ADOPTION OF IOT IN AUTOMOBILES FOR DRIVER'S SAFETY: KEY CONSIDERATIONS AND MAJOR CHALLENGES

AFREEN IQBAL, MUHAMMAD EHSAN RANA

Abstract:To accommodate the transportation needs of world's growing population, automobiles numbers are increasing rapidly around the globe. This resulted in increased number of road accidents and deaths. By adopting Internet of Things (IoT), vehicles can be turned into a Smart Vehicle Monitoring System (SVMS) to monitor driver's heath condition and prevent accidents due to emergencies. SVMS uses IoT devices in vehicles which connects, communicates and flow data using both IoT and cloud computing. This study reviews the existing literature and technologies in implementing Smart Vehicle Monitoring System (SVMS) to reduce emergencies and accidents caused by health related issues. It thoroughly evaluates IoT based infrastructural components needed for deploying SVMS in vehicles. This research also focuses on the key considerations and major challenges in executing health detecting IoT based steering wheel system into a car.

Index Term: Smart Vehicle Monitoring System (SVMS), Adoption of IoT in Automobiles, IoT for Driver's Safety, IoT for Healthcare, IoT Based Steering Wheel.

1 INTRODUCTION

THE demand of smart and connected cars supporting internet access and intelligent devices is continuously increasing in today's era. According to Statista 2015, the number of cars currently operating in the World include 947 million passenger cars and 335 million commercial vehicles [1]. By the year 2020, it is predicted that car manufacturers will attempt to include features of in-built connectivity, internet access and IoT systems in most of their automobiles [2]. Internet of Things (IoT) offers a unique blend of smart system which can connect identifiable devices through internet using a set of standard protocols that provide the potential to produce current processes of businesses and even create entirely new ways to operate on various heterogeneous networks [3]. Nowadays, essentially all machines at our homes, offices, cars and production plants are interconnected with one another via internet. IoT has established its name in every field to make our life more comfortable and safe. By generalizing the idea of IoT to automobile industry, it can be split into three different branches [4]. First branch is connectivity between vehicles-to-vehicle that is based on connection between two or more nearby vehicles. Second branch focuses on vehicle-to-infrastructure, it is a connectivity with the external infrastructure. Third branch is vehicle-to-device, this includes connection with the hardware or internal/external devices [5]. IoT network simply interconnects devices or things which are embedded with software, sensors, actuators, network connectivity and other electronics that allows them to exchange and assemble data to make them responsive. [6]. Internet of things (IoT) commonly refers to situations where technology capability and network communication spreads to devices, and these computing devices produce, consume and exchange data information with slight human involvement.

- *Afreen Iqbal, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. E-mail: afreenvoh@gmail.com*
- *Muhammad Ehsan Rana, Asia Pacific University of Technology & Innovation, Kuala Lumpur, Malaysia. E-mail: muhd_ehsanrana@apu.edu.my*

New IoT products like internet enabled devices, car automation components, and energy management devices have taken us towards an idea of "Intelligent steering-wheel system", offering more comfort and safety to the drivers on the road.

2 INTERNET OF THINGS

Internet of Things (IoT) is a combination of two terms: internet and things; internet is defined as network providing a diversity of data information and communication which connects billions of users with some typical internet protocols [7]. Different sectors and departments are connected by internet via multiple technologies to maintain the communication and transfer relevant information to each other. Multiple technologies like mobile phones, personal computers and business organizations are connected to internet. The second term is things, things are those objects which turn smart by inserting technological device into it [8]. According to Khan, R. et.al, IoT can be simply defined as an interface between the digital World and physical reality. The physical reality interfaces with the digital World by means of a plethora of connected devise including actuators and sensors [9]. In Figure 1 below, computers, devices, automobiles, buildings, and other things embedded with software, network connectivity, sensors and electronics are connected to each other and transmitting data to one another over the internet [10].

