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IOT TECHNOLOGIES AND MACHINE LEARNING ALGORITHMS – A STUDY

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ABSTRACT

IoT – The technology buzzword of the internet has gained attention among researchers, scientist, engineers, software developers, academia and much more professionals over the years for its effectiveness and increased use in many applications. IoT technology enables communication among real world objects to interact in an intelligent way. In turn, IoT is all about connectivity and automation that require intelligent algorithms to make the smart objects work together. On this aspect, this paper aims to discuss the technology elements of IoT, applications and how machine-learning algorithms are applied in IoT data classification and prediction.

KEYWORDS: IoT, Machine learning, Classification, Prediction, RFID, NFC, WI-FI, WSN.

INTRODUCTION

The possibility the IoT brings to human is endless. It is a combination of two distinct set 'Internet' and 'Things'. It works the similar way the nodes in the internet work. In turn, IoT is called the next evolution of the internet. This enable users and nodes not only share information provided by human and data stored in databases but also information provided by things in physical world. The concept of IoT allows physical objects or things around us to interact with each other in an intelligent way with the aid of key elements like Radio-Frequency Identification (RFID) tags, processors, sensors, actuators, WAN, W-LAN etc.,with minimal human intervention. British technologist Kevin Ashton first coined the term "Internet of Things" - IoT in the year 1999. Since then, it has gained huge attention with the innovation of smart things or physical objects such as mobile phones, wearable stuffs etc., and techniques such as embedded and ubiquitous communication, pervasive computing, cloud computing and data analytics. There is no single or universal definition of IoT. IoT refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items and allowing these devices to generate, exchange and consume data [1]. Everyday objects or things refers not only to electronic devices or technological developments but it also include things that we do not imagined of electronic at all such as food and clothing [2]. IoT enables things from anywhere and at any time to have connectivity for anything to gather, analyze and distribute among them. CISCO forecasted that the number of everyday physical objects and devices connected to the internet in the year 2010 was around 12.5 billion, and is likely to be 30 billion in 2016 as the number of smart devices per person increases and to 50 billion by 2020 [3]. With increase in smart objects and things, the use of IoT is widespread in many context ranging from home automation in domotics,industry automation in business sector to disaster/emergency control management in government projects. The remainder of the paper is organized as follows. Section 2 describes the various communication and networking elements that enables IoT to be ubiquitous in nature. The broad classes of IoT application areas are addressed in Section 3 of the paper. The importance of machine learning algorithms in IoT data classification and Prediction are explained in Section 3. Section 4 highlights machine learning on IoT applications.

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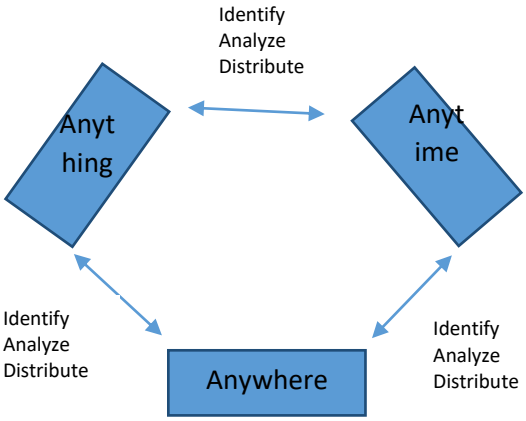

Figure 1: IoT

IOT TECHNOLOGIES

IoT resides on three basic technology components for the everyday 'things' to be equipped with tracking and sensing [4]. When the 'things' are properly equipped it allows to gather, analyze, communicate and distribute data among themselves. The components include hardware, software, and presentation tools.

1.1. HARDWARE

Hardware components such as RFID, WSN, actuators, NFC, WI-FI, and Bluetooth are used in IoT to identify the physical objects in the real word and are referred over the internet [5]. Integrating these hardware components into IoT enables it to be ubiquitous in nature.

RFID – RADIO FREQUENCY IDENTIFICATION

One major innovation in embedded system is RFID, which is used for the design of microchips called tags for wireless data communication. "A radio-frequency identification system uses tags, or labels attached to the objects to be identified. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response. RFID technology plays an important role in IoT for solving identification issues of objects around us in a cost effective manner [6]. The technology is classified into three categories based on the method of power supply provision in Tags: Active RFID, Passive RFID and Semi Passive RFID. Passive RFID tags are not battery powered and they use the power of the reader 's interrogation signal to communicate the ID to the RFID reader. Active RFID readers have their own battery supply and can instantiate the communication. The main components of RFID are tag, reader, antenna, access controller, software and server. It is more reliable, efficient, secured, inexpensive and accurate. RFID has an extensive range of wireless applications such as distribution, retail and supply chain management, transportation and access control application, tracing, patient monitoring, military apps etc.

