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Solar energy based blockchain enabled health care monitoring using IoT

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Abstract - *The Internet of Things (IoT) tends to transform our lives and make it more comfortable is an auspicious technology in which the heterogeneous devices having embedded sensors are connected to a single platform and these devices can then interact with each other. As the demand for IoT is increasing there is a need to connect enormous number of smart devices with each other. One of the major applications of IoT is smart health care. It involves numerous health sensors which collect data and transfer it to clouds. This requires huge amount of data to be transferred between devices, large connectivity, high security, and privacy. Another thing is all these sensing devices have limited lifetime. So, there is a need to provide constant power supply to all the IoT devices. Also, the demand for energy has increased exponentially and to satisfy our wants non-renewable resources are being sacrificed. These number of challenges are needed to be considered to complete our vision of global connectivity using IoT. So, to overcome all these challenges we have proposed a method in which solar energy is used to provide power supply to the sensors and for ensuring security of data blockchain can be used. In this paper we are measuring the body temperature using DHT11 sensor and heart rate using Pulse meter sensor. Then we have interfaced the NodeMCU and sensors with the IoT platform. In our case we have used the Thingspeak as our IoT platform. The data of each sensor has been uploaded on the field of our channel with every time stamp. So that user as well as doctor can see the condition of the patient. For ensuring security of data, we have proposed one block diagram which shows how blockchain can be used for storing data. Also, the power supply is given to NodeMCU through energy generated by solar panel.*

Key Words: IoT, Solar energy, Blockchain Technology

1. INTRODUCTION

Rural health is the main issue in India, especially in developing countries where there is a broad urban disparity in the provision of medical care, where there are more than half a percentage of the population in rural areas. In rural areas, the infrastructure is inadequate and inadequate. In these areas. In these areas. Furthermore, diagnostic equipment is set up and maintained costly and demanding. Most people die of preventable diseases such as diarrhea, which are curable, the typhoid and measles. The number of people without essential access is about 1.7 billion in medicines. In the rural health sector, the major problems are low wages, lack of education and restricted access to services by village people. Several other innovations to map the vital signs of the human body were created in the last decade. Vital signs are the body's most calculated functions of profound significance. The four key indicators that medical practitioners and health professionals regularly track are body temperature, pulsation, respiration, rate, Blood pressure, saturation level of blood oxygen.

With the increase in technological advancements in today's era healthcare has also seen a rapid transformation from traditional hospitals to distributed patient centric approach. This became possible due to emerging technologies like IoT, communication technologies and blockchain etc. IoT is the connection of devices to a single platform i.e., internet. IoT has made human's life easier and comfortable. IoT has in recent decades gained so much attention due to its widespread applications. Some of the applications where IoT find its use are smart healthcare, smart city, smart industry etc. Healthcare is one of the most fundamental needs of any human being. So, there is a constant focus by every country on providing the best healthcare facilities to every citizen. Due to this smart healthcare is gaining more attention because with the help of IoT treatment can be given to patient every time, anytime and anywhere. In one study it was said that 27% of the total deaths happen in India with no medical attention at the time of death. According to the Lancet Medical journal 3.6 million deaths took place all over the world due to lack of healthcare access. There are villages where people still don't have access to healthcare facilities. People must rush to cities for their treatment and going for check up to a city every 3-4 months incurs huge cost. In this technological world there are situations where people die because for getting treatment from a medical specialist, they must travel long distances. But the emerging technology like IoT have helped in overcoming this limitation. For example, if a person lives in a village and he is suffering from diabetes then he doesn't need to travel to city every time for his check-up. Sensor can be used to measure patient's sugar level and this data can be transmitted to cloud where doctor can have access to this data. And if in case any emergency arises the patient can be alerted, and preventive measures can be taken. Now the problem is the patient's data is highly sensitive and the sensors used have limited battery lifespan. So, to overcome these challenges in this paper we have proposed a method in which blockchain technology and solar energy can be used. In case of blockchain technology cryptographic function is used to ensure the security of data. Person connected to blockchain network can only access the

data. In this way security of patient's data can be ensured. Another one of the challenges is to increase the lifetime of IoT devices. Let us consider a case like if a person is travelling to some place and if the battery of IoT devices get over then the data will not be able to transmit to hospital server. And due to some reason, he/she faces any emergency then it can lead to death of patient. For this solar energy can be employed to generate power to charge the IoT devices. Solar energy is a renewable source of energy which can help in increasing the lifetime of the IoT devices or wireless sensor nodes. The solar energy production is suitable for the areas where there is a hot region, and a lot of research is being done in this area to make semiconductor technology using this idea. So, for this research project the focus is on generating power supply using solar energy and charging the IoT devices. Also, this method is feasible enough to be deployed for practical purpose. The data was transferred to cloud platform for monitoring purpose. But for the same blockchain technology can be used for avoiding any external malicious attack.

