Software Application for Room Thermostats using Artificial Intelligence

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Abstract: The increase in demand of power and opening of new string to control power is smart software tool using artificial intelligence. This will surely change the world of future as AI (artificial intelligence) is equipped with our heavy machinery like brain to regulate the generation, distribution to consumption. But upcoming future encourages us to do more smart way to think and develop out of box idea. This cajoled my interest in this topic to pursue my thesis by proving software interface for customer side. It seems the major factor temperature, humidity and intensity of light are responsible for approaching to comfort zone. The two other factor air quality and carbon in local area is secondary factor. To achieve this composition we need an application which capture all information and take decision according to that. The excellence in AI has recently come into focus and had promising future, but right tool with pioneered engineering lead to many solution of question such as: How it is possible? Or How it is going to work in future.

***Keywords* - Artificial Intelligence, Temperature, Humidity and Intensity**

I. Introduction

Presently a-days, in the created nations, individuals spend over 90% of their time inside a room [1]. Agreeable indoor conditions do extensively enhance our well-being, prosperity, and execution. Then again, indoor space involves significant vitality utilization, and in fact structures take a vast offer of the world's aggregate vitality. In Switzerland, for instance, around half of their essential vitality utilization is credited to home application of power [2].

Keeping in mind the end goal to give an increment indoor space, today developments progressively are dependent on building analysis system (BAS). These frameworks utilize improved plans for ventilation, warming, lighting and aerating and cooling. The utilized plans are grounded in insights and standard qualities like the span of the room or its temperature [3]. For instance, warm space in homes is controlled by straightforward dry knob temperature settings. Likewise, temperature sensors are not constantly set at fixed point around inhabitants. Every one of these system manages the building in light of normal qualities that are not client focused parameters. The rise of cutting edge detecting and incitation system permit, be that as it may, structures to be more proficient and receptive to tenant's needs than any time in recent memory.

The open doors offered by new advances can change the manner by which we interface with a building. Considering that individuals invest a lot of time inside, how might we enhance their life quality and guarantee the best indoor client encounter while lessening vitality utilization, utilizing advance new artificial intelligence?

This undertaking researches this inquiry from a computer science perspective. All the more accurately, we go for incorporating a sensor arrange into the fabricated condition of office work environment, which can likewise order the gathered information and figure the space level in the given setting. This can be utilized to survey another vitality sparing technique to perceive how it thinks about to the next vitality system as far as tenants' space.

In rundown, the three primary objectives of this work are as per the following:

- Understanding current hypotheses about human indoor space and human-building connections with the objective of characterizing what we have to detect
- Designing a framework to gauge the parameters expected to register HIC and HBI (sensor organize, information accumulation, information stockpiling)
- Testing the framework in test condition and make starter investigation on the gathered information

II. Understanding Indoor Human Comfort

Being comfortable involves all the dimensions of physical environments, and also depends on the person's psychological and behavioural aspects. Here, our goal is limited to summarizing only the standard methods or techniques that define the criteria for evaluating all parameters and that can have impact on indoor comfort with environmental consideration.

In most studies we found four sub-comfort dimensions: Thermal, Visual, Acoustic, and Respiratory. These aspects are generally quite well known and many standards specify minimum and maximum thresholds for the relevant parameters (light, temperature, sound power, etc.).

2.1 Thermal comfort

Individuals have dependably endeavored to make situations that are thermally agreeable. This can be followed ever of and building plan. The ISO principles characterize warm space. This definition is generally settled upon. Notwithstanding, finding the physical parameters that create warm space is by all accounts a test [4]. In the event that we take for instance two people: one is completing a physical action open air and the other is sitting behind the PC in a room, the warm situations are extraordinary however both may feel similarly good. This articulates warm space is a blend of numerous physical parameters, and unmistakably confounded that simply the air temperature.

The most known and standard indicator for thermal comfort is the Predicted Mean Vote (PMV). PMV (ISO 7730 standard) has become the most used index for measuring thermal comfort. More precisely, PMV is a prediction index that can be used to compute thermal comfort by using a model that can predict the mean value of the votes of a large group of people. It refers to a thermal scale that runs from Cold to Hot. This scale was developed by Fanger and adopted as an ISO standard (ASHRAE standard scale) [5]. The recommended PMV value is between -0.5 and +0.5 for an interior space [6].