WSN - WIRELESS SENSOR NETWORK

The advances in many thousands of inexpensive integrated circuits and wireless devices capable of computation and communication provide way for efficient low cost, less power consuming devices for sensing applications. WSN consists of a large number of intelligent sensor, enabling the collection, processing, analysis of information gathered in a variety of environment [7]. The sensor node of WSN is equipped with a transducer, micro, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processor and stores the sensor output. The transceiver receives commands from a central computer and transmits data to the computer. The power for each sensor node is derived from a battery.

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WSN plays an important role in extensive applications such as industry automation, automated and smart phones, video surveillance, traffic monitoring, medical device monitoring, weather condition monitoring.

NFC – NEAR FIELD COMMUNICATION

NFC is a type of a radio communication protocol enables short-range communication between devices. NFC is built on RFID standards and it works similar to RFID. It includes tags and small transmitter that send information to other smart devices that are close in proximity to one another. NFC tag contains a unique identification, provides communication enablement between smart devices. NFC operates within the unlicensed RF band of 13.56 MHZ [8]. NFC has a range of around 10cm, which is much shorter than that of Bluetooth, which can transmit data up to 10 meters.The data transmission speed of NFS is just 424 Kbits/sec, which is lower than the speed of Bluetooth.However, what made NFC more popular is its compatibility and easy to use capability. It can communicate with other wireless technologies and be able to interact with many different NFC transmissions. NFC is also secure and easy to use with other technology.

WI-FI

Another suitable communication technology for IOT is Wi-Fi. Wi-Fi for IOT has become a ubiquitous standard of connectivity and is used in all applications of IOT. Wi-Fi provides a major advantage in capacity, coverage and ease of use. Since the smart devices are increasingly growing, a more increasing Wi-Fi coverage and capacity will also be required. A new low power, long-range version of WI-Fi named Wi-Fi Halow[9]will enable thousands of smart devices to be connected to a single Wi-Fi access point. This Wi-FIHalow is expected to be launched for a certification process in 2018. It is also expected that the range of Wi-FI will be doubled twice the today availability.

ACTUATORS

After the data is collected with the help of sensors it has to be processed, analyzed and reported. This is done with a help of device called actuators. It converts energy into motion. In IOT, actuators are used whenever there is a need to switch on/off device or equipped by applying a force [10].

BLUETOOTH

With inclusion of mess network capabilities, Bluetooth smart (Bluetooth 5) is poised to become the universal language of IOT because of its quadruple the range, double the speed, increase data broadcasting capacity of 800%, interoperability and less energy consumption [11].

1.2. MIDDLEWARE/SOFTWARE

IOT enables different communication tools, devices and application to interact with each other. Middleware is a mechanism that enables ondemand storage and computing tools for data analytics. It acts like an interface and facilitates the communication between internet and ‘things’ of IOT. Middleware addresses issues such as Interoperability across heterogeneous devices and context awareness, device discovery and management, scalability, data analytics,privacy and security [12]. Development of middleware for IOT is itself a big active area of research.

1.3. IOT DATA VISUALIZATION

Data visualization in IOT helps people understand the significance of data by placing it in a visual context. With increase in size of data flow in IOT, the need for good data visualization techniques are also required. The recent advancement in touch screen technologies such as smart phones and surface computing provides easy to understand visualization among the users who makes use of IOT [13]. Innovation in 2D and 3D techniques provides data visualization to be a meaningful fact to the users.

APPLICATIONS OF IOT

With increase in smart objects and things, the use of IoT is widespread in many application areas ranging from home automation in domotics, industry automation in business sector to disaster/emergency control

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management in government projects. Here, we group the application areas into three classes namely Domotics, Business enterprises and Government

