An Agent Based Simulation for Home Interior Designing

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Abstract

Interior design is the art of making a space both comfortable and aesthetically pleasing; this is achieved mainly by applying interior design principles. Human involvements in the field of interior design do not produce a perfect design and do not apply all relevant techniques in the field of interior design. Furthermore, designing interior space by getting the service of an interior designer consumes a considerable amount of time and money. This agent based simulation solution for the interior designing process, using agent technology can help to address the highlighted issues. There are several agents for different elements in the interior spaces in this technology, such as a chair agent, a table agent, a light agent, a fan agent etc. According to architectural principles, these agents will consist of different properties. By considering the individual properties, these agents adjust the required elements in the proper order using interior design techniques. The Final output is obtained by communicating between different agents. By implementing this kind of agent base interior designing system, normal clients as well as interior designers can be facilitated, as agent technology has both power and control.

Introduction

Interior design is a profession that combines multiple aspects, such as functionality, the enhancement of quality of life, culture of occupants as well as aesthetic attractiveness [4]. The interior design process follows a systematic, ordered method which includes research, analysis and the integration of knowledge into the creative process; whereby the needs and resources of the client are used to produce an interior space which fulfils the goal of maximum efficiency and aesthetic quality. The popularity and importance of interior design has increased because of the increasing awareness of the roles played by interior designers. Interior designers plan and organize the design and decoration of interior spaces to produce creative and technical solutions that are applied within a structure to achieve a perfect interior environment. Interior design solutions are based on environmental aspects, human psychology, architecture, product design, and traditional decoration. An interior designer is responsible for the interior design, decoration, and functionality of a client's space, whether the space is commercial, industrial, or residential. Interior designers work closely with architects and clients to determine the structure of a space, the needs of the occupants, and the style that best suits the client to get the maximum efficiency from the space.

An interior designer has to consider all the required principles and techniques when carrying out a suitable design for an interior space. In this field, most interior designers choose a speciality to focus on, as an individual is incapable of handling the vast variety of design problems that arise. Furthermore, professional best practices of using a wide range of different skills in the design process is frequently not adhered to. Obtaining the assistance of an interior designer requires a considerable amount of money, whilst finding the right interior

designer who creates something beautiful and functional according to ones perspectives can be a real challenge. However when one attempts to design without professional assistance, by referring to design books and other material, problems arise due to the lack of experience in design and the lack of awareness on design principles in the interior designing field.

It is recognized that computer simulation, especially agent-based simulation, is valuable for studying complex systems. Computer simulation in general and agent-based simulation in particular, is a primary research tool of complexity theory [7]. Several agent-based simulation applications have been developed in many domains ([5], [9]).Despite this growing interest in applying computer simulation to study complex systems, there are only a few simulation studies that have been done in order to understand and model various configurations of computer supported work ([3], [6]).
Using this agent-based technology system can help efficiently plan the interior design of a building during the design phase. After deciding on the size of the place and the furniture that is going to be used, agents will decide the way in which the interior design should be handled. For each different aspect there will be multiple agents that will communicate with each other in order to determine the final placement of objects and final selection of colours to be used. In this simulation, interior design principles related to each object will be the properties of each agent that are considered when placing objects in a space.

Current State of Interior Design

There are currently only a few interior designing/decorating systems and even fewer computerized designing systems related to interior design implemented in the world; of these, few use proper interior design principles for the purpose of design.

A. *Manual Interior Designing and Software Aided Manual Interior Designing*

The extensive use of computer design systems in commercial interior design is fairly new in the field. People still seek the help of professionally qualified interior designers to design their home/office/trade centres in the most aesthetically pleasing manner. This is done in accordance with architectural principles that are not known to everyone. However, nowadays newspapers and websites help to consult regular people with regards to interior design [8].

Software such as AutoCAD, with its robust modelling capabilities enables commercial interior designers and architects to shape and visualize their ideas unlike ever before. According to AutoDESK, the redesigned interface of AutoCAD uses a single, easy-to-learn environment for creating both solids and surfaces. Designers can even create solid objects that have faces defined by complex surfaces. Applying materials to a model is a simple task requiring one to simply drag materials from a predefined library onto any solid face or surface defined in their model.

