



A Study on Developments in Assistive Device Technology with Advent of IoT

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Abstract— *In today's fast growing technology driven world, Internet has become indispensable part of our daily lives. From applications providing services like cab booking online facility within minutes to healthcare updates and tips, weather updates to online shopping on smart devices, we remain connected to the Internet most part of the day. Internet-Of-Things is propelling this sustenance and dependency further. According to statistics published in 2011 by WHO Over 15 percent of population i.e. more than 1 billion persons in the world have some form of disability. Technology giants like Google, Microsoft are channelizing efforts so that this part of our community too benefit from the wave of Internet-of-Things.. This paper aims at surveying the devices in field of Assistive and Adaptive Technologies that are already available in market or under research and/or can be IoT driven for enabling the uniform opportunity and achieving the successful objective of Internet-Of-Things.*

Keywords— *Internet-of-Things, Assistive Technology Devices, Adaptive Technology, Accessible Technology, Smart Scooter, Smart walker*

I. INTRODUCTION

The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. It is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human. It has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), microservices and the internet. The convergence has helped tear down the silo walls between operational technology (OT) and information technology (IT), allowing unstructured machine-generated data to be analyzed for insights that will drive improvements human-to-computer interaction. IPv6's huge increase in address space is an important factor in the development of the Internet of Things.

II. IOT FOR DISABILITY SUPPORT

A disability is any physical, sensory, or cognitive impairment that makes daily activities more difficult. Many people are born with a disability. Others acquire a disability later in life, from an accident, an illness, or the aging process. Many older individuals are diagnosed with chronic conditions that lead to functional or cognitive disabilities. In the United States, for example, about 15 percent of people over the age of 65 require some form of assistance with their basic daily activities.² For much of history, many people with disabilities have had to rely on technologies that were designed for the nondisabled community. Even technology specifically designed for people with disabilities—such as Braille text for people with a visual impairment or text telephones (TTY) for people with a hearing disability—could require a high learning curve, be limited in availability, or have a high cost because of its specialized nature. Recently, however, the shift from analog technology to digital technology has eliminated many of these barriers. The reason is simple: digital information can easily be converted into voice, text, or even physical patterns (e.g., Braille), allowing the development of many more low-cost, readily available general purpose devices that also can be used by people with disabilities. The digital era has led to many advances in technology that have directly improved the quality of life for the disabled community. As discussed below, technology that improves accessibility for people with disabilities generally falls into three categories:

- A) Assistive technology (technology designed specifically to improve a disabled person's functional capabilities)
- B) Adaptive technology (technology that provides a mechanism that allows people with disabilities to use technology that would otherwise be inaccessible to them)
- C) Accessible technology (technology that has many broad applications but helps remove barriers and make the world more accessible for people with disabilities)

III. TECHNOLOGIES FOR DISABILITY

A. Assistive Technology

Assistive technology for individuals with disabilities is technology designed to improve the functional capabilities of such individuals. It includes a wide range of devices and services, including IT-enabled prosthetics and implants, custom computer interfaces and accessible communication tools. In the medical arena, researchers have designed IT-enabled devices for people with disabilities that radically increase their functional capabilities, including improved hearing for individuals with hearing disabilities and improved vision for people with visual disabilities. In addition, IT provides people with disabilities with many new tools to use to assist them in their daily lives.

B. Adaptive Technology

Adaptive technology is technology that provides a mechanism that allows people with disabilities to use technology that would otherwise be inaccessible to them. Because it makes information accessible in more ways and formats, IT is playing an important role in improving access to information among individuals with visual and hearing disabilities. Text-to-speech technology, for example, helps users with vision impairments to be able to “read” materials that are written. Computer screen readers, such as JAWS, and screen magnifiers help make computer output accessible for visually impaired users.

