Original Research Paper

Engineering

AN IoT BASED HOME AUTOMATION AND HUMAN PATH PLANNING USING EXPECTATION MAXIMIZATION ALGORITHM

Drisya Payyeri	M Tech ,Department of ECE, Vedavyasa Institute of Technology ,Malappuram Dt,Kerala,
Sreekanth M	Kabani Tech Maker Space, Shoranur,679121,Palakkad Dt,Kerala
Akash P	B Tech, Department of ECE,Sreepathy Institute of Management and Technology, Palakkad Dt, Kerala

ABSTRACT This project focuses on a method for learning models of people's motion behavior in an Internet of things (IoT) enabled indoor/home environment which maximizes energy. As people move through their environments, they often engage in typical motion patterns, related to specific locations and time. An IoT (Internet of Things) based sensor, controller and actuator architecture is developed, and through which identification of person and learning their motion pattern is achieved. Learning is based on the expectation maximization algorithm in machine learning. This algorithm, at the same time groups the trajectories which belongs to one's motion behavior and learn the characteristics and motions of persons in a very time crucial manner. Every node is equipped with a microwave radar human presence sensor, a Wi-Fi enabled microcontroller and relays to control multiple devices. Every node is connected to a central server using Wi-Fi based MQTT protocol. The MQTT protocol takes only low computing/ power requirement than conventional IP based communication and works with a generalized publish-subscribe scheme. This method is efficient for IoT environments due to the lower data rates. Every presence data is send to server and the algorithm learns with the new arrived data and predicts the next moves. The advantage of this method is efficiency in computing and lower requirement in storage of data.

KEYWORDS : Path planning, IoT, Home automation, Machine learning, Prediction, EM Algorithm, Face recognition

I. INTRODUCTION

Human presence detection is an on-going challenge in several scenarios and applications. One of them is in ambient intelligence and building automation. This project intends to create a system to be able to infer about presence using general information and statistics of usage and interaction with several types of devices. Ambient intelligence in computing refers to technology that is non-intrusively integrated in an environment, works without the need of intensive interaction from a user, and adapts, in an automated way, to the necessities of each user and context. The goal of this technology is the creation of complex systems with simple interfaces that enhance the quality of our daily lives. Internet of Things (IoT) is the network of physical objects with electronics, software, sensors and connectivity capabilities that allow these devices to communicate with each other and to exchange information. By fusing the information from each device, and through the interaction of each device with its environment, we are able to build complex systems that may enhance our quality of life.

The information about human presence on a domestic house is interesting for several reasons:

• Allows the automation of several actions such as turn on/off devices when someone arrives, turn off when they leave aid in some forms of intrusion detection.
• Allows learning the user's routines in a non-intrusive way, since it is fundamental to know when a user is at home or is he interacting with the devices remotely.
• Can help detect behaviour anomalies related to health conditions.

The idea is to process the data generated from interactions between the user, the devices and the platform in order create general metrics, not related to each device usage or characteristic, like for example average number of interactions per day, or number of interactions in the last half hour. These will then be used to train machine learning models for presence detection.

II. RELATED WORK

Many research projects have been developed in the home automation field to reduce the energy consumption and make a smart environment. Maren Bennewitz, Member, IEEE, Wolfram Burgard, Member, IEEE, and Sebastian Thrun, Member, IEEE, outlined "Learning Motion Patterns of Persons for Mobile Service Robots". This paper presents a way for learning models of people's motion behaviors in an internal environment. As individuals move through their environments, they do not move arbitrarily. Instead, they usually have interaction in typical motion patterns, related to specific locations that they could have an interest in approaching and specific trajectories that they could follow in doing so. Data concerning such patterns might help a mobile robot to develop improved individuals following and obstacle rejection skills. This paper proposes a formula that learns collections of typical trajectories that characterize a person's motion patterns. Data, recorded by mobile robots with optical device range finders, is clustered into differing kinds of motion with the utilization of the popular expectation maximization algorithmic rule. whereas at the same time learning multiple motion patterns. The EM-based learning procedure has been enforced for data no inheritable with laser-range finders. To accumulate the information Pioneer robots have been placed that are placed within the environments. The robots were aligned so that they coated virtually the entire setting. Typical range information obtained throughout the information acquisition part is gathered and further analysis is done. The results acquired using the data illustrates that exceptionally predictive models of human motion patterns can be learned.

