A Smart Internet of Things (IoT) Prototype for Accurate People Counting Towards Energy Efficient Buildings

ABSTRACT

According to the U.S. Department of Energy, 30% of the energy used in commercial buildings is wasted. Much of HVAC energy is wasted due to the lack of building occupancy information, such as occupied or vacant. If the number of humans in each pre-determined thermal zone is aware, a building automation system (BAS) is able to intelligently adjust HVAC operation for each thermal zone to provide "just-enough" heating, cooling and ventilation to building users. For example, the ventilation damper in an HVAC diffuser can be best tuned according to the number of occupants in a thermal zone. Therefore, a people counting device that can be widely deployed with low price and failure rate, small form-factor, good usability, and conserved user privacy is highly desirable. Existing room occupancy detection sensors (e.g., passive infrared, camera, acoustic, RFID, CO_2) cannot meet all these above system requirements. In this work, we present an IoT (Internet of Things) prototype that collects room occupancy information to assist energy-efficient building operation. A proposed IoT prototype consists of a Lattice iCE40-HX1K stick board and a Raspberry Pi3 module. An application user interface is also developed to allow anonymous users to easily online acquire room occupancy information. If a pair of IoT prototypes are installed at each side of a door opening, when a person walks through this door, infrared signal communication between this pair of IoT prototypes is blocked and detected. Similarly, if two pairs of IoT prototypes are utilized, moving direction is obtained by comparing the occurrence time of two signal blocking events. Thus, the increase or decrease of the number of humans in a room is figured out. We carried out 200 trials of random testing of human walking through the door opening, and found a 97% success rate of event detection. The proposed design is completely made of off-the-shelf electronic components with an estimated cost of less than $160. In conclusion, the proposed design is miniature, non-intrusive, ease of use, low failure rate and cost-effective.

Keywords: Smart Building, Room Occupancy Counting, Internet of Things (IoT), Active Infrared, Gate Monitoring Module