The first section in this paper gives a general idea about the importance of Internet of medical thing and then discusses about the challenges related to it. The second section briefs about the work done by researchers in this field. In the third section the research objectives of the paper are discussed. The IV section gives the basic introduction of the technologies employed in our paper. In the further section the proposed diagram and the hardware implementation is shown. The paper is then concluded in the last section.

2. Related Work

The increasing deaths due to lack of access of healthcare facilities has led researchers to focus on the challenges and coming up with the best solution. Numerous architectures have been proposed in the different research papers to ensure security of patient's data and make it more reliable.

The author in [1] have proposed a sensor node architecture in which different body parameters are measured using medical sensors. The architecture consists of transceiver, processing unit and antenna for monitoring patient's health. The data is then transferred to gateway devices and from there to doctor for monitoring purpose. In case any emergency arises then patient can be alerted. The disadvantage of this architecture is the battery charge optimization and lifetime extension of the wearable device. Security issues as data is transmitted using IP address. In [2] the author has proposed an architecture in which content centric network has been utilized. Patient must send request to doctor which when accepted help connect server of patient and doctor. It uses digital signature for data transmission. In this method if the doctor is not present in one hospital, then the request is sent to another hospital and the life of the patient can be saved. But the problem with this method is it is not suitable for denser network and for mobile healthcare. Also, there is no discussion about battery lifetime in the paper.

Another paper in which a method is proposed for providing mobile health services [3]. If a patient living in village suffers from a heart attack and he need to be taken to a city, then it will take a lot of time. In that case mobile ambulance can be used. The ambulance consists of ultrasound machine, other medical equipment's. The patient's data can be transmitted to doctor, and he can guide the medical staff accompanying the patient. In the proposed method small cells have been employed to reduce the cost of installing macro cell base stations. The limitation of this method is that every data needs to be transmitted to cloud and security of data is less.

Tshiamo Sigwele et al. in [4] have proposed an architecture in which mobile edge computing have been employed. In this method mobile phone is used as a gateway. There is no need of transmitting all the data to the clouds. The data from sensors is sent to smart phone and only the critical data is sent to clouds. The wearable devices are connected to smart phone with the help of Bluetooth. The smart phone healthcare gateways have disadvantage that they can hardly cope due to limitations in terms of battery life, storage, processing power and display size. A large amount of battery will be drained which is a major concern.

The author in [5] have proposed a method in which smart cars have been used. If a person is traveling in a car and he faces any emergency, then the smart car will automatically work to find out the nearest hospital. This method is not cost effective.

In [6] cloudlet based mobile healthcare system has been proposed. In the proposed model the patient communicates with the nearest cloudlet instead of communicating with main cloudlet. Then all the cloudlets will communicate with each other to provide requested services to the users. If the nearest cloudlet can execute the task, then it will execute it, otherwise the task is sent to another nearest cloudlet. The completed task is then sent back to mobile user. So different cloudlets can be made for different departments in hospitals. The challenges associated with this method is energy efficiency, latency, reliability, and security of patient's data. If the battery gets depleted, then monitoring will get paused and it can only resume when the battery is replaced. There are many different cloudlets which can lead to multiple security vulnerabilities.

The author in [7] have proposed cloud computing for smart healthcare. The main purpose of using cloud computing is accessing data anywhere and at any time. The data collected using sensors from patient is stored in a table called patient health record. The PHR is centralized in the cloud infrastructure. But the problem with this method again is security and privacy of data. A framework is needed to see there is no external malicious attack.

In this paper solar energy based blockchain enabled health care monitoring method has been proposed. The state-of-the-art technologies like IoT, blockchain and one of the best alternating green technologies i.e. solar energy has been used to overcome the challenges studied in the related work. Medical staff can be informed in case any emergency problem arises. Also, the proposed system is cost effective and can be implemented in real time.

