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Self-learning, Context Aware Music Player for IoT

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ABSTRACT

The self learning music system proposed in this paper aims at combining two technologies IoT and machine learning that work best together resulting in a truly intelligent system that can learn and take decisions. This study of using machine learning in n IoT environment introduces a system that can take decisions on its own and by learning user preferences over a training period. It gives us a self learning system that updates itself based on users preferences(feedback). For which the system needs an initial training period to understand the users preferences under different conditions. After which the system uses various machine learning techniques to accurately predict a song, given the users state(Activity).

Index Terms—Machine Learning, Self-Learning, Internet of Things (IoT), context awareness, music recommendations, sensors.

I. INTRODUCTION

The world is getting connected at much faster rate with low cost sensors and distributed intelligence this will have a great impact on industry as we are producing more data than we can process. with this huge amount of growing data our business needs to adapt and evolve quickly to maintain their place in this competitive field.

A. How big is IoT

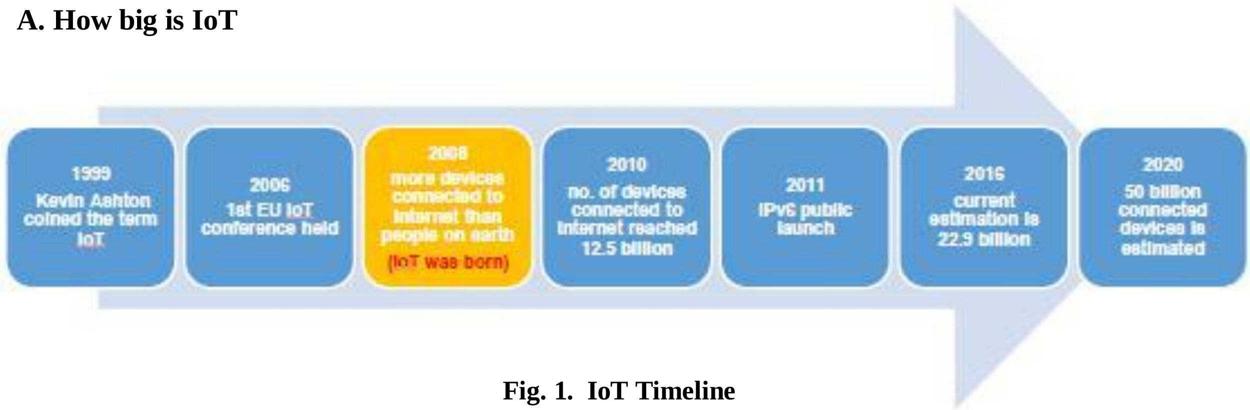

Fig. 1. IoT Timeline

As shown in Fig 1. IoT was born in 2008(inflection point)

at a point in time when there were more things connected to internet than there were people on earth. After this remarkable success the numbers continued to grow exponentially thus triggering a public launch of IPv6 in 2011 as IPv4 fell short of addresses to accommodate such growing internet population. [1] has stated that According to Cisco by 2020, we are expected to have 50 billion connected devices which makes IoT one of the most sort after research area.

IoT will unearth more than $1.9 trillion in revenue before 2020. IDC estimates technology and services revenue will grow worldwide to $7.3 trillion by 2017 (up from $4.8 trillion in 2012).

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”IoT makes Things to connect and communicate whereas Machine learning makes them learn and then think”. IoT is giving power to things to communicate and take decisions, whereas machine learning gives them power to learn how to make decisions in complex environments without any human interaction. As machine learning system need lots of data it didn’t flourish in its early stages, because of IOT it has got its much needed fuel that is large amount of context data. hence convergence of both will bring great changes in future.

This convergence creates a network connecting people, data, and things. This convergence connect intelligent things that sense and transmit a broad array of data, helping creating services that would not be obvious without connectivity and analytical intelligence. The use of platforms is being driven by transformative technologies such as cloud, things, and mobile. Networks of things connect things globally and maintain their identity online. Mobile allows connection to this global infrastructure anytime, anywhere. The result is a globally accessible network of things, users, and consumers, who are available to create businesses, contribute content, generate and purchase new services.

