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Smart Virtual Assistant a Broad Perspective

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Abstract - In today's era of increasing Internet of Things applications, each application/device has provided a means to ease the lives of users one way or the other. This paper throws light on the concepts of synergy between IoT and Machine Learning. Fundamental objective is to develop an application that will help bring the control of various household devices to the user's smartphone. The application's main purpose would be to understand the context of the user and train itself to make the operation of devices more efficient. This would also help the users to monitor the rates at which they are utilizing power and take necessary measures to bring it under control.

Keywords **- Internet of Things, Machine Learning, Cloud.**

1. Introduction

Internet of Things is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity. This has enabled these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence. Machine learning explores the study and construction of algorithms that can learn from and make predictions on data. Such algorithms operate by building a model from example inputs in order to make data-driven predictions or decisions, rather than following strictly static program instructions.

The core idea is to use the concepts of IoT along with the concepts of Artificial Intelligence to develop a Smart Virtual Assistant. This Assistant's main objective is to provide theuser with the capability of controlling household devices in an efficient and smarter method. The approach we are using is to use a Smart Device to send a request to central server hosted on a micro-controller, following which this server will execute the query and also store the particular query on a cloud server. We aim to use a Machine Learning algorithm to find patternsin the stored queries on the cloud, using the recognized pattern we will be able to provide the users with an implicit control over the household devices.

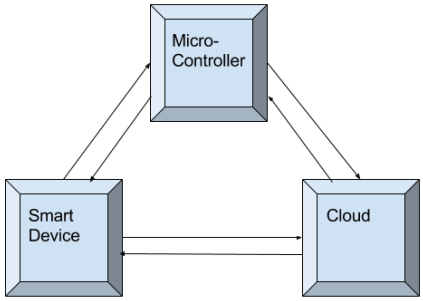


Fig 1 Basic block diagram of the system

2. Internet of Things

The Internet of Things (IoT) is a network of physical objects such as electronic devices, sensors having network connectivity which enables these objects to collect and exchange data.It is also known as "Ubiquitous Computing". IoT is an environment in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT allows objects to be sensed and controlled remotely across existing network, creating opportunities for more direct integration between the physical world and computer-based systems and resulting in improved efficiency, accuracy and economic benefit. Typically, IoT is expected to offer advanced connectivity of devices, systems and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications.[1]

Fig. 2IoT Network

IoT Elements:

a) Hardware - Made up of sensors, actuators and embedded communication hardware

b) Middleware - On demand storage and computing tools for data analytics and

c) Presentation - Easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications.

Hardware - Typically a node contains sensor interfaces, processing units, transceiver units and power supply. Most of the times, they comprise of multiple A/D converters for sensor interfacing. Modern sensor nodes have the ability to communicate with each other.

Middleware - A mechanism to combine cyber infrastructure with a Service Oriented Architecture (SOA) and sensor networks to provide access to heterogeneous sensor resources in a deployment independent manner. This is based on the idea to isolate resources that can be used by several applications.

Presentation - Presentation is nothing but the GUI (Graphical User Interface) required to present the information retrieved from the sensors and give user an easy approach to interact with the system.

IoT Applications:
The Internet of Things (IoT) allows us to use technology to enhance our comfort, improve the energy efficiency and simplify the tasks that consume our home and work life and give us greater control over our lives. The basic classes of applications are:

- Connected Home
- Wearable
- Industrial
- Smart Metering

3. Machine Learning Approaches

3.1 Decision Trees

A decision tree is a flowchart-like structure in which each internal node represents a "test" on an attribute, each branch represents the outcome of the test and each leaf node represents a class label. The paths from root to leaf represents classification rules. In decision analysis a decision tree and the closely related influence diagram are used as a visual and analytical decision support tool, where the expected values of competing alternatives are calculated. A decision tree consists of 3 types of nodes: Decision nodes, Chance nodes, End nodes.[5]

