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Design of a Fuzzy based System for Automatic Heating, Ventilation and Cooling in Home

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Abstract*—The indoor and vehicular environmental comfort equipment is heating, ventilation, and air conditioning (HVAC). Its purpose is to provide thermal comfort and reasonable quality of indoor air. A right-sized HVAC device can provide the desired convenience and operate effectively. The correct size of the HVAC system is the choice of equipment and the configuration of the air distribution system to meet the house's expected specific heating and cooling loads. The HVAC system starts with an accurate understanding of the space heating and cooling loads. This helps in residential structures, such as single family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings, where temperature and humidity are controlled by safe and stable building conditions, using fresh outdoor air. There are many approaches that can be used to achieve energy-efficient HVAC systems, considering the rapid developments in science and technology today. A good understanding of building comfort conditions is important in order to establish efficient systems. All about human satisfaction with their thermal environment is thermal comfort The cornerstone for a comfortable indoor climate is the maintenance of optimum temperature and air circulation. The HVAC (Heating, Ventilation and Air Conditioning) system plays this role. Both heating, ventilation and air conditioning systems account for 60% of the overall energy usage in the world, which calls for sustainable HVAC solutions. Without compromising the services offered by the building in a sustainable manner, the energy usage of buildings must be decreased, thereby ensuring a safe indoor atmosphere for people. In this project, we will adjust the temperature inside the room depending on the ambient temperature to make people feel relaxed, whether the outside temperature is hot or cold. We used Peltier here to verify the refrigeration response and nichrome wire to verify the heating response.

I. INTRODUCTION

Heating, ventilation and air conditioning systems are the main consumers of building electricity. In this research, the control of a building's air-conditioning system is examined for efficient energy activity and a comfortable climate. The total mass flow rate is split by a certain percentage between all rooms using a fuzzy logic system to achieve the optimal output for each room. The proposed Building Management System (BMS) was found to be capable of managing temperature errors under various operating conditions and within reasonable limits. The BMS will save the flow rate of chilled/hot water and the ability of rooms to cool/heat. In an effort to enhance energy efficiency and occupant comfort for various loading conditions, a building management solution is proposed. This is especially complicated when considering other elements of environmental activity, such as solar benefit, natural ventilation, thermal comfort, and so on. It applies to ventilation and air conditioning for heating.

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In an effort to enhance energy efficiency and occupant comfort for various loading conditions, a building management solution is proposed. HVAC is a significant component of residential structures such as single-family homes, apartment complexes, hotels and senior housing, medium to large industrial and office buildings such as skyscrapers and hospitals, vehicles, trains, using fresh air from outside, where safe and stable building conditions are controlled in terms of temperature and humidity. It is important that during the design process, even where separate systems are involved, all aspects of HVAC systems are considered together. This is because of the heating, cooling, humidity regulation and ventilation interaction. This is especially challenging when other aspects of environmental behaviour are taken into account, such as solar gain, natural ventilation, thermal comfort, etc.