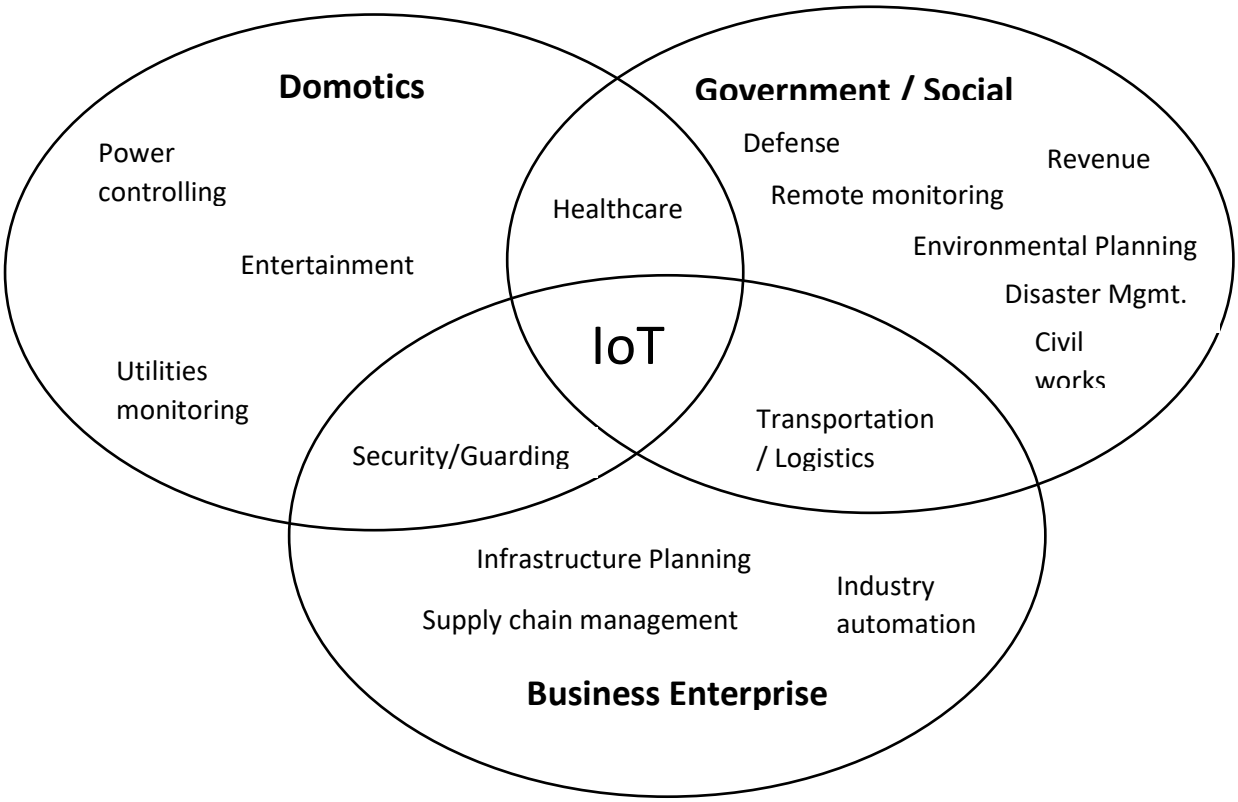

Figure 2: Applications of IoT

Potential offered by the IoT make possible the development of a large number of applications The above figure depicts the applications ofIoT technologies, which are grouped into three different categories namely Domotics, Government/social and business enterprise. Now anyone, from anytime and anywhere can have connectivity for anything and it is expected that these connections will extend and create an entirely advanced dynamic network. IoT technology can also be applied to create a new concept and wide development space for smart homes to provide intelligence, comfort and to improve the quality of life. Home automation (Domotics) can be useful to those who need to Access home appliances while away from their home and can incredibly improve the lives of the disabled.Home Automation is automation of the home, housework or household activity. Home automation may include centralized control of lighting, HVAC (heating, ventilation and air conditioning), appliances, security locks of gates and doors and other systems, to provide improved convenience, comfort, energy efficiency and security. Home automation for the elderly and disabled can provide increased quality of life for persons who might otherwise require caregivers or institutional care [24].

With lower cost and lower power requirement, IoT processing elements plays a crucial role in variety of Business Enterprises. Staring from infrastructure planning to supply chain management, the IoT made the working process of the system much simpler and effective. The role of IoT in transportation provides enormous advantages. IoT made roadways an smarter environment by enabling vehicles equipped with tags and sensors that send important information to traffic control sites and transportation vehicles to better route the traffic, help in the management of the depots, provide the tourist with appropriate transportation information, and monitor the status of the transported goods [25].

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The services offered by IoT to the Social/Government are enormous and growth rate is increasing day by day. IoT bring benefitsto remote healthcare at home or inthe Government/Social sector. It provide many benefits in thehealthcare domain such as tracking patients health record, identification and authentication of staffs working in the hospital, automatic data collection and prediction analysis etc., Recently, natural disasters and accidental disastersare takingplace more and more frequently. Technologiesin IoT, such like RFID and WSNcould play a crucial role in disaster alertingbefore it happens, and disaster recovery after it ends [26].

