Interactive Visualization of Heterogeneous Data for Energy Efficiency of Buildings

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ABSTRACT

Since 1997, Kyoto protocol has highlighted the importance of a rational usage of energy as well as a reduction of greenhouse-gas emissions. The France Environmental Summit ("Grenelle de l'Environnement") has fixed for 2020 the objective of reduce energy consumption of building sector by one-third. In this context, the main goal of the RIDER project (Research for IT Driven EneRgy Efficiency), is to develop a smart platform for multiscale and multistandard energy management of buildings. In this paper we present the visualization module that we have conceived and implemented for RIDER.

1. INTRODUCTION

In France, 43% of energy consumption comes from the building sector (offices, factories, shops and homes). Given the effect on greenhouse-gas emissions of energy consumption, it is necessary to this sector to adopt sustainable development principles. This involves the renovation of existing structures and the construction of low energy consumption and positive energy buildings.

Currently, data from building sensors are managed by Building Management Systems (BMS), which only provide analyzes of current situation. For example, if the temperature increases in a room, the BMS will adapt air-conditioning speed to reach the defined temperature. To improve energy efficiency, it is necessary to deal with building inertia, external conditions and room's neighborhood temperature. The RIDER project, conducted by a consortium of French universities and industries, aims to develop an innovative information system for energy efficiency optimization of a building or group of buildings. The RIDER green box is conceived to understand, anticipate and react to various situations with specific adapted predictive models.

As stated before, BMS tools can only be used to adjust building parameters or to provide feedback to the system manager. The user cannot modify the predefined rules to improve his comfort, the energy consumption or to update the building model. Indeed, a building is as a "living" entity, constantly evolving. For example, topology of rooms change over time, mainly through internal walls modifications. Therefore, it will be interesting to RIDER to recover user knowledge about the building. In particular, the visualization component aims to provide users with a better insight of their energy usage by visually detecting trends or gaps. Users can also provide information to update and improve RIDER model, which can help them control their energy consumption.

2. VISUALIZATION OF BUILDING DATA

In a single building, it is possible to find several types of sensors, working at different frequencies: CO2, temperature, pressure, humidity, etc. Therefore, we must deal with this massive, heterogeneous and multi-dimensional data (type, location and value of sensors). Then, our work in visualization evolves around two main axes:

Interactive multi-dimensional visualization techniques. We have integrated in our module the most commonly used visualization methods in building management systems (Hao et al, 2010), including curves, graphs, radar charts, scatterplots and parallel coordinates. We have also introduced 3D visualization of room space to allow users to better understand the sensors data and to perform some diagnostics. We have defined a particle system to modeling the internal space of a room. Particles use sensors position and value to calculate their own state (Aurenhammer, 1991). With this information, we are able to produce several 2D and 3D views (Alexa et al, 2003). As showed in figure 1, the particle system can be visualized as a point cloud or as a volume. The user interacts with the system using traditional techniques (selection, zooming, panning) and can annotate views to keep track of his analyzes. This information will then be used to update the RIDER building model.

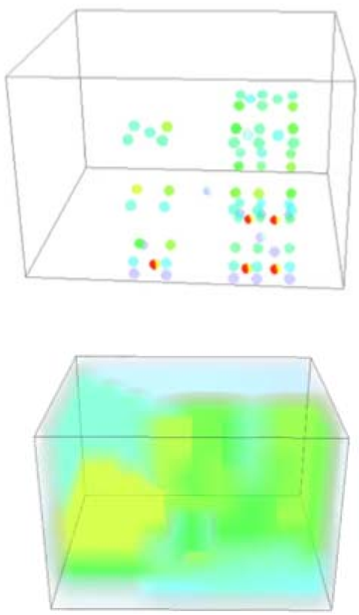

Figure 1: Point cloud (top) and volume (bottom) room visualization

A client / server model, in order to support multiple displays: personal computer, tablet, smartphone, video walls, etc. The server receives the data at varying frequencies, and performs calculations in order to provide the client with a smooth, adapted dataflow as in Level Of Details for 3D objects (Clark, 1976).

We have used our component with 2 datasets: the Green Data Center and a set of offices, both from the IBM Montpellier (France) building. Our multi-view tool allows to the easily identify hot/cold regions and airflows. By correlating measurements from all sensors, we are also able to get insight into sensors and furniture actual positions. This information may help to correct sensors configuration, to improve furniture positions (e.g. to place servers in the cool airflow reduces the need for supplementary cooling), and to better understand the human activity to improve RIDER rules (e.g. to lower the temperature of empty meeting rooms).

3. CONCLUSION

Nowadays, energy saving has become a crucial issue. The buildings where we work and live has been identified as a major source of energy consumption. The RIDER project aims to develop an innovative information system for optimize the usage of energy in the building sector. In this paper we have presented the visualization component that we have designed and developed for RIDER. We have explored two datasets and show how the several 2D/3D techniques of heterogeneous, multi-dimensional data visualization can allow users to analyze and improve energy consumption. RIDER is a work in progress. In the near future, we must to integrate data coming from the user comfort model and from an accurate physical model of the building.

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