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Internet of Things Analytics for Smart Home Applications

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Abstract: ***With advancement in smart home services on mobile and wearable devices, individual can smartly control his/her home appliances such as fan, refrigerator, TV, air conditioner, etc., in an efficient manner. Internets of Things (IoT) devices are extensively utilized to interchange the data between smart applications, mobiles, and wearables. IoT devices are responsible for monitoring and sensing the data about home appliances with the help of sensor nodes, the obtained data is then communicate to given high-end devices for taking the suitable action. The overall objective of this paper is to study the existing IoT analytics techniques which are used to build smart applications for homes. This paper also discusses the various challenges to design a suitable smart home using IoTs. Thereafter, a comparative analyzes are considered to evaluate the shortcomings of these techniques and various gaps are formulated in the existing techniques. Finally, a methdology has been devised which can overcome the shortcomings of existing models and help enhancing the functioning of human activity recognition in smart homes.***

Index terms: Internet of things, Home appliances, Smart home, Wearable devices, Data analytics.

I. INTRODUCTION

A smart home is a home which uses Internet of things (IoT) devices to make home appliances smart i.e., these devices can take action according to the user instructions and also smart homes enable remote access of these home appliances such as air conditioner, lighting, heating, etc. [1] Generally, in smart homes IoT devices are deployed to sense and monitor the home appliances. Some typical applications of smart homes are shown in Figure 1 [2].

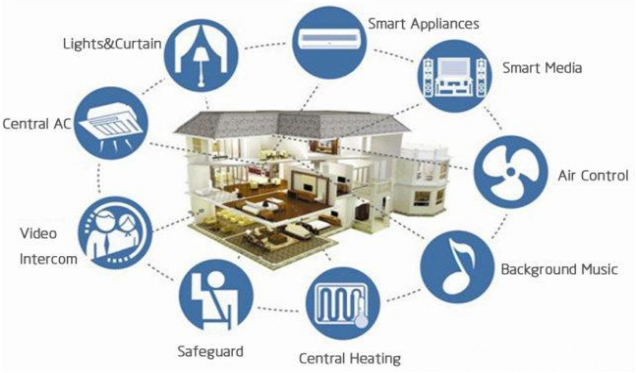

Figure 1: Applications of smart home

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Internet of Things (IoT) is one of the biggest technological advancement that has made electronic gadgets 'smart' by enabling them work autonomously. IoT devices aim at easing the user lives but they are totally user dependent. Machine Learning (ML) lets the user devices learn the user patterns and preferences [3].

IoT enabled devices give privilege to the user of accessing his devices, give commands to it and take instructions from it remotely which are being connected over the internet. ML is the learning of the machine without being explicitly programmed. Machine learns from the data being provided to it and gets trained [4]. The current limitations of IoT can be overcome by ML. ML provides IoT huge vastness in its applications. The user dependent IoT devices become cognitive with the help of ML. The smart devices will no longer need user input to work upon with the help of ML [5].

The rest of paper is summarized as: Related work is discussed in Section II. In Section III, comparative analyses between various applications are presented. Research gaps are formulated in Section IV. The medology to be followed is proposed in Section V. In the end, conclusion and future scope are presented in Section VI.

II. RELATED WORK

This section discusses the existing literature related to IoT analytics.

Alzubi et al. (2019) [1] designed a computer system that is trained on the acquired multimedia data and information that is being sensed with the help of Internet of multimedia things and digital image processing. Data obtained from plant specification card is analyzed and a decision is made whether to switch the pump on/off. The captured images were transmitted by multimedia sensors to image analysis and processing unit. ML techniques Convolutional neural networks (CNNs), Random forest (RF), and Support vector machine (SVM) are utilized to train the database. Various hardware tools used are Arduino, Breadboard, ESP8266, Soil Moisture Sensor, DHT11 Sensor, Light Sensor, Ultrasonic Sensor, Rain Drop Sensor, Relay and Water Pumps.

Suraj et al. (2018) [2] utilize dimage acquisition technique to detect state of different appliances that capture images with the distinct place inside the where the equipment just like admirer, pipe mild and also TV are installed through any Pi-Cam and also a USB Digital camera and that is coupled to the spinning canal of a couple of particular person servo motors. The spinning cams record pics that happen to be raised on to your versions which have been educated using dlib-c++ which usually detect the on/off state with the appliance.

Jianqinget al. (2018) [3] utilized a multiple pseudonym technique that generate pseudonyms for each gateway in the network model for securing the communication of each home. Encryption technique is used for securing network of IoT devices in smart homes. ML classification algorithm is used to deduce activities of smart home's IoT devices. A monitoring system is used to keep check on the traffic to and from smart homes. It used a Directed Random Walk scheme for outgoing traffic.

