Architectural Layout Optimization for Residential Home in Multiagent Environment

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Abstract

For human beings, one of the most important and essential thing is peaceful and quality living. Therefore, people must be related with architecture for their pleasant life. But, there may be some difficulties and theories to understand the Architecture easily. In this system, we introduce to Artificial Intelligent, one of the most popular computer science techniques. For architectural layout optimization, we can use Artificial Intelligence to generate human decision making as an architect. We want to highlight about an optimization of the architectural floor plan layout design with the use of AI during conceptual design stage. Moreover, automated optimization result will lead us to the new approach of integrating with the computer science and architecture. This system tends to implement generating architectural floor plan in multiagent environment and agents also make many-to-one negotiation to reach agreements. For instance, we use four agents namely planner agent, lighting agent, accessibility agent and bylaw agent in the system.

Keywords: architect, Artificial Intelligence, floor plan, negotiation, decision making

1. Introduction

Architecture can be defined as the art of articulation between function, aesthetics and structure for our quality living style. Artificial Intelligence can be interpreted as fake or simulated. The goal is to understand real intelligent systems by synthesizing them or systems that act like humans.

Today's world can say as the Age of Technology. If we can effort to make connection between Technology and Architecture, we will create architectural planning of our own easily. This connection presents an optimization model of the quantifiable aspects of architectural floor plan layout design and a method for integrating mathematical optimization and subjective decision making during conceptual design. The way to offer a new approach to floor plan layout optimization takes advantage of the efficiency of gradient-based algorithms, where appropriate, and uses evolutionary algorithms to make human decisions like an architect. Automated optimization results are comparable to other methods in this research area, and the new formulation makes it possible to integrate the power of human decision making into the process.

In order to combine architecture with Artificial Intelligence reasonably, we must consider first for spatial configuration which is concerned with finding feasible locations and dimensions for a set of interrelated objects that meet all design requirements for architect's decision. In this system, we focus on automation of spatial configuration includes layout planning, circulation space, function and usage of residential planning layout. Automation process needs several considerations because the component of the building layout does not have pre-defined dimensions, so every components of the design layout is resizable. [3]

Our approach to optimize spatial configuration is to define available space as a set of grid squares and use some algorithms to locate each square in order to generate particular room activity.

Another approach to optimize architectural layout is to decompose the problems into two parts: topology and geometry. Topology refers to logical relationship between layout components. Geometry refers to the position and size of each component in the layout. Topological decisions define constraints for the geometric design space so that the architect is able to review the feasible topological possibilities.

In this paper, this section presents introduction of architectural layout plan optimization. The rest of the paper is organized as follows. In Section 2, we illustrate the concepts of the architectural layout plan optimization. Section 3 describes the evaluation of methodology for the architectural layout plan optimization. Section 4 explains the procedure of the architectural layout plan optimization. Section 5 gives the conclusion of this paper.

2. Concepts of the Architectural Layout Plan Optimization

The main concept to optimize architectural layout plan is to create balance between topology and geometry as shown in Figure 1. Topology can be defined as the way to find logical relationship between layout components. Geometry can be defined as the position and size of each layout components.

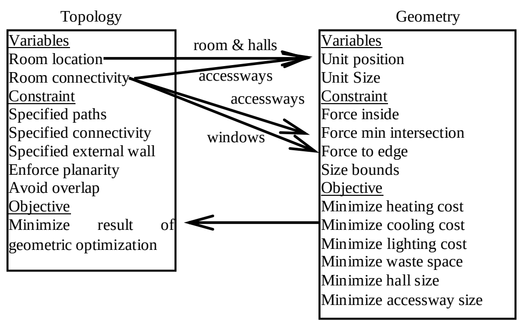

Figure 1. Schematic Showing the Relationship between the Topology and Geometry

We can make topological decisions as constraints for the geometric design space. For example, a topological decision that "room **i** is adjacent to the north wall of room **j**" restricts the geometric coordinates of room **i** relative to room **j**. The designer can review the feasible topological possibilities and select which one is suitable for connection between room units. The geometric optimization problem is posed as a process of finding the best location and size of a group of interrelated rectangular units. A unit represented as a point in space (x, y) and perpendicular distance from that point to each of the four walls {N, S, E, and W}.