According to [1]There is a lot of hype around IoT as it is best time for IoT with increasing number of connected devices and 5G being launched around the same time .So 5G will be timed well. The ecosystems will develop and they will be connected by 5G. In fact, Gartners infamous hype cycle report has the IoT at the peak of inflated expectations. Problem areas in IoT as stated by [2]:

Apply existing Machine Learning algorithms to IoT data. Use IoT data to complement existing processes.

Use the scale of IoT data to gain new insights.

Consider some unique characteristics of IoT data (ex streaming).

This study of converging both of these technologies motivated us further to create an intelligent self learning system that can update itself automatically with users changing preferences in an IoT environment.

II. REVIEW OF LITERATURE

A. Self-Learning

[3]have stated that in today’s environment there is no guarantee in availability of sufficient training data prior to classification, and that it is important to design machine learning algorithms that learn from new training examples even after the model is deployed that is also known as self learning. In this paper they have come up with a correlation mining algorithms based on kullback -leibler (KL) divergence and frequent set mining that exploits correlated context to enable self-learning. As in IoT all the devices are interconnected it is important for the devices to adapt itself when other devices or conditions change. Therefore a self-learning application is required in this kind of open environment. As context plays an important role in adapting based on user preference [3]have come up with an algorithm based on adapted apriory frequent set mining algorithm to discover correlations between context.

B. Reinforcement Learning

Any interactive system works by taking user feedback which ultimately serves them to satisfy the users current needs and later in order to improve future decisions or recommendations in a recommender system.

Learning is always driven by an objective and guided by some performance feedback. The components should be able to map these experiences with the objectives and determine actions. these actions with reference to the feedback helps system learn. As the learning takes place based on feedback they are called penalties and

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rewards. This type of learning based on feedback in a dynamic environment is known as reinforcement learning. This kind of learning helps to create a self adaptive system.

In some work done by [4] a bandit approach is used as a reinforcement learning task to systematically balance ex-ploration and exploitation , which is a central issue studied well in reinforcement learning. Their further experiments also show that their approach mitigates the difficulty of cold start and improves recommendation performance, as compared to traditional greedy approach. They have taken into consider-ation two factors for their music preference modelling task, which are; Music audio content -which suggest that a users preference is a lot based on the audio content of the song and, novelty - is about repeating songs at proper frequencies.

C. Recommender Systems

There are usually three basic approaches for recommenda-tion system. Content-Based, Collaborative filtering, Context aware and Hybrid.

1) Content-Based: Content based learning is all about the audio context in the song it compares musically similar attributes in a song such as tempo, genre, beats per second and so on. Content Based learning recommends similar songs lacking variety. However it may be found useful in case you want to create a theme based playlist. There is also a need for a seed song that represents the type of music a user likes to listen to.
2) Collaborative filtering: It compares two users instead of songs. CF searches for user who has similar user attributes and then recommends songs from that users library thus making it a community process. This approach is possible in a multi user system. This type of system recommends a more variety of songs as different users have collection of songs.
3) Context Based: In an everyday scenario musical pref-erence is more influenced by the emotional state of the user based on the activity the user may be performing at that time. Therefore to provide a user with a particular song that best suits its mood, a context based system is highly recommended. In [5] the authors have described various environmental fea-tures to consider in a context aware system. these features are 1) Time and Date, 2) Weather, 3) Lighting Conditions,
4) Humidity Conditions, 5) Temperature Conditions, 6) Noise Conditions and 7) the Listeners Activity. These features are required to identify and categorise environmental features that may affect a listeners mood or music selection process. They have further integrated all the textual meta data , context and environmental information to generate a suitable context aware playlist for the user. They have also stated that due to complexity of the system several intelligent algorithms need to be used at various stages of the system process. their proposed system is described into two parts similar to a machine learning system, 1) the Learning Process and 2) the Operational Process.

D. CONTEXT AWARE SYSTEM

Music recommendation systems help users find music that best suits their taste and an effective one consistently matches users preference.[6] states that Most of the current recom-mender systems provide solution for satisfying long-term needs for users but , according to recent studies in psychology and sociology of music it is said that users short-term needs are such that their emotional states (mood), activities or their environment.

For instance a user who is back home after a tiring day will prefer some soothing music which will relax him ,

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while when a user is working out he will want to enhance his performance by listening to energetic songs with high tempo.

