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Addressing the challenges of Visually Impaired using IoT

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***Abstract*—** Internet of Things is a new revolution of the Internet. IoT allows networked objects to be sensed and controlled remotely, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in reduced human intervention. People with complete blindness or low vision often have a difficult time self-navigating in unusual environments. In fact, mobility is one of the biggest challenges for visually Impaired.

IoT offers the assistance and support to the visually impaired people to achieve a quality life allowing them to involve in social activities. Assistive IoT technologies are powerful tools to increase independence and improve participation. Therefore, the purpose of this paper is to analyze how people with visual impairment can interact with and benefit from the IoT.

***Keywords*-** *Internet of Things (IoT), visually impaired, assistive technology, sensors, actuators, mobility*.

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I. INTRODUCTION

The Internet of Things [Fig.1] represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where it can be processed and utilized for various interesting purposes.

Fig. 1 Internet of Things

Some of the practical and realistic applications of IoT include:

- receiving warnings on your phone or wearable device when IoT networks detect some physical danger nearby.
- self-parking automobiles
- automatic ordering of groceries and other home supplies
- automatic tracking of exercise habits and other day-to-day personal activity including goal tracking and regular progress reports

Potential benefits of IoT in the business world include:

- location tracking for individual pieces of manufacturing inventory
- fuel savings from intelligent environmental modeling of gas-powered engines
- new and improved safety controls for people working in hazardous environments

We believe that IoT can enhance the mobility of visually impaired people in a wider range of travel activities, getting knowledge of surroundings using public transportation, navigation, etc. by utilizing mobile devices without requiring additional dedicated hardware or expensive equipments such as a Braille keyboard [1].

One of the most challenging issues faced by the visually impaired is the achievement of independent mobility , mostly depends on visual cues—traffic lights, road signs, landmarks, obstacles on sidewalks, etc. The inability or the decreased ability to go out alone imposes significant difficulties in their daily lives—work, shopping and other facilities. According to the World Health Organization, as of 2014, an estimated 285 million people are visually impaired worldwide [2]. Visual impairment can be prevented or treated, with cost-effective measures. It is projected that without timely and appropriate measures to control blindness, the current level of blindness would double by 2020, resulting in economic losses of close to US$150 billion to US$250 billion[3].

II. IOT ARCHITECTURE

A typical IoT solution is characterized by many devices that may use some form of gateway to communicate through a network to an enterprise back-end server that is running an IoT platform that helps integrate the IoT information into the existing enterprise. The roles of the devices, gateways, and cloud platform [Fig.2] are well defined, and each of them provides specific features and functionality required by any robust IoT solution.

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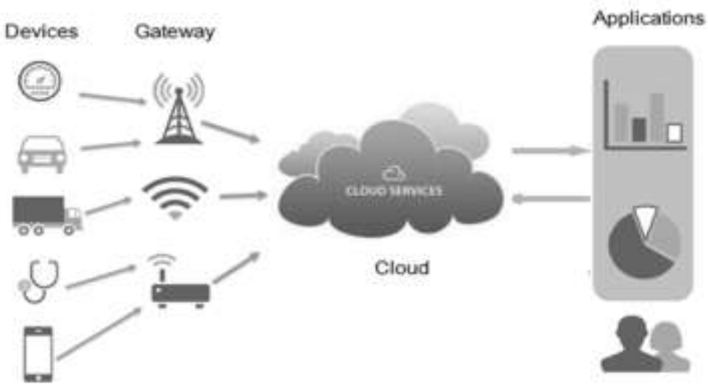

Fig. 2 IoT Architecture

A. Devices - Sensors and Actuators

The “Thing” in the IoT is the starting point for an IoT solution. It is typically the originator of the data, and it interacts with the physical world. Things are often very constrained in terms of size or power supply. Therefore, they are often programmed using microcontrollers that have very limited capabilities. The microcontrollers powering IoT devices are specialized for a specific task and are designed for mass production and low cost.

B. Gateways

The IoT gateway acts as the aggregation point for a group of sensors and actuators to coordinate the connectivity of these devices to each other and to an external network. An IoT gateway can be a physical piece of hardware or functionality that is incorporated into a larger “Thing” that is connected to the network. For example, an industrial machine might act like a gateway, and so might a connected automobile or a home automation appliance. An IoT gateway will often offer processing of the data “at the edge” and storage capabilities to deal with network latency and reliability. For device to device connectivity, an IoT gateway deals with the interoperability issues between incompatible devices. A typical IoT architecture would have many IoT gateways supporting masses of devices.