Vindice et al. (2018) [4] applied a living research method for comprehension users as well as to be aware of where did they make use of intelligent home devices throughout real-life environments. Two times associated with semi-structured selection interviews tend to be executed tough homeowners and witnessed the process of procedure installation through the person so that you can understand person needs. That applied some sort of start home visualization design for you to prototype procedure condition visualizations with the participants. Many people executed some sort of four-week journal analyze to achieve an improved image associated with evolving tactics and as well executed a couple co-design classes throughout that they asked players to mirror on his or her most substantial info requirements, because encouraged because of the accumulated details, and on his or her techniques used for interact through the particular intelligent home procedure to fulfill those people demands. All selection interviews, classes and on-site selection interviews have been audio-recorded and transcribed for afterwards analysis.

Yang et al. (2018) [5] analyzed different researchers that used clustering, frequent item set mining and k-means clustering for unsupervised traffic profiling. For supervised traffic profiling, it analyzes study of different researchers that used frequent item set mining, clustering, clustering combined with statistical methods, naïve bayes, decision tree classifiers and k-means. For mobile phone IoT device identification, it analyzes different techniques like kNN, SVM, Gaussian mixture, maximum-likelihood classification and threshold based classifier. For IoT device identification, it analyzed different techniques like Random Forest algorithm combined with decision trees and multi-class Ada boost, support vector machine (SVM), random forest and binary classifiers. For IoT device security, it analyzes different techniques like combination of multilayered perceptron and probabilistic neural network and RF fingerprinting. For IoTnetwork security, it analyzed different techniques like intrusion detection and mitigation(IoT-IDM), artificial neural networks (ANN), bio-inspired ML algorithm for improving wireless sensor network security and mobile security system using ML. For edge computing, it analyzed different ML algorithms like Clustering, Markov-model, Linear support vector machine, Cascade classifier, Deep learning, Linear regression algorithm and Bayesian Networks. For ML based SDN in IoT networks, it analyzed different ML algorithms like Clustering, Neural networks, SVM & Logistic aggregation and Bayesian.

Li et al. (2018) [6] used a K-means algorithm to find price clusters and to locate clusters in power alert system.

Molanes et al. (2018) [7] used a field programmable system on chip (FPSoC) that has a processor and FPGA fabric which is an implementation of machine-learning applications for IoT devices.

Thangavelu et al. (2018) [8] classified a traffic session for identifying IoT devices. It uses various algorithms likes preliminary (including Centroid, Euclidean distance, z-score and k-means clustering), fingerprinting at GW(S, X), clustering at Controller(P), nearestCluster(T;F), withinICR(F0;F1), estimateClusterDist(R) and updateModelClusters(T) for defining DEFT.

Tien et al. (2017) [9] studied IoT which has also been termed as servgoods, Artificial Intelligence and real time decision making during IoT and Artificial Intelligence.

Zhao et al. (2017) [10] used a server that collects vibration samples from each bin that are produced by the vibration motor and runs the algorithm to tell whether the bin is empty, half full, or full and sends the report on the user Smartphone. It monitors the fill-level by getting an example of vibration community maxima, featuring its many pairs of voltage and also vibration intensity. As being the fill-level improvements, the resonant voltage and also severeness additionally change for the reason that damping impact with the trash is usually different.

Guebli et al. (2107) [11] used a TV similar to user interface to overpower and handle this intelligent house's services. This generally used any PBNM architecture (Policy-Based Sites Management) that allows in order to determine procedures in order to be reproduced by each and every PEP (Policy Enforcement Point) to the oral appliance PDP (Policy Decision Point) will be accountable of managing and handling the system.

Brichn et al. (2017) [12] conducted many house visitations and semi-structured interview, in order to let participants think of home automation model while their particular own residence and daily activities. The idea used a new rule-based or perhaps a process-oriented notation in order to study user requirements.

Ploennigs et al. (2017) [13] implemented the basic three tiers of IoT architectures along with the cognitive systems in buildings. The supports an small business level, a new foundation level with an advantage tier..

Mougy et al. (2017) [14] formulated a system that supports each express identification in addition to wording talking in healthy English language for NLP. Pertaining to Sample identification element this makes use of manmade neural networks (ANNs) in addition to k-means clustering machine finding out algorithms. Pertaining to security goal, it's got access management attributes in addition to security from the necessary paperwork layer. Breach detectors can be accustomed to combat illegal access attempts.