Computerized interior design is a major technological advancement for designers as it has helped to speed up the design process. Computers have helped to reduce delays and cut the time that designers have to work on a project by half and also allowed for the electronic transfer of files. A project that could have taken several weeks now can be done within a couple of days by software such as AutoCAD. But designing is essentially a human act and as such any human involvement can lead to native errors unlike a fully automated system.

B. *Computerized Interior Designing Expert System.*

This technology is a computerized expert system [1] that allows home owners to enter their interior design requirements and select interior design treatments according to his/her design requirements. Through this technology, groupings of compatible interior design treatments are provided for the home owner to use in decorating their home. Another objective of this invention is to provide an expert interior design system which has the ability to validate selected interior design treatments, to ensure that the final interior design plan is integrated, consistent, aesthetically pleasing, and compatible with the homeowner's design wishes. In doing so this technology aims to reduce or eliminate the time and expense associated with employing a professional interior designer.

The above objectives are accomplished by the present computerized expert system. In order to provide home owners with selected interior design treatments in accordance with their preferences, the following are required;

- A computer processor
- A computer readable medium in electronic communication with the processor,
- A database in electronic communication with the processor which contains data to represent individual interior design treatments selectable by selection criteria
- An input device to communicate with the processor for inputting a homeowner's design requirements,
- An output device to communicate with the processor to provide an output to the homeowner.

This system process works by running a set of computer readable instructions embodied within the computer readable medium that enables the processor to receive the design requirements from the input device and select a set of interior design treatments by using the selection criteria in accordance with the design requirements, and producing an output set to the homeowner. As a result of this process the homeowner is provided the available interior design treatments according to the homeowner's design requirements. Fig.1 shows this approach using a flow diagram.

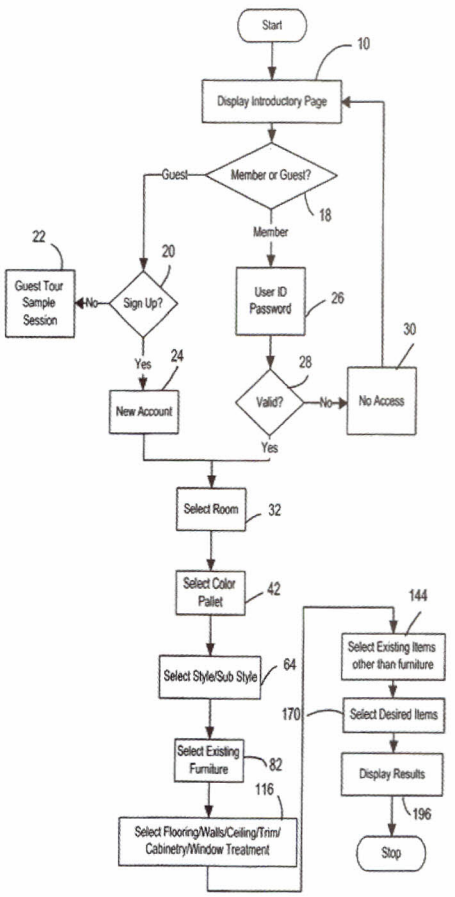

Fig. 1: Interior Designing Expert System

However like many other such expert systems, this computerized interior designing expert system also suffers a common issue, in its inability to adapt to changing environments, unless the knowledge base is changed.

Technology Behind Interior Design Simulation

Any Successful invention is backed by successful technologies that make the invention an effective one. So this section describes in comprehensive detail, the technological adaptation of the Agent methodology for interior designing simulation to deliver efficient and pleasing interior space.