C. IoT Cloud Platforms

The IoT Cloud Platform represents the software infrastructure and services required to enable an IoT solution. An IoT Cloud Platform typically operates on a cloud infrastructure (e.g. OpenShift, AWS, Microsoft Azure, Cloud Foundry) or inside an enterprise data center and is expected to scale both horizontally, to support the large number of devices connected, as well as vertically to address the variety of IoT solutions. The IoT Cloud Platform will facilitate the interoperability of the IoT solution with existing enterprise applications and other IoT solutions.

Across the different stacks of an IoT solution are a number of features that need to be considered for any IoT architecture, including

1. *Security* – Security needs to be implemented from the devices to the cloud. Features such as authentication, encryption, and authorization need be part of each stack.
2. *Ontologies* – The format and description of device data is an important feature to enable data analytics and data interoperability. The ability to define ontologies and metadata across heterogeneous domains is a key area for IoT.
3. *Development Tools and SDKs* – IoT Developers will require development tools that support the different hardware and software platforms involved.

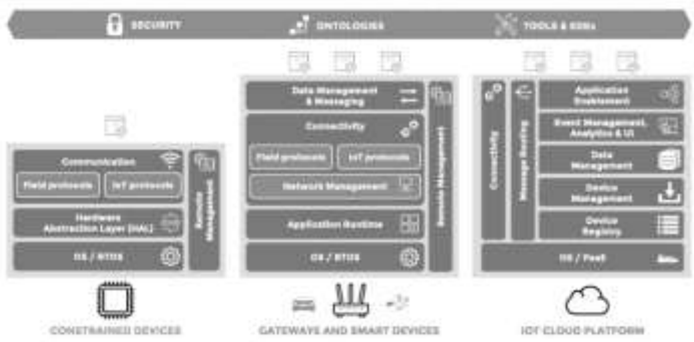

Fig. 3 IoT Cross Stack Functionality

III. KEY CHARACTERISTICS FOR IOT

The fundamental characteristics of the IoT are as follows [4]:

1. *Interconnectivity:* With regard to the IoT, anything can be interconnected with the global information and communication infrastructure.
2. *Things-related services:* The IoT is capable of providing thing-related services within the constraints of things, such as privacy protection and semantic consistency between physical things and their associated virtual things. In order to provide thing-related services within the constraints of things, both the technologies in physical world and information world will change.
3. *Heterogeneity:* The devices in the IoT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks.
4. *Dynamic changes:* The state of devices change dynamically, e.g., sleeping and waking up, connected and/or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically.
5. *Enormous scale:* The number of devices that need to be managed and that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet.

Even more critical will be the management of the data generated and their interpretation for application purposes.

This relates to semantics of data, as well as efficient data handling.

6. Safety: As we gain benefits from the IoT, we must not forget about safety. As both the creators and recipients of the IoT, we must design for safety. This includes the safety of our personal data and the safety of our physical well-being. Securing the endpoints, the networks, and the data moving across all of it means creating a security paradigm that will scale.

7. Connectivity: Connectivity enables network accessibility and compatibility. Accessibility is getting on a network while compatibility provides the common ability to consume and produce data.

IV. CHALLENGES FACED BY VISUALLY IMPAIRED

Blind people confront a number of visual challenges every day – from reading the label on a frozen dinner to figuring out if they're at the right bus stop [5]. Blindness may result from a disease, injury or other conditions that limit vision. Legal blindness means that a person has vision that measures 20/200 or worse, explains the Iowa Department for the Blind [6]. For example, someone with 20/200 vision sees an object from 20 feet that a person with perfect 20/20 vision is able to see from 200 feet. Knowing the challenges blindness creates may help sighted people understand what blind people face each day.

A. Environmental

People with complete blindness or low vision often have a difficult time self-navigating outside well-known environments. In fact, physical movement is one of the biggest challenges for blind people, explains World Access for the Blind. Traveling or simply walking down a crowded street may pose great difficulty. Because of this, many people with low vision will bring a sighted friend or family member to help navigate unknown environments. As well, blind people must learn every detail about the home environment. Large obstacles such as tables and chairs must remain in one location to prevent injury. If a blind person lives with others, each member of the household must diligently keep walkways clear and all items in designated locations.

B. Social

Blindness causes considerable social challenges, usually in relation to the activities in which a blind person cannot participate. All too frequently, blindness affects a person's ability to perform many job duties, which severely limits her employment opportunities, explains the World Health Organization. This may not only affect a person's finances, but also her self esteem. Blindness may also cause difficulties with participating in activities outside of a workplace, such as sports and academics. Many of these social challenges limit a blind person's ability to meet people, and this only adds to low self esteem.

C. Technology

Technology poses a challenge for blind people as well. For example, a blind person cannot read the information on a web page. Searching the internet requires screen reading software will read the information on a website, but this may require a significant amount of time to learn the process. People who have limited vision may have difficulty with viewing websites as well, particularly the small fonts, icons and screen colors used by many sites. People with low vision may require special equipment that can enlarge a screen significantly. Other technology, such as music players that require visual selection of music, or text messages, will also cause challenges for blind people.

