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Contents

Chapter - 1
Application of Machine Learning in Physics: An Overview

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Chapter - 1

Application of Machine Learning in Physics: An Overview

B. Dhanalaxmi, N. Rajeswaran and Kesava Vamshi Krishna V

Abstract

With the use of machine learning (ML), physicists and chemists may now quickly and effectively extract crucial facts from massive amounts of data generated by simulations or actual experiments. The physical sciences could advance significantly by adopting, developing, and using machine learning techniques to analyze high-dimensional complex data in ways that have never been conceivable before. Because they have largely concentrated on fitting pre-existing physical models to data and finding strong signals, machine learning applications to physical sciences have thus far largely been restricted to the "low-hanging fruits." We think that machine learning also offers a fascinating chance to understand the models themselves-specifically, the physical structures and principles that underlie the data. and that with more realistic constraints, machine learning will also be able to generate and design complex and novel physical structures and objects. Last but not least, physicists prefer models that are physically understandable rather than just those that fit their data. This can be achieved, for example, by maintaining relationships between predictions and the microscopic physical quantities used as input and by adhering to constraints that have physical significance, such as conservation laws or symmetry relations. It is possible for fields to share information both ways. Machine learning has drawn inspiration from statistical physics techniques since its inception. Many of the tools used in modern machine learning, like variation inference and maximum entropy, are improvements on methods developed by physicists. We wish to advance the cross-pollination in the specific setting of deducing physical principles from data. Physics, information theory, and statistics are all closely related in their quest to extract reliable information from noisy data.

Keywords: Physics, ai, machine learning and applications

1. Introduction

Artificial intelligence (AI) has advanced quickly over the past ten years, going from a science fiction concept to one that is already ingrained in a variety of technologies and is a part of each of our lives. The significant

success of deep learning techniques in solving issues in a variety of fields, such as computer vision, natural language processing, and speech understanding, has been a driving force behind this quick uptake. However, it is crucial for AI models to be able to not just make predictions but also be able to explain them as it enters risk-sensitive and safety-critical areas like healthcare, finance, and aerospace. This presentation will introduce the audience to this growingly significant subject of explainable AI, highlight key techniques in explainable deep learning, and go through current issues.

In theory, ML models' or algorithms' ability to learn from experience is similar to how people learn. Artificial neural networks are a class of machine learning models that take their cues from how the brain interprets data and learns from experience. This capacity for experience-based learning encouraged my colleagues and myself to explore introducing physics to ML models: Instead of training our model using mathematical equations, we show it examples of the input variables and the right answer.

For many commercial applications, including scientific challenges involving partially understood processes or situations where mechanistic models are impracticable due to the necessary computer resources, machine learning models have already achieved significant success. Due to their performance on spatiotemporal data, deep neural networks (DNN) are particularly well-suited for these applications. However, the necessity for enormous data sets, poor extrapolation accuracy, and lack of interpretability restrict the usefulness of DNN in many applications. This focus area looks at technologies that incorporate physics-based understanding to assist in the interpretation of the DNN solution and to constrain the search space to assist in reducing the need for training and validation data. Technologies that integrate physics with DNN are particularly interesting since they offer quick models for predicting complicated system behaviour when training, optimising.

1.1 Types of machine learning

Machine-learning algorithms use statistics to find patterns in massive amounts of data. And data, here, encompasses a lot of things, numbers, words, images, clicks, what have you. If it can be digitally stored, it can be fed into a machine-learning algorithm. Machine learning is a branch of artificial intelligence (AI) focused on building applications that learn from data and improve their accuracy over time without being programmed to do so. In machine learning, algorithms are 'trained' to find patterns and features in massive amounts of data in order to make decisions and predictions based on new data.

Reinforcement learning

- The machine ("the agent") predicts a scalar reward given once in a while.
- Weak feedback.

Supervised learning

- The machine predicts a category based on labeled training data.
- Medium feedback.

Unsupervised learning

- Describe/find hidden structure from "unlabeled" data.
- Cluster data in different sub-groups with similar properties.

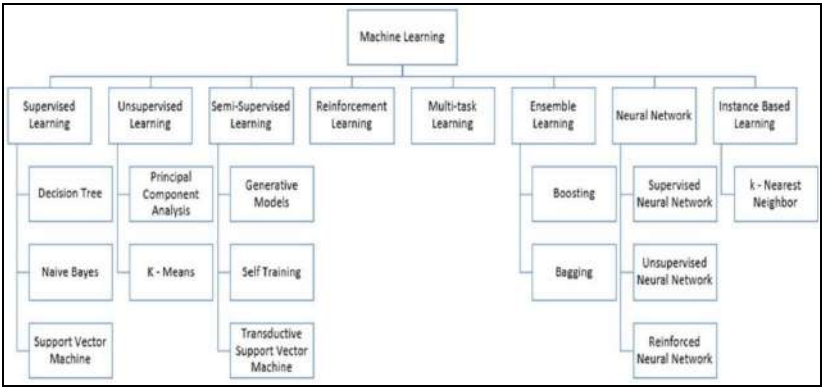

Fig 1: Types of Machine Learning

2. Hybrid analytics

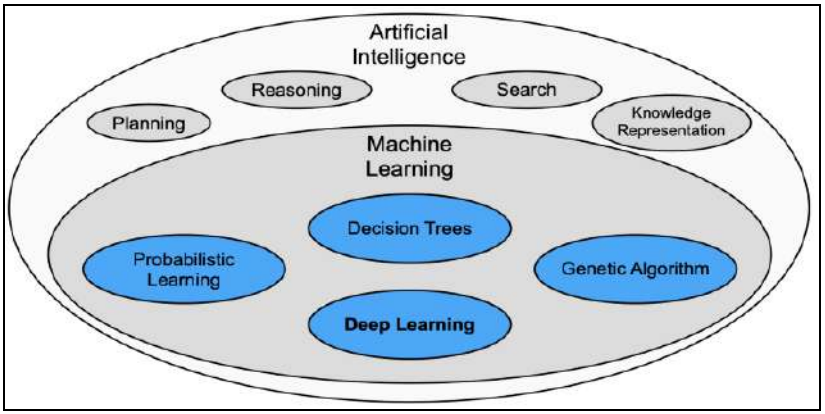

Fig 2: Artificial Intelligence with different algorithm

A machine learning technique would still be effective even if a system may, at least in theory, be explained using a physics-based model. Since ML models may gain knowledge through experience, they can also pick up physics: The ML model can learn the behavior of a physical system and produce precise predictions when given enough examples of that behavior. Many of us are familiar with this capacity to learn physics through experience rather than through mathematical equations, albeit we may not be aware of it: If you've ever played football, for instance, you've probably tried to make the ideal shot. You have to precisely forecast the ball's trajectory in order to accomplish it. A few factors that make this physics issue challenging are several variables such as the force at which you kick the ball, the angle of your foot, the weight of the ball, the air resistance, the friction of the grass, and so on and so forth.

In theory, ML models' or algorithms' ability to learn from experience is similar to how people learn. Artificial neural networks are a class of machine learning models that take their cues from how the brain interprets data and learns from experience. This capacity for experience-based learning encouraged my colleagues and myself to explore introducing physics to ML models: Instead of training our model using mathematical equations, we show it examples of the input variables and the right answer.

3. Machine learning vs physics-based models

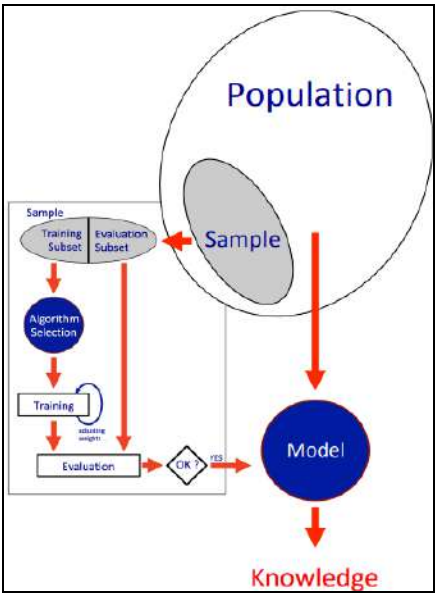

Fig 3: Machine learning Process

Step 1: Select and prepare a training data set

Training data is a data set representative of the data the machine learning model will ingest to solve the problem it's designed to solve.

- **Labeled data:** 'Tagged' to call out features and classifications
- Unlabeled data and the model will need to extract those features and assign classifications on its own.

The training data needs to be properly prepared-randomized, de-duped, and checked for imbalances or biases that could impact the training.

It should also be divided into two subsets: the training subset, which will be used to train the application, and the evaluation subset, used to test and refine it.

Step 2: Choose an algorithm labeled data

- **Regression algorithms:** Linear regression predicts the value of a dependent variable based on the value of an independent variable. Logistic regression is used when the dependent variable is binary in nature.
- **Decision trees:** Decision trees use classified data to take decisions based on a set of decision rules.
- **Instance-based algorithms:** K-Nearest Neighbor. It uses classification to estimate how likely a data point is to be a member of one group or another based on its proximity to other points.

Unlabeled data

Clustering algorithms: Identifying groups of similar records and labeling the records according to the group. This is done without prior knowledge about the groups and their characteristics.

Association algorithms: Association algorithms find patterns and relationships in data and identify frequent 'ifthen' relationships called association rules. These are similar to the rules used in data mining.

Neural networks: Them were vaguely inspired by the inner workings of the human brain. A neural network is an algorithm that defines a layered network of calculations featuring an input layer, at least one hidden layer, where calculations are performed make different conclusions about input; and an output layer. where each conclusion is assigned a probability. Algorithm is a set of statistical processing steps. The algorithm depends on the type and amount data set and on the problem to be solved.

Step 3: Training the algorithm (create the model)

Training the algorithm is an iterative process comparing the output with the results it should have produced, adjusting weights and biases within the algorithm that might yield a more accurate result, and running the variables again until the algorithm returns the correct.

Step 4: Evaluation of the model

Once the model is defined, its performance is evaluated using the Evaluation Subset. The hope and goal is that model learns a relationship that generalizes to new examples beyond the Training Subset.

Step 5: Using and improving the model

The final step is to use the model with new data and in the best case, for it to improve in accuracy and effectiveness over time.

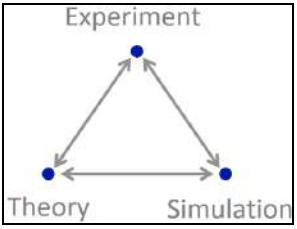

Fig 4: Pillars of Physics

4. Machine learning in physics

Machine learning based on physics has the potential to help scientists tackle issues they previously were unable to. It can assist shrink the design space and direct the selection of new tests, which can result in the design of better medications. Better fluid flow prediction, which occurs practically everywhere, from blood veins to river waters, may be one of its greatest promises. The oil and gas industry is also particularly concerned about fluid flow; physics-informed machine learning can aid in this effort by reducing the cost of simulation of fluid flows in complex geometries, which has historically been quite difficult.

The speed with which physics-based machine learning produces results-in just a fraction of a second-is one of its greatest advantages. The output of a fresh sample is particularly effective due to the neural network's flow structure. Additionally, the forecasts are remarkably precise when the training is successful. However, the technology has its limitations. It won't train well if there aren't enough samples available for training. Additionally, obtaining sufficient samples can be prohibitively expensive in many physical contexts.

To train our algorithms, we may have access to millions of images of dogs and cats, but we have less knowledge on, say, some chemicals. And even if there are many samples, it might not be enough to avert disaster. Self-driving cars make moment-to-moment decisions based on billions of samples. But that still isn't enough to eradicate all potential fatalities.

Self-driving cars require a huge amount of training data in order to be safe. They should ideally be fed with trillions of hours of real-world driving footage. But this is trickier than you may imagine. In addition to being expensive, some events-such as those related to collisions or the detection of roadside debris-are also extremely infrequent.

This means that before taking to the road, a self-driving car might not have gone through every possible driving scenario. The automotive industry is well aware of this shortcoming and has made efforts to address it. However, expectations from a few years ago that self-driving cars would be commonplace on our roads by 2020 did not come to pass. Because physics-informed machine learning is trained on samples, it doesn't extrapolate well on samples that are not somehow familiar to it. The reason why? Neural networks are very good interpolators, but not good extrapolators.

Imagine using a set of samples obtained under comparable circumstances to train a neural network. Given that they are excellent function approximators and have the ability to effectively represent high-dimensional functions, neural networks are likely to make excellent predictions in this situation. However, the outcomes may be unpredictable or incorrect if data from samples obtained under different circumstances is fed into the same network. For instance, scientists are unable to teach a neural network to distinguish between cats and dogs using only one image. To produce reliable predictions, these systems require millions of photos. This could provide a challenge for many kinds of machine learning, including that used to develop pharmaceuticals.

5. Strength and Limitations

Physics-informed machine learning may significantly advance customized treatment in addition to the creation of new materials and chemicals. Imagine having a technology that could create a medication-or a medication therapy-based on a patient's medical requirements, family history and other factors.

An individual's genetic profile is used to inform decisions about illness prevention, diagnosis, and treatment in the developing field of personalised medicine. Scientists are aware that genetics play a significant role in the

variation in drug responses, and those other factors such as age, diet, health, exposure to the environment, and other therapies might affect how well pharmaceuticals work.

By taking into consideration elements that a single doctor—or even a team of doctors-might not find, physics-informed machine learning could be of use. Neural networks that have been properly trained can detect issues that humans cannot.

By taking into consideration correlations among variables that are too complicated for a human to recognise, such networks are able to accomplish that. By incorporating counterfactual reasoning into neural network training, this trait can be strengthened even more. It holds promise for helping to create better experiments. Machines might be instructed by scientists to do a particular kind of study in order to arrive at a particular result. The experiments created by the machines are frequently superior to anything a human could have thought of.

6. Conclusion

Why use an ML-based method when a physics-based model that can describe the system in question already exists is a crucial question. The computational expense of the model is one of the crucial elements. With the aid of a physics-based model, we might be able to thoroughly characterize the system. However, it could be difficult and time-consuming to solve this model. Therefore, if we strive for a model that can provide real-time predictions based on current data, a physics-based method may fail. In this situation, a less complex ML-based model might be a choice. An ML model's computational complexity is primarily evident during the training process. Once the model has completed its training, making predictions based on fresh data is simple. This is where the hybrid approach of combining machine learning and physics-based modeling becomes highly interesting.

7. References

1. Cory DG, Wiebe Nathan, Ferrie Christopher, Granade Christopher E. Robust Online Hamiltonian Learning. New Journal of Physics. 2012;14(10):07-06, 103-013.
2. Wiebe Nathan, Granade Christopher, Ferrie Christopher, Cory DG. Hamiltonian Learning and Certification Using Quantum Resources. Physical Review Letters, 2014, 112.

