IoT Based Load Sensing Seats Controlling Lights and Fans

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Abstract— **In the present scenario, with the advancement of technology electricity plays an important role in our life. As the usage of electricity increases, the production also increases leading to the depletion of non-renewable resources, so conservation of electricity is the need of the hour. People tend to leave the lights and fans of the room switched on which adds to the power wastage. This paper emphasizes on automating the lights and fans of the room by using an energy-efficient system based on IOT using Arduino. Earlier works done on this issue has used motion sensors, load cells, and IR sensors to detect human presence in the room. These systems tend to be bulky and less accurate in detecting human presence. We propose a new method of load sensing based on the Force Sensing Resistor (FSR)sensor. FSR combines smart, lightweight, and power-efficient technologies for force and pressure sensing. Our designed system of smart seats is different, compact, and more energy-efficient. This kind of system will be extensively useful in places where the majority of the work is done seated. Such as office spaces, schools, college classrooms, salons, homes, trains, etc. It would help to lower energy the cost, prevent future resource depletion, raise the quality of life, and make a greener come to cleaner Earth.**

***Keywords*— IoT, FSR, sensor, Arduino, load-sensing, energy-efficient.**

I. INTRODUCTION

Energy conservation is the main priority nowadays, with the advancement of technology, automation plays a key role in conserving the energy and in turn the natural resources. People tend to leave the lights and fans of the room switched on, which adds to the power wastage. Earlier works done on this topic proposes a solution by counting the number of individuals entering the room and to light it up based on the light intensity and turn on the fans automatically [1]. Motion detectors were used to count the number of people present in the room. However, the PIR sensor holds major drawbacks. PIR sensors are highly sensitive to any kind of motion, therefore it can operate with any kind of movement be it a human or not. Therefore, it is not a very accurate sensor for the detection of human presence. Also, Passive InfraRed (PIR) sensors sense heat signatures in the room, they are not very sensitive if the room itself is warm. Hence PIR sensors are not able to detect human beings in the summer in some countries like India.

Previously all applications based on load sensing was done to solve fluid mechanic issues. Most studies focus on developing controller structure for the pump, to maintain stability and performance as shown in [2].

There are only a few examples of systems where a sensor-based load-sensing seat is applied to measure and control electrical appliances. Previous researches on this topic use a load cell application that converts force into an electrical signal. This system is very bulky as it also requires an HX711 load cell amplifier and uses many components such as nRF24LD1 transmitters, Relay, IR sensor, etc [3]. Our system uses a flexible, durable, thin sheet-like sensor that uses very little power making it a compact and energy-efficient system.

Our proposed solution is based on premise that within a room, in most cases, people spend most of the time seating during their work or wait. Then using load-sensing of chairs can be used to control the lights and fans within that room. It focuses mainly on areas like office spaces, salons, schools, and college classrooms where energy consumption is the most. The details of the proposal and principles are elaborated in the subsequent sections.

II. PROPOSED SOLUTION

Our solution includes the use of Arduino Uno, Force Sensing Resistor (FSR), ESP 8266, ThingSpeak cloud, and a relay driver circuit to control the lights and fans. In our system, the sensor uses the on-demand node activity where the devices are linked in a system through IoT, called node in a system. On-demand node activity is not scheduled and the node is by default in an active state with simple functionality. If it receives a wake-up signal, it switches to active mode, after activation data transmission takes place [4].

Our system consists of a Force Sensing Resistor (FSR) sensor as the main load sensing element. FSRs are thin, flexible sensors that can be put easily under cushions or foam of a chair. It will not affect the comfort of the chair. We will be using the FSR406 model as its most widely used and cost-effective. The sensor will be a square with a sensing area of 1.75x 1.5 square inches. It will be placed around the center of the chair below the cushions. When the sensor will sense an adequate load to signify a human load, it will send a signal to the relay through the Arduino to switch on the lights and fans and also send the data of the components to the cloud which

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will be used for monitoring the lights and fans. The cloud is used to set up a monitoring system. It can take voice commands to control any light or fan if the sensors fail to send the proper signal. The relay would be connected to the lights and fans of the area nearby so only those lights and fans would be switched on. Rest would work if someone is sitting near those fans and lights.

