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Application of Mechatronics in Hospital Patient Bed

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***Abstract*— Medical technology has profited from advances in numerous disciplines of engineering. The use of mechatronics in conjunction with biomedical engineering and human anatomy has enhanced the treatment procedure for patients dramatically. Conventional patient beds were found to be cumbersome, and modifications were required keeping in mind caregiver's convenience in operation and stress-free comfort for the patient. Mechatronics design is the appropriate way of performing concurrent design tasks with mechanical, electronic, informatics and intelligent control systems integration. Instrumentation engineering, in conjunction with biomedical and mechatronics engineering, has enabled the patient care to greater extent, providing comfortable smartly controlled patient beds in the hospitals. The paper reviews multiple research papers that showcase application and development of mechatronic devices used in the patient beds.**

Keywords—Mechatronics, SmartBed, Robotic Bed, Intelligent System.

I. INTRODUCTION

Mechatronics is the combination of mechanical and electronic parts. It is multidisciplinary activity, where various items and assembling framework plan work in a coordinated way. For diagnosis and treatment of patients, in addition to the expertise of clinicians a combination of appropriate medical instruments and assistive devices are required. Consequently, medical mechatronics emerges as a new technology to advance healthcare. It involves the merger of technologies and expertise from numerous fields, such as electric and mechanical system design, real-time clinical data analysis, assistive/rehabilitation robot creation, and machine/deep learning algorithms. Various procedures such as, endoscopic, medical imaging, etc. use implantable and robotic gadgets for minimal obstructive procedure with great level of accuracy and precision [6,7].

Since June 2001, Chang Gung University's Medical Automation and Rehabilitation Engineering Research Centre (MAREC) has worked at Chang Gung Memorial Hospital to develop key technologies for medical mechatronics systems / modalities and conduct clinical evaluations of newly developed modalities [4]. In this paper, accomplishments from several research projects and part of the localized rehabilitative modalities and technical aids developed in Chang Gung University, were reported.

Figure.1 represents the schematic of mechatronics, indicating mechanical, electrical, electronic, PC and differentframeworks working in coordination. New age machines, robots, and shrewd instruments are required for completing work in an orderly manner in different situations. [3]

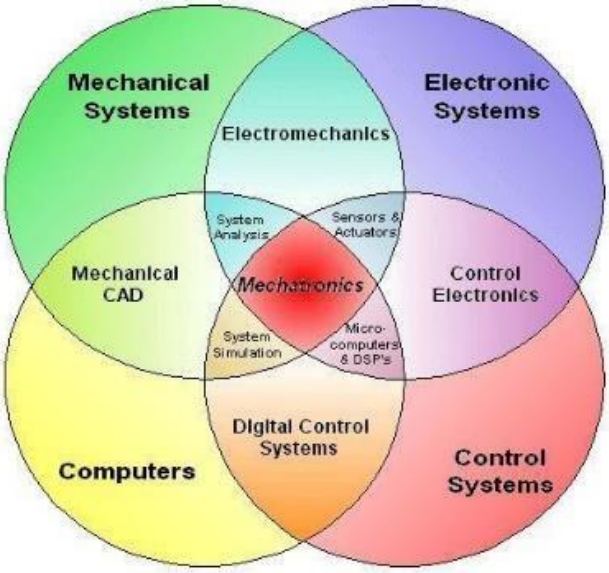

Fig. 1: *Mechatronics [3]*

II. ELECTROMECHANICAL PATIENT BED

In the paper, accomplishments from several researchprojects and part of the localized rehabilitative modalities andtechnical aids developed in Chang Gung University werereported. To list a few are EMG Biofeedback Traction Modality, Patient bed, dynamic postural control assessment and training system, body turning balance assessment, training modality, foldable multi-functional standing wheelchair, electrically driven wheelchair lifting device, etc. The most common and widely used application in healthcare is multifunctional, electromechanicallycontrolled patient beds. Special issue on Healthcare Mechatronics by a Chinese Journal of Mechanical Engineering states that mechatronics is a multidisciplinary field involving machinery, medicine, computer, and automation, which has been widely applied in respiratory therapy, urology robot, rehabilitation exoskeleton, artificial heart, etc. [4]

A research paper Mechatronic design and manufacturing of an affordable healthcare robotic bed was published in Journal for Rehabilitation and assistive technology engineering in 2016. It was discovered that mechatronic design is the only method for completing concurrent design activities that fully integrates mechanical, electronic, informatics, and intelligent control systems. This work presents the mechatronic design process of an affordable assistive robotic bed. Perfect blend of mechanical design with the integration of the electronics and the embedded

controls makes it suitable for all the positions of the robotic bed. There are 12 required positions as depicted in figure 2

which are the most important and required positions of the patients [5].