3. Raissi M, Perdikaris P, Karniadakis GE. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. Journal of Computational Physics. 2019;378:02-01, 686-707.
4. Knott, Paul. A search algorithm for quantum state engineering and metrology. New Journal of Physics. 2016;18(7):03-22, 073-033.
5. Eiben AE, Smith JE. Introduction to Evolutionary Computing (Berlin: Springer), 2003, 53.
6. Chen Boyuan, Huang Kuang, Raghupathi Sunand, Chandratreya Ishaan, Du Qiang, Lipson Hod. Automated discovery of fundamental variables hidden in experimental data. Nature Computational Science. 2022 July;2(7):433-442.
7. Zahedinejad Ehsan, Ghosh Joydip, Sanders Barry C. Designing High-Fidelity Single-Shot Three-Qubit Gates: A Machine Learning Approach. Physical Review Applied. 2016;6(5):11-16, 054-005.

Chapter - 2
Image and Text Dissemination using Li-Fi Technology

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Chapter - 2

Image and Text Dissemination using Li-Fi Technology

Dr. S. Mary Praveena, R. Ramakrishnan and R. Kanmani

Abstract

Wi-Fi is innovation utilizes radio waves to move the information between gadgets in light of the principles of IEEE 802.11 and this is the most ordinarily involved procedure for associating the electronic devices. Through this Wi-Fi one can associate with the web with remote passages openly puts like air terminals, railroad stations, libraries and other entertainment shopping centers and so forth Wi-Fi is having its own impediment on move speed and limit, starting at 2019, at nearby reach, a few sorts of Wi-Fi, running on suitable equipment, can accomplish velocities of 9.6 Gbit/s. This can be frustrated by the creating innovation called Li-Fi to move information like text, picture and voice. Li-Fi has no restrictions on its exchange limit and accomplished an accelerate to 224Gbit/s in its creating stage. In this chapter, Li-Fi is utilized to move information like text and pictures utilizing Arduino sheets to decrease the expense of the innovation. This proposed strategy is multiple times quicker than the current Wi-Fi procedure in moving information. The result of the this proposed paper is reasonable in electromagnetic delicate zones like airplane lodges, clinics and thermal energy stations without causing electromagnetic impedance utilizing Li-Fi information transmission.

Keywords: Wi-Fi, Li-Fi, VLC-image transmission

1. Introduction

Li-Fi or "light fidelity", alludes to remote correspondence frameworks utilizing light from light-discharging diodes as a medium rather than conventional radio frequencies, as in innovation utilizing the brand name Wi-Fi. Li-Fi is relied upon to be multiple times less expensive than Wi-Fi. Li-Fi enjoys the benefit of having the option to be utilized in electromagnetic delicate regions, for example, in airplane and thermal energy stations without causing interference.

Li-Fi has practically no restrictions on limit. The apparent light range is multiple times bigger than the whole radiofrequency range. Specialists have

arrived at information paces of 3.5 Gbps and have put forth an objective of arriving at 6 Gbps. The Li-Fi market is projected to be worth more than $6 billion every year by 2018. Low unwavering quality and high establishment costs are the likely disadvantages. The term Li-Fi was authored by Harald Haas from the College of Edinburgh in the UK. The D-Light task at Edinburgh's was subsidized from January 2010 to January 2012. Haas advanced this innovation in his 2011 TED Worldwide talk and aided start an organization to showcase it. Unadulterated VLC is a unique gear producer (OEM) firm set up to market Li-Fi items for mix with existing Drove lighting frameworks.

Li-Fi or "light fidelity", refers to wireless communication systems using light from light-emitting diodes as a medium instead of traditional radio frequencies, as in technology using the trademark Wi-Fi. Li-Fi is expected to be ten times cheaper than Wi-Fi. Li-Fi has the advantage of being able to be used in electromagnetic sensitive areas such as in aircraft and nuclear power plants without causing interference. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. While the US Federal Communications Commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitations on capacity. The visible light spectrum is 10,000 times larger than the entire radiofrequency spectrum. Researchers have reached data rates of 3.5 Gbps and have set a goal of reaching 6 Gbps. The Li-Fi market is projected to be worth over $6 billion per year by 2018. Low reliability and high installation costs are the potential drawbacks. The general term visible light communication (VLC), includes any use of the visible light portion of the electromagnetic spectrum to transmit information. The term Li-Fi was coined by Harald Haas from the University of Edinburgh in the UK. The D-Light project at Edinburgh's Institute for Digital Communications was funded from January 2010 to January 2012. Haas promoted this technology in his 2011 TED Global talk and helped start a company to market it. Pure VLC is an original equipment manufacturer (OEM) firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems.

In October 2011, companies and industry groups formed the Li-Fi Consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio-based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. A number of companies offer unidirectional VLC products.

VLC technology was exhibited in 2012 using Li-Fi. By August 2013, data rates of over 1.6 Gbps were demonstrated over a single color LED. In

September 2013, a press release said that Li-Fi, or VLC systems in general, do not require line-of-sight conditions. In October 2013, it was reported Chinese manufacturers were working on Li-Fi development kits.

2. Proposed algorithm

Rather than utilizing shading changing over synthetic, the utilization of RGB Drove as white light source can help the date rate up to 3Gbps. For a solitary miniature Drove, the transmission speed is 8 Gbps. We are utilizing Li-Fi to move two separate sorts of information: sound and text.

It is more affordable than different choices. In contrast with the current model, the information move speed is quick. Likewise, quick than Wi-Fi and it is un-hack able, which is given beneath shows the Square Chart of Transmitter Section. These light power vacillations were caught by the sunlight-based charger, which goes about as a photograph identifier, catching all Driven variances and communicating the sign to a preamplified speaker. Message to discourse programming is used similarly as a simple sign is conveyed through a cell phone. Text is given through programming, and the product converts and peruses resoundingly the given text. The sound signs created while perusing the message were sent through the previously mentioned variances in the Drove exhibit and the sound signs were then heard utilizing a pre-intensified speaker.

3. Working of transmitter board

The transmitter area includes a console associated with a PS2 connector and interacted straightforwardly with microcontroller IC AT89S52. IC AT89S52 additionally alluded as 8051, is a 40 pin IC, used to give sequential information correspondence. A precious stone oscillator with a recurrence of 11.0592 Mhz is utilized to give the ideal clock recurrence to the microcontroller for its working. Two paper capacitors of 27 pf are utilized to balance out the clock recurrence. A 9v dc voltage is furnished to the transmitter area with the assistance of a battery, which is venture down to 5v utilizing voltage controller IC 7805.

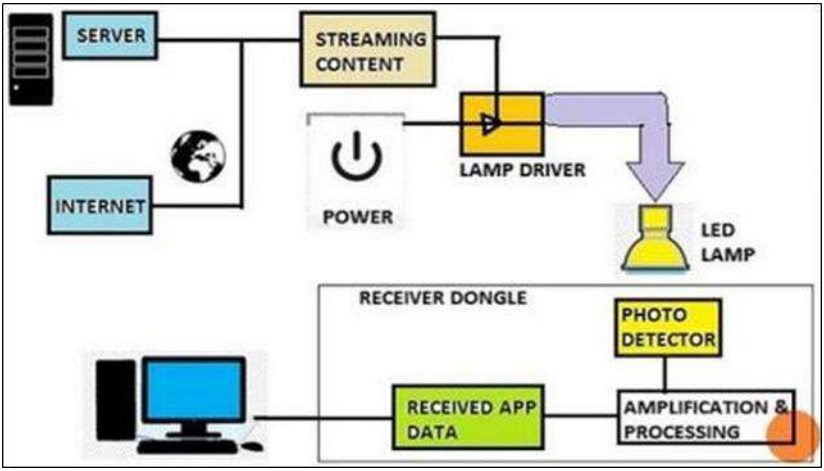

Fig 1: Architechture of LI-FI

A capacitor of 10uf and a resistor of 10k ohms are associated with the microcontroller to give the reset work. Two semiconductors, one NPN (IC TIP L6 122) and the other PNP (IC BC5578) are together utilized as a Darlington pair and are utilized to give push pull enhancement.

The result of this semiconductor pair is associated with a drove light. A green drove is utilized which sparkles on the off chance that the covers lock key is on. The console can be utilized to send alphanumeric information. The spacebar, delete, erase and enter orders can likewise be utilized. In the event that the covers lock key is on, letter sets in the capitalized and unique characters (!,@,#,$,%,^,&,*,(,)) can likewise be sent. Whenever a key is pushed on the console, the ASCII code of that key is sent straightforwardly to the microcontroller.

The microcontroller changes over the ASCII code into double and sends this information to the semiconductor pair.

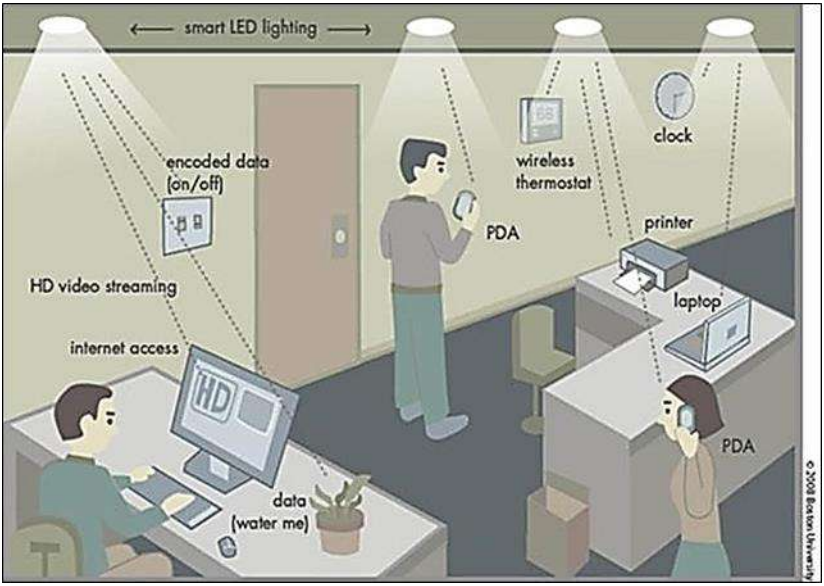

Fig 2: LI-FI Concept

The PNP semiconductor works at off state for example it peruses zero in the double code, while the NPN semiconductor works at on state for example it read one in the parallel code. This semiconductor pair then, at that point, sends the parallel heartbeat containing zeros and ones to the drove light. The drove light is on when it peruses a one and is off when it peruses a zero.

4. Working of receiver board

The beneficiary area includes a photodiode associated with the PNP semiconductor (IC BC 5578). A 9v battery is appended to the circuit to give the power supply. A voltage controller IC 7805 is utilized to venture down the 9v dc supply to 5v dc supply for the working of the microcontroller AT89S52. The microcontroller is associated with a precious stone oscillator of 11.0592 MHz to give the clock recurrence, alongside two paper capacitors of 27pf to settle this recurrence. A 10 uf capacitor is additionally associated with the microcontroller to give the reset work. A button switch is utilized to give the manual reset work. The microcontroller is communicated with the 16x2 LCD to show the information that is sent by the transmitter. The light from the drove light is made to fall on the photodiode.

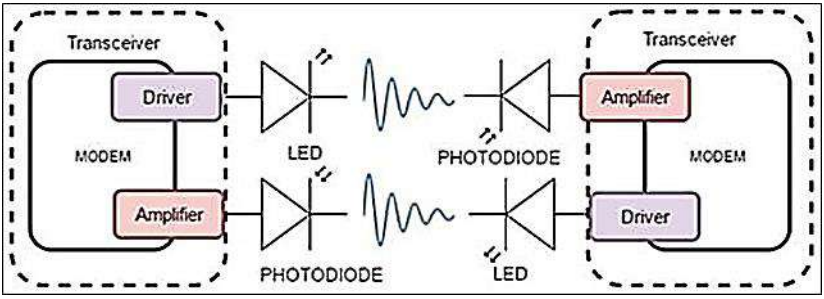

Fig 3: Transceiver Li-Fi based on VLC

The photodiode identifies the flickering of the drove, and sends this train of ones and zeros to the semiconductor. The PNP semiconductor is in on state when a zero is recognized by it and is in off state when a one is identified. This on and off condition of semiconductor is perused by the microcontroller and it changes over this paired code so exceptionally framed because of on and off, into an ASCII code. The microcontroller then sends this ASCII code to the 16x2 LCD for show, which is straightforwardly communicated with microcontroller.

As more and more people and their many devices access wireless internet, clogged airwaves are going to make it increasingly difficult to latch onto a reliable signal. But radio waves are just one part of the spectrum that can carry our data. What if we could use other waves to surf the internet? One German physicist, DR. Harald Haas, has come up with a solution he calls "Data Through Illumination" -taking the fiber out of fiber optics by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. It's the same idea behind infrared remote controls, but far more powerful. Haas says his invention, which he calls D-Light, can produce data rates faster than 10 megabits per second, which is speedier than your average broadband connection. He envisions a future where data for laptops, smart phones and tablets is transmitted through the light in a room. And security would be a snap-if you can't see the light, you can't access the data.

Li-Fi is now part of the Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. Li-Fi is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. Unseen by the human eye, this variation is used to carry high-speed data.

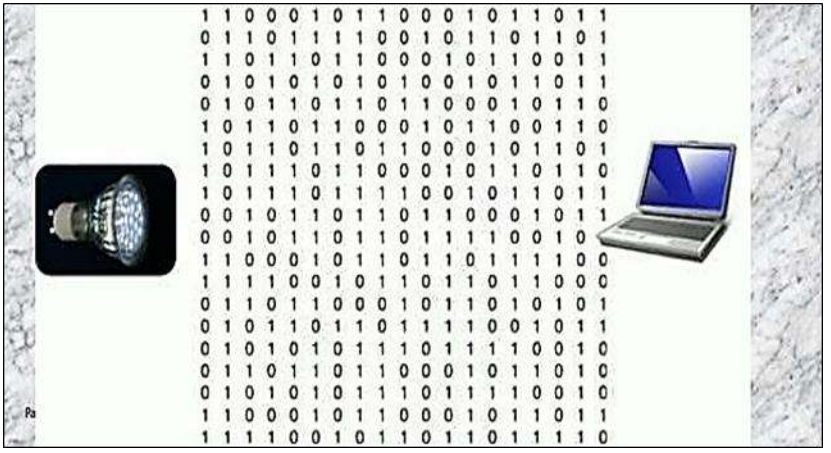

Fig 4: Data Streaming

Motivation

The capacity of radio waves are expensive less bandwidth insufficient spectrum, availability of these radio waves are limited. These radio waves are not available in aircrafts or in hospitals. They are congested due to the high usage of 2G, 3G, and 4G. The base stations used are only 5% efficient 0.95% of the efficiency is used in cooling the base stations. The security is also suffered. The Wi-Fi is penetrable through the wall. Security is the big issue here. One can hack the password. An unauthorized person can access the private matters. It is less economic. Availability of radio waves is less hence tariff rates are high. Due to this it is highly expensive. Moreover, radio waves cannot pass under sea.

