ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Volume 4, Issue 4, April 2017

IoT based Fuzzy System Management for HVAC in Medical Spaces

[1] Kamran Sayeed, [2] Kunal C J, [3] Vidyashankara V, [4] Bharath G C, [5] JV Alamelu
[1] [2] [3] Student, Department of Electronics and Instrumentation Engineering.
[4] Student, Department of Information Science Engineering.
[5] Professor, Department of Electronics and Instrumentation Engineering,
[1] kamran.sayeed18@gmail.com [2] kunal.jagadish7@gmail.com [3] vvudupa@gmail.com
[4] bharathgc06@gmail.com [5] jvalamelu@msrit.edu

Abstract :- **— Today, renewable energy (RE) sources have become an increasingly important part of power generation, as the reserves of fossil fuels get closer to depletion. Among the available RE technologies (such as solar, rain, wind, tidal, geothermal), wind and solar energy sources are the most promising options, as they are omnipresent, freely available, and environment friendly. Due to increased demand for fossil fuels and their limited supply, "Green Energy" is an important concept in today's world. However, there are few drawbacks associated with green energy since they are sporadic. As a result, energy management is utmost important to ensure maximum efficiency. The current work aims to develop a fuzzy logic system which obtains weather forecast information from the Internet, battery SOC, and based on set of rules, it determines the efficiency in which the system should run in order to obtain maximum efficiency.**

The fuzzy logic system provides several merits over classical control system, they are cost efficient, incorporate a wide range of operating conditions, and are more customizable in natural language terms. These systems can be easily incorporated in the hospital or in medical spaces. Further, based on predefined operating conditions for each economy level and the current room conditions, HVAC systems in hospitals are operated. The control information is sent from the Raspberry Pi to the Arduino Uno through ZigBee protocol. The room conditions data (i.e. temperature and humidity) is sent to ThingSpeak platform wherein it can be viewed in real-time and monitored. Laboratories in hospitals produce may produce fumes and harmful by-products, which have to be expelled out via an exhaust system. In addition to it in emergencies such as fires, proper ventilation for expelling smoke is essential. HVAC system is essential in hospitals and it is responsible for reducing the spread of air-borne diseases by providing proper ventilation and maintaining healthy atmosphere.

Keywords: **- Arduino, HVAC, Green Energy, ThingSpeak, Zigbee.**

I. INTRODUCTION

Standard power resources like fossil fuels and coal satisfy the bulk of our energy needs. Their main drawbacks are that they cause a lot of harm to the environment by releasing a lot of harmful substances during extraction and combustion, these resources are limited and due to the ever-growing need and their continuous usage, they will get exhausted in time, hence alternative methods are needed to produce energy.

Green energy is the energy that comes from natural sources such as sunlight, wind, rain, tides, geothermal heat etc. These resources are renewable, meaning they're naturally replenished and do not get exhausted. In contrast, fossil fuels take millions of years to form and hence will get diminished with rapid usage. The functioning of HVAC systems in hospitals is very critical. They are responsible for proving a comfortable environment to the patients. they must be designed in such a way so as to prevent the spread of air-borne diseases, provide proper ventilation in case of fires and an effective exhaust system for expelling gaseous chemical reaction by-products [8]. this paper focuses on harnessing the green energy, managing the energy supply using an efficient fuzzy system for the controlling of hvac elements [7] to manage the temperature and humidity in the medical spaces [1]. the schematic is shown in fig.1

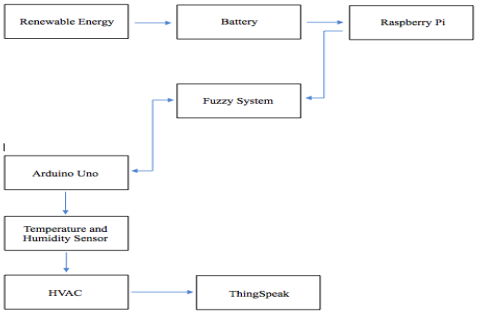

Fig 1. Schematic of IoT based Fuzzy management system for HVAC

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Volume 4, Issue 4, April 2017