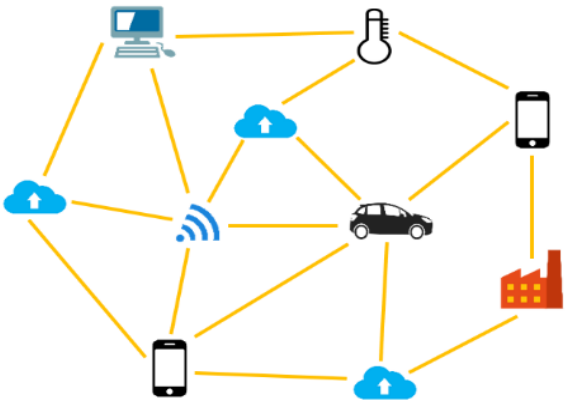

Figure 1:Basic Architecture of IoT [4]

According to Kamdar et.al, IoT is a network of smart objects that have the capacity to automatically organize, share information, acting or responding in face of circumstances and variation in the environment [11]. IoT is a platform where resources and information can be shared between two different devices by using internet. In other words, IoT is an idea of modelling various devices with a capability of having a wireless communication through internet that can be controlled and traced by using even a single mobile application [12]. IoT applications are rapidly extending virtually in all parts of our lives. Some of the major applications include, smart industry, smart energy, smart transport, intelligent healthcare etc. [13]. IoT is a revolution of things and internet; things make themselves identifiable and contain important yet intelligent data which can be used for analyzing context related decisions and transmit information to other devices. This transmission is associated with the appearance of cloud computing abilities [14]. In this competitive world, one of the key objective of an effective and on-demand resource sharing and intelligent communication is rapid growth. Due to this swift growth in technological demand, IoT and cloud computing have turned into a widely studied and applied technology in recent period. Integration of cloud computing and expansion of IoT is part of the current trend and future demands. It is declared by Singh Y, et.al that in near future, the number of devices connected through the internet would be hundreds of times greater than the number of individuals connected [15].

3. IoT Infrastructural Components for SVMS

In this section, researchers have briefly discussed some common IoT infrastructural components for implementing a Smart Vehicle Monitoring System (SVMS). Cloud is an indispensable part of current IoT based systems. Considering its importance and significance, it is discussed at length in a separate section.

3.1. Communication Technologies

a) Radio-Frequency Identification Device (RFID)

RFID based communication integrates the usage of electrostatic or electromagnetic connection in the radio regulatory portion to uniquely recognize an item, human or animal [16]. In IoT, RFID can be used to recognize an item, create metadata record of that item and control that item through radio waves. In real time, RFID reader which is connected to the internet can identify, monitor and track an item [17].

b) Global Positioning System (GPS)

GPS technology is used for position and location determination which is also called geo positioning. Smart phones nowadays also provide built-in GPS for navigation and tracking of devices and products [18].

c) Global System for Mobile Communication (GSM)

GSM is used to establish communication between devices. GSM transmits input signals or data by using sensors or digitize equipment in a form of output messages on devices of receiver [19].

d) WIFI

WiFi refers to wireless network technology that is based on IP addressing. Usually, to place up a wireless network, a wireless network adapter and an access point (AP) is essential. WiFi is a small range wireless transmission that interconnects PC, mobiles, and other hand-held gadgets [20].

3.2. Wireless Sensor Networks

Wireless sensor network (WSN) is a group of disseminated, autonomous sensors that are used to monitor environmental or physical condition and are widely used in many applications including home control, health monitoring, traffic control etc. [21]. Wireless sensor network can collaborate with RFID system to make accurate track of item's status, retrieve relevant information about position, temperature, frequency, movement, etc. [16]. There are number of sensors that can be used in SVMS as listed below:

a) Eye Blink Sensor

Eye blink sensor consists of a relay, IR sensor and eye blink frame. The driver needs to wear a vibrator device which is connected to a frame that consists of IR transmitter (IR transmit rays to drivers' eyes). Whenever driver closes his/her eyes, or the accident occurs, the vibrator vibrates. The relay is connected to a microcontroller board in order to provide extra current [22].

b) Acceleration Sensor/ Accelerometer

The acceleration/accelerometer sensor can detect even slight sudden change in speed in any direction or rotation. The accelerometer can continuously reads the data while driving. In cases where deceleration or acceleration hits threshold value or sensor tilts more than the expected degree, an accident alert can be generated [23].

c) Gyroscope Sensor

A gyroscope is a sensor device that uses gravity of earth to determine orientation. Gyroscope measures the rate of change of angular rotational velocity over time and provide units of mV/degree/sec [24].

d) Impact Sensor

An impact sensor detects sudden collision due to accident occurrence and can be used to immediately deploy airbags [23].

