International Journal of Engineering and Applied Physics (IJEAP)
Vol. 1, No. 3, September 2021, pp. 319~330
ISSN: 2737-8071

Adjoining Internet of Things with Data Mining : A Survey

Prof. Harshita Jain[1], Dr. Ritu Shrivastava[2]
[1,2]Dept. of Computer Science & Engineering
Sagar Institute of Research & Technology, Bhopal, MP, India

Article Info

Article history:

Received July 10, 2021
Revised July 30, 2021
Accepted Aug 29, 2021

Keywords:

Data Mining
Data Mining Functionalities
Internet of Things (IoT)
Challenges
IoT Vision
IoT Applications
IoT Limitations
Recommendation
Big Data optimization

ABSTRACT

The Interactive Data Corporative (IDC) conjectures that by 2025 the worldwide data circle will develop to 163ZB (that is a trillion gigabytes) which is ten times the 16.1ZB of information produced in 2016. The Internet of Things is one of the hot topics of this living century and researchers are heading for mass adoption 2019 driven by better than-expected business results. This information will open one of a kind of user experience and another universe of business opening. The huge information produced by the Internet of Things (IoT) are considered of high business esteem, and information mining calculations can be connected to IoT to extract hidden data from information. This paper concisely discusses the work done in sequential manner of time in different fields of IOT along with its outcome and research gap. This paper also discusses the various aspects of data mining functionalities with IOT. The recommendation for the Challenges in IOT that can be adopted for betterment is given. Finally, this paper presents the vision for how IOT will have impact on changing the distant future

Corresponding Author:

Prof. Harshita Jain,
Assistant Professor, CSE
Sagar Institute of Research & Technology,
Bhopal, MP, INDIA.
Email: ssh.harshita@gmail.com

1. INTRODUCTION

There are lot of sources which are producing data and that data is collected in large data repositories which are “data tomb” unless some information is taken out of it. They are data rich and thus there is demand of powerful data analysis tool and hence Data Mining. IOT deals with associating the items in the physical universe, with the sensors attached to it, to the internet. IOT is the next generation of internet. It is the network of physical devices, detectors, home appliances, actuators, software and other items embedded with electronics, which leaves to connect over the internet and permit to interchange data. Since IOT have bought a lot comfort to the lifestyle, so many researchers have expressed great interest in altering the internet by designing various systems like smart pen, global supply chain, intelligent transportation, smart home, healthcare etc. The basic idea of it is to connect all things in the world to the cyberspace. It is expected that things can be distinguished automatically, can communicate with each other, and can even make decisions by themselves. In fact, it is still expected that the emergence of it as a service provider will be a movement. Important conclusions are frequently made based not on the information- rich data stored in data repositories, but preferably along a decision maker’s intuition. The decision maker does not bear the legal documents to remove the significant information implanted in the terrible amounts of data. Technical advancements and available storage perquisites is accountable for such explosive information. Thus, there is an urgent demand for the development of instruments and techniques considering the depth psychology of such vast data. Meanwhile, the article on the Industry Analysis published in Feb 2018 states that According to Growth

Enabler & Marketsand Markets [37] analysis the global IoT market share will be dominated by three sub-sectors; Smart Cities (26%), Industrial IoT (24%) and Connected Health (20%). Followed by Smart Homes (14%), Connected Cars (7%), Smart Utilities (4%) and Wearables (3%). So, to handle the problem of increasing immense data, Data mining emerged as the new research area to meet this defiance. The popularity and importance of data mining has originated for two grounds: exponentially increasing volume of data and computational power. For example: The Internet of Things (IoT) has become quite a buzz word in recent years, and according to Gartner (world's leading research and advisory company) research, 25 billion connected "things" will be connected to the Internet by 2020 [37]. The consequence of the increasing stream of data and computational power creates a motivation to develop data mining applications to extract novel, potentially useful as well as ultimately understandable knowledge from large.

1.1. Data mining:

There are different views proposed by various researchers regarding the enormous amount of information. Data in such huge volumes do not constitute knowledge, i.e., They cannot be immediately exploited by human beings and useful information cannot be derived only by their reflection. Therefore, more elaborate techniques are needed in order to draw out the hidden knowledge and reach these data valuable to the end-users. Data mining was developed to extract Knowledge from the crude data, employing algorithms that could discover several statistic properties in the original information. Data mining produces results like association rules, clusters, decision trees and other structures that describe properties of the new information [39].

