-related and qualitative areas in gradations differ from each other in terms of security and emergency, while they also mean threshold areas of probability for interaction [6].

2.4 Actors and User Scenarios

In user scenario model that contain actors and use user scenarios, the concepts are used to define the actors, situated outside the system, and to help the system decide what to do (user scenarios) [13]. User scenarios help establish communication between agents, while allowing designers to identify spatial changes or modifications required by the system. Thus, by observing actors' behaviour, we might be able to anticipate the potential users of the system, to explore its functionality as well as attend to any potential or present problems. Accordingly, the scope of the project would be better understood by looking at the relationship between user cases and actors [10].

Remaining in interaction with the system as well as representing everything that requires system-related information exchange, the agents define those that are situated outside the scope of the system [10,13]. User scenarios define everything that is situated within the scope of the system [14]. Each user scenario describes a sequence of events, initiated by actors and illustrating interaction between the actor and the system.

The above-mentioned interaction can be defined with the following function (1):

$$I=f(H,K,O) \quad (1)$$

I: Basic relationships between the agents' environment and agents' behaviour.

H: Goals (high-level goals associated with inter-agent relationships).

K: Rules (created based on social and cultural factors, each agent must follow these rules when performing tasks).

O: Environment (agents are situated in a built environment containing design elements).

In this study, spaces and times where patients carry out their daily routines have been filmed using stop-motion animation technique to capture space and time frame-by-frame, and an expanded or a compact study of the relationship between the two has been carried out. Efforts have been attempted to implement this relationship in inner court and outdoor areas, both playing a major role in the treatment of patients, as well as to create various levels of socialization in outdoor areas where the playground was chosen as the topography in this study.

Although it is possible to create a wide variety of user scenarios, the following six user scenarios have been devised within the scope of this study:

AGENT 1: User Scenarios for Doctor-Nurse (Figure 1-2)

- Agent 1 - Scenario 1: Closed (Security), Purpose (Circulation), Low (Speed), Autumn time:3.00pm

- Agent 1 - Scenario 2: Semi-closed (Security), Purpose (Circulation), Normal (Speed), Winter time:3.00pm

- Agent 1 - Scenario 3: Open (Security), Purpose (Circulation), High (Speed), Spring time:3.00pm

AGENT 2: User Scenarios for Patient

- Agent 2 - Scenario 1: Closed (Security), Purpose (Circulation), High (Speed), Summer time: 10.00am

- Agent 2 - Scenario 2: Semi-closed (Security), Stroll (Circulation), Normal (Speed), Autumn time: 10.00am

- Agent 2 - Scenario 3: Open (Security), Meandering (Circulation), Low (Speed), Winter time: 10.00am