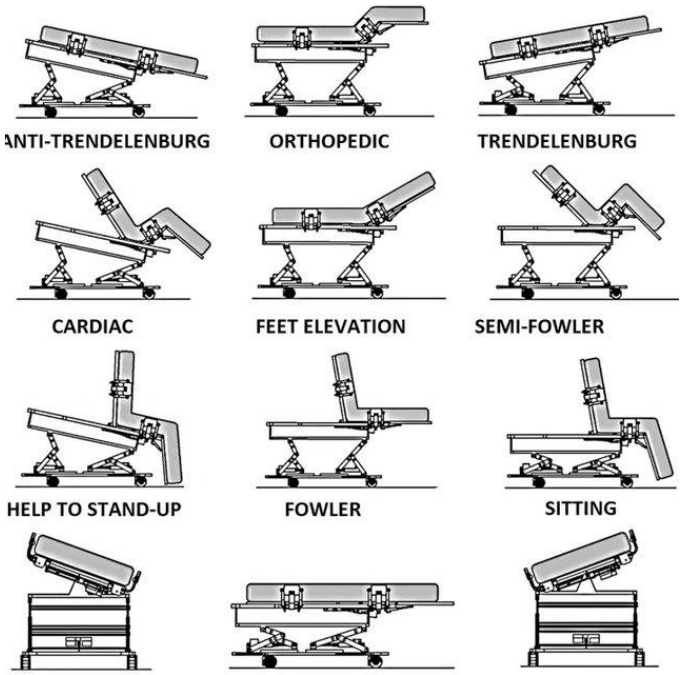

Fig. 2: *Twelve required positions of hospital bed [5]*

A. Mechanical design

Base mechanism: provides enough stability to prevent falls of the patient during handling.
Elevation mechanism: consists of two slider–crank mechanisms coupled to a six-bar mechanism which allows vertical and longitudinal displacement of the section mechanism.
Tilt mechanism: coupled to the elevation mechanism by six SAE grade 1 screws and nuts.
Slide-guard mechanism: slider–crank coupled to the backrest link of the sections mechanism.
Railing mechanism: designed as a four-bar mechanism for the patient's safety.
Brake mechanism: bed will stay at rest with a brake mechanism.
Header mechanism: mounting for an electronic interface andhas an adjustable linear guide.

B. Electronic design

Electronics feeds the sensor assembly such as tilt, lift, weight,etc. embedded in the bed. It also supplies power to all output devices such as LEDs, touchscreen, motors, etc. and are programmed via a central control device as shown in the figure 3and figure 4.

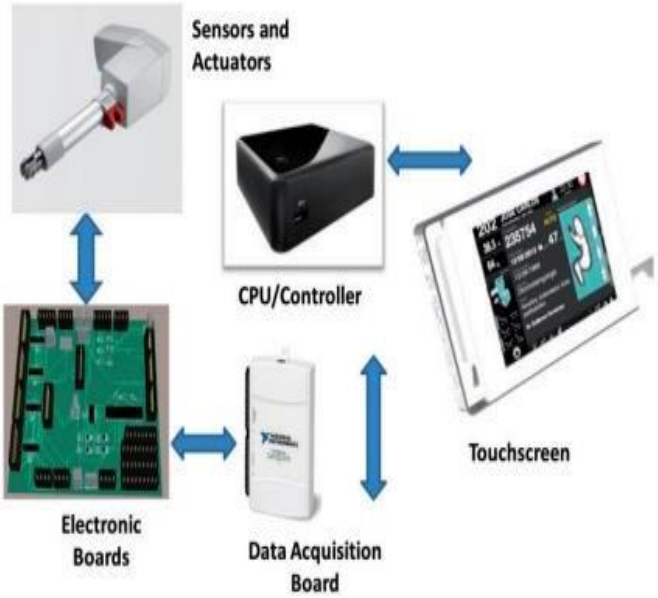

Fig. 3: *Electronic and control design for the robotic bed [5]*

Fig. 4: *Touch screen design control interface at the bedside [5]*

C. Control system design

The control system provides smooth motion between the bed positions. Actuators used for smooth motion are commanded to a desired position using polynomial interpolation between each position.

D. Intelligent system design

The main task of the intelligent system as shown in figure 5, is to decide when it is feasible and safe to move to the desired one. State transition diagram has been specially designed ensuring safe transitions between the bed positions.