Bertino et al. (2016) [15] used gain access to management device, essential store programmers, weaknesses evaluation along with intrusion detection to find timely and interesting solutions for IoT device security.

Ganz et al. (2015) [16] studied various data abstraction methods like Pre-processing, Dimensionality Lessening, Aspect Extraction, Abstraction/Inference, Semantic Reasoning & Representation. They employed program tools such as RapidMiner, WEKA, and SAMOA in addition to Orange. Various exploration methods that will are employed remodel raw warning data to be able to higher-level abstractions such as GeoSensor Info Abstraction for Environmentally friendly Checking Use, Pattern-based occasion recognition within warning systems, Building A sense of Indicator Info Employing Ontology, A strong Play with it within Hierarchical Acceptance, Octopus: Clever Architectural structures, Indicator Systems plus the World-wide-web regarding Issues, Facts Abstraction for Heterogeneous Serious Globe World-wide-web Info, Semantic Function Handling within Think about, Semantic Perception: Remodeling Sensory Findings to be able to Abstractions. They employed a built-in IoT data analytics resource called Expertise Order Toolkit (KAT) to use to be able to significance warning data coming from a variety of solutions in addition to permits control the particular raw warning data in addition to developing abstractions while using the common data study methods.

III. COMPARATIVE ANALYSIS

This section compares some well-known IoT analytics techniques based upon certain features. Table 1 compares some well-known IoT analytics with each other. The overall objective is to evaluate short comings in the existing literature.

Ref.	Year	Applications	Advantages	Disadvantages
[1]	2019	Smart Farming	Uses smart irrigation technique that provides water to the plants at required location and time. System is a base for Future agriculture without assistance that too with the best quality and at suitable 0temperature.	Needs a huge dataset to train the model in order to provide optimal accuracy.
[2]	2018	Home automation	To detect the state of different appliances, it uses vision based machine intelligence. Its detection system is unaffected by the number of appliances attached. Home automation system with cheap and easy installation.	Show the ON state even in the presence of sunlight or light reflection by mirror. Machine does not learn from different colors of the appliance it have not been provided training of.
[3]	2018	Smart homes	Smart Homes protected against passive attacks like traffic analysis attack. A multi-hop routing scheme is used to protect user privacy.	Parameter ‘e’ always needs to be small in order to decrease the network energy consumption.
[4]	2018	Smart homes	Living Lab approach has flexibility, provides imaginative places for that conversation of new basics as well as sustains long-term observational studies.	Clutter, Natural Live Facts as well as Reduced Record. Lack review guide given by a fall behind house firewood widget additionally seriously minimal the chance of obtaining designs observed system failures
[5]	2018	Traffic profiling	Literature Review of ML applications for IoT like Traffic Profiling, Smart Device Identification, Edge Computing with ML, IoT applications and Software defined networking. Presents a thorough study about ML for IoT- recent researches and their application domains with their technical progress. Also Presents various challenges and open issues of ML for IoT.	
[6]	2018	Smart homes	It monitors and manages user’s home energy consumption. Great functionalities like price forecasting and clustering with a power alert system.	It uses K-means algorithm which comes with the limitation that random chosen centroids and overlapped data may lead to unusual results. K-means algorithm also has the disadvantage number of clusters needs user specification that can make result sensitive to initial values which may not produce optimal results.

Ref.	Year	Applications	Advantages	Disadvantages
[7]	2018	Smart Homes	FPGAs have parallel arrangement of neurons in their layers which make them very effective for performing deep neural network inference.	FPSoC efficiency depends on type of operation involved in computing the objective function could fit the hardware resources.
[8]	2018	Fingerprint Identification .	It is scalable and based on hierarchical network architecture. The traffic is classified locally, without being sent to the Controller. The controller coordinates with its gateways to learn models for new unknown devices and updates the model dynamically. The traffic is classified locally, without being sent to the Controller. The controller coordinates with its gateways to learn models for new unknown devices and updates the model dynamically.	It does not analyze features below the network layer in the TCP/IP stack.
[9]	2017	Real-time decision making;	Discusses how to resolve “trolley” problems, How you can handle the health risks regarding not being watched finding out, approaches to create true unit brains together with understanding, common sense along with sense capabilities.	Inside a connected IoT, RTDM along with AI entire world, you will find enough opportunities for breaches involving comfort along with security.
[10]	2017	Smart Building, Waste Management	System is low-cost. It can also be easily installed by anybody without complicated instructions and can be easily installed over any waste bin.	Maintenance of the device is not easy. Cannot work with different kinds of waste like recyclable and non recyclable.
[11]	2017	Smart home	Provides recommendation system per user profile. Takes into consideration that user may not like all the Tv programs thus provide filtered results.	Uses TV console as the mean of interacting with the user without taking into consideration that TV might not be active all the time.
[12]	2017	Home automation	Helps in identifying the need of home automation systems and study the user requirement of which particular home automation system.	Less sample data is used for consideration. All the participants came from the same cultural background. Use of pen paper based technique for recording results.
[13]	2017	Cognitive IoT	Builds a self-learning and self-adapting building environment.	It cannot adapt to changing user requirements and conditions and provide the accurate prediction.
[14]	2017	Smart home and voice recognition	A secure as well as interoperable smart residence platform. It contains customer friendly interaction choices like all-natural words and text chatting. The working platform in addition picks up customer patters.	The user pattern recognition method operates through a sequence of events.
[15]	2016	IoT Security	Propose timely and interesting solutions to security for IoT.	Do not cover each of the issues with IoT security- gadget uncovering, i.d ., as well as verification; protected gadget destinations; examination as well as defense connected with firmware; IoT software management.