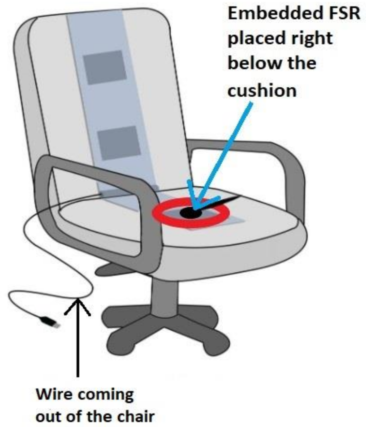

Fig.1(a) Placement of FSR sensor on the chair

Fig.1(b)Schematic showing the wiring of the system in an office desk.

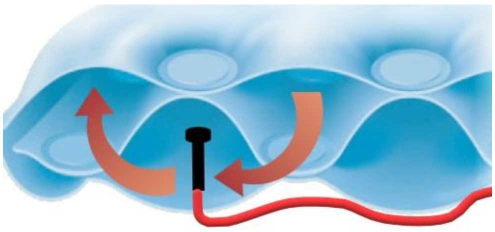

Fig. 2 Placement of the sensor between the cushion.

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III. WORKING PRINCIPLE

This is a simple project which works on the principle of piezoresistive sensing technology. When a person sits on a chair where the FSR is placed it sends a signal to the Arduino Uno. Force sensing resistor(FSR) as the name suggests uses a variable resistor that changes values on the application of force. FSR is built with robust polymer thick film (PTF)devices that exhibit a decrease in resistance with an increase in force applied to the surface of the sensor [5]. They are printed thin, flexible sensors. It can sense extremely feeble forces starting from 10g such as a light tough to a force equivalent to over 50 kgs. The **piezoresistive effect** causes a change only in the electrical resistance not affecting any other characteristic of the material. FSR's resistance changes as more pressure are applied. When there is no pressure, the sensor looks like an infinite resistor (open circuit), as the pressure increases, the resistance goes down [6].

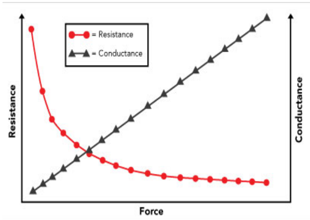

Fig.3 When force is applied to a force-sensing resistor, the conductance response as a function of force is linear.

$$\boxed{R \propto 1/F} \quad \text{or} \quad \boxed{F\ \alpha\ 1/R}$$

Arduino reads the data, and if the data is more than the threshold value then it sends a signal to the ESP 8266 WiFi module and the relay module. The relay switches on the lights and fans. Simultaneously, the Wifi module sends the data of the sensor and light or fan being on or off to the cloud as shown in the block diagram in Fig.5. The cloud works as a monitoring system and is also used as a failsafe in case the sensor malfunctions. The Arduino will be powered by the battery shield which will be connected to it. The battery shield will have two 9V rechargeable batteries. The FSR will be powered by the Arduino itself as it requires very little input of the range of 10mA.
The FSR will be placed underneath a cushion so that the pressure applied on it is distributed uniformly as shown in Fig.2. We recommend using this system with chairs and sofas made of foam. The foam acts as a very good shock absorber. The study of average maximum pressure on an office chair was measured as 31 kPA. This means 3.1 N/cm-2, which comes well within the range of sensitivity of our sensor and won't damage our sensor in any way [7],[8].

A threshold value of the analog reading of the sensor is set as per requirement. We will not be using the sensor to measure the amount of pressure or force. We will be using it to set a threshold value which if crossed will signify someone sitting on the chair which will switch on the lights and fans. The Arduino code is programmed in such a way that if the Analog value given by the FSR crosses the threshold value then a HIGH signal is sent to the relay driver circuit which will switch on the electrical components (lights and fans). The sensor has to be calibrated after placing the paddings, foams, and cushions on top. Or else, the weight of the same has to be given beforehand so that the sensor can be calibrated as per the requirement and sent. According to the threshold resistance set, if enough force is applied, the resistance will drop below the threshold and switch on the lights and fans.