A. Agent Technology

Agent Technology, especially the Multi Agent Technology plays a vital role in Interior Design as it provides a better solution for complex environments, as emphasized in the Pregogine's complexity science. In simpler terms an agent is a software program that works for the user proactively and recedes to the background once the job is done. Agent behaviour cause for effective resource consumption and can possess some human capabilities, such as intelligence, autonomy, reactivity, and pro-activity. Further the agent has to use reasoning to achieve its goals and build interactions with the environment to learn from the environment. Agents have sensors to perceive its environment and actuators to act on it as shown in Fig 2. The reasoning process takes place with this interaction. This kind of emerging intelligence is required to solve complex problems [2].

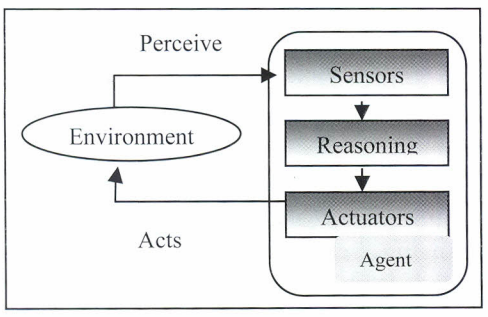

Fig. 2: Agents interaction with environment through actuators and sensors

The interior design process is a complex system where different entities are interconnected and behaviours of each entity are uncertain. In this context interaction among interior components can create novel designs. As changing the location of one entity affects another entity and a small disturbance may cause global change. This is also one of the features that can be seen in complex systems, which is known as the butterfly effect. Through this technology, interior components should autonomously adjust to suite with their new situation to create an effective design. Therefore the interior designing process should reflect this feature of self organization or adoption. This interior designing process is not at equilibrium, and one cannot expect the system to be stable until all the entities are correctly placed. So entities co-evolve with the environment and adopt with the situation to suite with the environment. As this process of interior designing reflects almost all the features of a complex system, this can be considered as a complex system.

In other fields, technology has a certain kind of power and control over humans. But with an agent like AI technologies both power and control are found within the technology, so as to minimize the errors that are likely to occur by human involvement. Furthermore agent technology suggests the problem solving strategy which could be used by sending messages to the appropriate entities, rather than applying algorithms. In this case, each agent which models the tables, chairs and other interior components is placed appropriately through communication. From the agent view point intelligence is an emergent field due to these interactions. As agent technology can work in an ubiquitous and interconnected environment by showing intelligence, accepting delegated commands and working together with humans to model interior spaces, it is the ideal solution to model these kind of complex systems. This can be a better

alternative to using an expert system which uses a static knowledge base.

B. Ontology

Any system requires domain knowledge or task related knowledge to perform the relevant tasks, especially in the agent based system. Ontology plays the key role in representing knowledge and typically carries knowledge in terms of a set of concepts within a domain and the relationships between those concepts for agents to work. Ontology can be defined in a variety of ways either as an XML file, database or simply a text file. In the case of interior design domain, agents should be provided with the domain knowledge to carry out the necessary placement of components. All the required knowledge is presented using ontology within the JADEX toolkit which was used to develop the system.

The Design

This agent based interior design simulation design according to MAS architecture that is illustrated in Fig 3, shows the four components that are interconnected. Request agent is the one that supplies inputs to the system. Then the resource agent gives the output and most importantly the message agent mediates the communication between other agents. Furthermore input and output of the system communicate through the message agent.

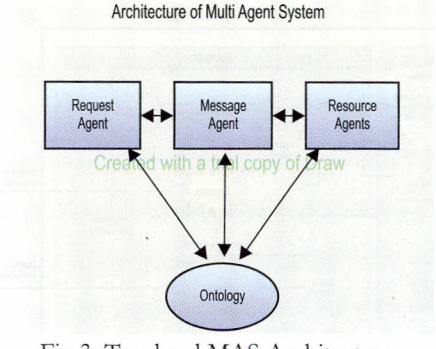

Fig 3: Top level MAS Architecture

For design and implementation simplicity, the overall system has been designed as a composition of a set of modules which can be implemented independently. Basically, on the top level view there are three core modules namely: the bathroom interior designing modules, bed room interior designing module and the dining room interior designing module.