II. DARKSKY API

The Dark Sky API is necessary to gather the weather condition information of the place where the hospital is situated, determine the battery status, hence the economy level at which the HVAC elements should operate. The Dark Sky API allows in finding the weather anywhere on the globe. The information identified are:

- Current weather conditions
- Minute-by-minute forecasts out to one hour
- Hour-by-hour and day-by-day forecasts out to seven days

They provide two types of API requests:

- A Forecast Request returns the current weather forecast for the next week in JSON format.
- A Time Machine Request returns the observed or forecast weather conditions for a date in the past or future in in the same JSON format.

A Forecast Request returns the current weather conditions, a minute-by-minute forecast for the next hour (where available), an hour-by-hour forecast for the next 48 hours, and a day-by-day forecast for the next week.

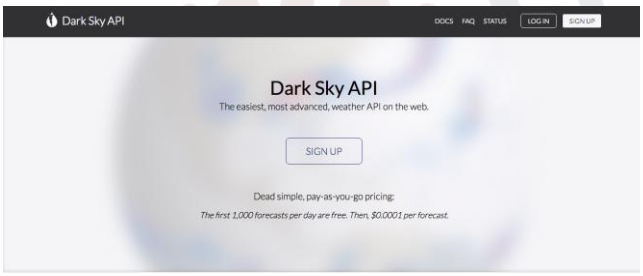

Fig 2. Dark Sky API

III. BATTERY MONITORING

The green energy (i.e. solar energy) harnessed from the solar panel is to be stored in a battery [9]. This battery supplies the required energy to the HVAC elements based on the economy level [5]. This economy level is determined through a fuzzy system by considering weather information and the battery status as inputs. Hence battery monitoring is necessary for the process.

The circuit incorporates a MCP 3008 ADC (Analog to Digital Converter), a Raspberry Pi 3 Controller and an OLED display. The ADC converts the received analog signals from the battery to their digital equivalent and then are processed in the Raspberry Pi 3 Controller. The processed Battery status then is displayed on the OLED display.

IV. FUZZY CONTROL SYSTEM

For the economic control of HVAC system in our process, we prefer using fuzzy logic.
The following are some of the advantages of using fuzzy controllers [2]:

1. Flexible, intuitive knowledge base design.
2. It has better ability to deal with non-linearity and uncertainty.
3. Convenient user interface. Easy end user interpretation.
4. Easy and fast computation.
5. Faster and more adaptive learning. No need of retraining the system once new data has been added.
6. FLC can incorporate a conventional design and fine tune it to certain plant non-linearities due to universal approximation capabilities.

To implement fuzzy logic technique to the real application of controlling HVAC system, it requires the following three steps:

1. Fuzzification – convert classical data or crisp data into fuzzy data or Membership Functions (MFs). Here we convert battery status, temperature and cloud cover which is the criap data into their fuzzy equivalent.
2. Fuzzy Inference Process – combine membership functions with the control rules to derive the fuzzy output. Here we combine the fuzzy data obtained with the control rules designed to derive the economy level.
3. Defuzzification – use different methods to calculate each associated output and put them into a table: the lookup table. Pick up the output from the lookup table based on the current input during an application. Here a lookup table is derived for different battery status ranges, temperature ranges and cloud cover status in terms of economy leve at which the HVAC elements should operate.

The fuzzy block diagram implemented for HVAC in IoT environment is shown in Fig 4.

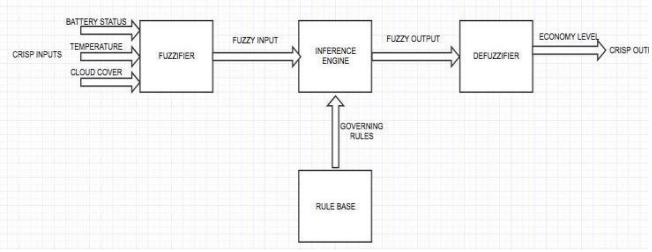

Fig 4. Fuzzy System Block Diagram

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Volume 4, Issue 4, April 2017

This block diagram explains the evaluation of the weather information (Temperature and Cloud Cover) and the battery status for the determination of the economy level at which the HVAC elements should operate [3].