These drawbacks gave rise to find a new invention and a new method of communication that is visible light communication. This technology is yet to come in the market that is based on data communication through light. We tried to incorporate the communication through light in dtmf and microphone. We got this idea from the daily life gadget that is our own phone which gives us the inspiration to use a keypad similar to a phone which will help us in transferring numeric data through light. Not only this but also a microphone that is also an essential part of a phone, has been a part of our project too. Picking up these daily usable things and using it to transfer data has been our inspiration. We have tried to make it flexible, a potable, and a self-sustaining project. This project cannot not only work on a white led light but any led light which can be connected to it. Hence making it a more environmental friendly project which can be worked under any light.

Photodiode

A photodiode is a type of photo detector capable of converting light into either current or voltage, depending upon the mode of operation. The common, traditional solar cell used to generate electric solar power is a large area photodiode. Photodiodes are similar to regular semiconductor diodes except that they may be either exposed (to detect vacuum UV or X-rays) or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device. Many diodes designed for use specifically as a photodiode use a PIN junction rather than a p-n junction, to increase the speed of response. A photodiode is designed to operate in reverse bias.

If a conventional silicon diode is connected in the reverse-biased circuit, negligible current will flow through the diode and zero voltage will develop across R1. If the diode casing is now carefully removed so that the diode's semiconductor junction is revealed and the junction is them exposed to visible light in the same circuit, the diode current will rise, possibly to as

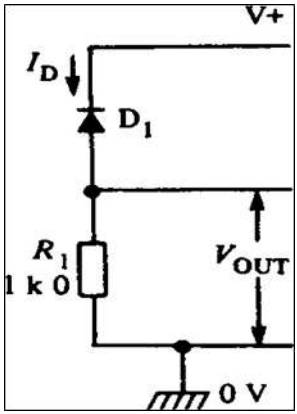

Fig 5: Reverse-biased diode circuit

Palani Raj *et al*. [5] presented the Text, Voice and Image Transmission using Visible Light and proposed the growth of the Li-Fi system using off the shelf electronic components. They utilized an embedded system with dual-core Advanced Virtual RISC (AVR) microcontroller (ATmega16L) interfaced to input/output circuits comprising of the Light Emitting Diode (LED), LM358N Operational Amplifier and a photodiode. Also, developed a user (Receiver PC) interface using Embedded C programming and the sample data (text, voice and image) transferred was monitored and the speed, efficiency, security and capacity of the system was examined and discovered to be top notch. Reported that this data transmission system is different from those in

existence because expensive components were not in the design, invariably reducing the overall cost of the implementation.

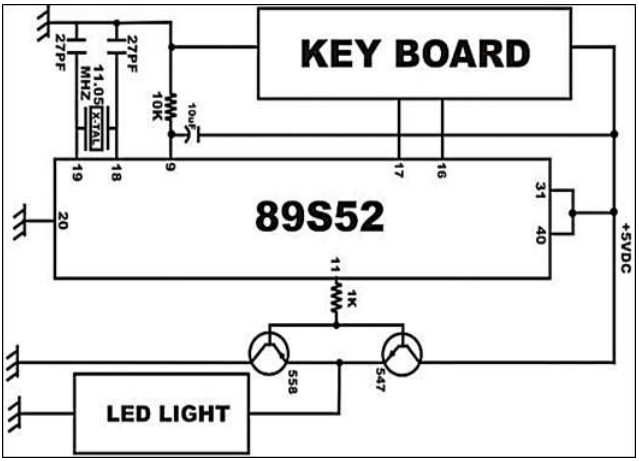

Fig 6: Transmitter Circuit

The Transmission and Reception of Images via Visible Light Communication by light or VLC (Visible Light Communication), and the author used a computing device and some hardware, for the transmission of information. In the receiver side, the information conceded by the modulated light was demodulated through a photodetector, which is usually connected to a similar computing device for the final recovering of the information.

In this article it was described that an application based on VLC using OOK (On-Off Keying) modulation, to transmit color images from a Rasp Berry Pi computer and several modules (LEDs and a sensor light) from Little Bits.

Fig 7: Practical Implementation

5. Conclusion and Future enhancement

The undertaking manages planning a straightforward and minimal expense information correspondence framework utilizing Drove, DTMF transmitter and collector, LCD, AT89S52 microcontroller unit that sends numeric information and furthermore helps in sound correspondence. The undertaking module is planned at the starter stage that peruses numeric information and unique characters *, # and makes sound correspondence conceivable however it tends to be upgraded further to peruse alphanumeric information as well as to empower video correspondence utilizing camera or some computerized device. The prospects are various and can be investigated further. Assuming this innovation can be placed into functional use, each bulb can be utilized something like a Wi-Fi area of interest to communicate remote information and we will continue towards the cleaner, greener, more secure and more promising time to come.

Results

The idea of Li-Fi is right now drawing in a lot of interest, not least since it might offer a real and extremely proficient choice to radio-based remote. As a developing number of individuals and their numerous gadgets access remote web, the wireless transmissions are turning out to be progressively stopped up, making it increasingly harder to get a dependable, rapid transmission. This might settle issues like the lack of radio-recurrence transfer speed and furthermore permit web where customary radio based remote isn't permitted like airplane or clinics. One of the deficiencies anyway is that it just works in direct view.

The visible light spectrum is 10,000 times larger than the entire radiofrequency spectrum. Researchers have reached data rates of 3.5 Gbps and have set a goal of reaching 6 Gbps. The Li-Fi market is projected to be worth over $6 billion per year by 2018. Low reliability and high installation costs are the potential drawbacks.

References

1. Roden S, Nucciarelli A, Li F, Grahamd G. Big Data and the Transformation of Operations Models: A Framework and A New Research Agenda. Production Planning and Control. 2017;28(11-12):929-944. Doi: 10.1080/09537287.2017.1336792.
2. Anoop Kiran A, Seshachalam D. Data Transmission using Visible Light Communication, International Journal of Engineering and Advanced Technology (IJEAT), 2020 Feb, 9(3). ISSN: 2249 – 8958.

3. Harald Haas. LiFi is a paradigm-shifting 5G technology, Reviews in Physics. 2018;3:26-31.

4. Anurag Sarkar, Shalabh Agarwal, Asoke Nath. Li-Fi Technology: Data Transmission through Visible Light, International Journal of Advance Research in Computer Science and Management Studies, 2015 June, 3(6).

5. Palani Raj, Freshton Jebastin P, Naveen Kumar M, Rusheyandhaar KK. Text, Voice and Image Transmission using Visible Light Communication, International Research Journal of Engineering and Technology (IRJET), 2020 Sep, 07(09).

6. Kuppusamy P, Muthuraj S, Gopinath S. Survey and Challenges of Li-Fi with Comparison of Wi-Fi, IEEE International Conference on Wireless Communications, Signal Processing and Networking, Chennai. 2016;2325:03.

7. Pradip Kumar Sharma, Shailendra Rathore, Jong Hyuk Park, Blockchain based distributed architecture with Li-Fi communication for a scalable smart city network, IEEE consumer Electronics magazine, 2018, 55-64. Doi: 10.1109/MCE.2018.2816745.

8. Lamya J Albraheem, Lamia H Alhudaithy, Afnan A Aljaser, Muneerah R Aldhafian, Ghada M Bahliwah, Lamya I Albraheem. Toward Designing a Li-Fi-Based Hierarchical IoT Architecture, IEEE Access, 2018, 6. Doi: 10.1109/ACCESS.2018.2857627.

9. Transmission and Reception of Images via Research in Computing Science, Liang Yin, Mohame Transforming Fibre into Wireless, 2017-2018, 147(12).

10. Wu F, Lin C, Wei C, Chen C. 1.1-Gb/s White-LED-based visible light communication employing carrier-less amplitude and phase modulation IEEE Photonics Technol. Lett. 2012;24(19):1730-2.

Chapter - 3
Glucose Level Checker using Breath Analyzer Method

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Chapter - 3

Glucose Level Checker using Breath Analyzer Method

V. Srividhya, Abinaya, Jenifer, Sonali Kumari, Rathna Sagar and K. Sujatha

Abstract

The main aim is to develop a prototype of Glucose level checker using breath analyzer method to detect the diabetes. There has been a constant demand for the development of non-invasive, sensitive glucose sensor system that offers fast and real-time electronic readout of blood glucose levels. In this project, we have proposed a new system for detecting blood glucose levels by estimating the concentration of acetone in the exhaled breath. A MQ138 (Formaldehyde Aldehydes gas detection) sensor has been used to detect the concentration of acetone in the exhaled air. Acetone in exhaled breath showed a correlation with the blood glucose levels.

Keywords: Glucose level, tinker cad, arduino

1. Introduction

1.1 General description

Non-invasive diagnosis technique is becoming more prominent in diagnosing diseases due to their pain free and simple monitoring methods. Non-invasive detection of blood haemoglobin was already reported. Diabetes can also be detected using non-invasive methods. Diabetes mellitus is a major health problem worldwide. This health condition arises from many complex metabolic disorders leading to high glucose levels in a person. High glucose levels can lead to many health disorders such as kidney failure, blindness, heart diseases and even premature death. Frequent testing and accurate determination of glucose levels is essential for diagnosis, effective management and treatment of diabetes mellitus. Therefore, there have been constant efforts to develop efficient and sensitive techniques for the determination of blood glucose levels. A number of vasive enzymatic and non-enzymatic methods and systems have been reported for the detection of glucose.

Conventionally, glucose level is determined from a small volume of blood sample collected by finger pricking. Though the test may not pose any

risk to a healthy adult who goes for the diabetes check-up in every 2 to 3 months, but it is very painful to the diabetic patients because every time they have to prick the finger. The current invasive method is based on the enzymatic catalysis principle where a thin needle is used to prick the finger of the patient to minimize the discomfort. To avoid such painful diagnosis, extensive research has been devoted towards developing non-invasive techniques that measure blood glucose levels without taking the blood sample.

In this project, it is reported about a non-invasive system for the determination of blood glucose levels from the detection of the breath acetone. Acetone is one of the volatile organic compounds (VOCs) present in the exhaled breath. The acetone present in the exhaled breath is a metabolic product of the body fat-buming. The breakdown of excess acetyl-CoA from fatty acid metabolism in diabetic patients leads to increase in the levels and exhaled or is excreted acetone reaches lungs breath acetone levels could be a measure of the blood glucose levels of a person. The breath acetone concentration ranging from 1.7 ppm to 3.7 ppm can be detected in diabetic patients, whereas it varies between 0.3 and 0.9 ppm for healthy humans. Over 1000 VOC's have been detected to date in the ppmy (parts per million by volume) to pptv (parts per trillion by volume) concentrations.

2. Literature review

Hippocrates of Cos in the 5th century B.C. used the smell of a patient's breath as a diagnostic medium, coining terms such as fetor hepaticus that survives to this date in the medical nomenclature (describing a condition involving liver failure). It took many centuries and the renowned chemist Linus Pauling in the 1970's to advocate orthomolecular medicine (i.e., relation of contents of human fluids to a healthy state of the body and mind) and to study the content of exhaled human breath in a first attempt to correlate physiological and metabolic processes to the compounds released from one's mouth.

The plethora of gaseous components and condensates found in breath are still being characterized nowadays by many workers in science and medicine. Only a few of the gas constituents are already known to be signalling metabolites or disease biomarkers. Among them nitric oxide, carbon dioxide, ammonia and isoprene can be used to monitor conditions from asthma to oxidative stress, from renal failure to blood cholesterol levels, in a non-invasive way.

Selective solid-state gas sensing nanoprobes have been prepared and used by our group to detect NO, ammonia, CO_2, etc. at levels in the low ppb range; Breath analyzer prototypes utilizing them have been demonstrated. Our group recently synthesized a novel nanocrystalline polymorph of tungsten trioxide with unique ferroelectric character, by means of scalable rapid solidification. This nanophase is stabilized for use at elevated temperatures and it was employed to detect a polar gas, acetone (a biomarker for type 1 diabetes) with extreme specificity in simulated breath samples. Acetone detection using chemoresistive sensors was reported before.

For example, Ryabtsev *et al.'s* Fe203, SnO_2 Cdo sensors showed sensitivities less than 5.2 to 10 ppm acetone but no testing for selectivity was reported. The sensitivity of Li *et al.'s* WO3 hollow-sphere gas sensors was only 3.53 to 50 ppm acetone. Zhu's *et al.'s* TiO_2-doped ZnO thick film had cross sensitivity to many other VOCs. Teleki *et al.'s* TiO_2 nanoparticles showed cross sensitivity to isoprene. Khadayate *et al.'s* WO3 thick film showed a 45 value of gas sensitivity to 50 ppm acetone (the only gas tested). Similarly, metal oxide sensors reported in other works either lacked satisfying sensitivity to low concentrations of acetone or showed cross sensitivity to other gases: Compared to the literature, the WO3-based nanosensor that our group has developed offers the advantage of both high sensitivity and good selectivity, which is a breakthrough in acetone detection.

3. Aim and Scope

To identify diabetes, a prototype glucose level checker is designed using a breathalyser. The creation of non-invasive, sensitive glucose sensor systems that provide quick, real-time electronic readings of blood glucose levels has been in high demand. In this study, presented a new method for measuring blood glucose levels by determining the amount of acetone exhaled. Acetone content in exhaled air has been measured using a MQ138 (Formaldehyde Aldehydes gas detection) sensor. There was a correlation between the blood glucose levels and acetone in exhaled breath.

4. Materials and Methods

4.1 Block diagram and circuit diagram

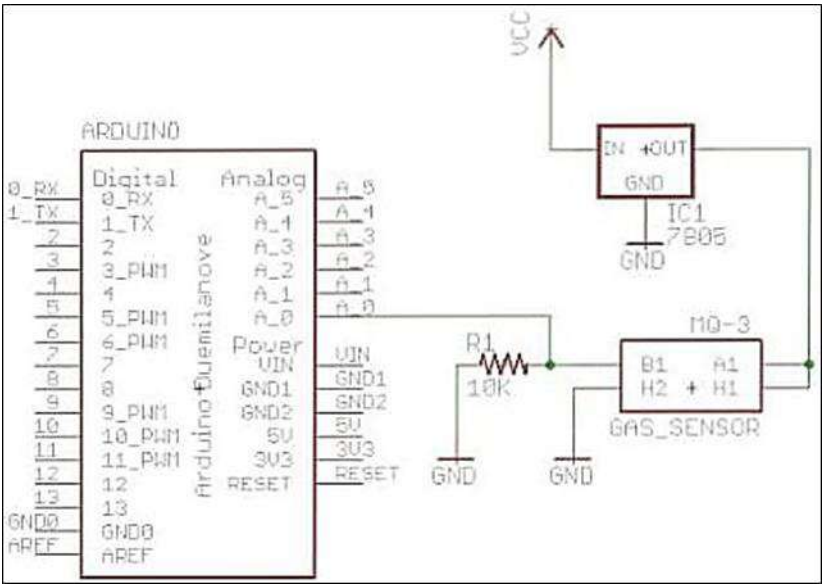

Fig 1: Circuit Diagram

4.2 Power supply unit

A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

The transformer steps up or steps down the input line voltage and isolates the power supply from the power line. The Rectifier section converts the alternating current input signal to a pulsating direct current. However, as you proceed in this chapter you will learn that pulsating de is not desirable. For this reason a filter section is used to convert pulsating de to a purer, more desirable form of de voltage.