3.3. Other Infrastructural Components

a) Addressing System

The ability to recognize a unique device from a massive number of devices is accomplished with the help of an addressing system that can be used in identifying and controlling each device individually through internet [16].

b) Middleware

Middleware is a key role player between things and application layer, the main goal of middleware is to abstract the communication capabilities and functionalities of the devices [16]. Middleware acts as a bond joining diverse domain of applications collaborating over diverse interface [25].

3. Cloud Computing

Cloud Computing is a well-known contemporary platform which is an extended system of parallel computing, distributed computing and grid computing. According to NIST [26], cloud computing allows users to have global, on-demand and ease-

of use capability to access the shared distributed services and resources; a pay-per-use model where customer pay the usage of service cost [27]–[29]. Using internet, cloud offers a huge pool of resources where services are organized in a manner that give benefits to its users. Services offered by cloud computing include, Software as a Service (SaaS): where users pay-per service usage, Platform as a Service (PaaS): where users buy a platform to build services and applications, Infrastructure as a Service (IaaS): where users buy full storage and computation services, and Network as a Service (NaaS): where users purchase a broad variety of virtual networks [15]. Cloud computing offers various deployment models to different categories of customers such as public, private, hybrid and community. These services are provided at a cost that is affected by numerous factors including availability, elasticity, level of convenience, scalability, storage and security [30]. Cloud computing is a source of accessing resources and services for both individuals and organizations by providing unification of hardware and software that can be used via internet from anywhere around the world [31]. It provides enormous opportunities for industries to broadcast IT services and computing resources. If properly executed and adapted, it will eventually increase the productivity, effectiveness and efficiencies in particularly manufacturing industries [29]. Internet of things always comes with enormous data that is either depicted, managed or exchanged in the real world. As 'things' are always increasing and technology is making its place within every object, the data being exchanged or managed by these technological-objects are also increasing which is causing an outburst of unstructured heterogeneous data [32]. As data is tremendously increasing in today's era, the ability to store and process huge data is becoming chaotic for embedded devices. This data can be accumulated and saved easily through the combination of internet of things and cloud computing [33]. In recent years, IoT and cloud computing is growing together in many areas of technology. The investment in cloud based infrastructure has enlarged around threefold from the year 2012 to 2017 and is likely to expand more by 2020 [30], [34]. Quantity of IoT devices connected in the year 2012 was estimated 8.7 billion and it is expected to increase massively by the year 2020 [35]. Due to this gigantic growth, IoT applications will suffer from limited storage, capacity, real-time data processing and security issues. Cloud computing can be used here to overcome the limitations in providing storage, security and processing requirements [30].

4. Integration of Cloud Computing in IoT Based Applications

The cloud-based IoT approach took its hold in many segments and applications that has made our daily life more convenient and flexible. Following are few sectors that are successfully adopting the Cloud-based IoT systems.

a) Banking

Nowadays, conventional banking has been converted into smart banking with the help of IoT and cloud computing as millions of transaction, finances and data can be handled on a single device. Banks collect data from customers using IoT and offer various smart solutions that can help the customer by advising in making a financial decision [36].

b) ***Healthcare***

Medical has a long history of utilizing traditional unconnected systems which are now gradually entering into a radical change of adopting wireless reprogrammable devices. This radical change brought advancement in healthcare by means of a medical IoT system that can be connected using mobile phones or gadgets. Medical IoT system is based on health-monitoring devices along with a recorder at the back-end of the device. The recorder remotely fetches health parameters of the patient and stores it in cloud which later can be analyzed and used to provide appropriate feedback for the healthcare staff and doctors. The feedback can be utilized to determine the health condition of patients and for instant responses to serious cases [37].

c) Transportation

These days smart vehicles are usually integrated with various devices such as controllers, sensors, GPS trackers, actuators, cell phones and network engaging technologies (e.g. cellular network, satellite network, wireless sensor network, etc.). With the use of IoT infrastructural components such as cloud computing, middleware and other communicative mechanism, we are able to retrieve and transmit data between car to car, drivers, and roadside devices like street lights, cameras, etc. [39].

