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A MULTI–INTERFACE SOFTWARE DESIGNED TO SHARE GEOMETRIES WITHIN DIFFERENT SIMULATION TOOLS

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Abstract *A computer system that consists of a set of several programs that share both the same geometric definition and a consistent set of definitions for construction elements, is under development. The system consists of a common program allowing different types of exportation to other simulation programs or to other modules.*

The main modules under development until now are: an interface to the Energy Plus program, which builds an "idf" file from a 3D geometric definition that was previously modeled in graphical mode; and a module, that will provide the necessary calculations to verify if a given shape fulfills the thermal regulation of buildings which is based upon the Energy Performance of Buildings Directive (EPBD) approved by European Parliament and Council. An interface with Radiance program is also being developed.

Using this system, which has been designed firstly for architectural conception, the user can perform different simulations with different aims, but sharing the same architectural shape and construction types, in order to check if the building fulfills thermal Portuguese codes and to perform energy simulations with Energy Plus or Radiance.

The use of this system has demonstrated that it can represent a great saving of time in simulations and helping to reduce the occurrence of design errors as well.

Since it allows performing simulations in a very quick way it can contribute also to help architects on achieving better solutions while designing, in terms of the optimization of all the parameter evaluated.

The use of energy plus to evaluate the comfort of the buildings while being design as shown that this methodology can help to find more sustainable solutions in terms of their architectural shape and construction elements.

1. INTRODUCTION

In Portugal the performance requirements of buildings, imposed by the new regulations, have increased in complexity and number. On the other hand, there is now available an increasing number of powerful simulation tools that allow performance evaluations that are improving in terms of accuracy and level of detail.
However, these tools for simulation are often independent from one to another and each one requires independently an accurate and laborious work for defining the input needed to perform the correspondent simulation and obtain evaluations of the building under design and to support design decisions.
So taking advantage of some tools available that allow different performance evaluation and with the aim of both, performing an increasing number of evaluations and simplifying the design process of buildings a multi-interface system is under development.
This system is being designed mainly for supporting architecture conception and it can be helpful on improving sustainability of buildings during their design process. So it has been considered very important that the system could take advantage of energy plus facilities to simulate comfort parameters. If buildings are design with the aim of achieving comfort [1] with minimal use of active systems, they can certainly achieve higher levels of performance in terms of sustainability.

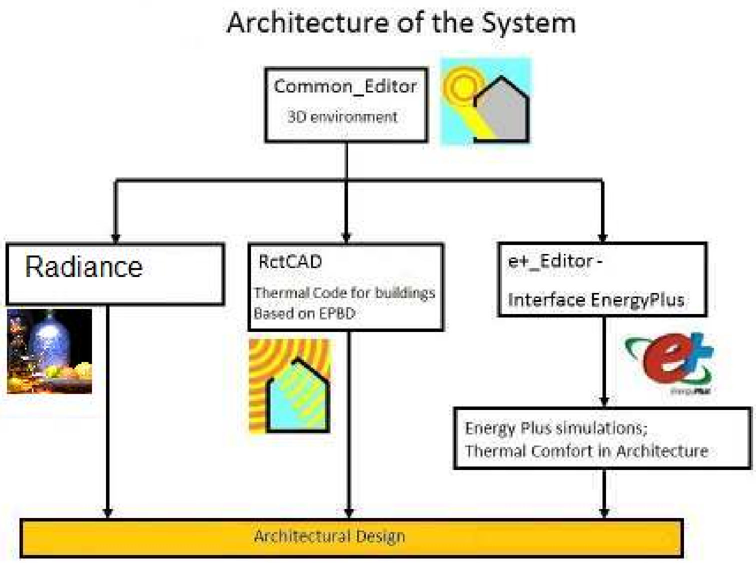

Figure 1: scheme of the architecture of the system.

This system is composed of different modules that are represented in the schema of Figure 1. The modules that are being developed until now are the following ones:

- **A Common 3D Editor module:** This module allows to represent a 3D sketch of the building being designed for later export to different simulation or evaluation tools;
- **An "energy plus" interface 3D editor module:** This module reads the geometrical definition previously generated by common 3D Editor. Also allows native energy

plus 3D definitions and support some additional energy plus definitions. When the 3D model is complete this module generates an "idf" file to be run inside Energy plus simulation program;

- **A module for thermal calculations based on the EPBD:** This module allows to check the compliance with the Portuguese Thermal Regulation for Buildings which is based upon European Directive EPBD Energy Performance of Buildings Directive from European Parliament and Council [2].
- **A module for Radiance**: this module exports files formatted according to Radiance program [3] needs.