Value	**Sensation**
-3	Cold
-2	Cool
-1	Slightly cool
0	Neutral
1	Slightly warm
2	Warm
3	Hot

TABLE 1: FANGER'S THERMAL COMFORT SCALE

2.2 Visual Comfort

Visual comfort is defined as a feeling of well-being in relation to the light (artificial or natural source) while performing a specific task [7]. A good visual comfort ensures that people have enough light for their activities, without exposing the eyes to a higher light level than to which it can adopt.

Luminance, illuminance, glare and contrast are the factors that are the most noticeable by human eye. These are objective measures, but how people experience this light can be rather subjective. These factors are the most representative of visual comfort, and can be measured with the following tools:

1. Illuminance (in lux) can be measured easily with a luxmeter
2. Luminance (in candela per square-meter) need a lot of material to be measured (luminancemeter)
3. Glare (in UGR) can also be measured with a luminancemeter

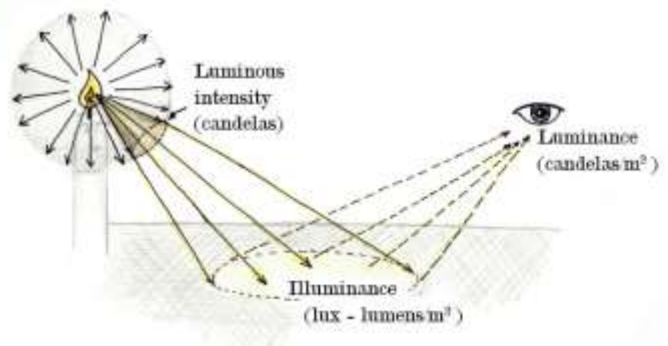


Figure 1: Measuring light levels

Due to the price and the complexity of measuring glare and luminance we decided to focus on illuminance. Illuminance is the amount of light falling on a surface (in our case on the working place) and is measured in lux. This value can indicate if the right level of light is provided for a certain task. A table in Appendix C has done by the Illuminating Engineering Society gives us the different illuminance levels for different tasks. For example, if you work behind your computer you need 500 lux to be comfortable or if you do precision assembly you need 1500 lux.

2.3 Acoustic Comfort

Appropriate building acoustic is a major contributor to work performance and well-being. People are more productive when they are not distracted by outside noise. To guarantee a good acoustic comfort, the first step is to fix a maximal noise level: a maximal decibel level. But the sensibility of the human ear varies depending also on the frequency. For example 60 dB to 1000 Hz is more disturbing than 60 dB to 250Hz. One well-established way to determine local acoustic comfort is to use the Noise Rating curves. These curves are developed by the International Organization for Standardization [8] to determine the acceptable indoor environment for hearing preservation, speech communication and annoyance.

2.4 Respiratory Comfort

The CO_2 (Carbon Dioxide) is the main indicator for the indoor air quality. It allows for measuring the indoor pollution which can vary with the presence of people in a room. The human body needs Oxygen and produces Carbon Dioxide. For example, an adult man at rest produces 20 liters per hour of Carbon Dioxide [9]. If the ventilation rate of an occupied room is insufficient, the air is quickly tainted. High level of CO_2 in air causes a less active breathing and premature fatigue, and thus it is highly recommended to work in a ventilated room.

III. SOLUTIONS TO BUILD

In recent years, a new kind of micro-controllers was built for casual users, electronics enthusiasts and hobbyists. It became a popular tool for electronics enthusiasts (before Arduino) because it was easy to use and to program [10]. These boards support a lot of input sensors (motors, led's,...) and open an infinite number of possibilities to develop new applications. Today, the most known implementation of easy-to-program boards is produced by Arduino [11]. Arduino is an open and versatile platform used for the development of electronic prototypes. The goal is to build quickly prototypes. A lot of military, scientific or business products exist because of Arduino. Even many commercial solutions appeared based on Arduino. In this section we will discuss the most known of them and try to compare them.

3.1 Open-Source Hardware and Software

Complete open source solutions like BeagleBone, Nanode, Arduino or Raspberry Pi offer powerful development platform and are quite less expensive than commercial solutions. A large community of developers exists around them which specially facilitate the debugging.