III. PROBLEM DEFINITION

The goal is to reduce the energy consumption of building by the help of machine learning and IoT technologies. Energy optimization implies the reduced maintenance cost of a smart home. One may employ a static energy management scheme where a fixed number of devices (for example, electric lights, fans, or refrigerators) are kept on for a fixed amount of time every day, Or manually control loads while leaving or entering particular locations inside the building. An obvious solution to save energy is to control those devices intelligently while leaving or entering particular locations inside the building. However, such explicit awareness for manual operations is orthogonal to the concept of home automation, which is also a desirable feature of ubiquitous computing. Therefore, a smart energy management system needs to be designed that will operate in a proactive mode to conserve energy during the inhabitants prolonged absence from the house or certain locations within it. At the same time, This has to be accomplished without human intervention.

IV. PROPOSED SYSTEM

The proposed system shows the design and development of the machine learning based building automation for energy efficient building standards. The Camera is connected to the MQTT server collects the image of individual and being processed under facial recognition algorithms. The main component of the proposed system is MQTT sever which acts as the central processing station for all the sensor nodes. Dividing the building into several sub sections and

sensor nodes which consist of a Wi-Fi enabled microcontroller (ESP8266) are placed. A relay driver circuit and Sensors are also connected to the microcontroller module. The microcontroller collects the data from the human detection sensor such as PIR and transmit the collected sensor data to the MQTT server which act as the centralized controller for sensor network and the server process the data from all sensor nodes to determine the path of the user and make logical decisions to control the AC lodes and give commands to the node which is to be controlled (ON/OFF). The current sensor used to measure the power consumption of each dc devices will help the calibration of devices and decrease the total power consumed.
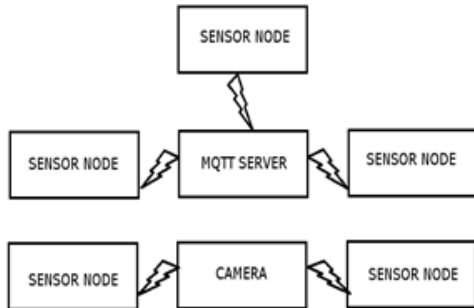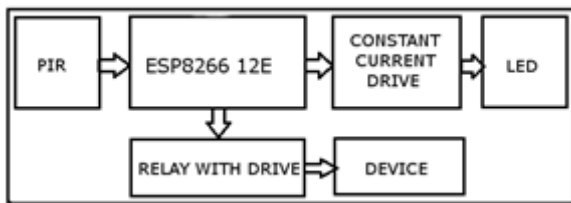

Figure 1: BLOCK DIAGRAM

Figure 2: SENSOR NODE

The main section of block diagram is the MQTT broker (server) and it provides centralized control for sensor network. The MQTT broker communicates with sensor network through Wi-Fi. Each network consist of ESP8266 (microcontroller with Wi-Fi), Human detection sensor such as PIR (passive infrared), current sensor, relay with drive and constant current drive. The main functions performed by python are facial recognition and implementation of machine learning algorithms. To perform facial recognition we use pi-cams. The MQTT broker communicates with sensor node through Wi-Fi. The ESP8266 provides the Wi-Fi connectivity as well as logical operations. The PIR is used for detection of human presence and the sensor data were sending to MQTT server through ESP8266. MQTT server gives commands to control the relay drive IC for controlling the relay unit through ESP8266.

If the face is recognized the system proceeds to the path identification. From the face recognition check the users name or the key and check whether the user is entering for the first time or have any previous records. If it is the first entry then the AC load at the place of the user will turn on based on the presents of the user, and record all the motion patterns of user. If the user has any previous records then the system will load the path and accordingly control the loads at the destination and the next node. If there is any change in the predicted path from the users path then the loads will not control based on the prediction ,instead of that it learn the new path until he return to a path that is known by the system.

Esp8266
The ESP8266 is a cheap microchip including WiFi with full Transmission Control Protocol/ Internet Protocol stack and microcontroller capability made by Espressif Systems. This tiny module permits microcontrollers to attach to a WiFi network and create straight forward TCP/IP connections using Hayes-style commands. The term "NodeMCU" by default refers to the microcode instead of the development kits. The ESP8266 microcontroller integrates a 32-bit reduced instruction set computing processor, which reaches a most clock speed of a hundred and sixty megacycles per second. The period of time package (RTOS) and Wi-Fi stack enable concerning eighty of the process power to be accessible for user

application programming and development. ESP8266 have low power consumption as it is designed for mobile devices, wearable electronic components and IoT applications with a mixture of many proprietary technologies. There are mainly 3 modes of operation: active mode, sleep mode and deep sleep mode. This enables powered styles to run longer.

