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IOT-BASED OCCUPANCY MONITORING TECHNIQUES FOR ENERGY-EFFICIENT SMART BUILDINGS

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ABSTRACT—

The proliferation of (IOT) Internet of Things devices such as phones, cameras, sensors, and RFIDs, it is possible to have massive amount of data for tracking and localization of people within buildings. Such monitoring are enabled by capabilities of occupancy, there are opportunities for extensive for the energy improving consumption via smart HVAC of buildings control. In respect of this, the challenges of major that we envision are 1) to achieve monitoring occupancy in a intrusive minimally way, e.g., using the existing infrastructure in data The goal is to lay down a framework for future research to exploit the spatio-temporal data obtained from one or more of various IoT devices such as temperature sensors, surveillance cameras, and RFID tags that may be already in use in the buildings. A comparative analysis of existing approaches and future predictions for research challenges are also provided.

1. INTRODUCTION

Smart buildings are reality in becoming a integration with the (BMS) Building Management Systems [1] with the communication of infrastructure and underlying monitoring that consists of devices smart such as cameras, sensors, meters, RFIDs and actuators. These smart devices, along with the infrastructure of communication, are referred to (IOT) Internet of Things. The BMS manage various crucial components of the buildings such as heating, ventilating, and air conditioning (HVAC), gas, lighting, security system, and fire system, and it can communicate with the IoT devices.

2) PROBLEM DEFINITIONS AND CLASSIFICATIONS

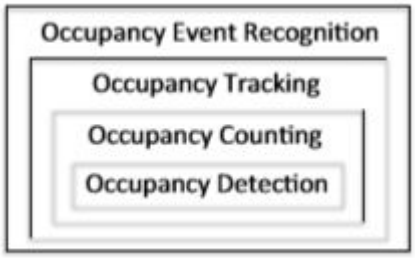

Fig. 1: Occupancy monitoring problems.

These are interrelated but depending on the goal of the application, in the past, various forms of the problem are studied. We show them in the form of subset/superset

3) COMPARATIVE ANALYSIS AND FUTURE PREDICTIONS

summarizes the existing occupancy monitoring approaches in terms of the used infrastructure and techniques applied. The table indicates that most of the existing works relied heavily on sensor's which need to be specially deployed. While different techniques are used based on artificial intelligence, machine learning and statistics, multi-modal data fusion was not applied in most of the works. Combination of WiFi, sensors, cameras and other resources at the same time was not investigated at all. The analysis of these helps us to determine a number of future trends in the area of smart buildings:

• Exploiting IoT with in the Buildings: With the proliferation of IoT devices and technologies, there is a great potential to exploit their communications for occupancy monitoring. In addition to smart phones, the upcoming years will witness the use of wearable sensors, glasses, watches and RFIDs on objects. If one can collect the signals emitting from these devices, they can help increase the accuracy of occupancy monitoring significantly.

Typically, the goal is to only rely on the WiFi and user's wireless devices to get zone level occupancy information and then complement this information with other IoT devices, if any, in order to further increase the granularity of occupancy information. • Using Localization: While zone-based coating of people provides a coarse-grained occupancy detection, the exact number and location of the people are still needed for especially shared spaces in the buildings. Indoor localization has the potential to reduce the zone of detection enough for occupancy inference in shared spaces . Thus, there is a need to integrate localization with the existing monitoring systems to significantly increase the energy gains.

• Multi-modal Data Fusion: In order to increase the accuracy and reduce the costs, fusing data coming from multiple sources within the building is another important trend. As mentioned, with the maturing of IoT technologies, there will be additional sources that can provide additional data for fusion. The techniques in [35] can be adapted for various buildings with different IoT devices. • Privacy Preservation: While most of the occupancy monitoring approaches focus on the people

count and do not track the individuals, accurate occupant tracking may pose challenges regarding privacy. The existing techniques for user localization privacy are mostly based on the mechanisms applied at client side. New privacy mechanisms are needed to be applied to occupancy tracking.

4) . CONCLUSION

In this paper, we analyzed and surveyed the efforts for existing monitoring occupancy in smart buildings for efficiency of energy purposes. Specifically, we identified first types of the problems that are related to people occupancy. We also discussed the research of past that's focused on olely using cameras and sensors. Finally, we investigated the current efforts where IoT comes into picture with the involvement of smart phones, motion sensors and WiFi APs. The existing approaches indicated a trend towards the use of existing IoTs that are available within the buildings. Goal with using the minimal software and hardware costs, smart buildings of future have a great potential to save the energy by smart control employing strategies on HVAC through the help of data collected via IoT. We concluded the paper by identifying major future trends in this emerging area.

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