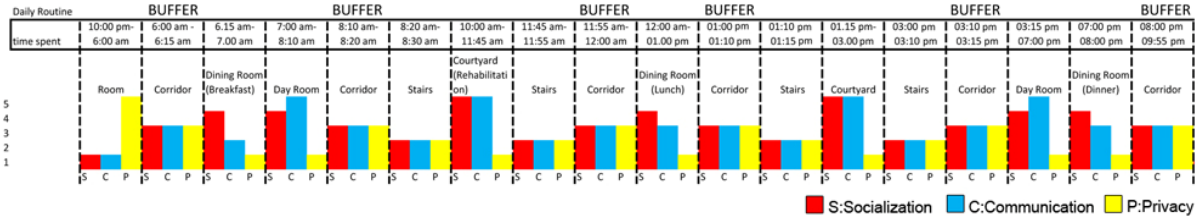

Figure 8. Patient's Daily Routine and Time Schedule

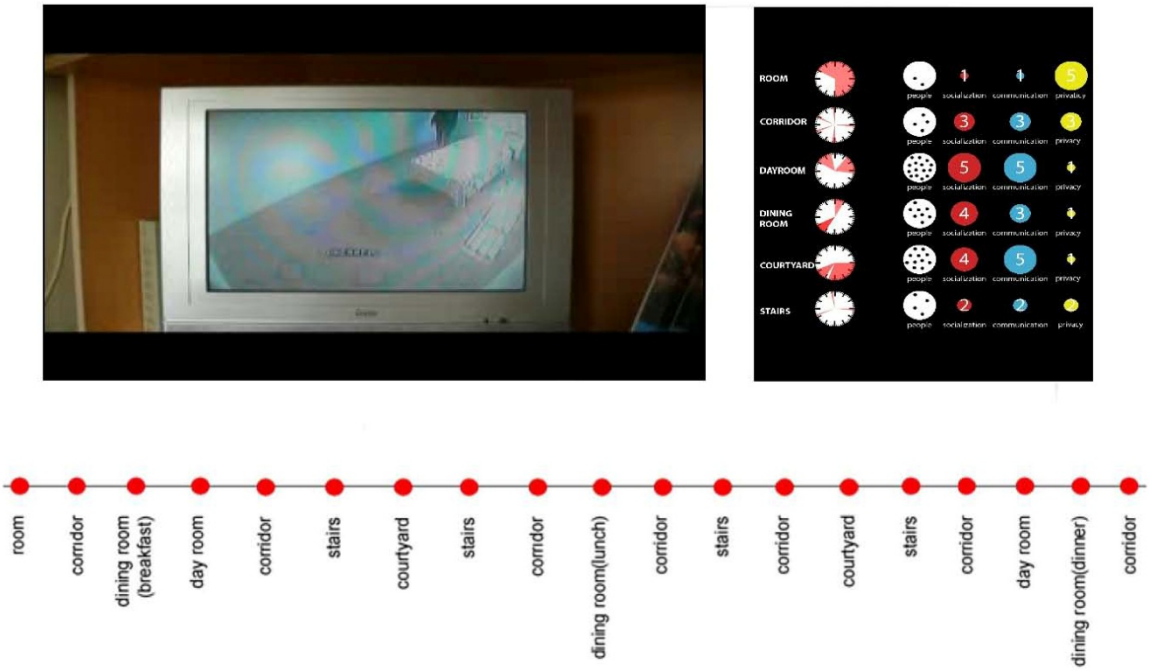

Figure 9. Analysis of the hospital spaces

2.5 System Rules and Limitations

Having aimed at creating a system that can simulate users' behaviours and actions, this study has focused on developing a computer program in order to observe the travelling patterns of the users (doctors, patients and nurses in this case) based on regular behaviours they exhibit within the hospital facility. In this context, rules and limitations governing the agents have been specified (Figure 3).

2.5.1. Rules

Rules concerning the agents are as follows:

- Agents consist of doctors-nurses and patients.
- Each agent represents a user of the hospital facility.
- The site chosen for the study has been split into grids. Each grid represents a cell where agents can travel freely.
- Agents may be male or female.
- Each agent has a specific route defined by the user: purposive/goal-directed, meandering and random
- Agents having specific routes move around the hospital according to their areas of interest (disease, illness, treatment etc.) or other purposes.
- Agents are capable of moving in every direction within the environment they are situated.
- The number of agents is set by the user(s) of the program.
- User age group is not specified.
- Walking pace of agents is determined by the security. Accordingly, the security levels are specified respectively as low, moderate and high.
- Security is also specified according to the topography type.
- Travelling pace of agents is specified by different scenarios, which respectively are fast, moderate and slow. Travelling pace is directly correlated with the scenario type as well. Also, it is not based on any age or gender group. The walking pace (purpose, meandering and random) of agents are automatically selected based on agent group selection.
- Agent behaviour in different seasonal hours and times is selected.
- In addition to walking, it is assumed that agents are performing other actions including sitting and interacting. The inner court, where the socialization occurs, is one of the focal points of the study.