C. Accessible Technology

Accessible technology is technology that has many broad applications but helps remove barriers and make the world more accessible for people with disabilities, giving them more access to information, communication, and independence. The fact that digital information can easily be converted into voice, text, or even physical patterns has led to the development of many low-cost, readily available general purpose devices that also can be used by people with disabilities. Many accessible technologies were not originally designed to address specific disabilities but were rather adapted for them. Speech recognition software, for example, has many uses such as dictation or automated telephone systems; however, the technology can also provide independence for quadriplegics by allowing them to control a computer with their voice. Similarly, a German research institute designed a hands-free computer interface for computers in an industrial setting that uses eye movement to control a cursor; the researchers quickly realized the technology’s usefulness for quadriplegics.

TABLE 1
ASSISTIVE DEVICES STUDY -MOBILITY IMPAIRMENT

SNO	BASIC DEVICE	USE	IoT DRIVEN DEVICE	AVAILABILITY AND COST
1	Wheelchairs	Wheelchairs are devices that can be manually propelled or electrically propelled and that include a seating system and are designed to be a substitute for the normal mobility that most people enjoy.	Permobil's wheelchair is an apt illustration of the concept of the Internet of Things, the notion that virtually every product around us will one day be online and communicate with us and with other products. The wheelchair taps a cellular connection to relay results of diagnostic tests, fire off an alert if it has fallen over and let family members track a loved one.	In CTIA wireless industry conference a motorized wheelchair built by Sweden's Permobil was demonstrated. This wheelchair, a modified version of the company's roughly \$35,000 flagship F5 model, hooks up to the Internet through an AT&T connection.
2	Scoters	A scooter is useful for persons without the stamina or arm/shoulder flexibility necessary to use a manual wheelchair. Also, swivelling the seat of an electric scooter is generally easier than moving the foot supports on most conventional wheelchairs. A mobility scooter is very helpful for persons with systemic or whole-body disabling conditions (coronary or lung issues, some forms of arthritis, obesity, etc.) who are still able to stand and walk a few steps, sit upright without torso support, and control the steering tiller.	The autonomous self-driving mobility scooter works by allowing users to stay connected to the Internet and browse as much as they want without having to pay attention to where they're going. Reaching a maximum speed of 4mph, the autonomous self-driving mobility scooter uses as series of laser sensors that allow it to navigate through areas and avoid obstacles. The mobility concept has been deemed successful for being able to help reduce the instance of accidents	Created as a mobility concept by a team of researchers at the National University of Singapore, the autonomous self-driving mobility scooter enables users to never stop using their digital devices. In addition to the convenience of being connected to Internet one can further be using more assistive devices too. These devices are still not under production and are under study.

			<p>between pedestrians. Moreover, the autonomous self-driving mobility scooter helps to reduce the need for traditional cars in urban areas and campuses as well.</p>	
3	Walkers	<p>A walker or walking frame or Rollator is a tool for disabled people who need additional support to maintain balance or stability while walking. It consists of a frame that is about waist high, approximately twelve inches deep and slightly wider than the user. Walkers are also available in other sizes, such as for children, or for heavy people. Modern walkers are height-adjustable.</p>	<p>From Technical Research Centre of Finland (VTT), Researchers have developed a smart walker prototype that supports independent living among the elderly by making the traditional walker smart. They have retrofitted it with sensors and digital software that analyze user's physical condition and daily activities. This allows the device to collect useful information on user's daily rhythm, walking distances, duration and speed of walking, in addition to hand grip strength. Such information can then be used to monitor user's wellbeing and physical condition.</p> <p>Also Furtwangen University developed "IoT Walker" and "IoT Wheelchair" using PTC's ThingWorx. The "IoT Wheelchair" and the "IoT Walker" are being developed to include a Raspberry Pi microprocessor that will connect to the cloud and thus to PTC's ThingWorx- an application development platform for the IoT.</p>	<p>Prototype developed by couple of universities are driving the research further to improvise and provide marketable Smart walkers.</p>
4	Canes	<p>A white cane is used by many people who are blind or visually impaired. Its primary uses are as a mobility tool and as a courtesy to others, but there are at least five varieties, each serving a slightly different need.</p>	<p>SmartCane™ device is an electronic travel aid which fits on the top fold of the white cane. It serves as an enhancement to white cane and overcomes its limitations by detecting knee above and hanging obstacles. For safe mobility, it is important that such obstacles are detected early. The cane has other uses as a spatial awareness device as it can detect presence/absence of objects in the surroundings. Further, as compared to the white cane, the detection</p>	<p>Developed as a university project, taken over by Phoneix medical System(P) Ltd, India is available in market.</p>