4. Use of IoT to Tackle Emergency Situations while Driving

Interconnection of things (devices) with each other via internet symbolizes the strength of IoT. The scope and application of IoT based systems is huge ranging from smart construction to smart city applications [40]. The emergency within a smart city can be tackled using IoT systems and wireless sensors devices which can enhance the emergency and disaster relief systems known as critical and rescue operations. One of the proposed system in a smart city for emergency and disaster relief system is CROW. CROW integrates several communication technologies (such as; Bluetooth IEEE 802.15.1, WIFI IEEE 802.11n) and other devices (smart phones, microcontrollers, sensors etc.) to enable end-to-end network connectivity, which is monitored by internet of things, and cloud computing platform [41]. A true smart city must get alerts of the situations, able to analyse the circumstances and to inform optimally at all times. The entire CROW system uses an IoT platform as a back-end to record, push, publish, sense and analyze the data. Additionally, this system can be used for real wireless body-to-body implementation using routing protocol for disaster relief context [41]. Every year, huge number of people die around the world in road accidents. According to statistics, among the leading causes of deaths, road accident deaths are comparatively less but still quite significant [42]. However, when the road accident occurs due to medical issue, it is easier to discover who is at fault. Sometimes, the road accidents are caused by pre-existing medical issues in drivers who are suffering from heart disease, diabetes, seizure disorder etc. [43]. Today, with the presence of smart technologies all around us, it is possible to detect health of drivers while driving and analyze the real-time data to make an alert before fatal accident occurs [44]. Driver's health is the most important factor while driving on the road as it might impact and influence the overall traffic on the road. A mistake caused by driver due to his/her health can create danger to nearby vehicles. According to ABC12 news of

Saginaw County Michigan, a driver suffered from heart-attack during driving caused him to crash into another car on the passenger side where a man along with his 14-year old daughter was travelling. As a result, two of them died on the spot and another got seriously injured [45]. Traffic deaths are one of the most leading reason of deaths in the World. Nationally, deaths due to road accidents in the 100,000 population is 10.9 compared to other reasons of deaths. However, other deaths factors can cause road accidents if the patient is driving and face an emergency. On January 3, 2019, ABC news goes through the data of Western Australia's road accidents in 2018, on which ABC news claimed that road accidents due to fatigue and distraction are contributing more than alcohol and over-speeding [46]. In Victoria, fatigue driving causes 50 deaths and approx. 300 fatal injuries each year [47]. Additionally, it is stated in Governors Highway Safety Association report for the year 2015 that estimated 5,000 people died due to drowsy and fatigue drivers [48]. This research explores the opportunities that can be utilized by adopting internet of thing with cloud computing in the intelligent transportation industry to reduce the number of health-related road accidents. The information processing, sensors and communication technologies is provided to vehicle users by intelligent transportation system to raise efficiency, ease and safety of transportation system [49]. Furthermore, it is specified that the smart vehicles that are embedded with intelligent engine technology, electronic sensor devices, information data transmission device, wireless communication, and driver assistance system are known to be the high-performance and efficient automobiles [50]. Presently, IoT usage is still in its initial stage in the field of transportation and most of the research on intelligent transportation system has not adopted the IoT technology as a qualifying infrastructure or as a solution to transport problems [39].

4. Human Body Measures Detectable by Sensors

In this section, authors have described some important sensors that are commonly used to detect human body measures.

a) Heart Attack Detection and Heart Rate Monitor

Heart attack is usually caused by blockage of arteries. Heart rate can be measured through a heart rate monitor device that displays the heart rate readings. To measure the blood pressure and heart rate, an easily available high performance and low power microcontroller board can be used. This microcontroller can use a pulse sensor based on a plug and play heart rate sensor. Sensor works by putting finger on a sensor which intends to give numerical output of heart beat [51].

b) Drowsiness, Dizziness Detector

Fatigue, drowsiness and dizziness is a condition when a person slowly goes into an unconscious state of mind which can lead him to lose control over everything. Drowsiness or fatigue can be detected using infrared heart-rate sensor or pulse sensor. The sensors are non-intrusive that measures heart pulse wave from the finger or hand. The blood oxygenation can be detected from the finger which will cause reflection of infrared light off the skin and to the closest transmitter. A microcontroller which is wired with sensor will pick up the fluctuation of oxygenation. By using simple frequency calculation, it can be detected easily if a person is feeling drowsy or going into fatigue state [52].

c) Sugar Level Detector

Sugar or glucose is among the key aspects of human health and maintaining its level is extremely important as its slight imbalance in human body can cause weakness, dizziness, etc. [53]. To monitor the sugar or glucose level of a driver, an IoT based system can be deployed in the vehicle. The required sensors can be easily connected with a microcontroller. Additionally, this microcontroller can be connected with the cloud using Wi-Fi. In this case, the values of the monitored glucose is received in analogue [54].