Some of the existing systems provide playlists made specifi-cally for some activities, but as they are made by others based on their musical preference they might not be suitable for all. Thus we need a more real time context aware system that is able to understand our current needs. It is known that different people prefer different music for different activities on day to day basis. But with our mobile phones music player we have to manually create a playlists four our moods or activities, which is a very time consuming and a tiring task. [6] presents a similar system that automatically recommends songs for daily activities based using sensors in our mobile phones. they have proposed a system that combines activity inference with music content analysis. They perform following task in their research; 1. Automated activity classification, 2. Automated music content analysis, 3. Solution to the cold-start problem, 4. Implementation and evaluation.

E. Activity Aware Learning

XPOD is a mobile music player that considers emotional and activity data generated from a body media device to play songs best suited for the users current activity. This system also needs a training period that generates Dataset for the system to learn and make inferences. They have tested following machine learning algorithms on their dataset; 1.Decision trees, 2.AdaBoost, 3.Support vector machine, 4.K-nearest neighbours, 5.Neural network. of a variety of interchangeable add-on modules known as shields. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.

Communication: We will be using Serial communication (also known as UART) to send data from arduino to the computer through USB serial COM ports.

F. Evaluation of Literatur

TABLE I

Comparision of Existing System With Proposed System.

Sr. no.	System	Music Li-brary	Learning Type	User Feed-back	Environment	Factors that infers user preference	Factors that infers song context	Approach	Is Adaptive?
1	[XINXI et al., 2013]	Online library with multiple users	Reinforcement learning	Song Rating	Web based with multi-ple users	User rating	Audio con-tent	Multi-armed bandit approach	Yes
2	[Gordon et al., 2007]	Local library	Unsupervised, feature extraction	Not consid-ered	Web based	Contextual and envi-ronmental	Global tim-bre,Tempo, Musical key	Constrained-based	Yes
3	[XINXI et al., 2012]	Local library	Incremental train-ing,Feature extraction	implicit	Remote-server and Mobile phones application	Context labels,User activity	Audio con-tent	Probabilistic	Yes
4	[Dornbush et al., 2005]	Local library	unsupervised	Song prediction rating	IoT, client-server	User activ-ity(active, passive, resting)	Genre,Artist, Title,BPM	Machine learning	yes
5	Proposed system	Local library	Self learning	Song prediction rating	IoT	User activ-ity, context	Genre, Artist, Title, BPM	Machine learning	yes

III. SOFTWARE REQUIREMENT

1) Operating system: unix
2) Coding Language :c++,Python, JS
3) Database :MYSQL
4) IDE : Arduino IDE

Design Overview: The system components consist of an an-droid mobile phone, an Arduino Uno, a Bluetooth module and sensors for tracking users activity. The users android device is used as a music player and for giving feedback, with a simple and intuitive GUI that anyone can pick up and use without prior training. The arduino board logs the data from three sensors: accelerometer, thermistor and a pulse rate sensor

The coding is done using a arduino IDE and the code is downloaded onto the board later. the database is maintained over MySQL.

IV. HARDWARE REQUIREMENT

Microcontroller : The one we are using is Arduino Uno. Arduino is a single-board microcontroller designed to make the process of using electronics in projects more simplified and accessible. The hardware consists of a simple open source hardware board. An Arduino board consists of an Atmel 8-bit AVR microcontroller with other compatible components that allow us to program and incorporate into other circuits. Another important aspect of the Arduino is the availability

UART: A Universal Asynchronous Receiver/Transmitter, abbreviated UART, is a piece of computer hardware that translates data between parallel and serial forms. We will use UART to transfer our data from arduino to the computer through serial COM ports for further processing. we will also be using a Bluetooth module to communicate with the mobile app on our android device.

Sensors

1) Accelerometer: An accelerometer is a device that measures acceleration. When it is kept horizontal at rest, it measures 9.8 N/Kg downward. Whenever there is a tilt, a small component is left at the downward face, which can be detected. we are using one with an on-chip oscillator with 1% variation over the operating temperature range. Power supply: 3-5v (stable internal low voltage) Acceleration range: + 2 + 4 + 8 + 16g The spacing of the pins: 2.54mm X, Y, Z output.
2) Thermistor: NTC thermistors are the ideal solution for monitoring temperature at 37C (normal human body temperature). NTC thermistors can provide unparalleled accuracy and sensitivity in the body temperature range.we are using the one with Operating voltage 3.3V-5V; The output in the form: Digital switching outputs (0 and 1); A fixed bolt hole for easy installation; Small board PCB size: 3.2cm x 1.4cm; Wide voltage LM393 comparator. Pulse sensor :The sensor consists of an infrared emitter and detector mounted side-by-side when pressed closely against the skin some amount of light gets reflected back to the detector when the blood pressure rises as the heart pumps.The detector passes more current when it receives more light, which in turn causes a voltage drop to enter the amplifier circuitry and thus a heart beat is recorded using a pulse sensor. we use one with Voltage of 3V to 5V and Current consumption of 4mA at 5V