			distance is increased from 0.5 meters to 3 meters. It informs about the presence of objects before actually touching the object with the cane and thus helps in preventing unwanted contact. This avoids socially awkward situations like collision with people while walking or unsafe collisions with animals or into trash.	
5	Crutches	A crutch is a mobility aid that transfers weight from the legs to the upper body. It is often used for people who cannot use their legs to support their weight, for reasons ranging from short-term injuries to lifelong disabilities.	INTERCRUTCH is a IoT crutch design which can assist doctors to assess injuries conditions, also easy for patient self-monitoring. In crutch, there's a pressure sensor detection, data will be recorded in APP and upload to Cloud, so doctor and health care workers can check it easily, as injuries back at clinic. Also, injuries can check their status on phone any time. Besides, patient and doctor both will know well injury condition. So if patient's condition get worse, not just doctor but the patient will notice. The analyzed data not only will assist doctor to assess and patient to self-monitoring, it also helps them communicate with each other. After collected lost of users data, we can use the machine learning to go a step further.	This product needs to be patented for production.
6	Prosthetic devices	A prosthesis, prosthetic, or prosthetic limb is a device that replaces a missing body part. It is part of the field of biomechatronics, the science of using mechanical devices with human muscle, skeleton, and nervous systems to assist or enhance motor control lost by trauma, disease, or defect.	Smart Bionic Limbs are Reengineering the Human. Scientists are building bionic limbs with machines intelligence that can sense their environment and predict a user's intentions. Smart robotics will enhance the powers of the able-bodied, too.	It is an area of on-going research.
7	Orthotic devices	Orthotics combines knowledge of anatomy and physiology, pathophysiology, biomechanics and engineering. Patients who benefit from an orthosis may have a condition such as spina bifida or cerebral palsy, or have experienced a spinal cord injury or stroke. Equally, orthoses	Sensoria Inc., a leader in wearable fitness technology, has partnered with the world's leading orthotics company to deliver the first ever IoT orthotic device. Together with Orthotics Holdings, Inc. (OHI), Sensoria will	The device is currently undergoing market studies, and was expected to be available in 2016.

		are sometimes used prophylactically or to optimise performance in sport.	debut and demo the new Smart Moore Balance Brace at Health 2.0—a global conference for healthcare technologies. The Smart Moore Balance Brace is an internet connected version of the Moore Balance Brace (MBB), a medical device which launched in 2010. The foot and ankle support was designed to help reduce the risk of falls in the elderly by improving balance and stability for its wearers, and is now getting a smart update to help clinicians monitor their patients' adherence, activity levels and gait parameters.	
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TABLE 2
ASSITIVE DEVICE STUDY- VISUAL IMPAIRMENTS

SNO	BASIC DEVICE	USE	IOT DRIVEN DEVICE	AVAILABILITY AND COST
1	Screen readers	Screen readers are software programs that allow blind or visually impaired users to read the text that is displayed on the computer screen with a speech synthesizer or braille display. A screen reader is the interface between the computer's operating system, its applications, and the user. T	Screen readers are smart are currently available for use with personal computers running Linux, Windows, and mac, IOS, Android, and more. Each screen reader incorporates a different command structure, and most support a variety of speech synthesizers too.	Prices range from free to \$1,200.
2	Braille and braille embossers	Braille is a system of raised dots formed into units called braille cells. A full braille cell is made up of six dots, with two parallel rows of three dots, but other combinations and quantities of dots represent other letters, numbers, punctuation marks, or words. People can then use their fingers to read the code of raised dots.	Using mobile Braille printing it is no longer necessary to connect your Braille embosser to a computer or to use a Braille editor. The V5 embossers introduce the Wi-Fi network port to Braille printing. This makes embossing from your smart phone possible. With the Index direct Braille function (idB) it is easy for everyone to print standard	Index Braille is the world market leader for Braille embosser production. New V5 embossers allow printing straight from mobile phone. This product is under development.