The final section, the regulator, does just what the name implies. It maintains the output of the power supply at a constant level in spite of large changes in load current or input line voltages. Now that you know what each section does, let's trace an ac signal through the power supply. At this point you need to see how this signal is altered within each section of the power supply. Later on in the chapter you will see how these changes take place. An input signal of 115 volts ac is applied to the primary of the transformer.

4.3 Simple 5v power supply for digital circuits

- **Brief description of operation:** Gives out well regulated +5V output, output current capability of 100 mA.
- **Circuit protection:** Built-in overheating protection shuts down output when regulator IC gets too hot.
- **Circuit complexity:** Very simple and easy to build.
- **Circuit performance:** Very stable +5V output voltage, reliable operation.
- **Availability of components:** Easy to get, uses only very common basic components.
- **Design testing:** Based on datasheet example circuit, I have used this circuit successfully as part of many electronics projects.
- **Applications:** Part of electronics devices, small laboratory power supply.
- **Power supply voltage:** Unregulated DC 8-18V power supply.
- **Power supply current:** Needed output current + 5 mA.

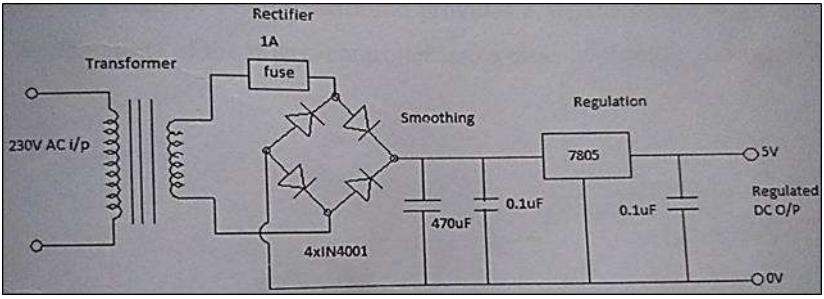

Fig 2: Power Supply Circuit Diagram

4.4 Processing unit

Arduino

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of

hardware (called a programmer) in order to load new code onto the board - you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

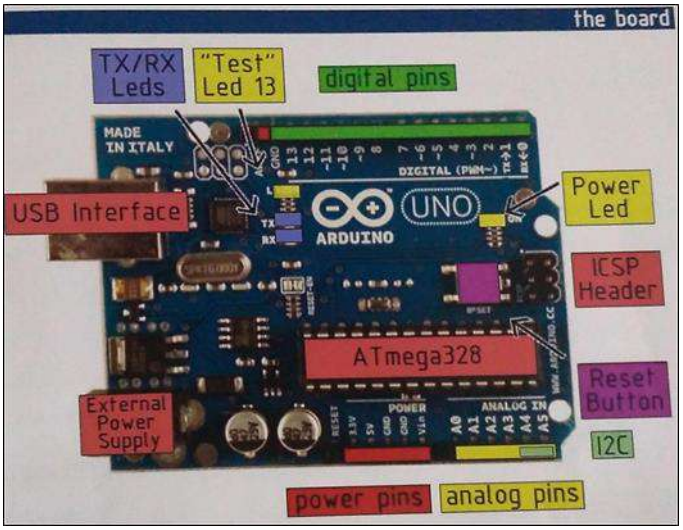

Fig 3: Overview of arduino

4.6 Development support

Programming

Arduino is common term for a software company, project, and user community that designs and manufactures computer open-source hardware, open source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

The Uno can be programmed with the Arduino Software (IDE). Select "Arduino/Genuino Uno" from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Uno comes pre-programmed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- **On Revl boards:** Connecting the solder jumper on the back of the board (near the map of Italy) and then rese ing the 8U2.
- **On Rev2 or later boards:** There is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Results and Discussion

Recording of blood glucose levels

Signals may be collected invasively by using needles. The needles are positioned in the regions of finger from where the blood samples are to be collected. Some preprocessing is considered in this acquisition stage, such as notch filters and band pass filters to remove the noise.

Difficulties, limitations and future scope

Recently, the medical services business has witnessed tremendous mechanical innovation and its use in the goal of medical care-related concerns. This has an enormous impact on medical care administrations, which are already available at the click of a button [2]. Formalized paraphrase IoT has successfully disrupted the medical services market by utilizing intelligent sensors, dispersed computing and systems administration innovation. IoT, like any other technology, IoT has its own set of difficulties and challenges that could be investigated in future studies [5].

Normalization

Many manufacturers offer a diverse range of products in the medical services sector. The majority of these things promise that they will comply with industry-standard plan norms and conventions. In any case, there is a lack of authenticity. As a result, the establishment of a dedicated gathering appropriate for standardizing these Healthcare IoT gadgets based on correspondence protocols, data total, and entrance interfaces is essential [2]. The approval and standardization of electronic clinical records captured by Healthcare IoT devices should also be carefully considered [11].

Information Privacy and Security

The use of distributed computing has changed the rule of continuous checking. In any event, this has rendered medical services networks more vulnerable to hackers. This may result in the misuse of sensitive patient data, which may have an impact on the treatment cycle [2]. Formalized paraphrase many precautions should be made during the planning process to protect an IoT framework against this nasty attack. To prevent an attack, clinical and detecting devices in a Healthcare IoT network should set up and employ personality confirmation, secure booting, adaptability to internal failure, approval of the board, whitelisting, secret word assurance, and secure matching conventions [7].

Furthermore, network conventions such as Wi-Fi, Bluetooth, and ZigBee should be used in connection with trustworthy direction plans and message integrity checking procedures. Because IoT is a network in which every client is linked to the worker, every flaw in IoT security administrations jeopardies the patient's safety. This could be remedied by integrating refined and dependable calculations and cryptographic techniques into a more secure environment [2].

Nonstop monitoring

Numerous medical services settings, for example, chronic illnesses, heart infections, and so on, necessitate long-term monitoring of the patient during therapy. In such instances, the IoT framework should be capable of executing viable continual checking [2].

Ecological impact

The development of a Healthcare IoT framework necessitates the incorporation of numerous biological sensors as well as semiconductor-rich devices. Earth metals and other hazardous synthetic chemicals are routinely used in assembly and manufacturing. This could have a harmful impact on

the climate. As a result, an appropriate administrative body should be established to monitor and control sensor fabrication. Furthermore, more research should be conducted to develop biodegradable sensors.

5. Conclusion

- In this project, the applicability of the breath acetone sensing method to the determination of glucose in human blood was demonstrated.
- We have used acetone sensor for monitoring acetone levels in the exhaled breath
- Our project is very electrically safe.
- There is no electrical contact made directly to the patient that uses the mask.
- The device operates at a very low voltage and is very unlikely to hurt the user.
- The device is unlikely to endanger the patient or the environment in any way.
- The momentum study looked at many aspects of the IoT plot for medical services. This article thoroughly examines the design of a HealthCare IoT framework, its components, and the connections between these segments. Furthermore, this research tends to emerge in medical care programs that have investigated IoT-based advances. By utilizing these ideas, IoT innovation has assisted medical care specialists in following and diagnosing a variety of diseases, calculating a variety of wellbeing measures, and delivering demonstration offices in remote areas.
- This has shifted the medical services business away from a clinic-based paradigm and toward a more understanding-based structure. We also discussed the many types of the Healthcare IoT measure, as well as their most current trends. The difficulties and concerns presented by the design, development, and implementation of the Healthcare IoT framework have also been investigated. These concerns will determine the foundation of future development and exploration goals in the coming years. Furthermore, comprehensive up-to-date data about Health care IoT gadgets have been accommodated by users who need to begin their investigation as well as gain footing in the sector.

References

1. Chetan Sharma, Sachin Kumar, Anshul Bhargava, Shubhajit Roy Chowdhury. Field programmable gate array based embedded system for non-invasive estimation of hemoglobin in blood using photoplethysmography. International Journal on Smart Sensing and Intelligent Systems. 2013;6(3):1267-1282.
2. Lieschnegg M, Zacherl M, Lechner B, Weger C, Fuchs A. Non-invasive characterization of total hip arthroplasty by means of passive acceleration measurement. International Journal on Smart Sensing and Intelligent Systems. 2010;3(1):75-87.
3. Gavin JR. The Importance of Monitoring Blood Glucose. In US Endocrine Disease; Touch Briefings: Atlanta, GA, USA, 2007, 1-3.
4. Turner C, Walton C, Hoashi S, Evans M. Breath acetone concentration decreases with blood glucose concentration in type 1 diabetes mellitus patients during hypoglycaemic clamps, Journal of breath research. 2009;3(4):1-9.
5. Md. Mahbubur Rahman, Saleh Ahammad AJ, Joon-Hyung Jin, Sang Jung Ahn, Jae-Joon Lee. A Comprehensive Review of Glucose Biosensors Based on Nanostructured Metal-Oxides: Sensors. 2010;10:4855-4886.
6. Tong Wang, Yanan Yu, Huifeng Tian, Jingbo Hu. A Novel Non Enzymatic Glucose Sensor Based on Cobalt Nanoparticles Implantation-Modified Indium Tin Oxide Electrode, Electroanalysis. 2014;26:2693-2700.
7. Saci AA, Dolatabadi JEN, Najafi-Marandi P, Abhari A, De la Guardia M. Electrochemical biosensors for glucose based on metal nanoparticles. TrAC Trends in Analytical Chemistry. 2013;42:216-227.
8. Dongyuan Zhai, Borui Liu, Yi Shi, Lijia Pan, Yaqun Wang, Wenbo Li, *et al*. Highly Sensitive Glucose Sensor Based on Pt Nanoparticle Palyaniline Hydrogel Heterostructures, ACS Nano. 2013;7:3540-3546.
9. Updike S, Hicks G. The enzyme electrode, nature publishing group. 1967;214:986-988.
10. Luaibi Ahmed Y, Ahmed J Al-Ghusain, Asif Rahman, Mohammad H Al-Sayah, Hasan Al-Nashash. Noninvasive blood glucose level measurement using nuclear magnetic resonance. Proceeding of 8th IEEE GCC Conference and Exhibition (GCCCE), Muscat, 2015, 1-4.

11. Ramasahayam Swathi, Sri Haindavi Koppuravuri, Lavanya Arora, Shubhajit Roy Chowdhury. Noninvasive Blood Glucose Sensing Using Near Infra-Red Spectroscopy and Artificial Neural Networks Based on Inverse Delayed Function Model of Neuron. Journal of medical systems. 2015;39(1):1-15.
12. Muller U, Mertes B, Fischbacher C, Jageman K, Danzer K. Non-invasive blood glucose monitoring by means of near infrared spectroscopy: methods for improving the reliability of the calibration models. The International journal of artificial organs. 1997;20(5):285-290.
13. Dongmin G, Zhang D, Zhanga L, Guangming L. Non-invasive blood glucose monitoring for diabetics by means of breath signal analysis, Sensors and Actuators B: Chemical. 2012 Oct;173:106-113.
14. Vashist S. Non-invasive glucose monitoring technology in diabetes management: A review, Analytica Chimica Acta. 2012;750:16-27.
15. Mohammad Goodarzi, Sandeep Sharma, Herman Ramon, Wouter Saeys. Multivariate calibration of NIR spectroscopic sensors for continuous glucose monitoring. TRAC Trends in Analytical Chemistry. 2015;67:147-158.

Chapter - 4
An Overview of Electric Vehicles

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Chapter - 4

An Overview of Electric Vehicles

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Abstract

Due to their very low to zero carbon emissions, low noise, great efficiency, and flexibility in grid operation and integration, electric vehicles are a viable technology for attaining a sustainable transportation sector in the future. A vehicle that runs on electricity instead of an internal combustion engine, which produces power by burning fuel and gases, is said to be electric. In order to solve the issues of rising pollution, global warming, and decreasing natural resources, such a vehicle is seen as a potential substitute for current-generation automobiles. Even though the idea of electric cars has been around for a while, it has attracted a lot of attention in the last ten years due to the growing carbon footprint and other environmental effects of fuel-powered cars. The performance of EVs can be improved with the right motor type selection and design, including efficiency and stability. Since the outdated power structure was originally introduced with the first EVs, power management in electric vehicles has undergone a revolution.

Keywords: Electric vehicle, electricity, pollution, fuels and global warming

1. Introduction

In order to undertake a significant transition to electric vehicles and to solve issues with national energy security, vehicle pollution, and the expansion of local manufacturing capabilities, India presented the "National Electric Mobility Mission Plan (NEMMP) 2020" in 2013. Although the plan called for providing subsidies and building out a network to support e-vehicles, it essentially stayed on paper. The programme was unveiled with the intention of providing incentives for clean-fuel technology automobiles in order to increase their sales to up to 7 million units by 2020. One of the essential components of electric vehicles is the electric motor (EVs). Due to the wide range of topologies that might be considered as candidates for EV applications, the electric motor is attracting particular attention. Today, it can be powered by a single source or a mix of sources, and it can be guided by a

single algorithm or a combination of algorithms. This improvement resulted in noticeably better outcomes.

Electric vehicles are particularly environmentally friendly because they consume little to no fossil fuels, have fewer moving components that need to be maintained, and have minimal operating expenses (petrol or diesel). While some electric cars (EVs) employed lead acid or nickel metal hydride batteries, lithium ion batteries are now thought to be the industry standard for battery electric vehicles due to their longer lifespan, excellent energy retention, and self-discharge rate of only 5% per month. Although attempts have been made to increase the safety of these batteries, there are still issues with them due to the possibility of thermal runaway, which has, for instance, led to fires or explosions in the Tesla model S.