3.2 Commercial Hardware and Open-Source Software

Fully or partly commercial solutions offer great opportunities of development too. A lot of sensors-kit is pre-developed and the hardware is Arduino compatible. The negative point is that we have to buy their products, to be fully compatible, and for some solutions to be able to use the provide software.

3.3 Our Choice: Open Hardware, Open Software

Arduino-based platforms are powerful to develop complex and flexible projects. The community is big and a lot of research projects use this platform. Our choice is the Arduino compatible world and to take only open-source products such as Lux sensor, Temperature and Humidity sensor.

Fig 2: Temperature and Humidity sensor

Fig 3: Lux sensor

IV. PROTOTYPING

Once the hardware selected we started to prototype our first sensor node. After wiring all the components together we obtained our two first prototypes. To prototype we required an USB connection to a PC to transfer the source code on the micro-controller. To test and calibrate the sensors we tested different source codes.

Fig 4: Arduino Hardware for Prototyping

4.1 Technology Choices

4.1.1 Database Choice

The goal was to store the data and to visualize live data at the same time. The MQTT (Message Queuing Telemetry Transportation) allows us to do both at the same time and we do not waste time in storing the data and request them from the visualization tool. One client will connect to the broker to visualize the data and the other client will connect to the broker to store the data.

First we interested us in choosing a database. There are two types of databases: relational and non-relational. Due to the non-complexity of our data this was not relevant. We decided to store each message in our database on a single row at each time. For this project we have a lot of data that arrives each second. If you take a sensor node it sends 7 values to the broker each second. We produced 3 sensors nodes so we had 21 rows to store each second. For our database prototype we found the following possibilities:

1. MySQL
2. PostgreSQL
3. MangoDB

MySQL is the most popular web-database. There is a lot of documentation, it's a relational database, it's performance and it's security.

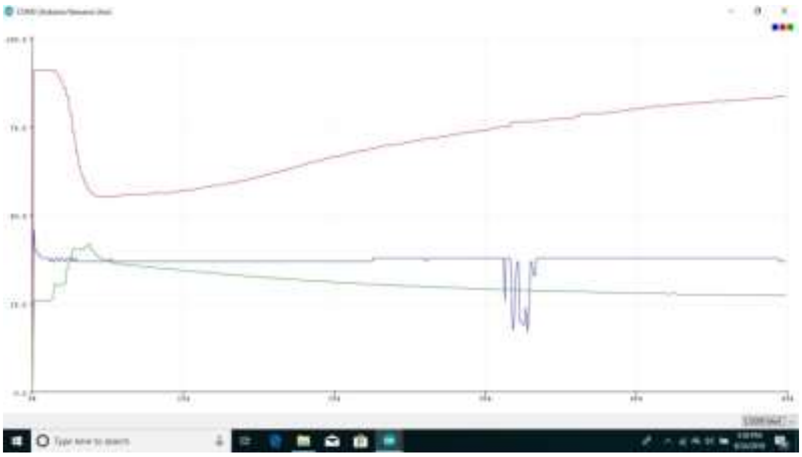
Postgre SQL is for more large-scale project and not really for prototypes. The configuration is quite complex and a daemon is needed to access to the database.

Mongo DB stores data in JSON-like documents that can vary in structure. Mongo DB allows to create records without first defining the structure, such as the fields or the types of their values.

We chose MySQL because it's quick and quite easy to install for a prototype. A lot of scripts exist to interact with a MySQL database. Mango DB is interesting but for prototyping and to save time it's too complex to install.