PIR Sensor
A passive infrared detector or PIR detector, measures the radiation diverging from objects in its visible space. All objects with a temperature more than the absolute zero emits a value of heat energy. This radiation isn't detectable to the human eye as it radiates at infrared wavelengths.PIR sensors permits you to sense motion within the range. they're tiny, cheap, low-power, straightforward to use and do not wear out. PIRs are primarily manufactured from a pyroelectric detector,which can observe levels of infrared emission. Everything emits some low level radiation, and therefore the hotter something is, the additional radiation is emitted. The detector in a motion detector is split in 2 halves. the explanation for that's that we are trying to observe motion (change) not average IR levels. the 2 halves are wired up in order that they cancel one another out. If one half sees additional or less IR radiation than the opposite, the output can swing high or low.

Relay module
A relay is an electrically operated switch. Most relays use an electromagnet or solid state relays to mechanically operate a switch. When it's necessary to manage a circuit by a separate low-power signal, or wherever many circuits should be controlled by single signal we tend to use relays. Relay board module is built for controlling higher current loads from the Digital, Microcontroller, computer, Arduino Uno Etc. This board has one on-board relay which may switch up to 5Amps. Relays terminals (C, NC, NO) are accessible through screw terminals that makes wiring up the board very simple. There's free-wheeling diode which is able to additional shield your microcontroller from relay kick back. And Reverse supply protection included for Accidental supply reverse connection. This can be a 5V 1-Channel Relay interface board which may be controlled directly by All Digital and every small controllers like Arduino, AVR, PIC,8 051,Raspberry pi Etc.

Constant current drive
Constant current light-emitting diode drivers are made for a selected range of output voltages and a set output current .By varying the voltage on the circuit it permits the current to stay constant. LEDs get brighter for higher current values. But the LEDs draws additional current if the they don't seem to be regulated properly. Thermal Runaway lowers LED life-span and burn outs happens because of the variations in temperature. To drive a high power LED the solution is to use a constant current driver. Constant Voltage Drivers switches fluctuating or alternating current to a low direct voltage. A continuous voltage can be obtained in spite of the value of current load placed on it.

V. SOFTWARE DESCRIPTION

EasyEDA
EasyEDA allows the designing, simulating, sharing of schematics and printed circuit boards. Also it enables the creation of Gerber files and pick and place files and documentary outputs in several formats like PDF, PNG and SVG. The tool allows the modelling and correcting of schematic diagrams and SPICE simulations. And also the fabrication, management and manufacturing of printed circuit board layouts.

Arduino IDE
Arduino IDE is here used for programming the ESP8266 module. The Arduino project provides a cross-platform application written within the programming language Java. Arduino IDE includes a code editor with basic assembling options and provides easy one-click mechanisms to compile and transfer programs to an Arduino board. It additionally contains a message space, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. The Arduino IDE supports the languages C and C++ exploitation special rules of code structuring. The Arduino IDE provides a software system library from the Wiring project that provides several common input and output procedures. User-written code solely necessitates 2 basic functions, for beginning the sketch and the main program loop, that are compiled and connected with a program stub main () into a possible cyclic supervisory program with the gnu tool chain.

Open CV

OpenCV is an open source pc vision and machine learning software package library. OpenCV helps the user to utilize and modify the code. The library has several algorithms, including set of each classic and progressive pc vision and machine learning algorithms. These algorithms are used to notice and acknowledge faces, determine objects, classify human gestures in videos objects, sew pictures together to provide a high resolution image of a complete scene, notice similar pictures from a picture info, take away red eyes from pictures taken exploitation flash, follow eye movements, acknowledge scenery and establish markers to overlay it with increased reality, etc.

Python IDLE

IDLE is an integrated development atmosphere for Python, that has been bundled with the default implementation of the language. It's packaged as a part of the Python packaging. It consists of many UNIX distributions. It's fully written in Python and therefore the Tkinter graphical user interface toolkit (wrapper functions for Tcl/Tk). IDLE is meant to be an easy IDE and appropriate for beginners, particularly in an academic surroundings. to it finish, it's cross-platform, and avoids feature clutter. IDLE has been criticized for varied usability problems, as well as losing focus, lack of repetition to writing board feature, lack of line enumeration choices, and general interface design; it's been known as a "disposable" IDE, as a result of users oftentimes pass on to an additional advanced IDE as they gain expertise.

GIMP

GIMP is an image editor available for operating systems like GNU/Linux, OS X, and Windows etc. It is free software which allows changing its source code and distributing the changes. This mirrored its new existence as being developed as free Software which is a part of the GNU Project. From the time it was released, the number of computer architectures and operating systems supported has expanded considerably. This user friendly software enables the user to edit the images, include text inputs, design and manipulate the image files etc.