4. Adoption of IoT in Automobiles for Driver's Safety

To monitor health-related issues, researchers have come up with different ideas and techniques. One of the most popular technology available in the market is a smart wearable watch which monitors various health features of the person wearing it. Smart wearable watches are used as fitness monitor, health monitor and mobile [55]. According to Jo Best, people buying these smart, yet fashionable gadgets are typically richer, teenagers, and those who are interested in maintaining good health, not the people who actually really need to monitor their health as they cannot afford to buy it or are too lazy to buy [56]. Moreover, very few car manufacturers are adding systems like sensors and video cameras in their vehicles to analyse driver's behavior [57]. Furthermore, there are only few researches that propose implementation of smart health monitoring IoT technology in steering wheels. Some of the proposed IoT systems for vehicles are discussed below. Sehgal et.al contributed their work in providing a solution for alarming the drowsy driver. They fitted self-powered IRIS scanner in front of driver's dashboard to scan the eyes of the driver. Whenever the driver feels sleepy and closes his eyes for more than 2 seconds, an alarm will ring to wake him up. They have discussed some attractive features that are based on interconnectivity of sound system and sensors within a car. The sound system will trigger alarm to alert the driver before the fatality occur. The motive of Sehgal et.al research is to keep a drowsy driver life safe as well as enhance the safety of nearby drivers. [58]. Nanda and Hotur, published a paper on Smart-Vehicle implementation using IoT and cloud extension. In this paper they proposed an idea of pay-as-you-go service in order to provide a better driving experience. They used the basic concept of a connected vehicle by ensuring the provision of internet access and established a connection between car-to-car, car-to-infrastructure, car-to pedestrian and car-to-mobile/car to cloud using IoT. They introduced 4G and 5G networks to make a stable communication link. The motive of this innovation is to enhance the capabilities of smart vehicle by providing faster data transmission. This implementation benefits vehicles to stay connected and helps in avoiding the road accidents. [38]. Research conducted by Jesudoss et.al focuses on drunk and rash driving detection. The main motive of their research is to propose a solution for avoiding road accidents due to drunk driving or over-speeding. They have applied three types of sensors in a steering wheel that include; alcohol detection sensor, eye blinker sensor, over-speed control sensor. Alcohol detection sensor is used to check if the driver is drunk or not. Eye blinker sensors are used to determine the driver is sleepy or not by monitoring his/her

eyeball movement. In case it detects drowsy eyes, alarm will be triggered to wake the unconscious driver. Car speed control sensor will reduce the speed of the car if it goes up from a normal speed limit. In all these situations, an automated message will be sent to both driver and local police to prevent any accident. Researchers claim that adoption of this method will reduce accidents to a great extent. [59].

5. Challenges in Implementation

There are substantial challenges that might be encountered and need to be thoroughly considered while implementing IoT based health detecting car staring systems: The data retrieved from IoT devices is variable in term of structure and often attain in real-time. However, handling this real-time data is a considerable issue as the whole routine of connected applications is severely reliant on the properties of this data management service. [60]. Connectivity of devices is sometimes unreachable while the car is on a remote highway (i.e. away from IoT infrastructure or in a non-connectivity zone). Significant amount of expenditure and investment is needed in maintaining the servers to deal with information exchange [61]. Structure of network protocol is not an easy task as it need to satisfy the requirements of cost, ease-of-use and performance of the whole system [60]. Network topology and protocol should be selected carefully depending upon several factors. Each network topology and communicating protocol has its own strengths and limitations. [62]. Reliability in delivering IoT based data from an authentic and accurate source is very important, specifically when it comes to the field of emergency control-based applications having many stringent requirements [63]. There are several considerations in selecting communication devices and protocols, including effects on the human body, latency and security. Selected devices and sensors should not have any negative effect on the human body. These should also possess strong security and privacy features to avoid leaking and hacking attempts. [64]. In the era of fast-moving cars and rapidly changing network topologies, it is challenging to retain connection between nodes and allocate resources for exchanging data in real time. [65].

6. Conclusion

In conclusion, this paper discussed the importance of IoT in automobiles for driver's safety and how IoT can be used to curb road accidents that are caused by drivers' health issues. This paper also highlighted some effective and unique features based on interconnectivity of sensors in the car that will lead to a safer journey for drivers. In the end, this paper also mentioned substantial challenges that can be encountered and needs to be considered while executing health detecting IoT based steering wheel system into a car.