Knowledge mining, Knowledge extraction, Data/Pattern analysis, Data archaeology, Data dredging are the other names of Data Mining. It is the process for the extraction of valuable information about the huge amount of data. Data Mining is one of the most constitutive analysis steps of the "Knowledge Discovery in Databases" or KDD Process. The term KDD is used for the explorative process of extraction of knowledge from data. It is specified as: "KDD or Data Mining is non-trivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data" [39]. The term data mining, a subset step of KDD Process, is practiced only for the discovery as well as the analysis stage of the KDD process. Data mining is concentrated because it is more time consuming as well as most significant among KDD steps in the current scenario. Various KDD steps include the tracing:

A Data cleaning (this point deals with noise and inconsistent information)

A. Information integration (multiple data sources are being merged)
B. Data option (interesting data is selected)

C. Data translation (at this stage data is transformed or consolidated into appropriate forms by performing summary or aggregation operations)
D. Data mining (an essential process where intelligent methods are used in order to extract data patterns)
E. Pattern evaluation (to distinguish the truly interesting patterns representing knowledge based on some interesting measures)
F. Knowledge presentation (where visualization and knowledge representation techniques are employed to present the mined knowledge to the user).

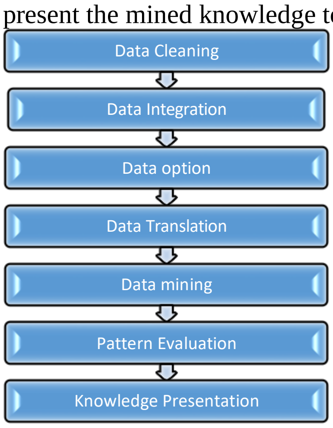

Figure 1. Basic Steps of KDD process

The workflow of Data mining is shown through Figure 2.

It is a young interdisciplinary field, taking out from fields such as database systems, information warehousing, statistics, machine learning, data visualization, data retrieval, and high- performance computing. Other contributing areas include neural nets, shape identification, spatial data analysis, image databases, signal processing, and many application fields, such as business, economics, Bioinformatics and Internet of Things (IOT).

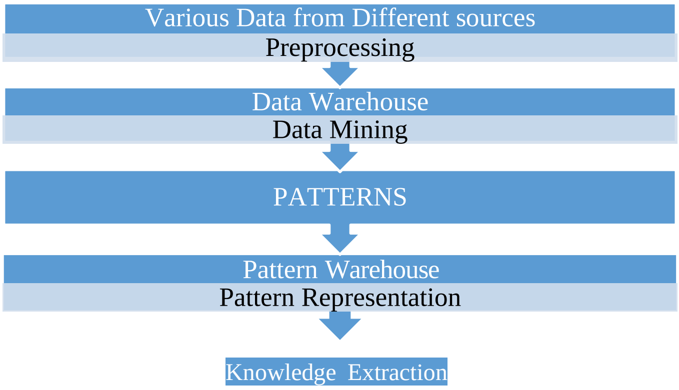

Figure 2. Workflow of Data Mining

1.2. Internet Of Things (Iot):

The term "Internet of Things" was coined in the late 1990s by entrepreneur Kevin Ashton. Ashton, who's one of the founders of the Auto-ID Center at MIT, was part of a team that discovered how to link objects to the Internet through an RFID tag.

The ***Internet of Things*** is the concept of everyday objects – from industrial machines to wearable devices – using built-in sensors to gather data and take action on that data across a network. So, it's a building that uses sensors to automatically adjust heating and lighting. Or is a production equipment alerting maintenance personnel in case of failure. It refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. Internet of Things is the future of technology that can make our lives more efficient [34].

In IoT discussions, it's recognized from the onset that analytics technologies are critical for turning this tide of streaming source data into informative, aware and useful knowledge. But how do we analyze data as it streams nonstop from sensors and devices? How does the process differ from other analytical methods that are common today?

In traditional analysis, data is stored and then analyzed. However, with streaming data, the models and algorithms are stored and the data passes through them for analysis. This type of analysis makes it possible to identify and examine patterns of interest as data is being created – in real time. So before the data is stored, in the cloud or in any high-performance repository, you process it automatically. Then, you use analytics to decipher the data, all while your devices continue to emit and receive data.

As depicted in Fig 3, IoT collects data from different sources, which may contain data for the IoT itself. KDD, when applied to IoT, will convert the *data* collected by IoT into useful *information* that can then be converted into *knowledge*. The data mining step is responsible for extracting patterns. Ultimately the knowledgeable patterns are converted according to the type of analytics.

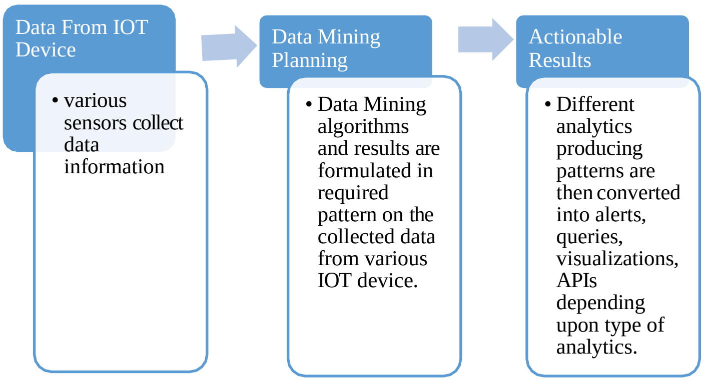

Figure 3. Workflow of IoT

With advanced analytics techniques, data stream analytics can move beyond monitoring existing conditions and evaluating thresholds to predicting future scenarios and examining complex questions.