IOT AND MACHINE LEARNING

The future of smart Internet (IOT) is expected to have billions and billions of smart devices connected together. Therefore, the sheer volume of data created by them will increase to an unimagined level. This data may have extremely valuable insight into whatis a valid data and what is not [14]. The analyze of data plays an extremely important role in pointing out the conflict that arise in IOT applications. It is impossible for human to review and understand this data and doing so with traditional methods. To improve the speed and accuracy of the data analysis for IOT to live up to its promise, and to make data analysis and decision making to be scalable, it is preferably automated. One way to implement is with the aid of machine learning of AI. Figure depicts the applicability of machine learning algorithm in IoT.

Machine learning is a subfield of AI that learns and adapts automatically through experience. It focuses on prediction based on known properties learned from the training data. In IOT, machine learning can help review and analyze the data collected from the environment to find patterns or similarities that can be learned from, so that better decisions can be made. Machine learning gives IOT and devices connected in IOT a brain to think which is called “Embedded Intelligence” [15].

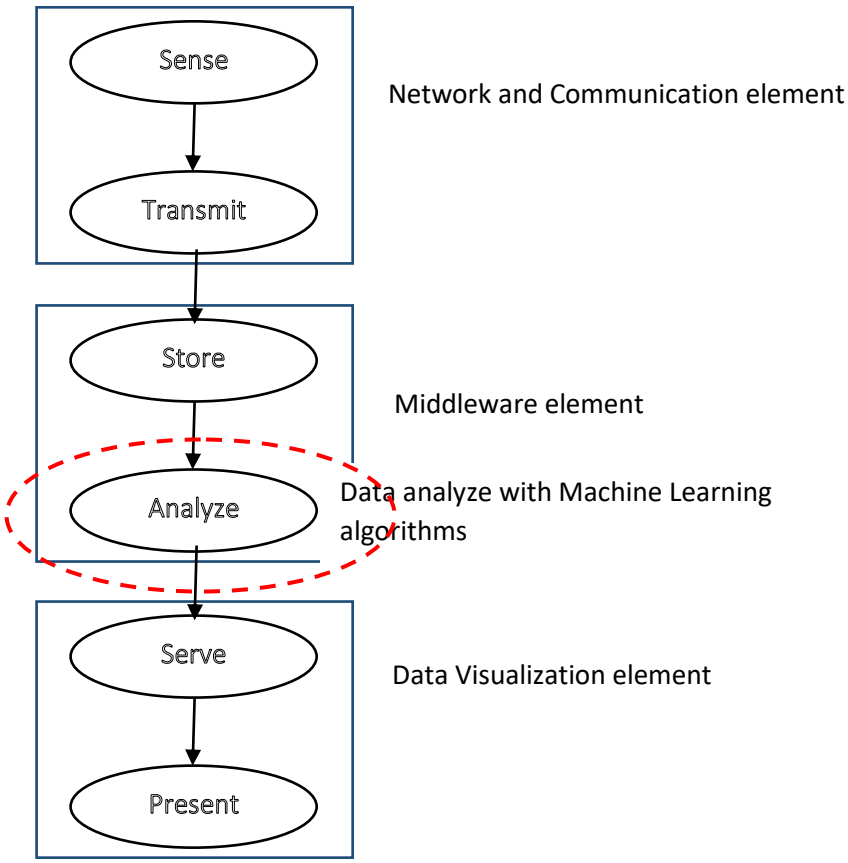

Figure 3: Machine Learning in IoT

1.4. MACHINE LEARNING ALGORITHMS

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With increase data volume in IOT, problem exist mainly in how to classify the data, how to organize and used to make automated decisions. Data classification is the foundation for the intelligent identification and management of massive information in the internet of things.

CLASSIFICATION ALGORITHMS

Data classification is the foundation for the intelligent identification and management of massive information in the internet of things. In classification, a classifier is learned from a set of training examples with class labels. The performance of a classifier is determined by its classification accuracy. Classification techniques in data mining are capable of processing a large amount of data. It can predict class labels and classifies data based on training set and class labels and therefore can be used for classifying unseen available data. [16]. Following are some classification algorithms widely used in applications of IoT.

A) **K-NN (K-Nearest Neighbor):** Is a classification algorithm that classifies a data sample based on the labels of the near data samples.
B) **Naïve Bayes:** Naïve Bayes is an another classification algorithm that assign class labels to problem instance, represented as vectors of feature values, where the class labels are drawn from same finite set [17].
C) **Decision trees:** Decision Tree Classifier poses a series of carefully crafted questions about the attributes of the test record. Each time it receive an answer, a follow-up question is asked until a conclusion about the class label of the record is reached.

PREDICTION ALGORITHMS

Prediction is similar to classification. It first construct a model and use the constructed model to predict unknown value. It is different from classifier in the sense classification refers to predict categorical class label that are discrete or nominal. Whereas, Prediction models are continuous-valued function, i.e., it predicts unknown or missing values [18]. Following are some commonlyused method for prediction.