Initially, the Crisp Inputs are fed to the Fuzzifier. Here the battery status obtained from the battery monitoring setup and the outside temperature and cloud cover obtained from the Dark Sky API are the Crisp Inputs. Then the fuzzy input from the Fuzzifier is fed to the Inference Engine. The Inference Engine evaluates these fuzzy inputs based on the governing rules made in the Rule Base. The evaluated fuzzy output is then fed to the Defuzzifier. The Crisp Output, which is nothing but the Economy Level is obtained. Based on this economy level, the HVAC elements operate.

Some Snippets of the fuzzy system from MATLAB are shown below.

V. FUZZY CONTROL SYSTEM RESULTS

The fuzzy control system was implemented in MATLAB using the fuzzy logic toolbox.

The membership functions for temperature, cloud cover and battery SOC and economy level are shown in Fig. 5 – 9.

The rule based output is shown in Fig. 10.

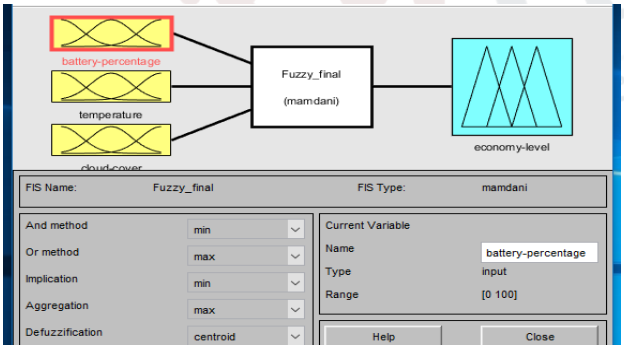

Fig 5. Membership Functions

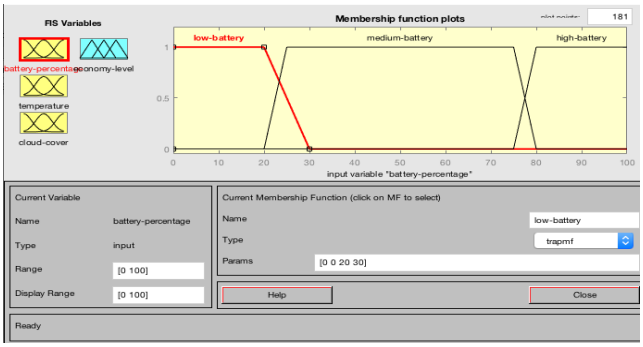

Fig 6. Battery Percentage Member Function

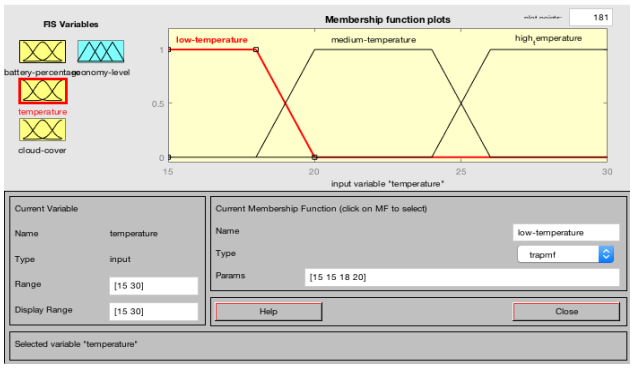

Fig 7. Temperature Member Function

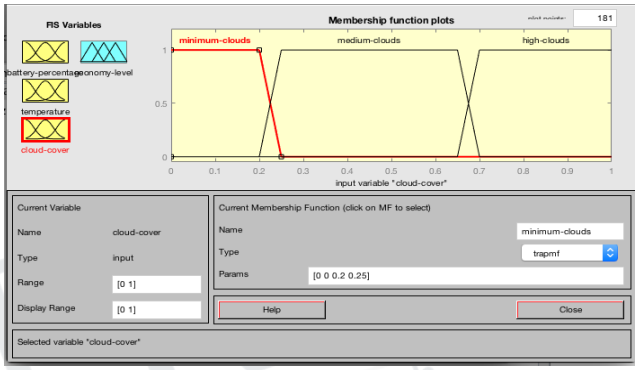

Fig 8. Cloud Cover Member Function

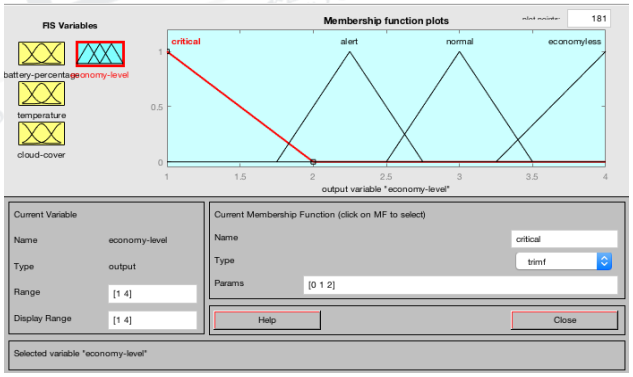

Fig 9. Economy Level Member Function

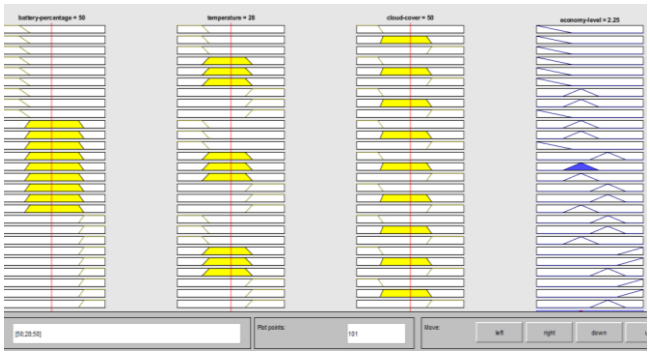

Fig 10. Output based on Rule Base

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Volume 4, Issue 4, April 2017

VI. THINGSPEAK

ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. It enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.