3. RESEARCH OBJECTIVE

This research deals with designing a system by amalgamating various emerging and green technologies like IoT, Blockchain and solar energy. This study attempts to achieve the following objectives: -

- To provide more efficient, reliable, and best healthcare monitoring system to every person living in remote areas and saving the cost of treatment.
- To interface different medical sensors like temperature sensor, pulse meter sensor etc with micro controller and transmit the data to cloud server.
- To secure the confidential data collected by IoT devices by using Blockchain technology instead of cloud platform.
- To increase the lifetime of IoT devices by using renewable source of energy i.e., solar energy for generating power supply.
- To alert patient and doctor in case any medical emergency takes place.

4. PERIMILINARIES

In this section, we will go through a lot of basic concepts that are involved in our system design. The techniques like IoT, Solar Energy and Blockchain are the main building block of our system design. First, we will understand about these two technologies and then we will implement these technologies in our system design.

4.1 Internet of Things

The Internet of Things (IoT) is essentially a web-based object network who can gather and share information has been created from the contact between the machine(M2M), i.e., the relation of machines. A human-independent network. M2M refers to the cloud connection of a computer, Data collection and control. Devices can be digitally viewed from anywhere to be managed. The connectivity ensures that we collect more data from more sites, ensure greater productivity and improve IoT security and safety. The creation and integration of data, procedures and stuff on the Internet will make such connections more meaningful and significant and provide more opportunities for people, enterprises, and industry. The IoT platforms also help organizations which reduce costs by enhancing process effectiveness, asset use and productivity. In our system design we are basically using IoT so that we can transfer our patient data from one place to another over internet.

4.2 Solar energy

Solar energy is a type of renewable source of energy, and it is using in a various field. Its technologies are commonly recognized as passive solar energy or active solar energy depending on how they absorb, transmit, or transform solar power into solar energy. Solar technology involves the use of photo voltaic devices, solar energy, and solar water heating to harvest energy. Solar approaches include a building orientated to the Sun, materials chosen that have desirable thermal weight or light-distribution properties and air circulation space architecture. There are various types of solar cell like Poly crystalline, Mono crystalline and thin film. The choice of solar cell is completely depending on the price. We must make a trade-off between the price and efficiency. Mono crystalline cells are good in efficiency, but they are costly as well.

4.3 Blockchain Technology

Blockchain is considered as a highly secure system. The data security is the biggest concern of our system design. Cloud is less secure as compared to the Blockchain. The digital signature and encryption are the biggest advantage of blockchain technology. There is a complete regulation of fraud here. A device built into data stored in many locations is not so easy to access hackers, and if so, it can easily retrieve any piece of information. Blockchain system is completely decentralized there is no higher authority. So, we can forget about the fees because intermediaries don't have to pay.

A blockchain is a diary or tablet with transaction details. A hash is generated for each transaction which is a number and character string. In the order in which transactions took place, they are entered, and the order is highly significant. The hash not only relies on the transaction but also on the hash of the prior transaction. Even a minor transaction shift produces a whole new hash. The nodes search to ensure that a transaction is not modified through the hash inspection. If most of the nodes accept a transaction, the transaction is entered in a block. Each block is the previous block and makes the Blockchain together. A Blockchain is effective because it has a copy of the Blockchain on many computers called nodes.

5. PROPOSED SYSTEM

The proposed system is a smart healthcare monitoring system for providing best medical facilities to every person,

anytime and anywhere. In our proposed system various state of the art technologies have been combined in order to cope up with the need of increasing health related problems. There are numerous research work going on in this field and various architectures have been proposed earlier.