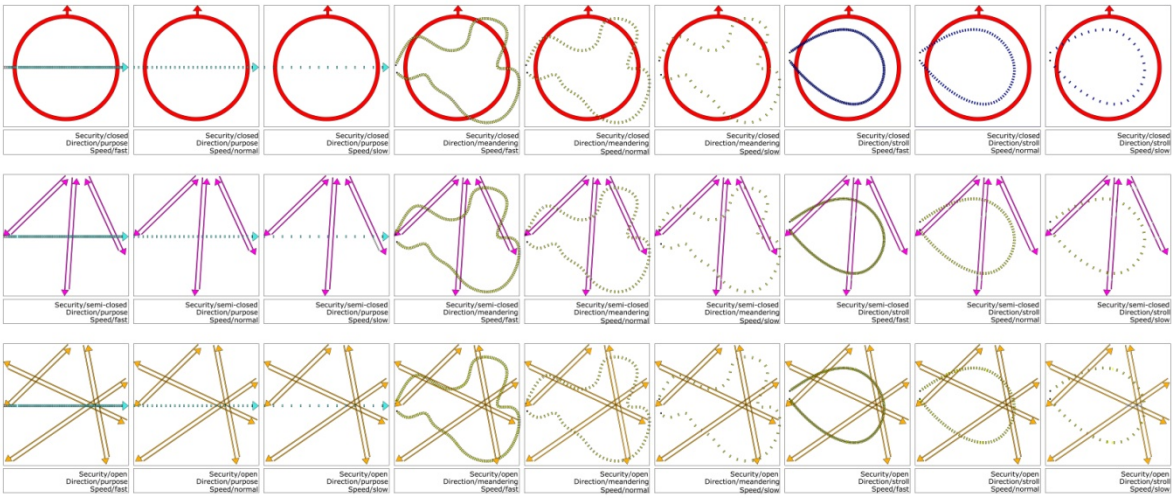

Figure 10. Possible Activity and Interaction Map

2.5.2. Limitations

Limitations concerning the agents are as follows:

- Agent 1's (doctors and nurse) actions depend on the severity of agent 2 (patient)'s illness. That is to say, patients with severe medical conditions must act always depending on agent 1.

- The point of departure of each agent is from the inside out, and the point of arrival is from the outside in.

The hours and times when the hospital facility is being used are represented by time intervals. The time interval we especially focused on in this study is the rehabilitation period spent in the inner court.

3. Conclusions

Agent-based systems used in architectural design field significantly contribute to the decision-making process in the pre-design stage by minimizing or eliminating any potential problems that could happen with the facility. Obstacles, challenges users faced in the use of hospital reveal non-efficacious designs while remaining inadequate to meet end-users' requirements in the post-construction process.

Through the system we developed within the scope of this study, we aimed to investigate the relationship between the users and the way the space was designed, in a virtual environment where each human user is represented by an agent. By selecting two different agent groups where each agent represents human users (doctors, nurses and patients), we have studied the traveling/movement patterns-specified as meandering, purpose and fast -of the agents in different times of the year, designated hours of the day in environments with different levels of security; thus, based on the obtained results, this study has aimed at contributing to the making of better designs with better structured settings for human users (Figure 4-5).