Contrary to popular belief, India's future for electric vehicles is very promising. Low manufacturing and operating costs are due to the introduction of ground-breaking EV technologies in India and around the world, as well as to the commitment to share this technology for the benefit of all. Electric vehicles have shown to be one of the most economical and environmentally friendly substitutes for fossil fuel-powered automobiles. Given the skyrocketing fuel prices, this is a significant bonus for the adoption of EVs in India. Here, it is especially important to highlight the significant steps the Indian government has done toward EV adoption. The government is pushing newer potential vehicle owners to choose an electric vehicle (EV) rather than a fossil-fuel vehicle through tax subsidies and stronger regulations.

2. Electric Vehicle

An electric vehicle (Shown in Fig.1) is powered by an electric motor instead of a petrol engine. The electric motor gets energy from a controller, which regulates the amount of power-based on the driver's use of an accelerator pedal. Battery-electric vehicles have a sizable battery that powers one or more electric motors and are entirely electric and fuel-free. As new models are released, driving ranges for battery-electric vehicles increase from 80 to more than 300 miles. In comparison to gas-powered vehicles, battery-electric vehicles require less maintenance (such as oil changes, smog checks, spark plug changes, and replacing a catalytic converter or other wear-and-tear parts). A battery-electric automobile can be charged at home using a regular 120-volt or 240-volt house socket or away from home at charging stations at the mall or the office. One benefit of battery-electric cars over plug-in hybrids is the capability to use DC fast chargers, which provide more than 100 miles of range in 30 minutes.

Even at relatively high speeds, plug-in hybrid electric vehicles allow for both gas-only and electric-only operation. Plug-in hybrid vehicles are able to travel 20 to 55 miles on electricity alone while emitting no pollutants during that time. Their batteries are smaller than those of battery electric vehicles. When the automobile's electric range is exhausted, it shifts to gas and continues to operate as a typical car would. The vast majority of plug-in hybrid electric driving can be done in electric-only mode in California because the average commute is under 30 miles.

Unlike battery-electric vehicles or plug-in hybrids, fuel cell electric vehicles use electricity to operate. Its power system is made up of a stack of many cells that chemically combine oxygen from the air and hydrogen gas from the car's tank to create energy. Fuel cells may be refuelled at hydrogen filling stations, which are becoming more prevalent in California, in around five minutes and have a driving range of 300-400 miles on a single tank. Automakers offer three years' worth of free hydrogen fuel as an added bonus for fuel cell drivers. Many Californians choose to drive electric vehicles as a result of incentives like this.

- Indian Industry is observing a wave of Electric Vehicles. We are the 5th largest Automobile Industry in the world and are ready to conquer more by 2030.
- India is ranked 13th among the 20 most polluted cities in the world. To change this, we must make use of electric vehicles
- Electric vehicles are environmentally friendly. They don’t release harmful gases or smoke into the air, which helps to reduce pollution and fight global warming.

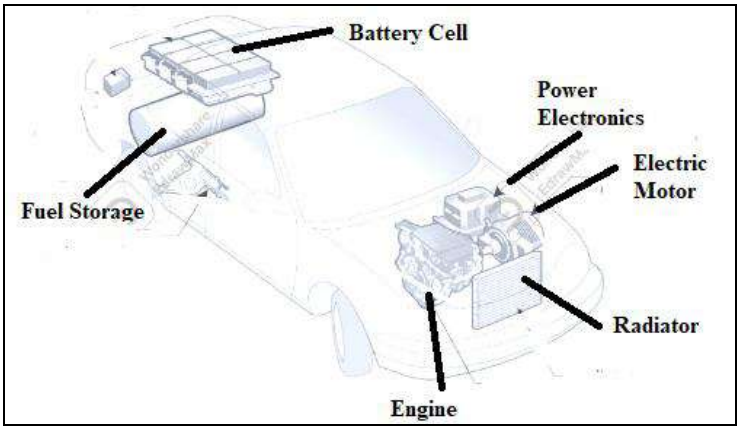

Fig 1: Internal view of Electric Vehicle

3. Types of electric vehicle

There are four types of electric vehicles available:

1) Battery Electric Vehicle (BEV)
2) Hybrid Electric Vehicle
3) Fuel Cell Electric Vehicle (FCEV)
4) Plug-in Hybrid Electric Vehicle (PHEV)

1. Battery Electric Vehicle (BEV)

In Fig. 2, Compared to an internal combustion engine, battery powered electric vehicles have approximately 99% fewer moving parts that need maintenance.

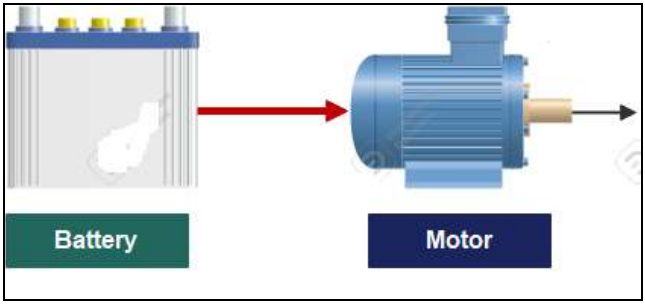

Fig 2: Battery Electric Vehicle

Advantages of a BEV

- Creates very little noise.
- No exhaust, spark plugs, clutch or gears.
- Doesn't burn fossil fuels, instead uses rechargeable batteries.

BEVs may be charged overnight at home, giving them enough range for routine commutes. Although regenerative braking or travelling downhill can help reduce this by charging the battery packs, longer or more difficult trips may need charging the fuel cells before you arrive at your destination. An electric automobile can take anywhere from 30 minutes to more than 12 hours to fully charge. The size of the battery and the charging station's speed are both important factors. In the real world, one of the main issues with electric cars is range, but this is something the industry is addressing.

2. Hybrid electric vehicles

Hybrid electric vehicles provide a combination of battery and gasoline (or diesel) power rather than just depending on an electric motor. They are

therefore superior for long-distance travel because you can switch to conventional fuels rather than looking for charging stations to top off the battery. HEVs are also referred to as parallel or series hybrids. HEVs have an electric motor in addition to an engine. Fuel powers the engine, while batteries provide electricity for the motor. Both the engine and the electric motor turn the transmission at the same time. Wheels are then propelled by this.

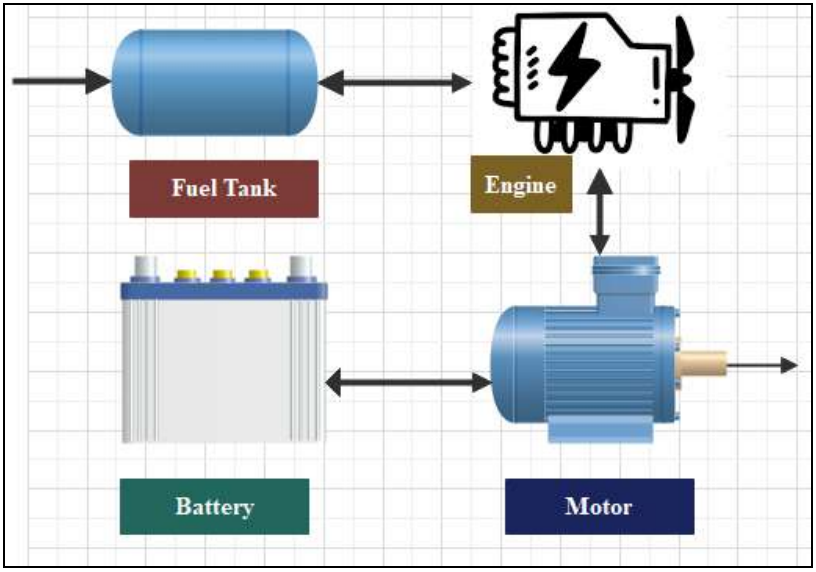

Fig 3: Hybrid Electric Vehicle

In Fig.3, the fuel tank supplies energy to the engine like a regular car. The batteries run on an electric motor. Both the engine and electric motor can turn the transmission at the same time.

3. Fuel Cell Electric Vehicle (FCEV)

Another name for FCEVs is zero-emission vehicles. To create the electricity needed to power the car, they use "fuel cell technology." In Fig.4, fuel's chemical energy is instantly transformed into electric energy. The electricity needed to power this vehicle is produced on the FCEV itself.

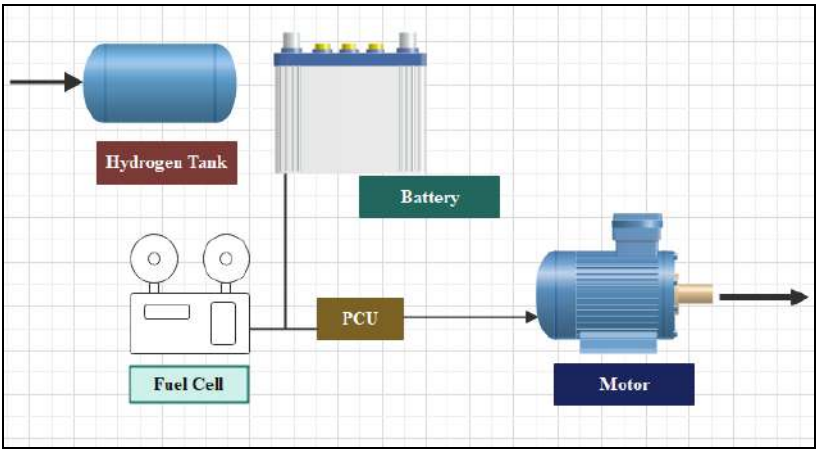

Fig 4: Fuel Cell Electric Vehicle

4. Plug in Hybrid Electric Vehicle (PHEV)

Of course, PHEVs share the same drawbacks as combustion engine vehicles, such as the need for greater maintenance, increased engine noise, pollutants, and increased fuel costs. In Fig.5, PHEVs have smaller battery packs, which results in a shorter range. TWI has played a significant role in the development of electric vehicles by helping to make the vehicles themselves lighter, assisting with joining and welding, preventing battery combustion, and more. The term "series hybrid" also applies to PHEVs. Both an engine and a motor are present. You have a choice of two types of fuels: conventional fuel (like gasoline) and alternative fuel (such as bio-diesel). A battery pack that can be recharged can also power it. The battery can receive external charging. PHEVs operate in an all-electric mode at startup and continue to do so until their battery pack is empty. When the battery runs out, the engine kicks in and the car becomes a regular, non-plug-in hybrid. An external electric power source, an engine, or regenerative braking can all be used to charge PHEVs. The electric motor functions as a generator when the brakes are engaged, utilising the energy to charge the battery. The engine's power is supplemented by the electric motor; as a result, smaller engines can be used, increasing the car's fuel efficiency without compromising performance.

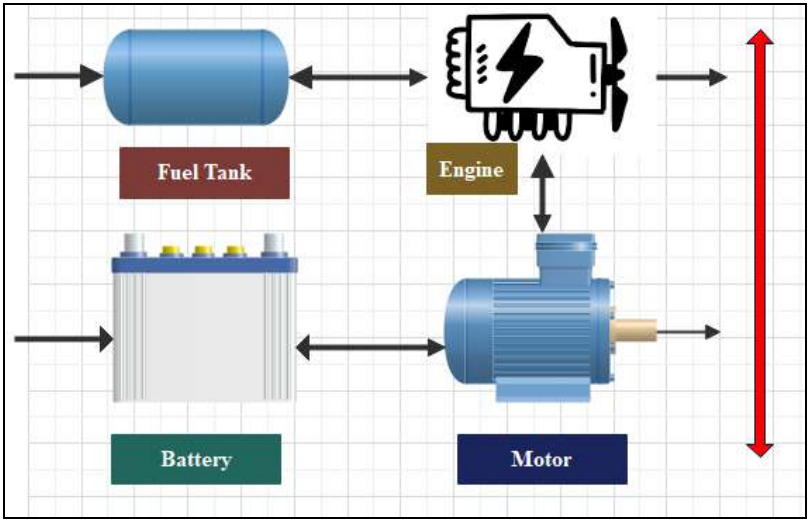

Fig 5: Plug in Hybrid Electric Vehicle (PHEV)

4. Challenges

A battery must function at various temperatures. At cold temperatures, the battery's performance is noticeably diminished. At low temperatures, the cell's power and energy are also significantly impacted. Additionally, it limits the battery's use in cold weather. The electrolyte becomes more viscous at low temperatures, which decreases its ionic conductivity and raises the battery pack's internal resistance. Lithium plating, lithium dendrites, and a rise in charge-transfer resistance are further characteristics of Li-ion batteries' low temperature performance. Overall, operating a battery at low temperatures leads to poor performance and an acceleration of the ageing process. The energy storage system (ESS), which is utilised in micro-grids, renewable energy systems, and electric vehicles (EV), is very prevalent. EV use has significantly increased globally, and it was thought that they were a good replacement for internal combustion engines (ICE). As it stands, ICE vehicles, ships, cargos, and aircraft have utilised one-third of all fossil fuel. 1% of vehicles in the transportation industry were powered by electricity, 2% by biofuel, 3% by natural gas, and 94% by oil. According to research, the main generators of carbon dioxide (CO_2), sulphur dioxide (SO2), carbon monoxide (CO) and nitrogen oxides-which are the main contributors to air pollution and greenhouse gases are businesses and ICE.

The ESS is utilised in EVs to power the EV motor as well as other features like the navigation light and air conditioning. When driving an EV, the CO, CO_2, NO and SO_2 gases are not noticeable, which helps to address

the issues with fossil fuels and the environment and makes EVs deemed to be zero-carbon vehicles. Batteries, super capacitors, fuel cells, hybrid storage, and power, temperature, and heat control are all included in the energy storage category. Systems for managing energy take into account battery monitoring for voltage and current, charge-discharge control, estimates and protection, and cell equilibration. Several important features of lithium-ion batteries, including temperature and safety, life-cycle and memory effects, environmental consequences, and recycling procedures are covered in this paper's challenges and issues.

5. Conclusion

In particular, three major EV categories are covered in detail: battery electric vehicles (BEVs), plug-in electric vehicles (PHEVs), and hybrid electric cars (HEVs). Additionally, the current chapter compares and contrasts these different types of vehicles and reviews and analyses the most recent developments in EV technology. We can draw the conclusion that HEVs can play a significant role in easing the switch to completely electric vehicles. As long as problems with autonomy, durability, and affordability are handled, this transformation will proceed more quickly at the battery level.