To assess the future using these data streams, you need high- performance technologies that identify patterns in your data as they occur. Once a pattern is recognized, metrics embedded into the data stream drive automatic adjustments in connected systems or initiate alerts for immediate actions and better decisions.

Essentially, this means you can move beyond monitoring conditions and thresholds to assessing likely future events and planning for countless what-if scenarios.

2. LITERATURE SURVEY

In this paper, the literature survey is in concise tabular form which involves the description of various work which has been done in different category of IOT in evolutionary way. Table 1 describes briefly the background study on the basis of: Related work, Category, Proposed Mechanism, Outcome, Research Gap.

Table 1. background study

Related work Reference	Category/ Application	Proposed Mechanism	Outcome	Research gap
An analysis of RFID authentication schemes for internet of things in healthcare environment using elliptic curve cryptography [10]	Healthcare environment	Elliptic curve cryptography	Authentication based security was achieved.	More secured approach can be opted.
Information fusion to defend intentional Attack in internet of things [7]	Defending intentional attacks in IOT	Fusion based defense based on collected one-bit feedback	Enhances the robustness of IOT	Various other attacks can also be considered and relevant techniques can be applied
Defending connected vehicles against malware: challenges and a solution framework [2]	Defending vehicles Against malware	Cloud assisted Vehicle malware defense framework	Unique challenges like signature-based detection, signature scanner etc. Were solved out.	The gateway alone, with its limited onboard Resources, may not be able to
				detect all malware in the Pass-through traffic.

Internet of things for smart cities [3]	Smart city vision	Based on (Padova smart city project)	Various problems of city like noise, air pollution, smart parking etc. Were sort out using IOT.	More improvement on the privacy and security issues is required.
Securing the internet of things: A standardization perspective [5]	Standardize security Solutions for the IOT ecosystem	The use of *1)* raw public key in DTLS *2)* extending DTLS record layer to Protect group (multicast) communication *3)* profiling DTLS	The DTLS (datagram transport layer security) for IOT applications was adapted and Enhanced.	A standardized security framework For the IOT that is interoperable together with TLS, CORE, and LWIG WGS is still to be worked on.
A vision of IOT: applications, challenges, And opportunities with china perspective [8]	Policies, R&D plans, applications, and standardization of china based on IOT.	Three-layer architecture (sensing, application, network & service layer) including Three platforms (sensing and gateway platform, open application platform, resource and administration platform) was proposed.	Architectural, standard, privacy and security, interoperability issues were sorted out.	Low power nodes and Computing, low cost and low latency communicatio n, identification And positioning technologies, self- organized distributed Systems technology, and distributed intelligence are still to be solved.
Privacy-preserving channel access For internet of things [9]	Privacy-preserving TDMA wireless Access mechanism for a multi- trust-domain network of IOT	Zero-exposure slot allocation scheme. Protocol has been designed and Implemented in tinyos-2.x along with add-on hardware on mica2 motes for collision detection and resolution.	Prevention of inter trust- Domain privacy exposure by not relying on any explicit In-packet information including mac layer source and destination Addresses.	A formal proof of convergence And its analysis, support for variable rate traffic Using multiple slots per node per TDMA frame, and comparison Of the protocol with other similar privacy- preserving Protocols.

