EDVIS-GAME

A framework for utilizing game engine reporting agents for environmental design education and visualisation

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Abstract. In recent years, the architectural design process has witnessed a demand for professionals who can resolve the highly complex social, cultural, technological, and economical issues associated with “Sustainable Design”. At present, many designers use environmental data generated from building performance simulation applications such as “Ecotect”. The wealth of data generated from such applications is often presented in a rather complicated format through graphs and tables, relying significantly on the designer’s expertise to read, analyze, interpret and correlate these data. This paper presents a framework for developing a method that helps design students and untrained professionals to visualise and understand the implications of these environmental data during the different stages of the design process. This method mainly targets students and designers who are not fully equipped to solidly interpret these complex data sets or use them in the decision-making process. The proposed method aims therefore to present relevant analysis of the environment-related data within the context of a simple, user-friendly virtual game environment, relying on embodied agents within the game engine to trigger events and actions performed by the users, and present pertinent data subsequently.

1. Introduction

The ever-growing complexity of design concepts and the increasing pressure to “design for sustainability” have introduced more variables and more complexity in the design and decision making process. One of the major challenges that designers confront in their initial concepts is accommodating
their design for sustainability. A sustainable design aims to address two main targets for a high performance building; maximizing occupant satisfaction with the designed environment and minimizing the energy requirements of the building throughout its lifecycle. Through modern service engineering, architects tend to overcome the challenge of creating comfortable interior conditions to achieve occupant satisfaction in almost any climate, but in achieving this—in many cases—these conditions demand the use of high grade energy and valuable resources. The challenge for architects now is to adopt an approach for design assessment in its various stages that would eventually help reduce the reliance on these precious resources while still providing a sensible level of satisfaction for a building's occupants.

Whilst there currently exists many building performance simulation packages such as Ecotect, TAS, IES Virtual Environments, and while these packages present data in various formats (tables, graphs, plans, sections and even 3D), they generally rely on specialist knowledge to both frame the question and interpret the resultant output and therefore pose numerous challenges, especially to design students and untrained professionals who are not fully conversant with interpreting environmental design. Generated results are often presented numerically, through complex graphs and/or tables as so called “Fever Curves” (Herkel et al, 1999), and can often only be read and critiqued by highly experienced users. Poor analysis and lack of understanding of these results and their implications may lead to inaccurate design decisions, bad judgement, and higher risk of errors that will eventually lead to unexpected effects on building performance and waste of resources.

This paper presents framework seeking to develop a new method that can help ensure that designers and decision-makers have a more solid comprehension of the building’s potential performance at various design stages, giving the opportunity to iterate design and produce alternatives leading to improved building performance. The proposed method relies on extracting custom environmental data from an environmental building analysis application (like Ecotect), and representing a report analysis of parts of this data that are relevant to the current users’ experience. The generated report is presented in a simpler and more user-friendly virtual context within a “game”, relying on embodied agents within the game engine to trigger events and actions performed by the users, and present relevant data subsequently. This method is envisioned to be of great value within the architectural education context, where calculation data, analysis, guidelines and suggestions are presented within an engaging interactive narrative context, which improve students’ perception and comprehension of their design decisions and strategies to tackle sustainable design variables.
1.1. GAMES AND ENVIRONMENTAL DESIGN EDUCATION

In recent years, young generations have developed a new paradigm and pattern of life where “games” are significant part of it. Immersion and engagement in game engines has become an extension to their life. Recent studies showed that teenagers spend more time playing online or video games than playing outdoors. This paradigm and these facts cannot be ignored, and the best strategy is to incorporate it in other aspects of their life, mainly education. Many design instructors have realised that the traditional design environment is blinkered, and does not have the flexibility and engagement the young generations are accustomed to, and have taken an interest in what the effects these games have on players, and how some of the motivating aspects of video games might be harnessed to facilitate learning (Dickey, 2005). That is why many design courses demand the students to import and present their design model into a 3D game engine, to accommodate the immersion paradigm and increase the sense of space, engagement and interaction. It is even noticeable that many 3D application packages have evolved to become more game-like.

Technically, game engines offer much more effective, reliable, high-quality, and cheaper (in terms of cost and time) means of visualisation in comparison to traditional CAAD packages and tools. The “Game” context is generally pervasive in the society, where many people are attracted to and familiarised with. Furthermore, the entertaining and engaging interactive narrative nature of the game has outdone the traditional learning and visualisation tools; allowing better comprehension, investigation, analysis, and experience sharing within a virtual environment. This effect is achieved through the introduction of the game's “play” metaphor (Woodbury et al, 2001), and by immersing the designers and students within the game's virtual environment as active participants rather than passive observers, encouraging them to think about their architecture more as a social and spatial experience than schematic plans and series of calculations.