The Internet of Things (IoT) provides access to a broad range of embedded devices and web services. ThingSpeak is an IoT platform that enables you to collect, store, analyze, visualize, and act on data from sensors or actuators, such as Arduino, Raspberry Pi, BeagleBone Black, and other hardware. For example, with ThingSpeak we can create sensor-logging applications, location-tracking applications, and a social network of things with status updates, so that we could have our home thermostat control itself based on our current location [5].

ThingSpeak acts as the IoT platform for data collection and analytics that serves as a bridge connecting edge node devices such as temperature and pressure sensors to collect data and data exploratory analysis software to analyze data. ThingSpeak serves as the data collector which collects data from edge node devices and also enables the data to be pulled into a software environment for historical analysis of data [4].

The primary element of ThingSpeak activity is the channel, which contains data fields, location fields, and a status field. After the creation of a ThingSpeak channel, one can write data to the channel, process and view the data with MATLAB code, and react to the data with tweets and other alerts. The typical ThingSpeak workflow allows to:

1. Create a Channel and collect data
2. Analyse and Visualize the data
3. Act on the data using any of several Apps

In our work, ThingSpeak is used for retrieving data from the sensor and displaying them in graphical form which helps in easier statistical analysis. It continuously updates the data and displays he latest information retrieved. The ThingSpeak channels are shown in the Fig 12 and Fig 13.