			documents such as txt, doc, docx and pdf. Index direct Braille removes a time consuming step, known as the Braille editor, from Braille embossing.	
3	Desktop video magnifier	Desktop video magnifiers are electronic devices that use a camera and a display screen to perform digital magnification of printed materials. They enlarge printed pages for those with low vision. A camera connects to a monitor that displays real time images, and the user can control settings such as magnification, focus, contrast, underlining, highlighting, and other screen preferences. They come in a variety of sizes and styles; some are small and portable with handheld cameras, while others are much larger and mounted on a fixed stand.	In contrast to stand-mounted cameras, handheld cameras are designed for bringing the camera to the material to be viewed. They can magnify almost anything within reach including labels on packages of food and medicine. Handheld cameras are often on rollers, which make them easier to move across a flat working surface. Some manufacturers of video magnifiers that use handheld cameras offer a writing stand as an accessory.	America Foundation for Blind has listed various portable CCTV technolomagnifiers available. Typically, video magnifiers that use a camera mounted on a fixed stand and xy table are in the \$1,800 to \$4,000 price range. Lower cost video magnifiers that plug into a TV are in the \$400 to \$1,000 price range.
4	Screen magnification software	A screen magnifier is software that interfaces with a computer's graphical output to present enlarged screen content. It allows users to enlarge the texts and graphics on their computer screens for easier viewing. Similar to desktop video magnifiers, this technology assists people with low vision. After the user loads the software into their computer's memory, it serves as a kind of "computer magnifying glass." Wherever the computer cursor moves, it enlarges the area around it. This	Today's full-featured screen magnifiers can magnify all items on a screen, including the mouse pointer, text cursor, icons, buttons, and title bars. The magnifiers also provide a set of mouse tracking features. Persons with considerable vision may not need a screen magnification program. Instead, they may use a larger monitor that allows for larger text or graphics while keeping all material on the screen. Larger text and graphics can be achieved by lowering the screen resolution so that	Fully featured products are already available in the market at reasonably affordable price, like UltraProLink Mobile Phone Screen Magnifier.

		allows greater computer accessibility for a wide range of visual abilities.	bigger pixels are used. Recently, screen reader manufacturers have added text-to-speech output to their products. This allows people with low vision to use a combination of magnification and speech. If a user requires primarily speech output or is losing vision, a screen reader may be a better choice.	
5	Large-print and tactile keyboards	A large-print keyboard has large letters printed on the keys. On the keyboard shown, the round buttons at the top control software which can magnify the screen (zoom in), change the background colour of the screen, or make the mouse cursor on the screen larger. The "bump dots" on the keys, installed in this case by the organization using the keyboards, help the user find the right keys in a tactile way.	Bluetooth enabled, low vision keypads are designed specifically for iPad, iPhone, and iPod devices. Nicely designed for the visually impaired. Large print keyboards are designed to help the visually impaired with their computing needs. Traditional keyboards can have small black letters on white/ivory keys that can be difficult to view and identify by many people with low vision. Bright and bold, these large print keyboards make it easy to type out a quick email to a loved one or put the finishing touches on your next bestseller. Some of the large print keyboards listed below also feature high contrast colours so that visually impaired individuals can still see the letters and numbers when they type. We offer keyboards with large bold print on the keys, some with even larger keys in addition to bold print, and large print and Braille self-adhesive stick-on key top labels for sticking onto the keys of a new or existing	These products are already in market at a reasonable price like products by LS & S , catalogue of products for the visually impaired and hard of hearing.