II. Literature Survey

In[1] Fernandes et al suggested a methodology for the management of heating, ventilation and air conditioning (HVAC) to be included in the Supervisor Control and Data Acquisition House Intelligent Management (SHIM). In[2] PriyaBhavesh Karhade, proposed the feasibility and optimization of HVAC systems using programmable controllers such as PLC, Arduino and microprocessors was suggested.HVAC (heating, ventilation and air conditioning) systems are used optimally for the regulated management of indoor environmental characteristics; some software is used to obtain ambient temperature. In[3],ArshaViswambharan et al indicated that the basis of a comfortable indoor atmosphere is to maintain optimum temperature and air circulation. Systems for heating, ventilation and air conditioning (HVAC) play this function. In[4], Filip Belic et al suggested that in recent decades, making buildings more energy-efficient while preserving thermal comfort has been an important issue, including improving the performance of systems for heating, ventilation and air conditioning (HVAC).
In [5] John ,et al proposes the efficient energy consumption management of HVAC systems in smart grids with variable, a self-management architecture for multi-HVAC systems in buildings, based on the Autonomous Cycle of Data Analysis Tasks.In [6] Hossein Mirinejad et.al,proposed that the two main objectives in the control of Heating, Ventilating and Air Conditioning (HVAC) systems are increasing thermal comfort and reducing energy consumption. This is achieved by using fuzzy logic control method for the control of HVAC systems.In[7]Smit Gupta et.al proposed that the integration of advanced sensor, Arduino and Internet of Things (IoT) devices into infrastructures and the installation of energy management systems are intended to design and incorporate energy-efficient controls in building HVAC systems.In[8], Gaurav, Amrit Kumar, says that retrofitting the building architecture, renovating old facilities or adding intelligence to the BMS can solve the energy saving issue. Enhancing the control algorithms is much more sustainable and cost-efficient.In[9] wayne,bequette,says that we chose to adopt the grey-box approach to model our method based on qualitative research, literature reviews. The mathematical framework of the models is developed and unknown physical processes are quantified using the method of data fitting.In[10]Ouladsine et al, the efficiency of model-based optimal control is based on the precision of device models. Grey-box models are often accepted in AC optimal control because the structural complexity of grey-box models is greatly reduced compared to physical models.

III. Proposed Methods

Lower energy bills are the key attraction of converting to a smart energy-efficient device, which is a lifetime gain for individuals. In order to regulate the air temperature within the "Air Conditioned" space along with moisture control, air filtration and air-borne particle containment. To measure the heating, cooling requirements based on room temperature, cooling time needed, cooling time required. In this process, according to the temperature in the outside world, we will vary the temperature inside the room. We used peltier to verify the cooling response in our system and nichrome wire is used to verify the heat response. We monitor the air temperature within the room space along with humidity control, air filtration and air borne containment. The block diagram of the proposed work is shown in Figure.3.1.

IV. Software Implementation

Fuzzy Logic is a variable processing approach that allows the processing of multiple values via the same variable. Fuzzy logic aims to solve issues with an open, imprecise data continuum that allows an array of specific conclusions to be obtained. Fuzzy logic is designed to solve problems by taking into consideration all the data available and making the best possible decision. In practice, both of these constructs allow for several "true" condition values. Rather than Real being equal to 1 numerically and False being equivalent to 0.

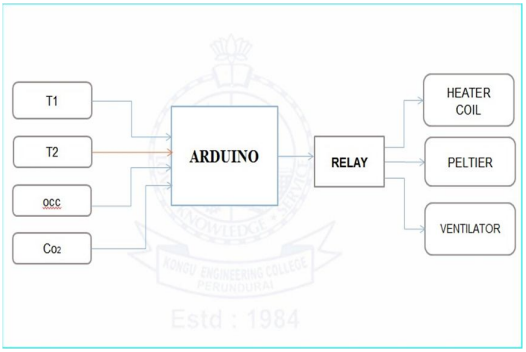

Fig 3.1 Block diagram of proposed work

A. Algorithm

For the implementation of a Fuzzy controller in MATLAB, the following steps are taken.

- Defining linguistic influences and words.
- Develop functions for membership for them.
- Develop a knowledge base of rules.
- Convert crisp data using membership features to fuzzy data sets
- Test instructions in the rule base. (Inference Engine)

The outcomes of each rule are combined. (Engine for inference).

B. Input and Output of the Controller

Here we are giving two inputs as, atmospheric temperature and occupancy and the output is heater and cooler. For this set of rules are written for execution.