Connected vehicles: solutions and challenges [6]	Internet of vehicles.	The state-of the-Art wireless solutions to vehicle- to-sensor, vehicle-to vehicle, Vehicle-to-internet, and vehicle- to-road infrastructure Connectivity.	On the basis of literature survey various challenges and their solutions were addressed.	Low cost connectivity, reliability, performance and efficient connection while harsh communication environment inside and/or outside the Vehicle.
The cluster between internet of things and social Networks: review and research challenges [4]	Social internet of things (SIoT).	SIoT architecture was proposed.	Sociality was increased (or connectivity) and improved pervasiveness (or availability) was achieved.	Interoperability, heterogeneity, self-operation, management, security, privacy, trust, interaction & interfaces.
A practical evaluation of information processing	Presents an efficient Workflow to extract meaningful information from raw sensor data Based on the current state-of-the-art	Approaches like pattern based event, octopus, envision, pattern based event detection, hierarchical recognition,	Data processing and abstraction Techniques that are adaptive.	High-performance computing and efficient Processing of very large amounts of
And abstraction techniques for the internet of things [17]		information abstraction were used.	The capacity of handling multimodal data	data is the issue which has to be sorted out
An IOT-aware architecture for smart Healthcare systems [18]	Smart Hospital system (SHS)	RFID, WSN, and smart mobile, Interoperating with each other through a constrained application Protocol (COAP)/ipv6 over low- power wireless personal area network (6lowpan)/representational state transfer (rest) network Infrastructure.	Power-effective remote patient monitoring and Immediate handling of emergencies, automatic monitoring and tracking of patients, Personnel, and biomedical devices within hospitals and nursing Institutes.	Technology is limited To patient/devices monitoring and tracking in quite small Environments.
Keep your promise: mechanism design against Free-riding and false-reporting in crowdsourcing [20]	Crowdsourcing mechanisms	Mechanism EFF, mechanism DFF	Eliminates dishonest behavior with the help from A trusted third party for arbitration. DFF discourages dishonest behavior. No user could have a utility gain by unilaterally being Dishonest	To make The mechanism robust against free-riding and false-reporting without assumption
Efficient multipattern event processing over High-speed train data streams [16]	Train onboard System.	A multipattern complex event detection Model, multipattern event processing (MPEP), constructed by Three parts: *1)* multipattern state	Optimize The complex event detection process and improve its throughput By eliminating duplicate automata	Safety related industrial system, reliability and security. Single-pattern event

		transition *2)* failure transition *3)* state output.	states and redundant computations. It also provides better Detection ability than other models when processing real-time Events stored in high- speed train juridical recording unit (JRU).	processing Needs more exploration.
Meta expert learning and efficient pruning For evolving data streams [15]	Pruning function	Algorithms such as meta expert learners and boosting (and WM) algorithms	Better prediction accuracy without Necessary higher memory consumption	Efficient analytic algorithms are required To predict on the fly and handle concept drift.
Friendship selection in the social internet of things: Challenges and possible strategies [14]	Social internet of things (SIoT): friendship selection	Network navigability in SIoT networks through simulations. Heuristics for local link selection that have different impact giant component, average degree, and local clustering. Approach to dynamically adjust the threshold in the number of connections on the basis of the number of hubs in the network	The friends that minimize the local Neighbor degree is the approach that allows for reaching the Best global network navigability	Adoption of more Powerful friendship selection strategies.
An internet of things framework for smart Energy in buildings: designs, prototype, And experiment [19]	Energy efficient smart buildings.	IOT framework With smart location-based automated and networked energy control inspired by “energy proportional Computing” in modern computers.	Led to significant economic benefits in term of energy saving, Improving home/office network intelligence, but also bought in a Huge social implication in terms of global sustainability.	More IOT networking and Computing technologies are required to improve the energy efficiency in buildings.

3. DATA MINING FUNCTIONALITIES FOR IOT:

One of the most important questions that arise now is, how do we convert the data generated or captured by IoT into knowledge to provide a more convenient environment to people? This is where knowledge discovery in databases (KDD) and data mining technologies come into play, for these technologies provide possible solutions to find out the information hidden in the data of IoT, which can be used to enhance the performance of the system or to improve the quality of services this new environment can provide.

It is naturally anticipated that KDD is able to find “something” from IoT, by using the following steps: selection, preprocessing, transformation, data mining, and interpretation/ evaluation [41]. Of these steps, the data mining step, as the name suggests, plays the key role in extracting interesting patterns (rules) from the data. The other steps can be broadly divided into two steps: the data processing step (consisting of the selection, preprocessing, and transformation steps), which is to be taken before the data mining step, and the decision-making step (consisting of the interpretation/evaluation step), which is to be taken after the data mining step. Various functions of Data Mining algorithm and Various Data Mining Models that can be carried out on the IOT data are discussed:

3.1. Data Mining Algorithms:

Prediction: Predictive model determined the future outcome rather than present behavior. The predictive attribute of a predictive model can be geometric or categorical. It engrosses the ruling of set of characteristics relevant to the attribute of interest and predicting the value distribution based on the set of data similar to the selected object (S) for example one may predict the kind of disease based on the symptoms of patient. The predictive modelling can be done by either of these two ways. But while inducing IOT, time series analysis is mostly used for real time data analysis.

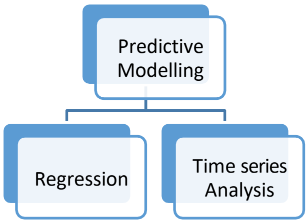

Figure 4. Types of Predictive modelling

a. ***Classification:*** Classification is used to builds models from data with predefined classes as the model is used to classify new instance whose classification is not known. The instances used to create the model are known as training data. A decision tree or set of classification rules is based on such type of mechanism of classification which can be retrieved for identification of future data for example one may classify temperature. Popular classification algorithms for model building, and manners of presenting classifier models, include (but are not limited to): Decision tree, Support Vector machine, Naïve Bayes, Neural Network, Nearest Neighbors etc.

