Lightweight Smart Glass System with Audio Aid for Visually Impaired People

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***Abstract*—In this paper, we present a new smart glass system for people who are blind or have low vision. Individuals with visual disability are difficult to communicate effectively with their environment. The blind or visually impaired rely largely on their other senses such as hearing, touch, and smell in order to understand their surroundings. It is pretty hard for them to go out alone, not to mention finding toilets, subway stations, restaurants and so on. Giving blind people the great accessibility to their environment is the objective of the smart glass system. This smart glass system can see the world for them and give voice instructions and hints through wireless bone conduction headphones. This smart glass system will help visually impaired people gain increased independence and freedom in city life. And we have implemented an application of public signs recognition on the smart glass system. This application can detect and recognize the public signs in cities, and give corresponding voice hints to the blindness. The proposed prototype system is based on Intel Edison, and the application in the system is written in C++ with libraries of OpenCV. Extended demonstration of the system will be presented to show how the system helps the blindness "see the world" .**

Keywords*—Smart glass system, Intel Edison, blindness, public signs recognition

I. Introduction

According to the WHO (World Health Organization) report, as of 2012 there were 285 million people estimated to be visually impaired worldwide, of which 246 million had low vision and 39 million were blind. The majority of people with poor vision are in the developing world and over the age of 50 [1]. Individuals with a visual disability are difficult to communicate effectively not only with ordinary people, but also with their environment. Blind people can have difficulty interacting with their environment, because it can be hard to perceive where someone is and to get from one place to another place. Movement can become restricted, leading to having little contact with the surrounding world. The blind or visually impaired rely largely on their other senses such as hearing, touch, and smell in order to understand their surroundings. Blindness is often a great obstacle of their living life. It is pretty hard for them to go out alone, not to mention finding toilets, subway stations, restaurants and so on. However, there are not many products that can help the visually impaired people in city life. If the visually impaired people can "see" the world with the help of other devices, they will gain increased independence and freedom in city life, and this is precisely why we built such a smart glass system.

The proposed smart glass prototype system is based on Intel Edison. The Intel Edison [2] is a tiny computer offered by Intel as a development system for wearable devices. Its dimensions are $35.5 \times 25 \times 3.9mm$, with components on both sides. The board's main SoC is a 22 nm Intel Atom "Tangier" (Z34XX) that includes two Atom Silvermont cores running at 500 MHz and one Intel Quark core at 100 MHz (for executing RTOS ViperOS). The SoC has 1 GB RAM integrated on package. There is also 4 GB eMMC flash on board, Wi-Fi, Bluetooth 4 and USB controllers [3]. Edison is powerful in computing but small in shape which makes it perfect to build a wearable device.

Fig. 1: Snapshot of the prototype smart glass.

Public signs in cities can act as guides for people. Following the public signs, people can find public infrastructure, such as public toilets, bus stations, subway stations, hotels and so on. So finding and recognizing the public signs outsides would help someone who is blind or visually impaired gain increased independence and freedom. So we have implemented an application of public signs recognition in this developed smart glass system. This application can automatically detect, analyse and recognize all kinds of public signs around the blindness and visually impaired and give corresponding voice hints through wireless bone conduction headphones. With the help of this smart glass system, the blindness may find bus stations, subway stations, restaurants, hotels and so on. The blindness may even go for a trip alone. Fig. 1 is the snapshot of the glass. As you can see, the smart glass is lightweight, convenient for the blind users. The paper is organized as follows. In Section 2, we present the design of the smart glass system. Section 3 introduces the experiment results. And Section 4 concludes our work.

II. System Design

The smart glass system design contains two parts: hardware design and software design. And The block diagram of the