1.1 Objectives

The main objective for the development of this system is to improve the knowledge that can inform conceptualization of architectural shapes during the design process. According to this objective other aims have been raised:

- to develop a system that can be better adapted to architectural design in terms of its knowledge needs;
- to reduce repetitive and redundant tasks and eliminate repetitions of geometrical procedures during the design process as well as preventing design errors that can occur;
- to develop an intelligent system that provides some expert system procedures that can perform searches of optimized solutions.

2. METHODOLOGY

The System is developed using Swi-Prolog programming language [4] – a language with a hybrid paradigm that allows both knowledge representation and object oriented programming (OOP).

Knowledge representation facilities are particularly useful to adapt to designer needs and also to ensure that error occurrence is minimized.

The Prolog language was chosen to develop this system because it is very appropriate for developing expert system algorithms that also will be implemented in a more advanced state of development. Examples of this are searches algorithms, which have been already tested in a previously developed work [5].

Object oriented programming techniques are specially used in terms of 3D viewing and user interface.

3. DEVELOPMENT OF THE SYSTEM

The architecture of the system was conceived by developing an environment with graphical entities that could be as more appropriate as possible, in knowledge terms, for the purposes it is being designed.

Architecture is seen here as a structure of spaces in a three dimensional environment. The architect, when designing a building, in the earlier steps of the process, performs sketches of volumes where he can imagine the shape of the building and the links of different rooms considering their functions. So, to better adapt to this conceptual needs, the main entity of the common 3D Editor module was defined as the “space”. The user sketches a building by handling spaces in a three dimensional environment. The “space” was also found as the entity that could be more general and common to all other modules connected and that could easily be exported to the different environments were simulations would be done. In fact for each module a different type of entity is needed:

- **Inside Common 3D Editor module:** the main entity is the “space” – a space is also defined as a class of object in OOP terms – however a “space” is built of several “common surface” objects (walls, roofs and floors) and “sub surface” objects (windows or doors); “spaces” can also be grouped by the user if they are similar in terms of its thermal behavior, or if they have a conceptual unity, for instance, if they correspond to a specific dwelling;
- **Inside “energy plus” interface 3D editor module:** the main entity conceptualized here is the “zone” – also the corresponding OOP object defined is the “zone” – when the user imports the geometrical definition from the common 3D Editor, if no groups are defined “spaces” are automatically converted into “zones”, otherwise groups of “spaces” will correspond to new “zone” objects inside this environment;
- **Inside the module for thermal calculations based on the EPBD:** the main entity conceptualized here is the “dwelling unit”. Similarly to the “zone” entity of “energy plus” interface 3D editor; if “spaces” are grouped, each group will be exported from common 3D Editor as a “dwelling unit”; otherwise every “space” will be included in only one “dwelling unit”.

4. DISCUSSION

The system developed has proved that it can provide a good solution for conceptualizing architecture. Also the graphical interface described and particularly the mechanism of construction objects based on the interaction between visualization and mouse selections has proved to be well adapted to architectural design tasks in knowledge terms.

The mechanism of exporting to the other modules as proved to be a good solution for reducing repetitive and redundant tasks and eliminate repetitions of geometrical procedures during the design process.

Although for the moment some parts of this system under development are not totally concluded the architecture developed seems to represent a good contribute to evaluate buildings while being designed in a more integrated process, and to improve their sustainability, as well.

The energy plus interface module does not cover all the objects available inside energy plus simulation program, since it is focused on trying to promote a more sustainable architecture and so geometry and passive strategies related energy plus objects are more detailed.

There are available other similar tools at the market, like for instance OpenStudio software developed by National Renewable Energy Laboratory [6] or design builder, developed by DesignBuilder Software Ltd [7] among others.

Despite the fact that those tools are in a state of development much more advanced, than the system now presented, there are some features that no one of these tools provide at this moment:

- be adapted to the Portuguese needs in terms of compliance with the national building regulations;
- provide the capacity of including expert system procedures or artificial intelligence algorithms that are being developed with the aim of both: reduce the occurrence of errors and/or automatically search for optimized solutions;

5. CONCLUSIONS

The use of this system proved that it could contribute to reduce the time spent in simulation tasks, particularly those of graphical representation, and that it can be used as a design tool for architecture conception and so can contribute to improve sustainability of buildings while being designed.

Some tests have revealed that different distribution of spaces in the plan of the building lead to different results in terms of thermal comfort, so it can be concluded that it is very important to test different architectural shapes while designing in order to a achieve better solutions in terms of buildings sustainability.

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