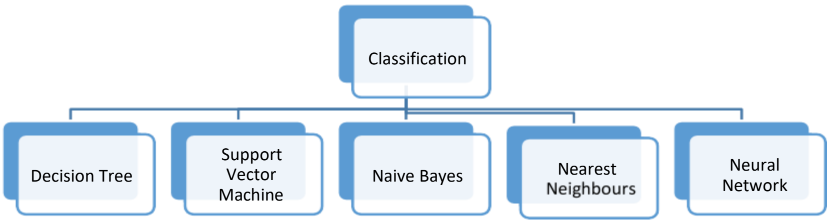

Figure 5. Types of Classification

b. ***Mining Frequent patterns, Associations and correlations*****:** Frequent patterns can be defined as a pattern (a set of items, subsequence, substructures, etc.) that appears intermittently in data. An intermittent item set is a set of data that occurs frequently together in a transaction data set for example, a set of items, such as table and chair. Subsequence means first of all buying a Computersystem, then UPS, and thereafter a printer. This appears frequently in a shopping history data base and is called a frequent sequential pattern. Substructure as particular structural forms such as sub graphs, sub tree. If a substructure appears intermittently, it is named as a frequent structural pattern. Discovering such type of frequent pattern plays an important role in correlation mining association clustering and other data mining tasks.

c. **Outlier Analysis:** Outer analysis is an object in database which is significantly different from the existing data. “An outlier is an observation which deviates so much from the other observations as to arouse suspicions that it was generated by a different mechanism”. Deviants, Abnormalities, Discordant and Anomalies are also referred as outliers in data mining and statistics literature. The outliers may be of particular interest, such as in the mining or outlier analysis. The outlier can be diagnosed with the help of statistical tests that assume probability model for the data. Some of the most common methods to detect outliers are:

- Z-Score or Extreme Value Analysis (parametric)
- Probabilistic and Statistical Modeling (parametric)
- Linear Regression Models (PCA, LMS)
- Proximity Based Models (non-parametric)
- Information Theory Models
- High Dimensional Outlier Detection Methods (high dimensional sparse data).

4. RECOMMENDATIONS

To various research issues and challenges here are some recommendations given in Table 2.

Table 2. Chllenges and Recommendations

	Challenges	***Recommendation***
1.	To store, read and write large volume of data with fast and effective mechanism.	Use of Hadoop Distributed File System, Apache spark (in memory computing software)
2.	Integration of Heterogeneous data in efficient time.	Use of MongoDB, Apache Cassandra, Apache HBase, MarkLogic's
3.	To extract deep hidden knowledge from large volumes of data.	Various Data Mining Techniques
4.	To find the fault and harder to correct the data.	Fault tolerant tools can be used
5.	Effective and security solution to share data between different applications and systems.	Proper use of data tagging and enforced time stamps
6.	Accuracy and Efficiency in big data processing.	Support Vector Machine (SVM), K-nearest neighbor (KNN), Naive Bayes (NB), Linear discriminant analysis (LDA), C4.5, C50 and ANNs
7.	Algorithm adoption for parallel platforms	parallel association rule mining and parallel *k*-means algorithm
8.	Security of Big Data	Attribute-Based Encryption, Light weight encryption. asymmetric encryption, regular audits, and hash chaining
9.	Privacy of Big Data	Anonymization of data, opt for Differential privacy
10.	Universal standardization of architecture	Circumvent infrastructure and economic deficits using IaaS and open-source software
11.	Lack of Interoperability	Advance in the creation and adoption of digital agendas
12.	Lack of standardization of protocols	We expect pioneering standardization groups to collaborate on different layers of the Internets of Things. Till then ambient computing holds the scenario.
13.	To use flood of big data for prediction, optimization and decision	Make use of machine learning, big data software and service platforms and Apache Spark Streaming tool.

5. DISCUSSIONS: INTERNET OF THINGS: VISION 2030

When taking a gander at the present cutting-edge innovations, they should give an unmistakable sign of how the Internet of things will be executed at an all-inclusive level in the years to come and also showing critical viewpoints that should be additionally contemplated and created in the coming years. Right off the bat, the need exists for huge work in the territory of administration. Without an institutionalized approach it is likely that a multiplication of structures, distinguishing proof plans, conventions, and frequencies will create one next to the other, every one devoted to a specific and separate utilize. This will definitely prompt a discontinuity of the IoT, which could hamper its ubiquity and turn into a noteworthy impediment in its take off. Interoperability is a need, and between label correspondence is a pre-condition all together for the reception of IoT to be across the board.