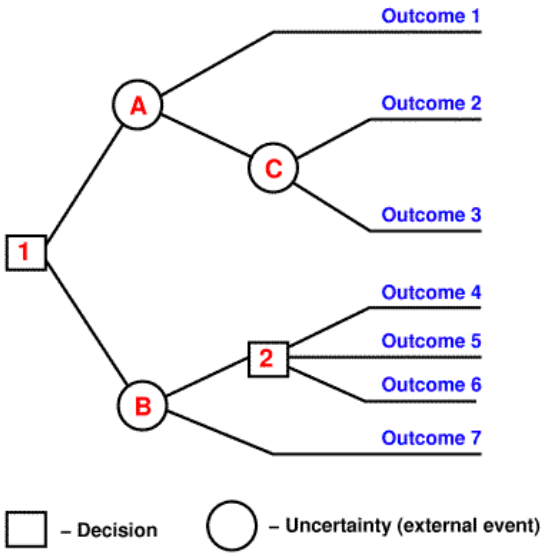


Fig. 3Decision Tree

3.2 K-NN

In pattern recognition, the *k*-Nearest Neighbors algorithm (or *k*-NN for short) is a non-parametric method used for classification and regression.[2] In both cases, the inputconsists of the *k* closest training examples in the feature space.

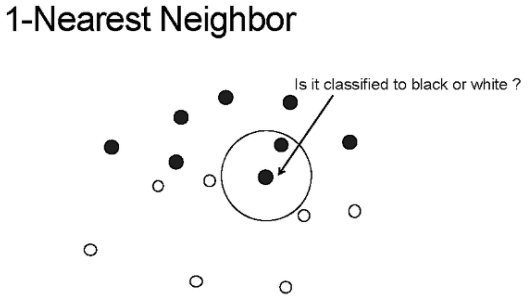


Fig. 4 1-Nearest Neighbor[6]

3.3 Linear Regression

Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. [4] For example, a modeller might want to relate the weights of individuals to their heights using a linear regression model.

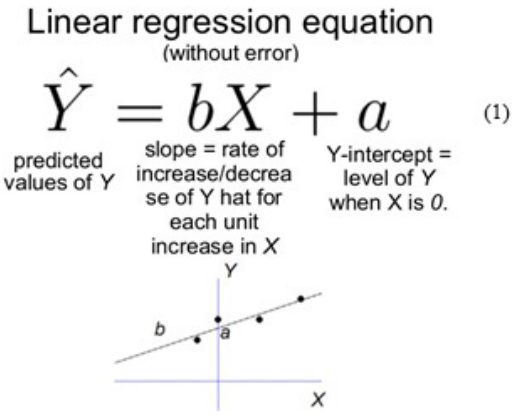
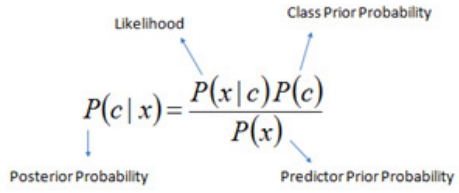


Fig. 5 Linear Regression equation[4]

3.4 Naive Bayes

Naive Bayes is a simple technique for constructing classifiers: models that assign class labels to problem instances, represented as vectors of feature values, where the class labels are drawn from some finite set. It is not a single algorithm for training such classifiers, but a family of algorithms based on a common principle: all naive Bayes classifiers assume that the value of a particular feature is independent of the value of any other feature, given the class variable. An advantage of naive Bayes is that it only requires a small amount of training data to estimate the parameters necessary for classification.[3]



$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c) \quad (3)$$

Fig. 6 Naïve Bayes Formulae

3.5 Neural Networks:

In machine learning and cognitive science, artificial neural networks (ANNs) are a family of models inspired by biological neural networks (the central nervous systems of animals, in particular the brain) and are used to estimate or approximate functions that can depend on a large number of inputs and are generally unknown. Artificial neural networks are generally presented as systems of interconnected "neurons" which exchange messages between each other. The connections have numeric weights that can be tuned based on experience, making neural nets adaptive to inputs and capable of learning.