Unit is grouped into several categories based on their function: Rooms, Boundaries, Hallways, and Accessways. Rooms are Units used for sustained living activity as determined by the designer. A Boundary is a Unit that has other Units constrained inside of it, and it is not considered as living space. A Hallway is a Unit with no physical walls that is not a living space. Hallways function as pathways. An Accessway is a Hallway that is constrained to geometrically intersect two Units. Accessway are generally restricted to be small, and they are forced to intersect two other Units.

Any building on Pyay Road, Kabaraye Road, University Avenue Road and U Wisara road shall be erected with 20' clear space at the front, 6' at the back of their own land.

Any building has back district street (BDS) with more than adjacent one street; building's facade shall be erected towards the opposite of BDS as Main Street. If own land does not include BDS, building's facade shall be erected towards any street with 12 feet clear space at the front, 6 feet at the back and 3 feet at each side. The external rectangle represents the building Boundary, the living room, bedroom, and bathroom are Rooms, the hall is a Hallway, with Accessway. Units that are along external walls may also have windows and its height can be fixed for each Unit. wN,wS,wE,wW represent the width of the north, south, east and west window, respectively.

We can analyze architectural zoning and accommodations for one storey and two stories building for our system of architectural layout plan optimization. Average area and unit type can get from comparative analysis of case studies.

3. Evaluation of Methodology for Architectural Layout Plan Optimization

An agent is a computer system that is situated in some environment and that capable of autonomous action in this environment in order to meet its design objectives. The agent takes sensory input from the environment, and produces as output actions that affect it. The interaction is usually and ongoing, non-terminating one.[1]

If the system contains a number of agents, which need to interact with one another through communication, this interaction between agents can be defined as multiagent environment. For more general settings, where agents must reach agreements on matters of mutual interest, richer techniques for reaching agreements are required. Negotiation is the generic name given to such techniques and some negotiation techniques that have been proposed for use by artificial agents.

The proposed system will be based on architectural layout plan which is being developed in our country. The frame work in Figure 2 has a layered architecture, with consists of three layers. The communication layer provides the location and dimension which will enable users to communicate with architectural layout plan. The second layer, which is called the "Negotiation Framework", contains actions which are common in all users.

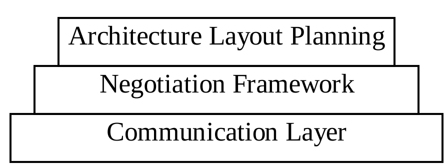

Figure 2. Layers of the Framework

The up most layer, which is named as architectural layout plan contain the feasible layout plan which are specific to a certain application domain or to a specific user's choice. It also communicates between architecture for each city to meet user's requirements. The system accept user's enquiry and approve user's information with architectural theory and promulgated law and store the reservation information in each related unit containing dimension and location with users' choice.

4. Procedure of Architectural Layout Plan Optimization

The goal of this system is to optimize architectural layout plan with users' choice. All room units are optimized with architectural theory and promulgated law. We can consider the components of layout plan (such as room unit, door, window and constructible area on plot) as agents and these agents negotiate with each other. For example, planner agent make rectangular room units and arrange them to form architectural layout plan, lighting agent check external wall to provide sufficient lighting to layout plan and fix with window units, accessibility agent check for joined wall and locate door units to ensure access between individual room units and bylaw agent restricts whether the resultant layout plan can erect within constructible area or not. After making negotiation among agents, we can get the optimized architectural layout plan with users' choice.

4.1. Detail Design of the System

In this system, users can choose two ways. If user wants to type his favorable dimension, the system can perform automation design process to create layout plan in optimized architecture drawing with his desire choice. The other way is to display predefined layout plans if the system receive no dimension from user. User can choose any plan as he likes most from database. Users can choose plot size, no. of storey, room type, window detail and door detail. Figure 3 shows the detail design of the system.