References

[1] Statista, "Number of vehicles in use worldwide 2015 | Statistic," 2015. [Online]. Available: https://www.statista.com/statistics/281134/number-of-vehicles-in-use-worldwide/. [Accessed: 25-Feb-2019].

[2] P. Hassani, "Top 14 Advanced Car Technologies by 2020," 2017. [Online]. Available: https://blogs.systweak.com/top-14-advanced-car-technologies-by-2020/. [Accessed: 03-Jun-2019].

[3] E. Fleisch, M. Weinberger, and F. Wortmann, "Business Models and the Internet of Things," 2014.

[4] K. Dervojeda, E. Rouwmaat, P. Netherlands, L. Probst, L. Frideres, and P. Luxembourg, "Internet of Things Smart machines and tools Business Innovation Observatory," Gen. Intern. Mark. Ind. Entrep. SMEs, 2015.

[5] A. Cohen, L. Arce-Plevnik, and T. Shor, "IoT IN AUTOMOTIVE INDUSTRY: CONNECTING CARS," 2016.

[6] L. L. Dhirani, T. Newe, E. Lewis, and S. Nizamani, "Cloud computing and Internet of Things fusion: Cost issues," Proc. Int. Conf. Sens. Technol. ICST, vol. 2017-Decem, no. December, pp. 1–6, 2018.

[7] S. Ramaswamy and R. Tripathi, "Internet of Things (IoT): A Literature Review," J. Comput. Commun., vol. 3, pp. 164–173, 2015.

[8] S. Agrawal and D. Vieira, "A survey on Internet of Things," pp. 78–96, 2013.

[9] R. Zaheer and S. Khan, "Future Internet: The Internet of Things Architecture, Possible Applications and Key Challenges," pp. 257–260, 2012.

[10] H. K. Singh, "IoT Basics," 2018. [Online]. Available: https://www.slideshare.net/hiteshkumarsingh10/iot-basics-86993434. [Accessed: 26-Feb-2019].

[11] M. N. Kamdar, V. Sharma, and S. Nayak, "A Survey paper on RFID Technology, its Applications and Classification of Security/Privacy Attacks and Solutions," IRACST - Int. J. Comput. Sci. Inf. Technol. Secur., vol. 4, 2016.

[12] M. Swan, "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0," J. Sens. Actuator Networks, 2012.

[13] F. Wortmann and K. Fluchter, "Internet of Things Technology and Value Added," Bus Inf Syst Eng, 2015.

[14] K. K. Patel, S. M. Patel, and P. G. Scholar, "Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges," Int. J. Eng. Sci. Comput., 2016.

[15] Y. Singh, P. Assistant, and T. Parmar, "Cloud of Things: A State-of-the-art Review on Integration of Internet of Things with Cloud Computing," 2016.

[16] A. Botta, W. De Donato, V. Persico, and A. Pescapé, "Integration of Cloud Computing and Internet of Things: a Survey," Italy, 2015.

[17] X. Jia, Q. Feng, T. Fan, and Q. Lei, "RFID technology and its applications in Internet of Things (IoT)," pp. 1282–1285, 2012.

[18] A. Damani, H. Shah, K. Shah, M. Vala, and A. Professor, "Global Positioning System for Object Tracking," 2015.

[19] A. S. Parab and A. Joglekar, "Implementation of Home Security System using GSM module and Microcontroller," 2015.

[20] S. Song and B. Issac, "Analysis of WiFi and WiMAX and Wireless Network Coexistence," Int. J. Comput. Networks Commun., vol. 6, no. 6, pp. 63–78, 2014.

[21] F. A. and S. E., "Wireless Sensor Networking in the Internet of Things and Cloud Computing Era," EUROSENSORS 2014, XXVIII Ed. Conf. Ser. , pp. 672–679, 2014.