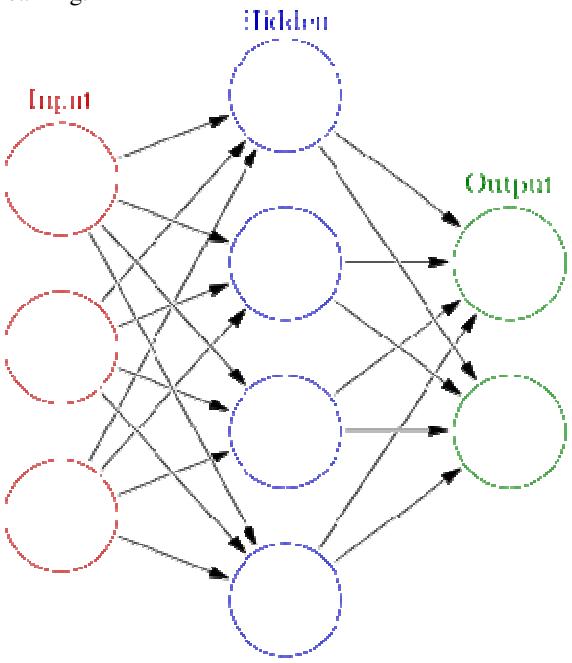


Fig. 7 Neural Network Representation

3.6 Logistic Regression

In statistics, logistic regression, or logit regression, or logit model is a regression model where the dependent variable (DV) is categorical. Logistic regression measures the relationship between the categorical dependent variable and one or more independent variables by estimating probabilities using a logistic function, which is the cumulative logistic distribution.

Thus, it treats the same set of problems as probit regression using similar techniques, with the latter using a cumulative normal distribution curve instead. Equivalently, in the latent variable interpretations of these two methods, the first assumes a standard logistic distribution of errors and the second a standard normal distribution of errors.

3.7 Support Vector Machine (SVM)

In machine learning, support vector machines (SVMs, also support vector networks[4]) are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked for belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

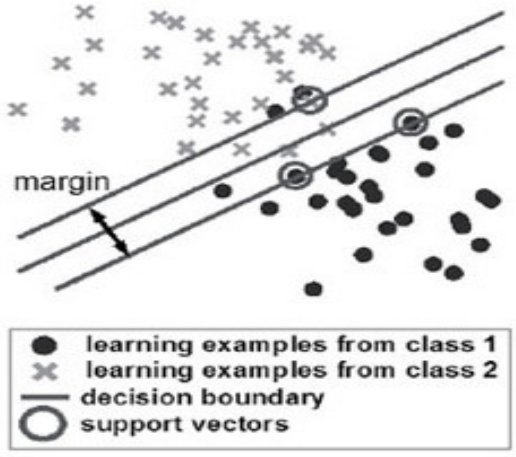


Fig. 8 Support Vector Machine[6]

4. Synergy between IoT and Machine Learning

The existing system deal with home automation using IoT paradigms. The proposed system works on synergy of two fundamental concepts viz. Internet of Things and Machine Learning. The Software developed is an android application which takes commands either through the UI or through the speech of user for turning ON/OFF the appliances. Raspberry Pi works as a server which redirects the commands from user or cloud to the physical devices for their respective applications. User data patterns are saved on the cloud so as to store data on cloud which will be used for further processing and do the task implicitly without user commands. No other information of user is required so as to maintain privacy in android system.

Internet of Things which is basically a distributed network of devices will provide the user with direct control over the devices in the network. User can toggle the status of device via the network and can also query for the status of the network. These user requests are stored in the cloud and are mined for patterns using Machine Learning techniques.

Machine Learning approach used to mine patterns is basically a classifier algorithm. Classifier algorithm, initially generates a hypothesis (classifier model) from the training dataset (supervised learning). Once, the hypothesis is generated new data point can be predicted using this classifier. Classifier algorithm for the proposed system is Support Vector Machine (SVM) due to its support for infinite features.

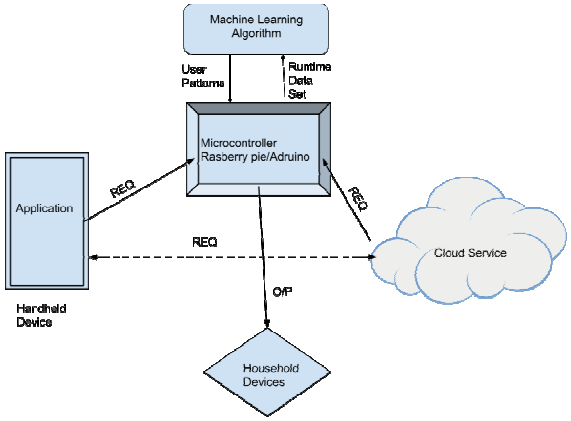


Fig. 9 Proposed system architecture

5. Training The System

We have used an SVM for learning the everyday habits of the users. Utilizing the binary classifier property of the SVM we resolve either a '0' (Off) or '1' (On) state for the various devices. Our SVM is trained over the following features:

- User ID. - Gives a sense of Priority to the resolved output
- Device ID. - Gives a dimension for the various devices in present in the house.
- Time Stamp. – A dimension for generating a timeline for various events taking place.
- State. – The current state set by the user to be learned by the SVM.