In the coming years, innovations important to accomplish the omnipresent system society are relied upon to enter the phase of functional utilize. It is generally expected that RFID innovation will progress toward becoming standard in the retail business. As this situation will advance, countless will be addressable, and could be associated with IP-based systems, to constitute the specific first influx of the "Web of Things". There will be two noteworthy difficulties with a specific end goal to ensure consistent system get to: the principal issue identifies with the way that today unique systems exist together; the other issue is identified with the sheer size of the "IoT". The IT business has no involvement in building up a framework in which a huge number of articles are associated with IP systems. Other current issues, for example, address confinement, programmed address setup, security capacities, for example, validation and encryption, and multicast capacities to convey voice and video flags productively will most likely be overwhelmed by continuous innovative improvements.

Another imperative perspective that should be tended to at this beginning period is the one identified with enactment. Different purchaser bunches have communicated solid worries about the various conceivable outcomes for this innovation to be abused. A reasonable administrative structure guaranteeing the privilege for protection and security for all clients should in this manner be actualized by all part states. A maintained data crusade featuring the advantages of this innovation to society everywhere should likewise be sorted out, a battle which underlines the advantages that this innovation can convey to standard residents in their regular daily existences be it enhanced sustenance traceability, helped living or more secure human services. "Information", in this unique situation, can be viewed as a "question" and under this vision a label conveys its own qualities, as well as the tasks it can deal with. The measure of knowledge that the articles in the IoT should have and assuming, how and in which cases this insight is disseminated or incorporated turns into a key factor of improvement later on.

6. CONCLUSION

The research work shows that the hype of IOT have impacted data mining more and more to improve and scale its capability in order to make it inter operable, scalable and more efficient in terms of computational cost and time. It also requires continuous improvements in the domain of infrastructure standardization, security and privacy, Data Maintenance and Knowledge extraction from Unstructured Data. The standard layout of protocols needed to be fixed from the future perspective. In future the role of optimization on the IOT data is also going to play an important role. Then the need of deep study of various optimization technique especially the nature inspired algorithm will be required and also to find the fitness of each algorithm for various different application of IOT will the important role [40]. The discussion in the paper have pointed out main open research issues of this arena and some of the Challenges have been tried to sort out by the proposed recommendation. The vision which is discussed in the paper gives us the idea about How IOT is going to be and what measures should be of prime focus while dealing with it. Since IOT is changing our life exponentially, so it becomes very important for us to know it completely.

“If you think that the internet has changed your life, think again. The IoT is about to change it all over again!”

ACKNOWLEDGEMENTS

I would like to express my special thanks of gratitude to my Vice Chacellor, my Director, Dean and my Guide who gave me the golden opportunity to do this wonderful survey on IOT Adjoining Data Mining, which also helped me in doing a lot of Research and i came to know about so many new things I am thankful to them.

Secondly i would also like to thank my parents, husband and friends who helped me a lot in keeping me motivated and to complete the paper within the limited time frame.

REFERENCES :

[1] J. Stankovic, “Research Directions for the Internet of Things,” IEEE INTERNET OF THINGS JOURNAL, VOL.1, NO. 1, FEBRUARY 2014, pp 1-7.

[2] Andrea Zanella, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, "Internet of Things for Smart Cities", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 1, FEBRUARY 2014, pp 22-33.

[3] Antonio M. Ortiz, Dina Hussein, Son N. Han and Noel Crespi, “ The Cluster Between Internet of Things and Social Networks: Review and Research Challenges”, IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 3, JUNE 2014, PP 206-216.

[4] Sye Loong Keoh, Sandeep S. Kumar, and Hannes Tschofenig, “ Securing the Internet of Things:A Standardization Perspective”, IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 3, JUNE 2014, pp 265

– 276.

[5] Ning Lu, Ning Zhang, Xuemin Shen and Jon W. Mark, "Connected Vehicles: Solutions and Challenges", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 4, AUGUST 2014, pp 289-300.

[6] Pin-Yu Chen, Shin-Ming Cheng and Kwang-Cheng Chen, " Information Fusion to Defend Intentional Attack in Internet of Things ", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 4, AUGUST 2014, pp 337 -349.

[7] Shanzhi Chen, Hui Xu, Dake Liu, Bo Hu, and Hucheng Wang, " A Vision of IoT: Applications, Challenges and Opportunities With China Perspective", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 4, AUGUST 2014, pp 349 -360.

[8] Debasmit Banerjee, Bo Dong, Mahmoud Taghizadeh, and Subir Biswas, " Privacy-Preserving Channel Access for Internet of Things", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 5, OCTOBER 2014, pp 430 - 446.

[9] Debiao He and Sherali Zeadally, " An Analysis of RFID Authentication Schemes for Internet of Things in Healthcare Environment Using Elliptic Curve Cryptography", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 1, FEBRUARY 2015, pp 72 – 84.

