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Model and Visualise the Relationship between Energy Consumption and Temperature Distribution in Cold Rooms

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Abstract

In the area of food and pharmacy cold storage, temperature distribution is considered as a key factor. Inappropriate distribution of temperature during the cooling process in cold rooms will cause the deterioration of the quality of products and therefore shorten their life-span. In practice, in order to maintain the distribution of temperature at an appropriate level, large amount of electrical energy has to be consumed to cool down the volume of space, based on the reading of a single temperature sensor placed in every cold room. However, it is not clear and visible that what is the change of energy consumption and temperature distribution over time. It lacks of effective tools to visualise such a phenomenon. In this poster, we initially present a solution which combines a visualisation tool with a Computational Fluid Dynamics (CFD) model together to enable users to explore such phenomenon.

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [Computer Graphics]: Interaction techniques I.3.8 [Computer Graphics]: Applications I.6.3 [Simulation and Modeling]: Applications

1. Introduction

In the area of food and pharmacy cold storage, temperature distribution is considered as a key factor. Uniform temperature distribution is always desirable in order to ensure good quality and high safety of the products. Conversely, uneven temperature distribution easily causes the deterioration of the quality of products through either increased respiration at higher temperature or by chilling or freezing injury at lower temperature. During the process of cooling it is a fact that large amount of electrical energy is consumed to keep the temperature in cold rooms at a suitable level.

In past years, many papers have been proposed to study the phenomena of transport (airflow, heat and mass transfer) during cooling [NHV*05, DVHN10, MA08, HVBN00] in cold rooms. However, few is focus on modeling and visualzing the change of temperature distribution and electricity consumption based on time. It lacks of effective visualisation tools to enable users to explore and analyse such a phenomena quantitatively.

In this poster we present a solution which combines a visualisation tool with a CFD model together to enable users to explore and visualise the time-dependent phenomena of energy consumption and temperature distribution in cold rooms.

2. Methods

2.1. Model

A transient CFD model has been developed to simulate the energy consumption of the cooling system and the temperature distribution inside an empty cold room for 20 minutes. The dimension of the empty cold room is 4.5m x 2.05m x 2.8m (length x width x height), with a door placed on the north wall and is closer to the east wall. A heat exchanger is positioned in the centre of the cold room and a monitoring temperature sensor is mounted on the top of the west wall.

2.2. Visualisation

In past years, several papers have been proposed [AM07, LTP09, HMM*05] to integrate information visualisation and scientific visualisation together to visualise enormous dataset. Similar to these papers, our visualisation tool was also developed to combine the power of information visualisation and scientific visualisation to assist users to analyse

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and explore the large amount of spatiotemporal based data from the CFD simulation. In particular, the interface consists of three components: temporal domain, variable domain and spatial domain, respectively.

The first component, as shown in figure 1 displays a simple two dimensional plot of the variable of total energy consumption of the cooling system versus time. It gives users an intuitive overview of the trend of the total energy consumption and helps them identify the time step of interest.

The second component, as shown in figures 2 displays the relationship between energy consumption and temperature distribution in parallel coordinates based on pre-selected time step. Moreover, the spatial dimensions are also added into the parallel coordinates so that users can verify the complex relationship of them easily and the corresponding spatial features can also be extracted.

The third component, as shown in figure 3 allows users to explore and observe the distribution of temperature in spatial domain more intuitively.

Each of the three components is not only an interface but also a visualisation themselves, thus enabling efficient screen-space usage. These three components are tightly linked and plentiful interaction allows user to explore the dataset step by step.

Figure 1: *Temporal view.*

Arising from this first-stage development, it is planned to construct a comprehensive framework that will enable users to explore and interact with the relationship between energy consumption and temperature distribution.

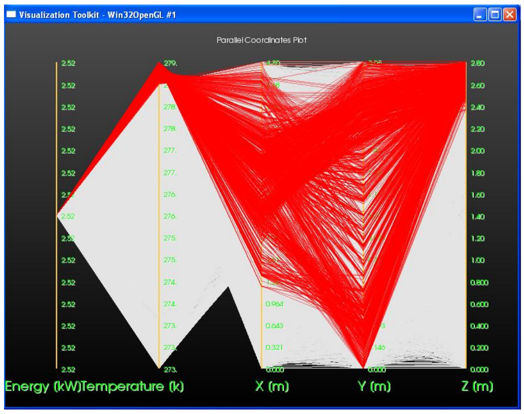

Figure 2: *Multivariate view. The figure reveals that where the temperature at 279K is distributed in the cold room.*

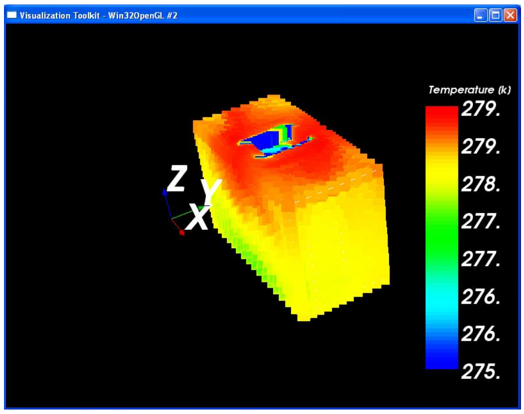

Figure 3: *Spatial view.*

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