Table 1. User Data Patterns Table

User ID	Device ID	Timestamp	State
U1	D1	05:30	0
U2	D1	17:45	1
U1	D2	06:20	1
….	….	….	….
Un	Dk	HH:MM	0/1

The Various parameters used for training are:

- SVM type: set type of SVM -> C-SVC
- Kernel type: set type of kernel function -> linear: u'*v
- Cost: set the parameter C of C-SVC -> 5000
- Cache size: set cache memory size in MB -> 40
- Epsilon: set tolerance of termination criterion -> 1e-3

The Kernel used is a linear kernel, which helps to partition data based on the 3D plain generated by the 3 dimension, depending on the side of the plain the "State" dimension is predicted, it is classified as 0 or 1. The training takes place over a runtime data set, which changes with every update made by the user. The user patterns after generation on training data set are then reverted back to the application. Finally the user is shown a graph of the daily proceedings generated with the help of the SVM.

6. Results

Thus, we implemented the combination of IoT and SVM in an android application which lets you select the area of the house which in turns gives you a list of electronic devices which are to be turned ON or OFF,also with the use of SVM the application predicts the states of those devices and automatically turns them ON or OFF based on the user pattern. The android application looks as follows:

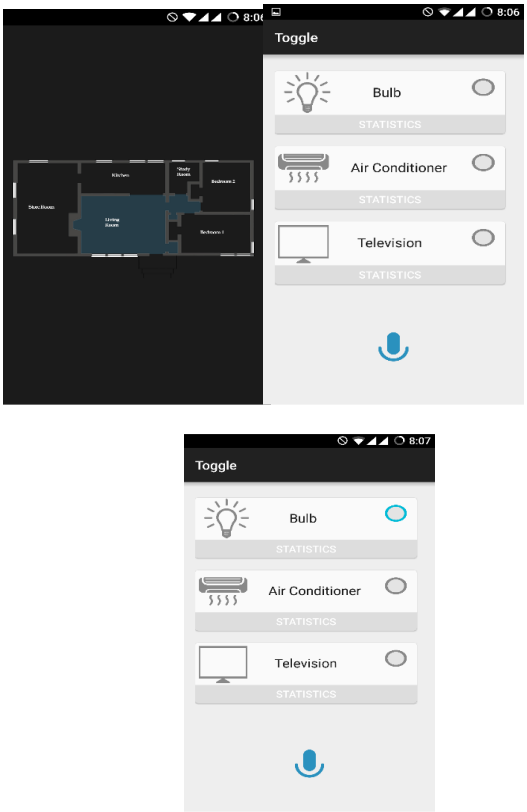


Fig. 10 Android Application Screenshots

The SVM gives the graph for the status of device as follows:

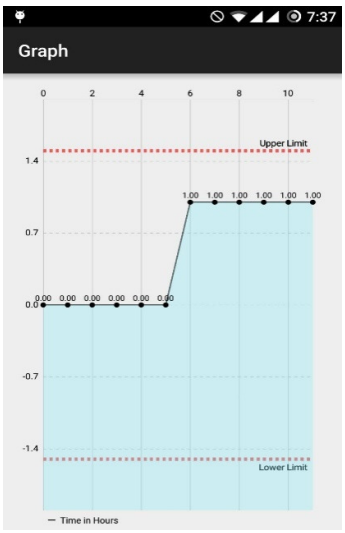


Fig. 11 SVM Graph Screenshot

7. Conclusion

Thus, using the core concepts of Internet of Things and Machine Learning in a combination results in an effective and efficient system. The Machine Learning concepts add intelligence to the conventional IoT network. Advanced Machine Learning techniques like Active learning and Adaptive learning can be used over Support Vector Machines (SVM) for more user oriented intelligent systems.

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