V. IOT FOR VISUALLY IMPAIRED

From the technical perspective, the proposed IoT architecture for visually impaired is shown in Fig. 4. The three basic layers and their functionalities are as follows.

A. Perception layer: This layer consists of sensors and actuators, monitoring stations such as (cell phone, tablet, PC, smart phone, PDA, etc.), nano-nodes, RFID tags, readers/ writers to identify objects and gather information.

B. Network layer: This layer transmits information obtained from the perception layer. It mainly comprises converged network made up of wired/wireless privately owned networks, Internet, network administration systems, etc.

C. Application layer: This layer satisfies the needs of the users with the help of intelligent solutions that make use of the IoT technology.

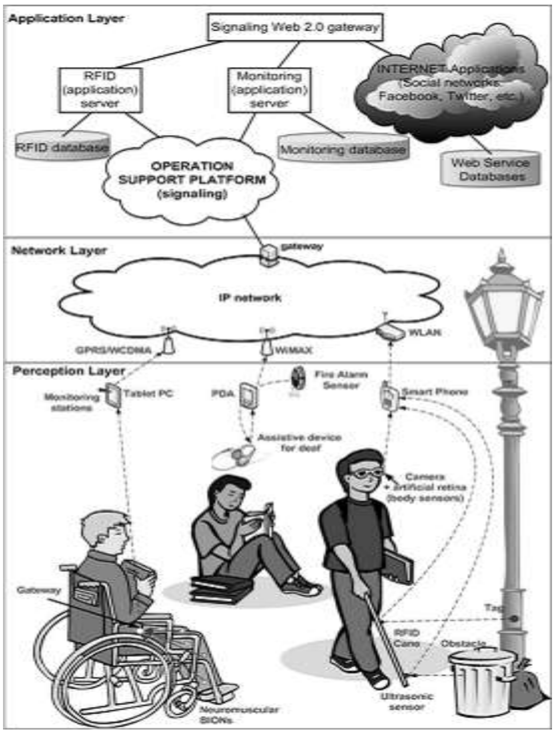

Fig. 4 IoT for Visually Impaired

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VI. IoT ENABLED SOLUTION FOR VISUALLY IMPAIRED

Some possible solutions for visually impaired using IoT are as follows.

A. Body micro-and nano-sensors.

A retinal prosthesis is developed to restore some vision to patients affected by retinitis pigmentosa and age-related macular degeneration, two diseases that cause degenerative blindness. A camera mounted on a pair of glasses can be used to transmit image data to an implant attached to the retina, which is formed by an array of body micro-sensors. This artificial retina uses electrical impulses to stimulate the appropriate ganglion cells, which convert these electrical impulses into neurological signals. The generated response is carried via the optical nerve to the brain. Bio-Retina [Fig. 5] is designed to replace the damaged photoreceptor in the eye with the equivalent of a 5000pixel(second generation)retinal implant. It transforms naturally received light into an electrical signal that stimulates the neurons, which send the images received by Bio-Retina to the brain. The implant's nano-sized components are powered by a special pair of activation eyeglasses.

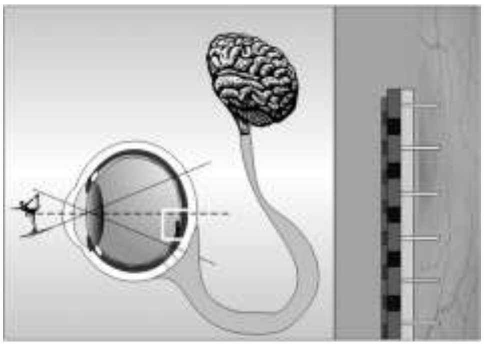

Fig. 5 – Positioning of the retinal implant (left); bionic chip and its interface with the retina (right).

B. RFID-based assistive devices

An essential RFID-based application is the navigation system. It helps blind people find their way in an unfamiliar area. RFID tags are distributed through the area. They can be placed in the center of the sidewalks to orient the blind person and prevent possible falls near the border of the sidewalk. The RFID cane [Fig. 4] has a tag reader with an antenna that emits radio waves; the tags respond by sending back their stored data, hence identifying the location of the blind person. The tag reader (RFID cane) transmits via Bluetooth or ZigBee the data read from the RFID tag, which includes the tag ID string. This data is sent from the monitoring station through the network layer to the RFID server of the application layer. The blind person can record the destination's name as a voice message using the monitoring station. Directions are received by the monitoring station and played as voice messages.

C. Computer Vision Based Assistive Technology Systems

The Vibratory Belt along with the Virtual White Cane [7] can be used to enhance the visually impaired user's mobility. The Virtual White Cane combines a laser pointer and smart phone to simulate a cane [Fig 6a]. The laser aligns with the camera to generate a baseline (*tx*) and pan angle (α) [Fig. 6b].