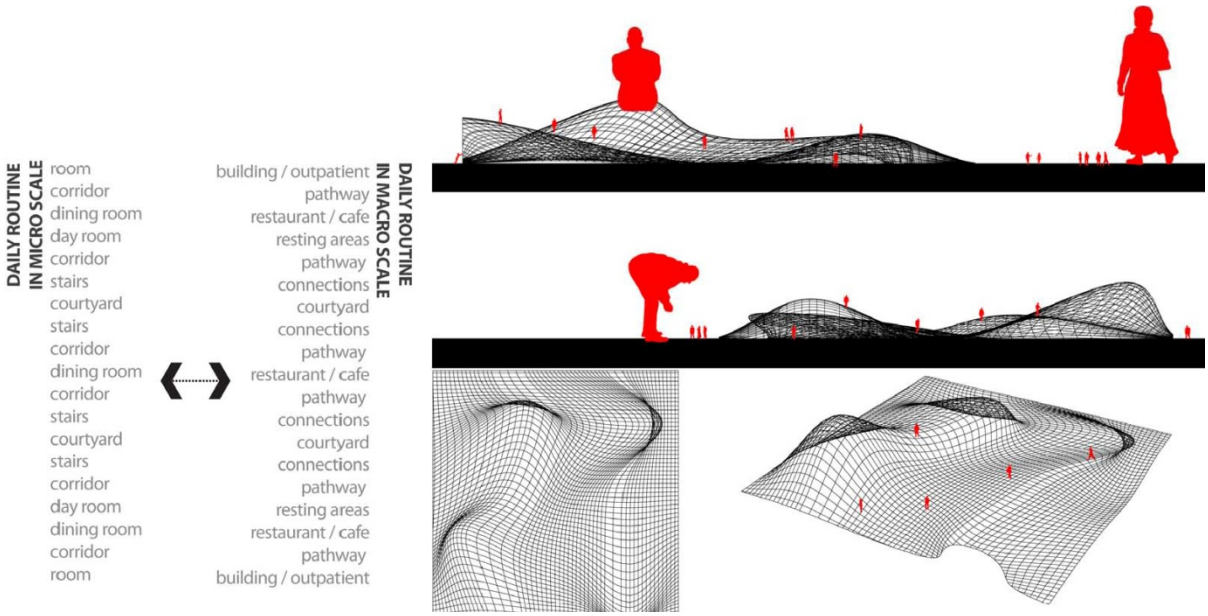

Figure 11. Daily routine in micro and macro scale

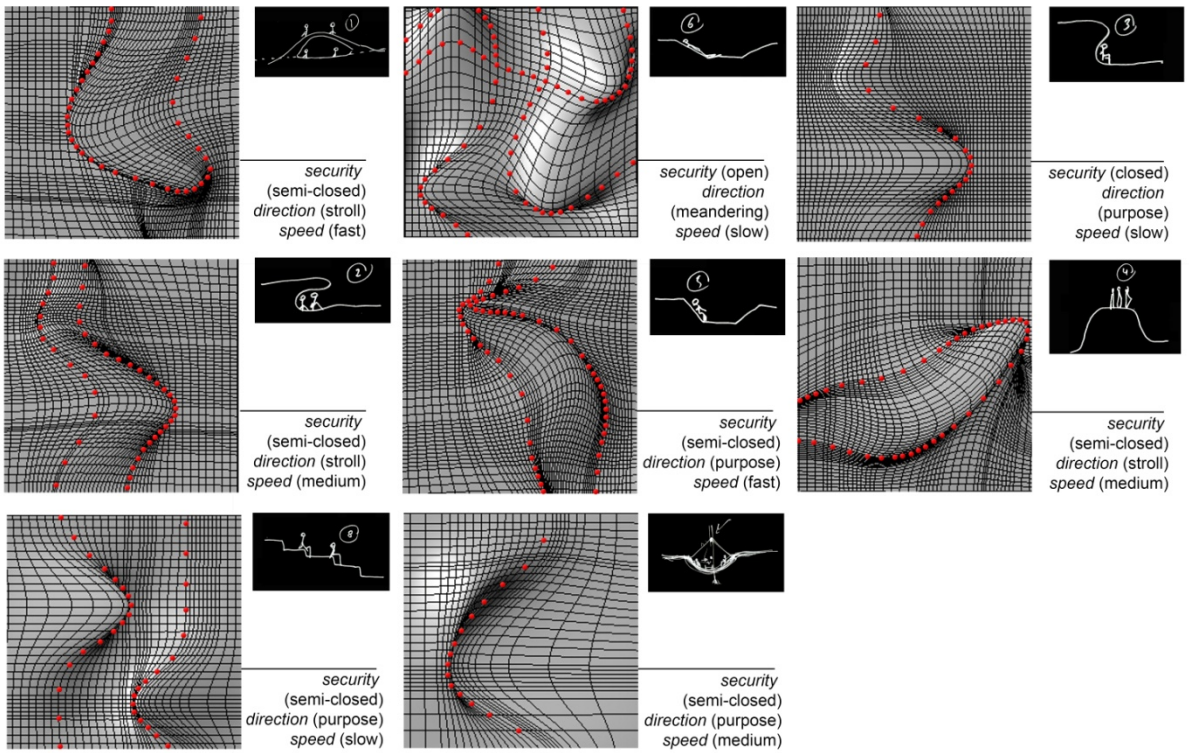

Figure 12. Activity map images

Acknowledgement

This research is an outcome of two simultaneous studies. First, I would like to thank the coordinator of Bakirkoy Interscalar Workshop, Nilüfer Kozikoğlu, and my group mates, Utku Külahçı and Barış Önal. Secondly, this work has been structured in Istanbul Technical University "MBL511 Knowledge Based Architectural Design" graduate course, which is given by Prof. Dr. Gülen Çağdaş. I would like to thank for her valuable critics, too.

References

[1] Cagdas, G., Knowledge Based Architectural Design, ITU Graduate School of Science Engineering and Technology, Architectural Design Computing Graduate Program, Lecture Notes, İstanbul, 2008.

[2] Durmazoğlu, M. C., "An Agent Based System Tool To Support Designers for Free-Form Shape Evaluation: DROP", Master Thesis, ITU Graduate School of Science Engineering and Technology, İstanbul, 2008.

[3] Ozer, D.G., Sener, S. M."User Accessibility Optimization Using Genetic Algoritm: aDA", ITU AZ Journal, 10:2, pg.212-230, 2013.

[4] Ozer, D.G., Sener, S. M., Zaman, C."Optimization of User Accessibility Using Genetic Algorithm", Proceedings of 15. Generative Art Conference, Lucca, Italy, 2012.

[5] Macal,C. M. ,North, M. J., "Tutorial on Agent-based Modeling and Simulation Part 2: How to Model With Agents", Proceedings of the 2006 Winter Simulation Conference, 2006.