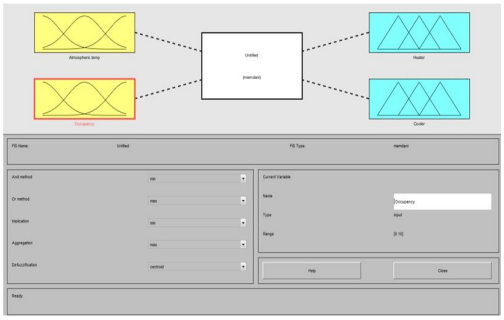

Fig 4.2.1 *I*nput and output of the controller

C. Membership Function

Fig 4.3.1 shows the membership function of the atmospheric temperature. Here we have set the temperature range and display range as 10 to 30◦ .Then the rules are written for working range for very chill,chill,normal,hot and very hot.

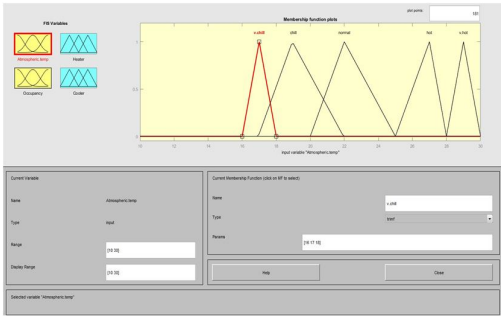

Fig 4.3.1 atmospheric temperature

Fig 4.3.2 shows the membership function of occupancy.This condition checks the occupancy level inside the room.

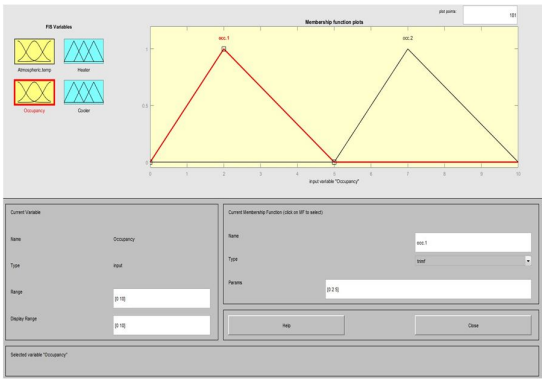

Fig 4.3.2 occupancy

Fig 4.3.3 shows the membership function of cooler.Change as passive for the cooler, that at which condition it will starts to work.

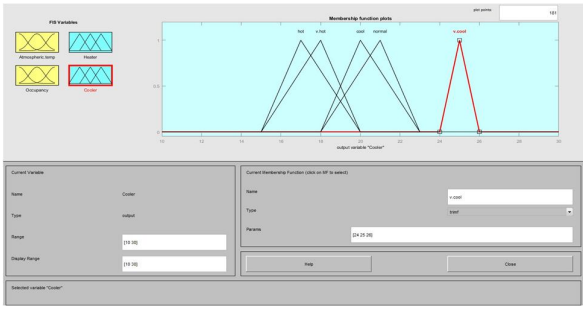

Fig 4.3.3 Cooler

Here in fig 4.3.4 shows the membership function of heater.we are writing the rules for the heater that at which condition it will starts to work.

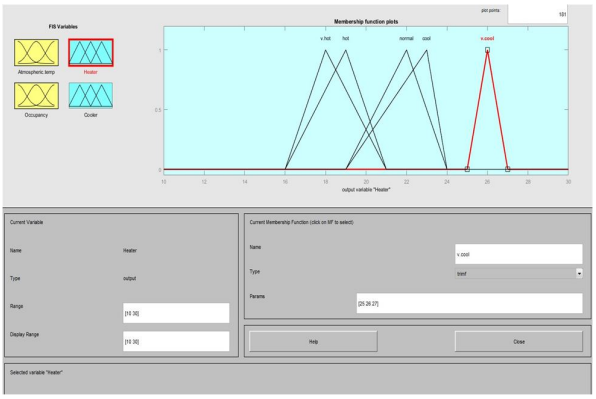

Fig 4.3.4 Heater

D. Rule View

Here in fig 4.4.1 shows the 1st rule view of heater.We can see that when atmospheric temperature is 19 and occupancy level of 2, the system will act as a heater with 22 degree Celsius.