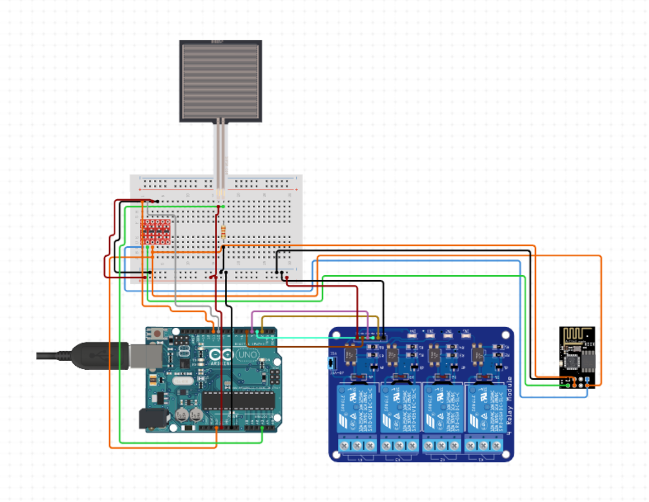

Fig.4. Circuit Diagram of the entire system using model FSR406.

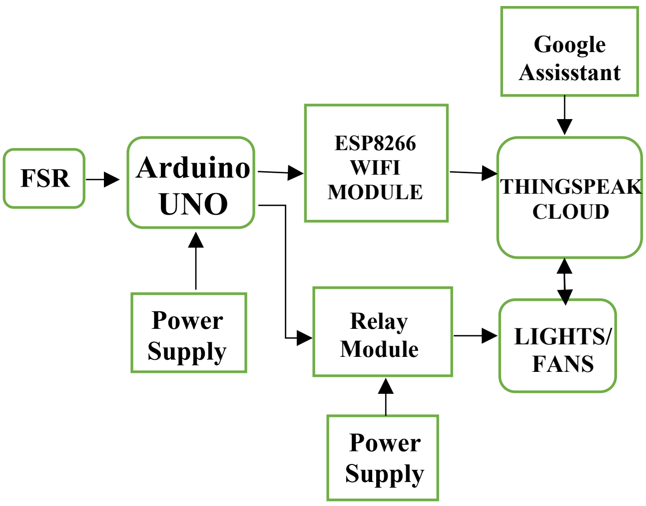

Fig. 5. Block Diagram of the entire system.

IV. Simultion Results

The circuit diagram is shown in Fig.4. It shows how the components are connected. This is a circuit that has been used for simulation. We have connected a 220V bulb with a 5V dc relay. We have also used a vibration motor with a variable resistance, which mocks an FSR, the code is used in Arduino is the same which is used for an FSR. The resistance here acts as the internal resistance of an FSR which when varied, mocks the change in force detected by an FSR. We used a 9V battery to power our relay. The simulations have been done under ideal conditions accurately in TinkerCAD online.

The FSR was connected with the Arduino UNO and that was connected with the relay which powered the bulb. According to the signal received by the sensor, the relay was controlled. The threshold value of 500 was set for the vibration motor after observing the analog reading of the motor on varying resistance. The threshold value for resistance was set to 50Ω.

The observation under different conditions are given below: The threshold value of r = 50 Ω.

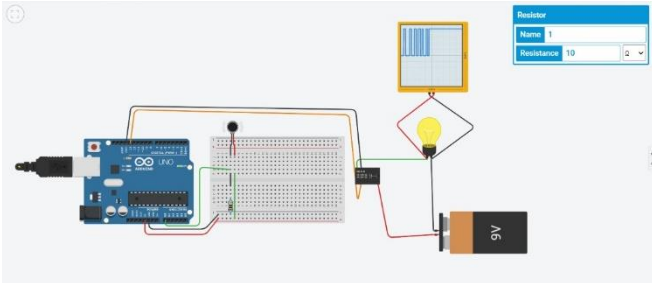

Fig.6(a)- When the value of r is toggled between the higher and lower value of threshold continuously between r=10 Ω and 100Ω

TABLE I SIMULATION RESULTS

S. NO	SIMULATION RESULTS		
	RESISTANCE	***FSR READING***	***STATUS***
1	10Ω	170	ON
2	30Ω	384	ON
3	50Ω	511	OFF
4	70Ω	597	OFF

Fig.6(b) – The table represents the simulation results

The oscilloscope in the above figure is the digital graphical output of the bulb with different values of the analog reading. In Fig.6(a)- the RESISTANCE has been varied frequently below and above the threshold value. That indicates the FORCE is varying too, which switches on and off the bulb as shown by the graph of the oscilloscope. In Fig.6(b)- the table represents the resistance, FSR's analog reading, and the status of the light bulb at different resistances. The FSR's analog reading is inversely proportionate to the pressure applied to it.