References

1. Silvestre BS *et al*. Innovations for sustainable development: moving toward a sustainable future, J. Clean. Prod, 2019.
2. Sun Fengchun. Current situation and trend of development of electric vehicle, Science Chinese people. 2006;8:44-47.
3. Mohammad Ali Abdelkareem, Hussein M Maghrabie, Ahmed G Abo-Khalil, Ohood Hameed Kadhim Adhari, Enas Taha Sayed, Ali Radwan, *et al*. Battery thermal management systems based on nanofluids for electric vehicles, Journal of Energy Storage, 2022, 50. 104385, ISSN 2352-152X, https://doi.org/10.1016/j.est.2022.104385.
4. Evanthia A. Nanaki. Chapter 2-Electric vehicles, Editor(s): Evanthia A. Nanaki, Electric Vehicles for Smart Cities, Elsevier, 2021, Pages 13-49, ISBN 9780128158012, https://doi.org/10.1016/B978-0-12-815801-2.00006-X.
5. Mohammad Kamrul Hasan, Md Mahmud, Ahasan Habib AKM, Motakabber SMA, Shayla Islam. Review of electric vehicle energy storage and management system: Standards, issues, and challenges, Journal of Energy Storage. 2021;41:102940, ISSN 2352-152X, https://doi.org/10.1016/j.est.2021.102940.

6. Bocklisch T. Hybrid energy storage approach for renewable energy applications J. Energy Storage, 2016.

7. Kouchachvili L *et al.* Hybrid battery/supercapacitor energy storage system for the electric vehicles, J. Power Sources, 2018.

8. Habib AA *et al.* A review: energy storage system and balancing circuits for electric vehicle application, IET Power Electronics, 2021.

9. Hyunjae Yoo, Seung-Ki Sui, Yongho Park, Jongchan Jeong. System Integration and Power-Flow Management for a Series Hybrid Electric Vehicle Using Supercapacitors and Batteries, IEEE Trans. on Industry Applications. 2008;44(1):108-114.

10. Noah Kittner, Ioannis Tsiropoulos, Dalius Tarvydas, Oliver Schmidt, Iain Staffell, Daniel M. Kammen, Chapter 9 - Electric vehicles, Editor(s): Martin Junginger, Atse Louwen, Technological Learning in the Transition to a Low-Carbon Energy System, Academic Press, 2020, Pages 145-163, ISBN 9780128187623, https://doi.org/10.1016/B978-0-12-818762-3.00009-1.

11. Zhou X *et al*., The current research on electric vehicle, 2016 Chinese Control and Decision Conference (CCDC), Yinchuan, 2016, pp. 5190-5194, doi: 10.1109/CCDC.2016.7531925.

12. Pranjali R. Tete, Mahendra M. Gupta, Sandeep S. Joshi. Developments in battery thermal management systems for electric vehicles: A technical review, Journal of Energy Storage, 2021, 35. 102255, ISSN 2352-152X, https://doi.org/10.1016/j.est.2021.102255.

13. KWE. Cheng. Recent development on electric vehicles, 3rd International Conference on Power Electronics Systems and Applications (PESA), Hong Kong, China, 2009, 1-5.

14. Heesung Park. A design of air flow configuration for cooling lithium ion battery in hybrid electric vehicles, Journal of Power Sources. 2021;239:30-36. ISSN 0378-7753, https://doi.org/10.1016/j.jpowsour.2013.03.102.

15. Gao Ciwei, Liang Zhang. Overview of the impact of electric vehicle charging on the grid, grid technology. 2011;2:127-131.

16. Shahid Ali Khan, Shakeel Ahmad, Kwun Ting Lau, Kejian Dong, Sihong HE, Huaqiang Liu, *et al*. A novel strategy of thermal management system for battery energy storage system based on supercritical CO2, Energy Conversion and Management.

2023;277:116676, ISSN 0196-8904,https://doi.org/10.1016/j.enconman.2023.116676.

17. Beier J. *et al*. Integrating on-site Renewable Electricity Generation into a Manufacturing System with Intermittent Battery Storage from Electric Vehicles, Procedia CIRP. 2016;48:483-488.
18. Mwasilu F *et al*., Electric vehicles and smart grid interaction: A review on vehicle to grid and renewable energy sources integration, Renewable and Sustainable Energy Reviews. 2014;34:501-516.
19. Cao Binggang, Zhang Chuanwei, Bai Zhifeng. Development and development trend of electric vehicle technology, Journal of Xi'an Jiao Tong University. 2014;1:1-5.
20. Zakaria H, Hamid M, Abdellatif EM, Imane A. Recent Advancements and Developments for Electric Vehicle Technology, 2019 International Conference of Computer Science and Renewable Energies (ICCSRE), Agadir, Morocco, 2019, pp. 1-6, doi: 10.1109/ICCSRE.2019.8807726.

Chapter - 5
Solar Based Jet Nebulizer with Sound Sensor

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Chapter - 5

Solar Based Jet Nebulizer with Sound Sensor

V. Srividhya, K. Deepak, T. Krishna Kumar, A. Naveen Kumar, N. Baranidharan and S. Nivetha

Abstract

Three of the 10 top causes of death worldwide are respiratory diseases. A nebulizer can be used to treat and diagnose several of these illnesses. Vaccines can be administered with nebulizers in a secure and effective manner. Unfortunately, nebulizers that are sold commercially are not made for usage in areas of the world where lung illness is most common since they are electricity-dependent, expensive and not made to be dependable in challenging working environments or with frequent use. The globe has become increasingly adept at finding solutions to the issues people encounter since the industrial revolution. However, improvements in the field of bio-medical equipment are largely influenced by patients who don't feel comfortable using the equipment, clinicians who may have considered improving the equipment, or the setting or purpose for which the equipment is being used. Our study focuses primarily on nebulizers, which will have a fundamental impact on the respiratory illnesses experienced by those who live in rural areas or primarily in locations with nebulizers but unstable electricity.The nebulizer's ability to operate independently will be highlighted by this initiative, which will power the devices using both solar and battery power.

Keywords: Jet nebulizers, solar energy, battery, respiratory illness, electricity

1. Introduction

When it comes to respiratory diseases like asthma, COPD, and other similar conditions, nebulizers are among the biomedical devices that are most helpful. The usage of nebulizers, however, is extremely beneficial in rural or urban locations because technology is readily available there. Hospitals and clinics there have nebulizers on hand, but they are not powered by electricity. The "Sun BASED JET NEBULIZER" project uses a technology that effectively uses solar energy to power a jet nebulizer.

2. Litrature survey

Greta Adorni, Gerrit Seifert, Francesca Buttini, Gaia Colombo, Luciano A. Stecanella, Irene Krämer, and Alessandra Rossi have proposed their paper by determining the biopharmaceutical limitations relating to the qualitative features of the medical goods, which have an impact on their safety, effectiveness, efficiency, and compliance, some of which were tested in various configurations. Using sodium fluoride as a reference formulation, the aerosolization parameters-including the aerosol output, aerosol output rate, mass median aerodynamic diameter, and fine particle fraction-were calculated in accordance with European Standard EN 13544-1. The fine particle fraction and the aerosol output nebulization time were compared, and the results showed a relationship between the two. In fact, when the rate of aerosol production was slowed down, the quality of the nebulization dramatically improved. Additionally, the respirable given dose and respirable dose delivery rate were used to evaluate the nebulizers' performance which define nebulization as the rate and volume of product that may be inhaled as respirable. The performance of the nebulizers varied depending on which of these two latter settings was used. According to the medicinal product, therapy, and patient characteristics, the variations in the rate and volume of delivered aerosol may offer pertinent information for selecting the best nebulizer [1].

Udaya dampage, Malmindi Ariyasinghe and Samanthi Pulleperuma proposed the "Compressed Air" mode and the "Oxygen Therapy" mode are the two operating modes of the proposed nebulizer. The patient's percentage of oxygen saturation, as measured by the SpO2 sensor, will determine when an automatic switch from one mode to another will occur. The patient will get compressed airflow in accordance with the minute ventilation that was calculated using a temperature sensor-based algorithm. The electronics in the compressor controller makes sure the patient gets the right amount of compressed air for the flow rate. If the liquid level sensor determines that there is no longer any medicine inside the nebulizer chamber at the conclusion of the drug administration, the nebulization procedure will stop. The motor speed was dynamically controlled in relation to the minute ventilation [2].

Arzu Ari, Armele Dornelas de Andrade, Meryl Sheard, Bshayer AlHamad, James B. Fink proposed their model that adults and children with respiratory disorders are treated using various nebulizer and interface kinds. In order to compare the effectiveness of a mesh nebulizer (MN) with a proprietary adapter and a jet nebulizer (JN) in various configurations in adult

and paediatric models of spontaneous breathing, this study was conducted. In simulated spontaneously breathing adult and juvenile models, we expect that the delivery efficiency of JN and MN will vary based on the interface employed during aerosol treatment. While we anticipate that JN will transport aerosols less effectively than MN, we also predict that, under all research settings, adult lung model lung deposition will be greater than paediatric lung model lung deposition [3].

Sean D. McCarthy, Héctor E. González, and Brendan D. Higgins explained their paper by Patients with respiratory diseases often benefit from aerosol treatment to deliver medications to their lungs. By specifically targeting sick lung areas for quick action, using smaller dosages than oral or intravenous administration, and reducing systemic adverse effects, aerosol treatment enhances therapeutic results. The effectiveness of aerosol therapy depends on lung shape, breathing patterns, aerosol droplet features, illness, mechanical ventilation, pharmacokinetics, and the pharmacodynamics of cell-drug interactions in order to best treat critically sick patients.

While medication formulations and device mechanisms have an impact on aerosol properties, the majority of other variables depend on unique patient features. This has prompted greater attempts to develop more individualised therapy strategies to enhance pulmonary medication delivery and enhance the choice of efficient pharmacological classes for unique patients [4].

Vandana Batra, G.R. Sethi and H.P.S. Sachdev proposed their model to evaluate the relative performance of a jet nebulizer and a metered dosage inhaler (MDI) with spacer for the delivery of aerosolized salbutamol during a bronchial asthma attack. Randomized prospective trial was the design. Emergency room setting Methods: Heart rate, respiratory rate, pulses paradoxus, arterial blood gas analysis (in all instances), peak expiratory flow rate, and other clinical and laboratory measures of severity were used to evaluate the severity of asthma in 60 participants with acute asthma who were between the ages of 1 and 12 years (wherever possible). According to the Consensus Guidelines, the individuals were randomly divided into two equal groups and given aerosolized salbutamol by nebulizer (Group I) or MDI-spacer (Group II). Following the establishment of therapy for 20, 40, and 60 minutes, the therapeutic response was successively evaluated [5].

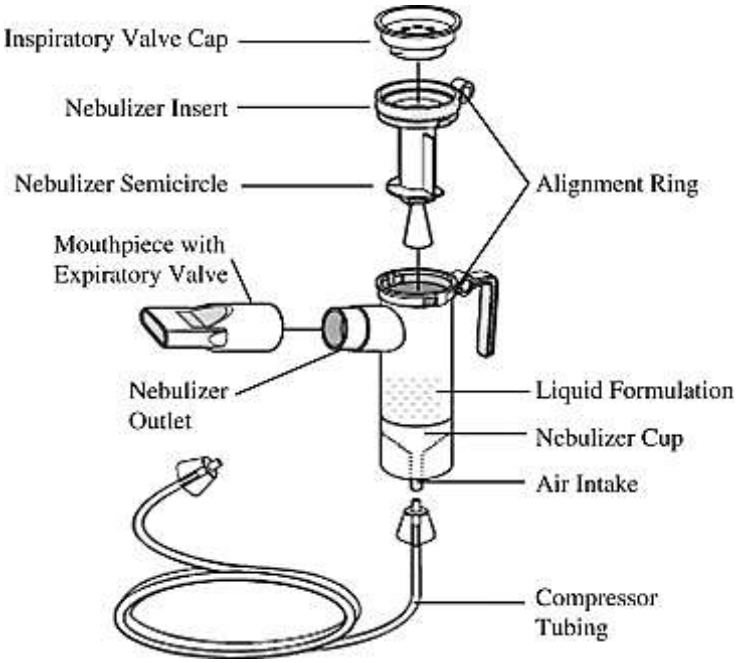
Khubaib Yousuf Ghadai, Rahim Daud Agha, Talal Iqbal Khan, Muhammad Azeem Uddinhave proposed their paper by telling that The goal of this project is to manufacture a Nebulizer that does not depend on

electricity for itsworking. Pakistan is ranked top among those countries having worst health care sector. One of the reasons for Pakistan being so worse in the health sector is the electricity shortage the country is facing and there are rare signs of betterment for the next 5 to 10 years. Keeping in knowledge that there are multiple medical equipment that can be used without electricity as a power source. Nebulizer being one of that health care equipment is used by people normally young children and old age people. Over 6.9 million Pakistanis have respiratory diseases as per Pakistan Bureau of Statistics. Our goal is not just manufacturing it but also making to it accessible to the common people by installing it in different rural areas with the help of NGO's and hospitals [6].

3. Related work

3.1 Nebulizers

Nebulizers turn liquid formulations and suspension into medicinal aerosol. Recent developments in the creation of new nebulizers have the potential to enhance the administration of aerosol medications to patients with respiratory disorders. Jet nebulizers, ultrasonic nebulizers, and mesh nebulizers are the three categories into which nebulizers fall. Jet nebulizers are frequently used to treat patients with respiratory disorders, although they are large and power sources are needed. Jet nebulizers chill the medication solution inside the nebulizer and raise solute concentration in the residual volume as a result of aerosolized droplets and solvent vapour that permeates the outgoing air.Despite being more effective and portable than jet nebulizers, ultrasonic nebulizers cannot deliver proteins or suspensions. Heating problems that cause proteins to get denatured during aerosol treatment are eliminated with the invention of mesh nebulizers that employ lower-frequency waves. Mesh nebulizers have also been demonstrated to be effective at delivering suspensions, liposomes, and nucleic acids. This research aims to describe the various nebulizer types that are available and assess their efficacy in aerosol medication delivery because there are many nebulizers in each category that have been introduced to the market. Additionally, methods for the best inhalation therapy for pulmonary illness patients will be researched.