Here fig 4.4.2 shows the 2nd rule view of cooler. we can see that when atmospheric temperature is 19 and occupancy level of 4,the system will act as a heater with 21.7 degree Celsius.

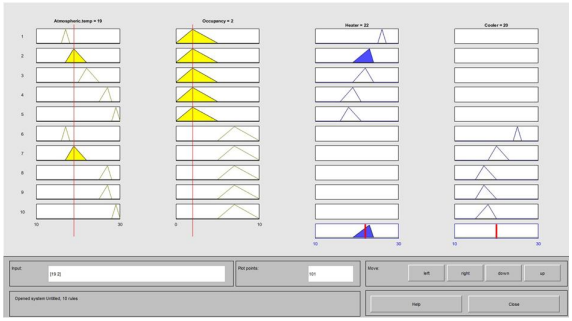

Fig 4.4.1 1st Rule View of Heater

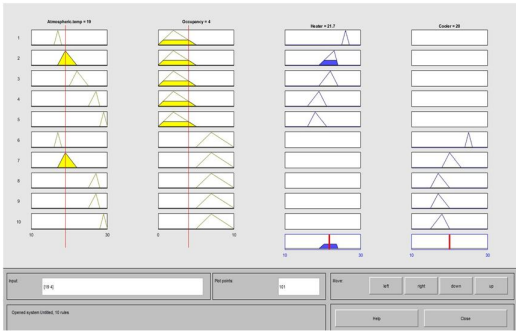

Fig 4.4.2 2nd Rule View of Heater

Here in fig 4.4.3 shows the 1st rule view of cooler.we can see that when atmospheric temperature is 26 and occupancy level of 6, the system will act as a cooler of 20 degree Celsius.

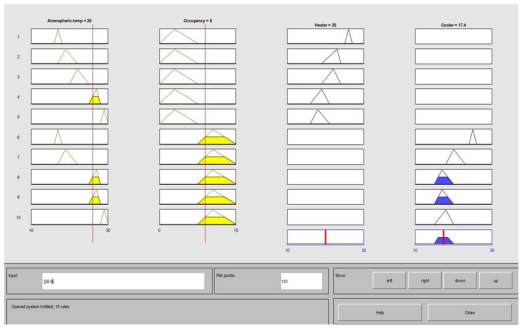

Fig 4.4.3 1st Rule View of Cooler

Here in fig 4.4.4 shows the 2nd rule view of cooler.we can see that when atmospheric temperature is 29 and occupancy level of 9, the system will act as a cooler with 17.6 degree Celsius.

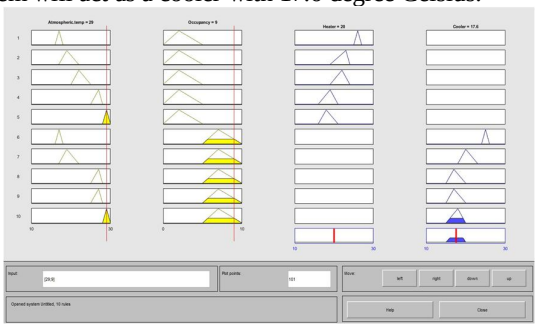

Fig 4.4.4 2nd Rule View of Cooler

V. HARDWARE DESCRIPTION

A microcontroller board based on the ATmega328P is the Arduino/Genuino Uno (datasheet)as shown in fig 5.1 It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB link, a power jack, an ICSP header and a reset button, of which 6 can be used as PWM outputs. It contains everything required for the microcontroller to sustain it. To get started, just plug it into a computer with a USB cable or power it with an AC-to-DC adapter or battery.

Fig 5.1 GENUINO UNO

An electronic power supply that incorporates a switching regulator to effectively convert electrical power is a switched-mode power supply shown in fig 5.2. Like other power supplies, while converting voltage and current characteristics, an SMPS transfers power from a DC or AC source to DC loads, such as a personal computer. This greater efficiency of power conversion is a significant advantage.Owing to the smaller transformer size and weight, switched-mode power supplies may also be substantially smaller and lighter than a linear supply.