In this project a more efficient and effective small prototype of smart healthcare monitoring is proposed based on easy-to-use micro controller with solar energy-based power supply. This research focuses on developing optimized solution and modules hooked up with array of sensors to manage, monitor, display and alert the patient and medical staff as and when required using the advantage of cloud service to utilize the state-of-the-art sensing and renewable source of energy. The proposed system utilizes different medical sensors like pulse meter, temperature sensor, ECG etc to measure the various body parameters like sugar level, body temperature, oxygen level and update those measured values in a cloud database in real time. Hence IoT allows the monitoring of data from anywhere, anytime and every time. All the medical sensors are connected to a micro controller and the sensed data from micro controller goes to cloud platform. Micro controller is charged using power supply generated from solar energy to increase the lifetime of the IoT devices. Solar energy is an important source of renewable energy and an alternative green technology. Solar technology involves the use of photo voltaic devices, solar energy, and solar water heating to harvest energy. Solar approaches include a building orientated to the Sun, materials chosen that have desirable thermal weight or light-distribution properties and air circulation space architecture. In this way the lifetime of our sensor devices can be increased. In this research work data from sensors is transferred to cloud platform i.e., Thingspeak. But the data from clouds can be easily accessed by a non-authorized person. So, to prevent any external malicious attack and ensure security of confidential data Blockchain technology is employed. This technology uses cryptographic algorithm for ensuring security of data. In this way data can be accesses only by people who are connected to this blockchain network. If any person wants to access the data, then using smart contract it is seen whether the person is authorized to access the data. In case any emergency arises then the patient and doctor can be notified through an application or message service. The proposed research work is implemented on hardware and data is sent to cloud platform.

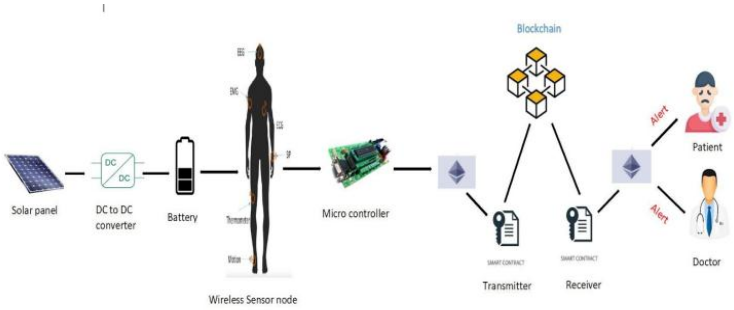

Fig -1: Proposed block diagram for healthcare monitoring system

6. HARDWARE DESCRIPTION

6.1 NodeMCU

NodeMCU is an ESP8266 based, open source IoT platform Chip Wi-Fi. The firmware uses Lua scripting language. The ESP8266 is a low-cost wireless chip produced by Espress. The design kit includes all GPIO, PWM, IIC, 1-Wire and ADC Board. There are 1 analog (A0) and 9 digital pins in the NodeMCU (i.e.D0-D8). It uses USB as a source of electricity. It has 128KB and 4MB of memory Storage. It supports protocols for serial communication, i.e., UART, SPI, I2C and so on. To use this, we can link serial protocols with LCD's allowed by standard devices such as Accelerometer, RTC chips, GPS modules, touch screens, SD cards and so on.

6.2 DHT11

DHT11 sensor is used for measuring body temperature. It is easy to use but it takes an attentive time to collect data. It is made up of three pins i.e., one for power and the last one for ground power. For digital output the temperature range of DHT11 is between 0-50° C and +-2° C. DHT11 contains a sensor for humidity, an NTC sensor for temperatures (or thermistor) and an IC at the back. The IC monitors and processes this improvement in resistance that prepares a micro controller for reading. The NTC temperature sensor is used as a thermistor for calculating temperatures.

6.3 Pulse meter

Heart rhythm can be calculated based on the difference in optical strength as light is distributed or absorbed by the beat of the heart during its journey through the blood. A light emitting diode is used as the basic heartbeat sensor and a sensor like a resistor or a photo diode light detection. The pulses of the heartbeat trigger a shift blood supply to various areas of the body. If a tissue lights up it either reflects with the light source, i.e., light emitted by the led (a finger tissue) or the light passes (earlobe). The number of the absorption of light is based on the tissue blood volume. The output of the detector is electrical signal shape and heartbeat rate proportional.

6.4 Lithium-ion battery

The best thing about lithium-ion battery is that they can charge at a very large number in their lifetime. It is also known as Li-on Battery. In this project we are using 1.2 Volt of 4 lithium batteries. We will not get the same amount of voltage from these batteries. As we are aware that our NodeMCU works in 3.3v to 5v range. So, we will get a maximum of 4.8 volt from these batteries. And it will be a safe operation for our micro controller.

