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Publish-Subscribe Architecture for Delivering Assistance to Visually Impaired People

Ricardo N. Rodrigues * **Alexsander V. Canez** *
Gisele M. Simas * **Regina Barwaldt** *

* *Universidade Federal do Rio Grande, Rio Grande, RS, Brasil (e-mails: ricardonagel@furg.br, alex.avc@hotmail.com, giselesimas@furg.br, reginabarwaldt@furg.br).*

Abstract:
Visually impaired people face many difficulties in everyday tasks. In this paper we present a distributed architecture for delivering Assistive Technologies that can help a user in such tasks. The architecture allows a user using a internet enabled device to send images, video and GPS location to remote "Helpers" that can send messages back with helpful instructions or tips. The Helpers can be programs running on a remote server or real people invited by the user. The architecture is based on a publish-subscribe paradigm using MQTT protocol. A system, based on the proposed architecture, was implemented with a collision detector, a scene classifier and a object recognized. A qualitative analysis of experiments have shown positive results and pointed out some improvements.

Keywords: System architectures; Computer vision; Distributed systems; Computer applications; Obstacle detection; Scene analysis; Object recognition.

1. INTRODUCTION

The World Health Organization (WHO, 2014) estimated in a survey in 2012 that there are about 285 million people in the world with some kind of visual deficiency, being 246 million with partial sight and 39 million with total blindness. These people are constantly excluded because of their disability, but new Assistive Technology solutions are being researched and developed to improve their social inclusion.

Recent advances in computer vision, electronic devices, microprocessors and wireless communication motivate the cientific comunity to search new solutions that combine such technologies to improve the quality of life of visually impaired people. For an assistive technology to have a positive affect, several issues need to be explored, such as: which paradigms and computational architectures should be employed; which devices should be used; how the available technologies should be combined.

In this context, our paper proposes a distributed architecture based on publish/subscribe paradigm to support assistive technologies for visually impaired people. The main features of the proposed architecture are:

- It is flexible and customizable, differing from other works that target a specific type of assistance. Our solution enables the communication between users and different "Helpers" by defining a underlying architecture for message exchange.
- It enables the "Human-in-the-loop" paradigm by allowing a user invited person to receive data and send help when requested. This opens the door for including social networks in assistive technology solutions.
- It aims in providing an accessible and low-cost solution, since it does not require a specific device or sensor. In fact, our target is the use of common devices, such as smartphones and tablets.
- It is inspired in the ubiquitous computing paradigm, which advocates that technology shoud be omnipresent (pervasive), invisible in devices or spread over the environment and its usage should be transparent to the user.

We also present a system implementation based on the proposed architecture with three functionalities: collision detection, scene classification and object recognition. Figure 1 illustrate an example where a blind user is warned on the presence of an obstacle and the object is properly recognized, allowing him a safer locomotion and improving environment awareness.

This paper is organized as follows: section 2 describes some related works; section 3 presents the proposed architecture; in section 4 the implemented system, based on the proposed architecture, is detailed; in section 5 we report some experiments and a qualitative analysis; finally, in section 6 we present our conclusion.

2. RELATED WORK

Researches related to Assistive Technology for the visually impaired are in constant development. The following are reported some examples of recent works in this area.

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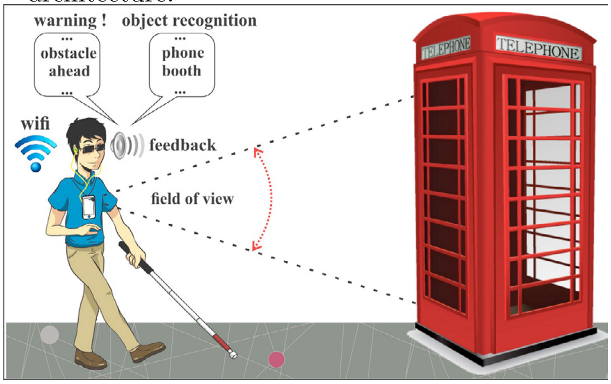
Fig. 1. Illustration of an application based on the proposed architecture.