Fig 5.2 Power Supply Switched Mode

Fig 5.3 Heating coil shows the nichrome 80/20 (80 percent Nickel, 20 percent Chromium) wire, ribbon, or strip is used for most resistance wire heating components. Nichrome 80/20 is an ideal material because when it is heated for the first time, it has relatively high resistance and forms an adherent layer of chromium oxide. Metal would not oxidize below this layer, preventing the wire from splitting or burning out. We are using Nichrome wire as a heating element in our project.

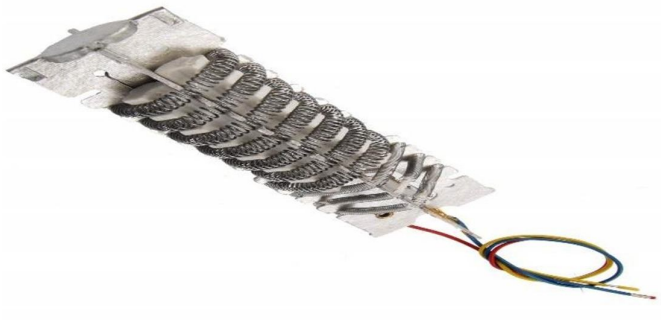

Fig 5.3 Heating Coil

Fig 5.4 shows the Thermistors ,which are widely used as limiters of inrush current, temperature sensors, protectors of overcurrent self-resetting, and heating components that are self-regulating. A thermistor is a type of resistor that is heavily temperature-dependent, more so than conventional resistors.
With NTC thermistors, the resistance decreases as the temperature increases usually due to an increase in conduction electrons that are bumped up by valency band thermal agitation. As a temperature sensor, or in series with a circuit as an inrush current limiter, an NTC is typically used.

fig 5.4 Thermistor

An electric switch that is powered by an electromagnet is a power relay module. The electromagnet is triggered by a micro controller's separate low-power signal. The electromagnet pulls, when triggered, to either open or close an electrical circuit.

Fig 5.5 Relay Module

In accordance with the Peltier effect, thermoelectric coolers work. The effect induces a temperature that is the difference between two electrical junctions by transferring heat. To generate an electric current, a voltage is applied through connected conductors. Heat is removed at one junction as the current flows through the junctions of the two conductors, and cooling happens.

Fig 5.6 Peltier Module

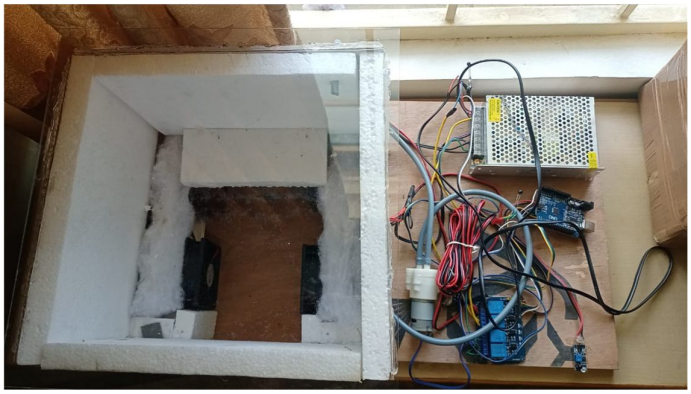

Fig 5.6 Hardware Implementation

The above fig 6.1 shows the complete hardware implementation of the proposed work.

VI. Conclusion

A heating, ventilation and air conditioning system (HVAC) is a very important component of a building that is safe, comfortable and energy efficient. The cornerstone for a comfortable indoor climate is the maintenance of optimum temperature and air circulation. The temperature inside the room is changed to make people more better if the outside temperature is dependent on the ambient temperature. Different parameters are taken from the room and the air flow rate into the room is adjusted to regulate the cooling or heating required by the room. Peltier is used to check the cooling response and the heating response is confirmed by nichrome wire.

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