As the threshold value of the sensor was set at 500, whenever the analog reading rose above 500 the bulb switches off, and whenever it drops lower than 500 it switches on. During the simulation the observed functioning of the FSR matched with the expected values, where it was seen that when the resistance value is high the bulb is not switched on, signifying enough force is not exerted on the sensor and vice- versa. It matches the mathematical relation of inverse proportionality between the force applied and the resistance of the sensor. The simulation results showed a positive outcome of the system desired.

V. Working and Linking with the Cloud

The Arduino Uno board is connected to the ESP 8266 WiFi module which will be used to link the Arduino Uno board with the ThingSpeak cloud. The Wifi module will be connected to the router or the mobile hotspot available. It will be using the HTTP protocol to send and retrieve the data through the API keys. The cloud will have the reading of the FSR and the status of the lights and fans whether it is switched on or off. If the sensor fails to send the signal to the lights and the fans, then the user can control the status of it using voice commands from the Google Assistant.

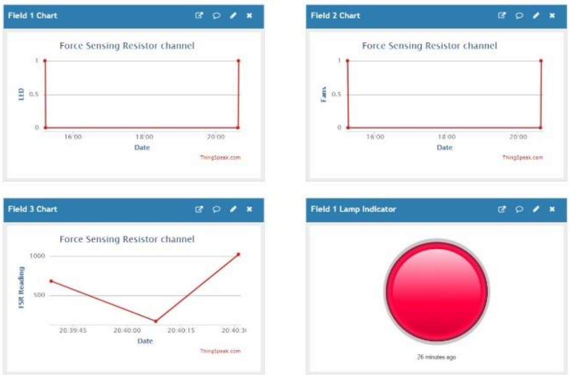

Fig. 7. ThingSpeak Cloud showing the data of the system and status of the lights.

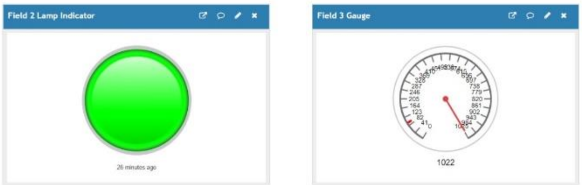

Fig. 8. ThingSpeak cloud showing the status of the fans.

We have shown only one light and one fan as a demo, the numbers of components can be increased as per requirements. Fig.7 shows the reading of the FSR and the reading of the value of the light and fans, the red light shows that the light is on. Fig. 8 shows that the fan is on and the gauge on the right shows the reading of the FSR. The entire system's connection with the cloud using ESP8266 is shown in Fig.4.

VI. Discussion

This system is designed to reduce the wastage of power and make the system more energy efficient. It is not the traditional way to detect human presence and controls electrical elements. It uses more modern, efficient, and unconventional technology. The sensor, FSR is designed and known to sense a wide range of forces. It is also very precise and accurate with its reading which makes it possible to distinguish a human over anything else. It requires very little power to operate and has a long shelf life. This system can be used to power the majority of the lights and fans which remain unnecessarily and adds to energy wastage.

The Arduino we used for our system can be substituted by microcontrollers to further improve energy efficiency. Not only 8-bit microcontrollers like the Atmega328p even 32-bit microcontrollers that run at 48MHz with similar memory are available for a lower cost. STM32 series stands as the strongest microcontroller to date. They can provide a greater advantage of controlling larger numbers of devices. However, using the microcontrollers add to the complexity of the system because it requires external hardware and additional compilers and boot loaders. PSoC (programmable system on a chip) can add further benefits and advantages over using a microcontroller. Its easy and versatile configuration is very useful for fast prototyping, we can also declare any pin as an analog or digital pin. It has the best analog support to date. In essence, it is a single chip, that does everything to take up multiple chips.

Currently, the works on load sensing seats equipped with many other technologies such as AI are mainly being used in the automobile industry [9]. Our designed system can be a new and more efficient technology to be used for such applications. Future works can include applications of class attendance monitoring system using load sensing seats similarly smart bus seat occupancy system. Both these systems will be a monitoring system associated with other technologies of how many passengers or students are present on the bus or class. This system can also be implemented in the recreation industry such as amusement parks where safety plays a major role. According to industry officials, 95% of amusement park accidents happen because visitors are often irresponsible and don't follow instructions strictly given to them or displayed at the entrance of a ride. The technology used in our system can be used with existing safety monitoring systems to build a more safe environment. We use a cloud platform to connect all the components and sensors of the system. The working lights, fans, and sensors can be monitored through viewing the lamps and graphs in the cloud window as shown in Fig.7 and Fig.8.