With the ever-growing call for green and environmental-friendly designs, there has been a high demand for designers to resolve the highly complex social, cultural, technological, and economical issues in “Sustainable Design”. Design for the environment has evolved the traditional design method from just masses and social spaces, and introduced series of new variables and equations that the proposed design should fulfil and resolve to become acceptable. Design students are thus facing bigger challenges to develop their ideas, and there is a big risk of getting more involved into these variables and equations could hinder their creativity and sense of space. Thus it could be valuable to introduce a method which facilitates the interpretation of environmental analysis calculations in an interactive...
narrative virtual context, and preset the data relevant to the spatial experience in terms of space and time.

2. EDVis – Game Development

2.1. EMBODIED AGENTS

The problem with the principle of Interactive narrative in a game context is that with more interactivity offered for participants, the author’s management of narrative techniques is reduced (Tallyn et al, 2005). This problem has been addressed through some methods like defining a pre-designed story path, or implementing sequential goals to advance the storyline. These methods have been proven to be inflexible, have little consideration to users’ interaction, and do not emulate real-life activities.

Agents’ technology has been recently introduced into game engines to tackle these issues and enhance the interactive narrative virtual experience. It offers a higher degree of believability, and real-time response to dynamic environments and users’ interaction. Recently, with the growing complexity of the game’s tasks and objectives, developers are encouraged to implement the multi-agent structure within their system. A multi-agent system MAS is comprised of a set of multiple assorted and diverse agents, which are embodied within the system, and have the capability to interact with each other as well as the system environment (Wooldridge and Jennings, 1995). This approach enables developers to simplify complex objectives—which are rather problematical and beyond the capabilities of a single omniscient agent—to smaller more simple tasks. These tasks are allocated subsequently to multiple autonomous agents, which communicate, negotiate and collaborate with each other in a peer-to-peer fashion to resolve different aspects of the problem and present the solution back to the observer.

The scope of an agent in a MAS is restricted to its knowledge, its goals, its computing processing resources, and its perspective (Wooldridge, 2002). While multiple agents have a notable autonomous nature, they still have to communicate and interact with each other to supplement the overall objective of the system. Agents’ interaction can be either cooperative, where agents act as a team to achieve specific goals, or competitive where agents try to exploit their benefits and dominate over other agents (Siebers and Aickelin, 2008). The technology of a multi-agent approach embodied within virtual worlds is based on two principles. Firstly, agents that retrieve information about the virtual environment are directly embodied within this game and trigger actions, events and inputs performed by users’ interaction. Secondly, the responsibility for extracting, filtering, analysing, and reporting of information is distributed between different types of agent (Fielding et al,
In this format, the embodied agents not only become a complementary part of the system, but also the architect of the users’ narrative experience within the game. The storyline of the users’ game is no longer sequential or pre-structured; it is scripted according to the players’ actions, inputs and preferences. Having a powerful narrator in the game, which could be a non-player character, enriches the users’ virtual experience and gives them more control with higher degree of interactivity.

2.2. SYSTEM ARCHITECTURE

The building’s initial design CAAD model is imported to both Ecotect\(^1\) and the world editor of the C4 game engine\(^2\). After the user initially provides basic information about the building within the game engine (like the number of zones and areas to be assessed), a specific script is generated by the game. This script is written in LUA (which is the scripting language used by Ecotect to custom settings, operations, and calculations). The users can use the code in the script manager tool within Ecotect. This script can be used to automate calculations and export data in the required format for the embodied agents. The environmental data generated from Ecotect are stored outside the game, but can be accessed directly through both the game engine, and the embodied agents. The C4 game engine is used to create the virtual world for the users’ experience, and also to trigger specific actions and settings made by the user at real-time, thus the engine can pass messages to the embodied agents for further processing. The embodied agents comprise three different multi-agent structures (Figure 1).

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\(^1\) Autodesk Ecotect – www.ecotect.com

\(^2\) Terathon C4 Game Engine - www.terathon.com/c4engine/index.php
- **Retrieving agents**, which collect information. They are invisible part of the game world and, like the players themselves, can only perceive a limited part of the total environment. This information is then processed and filtered, and accordingly the retrieving agents obtain the relevant data from the external environmental data store.
- **Analysis agents**, which receives the relevant data passed from the retrieving agents and start further investigations, calculations and filtering to produce a set of results related to the users’ actions or queries.
- **Reporting agents**, which receive the result set from the analysis agents and pass them back to the game engine to be presented within the users’ virtual experience automatically or on demand for every examined zone of the proposed building.

2.3. SCENARIO OF SIMULATION

The game starts by providing the users the opportunity to set their virtual experience’s context according to their preferences. These include:
- Setting specific date and time to run the game at.
- Setting weather condition (sunny, cloudy, rainy …)
- Choosing the types of data to be analysed and considered in generating the runtime reports.