3.2 Jet Nebulizers

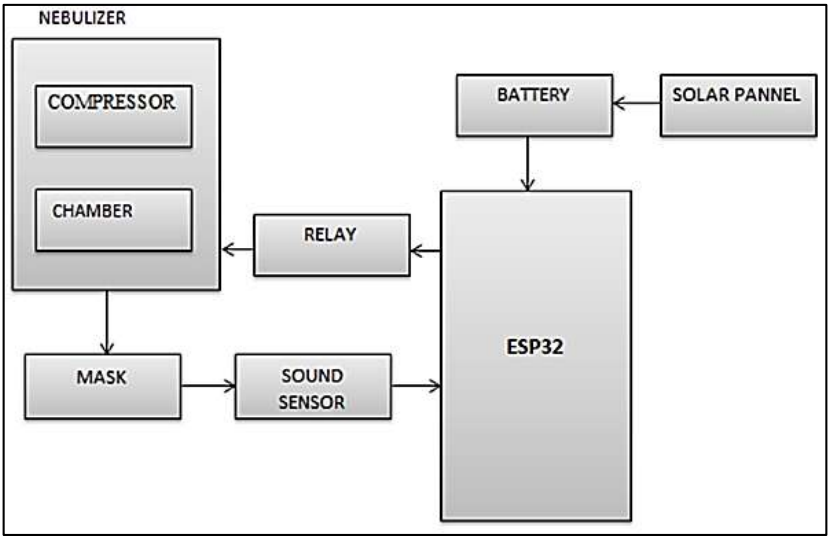
Historically, pulmonary disorders have been treated with jet nebulizers. In order to create a variety of particle sizes that are blasted into one or more baffles, these nebulizers need to draw medication up through a capillary tube from the nebulizer reservoir at a rate of 2 to 10 L/min. The baffles then remove larger particles from suspension and return them to the reservoir.Jet nebulizers are efficient at delivering formulations that cannot be administered by dry powder inhalers and pressurised metered-dose inhalers (pMDIs) (DPIs). Drugs that may be administered with jet nebulizers include antibiotics, mucolytics, liposomal formulations, and recombinant products like Pulmozyme® Inhalation Solution. Jet nebulizers, on the other hand, might be challenging to operate since they require pressurised gas and extra tubing. Several otherStudies have demonstrated their shortcomings in terms of medication delivery (6-8). These factors have led to the development of many new types of jet nebulizers throughout time. New jet nebulizers contain reservoirs that store aerosols or use baffles to minimise the size of big particles and boost the effectiveness of aerosol therapy thanks to advancements in nebulizer design. Additionally, they produce aerosols with increased breath efficiency, which results in improved medication delivery, a higher fine-particle percentage, and less drug loss upon expiration.

3.3 Solar Power

Medical services greatly benefit from biomedical electronics. For various purposes, numerous varieties have been produced. The problem of powering these gadgets still exists. Self-harvesting, self-storing, and self-powering biomedical electronic devices are in great demand. Recent developments in solar cell technology have produced hybrid and organic solar cells, which are appealing for use in biomedical electronic devices because of their important characteristics including light weight, flexibility, biocompatibility, and size reduction, among others. In this study, we attempt to highlight some recent efforts to power various kinds of biomedical equipment using solar energy. Implants, electronic skin, radio-integrated monitoring, tooth brushes, and diagnostic tools are among the topics discussed. The use of sun's electricity in nebulizers is currently not deployed, and this venture puts emphasis on sources of renewable electricity.

4. Methodology

In this project the electric energy is generated from the solar panel and this voltage is stored in 12V battery. This stored voltage is used to power up the circuit. A sound sensor is fixed inside the mask. If any block occurs during the respiration, this is sensed by the sound sensor. If any blocks is measured, the controller will turn on the compressor through the relay. If the respiration block is not detected it will turn off the compressor. The whole process is automated and controlled by the controller (ESP32).



5. Proposed output

The name of this project is "SOLAR BASED JET NEBULIZERS." Nebulizers, which are often powered by electricity, spray medicine into incredibly fine particles for inhalation, making it easier for those with asthma to breathe. But an alternative was required in areas where lung disorders like asthma and other respiratory issues are widespread but reliable energy is not. This problem can be solved by our project, allowing us to discover a different way to power the nebulizer. The solar-powered jet nebulizer operates on the electricity generated by both the battery supply and the solar panel used in this project.

6. Conclusion

This project explains the need for electricity in rural areas and emphasises how it can be used by incorporating solar power into our project. We can then use the power to make the nebulizer function in situations where there is a shortage of electricity or no electricity is available at a time of emergency. This concept employs both solar and battery power to run the jet nebulizers that may be used by patients with respiratory conditions including asthma, COPD, and others. In order to improve power generation utilising dependable energy sources like solar, we need employ them more efficiently. This would enable even important medical equipment to produce its own power from a dependable source.

7. References

1. Greta Adorni, Gerrit Seifert, Francesca Buttini, Gaia Colombo, Luciano A Stecanella, *et al*. Aerosolization Performance of Jet Nebulizers and Biopharmaceutical Aspects, 2019.
2. Udaya Dampage, Malmindi Ariyasinghe, Samanthi Pulleperuma. An Automated Jet Nebulizer with Dynamic Flow Regulation, 2021.
3. Arzu Ari, Armele Dornelas de Andrade, Meryl Sheard, Bshayer AlHamad, James B. Fink. Performance Comparisons of Jet and Mesh Nebulizers Using Different Interfaces in Simulated Spontaneously Breathing Adults and Children, 2019.
4. Sean McCarthy D, Héctor González E, Brendan Higgins D. Future Trends in Nebulized Therapies for Pulmonary Disease, 2020.
5. Vandana Batra, Sethi GR, Sachdev HPS. Comparative efficacy of jet nebulizer and metered dose inhaler with spacer device in the treatment of acute asthma, 1996.

6. Khubaib Yousuf Ghadai, Rahim Daud Agha, Talal Iqbal Khan, Muhammad Azeem Uddin. Self-Powered Nebulizer, 2017.

Chapter - 6
Blood Warmer and Clinical Sterilizer

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Chapter - 6

Blood Warmer and Clinical Sterilizer

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Abstract

At first maintaining the temperature is the most important factor in handling the device effectively and safely. The main use of this device is it can warm blood and infusion and as well as it can be used as a sterilizer in clinics to sterilize the materials used during minor procedures. 37.5 degrees Celsius is the average body temperature for humans. The blood is stored in chilled storage in blood banks. Injecting chilled blood into a patient directly is risky. Real-time comparison of blood bag and patient body temperatures prevents hypothermic side effects in the patient's body during transfusion, and heating of the IV line to thermal equilibrium is then applied in response. The heart of the warmer for blood infusion is a THERMOCOUPLE, which is a very suitable temperature sensor with an NTC (Negative temperature coefficient).

While coming to the sterilizer there is a slight temperature increase in the device to make the used apparatus sterilizer. The apparatus is portable, benefits include quick results, clear digital temperature indicator and no contamination. To better grasp the previously mentioned concept of warming blood, here is a model that does the same purpose using simple electronic circuitry which is at beginner level. The device can be made more dynamic, but less expensive, with the basic controllable electrical circuitry. The component specifications, accuracy, functionality and aesthetics of the actual device are unquestionably completely different. Instead of blood, ingesting water or dextrose was the recent method. But with this project, a real-time warmer and sterilizer can be functionally simulated.

Keywords: Blood warmer, sterilizer, hypothermia

1. Introduction

The clinics and health centres generally uses the infusion fluids and surgical equipments. Some of these fit the definition of blood warmers and

clinical sterilizers. For patients who urgently need blood transfusions to keep the body's equilibrium, these devices are crucial. Bloods are generally stored in cold storage in the blood bank from 4 to 8 degrees Celsius. In the absence of blood warmers, the patient may experience major consequences from blood loss; warmers offer a mechanism to restore the blood fast without compromising its quality. When it comes to treating patients who have suffered blood loss, these are some of the most crucial medical equipment in a hospital. This article provides a summary of the devices that belong under this category as well as some guidelines for maintaining them.

The danger of hypothermia is reduced by using a blood warmer to warm blood or other fluids. For the maintenance of the cells, blood is maintained chilled. Haemolysis, or the disintegration of the blood cells, must also be avoided, therefore it is imperative to reheat it to the proper temperature. The cooler blood may cause the patient to become hypothermic if the transfusion is carried out too soon without enough warming. Maintaining a precise temperature balance over time is important. Most medical and surgical devices used in health care facilities are made of heat stable and therefore undergo heat, primarily steam, sterilization. Sterilization destroys all the microorganisms on the surface of an article or fluid to prevent disease transmission associated with the use of that material. At the same time in order to prevent infection for patients during minor surgeries, surgical equipments such as forceps, scalpel, scissors etc., should be sterilized and used.

2. Literature survey

C.F. Adams, J.D. Chirawurah, P.E Agbekoh, and Elsie Effah Kaufman.

The author has displayed the Design of a Blood-Warming Device for Resource-Limited Settings. To prevent hypothermia during transfusions, blood must typically be warmed up to a temperature of 37 °C from storage temps of 1-6 °C. Blood warming is a significant concern in Ghana, according to needs assessments at several institutions. Blood can be warmed using local techniques such as hanging blood bags from walls to warm them, soaking them in warm water, or placing them under running water. These techniques are ineffective, dangerous, and time-consuming. There are effective blood warmers, but they are exceedingly expensive and out of reach for the resource-constrained facilities assessed. The aforementioned issues in resource-constrained environments were addressed by the development of a low-cost, safe, and effective blood warming and thawing system. To minimise heat loss to the environment, the device's components are housed in a housing that is

insulated with polymer foam. This intervention is expected to be extremely helpful when quick blood transfusions are necessary to save lives.

S. Sanjay and D. Jintuexplains that the most important factor in handling the patient effectively and safely is maintaining temperature. Any errors in this regard could result in a condition that is dangerous to the patient's life. We are all aware that blood is kept at a lower temperature in blood banks. Since a human's body temperature is 37.5 degrees Celsius, it is extremely risky to immediately inject chilled blood into a patient. Real-time comparison between blood bag and patient body temperatures, as well as appropriate heating, are offered to prevent hypothermic adverse effects in the patient body during transfusion. Although a blood warmer offers the benefits of being sterile, portable and having a clear digital temperature signal, it also has drawbacks and difficulties, including the inability to cool heated blood and usage restrictions. The component's correctness, dynamicness and look may not match those of the final product.

Mukul Lokhande and Arya Gaikhehas proposed the use of temperature differential signals for proportional heating of the cold blood is the project's fundamental idea. The patient's body and the blood bag each have their own temperature difference. Since the thermistor's detecting range is in microvolts, error signals are frequently input to the heating circuit because otherwise there won't be enough heat generated. It must therefore be enhanced appropriately. It is not design, but rather the first stages, virtually a simulation of the hotter's fundamental operation. The component specifications may therefore be different from the one. Blood is kept at a cooler temperature to slow the growth of microorganisms. Now, if it is immediately infused into the patient's body, it causes an unpleasant reaction between normal blood and transfused blood known as "Hypothermia," which puts the patient in danger of dying. As a result, blood cells are sheared, metabolism is slowed due to hypodynamics, ague, vascular spasms, arthritis pain, stomach pain, platelet dysfunction, increased blood viscosity, and impaired CVS function occur. BLOOD INFUSION WARMER is used to prevent it. By measuring the temperature differential between the two, this gadget heats the blood in the blood bag until it is equal to the blood heat. Therefore, it is a necessary tool in operating rooms, intensive care units, or other places that necessitate transfusion therapy to prevent accidents related to cold transfusion.

Thomas G. Poder, Wendyam G. Nonkani and Élyonore Tsakeu Leponkouoit explains. To prevent causing hypothermia and its detrimental effects, fluid warmers should be used during blood transfusions.

Manufacturers' fluid warmers can go as hot as 43 °C. The maximum heating temperature in relation to the risk of hemolysis is not, however, explicitly stated in the recommendations of national regulatory authorities. We carried out a thorough literature review and meta-analysis to close this gap. This evaluation was restricted to fluid warmers that employed contact heating to mimic clinical practise; hence, studies that used radiofrequency or microwave heating were disregarded. There were 24 observational studies total, 17 of which were the focus of a meta-analysis. Preliminary descriptive analysis revealed that several variables, such as blood age, anticoagulant type, duration of heat exposure, stirring the blood during heating, and various components of the blood flow circuit, can affect the degree of haemolysis during blood heating with a liquid warmer (e.g., type of infusion pump with pressure and flow, type of microfilter, and type of tubing). Also contributing to study heterogeneity were the initial free haemoglobin levels in several tests, as well as the time interval between sample and haemolysis assay.

Jin-Hong Yoo explains blocking the spread of microbes or pathogens can be summed up as the primary goal of infection control [1]. Two directions should be used for blocking. Preventing vertical transmission is the first, and preventing horizontal or lateral transmission is the second. Pathogens spread vertically when they pass from one generation to the next. The regulation of antibiotic use and usage is necessary to stop vertical transmission and calls for antibiotic stewardship. Lateral transmission is the spread of a disease into its surrounds or the transfer of a pathogen's resistance to other pathogens of the same generation. One of the most important elements of infection control is thorough knowledge of sterilisation and disinfection. Unlike disinfection, sterilisation totally eliminates spores. Oxidants and non-oxidants are different types of disinfectants. With Spaulding's classification, one may decide which approach to use. In-depth reviews of disinfection and sterilisation are provided in this piece, along with a wealth of material ranging from fundamental to practical. Using Spaulding's classification as a starting point, one should decide whether to disinfect or sterilise. A spore-killing technique, such as sterilisation, should be chosen, especially when dealing with a crucial item. A wise and accurate choice of the proper disinfectant (or chemical sterilant) is also necessary for sanitising Mycobacterium species or non-enveloped viruses. The key to disinfection and sterilisation is selecting the right technique for the right application.

S. Mohapatra has proposed the foundational elements of hospital infection control procedures are sterilisation and disinfection. Many hospitals carry out various surgical operations every day. Many invasive

treatments are carried out in various healthcare facilities. The risk of introducing infections into the patient's body is enhanced when a medical device or surgical instrument comes into touch with the sterile tissue or mucous membrane of the patient during the various processes. Also, there is a potential that an infection will spread from one patient to another, from a patient to a member of the medical staff and vice versa, or from the environment to the patient through improperly sanitised or disinfected equipment. To stop the spread of these diseases, medical staff, laboratory workers and healthcare providers should all have better awareness of these approaches.

3. Related work

C.F. Adams, J.D. Chirawurah, P.E Agbekoh, and Elsie Effah Kaufman has displayed the Design of a Blood-Warming Device for Resource-Limited Settings. To prevent hypothermia during transfusions, blood must typically be warmed up to a temperature of 37 °C from storage temps of 1-6 °C. Blood warming is a significant concern in Ghana, according to needs assessments at several institutions. Blood can be warmed using local techniques such as hanging blood bags from walls to warm them, soaking them in warm water, or placing them under running water. These techniques are ineffective, dangerous, and time-consuming. There are effective blood warmers, but they are exceedingly expensive and out of reach for the resource-constrained facilities assessed. The aforementioned issues in resource-constrained environments were addressed by the development of a low-cost, safe, and effective blood warming and thawing system. To minimise heat loss to the environment, the device's components are housed in a housing that is insulated with polymer foam. This intervention is expected to be extremely helpful when quick blood transfusions are necessary to save lives.

Sterilization refers to any process that removes, kills or deactivates all forms of life (particularly microorganisms such as fungi, bacteria, spores, and unicellular eukaryotic organisms) and other biological agents such as prions present in or on a specific surface, object, or fluid. Sterilization can be achieved through various means, including heat, chemicals, irradiation, high pressure and filtration. Sterilization is distinct from disinfection, sanitization and pasteurization, in that those methods reduce rather than eliminate all forms of life and biological agents present. After sterilization, an object is referred to as being sterile or aseptic.