Fig.6a Virtual White Cane

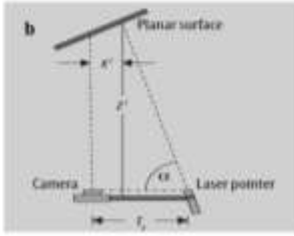

Fig. 6b Triangulation to measure the object's distance

The camera captures the laser's reflection off the planar surface, which become input to a smart phone application that uses active triangulation to calculate the object's distance from the user. The application then uses the Smartphone's vibration to alert the user to the object's proximity.

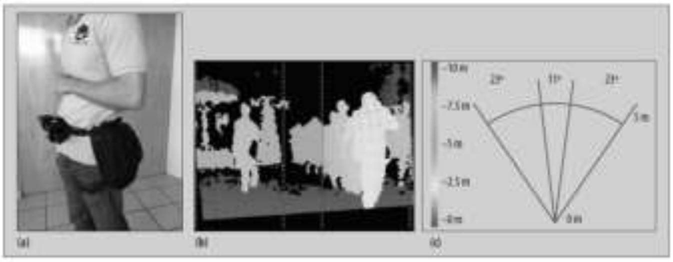

Fig. 7 Vibratory Belt. (a) Complete prototype worn by the user, (b) depth map that the camera inputs to the embedded computer, and (c) obstacle map showing the position in degrees (horizontal axis) and the distance in meters (vertical axis)

Fig.7a shows a user wearing the Vibratory Belt, which contains a camera connected to an embedded computer, an inertial measurement unit (IMU), and three small vibrating motors. The camera provides depth images, such as that in Fig.7b, and the computer calculates the distance of the closest obstacles in three positions in front of the user, as in Fig.7c. To separate the floor from the objects, the IMU calculates the camera's orientation. Both the Virtual White Cane and the Vibratory Belt rely on a haptic interface to provide feedback to the user.

CONCLUSION

In this paper, an overview of the available IoT solutions for visually impaired people is provided. A variety of assistive technologies for assisting the visually impaired were analyzed.

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This analysis helps in choosing an optimal aid for the blind. These suggested techniques remain wide open for future investigation.

References

[1] Jee-Eun Kim, Masahiro Bessho, Noboru Koshizukaand Ken Sakamura, Mobile Applications for Assisting Mobility for the Visually Impaired Using IoT Infrastructure Interfaculty Initiative in Information Studies, The University of Tokyo. YRP Ubiquitous Networking Laboratory. {kim, besshy, koshizuka, ken}@sakamura-lab.org

[2] WTO: Visual impairment and blindness. World Health Organization. http://www.who.int/mediacentre/factsheets/fs282/en/

[3] Rohit Khanna MBBS DO MCEH, Usha Raman PhD, Gullapalli N Rao MD, Blindness and poverty in India: the way forward. http://onlinelibrary.wiley.com/doi/10.1111/j.1444-0938.2007.00199.x/full

[4] Keyur K Patel1, Sunil M Patel, PG Scholar, Assistant Professor, Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges, Department of Electrical Engineering Faculty of Technology and Engineering-MSU, Vadodara, Gujarat, India

[5] Erin Brady , Meredith Ringel Morris , Yu Zhong , Samuel White, and Jeffrey P.Bigham, Visual Challenges in the Everyday Lives of Blind People, http: //www.cs.cmu.edu/~jbigham/pubs/pdfs/2013/ visualchallenges.pdf

[6] Kate Beck, Challenges that blind people face, http://www.livestrong.com/article/241936-challenges-that-blind-people-face/

[7] Juan R. Terven and Joaquín Salas, *Instituto Politécnico Nacional*, *Mexico*, Bogdan Raducanu, New Opportunities for Computer Vision– Based Assistive Technology Systems for the Visually Impaired, Computer Vision Center, Spain

[8] Dr. Ovidiu Vermesan, SINTEF, Norway, Dr. Peter Friess, EU, Belgium, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems

[9] The Three Software Stacks Required for IoT Architectures IoT software requirements and how to implement them using open source technology http://insights.ubuntu.com/wp-content/uploads/4a5b/Eclipse-IoT-White-Paper-The-Three-Software-Stacks-Required-for-IoT-Architectures.pdf?utm_campaign=Device_FY17_IOT_Vertical_EG&utm_medium=edgegatewaycontentblock&utm_source=ubuntuwebsite&utm_content=eclipsewhitepaper

[10] Siddesh G M, Manjunath S,Srinivasa K G, Application for Assisting Mobility for the Visually Impaired using IoT Infrastructure, Department of ISE , M S Ramaiah Institute of Technology, India, Bangalore- 560054