The public sector has the maximum amount of power wastage in public waiting rooms, stations, offices, etc. Even at home, people tend to forget to switch off the fans and lights once they leave a room adding to power and energy wastage. Studies say 29 % of the energy of total energy consumed is used only for the lighting of which approximately 20% can be saved if lights are switched off properly. A study done at Boston University showed that if one light was turned off for one hour a day, they could save 7,33,475 kWh per year, which means 1,161,000 pounds of carbon dioxide. This can also reduce greenhouse gas emissions by 0.15 pounds per hour. In India, it was seen on average 5% of electricity consumed on every month is Vampire power. Approximately the power wasted by fans was 2-6 Watts and lights were approximately 18 Watts [10]. This project mainly focuses on reducing the wastage of electricity and power. The schematic showing three different levels of the system are given below. First, the floor plan schematic shows how the seats in different rooms on an entire floor are connected by the blue lines.

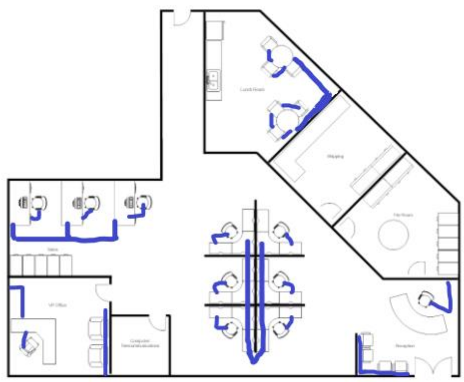

Fig 9(a): Schematic showing the connections of the desks and chairs on a floor plan.

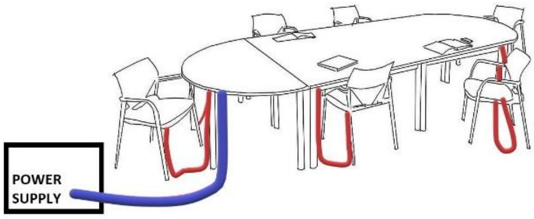

Fig 9(b): Schematic showing a meeting table. It shows how the wires would be connected between the chairs, table, and main power supply.

Fig 9(b) shows how a single meeting table can be connected with the chairs (shown in red). The final connection wire to be sent to the main power supply is shown in blue. This wire will contain multiple small wires and a wire wrapper or zipper will be used to compact them.

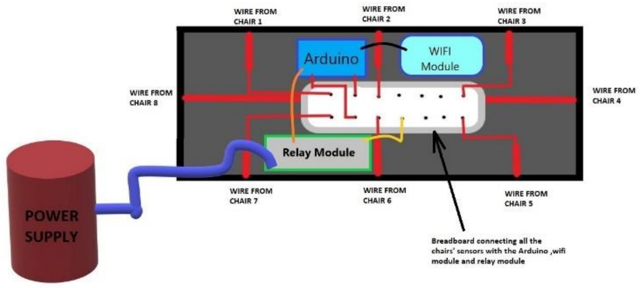

Fig.9(c).Schematic showing the wiring circuit under the table.

Finally, Fig.9(c) shows the under-table wiring of the system where 8 chairs are connected with the Arduino using a breadboard. The Arduino is connected with the wifi module to send the data to the cloud. The relay module and Arduino uses a battery of 9V to power up. The Relay module can be 4-Channel or 6 channels depending on the need. It sends 4 or 6 wires as per the number of channels used. All these wires are clubbed together and sent, to the power supply i.e. the switchboard. The final connections have to be altered in the way shown in Fig.10 to be able to control the lights and fans using the relay module.

Fig 10. Diagram showing the connection of relay to power a bulb.

VII. CONCLUSION

Here, we have proposed a new solution for load sensing seats based on a design of smart seats controlling the main electrical components of the room. Our method is different from those already existing and shows positive results as shown in the simulation section. Here we work on a physical concept based on pressure-force detected by FSR. We have developed a system that will help in the conservation of energy and contribute to a higher quality of life.

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