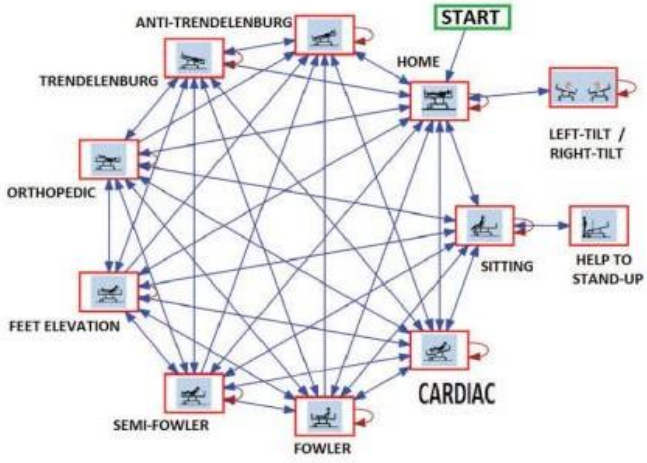

Fig. 5: *State transition diagram [5]*

III. MECHATRONIC SMART BED

Monitoring the patients' movements along with pre-set alarm system for probable dangers such as unexpected falling of the patient off the bed, is possible with the concept of a smart bed. It sends information to the caregiver and/or patient's family remotely using mobile device through cloud technology as represented in the figure 6.

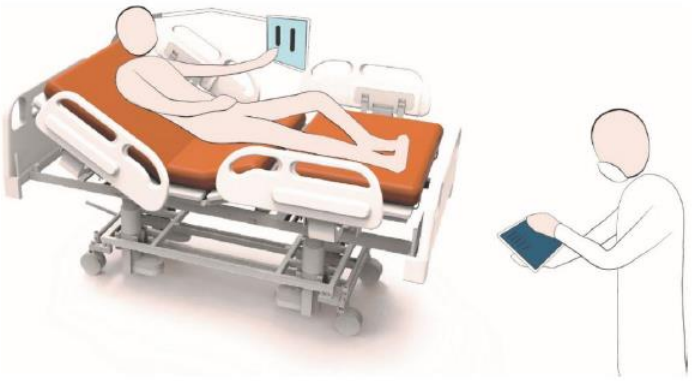

Fig. 6: *SmartBed Concept design [1]*

Eiji Onchi et al, in 2016 in the research paper published in IEEE International Conference developed a SmartBed. This would enable the caregiver to remotely monitor patient's position using GUI (graphical user interface), with all the controls for positioning of the bed, contactless control system avoiding any infection through contact, providing a sense of autonomy to the patient [1]. SmartBed had 4 sections namely, mechanical design, electronic design, software design and graphical user interface.

A. *Mechanical design*

Six actuators are used in the design with four linear column actuators having stroke length of 380 mm. A load of 700 N to 1500 N was used in the design to enable various movements with the minimum stress on the mechanical components. The two actuators with stroke length of 200 mm and 100 mm are used at the head and foot section as represented in figure 7.

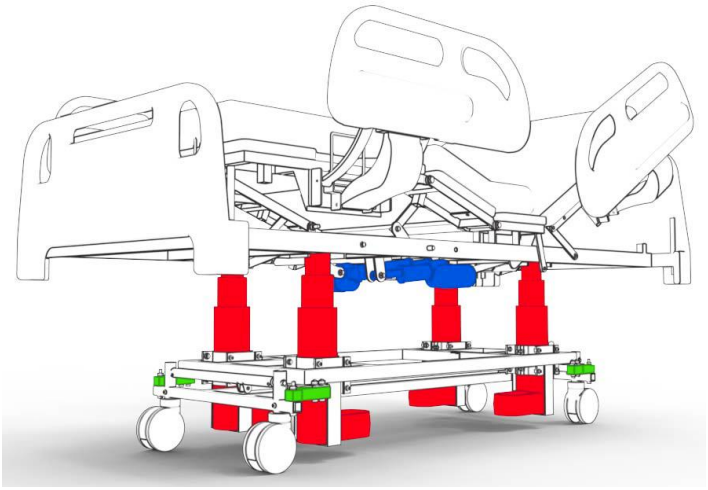

Fig. 7: *Actuators (red) and load cells (green) [1]*

B. *Electronic design*

In the electronic section, the SmartBed uses Android Operating system with two tablets, one used by the patient for commands and alarm and the other by the caretaker.