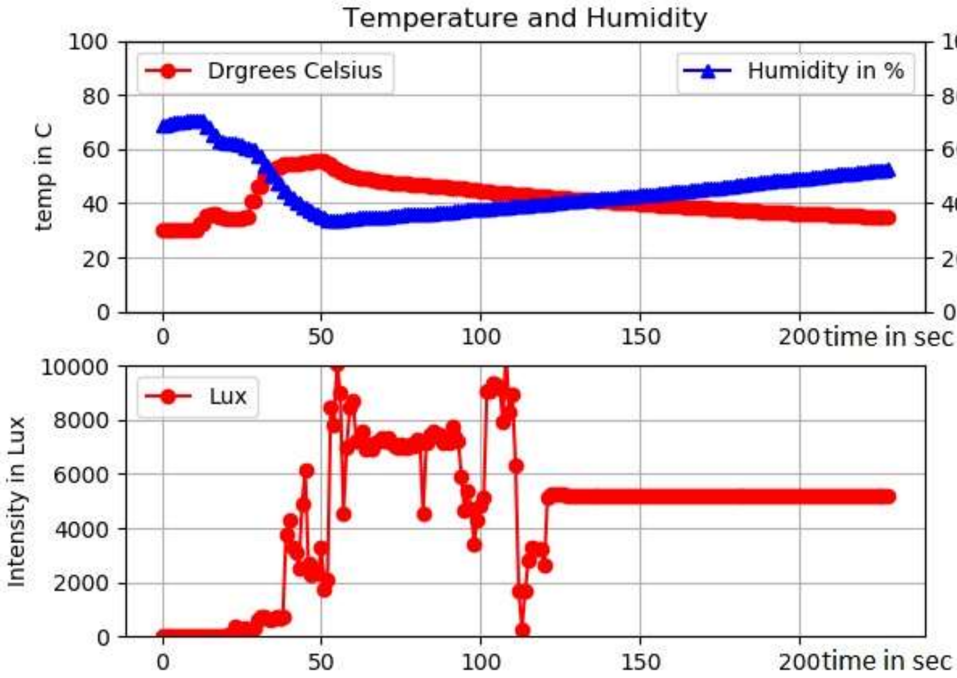
4.2 Performance Tests Environment

We tested our system in the Human institute offices in Bhopal (Vaishnavi Institute of Technology & Science). The offices are composed of an open-space of 6 meters per 10 meters and two individual offices of 3 meters on 5 meters. The open-space regroups 8 work desks, the first individual office one work desks and the last one work desk. We decided to produce all required information from all this office to make comfort zone by installing two of our devices.



Graph 1: For Temperature, Intensity and Humidity

We took time to make our system easy to deploy. Indeed, you just need to plug the devices to begin to use the system. First we plugged to the system to check the smooth running of the software by heating using hair dryer as we observed the drop in humidity as dryness increases and temperature rises. And the heated system took long time to reposition on ambient room condition.



Graph 2: Before Heating and After Heating

In this following graph same procedure is followed but to check the functional speed of sensor and our software. It is done with aim to calculate by changing artificial light and wind speed using hair dryer and heating coil temperature to measurement the randomness in data. As fast we can conclude that randomness of information- they are more static in our system.

4.3 Performance Measurement Procedures

To show if our system was robust enough we decided to track all possible errors and to measure the network performances by defining these following measures:

1. We compute the time that it takes to a data to go from the sensor to the visualization tool.
2. We log the possible interruptions of the system.

To measure this we added a time-stamp when a message leaves the Comfort Box and another time-stamp when the same message arrives to a MQTT client. We compare then the two time-stamps.

To measure if the system has interruptions we configure a simple tracking system.

The Internet gateway contains a try-catch statement and writes the errors in a log file if some errors appear. We do the same thing on the broker, the Python DAO and on the client side.

The final goal was to launch our system during 4 days and to see how the system behaves. During this test-phase we had to check if there were errors on our system.

Fig 5: Final Layout of Device

IV. RESEARCH METHODOLOGY

V. RESULTS AND DISCUSSION

The main goal of this project was to understand and capture human indoor comfort by controlling using artificial intelligence. As mentioned in the introduction we divided the project into three parts: The first was to understand human indoor comfort and human building interactions in order to define the parameters that we have to sense. The second part consisted in designing a system that collects data in order to compute human indoor comfort and human indoor interactions. The last part consisted in testing the system. Different studies and researchers have built systems to track comfort, but they are generally focused on thermal comfort and they do not care about visual, acoustic or respiratory comfort. To conclude, we could prove that the system has usability in the indoor environment. Moreover, we could demonstrate that people tend to wait before improving their comfort level. Potential applications for such a technology are unlimited and yet to be explored.

VI. ACKNOWLEDGMENT

This work is outcome of the Research project- “A Case Study on Ethereum” at Vaishnavi Institute of Technology & Science affiliated to Rajiv Gandhi Technological University of MP, INDIA. The work is done under the Guidance of Mr. Sumit Sharma, Head of Department of Computer Science at Vaishnavi Institute of Technology & Science affiliated to Rajiv Gandhi Technical University respectively

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