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INTERNET OF THINGS FOR INDUSTRIAL WORKSPACE AND 4 OTHER FIELDS-KEY TECHNOLOGIES AND APPLICATIONS

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***Abstract*— IoT along with sensors holds a great potential for providing cutting edge solutions for innovative services in. Assistive technology for disabled, Independent living for Elderly, Industrial workspace, Mobility and Automotive Industry. In a typical IoT based system, smart sensor nodes or devices collect large amount of data for processing, and communicate with each other using transmission link for exchange of data and providing innovative services. In context to the current stance of IoT, IoT evolution, different technologies and applications of IoT for these domains are systematically accessed in this paper using the published literature. After the rigorous review, challenges that exist in the domains are also highlighted along with future direction for the researchers to evaluate current standing of IoT and to improve or contribute to these applications.**

***Keywords*— Internet of Things, Smart Industrial Solutions, Smart devices, Sensors.**

I. INTRODUCTION

With the advent in technology, Automation has revolutionized the daily tasks which required laborious efforts and specialized equipment for the acquisition of data and completion of tasks[1].Internet of things can be described as a huge matrix of individually identifiable things connected wirelessly via smart sensors to share, acquire or process data without intervention of human [2]. Wireless communication of technology has increased the automation, control and acquisition of data over the years [3]. Data acquisition being the main source of analysis of any problem is of vital importance. IOT has revolutionized the concept of device communication and connection over the course of years as everything in a modern smart house is connected and can be controlled from TV to even ACs. Its effectiveness, low cost deployment and low maintenance are the key features for which it found its application in other fields such as remote healthcare, surveillance, agriculture remote exploration and traffic management[2, 4, 5]. Wireless sensor network enables the user to work from a base station with information sharing via multiple nodes which are spread for data acquisition, computing, processing, connectivity and other purposes [6]. These nodes are deployed on the subject field making data acquisition and control possible [7].

These features of the IoT have resulted in the smart applications of IoT in different domains. IoT based systems utilize controllers, computing power and sensors along with the actuators to make the decisions for different applications by monitoring the environment or parameters using the sensors, processing the acquired data and utilizing it to make informed decisions for the smart technology [8–10]. This data can be visualized by the user with the access of the internet connected visualizing device or cloud and remote access for the control of the devices and applications is also available. Based on the potentials of IoT in the domains described in previous lines, this study targets the identification of solutions and applications in the fields of Industrial Workspace, Aautomotive Iindustry, smart homes, assistive technology for the disabled and independent living solutions for the elderly along with the trends, architectures, and technologies of IoT for these applications.

Paper is set in a way that Section 1 discusses the introduction. Chapter 2 provides overview of IoT along with the development over the course of years. IoT key technologies are briefly discussed. In section 5, State of the art developments of IoT for sustainable environment, automotive, agriculture, healthcare and related fields are discussed and summarized followed by limitations and challenges in section 6. Section 7 concludes the findings of the study along with future direction based on the challenges.

II. INTERNET OF THINGS

Internet of things as name suggests is the network of the connected devices which communicate with each other and

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can transfer data with each other for creating a connected environment of data acquisition and processing. IoT device acquires data from the surroundings, process them and communicate them to the cloud. This connected device proves to be beneficial for remote applications by providing the control and access to user of the data and the system through which he can control the environment of the applications stats. This data is uploaded and can be stored at the cloud for the applications and future analysis as well. This communication of the IOT is two way, providing control over the devices. Wireless communication of the devices has enabled the IOT to expand to those industries where the concept of automation was never perceived to exist. Increasing development in technology has opened new horizons for IOT to find its applications in. Each passing year is yielding into devices availing internet services which has brought the world/devices closer making control, information sharing, monitoring easy and quick. Figure 1 represents IoT based device and the communication via cloud to user.

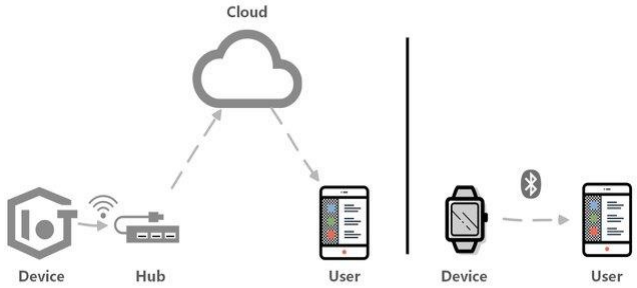

Fig. 1. A typical IoT Device architecture[11]

Figure 2 explains the evolution of Internet of things and how it started with first human to human exchange of information to the internet based services providence such as e commerce which evolved to mobile applications and tags for deployed devices for applications from machine to machine communication utilizing information exchange via internet.

III. IOT KEY TECHNOLOGIES

An IoT device comprises of multiple key technologies which enables the smart data acquisition, communication and decision making possible. These key technologies are listed as follows.