6.5 TP4056 charge module

This is a type of charging module which can charge our lithium batteries at a constant voltage with the safety of the solar panels. It can hold the maximum voltage up to 12 volts. The other best thing about this module is that it can connect with the two-power supply. First, it can connect to the solar power supply. If in any emergency or due to any other circumstance, we are not able to receive solar energy then we can connect our module to electrical power supply and can charge our batteries.

6.6 Solar panels

To receive the solar energy, we require these panels so that we can charge our batteries. Solar panel converts the solar light into electrical form which can be further used for performing different functions.

7. SOFTWARE DESCRIPTION

7.1 IoT platform

ThingSpeak is an open-source IoT application and API for storing and retrieving data from things over the Internet or via a local area network using the HTTP protocol. It also provides monitoring of application locations, the creation of applications for sensor logging, and status updates. It also facilitates the MATLAB numerical computer software that allows researchers to view and analyze the uploaded data without buying the MATLAB licensed version.

7.2 Arduino IDE

It is an open-source IDE which makes it easy for the user to write the code for NodeMCU and Arduino. It supports the languages C and C++.It contains a text editor for code writing, a message area, a text console, and a series of menu.

8. OPERATION OF THE PROPOSED SYSTEM

In this section we will discuss about the working of our design. As we have seen so far renewable energy is the future of our world. So, our first priority is to design a power source which provides an output voltage that can charge our batteries. The below figure shows the hardware set up for converting solar energy into power supply.

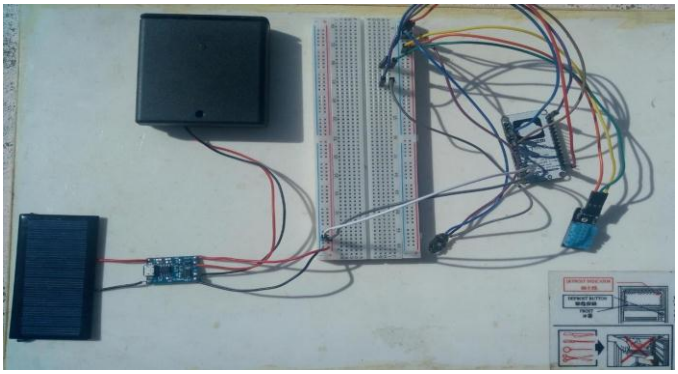

Fig - 2: Solar charging system

We cannot receive solar energy all the time. Our panel works for only 6 hours a day. For example, in the night time our panels are at low voltage and batteries are at high voltage and it's obvious that the movement of electrons from high potential to low potential will degrade our solar panels. The charge module will protect our batteries as well as it will provide a constant voltage to the batteries. This TP4056 module provides a constant current and voltage output. Now we will connect our panel to the charging module so that it will give a constant output voltage of 5 volt to the batteries. The input voltage range for this module is 4V to 8 V. We connected a 6V solar panel at the input side of the module so that at the output side we have around 5V. Now we will provide this voltage to our batteries and from there we will take the power supply for our NodeMCU. As we are aware that the output of our batteries will not exceeds from 5V so it will be a safe operation for our design.

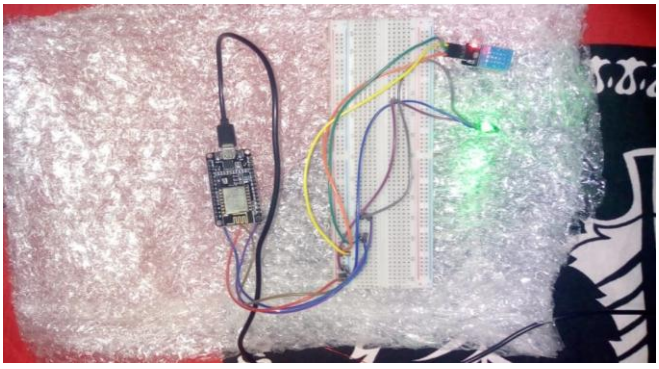

Fig- 3: Sensor interfacing with NodeMCU

The above figure shows the two sensors i.e pulse meter for measuring heart rate and temperature sensor connected with NodeMCU.