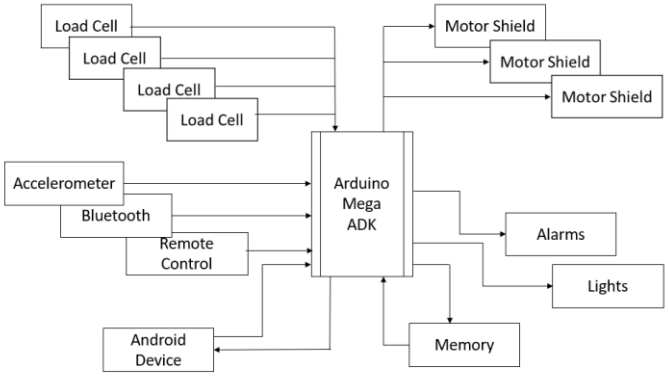

Fig. 8: *Mechatronic Bed Modules [1]*

As shown in the figure 8, four load cells are placed at the base of the bed to measure the average gravity center and weight of the patient. Each load cell carries out independent measurement which is used for further analysis after proper processing of the data. Each load cell also enables to get the historic data of patient's weight and gravity center from time to time. It also has a bright white LED strip relay for alarms. Light helps guide the caregiver at night. It is also connected to the hospital's audio alarms system to ensure minimal response time of the nurses and immediate assistance in case of an emergency.

C. *Software design*

As shown in figure 9, four layers are stacked from top to bottom: HMI layer, consisting of GUI used to control the bed, application layer, providing necessary software, android OS layer, serving as a link between hardware and application layer and the hardware layer, with CPU, memory, storage, etc.

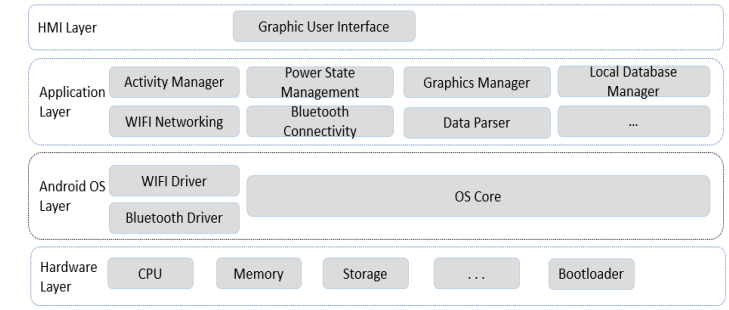

Fig. 9: *Software Architecture [1]*

D. Graphical user interface

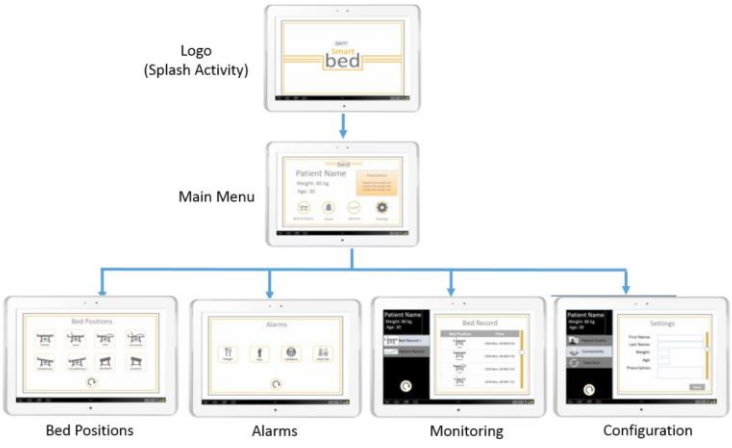

Fig. 10: *Graphical user interface [1]*

Proposed graphical user interface as represented in figure 10, performs six activities such as splash at the start of the software, main menu with visual and functional activities, bed positions setting as per the requirement, alarms to express need for assistance, monitoring of the bed position and configuration of the patient profile.

IV. Voice Actuated Hospital Bed

Kajol. H et al, worked on a prototype to build a smart intelligent bed that responds to voice commands for operation of the bed. It was designed keeping in mind the immobility of patients. Intelligent bed has 4 modules namely, mechanical, electronic, software and voice module [2].

Mechanical system design requirements that were considered were the wiper mechanism for free movement of the bed, loading capability and fine adjustments of bed as shown in figure 11.

A. Mechanical design

Fig. 11: *Mechanical structure [2]*

B. Electronic design

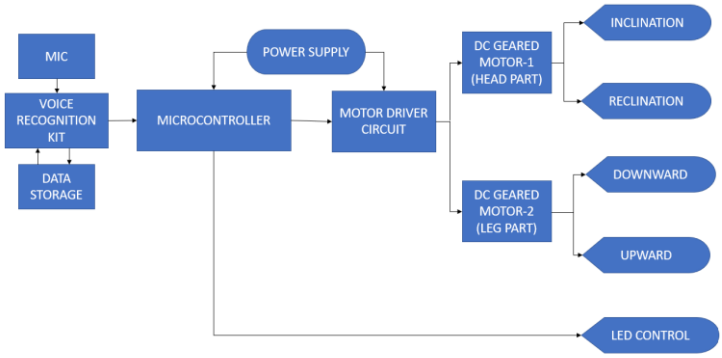

Fig. 12: *Electronic system [2]*

Commands are picked up by the mic and fed to the voice recognition kit. Voice commands are converted to ASCII character which are then fed to the microcontroller which controls the motor driver circuit. As per the command, the motor driver circuit operates the motors, enabling rotation and movement of the bed.