[6] Internet: "Interscalar Istanbul Ölçekler arası bir diyalog girişimi", Nilufer Kozikoglu, http://www.yapi.com.tr/haberler/interscalar-istanbul-olcekler-arasi-bir-diyalog-girisimi_64994.html, accessed: 10.11.2018.

[7] Gandhi, ***T. R.*** "Optimization of Hospital Design: A Matter of Patient Safety and Efficiency" (pHD thesis), Medical University of South Carolina, USA, 2008.

[8] Ophir, Y. "Collective Intelligence:An Agent-Based Approach to Programmatic Organization in Architecture", International Journal of Architectural Computing, Vol. 7, No: 3, pp. 479-499, 2009.

[9] Janca, P.C., Gilbert, D. "Practical Design of Intelligent Agent Systems". In: Jennings N.R., Wooldridge M.J. (eds) Agent Technology. Springer, Berlin, Heidelberg, 1998.

[10] Cenani, S. "Kullanıcı Hareketlerinin Etmen Tabanlı Sistemler ile Temsili: Alışveriş merkezi örneği", Master Thesis, ITU Graduate School of Science Engineering and Technology, İstanbul, 2007.

[11] Nwana, H.S. "Software agents: an overview", The Knowledge Engineering Review, 11:3, September 1996 , pp. 205-244

[12] Russell, S.J., Norvig, P. "Artificial Intelligence: A Modern Approach", Prentice Hall Inc., 1995.

[13] Jacobson, I., Christerson, M., Jonsson, P., Övergaard, G., Object-Oriented Software Engineering: A Use Case Driven Approach, ACM Press, Addison-Wesley, New York, 1992.

[14] Boggs, W., Boggs, M., Mastering UML with Rational Rose, Sybex, CA, U.S.A., 1999.