A. Bathroom Interior designing Module

In the bathroom designing simulation, when the user inputs the size of the interior space that will be used for the bathroom, the fittings required, the preferred colours from the colour collection, the technology determines the most suitable places for the selected bathroom fittings according to architectural principles and the size selected by user. It also provides an output using interior design principles by considering the user's taste, and selecting the matching colours for the preferred colour collection. A typical MAS architecture for the bathroom designing module is illustrated below in the Fig 4.

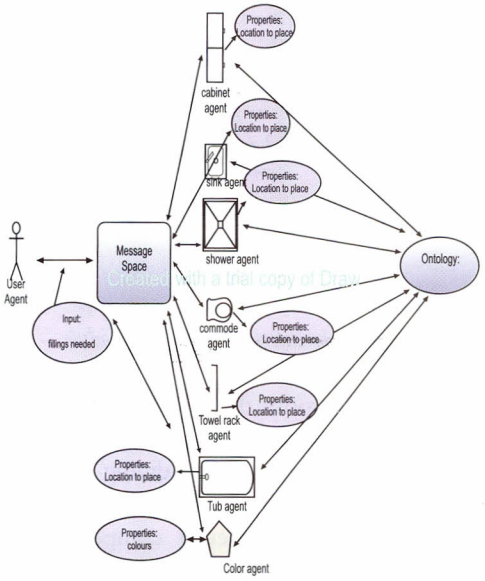

Fig 4: Bathroom designing architecture diagram

C. *Bedroom Interior Designing Module*

In the bedroom designing simulation when the user inputs the size of the bedroom; the appliances needed for the bedroom, the user type (adult or child) and type of theme preferred, the bedroom instruments (appliance) are placed in the most suitable place, according to architectural principles and the selected size. By considering the user's taste, as well as interior design principles, thematic concepts can be chosen from the given list.

This design process is shown in Fig 5 below.

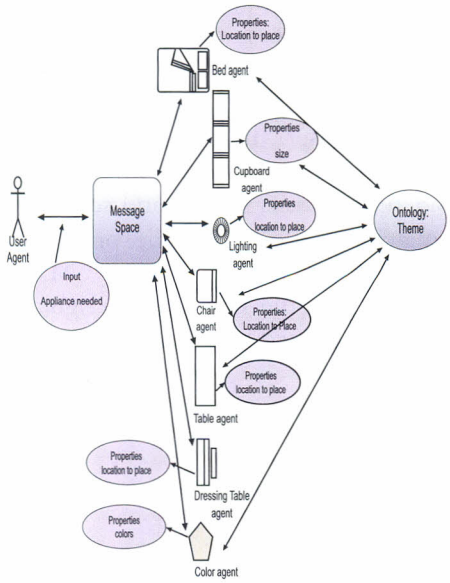

Fig 5: Bedroom designing architecture diagram

D. *Dining Room Interior Designing Module*

In the dining room designing simulation when the user inputs the size of the dining room, type of the dining room (i.e. whether it with a kitchen or only dining room), the interior components and theme preferred, the dining room instruments are placed in the most suitable places according to architectural principles and the selected size.

By considering the user's taste as well as interior design principles, thematic concepts can be chosen from given list. A typical MAS architecture for the dining room designing module is illustrated in the Fig 6.

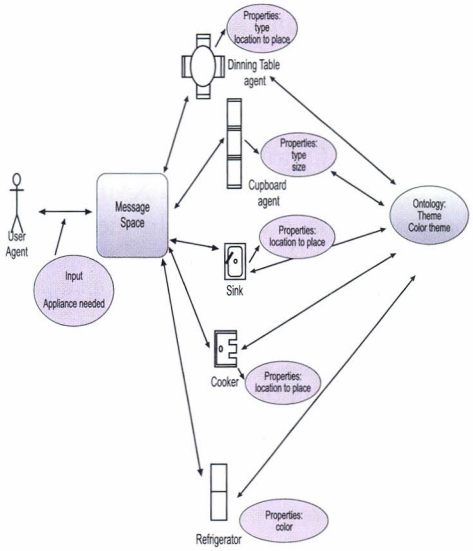

Fig 6: Dinning room designing architecture diagram

Implementation

Since the system mainly comprises of bathroom designing module, bedroom designing modules and dining room designing modules, implementation is carried out separately to achieve an increased level of flexibility and manageability. The typical agent working process is illustrated in Fig 7.