			keyboard. Low vision keyboard stickers are also great for when the number and letters are wearing off of your favourite keyboard.	
6	Navigation Assistance	Assistive technology for navigation has exploded on the IEEE Xplore database since 2000, with over 7,500 engineering articles written on assistive technologies and visual impairment in the past 25 years, and over 1,300 articles on solving the problem of navigation for people who are blind or visually impaired. As well, over 600 articles on augmented reality and visual impairment have appeared in the engineering literature since 2000. Most of these articles were published within the past 5 years, and the number of articles in this area is increasing every year. GPS, accelerometers, gyroscopes, and cameras can pinpoint the exact location of the user and provide information on what's in the immediate vicinity, and assistance in getting to a destination.	Lot of research is being done and number of papers are being published with solution to Smart Navigation System For Visually Impaired such as, Sensor Based Assistance System for Visually Impaired	This is ongoing research area and still there are quite a lot of navigation assistance already available over internet for free and chargeable. For example, Ariadne GPS, Be My Eyes, Blavigator, Blind Square, BrailleNote GPS, Buzzclip.

TABLE 3
ASSITIVE DEVICE STUDY- HEARING IMPAIRMENTS

SNO	BASIC DEVICE	USE	IoT DRIVEN DEVICE	AVAILABILITY AND COST
1	Hearing aids	A hearing aid or deaf aid is a device designed to improve hearing. Hearing aids are classified as medical devices in most countries, and regulated by the	Oticon has announced the launch of Oticon Opn, the first Internet of Things (IoT) hearing aid, which can be programmed to communicate directly with a full	Based on the models the products are priced and available in the market.

		<p>respective regulations. Small audio amplifiers such as PSAPs or other plain sound reinforcing systems cannot be sold as "hearing aids".</p>	<p>range of connected devices such as baby alarms, smoke detectors, and other health and safety-related technologies. According to Oticon, the Opnutilizes TwinLink™, a dual communication system that combines binaural processing with streamer-free, internet connectivity, without compromising battery life or physical size. The Opn is the first listening device compatible with the web-based service IFTTT (If This Then That), which helps to unlock potential for connected device communication. The Velox sound processing system allows Opn users to more naturally follow multiple conversations in noisy environments without using traditional directionality.</p>	
2	Assistive listening devices	<p>An Assistive listening device (ALD) is used to improve hearing ability for people in a variety of situations where they are unable to distinguish speech in noise. Often in a noisy or crowded room it is almost impossible for an individual who is hard of hearing to distinguish one voice among many.</p>	<p>There are quite lot of products and apps running on smart mobiles like below (PSAP)Mimi Hearing Amplifier (free) iOS Jacoti ListenApp (free) iOS ReSound LiNX2 /Beltone Legend.</p>	<p>Quite a lot of products and services are available for assistive listening devices, including softwares that are free on Android, iOS mobiles and are priced accordingly. For example-GN ReSound LiNX Smart AppReSound Smart App (iOS) Sumo XP Hearing Aids or BTE with Analogue, Semi Digital and fully digital versions.</p>
3	Amplified telephone equipment	<p>This type of assistive technology allows users to amplify the volume and clarity of</p>	<p>There are devices liked Amplicom - PowerTel 720 Assure+ DECT 6.0</p>	<p>These products are available in market and priced on the features in built.</p>

		<p>their phone calls so that they can easily partake in this medium of communication. There are also options to adjust the frequency and tone of a call to suit their individual hearing needs. Additionally, there is a wide variety of amplified telephones to choose from, with different degrees of amplification. For example, a phone with 26 to 40 decibel is generally sufficient for mild hearing loss, while a phone with 71 to 90 decibel is better for more severe hearing loss.</p>	<p>Cordless Phone with Digital Answering System - Black, that provides hearing aids T533 Doro Liberto 825 smartphone An excellent amplified, hearing aid compatible smartphone that gives you all the apps and advanced features of other major smartphones in a much simpler way.</p>	
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TABLE 4
ASSITIVE DEVICE STUDY-COGNITIVE IMPAIRMENTS

