Chapter 13
Mesh Network of eHealth Intelligent Agents for Visually Impaired and Blind People:
A Review Study on Arduino and Raspberry Pi Wearable Devices

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ABSTRACT

Smart assistive devices for blind and visually impaired (B&VI) people are of high interest today since wearable IoT hardware became available for a wide range of users. In the first project, the Raspberry Pi 3 B board measures a distance to the nearest obstacle via ultrasonic sensor HC-SR04 and recognizes human faces by Pi camera, OpenCV library, and Adam Geitgey module. Objects are found by Bluetooth devices of classes 1-3 and iBeacons. Intelligent eHealth agents cooperate with one another in a smart city mesh network via MQTT and BLE protocols. In the second project, B&VIs are supported to play golf. Golf flagsticks have sound marking devices with a buzzer, NodeMcu Lua ESP8266 ESP-12 WiFi board, and WiFi remote control. In the third project, an assistive device supports the orientation of B&VIs by measuring the distance to obstacles via Arduino Uno and HC-SR04. The distance is pronounced through headphones. In the fourth project, the soft-/hardware complex uses Raspberry Pi 3 B and Bytereal iBeacon fingerprinting to uniquely identify the B&VI location at industrial facilities.

INTRODUCTION

Over 253 million people across the world today are estimated to be blind or visually impaired (B&VI) (World Health Organization, 2020). Around 30 million B&VI Europeans need assistance for the spatial cognition indoor and outdoor (European Commission, 2020). About 90% of B&VI live at a low income that means these people cannot buy expensive assistive devices for spatial cognition. Approximately 20%

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of young B&VI in the UK do not leave their home, approximately 30% had traveled locally, and only 40% left their home alone and walked (Bruce, McKennell, & Walker, 1991). Most of the B&VI who explore new routes feel disorientation, fear, stress, and panic associated with being lost (Golledge, 1993). Being mobile is the crucial factor that contributes to the success of the B&VI (Goodwyn, Bell, & Singletary, 2009). The white canes and guide dogs remain the common aid associated with this disability despite over a hundred different assistive electronic devices developed last three decades (Chaudary et al, 2017; Elmannai & Elleithy, 2017). The additional training of B&VI, especially children (Gori et al, 2016), to use the innovative hardware and its integration into existing networks are the main sticking points nowadays. The first problem is solved by short-term courses, where B&VI people learn the assistive devices. The second problem does not have a single solution due to the heterogeneous soft-/hardware, as well as the standard smart city infrastructure, which is a dominant platform for communication of assistive devices, was not developed yet.

Internet of Things (IoT) hardware is produced by many companies such as Raspberry Pi Foundation, Arduino, Bosch, Silicon Labs. IoT software is represented by different operating systems like Raspbian, Android Things, Windows 10 IoT, Ubuntu Core. The assistive devices exchange data in metropolitan area networks (Yaqoob et al, 2017) via IoT data protocols like MQTT and CoAP (Dizdarevic et al, 2020) and different network technologies such as WiFi, Bluetooth, Ethernet (Rackley, 2007). On a short distance of up to 10 m, most IoT hardware, smartphones, and tablets implement the Bluetooth classes 2 or 3 to be connected directly (Woodford, 2020). Standard iBeacons (Trent, Abdelgawad, & Yelamarthi, 2017; Shovic, 2016; Lin & Lin, 2018) have an approximate range of 70 meters for the peer-to-peer Bluetooth low energy (BLE) connection. For larger distances, the client-server and/or wireless mesh network architectures (Zarzycki, 2016) are recommended.

For the spatial cognition, B&VI require specific functionality from the assistive devices:

1. Geographic Information and Global Positioning Systems (GIS and GPS) for navigation.
2. Ultrasonic/optical detection of the obstacles and distances to them.
3. Computer vision detection and recognition of the people and other objects like animals in front of and/or around the B&VI.
4. Indication of objects and places around B&VI via the BLE techniques, e.g. RSSI, AoA, and ToF, and recently proposed BLE based protocols, e.g. iBeacon, Apple Inc., and Eddystone, Google Inc., (Zafari, Gkelias, & Leung, 2020).
5. Integration into existing smart city infrastructure via wireless technologies, e.g. Bluetooth and WiFi.
6. Navigation assistance to solve the last 10 meters problem, e.g. the sound marking of the objects like the entrances and exits.

Nowadays, none of existing B&VI assistive devices implement together above-stated functionality (1)-(6). The most promising approach is the mesh network of eHealth intelligent agents since the number of network-connected devices is estimated to be 6.58 per person around the world in 2020 (Statista, 2020). It is a huge increase compared with 2003 (0.08), 2010 (1.84), and 2015 (3.47) that reflects the global tendency – IoT becomes the Internet of Everything, i.e. almost every new smart device might be connected to the network and humans are associated with these devices sometimes. BLE is preferable technology to connect the nodes directly, i.e. peer-to-peer (Draishpits, 2016), dynamically, and non-hierarchically in the mesh network on the short distances of up to 90 m due to the energy efficiency.

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