978-1-4799-8641-5/15/$31.00

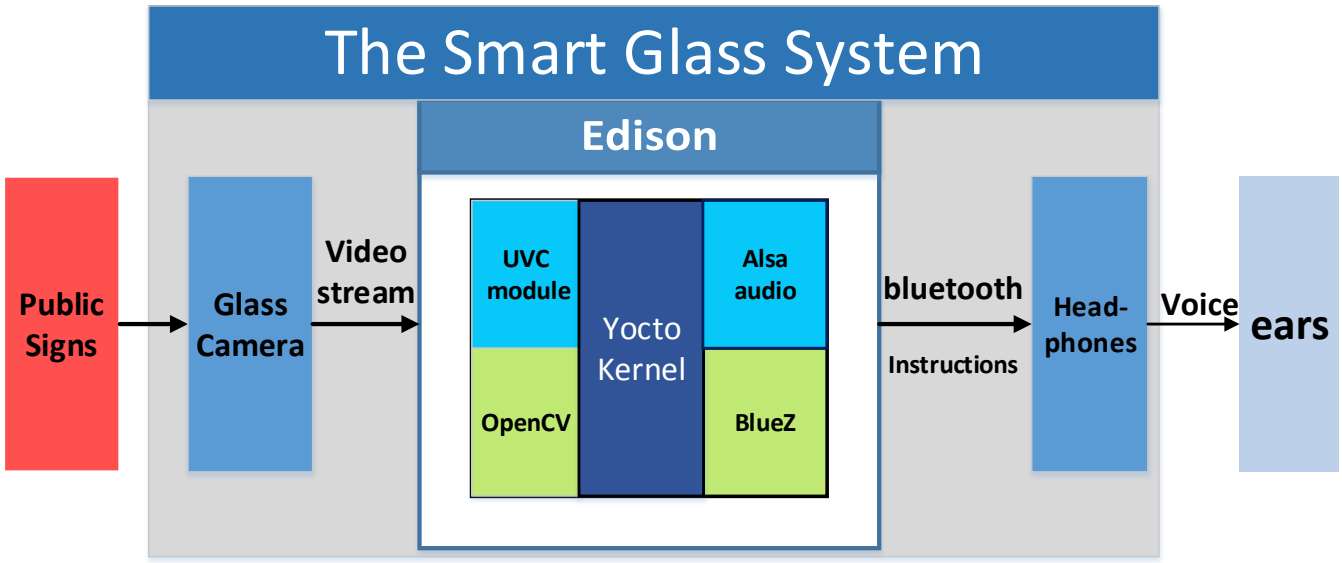

Fig. 2: The block diagram of the system.

Fig. 3: Intel Edison .

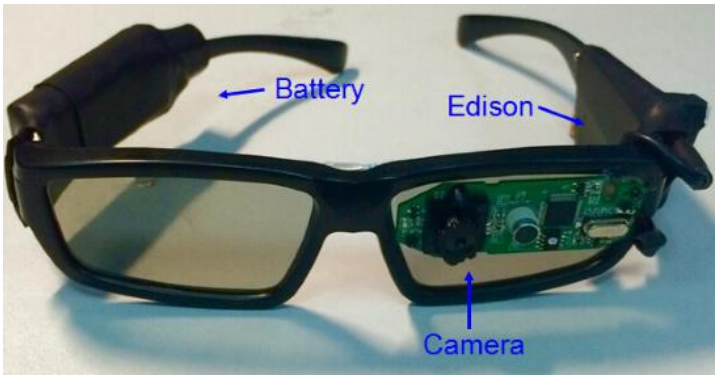

Fig. 4: Smart Glass .

system is in Fig. 2. As the system block diagram shows, the HD camera on the glass catches the video stream around the blind, and then transfers it to the Intel Edison chip. When Edison gets the video stream through UVC module, Yocto kernel calls the Opencv functions to analyze and process the images. When the system matches the public signs, Yocto kernel would give corresponding instructions according to the matched signs. And the system would call the Bluez module and Alsa audio module to transform the instructions to voice through wireless bone conduction headphones.

A. *Hardware design*

In hardware design, we built the smart glass system using Intel Edison breakout board as Central Processing Unit on one side of the smart glass. Edison combines a small, cheap, powerful, adaptable hardware platform and partner-enabled ecosystem with extended software compatibility and supportive online environment. Edison has integrated Wi-Fi, bluetooth Low-Energy* (LE), memory, and storage simplifies configuration and increases scalability. Fig. 3 shows the Intel Edison chip. As you can see, it's really small and suitable to build wearable devices. It's high performance and dual core CPU make it powerful in computing and processing data, so we use this chip to make complex image processing. Fig. 4 shows the prototype of the smart glass. Besides, we have a high digital camera in front of the glass. The smart glass is powered by the 7.4 voltage lithium battery, the battery is on the next side of the smart glass. The whole device is just like a normal sunglass. It's lightweight, easy for the blind to use. And The Edison runs the Linux based system which is provided by the Yocto project [4]. We set up Opencv 2.4.9 on Edison. The video stream will be captured by camera in front of the glass. Then the video stream will be transferred to Intel Edison, and processed into the Yocto system. When finding the public signs, the smart glass gives hints with a voice through the bluetooth bone conduction headphones.