[10] Adnan Aijaz , A. Hamid Aghvami, "Cognitive Machine- to-Machine Communications for Internet-of-Things: A Protocol Stack Perspective", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 2, APRIL 2015, pp 103 – 113.

[11] Ajinkya Rajandekar, and Biplab Sikdar ," A Survey of MAC Layer Issues and Protocols for Machine-to-Machine Communications", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 2, APRIL 2015, pp 175 – 187.

[12] Chayan Sarkar, R. Venkatesha Prasad, Abdur Rahim, Ricardo Neisse, and Gianmarco Baldini, " DIAT: A Scalable Distributed Architecture for IoT", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 3, JUNE 2015, pp 230 -240.

[13] Michele Nitti, Luigi Atzori, and Irena Pletikosa Cvijikj, "Friendship Selection in the Social Internet of Things: Challenges and Possible Strategies", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 3, JUNE 2015, pp 240 – 248.

[14] Mahdi Azarafrooz and Mahmoud Daneshmand, "Meta Expert Learning and Efficient Pruning for Evolving Data Streams", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 4, AUGUST 2015, pp 268 -274.

[15] Meng Ma, Ping Wang, Chao-Hsien Chu, and Ling Liu," Efficient Multipattern Event Processing Over High-Speed Train Data Streams "IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 4, AUGUST 2015, pp 295 – 306.

[16] Frieder Ganz, Daniel Puschmann, Payam Barnaghi, and Francois Carrez, "A Practical Evaluation of Information Processing and Abstraction Techniques for the Internet of Things, IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 4, AUGUST 2015, pp 340 – 355.

[17] Luca Catarinucci, Danilo de Donno, Luca Mainetti, Luca Palano, Luigi Patrono, Maria Laura Stefanizzi, and Luciano Tarricone. " An IoT-Aware Architecture for Smart Healthcare Systems", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 6, DECEMBER 2015, pp 515 – 530.

[18] Jianli Pan, Raj Jain, Subharthi Paul, TamVu, Abusayeed Saifullah and Mo Sha , " An Internet of Things Framework for Smart Energy in Buildings: Designs, Prototype and Experiments", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 6, DECEMBER 2015, pp 527 - 538.

[19] Xiang Zhang, Guoliang Xue, Ruozhou Yu, Dejun Yang and Jian Tang, "Keep Your Promise: Mechanism Design Against Free-Riding and False-Reporting in Crowdsourcing", IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 6, DECEMBER 2015, pp 562 - 573.

[20] Hongming Cai, Boyi Xu, Lihong Jiangand Athanasios V. Vasilakos, " IoT-Based Big Data Storage Systems in Cloud Computing: Perspectives and Challenges", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 1, FEBRUARY 2017, pp 75 – 13.

[21] Zhaozong Meng, Zhipeng Wu, Cahyo Muvianto, and John Gray, " A Data-Oriented M2M Messaging Mechanism for Industrial IoT Applications", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 1, FEBRUARY 2017, pp 236 – 247.

[22] Guang Yang, Shibo He, and Zhiguo Shi, " Leveraging Crowdsourcing for Efficient Malicious Users Detection in Large-Scale Social Networks", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 2, APRIL 2017, pp 330 -340.

[23] Altti Ilari Maarala, Xiang Su, and Jukka Riekki, " Semantic Reasoning for Context-Aware Internet of Things Applications", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 2, APRIL 2017, pp 461 – 474.

[24] Zhicheng Li, Hong Huang, and Satyajayant Misra, " Compressed Sensing via Dictionary Learning and Approximate Message Passing for Multimedia Internet of Things", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 2, APRIL 2017, pp 505 – 513.

[25] Shaoen Wu, Jacob B. Rendall, Matthew J. Smith, Shangyu Zhu, Junhong Xu, Honggang Wang, Qing Yang and Pinle Qin, " Survey on Prediction Algorithms in Smart Homes", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 3, JUNE 2017, pp 636 – 645.

[26] Wenbin Wu and Mugen Peng, " A Data Mining Approach Combining K-Means Clustering With Bagging Neural Network for Short-Term Wind Power Forecasting", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 4, AUGUST 2017, pp 979 –987.

[27] Kai Yang, Ruilin Liu, Yanjia Sun, Jin Yang, and Xin Chen, " Deep Network Analyzer (DNA): A Big Data Analytics Platform for Cellular Networks", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 6, DECEMBER 2017, pp 2019 – 2028.