A. Sensors

Sensors are devices utilized for measuring specific parameters of the surrounding providing the device with the data that enables it to perceive the environment in which IoT device is deployed. These Sensors are used for data acquisition of the parameters such as temperature, pressure, light intensity, hazardous gas levels, intrusion detection and related parameters specific to the application. This data is processed and utilized for smart decision making sensors a key part of an IoT device. Figure 3 shows some of the sensors utilized for the applications.

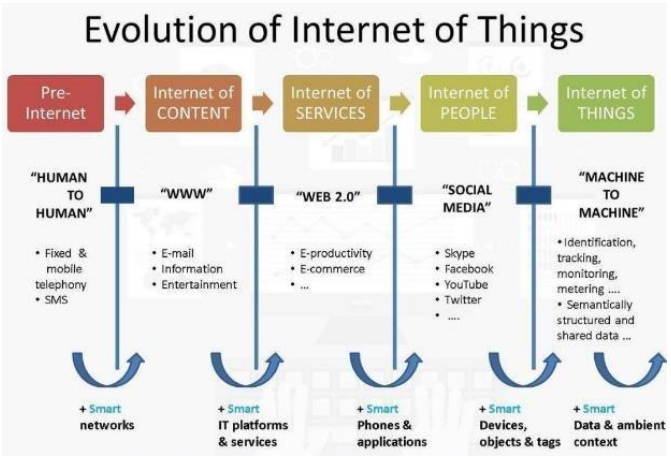

Fig. 2. Evolution of IoT [12]

B. Actuators

Actuators are the devices, motors or the moveable components that incorporate the mobility factor in IoT devices applications requiring removal or displacement of some of the parts. They provide control to the user over the environment.

C. Wireless Sensor Network

A WSN is a wireless network of autonomous devices/nodes that are spatially distributed in an environment capable of measuring/sensing some parameter such as temperature, humidity, light using sensors. These nodes comprise of controller, sensors, actuators, wire-less communication module and power source to sense and transfer the data. A wireless sensor network in IoT is of vital importance as they have been revolutionizing the concept of data collection and monitoring on a wider enabling the data acquisition at the same time more reliable and worthy.

D. Internet Protocol

Internet Protocol (IP) is the primary network protocol used on the Internet, developed in 1970s. IP is mostly understood as responsible for carrying the actual data packets of the Internet. These data packets are called "datagrams" in IP's header and are encapsulated into an IP-based protocol for delivery to another computer, typically a router or switch. The original design used a fixed length of 32 bits (four bytes), but with IPv6 this was extended to 128 bits (16 bytes) [13]. The most common protocols include TCP/UDP, UDP, CDN (Data Communication Network), NFS and SCANNELNET.

E. Cloud Computing

Cloud provides computing capability, accessibility and storage to the data acquired by the IoT devices which can be processed and analyzed for making decisions. Cloud provides two way communication between the user and the device deployed at the remote location providing access to the user and better visualization methods for making cheaper and reliable solutions to the applications.

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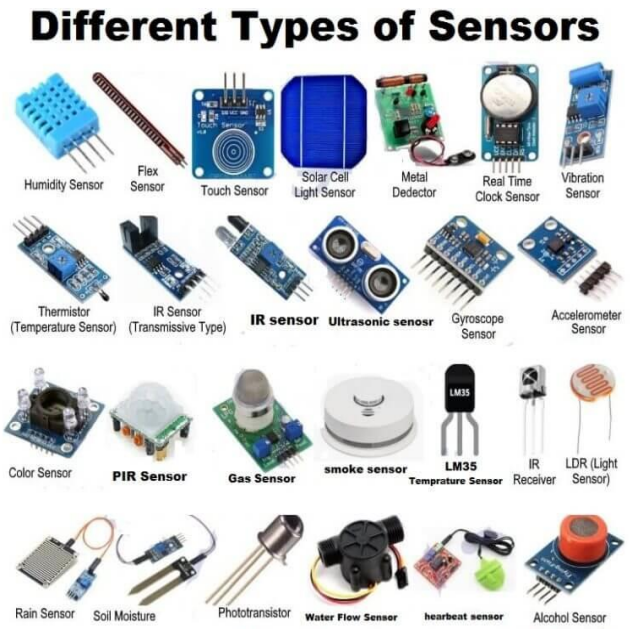

Fig. 3. Different types of sensors [14]

IV. IOT APPLICATIONS

In this section, some of the key applications of IoT are reviewed in the fields below in which it has shown its great potential. State of the art research work is reviewed.