There are constructed five stages in this system:

Stage(1): When preferred dimensions and accommodation types input from user, check for acceptable unit type and dimension with architectural theory.

Stage(2): Then planner agent comes to build a point for unit location and develop perpendicular distance from that point to N, E, W, S direction. Then, make processing with architectural design constraint to form floor plan layout.

Stage (3): The result from planner agent is applied with lighting agent so that it can perform sufficient light for floor plan layout. The lighting agent checks for the resulting floor plan for feasibility of external wall, joined wall and available space for window. Then make processing with window type and dimension from user input.

Stage (4): The result from planner agent is applied with accessibility agent so that it can perform possible access between individual units. The accessibility agent checks for the resulting floor plan for feasibility of external wall, joined wall and available space for door. Then make processing with door type and dimension from user input.

Stage (5): The optimized result from planner agent is applied with bylaw agent so that it can perform available built area within plot. The bylaw agent checks for the optimized resulting floor plan with legal constraint by using promulgated law so that the built area resulting from planner agent can be within the restricted area. Then make processing with legal constraints from local authority.

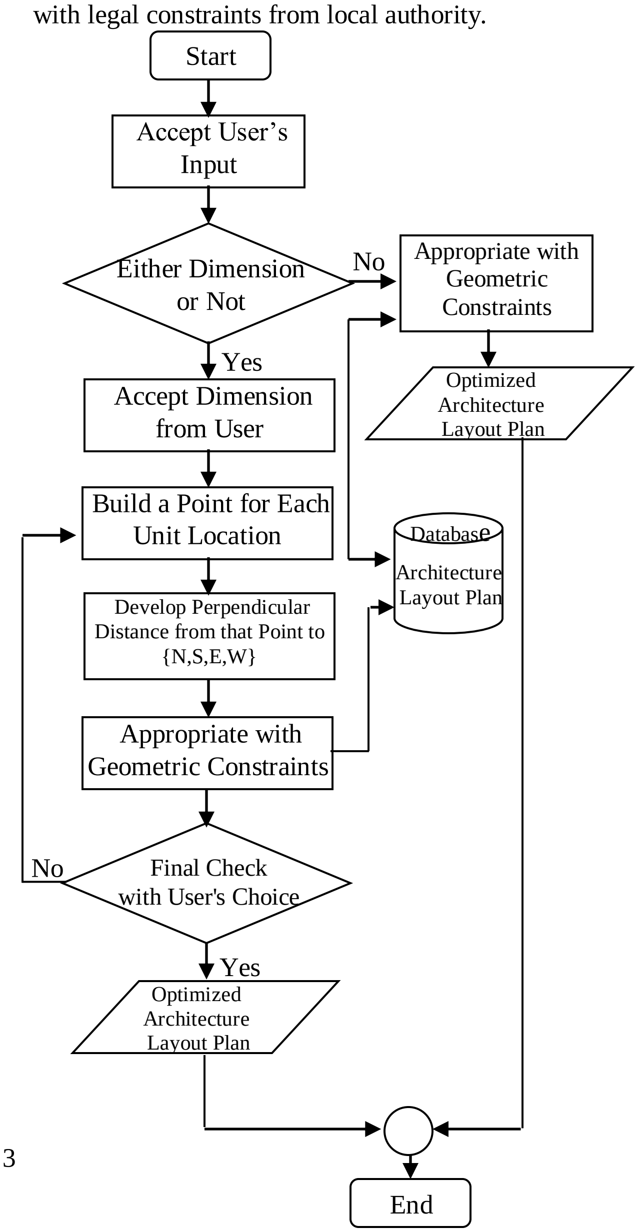

Figure 3. Detail Design of the System

4.2. Negotiation Model of the System

Negotiation usually proceeds in a series of rounds, with every agent making a proposal at every round. The proposals that agents make are defined by their strategy, must be drawn from the negotiation set, and must be legal, as defined by the protocol. If agreement is reached, as defined by the agreement rule, then negotiation terminates with the agreement deal. [2]

In our system, we select many-to-one negotiation to optimize architectural floor plan layout. In this negotiation, a single agent negotiates with a number of other agents. For the purpose of analysis, many-to-one negotiations can often be treated as a number of concurrent one-to-one negotiations. The nature of architectural floor plan contains architectural zoning for space planning, suitable openings for door and window to provide access between each room unit and to receive sufficient lighting for layout plan. We also need to consider for promulgated law so that we can build legally our design.