B. *Software design*

In software design, programs were written in C++ language, and the integrated development environment (IDE) of Eclipse was used to cross-compile programs for Yocto Embedded Systems, OpenCV was also used to implement

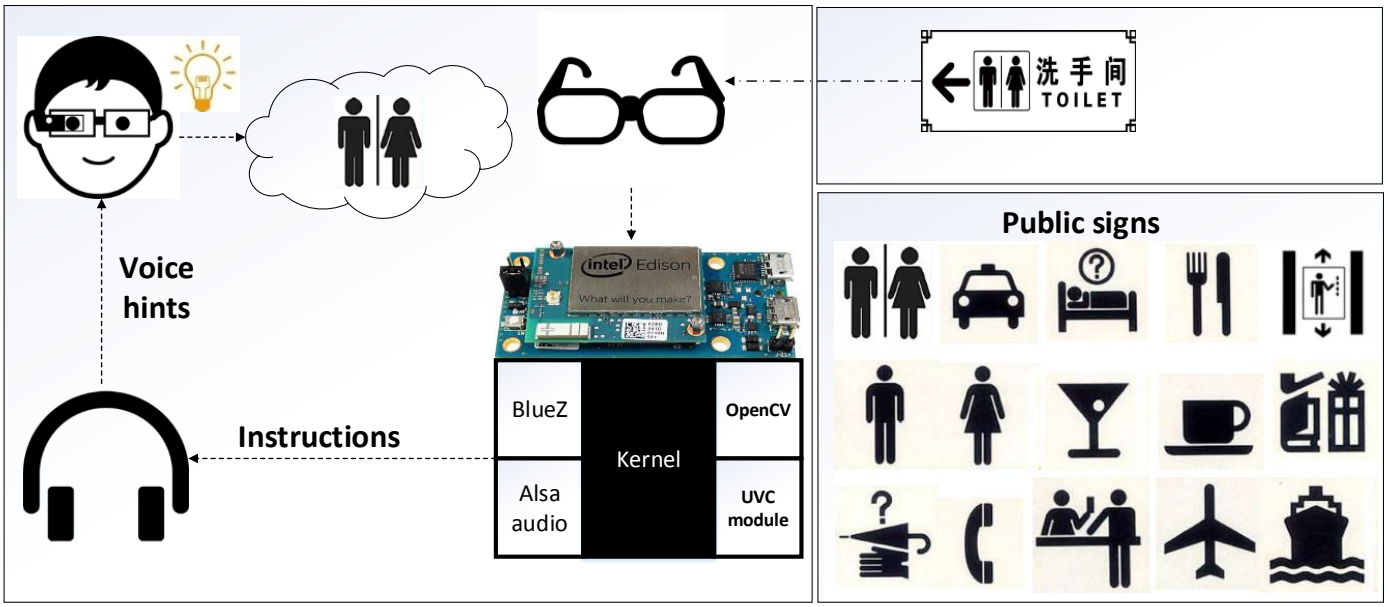

Fig. 5: Demonstration and snapshot of the prototype smart glass system.

the system. OpenCV is an open source library containing more than 500 optimized algorithms for image and video analysis [5]. We have implemented an algorithm in the Intel Edison to achieve the real time public sign match.

In the aspect of sign detection and recognition, we notice that the public signs are usually designed with unnatural color and shape, making them conspicuous and well-marked. Color-based and shaped-based method are the initial and simplest ones to be used for sign root detection [6] [7], but these methods are usually sensitive to the environment. So we use recognition algorithm based on feature extraction and description. Scale-Invariant Feature Transform (SIFT) [8] and Speeded-Up Robust Features (SURF) [9] are the most famous two algorithms in image recognition research field. SIFT detects interest points in different scale by image pyramid, and calculates a set of orientation histograms around one key point. Because SIFT feature matching algorithm has strong ability to match two images, it can handle matching problems such as translation, rotation, affine transformation between two images. Although SIFT has good performance, creating image pyramid take a lot of time. In order to speed up the computation time, SURF uses integral images instead of image pyramid. SURF algorithm is one of the best feature-based algorithms and has been widely used in computer vision applications [10] [11]. SURF algorithm is achieved by relying on integral images for image convolutions; by building on the strengths of the leading existing detectors and descriptors; and by simplifying these methods to the essential. This leads to a combination of novel detection, description, and matching steps [12]. We use the famous matching algorithm speeded-up robust features (SURF) to implement the real time sign recognition.