A. Industrial Workspace:

Industrial environment and workplace requires minimal amount of accidents, mishaps, smooth operation along with complete monitoring of the systems. IoT has found its applications due to its immense potential in industry. IoT in industrial applications is referred to as Industrial IoT [15]. Industrial automation is one of key fields where IoT has found its applications in reducing the downtime with detection and identification of earliest fault or malfunction signs and alerting the concerned person. With all the devices connected with sensors such as temperature, moisture and related operational monitoring sensors etc., immense amount of data is available in the industries which is utilized for the fault forecasting, status of equipment, performance and security [16]. IoT contributes hugely for latest industry in terms of fault forecasting, diagnosis and performance of the systems.

Black and decker, AW North Carolina have utlizied IoT based systems for automation of their industries due to the immense benefits discussed above [17]. Similarly Japanese company named as Hirotec Group have started the use of Industrial IoT to deal with downtime issues and boost up functional capabilities.

IoT has also found its applications in related industrial sectors such as warehouse for applications of automation, sorting, inventory management, climate control for food/produce cold storages, fault detection, alert and monitoring[18–22].

IoT has found its applications in Oil and Gas sector for data collection, monitoring and observations more reliable for operations[23]. IoT based applications for simulations of Distillation tower using the data captured by sensors, Fault alert framework via mobile application to the service technicians, equipment performance and maintenance, Pipeline monitoring and safety precautions for indoor poisonous gas level monitoring are some of the key sections where the potentials of IoT are explored and established [24–26].

B. Mobility and Automotive Industry

With the advent in technology, transport means such as cars, buses, trains and trucks etc. are being equipped with latest sensors and processing capabilities along with the actuators. These vehicles are utilizing sensors for getting connected and data acquisition and communication for getting connected. Applications of IoT in automotive industry utilize smart vehicular systems to monitor and report parameters that span from utilizing tyre pressure monitoring to proximity sensing of other vehicles. RFID has already been utilized in streamline production, movement, QC and customer service providence [27]. RFID based keyless entry systems are being utilized in cars for the automatic security systems. These systems are also being utilized for the push start features. RFID devices attached to the parts contain model name, manufacturer, its serial number, code, year of manufacture and location of the device in facility in certain applications. RFID based technology is being utilized which provides real time data used for services such as vehicular maintenance, operation/fault detection and managing new methods of recall effectively [28]. Communications such as vehicle to vehicle (VtoV) and vehicle to infrastructure will help in building sustainable environment with increasing number of vehicles for efficient traffic monitoring, route planning for safety purposes will be integrated with the infrastructure [29].

Author presented IoT based vehicle tracking system that utilized GPRS along with GPS sensor for tracking of vehicles[30]. Similar systems for vehicle theft protection tracking and navigation have also been implemented utilizing IoT for the cause [31–34].

C. Smart Homes/Buildings

A smart home and building is the one which is equipped with smart devices that are utilized for intelligent operation and functions to assist us. It is equipped with heating, cooling, lighting, ventilation and other related systems that can be controlled remotely using the mobile phone for ease and comfort of human. Over the course of years, different advancements have resulted in connected devices that have been incorporated in smart homes and buildings which has truly manifested the idea of smart homes and some of them are reviewed as follows.

In study [35], authors recommended utilization of RFID for integration of homes. Study proposed a novel concept of read-

out for a hierarchical slave master wireless reader architecture based on RFID for NFC and ultrahigh frequency applications.
Authors in study [36] reviewed the development of IoT and its utilization in the smart home. Different aspects of the IoT uses for smart homes were reviewed along with the modules involved in the study. Study discusses the features, advantages and disadvantages of the smart homes and IoT.
In study [37], authors proposed the utilization of smart connected community where architecture was based on multi hop network with RFID based interception that utilized 13 types of communication standards such as IEEE 802.11 etc.
In study [38], authors proposed RFID based tags usage for object identification. Authors proposed the model while considering the architecture, communication model etc. for smart homes.
A smart, easy and cost effective solution based on micro-web server was proposed which comprised of smart home gateway application based framework which could be connected via IP services [39].
In study [40], smart home application was developed which integrated cloud computing, web services and IoT. Framework utilized Arduino based device for controlling actuators and sensors via Zigbee.
In study [41], author presented a low cost functional solution based on Arduino along with Ethernet shield. It was a standalone low cost, effective smart system which can be controlled using Android application.
Authors in study [42] presented a smart home system which was low cost efficient and could be extended from smart home to smart buildings with ease.