SNO	BASIC DEVICE	USE	IoT DRIVEN DEVICE	AVAILABILITY AND COST
1	Memory aids	<p>Memory aids are any type of assistive technology that helps a user learn and remember certain information. Many memory aids are used for cognitive impairments such as reading, writing, or organizational difficulties.</p>	<p>For example, a Smartpen records handwritten notes by creating both a digital copy and an audio recording of the text. Users simply tap certain parts of their notes and the pen saves it and reads it back to them.</p> <p>External aids fall into two categories: "low tech" and "high tech." 1)Low tech aids include pencil/paper systems and simple organization tools. Examples include: a)Checklist: used to record lists for items (e.g., shopping list) and/or steps for specific routines (e.g., laundry routine, homework routine) Wall or pocket b)calendar: used to</p>	<p>This is ongoing research area where intelligent apps are being developed to handle memory aids on smart phones and other devices.</p>

			<p>record/check appointments and events (e.g., doctor's appointments, birthdays)</p> <p>c)Notebooks/daily planner: used to record/check information across several categories (e.g., calendars, contact information, expenses)</p> <p>d)Timer: used to monitor time during specific activities (e.g., homework, cooking task)</p> <p>e)Medication boxes: used to organize medications by day and time</p> <p>2)High tech aids include electronic devices that have a range of programming options and uses</p> <p>High tech aids include electronic devices that have a range of programming options and uses. Examples include:</p> <p>a)Digital voice recorder: a device used to record information "in the moment" for later recall. Example: Olympus Voice recorder™</p> <p>b)Programmable watch: a wristwatch used for alarms/reminders to help recall important activities/events. Example: Timex DataLink™</p> <p>c)PDA (personal digital assistant): a "pocket computer" with several features including: alarms, calendar, contact information, internet, e-mail, and music. Example: iPod Touch™</p> <p>d)Cell phone: a mobile phone that includes contact information; several</p>	
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			<p>models include alarm/calendar programs, and camera. Example: Samsung™, Jitterbug™</p> <p>Smartphone: a device that combines a full-featured mobile phone with handheld computer functions as well as GPS (global positioning system). Example: iPhone™</p>	
2	Educational software	<p>Educational software is software that assists people with reading, learning, comprehension, and organizational difficulties. Any accommodation software such as text readers, notetakers, text enlargers, organization tools, word predictions, and talking word processors falls under the category of educational software.</p>	<p>There are a wide range of products to support education for people with disabilities.</p> <p>SMART Hardware SMART Board interactive whiteboards, SMART Board for Flat-Panel Displays interactive overlays, SMART Podium (formerly Sympodium) interactive pen displays, SMART Response (formerly Senteo) interactive response system, SMART Slate (formerly AirLiner) wireless slates and Actalyst interactive digital signage SMART Software SMART Notebook 10, SMART Product Drivers, SMART Sync (formerly SynchronEyes) classroom management software Operating Systems Windows operating systems and Mac OS X operating system software</p>	<p>These products are already available in the market and priced according to the features offered and usability.</p>

IV. CONCLUSION AND FUTURE SCOPE

To broaden the scope and usability of devices and bring as much as support and ease for physically challenged to use the IoT based products is surely way ahead for achieving the true purpose of Internet Of things vision and mission. We observe a lot of technology advancements in field of Assistive Devices over a few years and also a lot of ongoing research as well. Yet, there is a vast gap in terms of making some of the technologies available to the target user at an economically affordable price. As part of objective of this paper we explored the current trends and developments in this direction. This paper may have missed a few devices or products unintentionally.

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