A) **Linear Regression:**Linear regression is an approach for modeling the relationship between a scalar dependent variable y and one or more explanatory variables called independent variables denoted X. [19]. It goal of regression is to task of fit a single line through a scatter plot. The algorithm consists of three stages - analyzing the correlation and directionality of the data, estimating the model and evaluating the validity and usefulness of the model [20].
B) **Neural Network models:**The NN model involves automatic learning of dependencies only from measured data without any need to add further information. The neural network is trained from the historical data (or from the environment) with the hope that it will discover hidden dependencies and that it will be able to use them for predicting into future [21].

MACHINE LEARNING ON IOT APPLICATIONS

Following examples illustrate some IoT application where machine learning is successfully implemented in the literature.

Example 1: In Home appliances

This is an implementation to reduce the energy cost of a coffee machine [22]. It focus on coffee machines located in common spaces where people usually do not care on saving energy, e.g. the workplace. The proposed prediction algorithm operates autonomously as efficient as possible to reduce the energy cost needed to operate the coffee machine.

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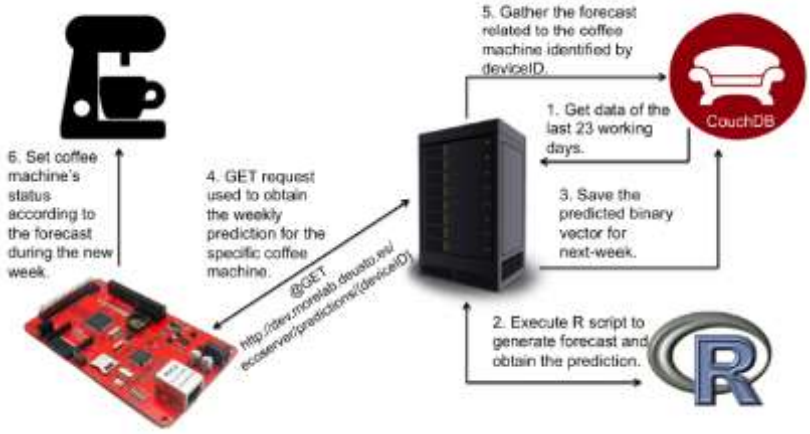
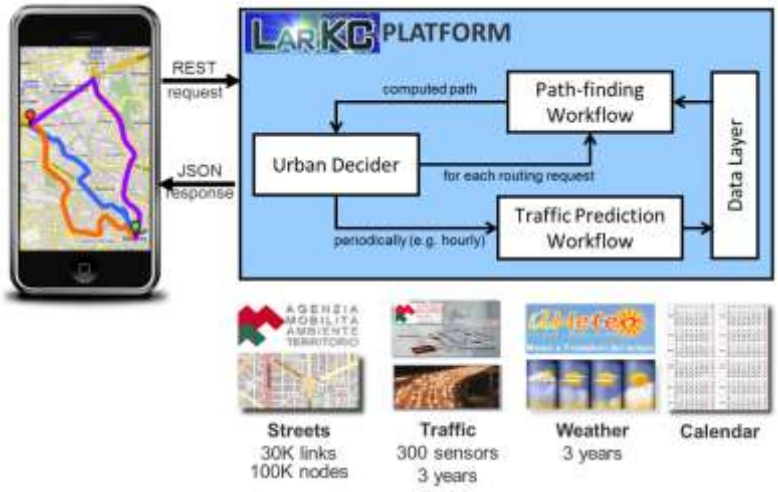


Example 2: Traffic Management

Transports nowadays become smarter with several networking elements like sensor, actuators and other processing powers. Modern city roadways are equipped with RFID tags and sensors that receive send data to traffic control sites and transportation vehicles to better route the traffic. LarKC [23] architecture exploits techniques of machine learning to provide easier scalability in the transportation domain. Figure shows, the whole system and it suggests several route to the destination.



CONCLUSION

The advancement of Internet technologies and proliferation of communication devices in Internet has emerged to a new technology the Internet of Things, which is going to automate everything from home appliances to controllingrobot in defense. A more effective research is needed in the field of IoT. Once successfully implemented, no doubt IoT is going to rule the world in the future. This paper highlighted the communication and networking elements that enable IoT to be ubiquitous. The paper also focused three class of IoT application namely domotics, business enterprise and Government/social sector. It is undoubted IoT holds the promise of improving people's livesthrough automation. In addition, to witness it, the need of machine learning for data classification and prediction were highlighted with application such as home appliance and traffic management.

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