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Capacity Control in Indoor Spaces Using Machine Learning Techniques Together with BLE Technology

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Abstract: At present, capacity control in indoor spaces is critical in the current situation in which we are living in, due to the pandemic. In this work, we propose a new solution using machine learning techniques with BLE technology. This study presents a real experiment in a university environment and we study three different prediction models using machine learning techniques—specifically, logistic regression, decision trees and artificial neural networks. As a conclusion, the study shows that machine learning techniques, in particular decision trees, together with BLE technology, provide a solution to the problem. The contribution of this research work shows that the prediction model obtained is capable of detecting when the COVID capacity of an enclosed space is exceeded. In addition, it ensures that no false negatives are produced, i.e., all the people inside the laboratory will be correctly counted.

Keywords: Bluetooth Low Energy (BLE); machine learning; COVID capacity control; level occupancy; occupancy detection; indoor detection

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1. Introduction

Knowing the location of people inside a building is very useful for many different scenarios (smart buildings, energy efficiency, emergency situations, obtaining patterns of movement, etc.). However, recently, capacity control in indoor spaces has become critical in the current situation in which we are living in, due to the pandemic. Being able to know, in an accurate way and in real time, the number of people who are inside a room is a relevant issue at present. In this work, we propose a new solution for this real problem in the university environment.

Indoor occupancy detection is a well-known problem that has been studied since the 1990s from different approaches as technology has evolved, with the first solutions using infrared sensors [1], and more recent ones using radio frequency identification (RFID) [2], near-field Communication (NFC) [3] or Wi-Fi technologies [4,5]. Among them, the most studied are Wi-Fi technologies, mainly because no additional hardware is needed for their use. However, the main drawback that it presents is that the signal strength of a wireless device may change over time, making it difficult to operate. In addition, a high battery consumption is required in the user's mobile phone because it needs to frequently scan the Wi-Fi signal. Other solutions combining hardware devices and algorithms for localization and tracking can be found in [6,7].

With respect to the other, more recent technologies, RFID [2] has the disadvantage of requiring the installation of antennas, as well as receivers in user devices. On the other hand, the main drawback/difficulty of NFC [3] is the need to be very close (<20 cm) to the NFC tags for them to work properly.

More recently, Bluetooth Low Energy (BLE) technology [8] has also been used for both location and occupancy detection. This technology presents numerous advantages compared to the previous ones; it is included on most smartphones, is low-cost, has easy