[22] K. K. B.M, S. Sethi, R. Kumar P, N. Kumar, and A. Shankar, "Detection of Driver Drowsiness using Eye

Blink Sensor," Int. J. Eng. Technol., pp. 499–504, 2018.
[23] S. K. R. Mallidi and V. V. Vineela, "IOT BASED SMART VEHICLE MONITORING SYSTEM," Int. J. Adv. Res. Comput. Sci., vol. 9, no. 2, pp. 738–741, 2018.
[24] B. Baker, "Accelerometer & Gyroscope Sensor Fusion," Contrib. By Digi-Key's North Am. Ed., 2018.
[25] S. Bandyopadhyay, M. Sengupta, S. Maiti, and S. Dutta, "Role Of Middleware For Internet Of Things: A Study," Int. J. Comput. Sci. Eng. Surv., vol. 2, no. 3, pp. 94–105, 2011.
[26] P. Mell and T. Grance, "The NIST Definition of Cloud Computing Recommendations of the National Institute of Standards and Technology," 2011.
[27] M. S. Fathi, M. Abedi, S. Rambat, S. Rawai, and M. Z. Zakiyudin, "Context-Aware Cloud Computing for Construction Collaboration," J. Cloud Comput., vol. 2012, 2012.
[28] Y. Singh Patel, K. Jain, and S. Kumar Shukla, "A Brief Survey on Benchmarks and Research Challenges for Green Cloud Computing," 2016.
[29] N. Muhamad Rawai, M. S. Fathi, Mohammad Abedi, and S. Rambat, "CLOUD COMPUTING FOR GREEN CONSTRUCTION MANAGEMENT," 2013.
[30] L. Dhirani, T. Newe, E. Lewis, and S. Nizamani, "Cloud Computing and Internet of Things Fusion: Cost Issues," 2017.
[31] W. SARADA, B. L. PRASANNA, and V.PADMALATHA, "A COMPARATIVE STUDY ON CLOUD MODELS AND SERVICES," Int. J. Adv. Res. Comput. Eng. Technol. , vol. 3, no. 10, 2014.
[32] A. Khanna, "AN ARCHITECTURAL DESIGN FOR CLOUD OF THINGS," vol. 29, no. 3, pp. 357–365, 2016.
[33] C. Chatterjee, "A Novel Design of IoT Cloud Delegate Framework to Harmonize Cloud-Scale IoT Services," Int. J. Innov. Res. Electr. Electron. Instrum. Control Eng., vol. 4, pp. 2321–5526, 2016.
[34] L. Columbus, "Roundup Of Cloud Computing Forecasts And Market Estimates, 2016," 2016. [Online]. Available: https://www.forbes.com/sites/louiscolumbus/2016/03/13/roundup-of-cloud-computing-forecasts-and-market-estimates-2016/#4e23ef802187. [Accessed: 23-Feb-2019].
[35] M. Greenfield, "IoT: number of connected devices worldwide 2012-2025 | Statista," 2016. [Online]. Available: https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/. [Accessed: 23-Feb-2019].
[36] Asare-Frempong, J. and Jayabalan, M., 2017, September. Predicting customer response to bank direct telemarketing campaign. In 2017 International Conference on Engineering Technology and Technopreneurship (ICE2T) (pp. 1-4). IEEE.
[37] F. Hussain Alqahtani, "The Application of the Internet of Things in Healthcare General Terms," 2018.
[38] A. Nanda and V. P. Hotur, "Smart-Vehicle Implementation using Internet-of-Things and Cloud Computing Extension," Asian J. Appl. Sci. Technol., vol. 1, no. 5, pp. 82–85, 2017.
[39] Wu He, Gongjun Yan, and Li Da Xu, "Developing Vehicular Data Cloud Services in the IoT Environment," IEEE Trans. Ind. Informatics, 2014.
[40] M. N. Sakib Miazi, Z. Erasmus, M. A. Razzaque, M. Zennaro, and A. Bagula, "Enabling The Internet of Things in Developing Countries: Opportunities and Challenges," 2016.
[41] D. Ben Arbia, M. M. Alam, A. Kadri, E. Ben Hamida, and R. Attia, "Enhanced IoT-Based End-To-End Emergency and Disaster Relief System," J. Sens. Actuators Networks, vol. 6, no. 19, 2017.
[42] B. Degroat, "Traffic deaths considerable compared with leading causes of death," no. February, p. 2018, 2018.
[43] What Happens When a Medical Condition Causes an Accident?" [Online]. Available: https://www.lorenzoandlorenzo.com/personal-injury-guide/medical-condition-accident/. [Accessed: 23-Feb-2019].
[44] P. Govindarajulu and P. Ezhumalai, "In-Vehicle Intelligent Transport System for Preventing Road Accidents Using Internet of Things," 2018.
[45] ABC12 News Team, "Driver's heart attack caused crash that killed him, 14-year-old Bailee Mantei," Tittabawassee, 08-Nov-2018.
[46] C. Bembridge, "WA's road toll hits a record low but speeding, drink-driving overtaken by a new type of danger," 03-Jan-2019.
[47] TAC Transport Accident Commision, "Fatigue statistics - TAC - Transport Accident Commission," 2018. [Online]. Available: http://www.tac.vic.gov.au/road-safety/statistics/summaries/fatigue-statistics. [Accessed: 24-Feb-2019].
[48] Governors Highway Safety Association, "Drowsy Driving | GHSA," 2015. [Online]. Available: https://www.ghsa.org/issues/drowsy-driving. [Accessed: 24-Feb-2019].
[49] Report of the Intelligent Transport Systems (ITS) High Level Policy Roundtable," 2016.
[50] R. Kumar Jakkar, R. Pahuja, R. K. Saini, B. Sahu, and Natwar, "Drunk-Driver Detection and Alert System (DDDAS) for Smart Vehicles," Am. J. Traffic Transp. Eng., vol. 2, pp. 45–58, 2017.
[51] N. Patel, P. Patel, and N. Patel, "Heart Attack Detection and Heart Rate Monitoring Using IoT," Int. J. Innov. Adv. Comput. Sci., vol. 7, no. 4, 2018.
[52] H. Abdul Rahima, A. Dalimia, and H. Jaafa, "Detecting Drowsy Driver Using Pulse Sensor," J. Teknol. , pp. 5–8, 2015.
[53] Goudjerkan, T., and and Jayabalan, M., "Predicting 30-Day Hospital Readmission for Diabetes Patients using Multilayer Perceptron" International Journal of Advanced Computer Science and Applications(IJACSA), 10(2), 2019. http://dx.doi.org/10.14569/IJACSA.2019.0100236
[54] R. Vasanthakumar, K. D. Darsini, S. Subbaiah, and K. Lakshmi, "IoT for monitoring diabetic patients□," 2018.
[55] T. Vu and A. Khoa, "WEARABLE SMART TECHNOLOGIES: NEW ERA OF TECHNOLOGY," 2015.
[56] J. Best, "Smart watches, fitness trackers and the