RESULTS AND DISCUSSIONS

The MQTT broker is installed in the on computer, so it can act as the inter mediator in between each nodes. The sensors are interfaced with the ESP8266 and the sensor data from the ESP8266 (client) is transmitted (wireless) to the MQTT server. The sensor is placed for the detection of presence of user at each node. The relay module is interfaced with the ESP8266 and the relay can be triggered according to the command from the MQTT broker. Image processing algorithms for facial recognition are developed and the authentication using face is performed. Using the constant current drive single dc voltage output is obtained for the led. The current sensor used to estimate the power consumption of each dc devices helps in decrease the total power consumption. Development and implementation of the machine learning algorithm is done and verifies by means of real life scenario.
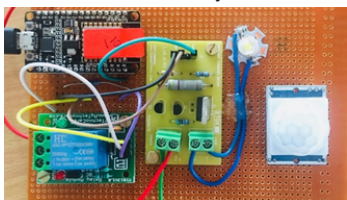

Figure 3: HARDWARE SECTION

Saving the previously recorded data, when next time a person enters the room verification is done using face recognition. If that individual have previously entered the room and have followed any path, after analyzing the previous information the "next" node, "current" node and "destination" node can be visualized in the window.
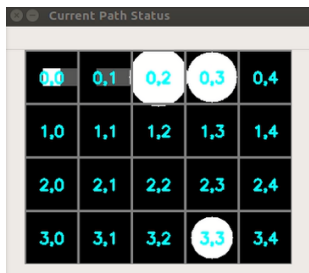

FIGURE 4: VISUALIZATION OF CURRENT PATH STATUS

CONCLUSION

The Development of the intelligent machine learning based building automation platform is done.

The project includes algorithms for time slots management and weakly routine tracking and decision making algorithms in future. Also this project aims at energy conservation in an efficient way, without manually controlling the AC as well as loads. The graphical representation of user's current position is done and can be monitored. In future the paths with overlaps can be calculated; also the entry of more than one person without confusing our system can be solved by replacing the PIR sensors with camera which provides identification than presence detection.

REFERENCES

1. Abhishek Roy, Sajal K. Das and Kalyan Basu, Members, IEEE, "A Predictive Framework for Location-Aware Resource Management in Smart Homes", IEEE Transactions on Mobile computing, Vol. 6, No. 11, November 2007
2. Adnan Akbar, Abdullah Khan, Francois Carrez, and Klaus Moessner, "Predictive Analytics for Complex IoT Data Streams" IEEE Internet of Things Journal, VOL. X, NO. X, XX 2017.
3. Blerim Qela, Member, IEEE, and Hussein T. Mouftah, Fellow, IEEE, "Observe, Learn, and Adapt (OLA)- An Algorithm for Energy Management in Smart Homes Using Wireless Sensors and Artificial Intelligence", Ieee Transactions On Smart Grid, VOL. 3, NO. 4, DECEMBER 2012
4. Iftikhar Alam, Shah Khusro, Muhammad Naeem, "A Review of Smart TV: Past, Present, and Future",2017 IEEE International Conference on Open Source Systems and Technologies (ICOSST)
5. Jiwen Lu, Venice Erin Liong and Jie Zhou, Members, IEEE, "Simultaneous Local Binary Feature Learning and Encoding for Homogeneous and Heterogeneous Face Recognition",IEEE Transactions on Pattern Analysis and Machine Intelligence, 2017
6. Joseph Siryani, Bereket Tanju, and Timothy Eveleigh, D.Sc, "A Machine Learning Decision-Support System Improves the Internet of Things" Smart Meter Operations",IEEE Internet of Things Journal.
7. Maren Bennewitz, Wolfram Burgard and Sebastian Thrun, Members IEEE, "Learning Motion Patterns of Persons for Mobile Service Robots", Proceedings of the 2002 IEEE International Conference on Robotics and Automation Washington May 2002
8. M Sreekanth, Abraham T Mathew and R Vijayakumar, "A novel model-based approach for resistance estimation using rise time and sensorless position control of sub-millimetre shape memory alloy helical spring actuator", Journal of Intelligent Material Systems and Structures, 2017
9. M. Mubashir, L. Shao, and L. Seed, "A survey on fall detection: Principles and approaches," Neurocomputing, vol. 100, no. 16, pp. 144-152, Jan. 2013.
10. Saeed Peyghami, Student Member, IEEE, Hossein Mokhtari, Senior Member, IEEE, Poh Chiang Loh and Frede Blaabjerg, Fellow, IEEE , "Synchronverter – enabled DC power sharing approach for LVDC microgrids ", IEEE Transactions on Power Electronics 20161