C. Software design

The voice used for training is received by the mic and fed to the voice recognition kit and converted to ASCII character and stored. LED ON indication is fed to 16th GPIO pin with 4 seconds delay. If no voice command is received, the LED will turn OFF. The voice command activates the motors. First the user trains the system for activation in secured mode. Once the system is trained, the user can choose the angle of alignment of the bed.

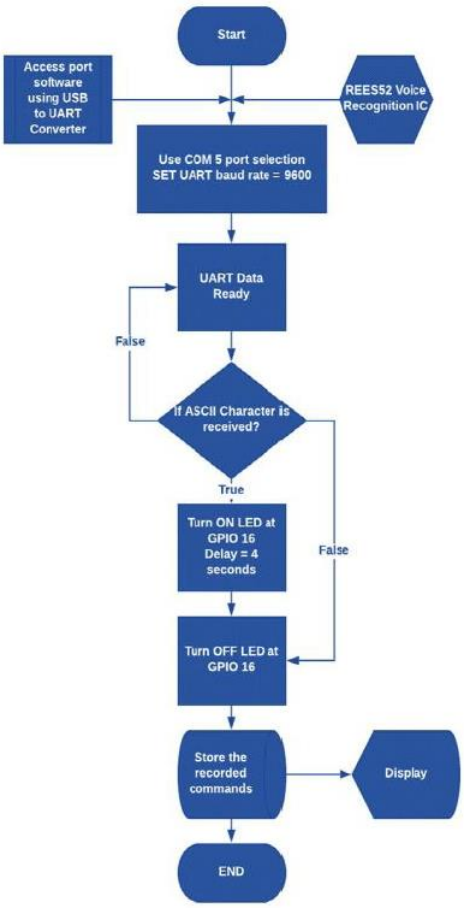

Fig. 13: *Main control algorithm flowchart [2]*

D. Voice module

Fig. 14. *Voice module chip [2]*

Figure 14 represents the voice module chip. Inputs fed to the motors for movement of the bed are all through the voice commands. In this system, the concept is built on the use of speech processing chip. The user trains the system by his / her voice and then operates the bed in a secure manner. According to the patients' requirements, various commands such as Incline (head movement), Recline (head movement), Upward (leg movement), Downward (leg movement), Lights on (led on), Turn off (led off), etc. can be achieved

CONCLUSION

In this review paper, we have discussed briefly about the multidisciplinary aspects of mechatronics. Mechatronics has various applications in medicine such as diagnosis, therapy, surgery, research where in the mechanical assembly are controlled by electronic circuits. We have tried to present our review on the various design of the hospital patient beds and how mechatronics has played an important role in automation and control.

ACKNOWLEDGMENT

We take this opportunity to acknowledge the researchers who have helped us understand the applications at the design level with deep understanding. We also thank our faculty members, Head of Mechanical Engineering department and the Technofocus team for this opportunity.

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Light Sensed Automated Blinds

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***Abstract*- Conceptual This undertaking is tackling the issue of squandered energy inside structures andhomes, since at present the lights turned on inside building don't use normal, encompassing sunlight. As opposed to having pointless light from the sunlight as a source, the robotized brightness detecting savvy curtains can detect how much light outside the window and, in the room, and then change the point of the curtains to reduce energy byusing the accessible open air light. Along these lines,the light source won't run at greatest power yield while there is abundance light getting through the window.**

Keywords- Energy, Arduino Microcontroller, Light dependent Resistor, Bi-Polar Stepper Motor.