NHS: Are wearables just what the doctor ordered? | ZDNet," 2018. [Online]. Available: https://www.zdnet.com/article/smart-watches-fitness-trackers-and-the-nhs-are-wearables-just-what-the-doctor/. [Accessed: 24-Feb-2019].

[57] A sensor system can detect drivers," 2017. [Online]. Available: https://www.ziaruldeiasi.ro/stiri/un-sistem-de-senzori-poate-detecta-simptomele-de-oboseala-ale-soferilor-si-declanseaza-o-alarma--152818.html. [Accessed: 19-Feb-2019].

[58] T. Sehgal, S. Maindalkar, and S. More, "IJARCCE Safety Device for Drowsy Driving using IOT," Int. J. Adv. Res. Comput. Commun. Eng., vol. 5, no. 9, pp. 186–188, 2016.

[59] A. Jesudoss, .B.O Muthuram, and .A Lourdson Emmanuel, "SAFE DRIVING USING IOT SENSOR," Int. J. Pure Appl. Math., vol. 118, no. 20, pp. 3745–3749, 2018.

[60] H. F. Atlam, R. J. Walters, and G. B. Wills, "Internet of Things: State-of-the-art, Challenges, Applications, and Open Issues," Int. J. Intell. Comput. Res. , vol. 9, no. 3, 2018.

[61] F. Jindal, R. Jamar, and P. Churi, "FUTURE AND CHALLENGES OF INTERNET OF THINGS," Int. J. Comput. Sci. Inf. Technol., vol. 10, no. 2, 2018.

[62] R. Van Kranenburg and A. Bassi, "IoT Challenges," a SpringerOpen J., vol. 1, no. 2, 2012.

[63] O. Helmi, M. Akbarpour Sokeh, and G. Sepidnam, "The Challenges Facing with the Internet of Things CHALLENGES OF INTERNET OF THINGS," Int. J. Sci. Study, vol. 527, p. 527, 2017.

[64] S. B. BAKER, W. XIANG, and I. ATKINSON, "Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities," IEEE, vol. 5, 2017.

[65] M. N. O. Sadiku, M. Tembely, and S. M. Musa, "Internet of Vehicles: An Introduction," Int. Journals Adv. Res. Comput. Sci. Softw. Eng., vol. 8, no. 1, 2018.