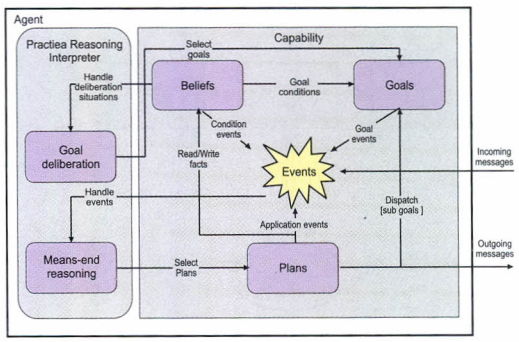

Fig 7: BDI agent working process

There are four major java classes to handle each module. They are; GoPlan.java, CheckingPlan.java, PickupPlan.java and TakePlan.java. Agents were defined using xml file which are integrated with java classes and are able to place the interior component in the correct place by being sensitive to the environment. The Algorithm used to integrate the above classes to agent behaviour so as to achieve the message passing phase is illustrated in Fig 8.

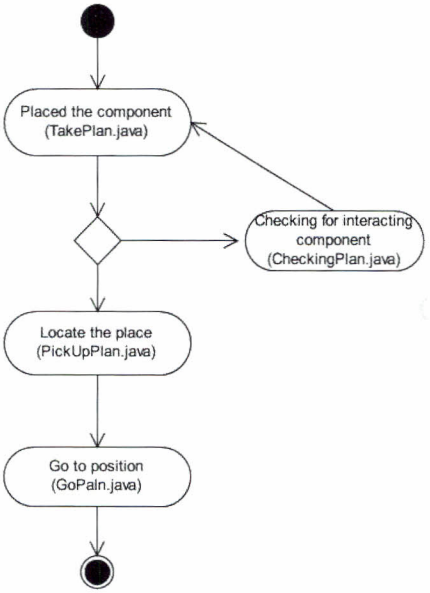

Fig 8: Message passing process

Evaluation

Any system's success or failure is identified through a proper evaluation mechanism. Therefore a systematic evaluation plan was carried out for Agent Based Interior Designing Simulation to gain a successful outcome. Since implementation followed a modular approach, initially unit testing along with functionality testing were conducted to test each module. In each individual module, including the bathroom designing module, the bedroom designing module, and the dining room designing module were tested for the expected functionality. After ensuring the proper functionality of each individual component, integration testing was carried out to check how well the modules were functioning after the integration. At the final level, a full system testing plan was designed using users who were looking to improve their interior space and users who have domain knowledge in the field of interior design.

Conclusion

Interior Design is a subject that applies to almost every type of building, including homes, hotels, corporate spaces, schools, hospitals, shopping malls, restaurants, and theatres. Complete interior design can be divided into sub sections such as bathroom designing, bedroom designing, dining room designing, living rooms etc. For this work, people need to get the service of an interior designer to have an accurate design. But obtaining the services of an interior designer generally tends to double the cost of the building/home. Furthermore, the existing systems for interior design are not fully capable to handle the issues at hand. So there is a clear need for an automated interior designing system to handle this matter and to help interior designers to do their work with maximum efficiency. By using agent technology, this system can plan the interior design phase of a building in an efficient manner. After deciding the size and other needed inputs for the design, agents will decide the way in which the interior design should be handled. Different multiple agents represent the interior components and final placement of objects that will be decided through communication between them. Interior design principles related to each object will be the properties of each agent which is used in deciding the placement. As such agent concepts such as sensitivity to environmental components, communication and negotiation address the interior designing

process comprehensively which create a complex system. Ultimately the implemented agent based interior designing simulation achieved its target successfully.

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