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V. SYSTEM ARCHITECTURE / SYSTEM OVERVIEW

The proposed system works in a two step process as shown in Fig. 2 and Fig. 3. The first step creates a rule base with the help of training samples. The second step creates an adaptive learning model.

Step 1: Rule extraction from training samples - In this step data from sensors, other devices or applications is monitored and a state is estimated for the user, every combination of data is classified into a unique state (running, sleeping, relaxed, exercising, etc). Then while in a particular state the action of the user in the system is recorded. Thus showing the relation between user state and action. This relation also known as mapping forms the rules for classification. This process of mapping state to action creates a rule base.

Step 2: Creating adaptive learning model with user experi-ence.In the second step whenever a user state changes, the rule base formed in step 1 is referred for the action mapped to that state and the action to be performed is predicted for that state ,the action with highest prediction is performed on behalf of the user . Then the user reaction for that predicted action is checked and updated if the reaction is positive then no change is done, but the reaction is negative the action is revoked and prediction is again performed until we have a positive reaction.

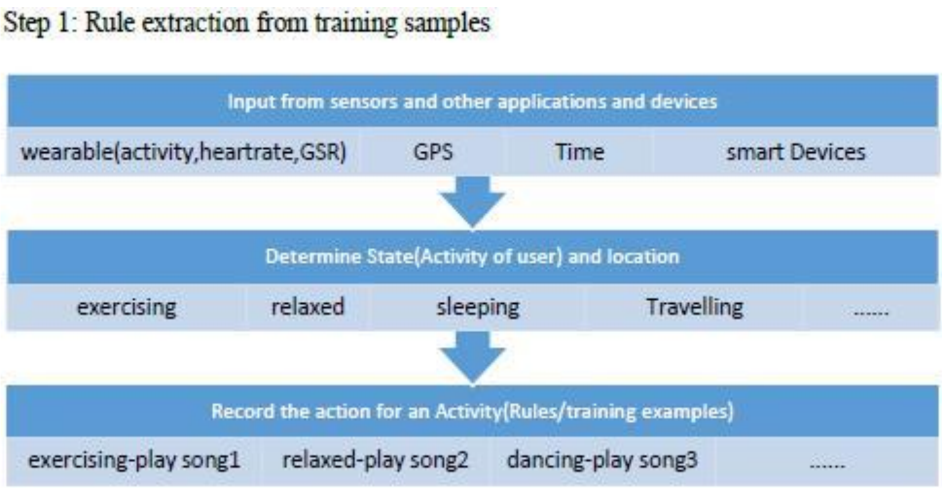

Fig. 2. Step 1-Rule extraction from training samples.

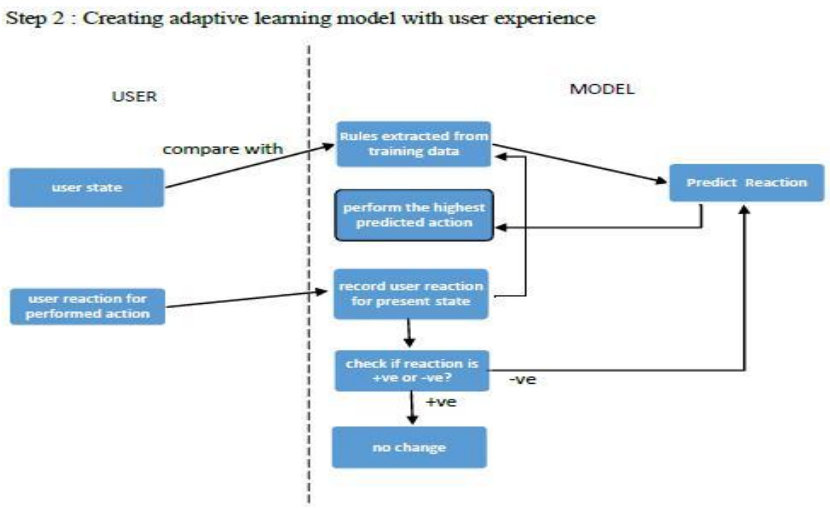

Fig. 3. Step 2-Creating adaptive learning model with user experience .