The retrieving agents pick users’ settings and seek the relevant data from the external environmental data generated from Ecotect. The game starts outside the building, where the data gathered by the retrieving agents is filtered by the analysis agents and passed to the reporting agents, which present the current outdoors temperature (according to the date and time set by the users). When the users enter any zone of the building, the retrieving agents are triggered to report entering this zone and thus retrieve all relevant data (relevant to the zone the users are at, as well as the date and time). The retrieved data is then passed to the analysis agents, which starts the examination process to find any unusual or unexpected figures, for example; highlighting periods of time during the day where the temperature would be out of the comfort range. The analysis agents flags all the problems found (for the zone’s current day and whole year), and start the correlation process, where the data is examined to develop a set of possible reasons that could be the cause of any out of the ordinary outcomes, not necessarily from the current zone, but also from corresponding zones, for example, solar radiation, fabric, or inter-zonal effects.

The analysis agents pass the flags and interpretations to the reporting agents to process and present to the users. A brief visual and textual summary of the zone's current status is generated from these calculations and interpretations in terms of thermal comfort and solar access and
presented to the users through the game’s “reporter” (Figure 2). The users are also given the option to generate a more detailed report for this zone for the current day, as well as for the whole year. The generated reports are presented in a simple and user-friendly manner, to avoid any confusion and uncertainty that could affect any judgement or decisions.

Figure 2. Screenshot of EDVis Game. The brief report generated for the current space (zone) and the current time.

The reporting agents also use the outcomes and possible causalities to presents a set of guidelines, suggestions, and design strategies that could be implemented to resolve any highlighted issues (Figure 3 and 4). The set of guidelines is developed from Climate Consultant\(^3\) (Milne et al, 2007), which is in turn based on the work of Watson (1983) and Loftness (1970). The role of the embodied agents is to identify the problem within the current space experienced by the user, and present the relevant set of guidelines and design strategies that designers can employ to resolve the issue. This set of guidelines presented by the system could be instigated either directly at real-time within the game environment -where the user can see the effects of this strategy on the generated report-, or indirectly outside the game context. It depends on the nature of the guidelines provided, which could be:

- **Geometric guidelines**, where the users have to make alteration in the physical design and the CAAD model, and reassess the new design subsequently. For example, changing orientation or adding a window or skylight. In this case, the guidelines can not be applied directly within the

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\(^3\) UCLA Energy Design Tool Group. http://www2.aud.ucla.edu/energy-design-tools/
game environment. Data in this case has to be regenerated from Ecotect and retrieved by the game.

Figure 3. A more detailed report for the current day and current zone, highlighting any irregularities and presenting a possible set of causalities.

Non geometric strategies/techniques, where the user can assess the effect of different techniques without changing the physical design or CAAD model. These are rather general design strategies that can be implemented to alter the thermal comfort range of the target zone. For example applying natural ventilation or passive solar heating. The thermal comfort range will be re-calculated at run-time and the reports affected accordingly.
Figure 4. Design guidelines screen, where a set of guidelines relevant to a specific reported problem is presented, which can assist negate this particular problem.

3. Summary and Future Development

EDVis-Game is a framework aiming to develop a method to benefit the design students and untrained professionals, by facilitating the comprehension of implication of environmental design strategies on a building in different design stages. This tool could be of great benefit to the users in three aspects:

1. **Users’ experience**: This is within an interactive narrative fully interrogative virtual environment. Design students benefit from this entertaining engaging context, which helps them assess different approaches and environmental design strategies and their implication. This can be opposed to relying on data represented in sheets containing schematics, graphs, numbers and tables.

2. **Environmental data visualisation**: which is presented in a more simple and user-friendly manner that facilitates comprehension and design decisions and that is relevant to the user’s experience in terms of space and time. This can be compared to the data representation of tools like Ecotect, where the reading and interpretation of data often requires significant expertise to relate the graphs and seek the problems’ and sources.

3. **Data Analysis**: The proposed tool adds another benefit to the users through analysing and correlating the relevant data, thus presenting the
users with a set of possible reasons for any problems triggered, as well as a set of guidelines and strategies to aid the users in overcoming these problems.

The project is currently under development, within its programming phase. Agents’ code is presently being implemented within the game engine’s code to reflect the system’s targets and objectives. After the programming stage of the project development, the system will enter the testing and evaluation phase. It will be introduced to design students to test its functionality and usability and assess its objectivity. Users’ feedback will be noted and the system design will be updated accordingly. Future development of this tool will include facilitating design modification as much as possible inside the game environment, and developing real-time re-calculation and report generation.

References