Public signs recognition contains three main steps: the first one is interest point detection, the second step is interest point description feature vector extraction, and the third is feature vector matching between two images. We have trained some usual public signs, then detected training interest points and extracted training interest point descriptors. After initializing and opening the HD camera in front of the glass, the grabbed video frames will be transferred to the edison chip, the algorithm detects interest points of each frame, and extract descriptions, and match query points with training points in database, if the numbers of matching points are more than the threshold, we believe the public sign is matched. Fig. 7 shows the algorithm flow chart.

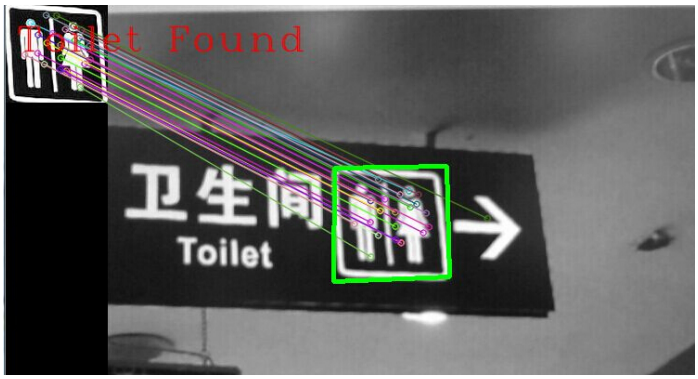

Fig. 6: Sign recognition result .

The algorithm extracts the key points and key feature vectors of the object sign, so it can recognize the signs with specific features no matter the signs is built in or not. Fig. 6 shows the recognition result. Because Edison has rich resources for computations and convenient access to local memories, the SURF algorithm can also run smooth and achieve real time sign recognition. When the system matches the public signs, it will give the corresponding instructions and hints with a voice. Fig. 5 shows how the smart glass system works, and some of the sign images in the database.

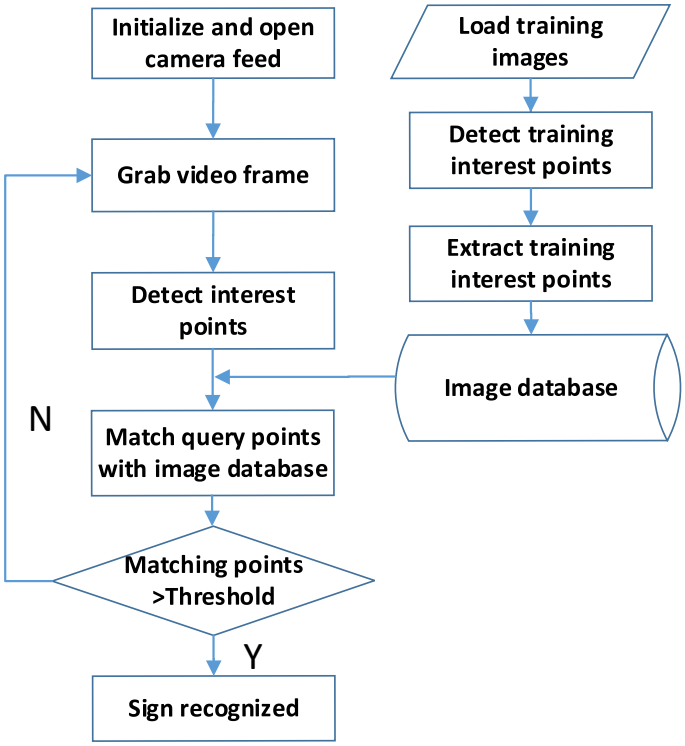

Fig. 7: Algorithm flow chart.

III. Result

We have tested some common public signs, almost all the signs can be detected and recognized instantly. Select a toilet corresponding feature database, and then start the recognition threads. Fig. 6 and Fig. 8 shows the recognition result in the real situation. During demonstration, when the camera on the glass captures the public sign, there will be corresponding voice hints in the headphones guiding the blindness to find the public infrastructure. The smart glass is lightweight, portable, and convenient for users. Users are easy to use the smart glass.

IV. Conclusion

The paper introduces a prototype system of lightweight smart glass for visually impaired people. We demonstrated how the smart glass was designed, including hardware design and software design. And we have implemented many excellent image processing, object recognition algorithms on the new lightweight smart glass system. This system can detect and recognize the object in real time. The smart glass would be useful for the visually impaired people in their city life. And in the soon future, we will implement more useful applications in the smart glass system, such as talking to wikipedia, google, voice guidance and etc..

V. Acknowledgement

This work was supported in part by NSFC (61422112, 61331014, 61371146).

Fig. 8: Sign match result .

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