I.INTRODUCTION

Natural sources incorporate coal, oil, and flammable gas, which are the three biggest wellsprings of energy consumed around the world In the event that these sources won't be renewed in our entire life, that impliesour usage rate is more noteworthy than our inventory rate, which will lead to in these sources at being the least spend.Accordingly, energy utilization decrease has turn out to be progressively significant, to ensure that we will have sufficient energy to support life later on. Albeit inexhaustible energy sources have become all the more broadly utilized, the most ideal way to lessen utilization of non-renewable energy sources is to lessen energy utilization. Because of this worry, many arising and creative innovations have acquired customer support throughout recent years. A portion of these developments incorporate high level assembling,Driven lighting, electric vehicles, and sun based advancements. Particularly as far as sun based advancements, worldwide creation has been expanding30% throughout the course of recent time, with costs falling almost 20% year. The energy effectiveness and assembling enhancements about this innovation have empowered their expansion underway, which has helped decisively with diminishing utilization of non- renewable assets.. Home upgrades are a enormous way humankind is endeavouring to do to decrease energy utilization whether that be through LED lighting, or imaginative structure plan. For home advancements, the emphasis has been on alternatives with proficient enhancements like better lodging outline plans, cool rooftops, and sun based boards. Sunlight powered chargers on housetop amplify the measure of daylight hitting them consistently, which thus gives energy to the house. These advancements are significant in view of the advantage they offer home purchasers in decreasing energy utilization and consequently energy cost.

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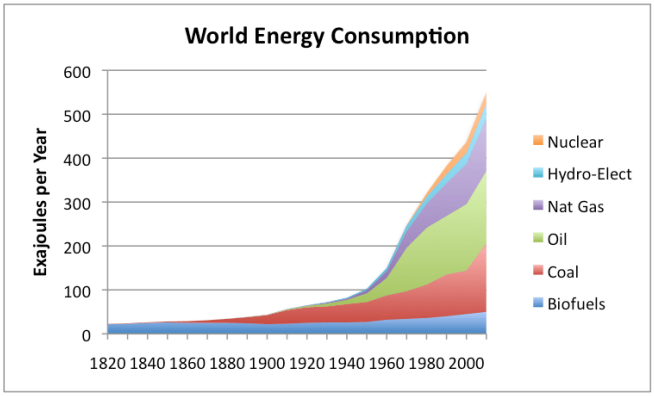

Fig 1: *Energy Consumption around the world*

II. MOTIVATION

As maintainability has come to the very front of current innovation, individuals are constantly searching for ways of being more economical in their daily existences. The field of smart-home innovation squeezes into the property holder's endeavor to turn outto be more reasonable. Going from sun powered chargers to indoor regulators, individuals are ceaselessly tracking down better approaches to propel this innovation. This is where the thought for robotizedblinds becomes an integral factor. As one extra mannerfor property holders to be more possible furthermore, placed away money, robotized blinds will allow belongings holders to shop electricity, and cash, by means of not having to control their lights and blinds truly. settlement holders waste strength by means of leaving lighting fixtures on and blinds shut throughout the day, proper when there may be a ton of regular light

for them to make use and to hold the fundamental percentage of mild in the room. The proposed sensible blinds will paintings nearby mild at the same time as normally changing the blinds to assist how lots light; henceforth, placing apart the belongings holder cash and strength. With a critical statistic on microcontroller coding, the patron will can change howplenty light that they remember to be a "great" level. the overall goal of our enterprise is in this manner to designa shape so that it will set apart energy and money by using uniting indoor lights and robotized blinds to givethe property holder a pleasant percentage of mild of their homes.

III. LITERATURE SURVEY

A automatic inside blinds frameworks changed into created with programmed behavior nearly same to the framework that become assessed in a past subject havea look at to check in a managed setting and not rely on real sorts in light situations, an office weather with a virtual window turned into made wherein mild occasions might be reenacted. Direct daylight turned into emulated with a LED spotlight and its mild result limits were set as triggers for the blinds frameworks tolower or increase the blinds. The planned light circumstances filled the predominant want of this assessment to assess unique expressive factors of interaction and computerization strategies with the blinds in a particularly quick length and in a controlled manner, without being challenge to or impacted through real sorts in proper daylight situations. The virtual window with an 'out of doors view' animated individuals to have the blinds open, at the same time asthe LED spot had the option to make glare and invigorated participants to carry down the blinds. It must be noticed that the mild force, range, and glare discernment edges had been specific for the digital window also, LED spot design of the 2 examinations and on this way no longer generalizable to genuine daylight situations. as an example, people by and largeare more open minded for glare from actual daylight with a view than from fake mild resources. The mechanized blinds framework become stretched out with an expressive connection factor to bring to the clients about its popularity and goals. This input deviceought to be 'surrounding' and implanted in the shape weather illuminating clients in an not noticeable way. that is regarded as a substantial nice for our framework,considering that workplace laborers anticipate it working discreetly within the basis with out scary them,at the same time as concurrently being mindful and receptive to their requirements. one of a kind instancesof encompassing data frameworks had been created forone of a kind regions making use of suggests, sounds, normal items, or workmanship portions to light up the consumer. on this evaluate, we check out the utilizationof a lighting fixtures machine inserted within the blindsto impart to clients about its popularity and expectations.