[16]	2015	Smart Buildings	It transform raw sensor data straight into higher-level abstractions that will be man and/or machine-understandable. It provides an application toolkit, which in turn includes a few of the most common procedures of info abstraction in a very simple to use method.	No approach that implements the complete proposed workflow with regard to converting raw information straight into device interpretable abstractions. Only handful of domain-independent strategies to process your IoT. Issues related to high-performance computing along with useful control involving substantial volumes of data.

IV. GAPS IN LITERATURE

From the extensive literature, following gaps have been formulated:

a) The majority of the existing researchers have focused on the data analytics only, but, how this data can be secured has been neglected in the literature.
b) It has been found that the existing ML techniques based IoT analytics suffer from the over-fitting issue, which may produces poor results.
c) Existing ML based IoT analytics techniques suffer from the parameter tuning issue. Generally, these parameters are selected based upon the hit and trial basis, which may perform efficiently for a given group of data for not for all. Therefore, it is require designing hyper-parameter tuning techniques for IoT analytics.

V. METHODOLOGY TO BE FOLLOWED

For the automation of smart homes, we propose a new mechanism using CNN and HAR. This technique will help in better classification of activities within smart homes. The feature extraction process during this mechanism is accurate and hence high classification accuracy could be obtained. In addition, HAR like features are effective and give text dataset with normalization. The methodology so followed may yield classification accuracy of over 90%. The methodology to be followed is listed as under

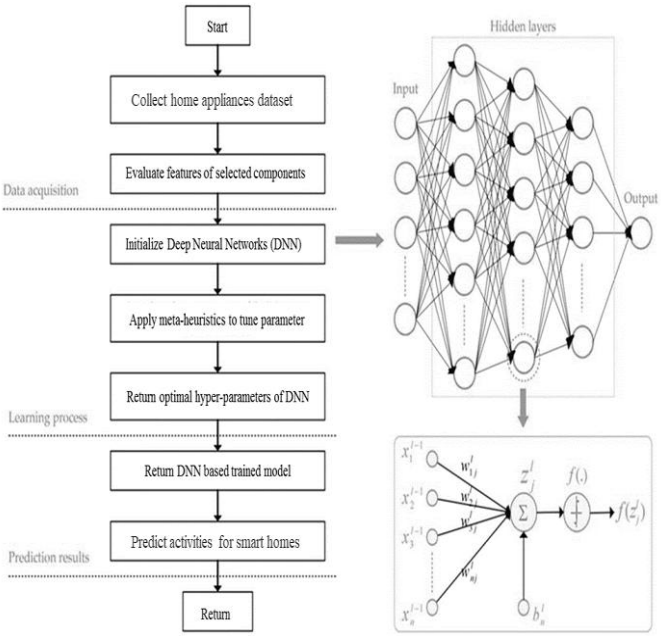

Figure 2: Methodology to be followed

Result of this approach is expected to produce better result in the range of 90 to 95%.

VI. CONCLUSION AND FUTURE DIRECTIONS

Many IoT analytics techniques have been designed and implemented so far to improve the performance of smart home appliances applications. Existing ML based IoT analytics techniques have been compared with each other based upon certain features. Although, IoT analytics techniques outperform the existing techniques, but, suffer from various issues. These issues are hyper parameter tuning, over-fitting and security of monitored home appliances data.

In this work, we have compared the existing IoT analytics techniques; however, no new technique has been designed. Therefore, in near future, we will design a novel IoT analytics technique which will consider security, assembling to overcome over-fitting, and soft computing to tune hyper parameters.

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