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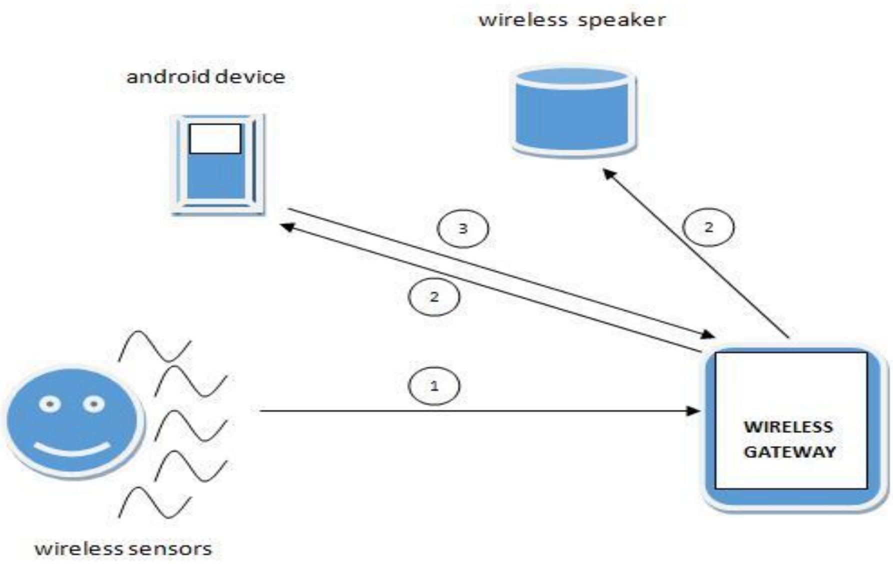

Fig. 4. Block diagram of proposed system

As the user starts the music player to listen to some mood appropriate music, the system is expected to work as follows:

1) The sensors will send current activity data to the Ar-duino, the arduino along with other context data predicts a song best suited for current user state with the help of machine learning algorithm and historic data collected in the training phase.
2) The predicted song is then played on the users phone.
3) The song can also be played on any wireless speakers.
4) The user then decides whether the song was suitable for his state by giving feedback from his android applica-tion.

VI. MATHEMATICAL MODEL

FUZZY SET THEORY

Let xt be the state of user at a time T, and Si be the song
played by user at that time.
Then, A :U [0,1]
For each x U , the value A (x) expresses membership degree of training sample x in fuzzy set A. where:
x is a base variable,
A is a fuzzy set, and
U is a domain of x.
Fuzzy set A is a particular class of activity that a state classifies to. Hence in initial training period (U) of the system we form a rule base of states to activity classes (s(A,B,C...)) and assign them with set of songs (si, ... sn-i) that the user played while in a particular activity class.
Some of the properties of fuzzy sets:

[1] The support S(A) of a fuzzy set A is a crisp set composed by all elements that belongs to A with a membership value greater than zero. More formally: S(A) =xU — (x) ¿ 0

[2] The core C(A) of a fuzzy set A is a crisp set composed by all elements that belongs to A with a membership value equals to 1. More formally:

C(A) = xU — (x) =1

These properties helps us understand how the user gradually stops listening to a song for a activity class he initially preferred to by observing the support and core functions. Let , A be a member function of song class and x is a state of user at a particular time , then if a user does not prefer to listen to a song s at a state x anymore the value of (x) will start decreasing and will become 0, and then according to S(A), system will then automatically stop playing the song s at a state x.

VII. CONCLUSION

This study report gives a brief understanding of the domains of the project. It covers introduction of both the topics machine learning and Internet of Things and how combining these two will look like. we have introduced a use case to better understand the concepts and proposed an architecture for the system.

Further in the research process we will be creating a model for an intelligent system by eliminating all the drawbacks of any existing system. The following study is to help understand the state-of-the-art of research and innovation in converging IoT and Machine learning and will encourage you to think towards the bright future of the Internet of Things.

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