IV. PROPOSED DESIGN

The blinds may be managed with an engine changed through an engine breakout board and an Arduino interface, taking into consideration the microcontrollerto change the blinds as required. The Arduino will decide how much indoor mild is essential additionally,how an awful lot the blinds need to be open. The framework ought to be financially savvy. This prerequisite is big in light of the truth that the thought behind this venture is to squeezed into the smart domestic innovation area; thusly, the framework has to work independently to store the customer coins and electricity once this framework is introduced. finally, the opposite client necessity is that the framework commonly maintains the precise degree of mild withinthe room, allowing the customer, an agreeable degree of mild that in the end depends on their selecting. these details are similar to quantifiable mission particulars cross, as a long way as viable this venture has the stepper engines having enough force to move the blinds with no without a hitch inconvenience. otherthan the size of the window, the rest of the framework will comprise of the Arduino, a bit circuit board, and the attachment for the divider outlet. The Arduino and circuit board will not require a ton of room and will be handily housed in a bit container, occupying insignificant room.

V. IMPLEMENTATION

5.1 Hardware Integration

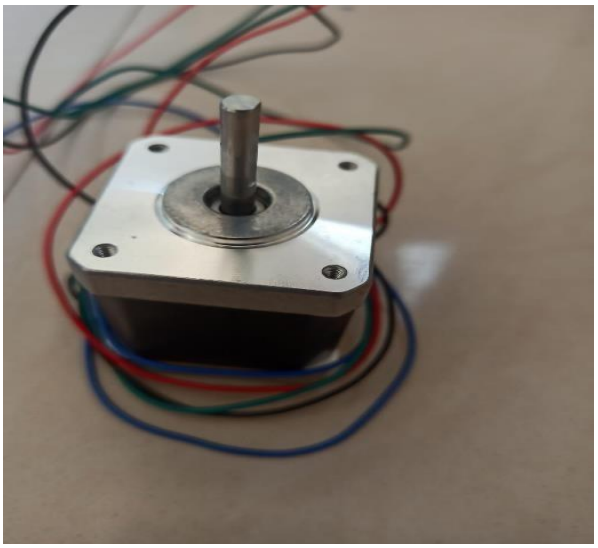

Fig.2.1: *Bipolar Stepper Motor*

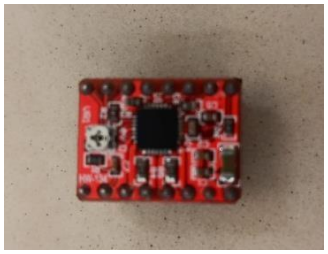

Fig.2.2 *Stepper Motor Driver*

To begin with, to make the framework absolutely unbiased, the plan utilizes an Arduino Uno Microcontroller to locate the light and manage the engines. this could recall the framework to run every time the Arduino has electricity, permitting insignificant cooperation with the framework from its consumer. Then, to allow the framework to experienceoutside mild, we bought 5mm LDR from. these sensorswere picked for 3 primary motives. inside the first area, the way that this item interfaces properly with the microcontroller being utilized. 2d, the sensor can understand mild ranges that's all that could likely be needed for this application. third, the sensor is low power, drawing underneath 0.5mA when getting used, increasing the proficiency of our framework. while planning a way to manage the engine, we picked a realistic engine driving force that would make control of the engine simple and could take an contribution of 5V from the Arduino. The engine picked is little and evaluated for the end result voltage of the engine motive force. The engine is NEMA four.2 kg-cm. The NEMA17 four.2 kg cm Stepper Motor can supply 4.2 kg-cm of pressure at 1.2A current in line with stage. we've got utilized a4988 stepper engine motive force. Later welding a header to the stepper engine driving force, we ought to then bind the four wires from the stepper engine straightforwardly to the motive force. tomanipulate the stepper engines using the driver, the development also, bearing pins of the driving force arerelated to the Arduino. With those pins, we will alternate the speed of the engine, and liken that to a wanted distance utilizing the accompanying situations.to manipulate the engine improvement, the development pin should shift back and forth amongst excessive and coffee, with a postpone among changingthe pin. delay is ultimately decided, in mild of the spacein line with step (60microns/step), the approach in stepwith transformation (2 hundred tiers/hearth up), and thevelocity (rpm).