Therefore, we can consider these factors as agents to negotiate model of the system as illustrate as Figure 4. There can be four agents; planner agent, lighting agent, accessibility agent and bylaw agent. In this system, planner agent is negotiated with lighting agent, accessibility agent and bylaw agent to form optimized architectural layout plan.

Begin

- Accept all user inputs. (Available plot area, no. of storey, unit detail, window detail, door detail, accessway/hallway)
- Assigned task to respective agents.
- Negotiate between agents using many-to-one negotiation.
- Appropriate user data and make reasonable plans.
- Show optimized architectural layout plans to user.

End

Figure 4. Negotiation Model of the System

4.3. Implementation of the System

The system is applied Architectural Rules and Y.C.D.C Rules for optimization process. Around 2200 Millions of possible case can be produced from our system. This system let user to choose plot size, different planning layout, no. of storey, dimension of Room (Width and Height), Door and Window specifications in Figure 5.

In this system, user can select predefined dimensions in each control box so that no error will occur related to unacceptable user input. These predefined dimensions are calculated with analysis of architectural floor plan layouts as case studies. Our system can avoid error in data entry stage by using reasonable and possible dimensions for each control box which are based on case studies. After user has been entered data, click 'Preview' button, the system displays preview for his layout plan, and also check for error. Figure 6 expresses the error check and display for the data entry.

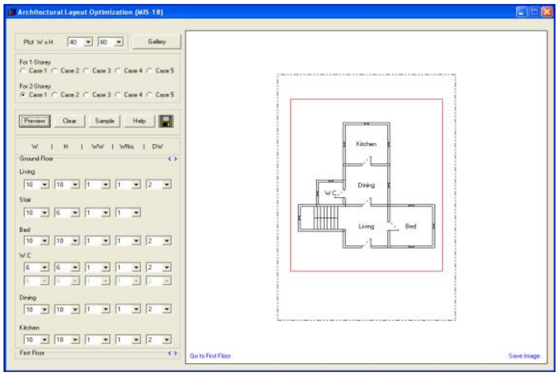

Figure 5. Sample Preview for 2-Storey

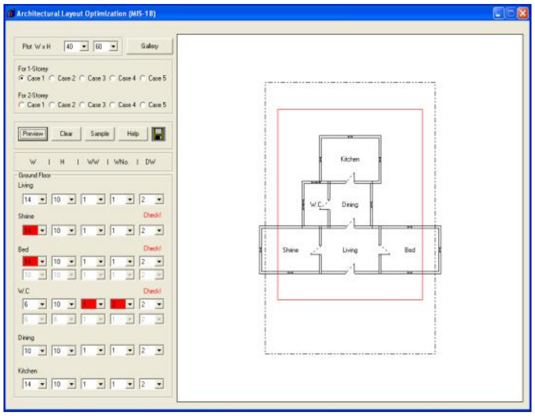

Figure 6. Error Display in Data Entry Form

5. Conclusion

This system has proposed a representation of spatial configuration in multiagent environment. The activities of space occupants are considered aggregates of a space's function. The general advantage of the representation is that space functions can be reasoned with architectural and geometrical design constraints. The importance of representation user activities is the enhancement of flexibility and creativity in multiagent environment.

Artificial Intelligence and Geometrical Constraints, feasible architectural layout with appropriate optimization can be generated as the final result. It will be very easy task for users to create meaningful floor plan layout of their own without having any architectural knowledge.

References

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