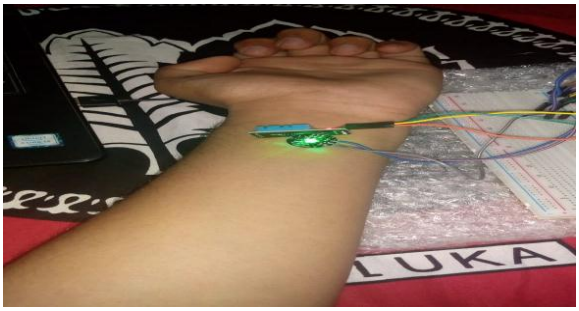

Fig- 4: Pulse meter sensor

In the figure 4 pulse meter is placed on hand to measure the values of heart rate of a person. Now the next part of our design here is that sensors will take the reading of patient and sent it to the cloud. The data will come to the Things speak platform and from here the doctors can easily monitor the data at their own place. In case of any emergency doctor and patient can be alerted through any message service or an app.

9. RESULT

The devices sense the data from the patient's body and send them to the cloud platform i.e. Thingspeak. The real time monitoring of the data can be done using this platform. The below figure shows the graphs for temperature and heart rate values. Different fields can be generated for different parameters. In these below figures readings are shown at continuous time interval. Here the temperature reading is shown in Celsius and heart rate reading is given in BPM i.e beats per minute. For any number of users this data can be calculated and uploaded on IoT platform.

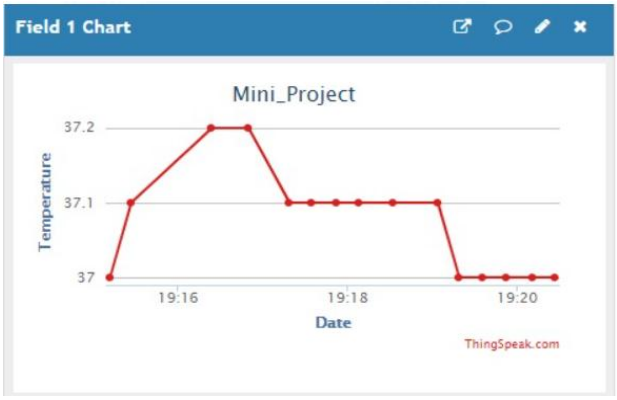

Chart -1: Graph showing body temperature

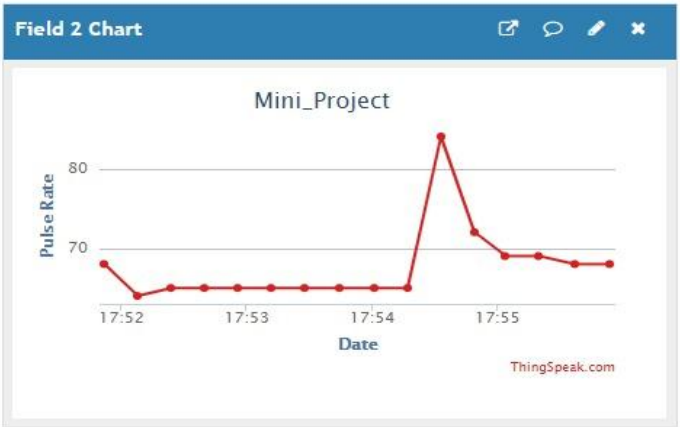

Chart -2: Graph showing heart rate values

10. FUTURE WORK

In this paper system was designed to charge IoT devices using solar energy. Further work can be done by the researchers to increase the efficiency of the battery. Research can be done on how dust can be removed from solar panel to increase the efficiency of charge electricity generation. It is also found that Blockchain technology is not 100% secure. So, work in this field can also be done for securing patient's data as it is highly confidential [8].

11. CONCLUSION

This paper presents an efficient and reliable system with solar energy technique. The various state of the art technologies is amalgamated together to provide best medical facility to every person and alert the medical staff in case of any emergency. In the first section of this paper relevance of healthcare monitoring and architectures proposed by researchers have been discussed. The main problem identified was the limited lifetime of the IoT devices and preventing our data from any external malicious attack. The second section talk about the method proposed using solar energy and blockchain technology. In the last section the hardware implementation for generating power supply from solar energy is shown. Also, how the interfacing of various sensors is done with NodeMCU and collected sensor data is transmitted to IoT platform. Power supply up to 4-5 V is received from solar charging module. Also, this paper sheds some light on the future work which can be done to make this proposed method highly efficient.

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