Fig 11. ThingSpeak home page

VII. THINGSPEAK RESULTS

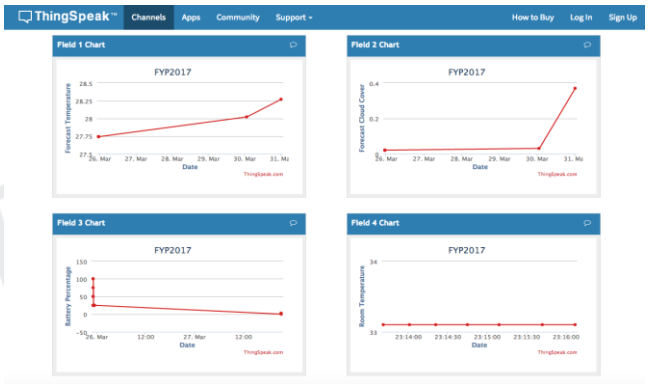

Fig 12. Forecast temperature & humidity, battery status and room temperature status

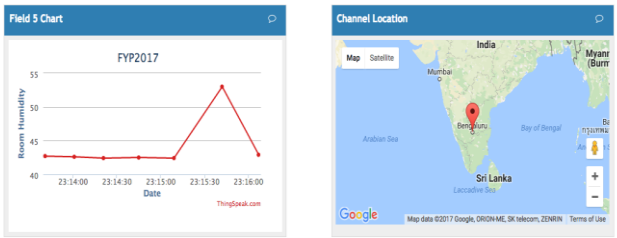

Fig 13. Room Humidity and Location status

VIII. CONCLUSION

This paper shows us the retrieval of the weather forecast with the help of the Darksky API, the battery status from the battery monitoring circuit, the Economy level with the help of the Fuzzy system and then display and updating of all the retrieved data with the help of IoT (ThingSpeak). From this paper we get a clear idea of controlling of the HVAC elements in the medical spaces with the help of IoT based Fuzzy Management.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Volume 4, Issue 4, April 2017

REFERENCES

[1] Ederson Luis Possselt, Fabiano Horn and Rolf FrediMolz, "Use of fuzzy logic to optimization of power systems based in green energy", UNISC October 2009.
[2] Ying Bai and Dali Wang, "Fundamentals of Fuzzy Logic Control - Fuzzy Sets, Fuzzy Rules and Defuzzifications", Advanced Fuzzy Logic Technologies in Industrial Applications, pp.17-36, published online January 2007.
[3] SK. A Shezan, Noman H Khan, Md. T. Anowar, Md. H. Delwar, Md. D. Islam, Md. H. Reduanul, Md. M. Hasan & Md. A. Kabir "Fuzzy Logic Implementation with MATLAB for Solar-Wind-Battery-Diesel Hybrid Energy System", IJIR ISSN:2454-1362, Vol-2, Issue-5, 2016.
[4] Cheah Wai Zhao, Jayanand Jegatheesan & Son Chee Loon, "Exploring IOT Application Using Raspberry Pi", International Journal of Computer Networks and Applications Volume 2, Issue 1, January - February (2015).
[5] Sheikh Ferdoush, Xinrong Li, "Wireless Sensor Network System Design using Raspberry Pi and Arduino for Environmental Monitoring Applications", Department of Electrical Engineering, University of North Texas, Denton, Texas.
[6] Prof. P. A. Jadhav, Jasim Faraj Hammadi, "Applications and Architecture of "Cloud-Based Internet of Things (IOT)", International Journal of Advanced Research in Computer Science and Software Engineering Volume 5, Issue 5, May 2015.
[7] Csaba Szasz, "HVAC elements modelling and implementation for net-zero energy building applications", IEEE May 2014.
[8] Dong Wang, Abhisek Ukil & Ujjal Manandhar, "Building HVAC Load Profiling Using EnergyPlus" IEEE 2014.
[9] Y-J Lee, A. Khaligh and A. Emadi, "advanced integrated bidirectional ac/dc converter for plug in hybrid electric vehicles", IEEE Trans, vol. 58, no. 8, pp.3970-3980, oct. 2009.

● ● ●