Medicine and surgery

In general, surgical instruments and medications that enter an already aseptic part of the body (such as the bloodstream, or penetrating the skin)

must be sterile. Examples of such instruments include scalpels, hypodermic needles and artificial pacemakers. This is also essential in the manufacture of parenteral pharmaceuticals.

Preparation of injectable medications and intravenous solutions for fluid replacement therapy requires not only sterility but also well-designed containers to prevent entry of adventitious agents after initial product sterilization.

Most medical and surgical devices used in healthcare facilities are made of materials that are able to go under steam sterilization. However, since 1950, there has been an increase in medical devices and instruments made of materials (e.g., plastics) that require low-temperature sterilization. Ethylene oxide gas has been used since the 1950s for heat- and moisture-sensitive medical devices. Within the past 15 years, a number of new, low-temperature sterilization systems (e.g., vaporized hydrogen peroxide, peracetic acid immersion, ozone) have been developed and are being used to sterilize medical devices.

4. Proposed work

The device satisfies the safety, portability, cost effectiveness and performance. In safety, friendly for the user as well as the environment, it does not cause any injury to the user and does not affect the blood integrity. The main method used in this device is the water bath method. The heat is produced in the form of steam, so that we can keep the device in the condensed state. While coming to the performance of the device it is efficient and user friendly, there is a slight difference in the change in temperature between the blood warmer and sterilizer.

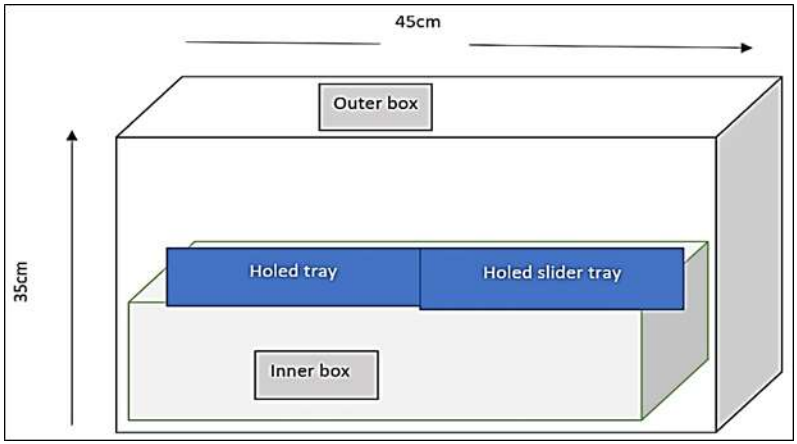
The expected temperature required for the obtained, the thermostat will automatically cut-off the current so, the energy is consumed. In order to prevent the heat liberation thermoforms is used, so that the heat loss is reduced.

Blood warming is 30 ^{o}C to 34 ^{o}C and for sterilization the temperature of the device is maintained around 80 ^{o}C to 90 ^{o}C. A thermostat is fixed to maintain the required temperature. When the required temperature is

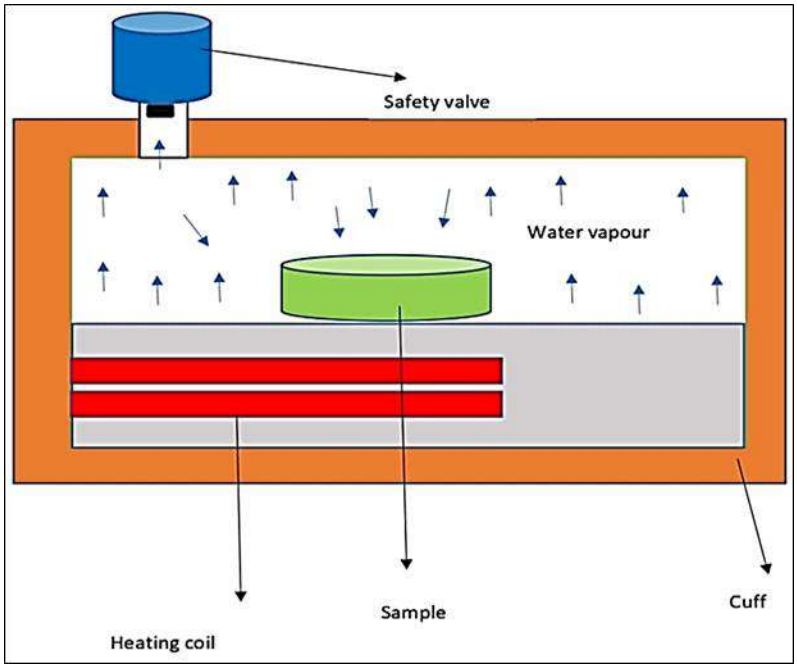
5. Methodology

The method around this project is the water bath. The design of the device is given below. In general, we know that immersion rods are used for heating the water. These immersion rods are made up of Nichrome materials which produces heat when electric current passes through it. The heating rod is immersed in the inner box and it is filled with water. When electric current

passes through the immersion rod it starts heating the water and at a latent temperature the liquid form of water changes into the steam or moisturous form of gas and makes the sample in the tray to be warmed. When preparing for sterilization the temperature must be raised to attain the required temperature to destroy the microorganisms.



Blueprint of the device



Working model of blood warmer and clinical sterilizer

6. Conclusion

In this paper it is concluded that the most effective method for lowering the patient's risk of hypothermia without causing haemolysis and prevent the patient from infectious microorganisms or pathogens is probably to make use of a blood warmer and clinical sterilizer set. The temperature maintenance of the blood warmer set to 40.5 °C helps to utilize the blood warmer probably in a perfect condition and the temperature maintenance of the sterilizer is probably around 89 ^{o}C. We can also conclude that it can useful in small primary health sectors, clinics, clinical camps, etc., everyone should exercise caution when using an infusion pump for RBC transfusion, especially at high flow rates.

References

1. Adams CF, Chirawurah JD, Agbekoh PE, Elsie Effah Kaufman. Design of a Blood-Warming Device for Resource-Limited Settings, 2013.
2. Sanjay S, Jintu D. Blood infusion warmer, 2014.
3. Mukul Lokhande, Arya Gaikhe. Blood infusion warmer, 2021.
4. Thomas G Poder, Wendyam G Nonkani. Élyonore Tsakeu Leponkouo. Blood warming and hemolysis: A systematic review with Meta-Analysis.
5. Jin-Hong Yoo, (Received: April 15, 2018 Publised online: May 11, 2018), Review of Disinfection and Sterilization-Back to the Basics
6. Mohapatra S. Sterilization and Disinfection, 2017.
7. Sterilization-https://en.wikipedia.org/wiki/Sterilization_(microbiology)

Chapter - 7
Deep Analysis on Biomaterials

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Chapter - 7

Deep Analysis on Biomaterials

John Arthur A., Paul Ephraim D., S. Saranya and B. Rengammal Sankari

Abstract

In recent times we all can observe that there are lot of improvement in medical sector on of such kind is the raise of biomaterials, this biomaterial plays a major role in biological system with their unique properties. These biomaterials are different from other materials by their unique properties. These properties are the factor which are to be determined before the introducing any material inside a biological system. A biomaterial helps to improve the quality of life and longevity of humans. Over the last decades it has become clear that the demand for biomaterials has increased rapidly due to the aging population that occurs in practically all the countries of the world, with the elderly being at higher risk of hard tissue insufficiency. Biological and mechanical biocompatibility of metal biomaterials requires much improvement. It is sought to achieve a longer shelf life of the implant biomaterial or that it lasts until the end of life without failures or need for revision surgery. Biomaterials must meet several criteria, such as excellent biocompatibility, adequate mechanical compatibility, high corrosion and wear resistance. Due to the complexity of selecting compatible biomaterial for right implantation is one of a complex process. This paper briefly describes the necessary factors for deciding the right material for implantation.

Keywords: Biomaterials, material science, dataset, mechanical property, data analysis

1. Introduction

Materials which are engineered to use inside a biological system are called biomaterial. the concept of biomaterials was introduced around 1970's to 1980's according to modern literature, but when rolling back the history, there were records of dental implants made out of nacre from seashells during the Mayan's era. Throughout the history there are plenty of recordings of foreign materials being more or less successfully introduced

into the body However, during the year 1960's and 1970's there are materials which has been designed to mount inside a biological system, and these set of developed materials are called the first-generation materials. These biomaterial science addresses both therapeutics and diagnostics. It encompasses basic science (Biology, Physics, Chemistry), Engineering and Medicine.

The translation of biomaterial science to clinically important medical devices is dependent on

1) Sound engineering design.
2) Testing *in vitro* in animals and humans.
3) Clinical realties.
4) The involvement of industry permitting product development and commercialization.

The fig 1.1 illustrate the path from scientific development to the clinical usage.

Fig 1.1

Professor Bill Bonfield, a scientist who was the first one to recognize the importance of understanding the mechanical property of tissue especially in bones in order to achieve a reliable skeletal protheses. The goal of the biomaterials was to achieve the required physical and chemical properties in order tomimic the lost organ or tissue and match the process with minimal toxic response.

The term biomaterial does not literally mean that the materials should be biological based or bio-related materials, the biomaterial can be anything from a metal, ceramics to a plastic and to varieties of composites. But, in order to name a material as a biomaterial there are certain criteria that are needed to be satisfied, these criteria are excellent biocompatibility, adequate mechanical compatibility, high corrosion and wear resistant, etc.

The major purpose of biomaterials is to serve as a replacement or restore the damaged body parts by interacting with living organism, and the most important factor that distinguishes a biomaterial from any other material is the ability to exist in contact with tissue of the body without causing an unacceptable degree of damage to that body and should not trigger any adverse reaction when put into service.

These biomaterials are being used in different parts of human body such as artificial valves in heart, stents in blood vessels, replacement implants in the shoulders, knees, hips, elbows and ears and orthodontics structures.

The structure of the Human Physiological system contains 96% of Oxygen, Hydrogen, Carbon and Nitrogen, which are building blocks of Water and Proteins. Other 4% of additional body mass comes in the form of bone minerals and blood which composed of Ca, P, Mg, and other extracellular fluid comprising of Na, Cl and K.

2. Necessary criteria for biomaterial selection

The Biomaterials are being differentiated from other materials by exhibiting some distinct characteristics that the normal materials can't exhibit. Fig 2.1 lists some of the most basic characteristics that a biomaterial should be satisfy.

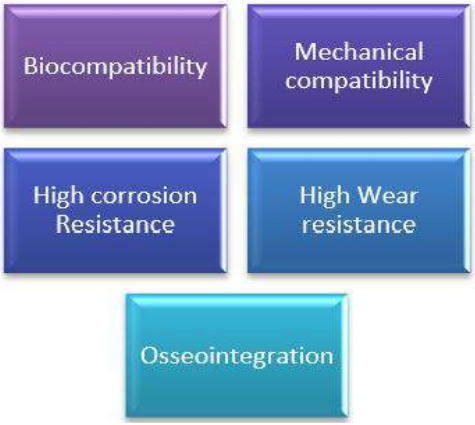

Fig 2.1

Biocompatibility

The term biocompatibility can be defined as the ability or capacity of the material to be used in close connection with the living tissue without causing any adverse effect to them. And the other important requirement is that the body parts or tissues of a patient coming into contact with the implants should avoid any physical irritation, inflammation, toxicity, mutagenic or carcinogenic action. Missing any one of the above-mentioned characteristics can lead to the failure of the protheses.

When an implant is introduced into the host body, various reactions take place inside the biological system, this reaction determines the acceptability of the materials by the system.

Considering the biocompatibility property there are 2 major problem that are being faced these are,

1) Thrombosis, which involves blood clotting and adhesion of the blood platelets to the surface of the biomaterial.
2) Encapsulation of fibrous tissue from the implanted soft tissue biomaterials.

Considering the Human physiological system, the whole body consist of 96% of Oxygen, Hydrogen, Nitrogen and Carbon which are building blocks of water and proteins. And the other 4% of the body mass consists of bone minerals, and blood composed of Ca, P, Mg and extracellular fluid which comprises Na, Cl and K.

Therefore, developing a material with these components as base can increase the compatibility with the physiological system.

Mechanical compatibility

The mechanical compatibility will not be the same for all materials, the required properties will be varied according to the implant site. All the Bioimplants will have the ability to withstand all forces and related loads. It is necessary for a Bioimplants to withstand all the forces, in order to avoid any fracture.

The mechanical properties determine the types of biomaterials to be chosen. Fig 2.2 lists some of the basic mechanical properties that are taken into consideration while choosing the materials.

During the development phase these biomaterials are subjected to repeated cyclic loads, and the fatigue strength of the materials are determined. And if any biomaterials break down or fracture due to the inadequate resistance or divergence in mechanical properties between the bone and the implant, are referred to the biomechanical incompatibility.

Fig 2.2

High corrosion resistance

The biomaterials are normally exposed to the critical level of humidity and in environment high percentage of localized corrosion. Therefore, corrosion resistance is a very essential characteristic.

The low corrosion resistance of implants in body fluid results in the release of metal ions not compatible with implants in the body, it has been studied that the released ions cause allergic and toxic reaction. When the oxide layer on the metal is broken, corrosion occurs, and the metal ions are being released. The outer is then passivated in a process known as regeneration. The rate of corrosion and the release of some metal ions are highly dependent on the regeneration time.

It is been studied that the presence of metallic ions in the tissue around implant has been reported to cause Carcinogenicity, Hypersensitivity, Allergy, Local Tissue Toxicity, Inflammation and genotoxicity.

High wear resistance and osseointegration

It is a very important that when an implant is been fixed it should not get loose or not to cause any reaction in the tissue in which it is deposited and also the bioimplants are created to improve the quality of life of the patient. The low wear resistance can create an adverse cellular response which leads to the release of harmful enzymes, inflammation, osteolysis, infection, pain and bone resorption.

The term Osseointegration can be defined as the direct anchoring of an implant by the formation of bone tissue around the implant without the fibrous tissue growth at the bone-implants interface. due to the absence of the interposition of the connective or fibrous tissue which establish a direct structural and functional connection, which result in the ability to withstand normal physiological loads without excessive deformation and without initiating a rejection mechanism.

Other factors

There are some unique characteristics that are required to decide a biomaterial. These are

1) Infection control.
2) Biodegradable and bio-absorbable properties.
3) Vascularization of the regenerated soft tissue construct.
4) Regeneration of tissue.

3. References

1. Hench LL, Thompson I. Twenty-first century challenges for biomaterials, Journal of The Royal Society Interface, 2010, 7(4). Doi: 10.1098/rsif.2010.0151.focus.
2. Wagner WR, Sakiyama-Elbert SE, Zhang G, Yaszemski MJ. Biomaterials Science: An Introduction to Materials in Medicine. Academic Press, 2020.