[28] Ruinian Li, Tianyi Song, Nicholas Capurso, Jiguo Yu, Jason Couture, and Xiuzhen Cheng, "IoT Applications on Secure Smart Shopping System", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 6, DECEMBER 2017, pp 1945 – 1955.
[29] Mohammad Wazid, Ashok Kumar Das,Vanga Odelu , Neeraj Kumar, Mauro Conti, and Minho Jo , " Design of Secure User Authenticated Key Management Protocol for Generic IoT Networks", IEEE INTERNET OF THINGS JOURNAL, VOL. 5, NO. 1, FEBRUARY 2018, pp 269 -283.
[30] Sabrina Sicari, Alessandra Rizzardi, Daniele Miorandi, and Alberto Coen-Porisini, "Dynamic Policies in Internet of Things:Enforcement and Synchronization", IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 6, DECEMBER 2017, pp 2228 -223.
[31] Omer Berat Sezer , Erdogan Dogdu, and Ahmet Murat Ozbayoglu, " Context-Aware Computing, Learning, and Big Data in Internet of Things: A Survey", IEEE INTERNET OF THINGS JOURNAL, VOL. 5, NO. 1, FEBRUARY 2018, pp 1 – 27.
[32] Feng Chen, Pan Deng, JiafuWan, Daqiang Zhang, Athanasios V. Vasilakos and Xiaohui Rong, Data Mining for the Internet of Things: Literature Review and Challenges", Hindawi Publishing Corporation, International Journal of Distributed Sensor Networks, Volume 2015, Article ID 431047.
[33] Somayya Madakam, R. Ramaswamy, Siddharth Tripathi," Internet of Things (IoT): A Literature Review, Journ Chun-Wei Tsai, Chin-Feng Lai, Ming-Chao Chiang, and Laurence T. Yang, " Data Mining for Internet of Things: A Survey", IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 16, NO. 1, FIRST QUARTER 2014, pp 77 – 98.
[34] Chun-Wei Tsai, Chin-Feng Lai, Ming-Chao Chiang, and Laurence T. Yang, "Data Mining for Internet of Things: A Survey", IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 16, NO. 1, FIRST QUARTER 2014, pp 77 – 98.
[35] David Hand, Heikki Mannila and Padhraic Smyth, Article " Principles of Data Mining", ISBN: 026208290x published by The MIT Press © 2001 (546 pages).
[36] https://makinganewreality.org/industry-analysis- internet-of-things-e721a9c18d3a
[37] IEEE Internet of Things, Towards a definition of the Internet of Things (IoT) Issue 1 – Published 13 MAY 2015.
[38] Harshita Jain, Dr. Akhilesh Tiwari, "Sequential Step Towards Pattern Warehousing", June 17 Volume 5 Issue6 , International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), ISSN: 2321-8169, PP: 665 – 670.
[39] Harshita Jain, Dr. Akhilesh Tiwari, "Study: Evolution of Nature Inspired Algorithms in Various Application Domains", IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 05, 2017 | ISSN (online): 2321-0613, PP : 1-6.
[40] Shen Bin, Liu Yuan, Wang Xiaoyi, , Research on Data Mining Models for the Internet of Things 978-1-4244-5555-3/10/$26.00 ©2010 IEEE.
[41] Furqan Alam, Rashid Mehmood, Iyad Katib, Aiiad Albeshri, " Analysis of Eight Data Mining Algorithms for Smarter Internet of Things (IoT)", International Workshop on Data Mining in IoT Systems (DaMIS 2016).
[42] P. Brezany, I. Janciak, and A. M. Tjoa. "GridMiner: a fundamental infrastructure for building intelligent Grid systems," Proc. 2005 IEEE/WIC/ACM International Conference on Web Intelligence (WI'05), IEEE press, 200, pp. 150~1.
[43] P. Brezany, I. Janciak, and A. M. Tjoa. "GridMiner: a fundamental infrastructure for building intelligent Grid systems," Proc. 2005 IEEE/WIC/ACM International Conference on Web Intelligence (WI'05), IEEE press, 200, pp. 150~156.56.

BIOGRAPHIES OF AUTHORS :

	Prof. Harshita Jain, Assistant Professor, Department of Computer Science & Engineering, Sagar Institute of Research and Technology, Bhopal She is persuing her PhD from UIT-RGPV, BHOPAL, INDIA. She has received Young Scientist Award Fellowship twice 2015, 2017, organized by MPCST, India. She has also been Nominated for International Scientist Awards 2021, organized by VDGOOD at Pondicherry. She holds 2 Patents 1 national and 1 Australian Patent. She has grasped a lot in research area at very young age. Her Research Interests includes Machine Learning, IOT, Data Mining, Artificial Intelligence, Optmization Algorithms.
	Dr. Ritu Shrivastava, Dean and Head, Department of Computer Science & Engineering, Sagar Institute of Research and Technology, Bhopal She has done her PhD from MANIT, Bhopal, India. She has teaching and research experience of 27+ years. She has been the recepient of Attammanthan award, Best teacher award, Women Scientist award and many more. She has long list of publications and has done renowned work in Patents.