D. **Independent Living for elderly:**

Independent living for elderly comprises of applications that assist the elderly in living a life which is independent and safe for them. IoT concepts have been explored in this domain for applications. Some of these studies are reviewed as follows
In study [43], monitoring system for elderly was developed for emergency detection which utilized data from mobile sensors of neighboring phones and utilized ML along with IoT for detection of anomaly or emergency situation and alert the corresponding caretaker or person.
In study [44], IoT based fall detection and warning system was developed which utilized accelerometer to detect any fall situation and alert the corresponding caretaker or medical assistance provider.
In study [45], IoT based system for mobility assistance, control and recognition is proposed. System assits the elderly and disabled by alerting them about the household items for collision avoidance and control.
In study [46], IoT and voice control based home automation and control is designed for fans lights etc. assisting the disabled people. System connects with the smart homes.
Different systems have been presented which utilize the IoT for the assistance of elderly in different ways providing them independent lifestyle with all the necessary precautions observing and alerting the caretakers in case of emergency.

E. **Assistive Technology for the disabled:**

People with disabilities require extensive care and assistance to get by and perform routine life tasks which are a compulsion. These assistance is needed for communication, mobility, consultation and in related daily tasks that are essential. Over the course of years different assistive technologies have been developed that are utilized for the aid of the person. IoT has revolution and found its applications in assistive technologies as well.
IoT based systems are presented in studies that provide communication assistance to the disabled people who are dumb deaf and blind for communication with normal people. Systems use sign language to speech conversion [47, 48], similarly text to audio/speech for blind and image to test to audio conversion[49] . Framework proposed in [50] aids the disable for surround feel by converting the voice from the environment into text using IoT and ML for deaf people to know what's happening. System proposed in [51] utilizes a pen for the conversion of text on book to the voice aiding the ones with blind disability to memorize what was written. Study in [52] presents a solution of interpreter for the deaf that converts sign language to speech and speech to sign language using 3d character. Systems utilize IoT for the processing and cloud computing which has proved its efficiency for the assistive technology.

V. METHODS AND DISCUSSIONS

In the 21st century, there have been countless advances in technology. There is a coherent theme running through this progression. The Aim of the literature review is to identify and evaluate evidence for support and profits of IoT in Industrial workspace, Independent living for elderly, smart homes and assistive technology for disabled. We used the SLR for the study of IoT roles in these domains and how it has revolutionized these industries. For this purpose, one hundred and twenty eight papers were downloaded from different repositories which were evaluated based on the keywords. In next step, titles were studies and twenty six papers were found to be in duplicates. In third step, articles were reviewed for their application domain and IoT based implemented studies falling in the concerned domains were included resulting with 45 papers.
Table 1 provides the details about the IoT applications reviewed in the study.

Table -1 IoT Roles Studied

IOT Application	**Percent**
Industrial Workspace	**20**
Mobility and Automotive Industry	**23**
Smart Homes/Buildings	**23**

Independent Living for Elderly	**17**
Assistive Technology for disabled	**17**

VI. LIMITATIONS AND CHALLENGES

After reviewing and analyzing the papers that were selected for SLR, following summarizes the insights that contribute for adoption of IoT at larger scale in reviewed fields and applications.

A. Standardization:

Standardization would assist to increase the compatibility of IoT devices resulting in better security across IoT devices and all vendors from the base to the cloud computing and interfaces at end users.

B. Better Power Management:

Major drawback for IoT based solution deployment is the issue of Power for nodes. An efficient power management system or techniques that would lower the power consumption by introducing the low power sensors along with energy harvesting methods and secondary source of energy which would increase the endurances of IoT solutions.

C. Security:

One of the major established challenge in IoT applications is of security problem. Few implementations address it by use of incorporated strategies for mitigation. It is evident that there is a need of IoT based solutions in Environment and related applications for utilization of proper end to end security of information and integrity of the devices that are deployed in the field.

D. Modular Hardware and software for Design:

Utilizing Modular hardware and software for the design of IoT applications in fields of environment, healthcare, assistive technology and related reviewed fields providing the users with the option to modify it according to their need and increased degree of reuse.

E. User Oriented Design:

Design of the commercial IoT solutions should be user centered and management, usage and deployment of the nodes for the non-expert should be easy and straight forward. Hardware should require minimal to none human intervention for maintenance during its life span and it should be intelligent enough to automatically correct its fault and in the network.

VII. CONCLUSION

This paper presents latest review of IoT applications for Assistive Technology, Automotive sector, Elderly assistance and related applications. IoT evolution over the course of years, IoT technologies along with applications are also discussed in details. Studies reviewed in this paper provide a concise and compact view of proposed solutions for the domains during the last 10 years. IoT applications for elderly lifestyle assistance and assistive technology for disabled were widely used. These provided control, guidance to the elderly and fall/emergency detection which would alert the concerned caretaker. IoT proved its wide applications for communication, mobility, interpretation and monitoring assistive technologies for the disabled people. IoT has proved its worth in these fields and how it is revolutionizing them. It was observed that most of the studies involved utilization of different sensors along with WSN and node. Large scale deployment of these IoT solutions still face a lot of limitations. However it is safe to say that future developments in IoT would need to utilize cloud computing and newer ways of connectivity for getting full benefits from fully connected ecosystem.

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