In (Cha et al., 2013) is proposed a navigation system for blinds using the Smartphone. The application uses the Google Map and Google TTS (Text-to-Speech) to lead the user to the destination. The system is basically divided into three stages. You must first inform the destination, then the voice recognition and Google TTS is applied, if the user is recognized by the system, then, in second step Google Map search and traces the route, the map is saved in the DB (database). Finally, the person is guided by the route through voice instructions to your destination.

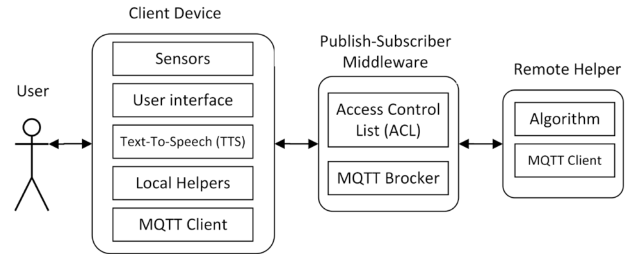
Varadarajan et al. (2014) system based at the principle Wireless Position System. Where the current position of the user is calculated point-to-point according to the level of the WiFi signal. The destination must be informed, in accordance with the current position is loaded a map where the person is guided by voice instructions, to the reach the destination a voice notification is issued stating that the destination has been reached.

The Nakajima and Haruyama (2012) uses communication technology visible light and geomagnetic sensing integrated into Smartphone. This consists of LED lights, a Smartphone with integrated receiver, headphones and a Panasonic cloud environment (LBS Platform) which is referred to as position information base. The Receiver abstracts the identification of visible light by Bluetooth to find the user's location, via WiFi receives the route the cloud and the position information for guidance is given through headphones. The geomagnetic sensor serves to guide the direction of travel.

Tapu et al. (2013) present a system that basically divides into obstacle detection (static and dynamic) and classification of objects to help visually impaired navigation through Smartphone. The detection is made based on the optical flow algorithm Lucas-Kanade, homographic transforms, the RANSAC (Random Sample Consensus) algorithm, agglomerative clustering technique, KNN (K-Nearest Neighbor). The classification is based on HOG (Histogram of Oriented Gradients) descriptor, K-means and BoVW (Bag of Visual Words) and has an image database on the device itself.

Du Buf et al. (2011) developed a navigation system for outdoor and indoor, integrated by GPS and WiFi localization with a geographic information system (GIS) database, with RFID tags in sidewalks, still has the obstacles detection obstacle with computer vision.

Fig. 2. Architecture overview.



We observe that most works found in the literature focus in a single objective, as object recognition (Tapu et al., 2013), localization and navigation (Cha et al., 2013; Du Buf et al., 2011; Varadarajan et al., 2014; Nakajima and Haruyama, 2012) or object detection (Du Buf et al., 2011; Tapu et al., 2013). Few works consider issues related to the architecture of a computational Assistive technology (Ghorbel et al., 2015; Murua et al., 2011; Shojanoori et al., 2014).

We also observe that most of the works propose the development of electronic gadgets for a specific target application (Jain, 2014; Tang and Li, 2014; Treuillet and Royer, 2010). This approach has the drawback that it usually result in a costly system with limited application scope. On the other hand, we defend the use of general purpose devices, largely accessible to a wide range of the population (e.g. smartphones, tablets), like in the works of (Cha et al., 2013; Tapu et al., 2013).

Finally, we observe that few works works focus on web based technologies (Murua et al., 2011; Cha et al., 2013) which could expand the available computational resources. Most works are based in local processing.

3. ARCHITECTURE

The proposed architecture can be divided in three main components as shown in Figure 2. The client device is responsible for the user interface as well as sensor data acquisition. The Publish-Subscribe middleware provides secure communication and the Helpers provide accessibility functionalities by receiving the data sent by the client, processing it, and sending back a text message to help the user. More details about each component is provided next.

3.1 Client Device

This component is responsible for providing an accessible interface to the user and for managing data acquisition from sensors attached to the device. The device will be composed of a hardware and a software part. The hardware can be, for example, a tablet (as implemented in our study-case), a smartphone or a dedicated device developed over Raspberry Pi board. Meanwhile, the software will be specifically developed to provide accessible user interface and other functionalities.

The sensors available may vary among devices. Common sensors available in most smartphones and tablets include GPS, camera, microphone, accelerometer, light sensor, etc. Depending on the functionality, the data from these sensors may be requested continuously, generating a data