# Improving Building Energy Efficiency by Kinect-based Occupancy Tracking and Mobility Detecting System

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## ABSTRACT

Nowadays, most building air conditioning systems still operate on a fixed schedule rather than real-time occupancy. In our study, we make an occupancy tracking software based on Kinect to reflect the number of people in a open lab. We then build a Markov Chain (MC) model after dividing the open area into 4 zones and calculating its occupancy respectively. When applying the real-time schedule of one week to a building model created with eQuest, we obtain a 22.1% energy reduction in space cooling.

## 1. INTRODUCTION

At the core of energy consumption in modern buildings is Heating Ventilation and Air Conditioning (HVAC) systems which are designed to operate at full capacity most of the time because it's often assumed a maximum occupancy. Although current HVAC systems are equipped with sensors, their management and control systems ignore the dynamic nature occupancy patterns in buildings. In addition, they are unable to proactively adjust to occupants' comfort levels. Understanding human mobility and occupancy patterns are key factors in successfully managing HVAC systems in buildings. The main contribution of our paper is to propose an energy-saving model based on occupancy patterns of human mobility in buildings. The most important features of the system are as follows: a) A real-time detection and tracking of human mobility in buildings based on Kinect. b) An occupancy prediction mechanism based on MC.

## 2. IMPLEMENTATION

### 2.1 Kinect-based Occupancy Counting Software

Our Occupancy Counting software is written using Microsoft Visual $C\sharp$ 2010, project WPF application programmed using C# and XML languages. Both types of Kinect are used and tested to insure that it works properly, i.e. Xbox Kinect and Kinect for Windows. The software, should be run on windows 7 or above, with a pre-installation of Kinect sensor drivers.

1. **Kinect initialization start:** This function will look up for any connected Kinect devices to your computer. If no device is connected: a box message will appear to inform you about this fact. The software display both RGB and Depth image, Figure 1 show the GUI of our software.

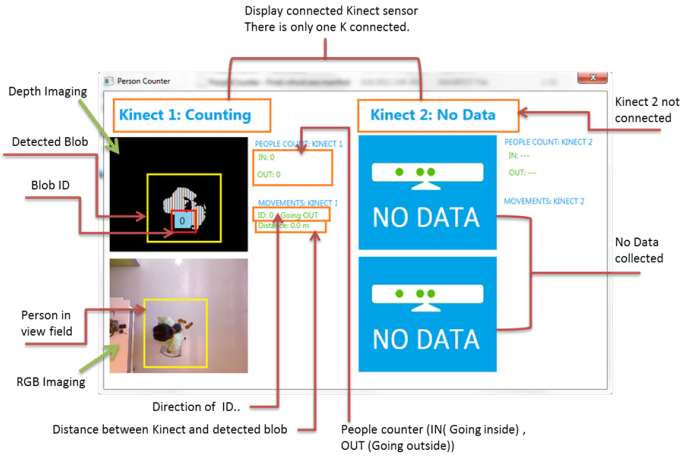


**Figure 1: Overview of the GUI of our Kinect-based Occupancy Counter x.**

2. **Capture frame events**: As part of the initialization, it makes sure that both RGB and Depth imaging are captured. ColorImageFrameReadyEventArgs: The event arguments provided in a KinectSensor. ColorFrameReady event when a frame of color data is ready.

3. **Depth camera feed generator:** Contains a per-frame buffer for depth data streamed out of a sensor. Also provides access to the dimensions and format of the data in addition to mapping between skeleton and color coordinate spaces. Once our Depth imaging is ready, we can start tracking blobs and draw markers.

4. **Generate Markers :** This draws a rectangle blue box with unique ID of people that is used is temporarily for the detection of multiple subjects passing in the field view.

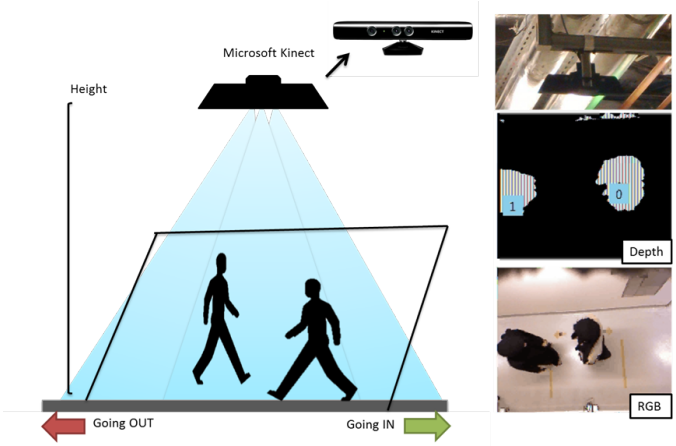


**Figure 2: The architecture of our tracking system**

People tracking through the Kinect sensor can be done using two methods:people tracking via human posture and an existing skeletal tracking by MSDN library. Both methods are implemented into our software to help us draw a fair comparison.


**Figure 3: Kinect sense even in dark view, which provide a high accuracy of data capturing**

## 3. RESULTS

## 4. CONCLUSION AND FUTURE WORK

## 5. REFERENCES

[1] Chuang Wang, Da Yan, and Yi Jiang. A novel approach for building occupancy simulation. *Building Simulation*, 4(2):149–167, 2011.