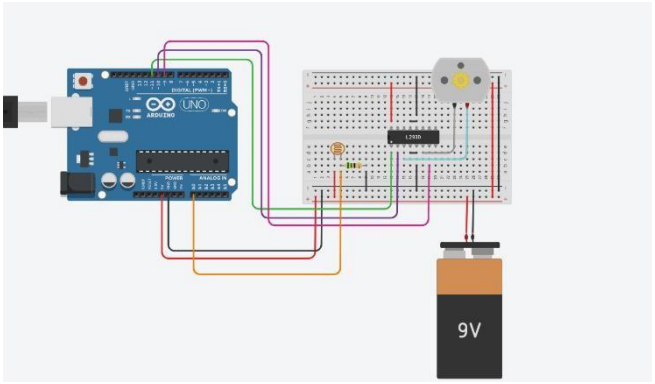

Fig.3.1: *Implementation of circuit.*

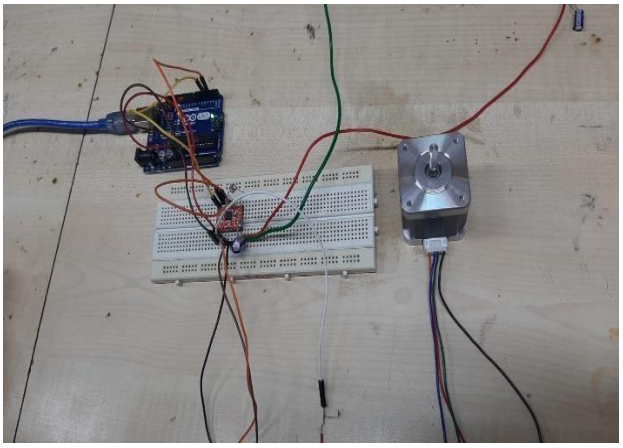

Fig 3.2: *Actual Circuit Implementation*

VI. RESULTS AND CONCLUSION

6.1 Conclusion

This became to devise a smart blinds framework to beable to can run all by myself, along these traces savingthe patron energy by way of exploiting outdoor lighting when it is ok and accessible to light the room.This objective turned into performed utilizing a blinds framework that integrated an Arduino, light sensors, awith no end in sight engine driving force, and pulley framework to open and near the blinds. This challengedemonstrates that that is a sensible desire for loan holders hoping to cast off their power bill. at some stage in the challenge, mild troubles had been determined and tended to, the greatest of which changed into getting forward motion on the pulleys to drag the blinds with sufficient energy. while this trouble was tended to and all the components were successfully tried, it became a depend of mounting thefull framework and testing it. happily, these assessments went nicely average, and the blinds worked as anticipated. nicely, and the blinds operated as intended.

6.2 Social Impact

This venture has tackled the issue of squandered energyinside structures and homes, in light of the fact that at present the lights turned on inside building try not to use normal, encompassing light from the sun. The robotizedlight detecting smart blinds can detect how much light external the window and in the room, and then change the point of the blinds to save energy by using the accessible open air light.

VII. ACKNOWLEDGMENT

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Evaluation of hybrid acid and alkaline base pretreatment for fractionation of lignocellulosic biomass

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Abstract—-Most of the fuels and chemicals essential to modern human civilization are derived from fossil fuels, which are non-renewable resources and have harmful effects on the environment and human health. As fossil fuels play an important role in today's modern world, there is a need to find an alternative. Lignocellulosic biomass is one of the alternatives that has shown tremendous potential to gradually replace fossil fuels with a cheap and renewable source. Pre-treatment is the first and is considered to be one of the most important steps in the biorefining process, accounting for 40% of the total process cost. In this project, we investigated the fractionation and hybrid pre-treatment of various lignocellulosic biomasses such as rice straw, wheat straw, and birch wood to convert them into glucose and other high-value products and to make the process more economical. This was done using a mix of physical and chemical methods to pre-treat the biomass, physical methods such as ball milling, microwave, and chemical methods such as alkaline, oxidative and acidic pretreatment were investigated. It was found that by treating birch wood with alkali and acid in series, the biomass could be efficiently fractionated. After alkali treatment a thick brown liquor is obtained which was precipitated to obtain lignin, reducible sugars were detected after acid hydrolysis which we assumed to be xylose from hemicellulose hydrolysis.

Keywords—Lignocellulosic Biomass, Pretreatment, Hybrid pretreatment, acid, alkali

I. INTRODUCTION

Most of the chemicals produced in the world today are derived from fossil fuels or natural gas, from fertilizers to plastic bags that we use in our daily lives, fossil fuels are becoming increasingly important. According to a report, 3.9 million tons of crude oil were extracted in 2017 and that number has grown since then [2]. India imports around 82% of its oil and 45.3% of natural gas / LNG [3]. In 2019 India imported 209.3 MT of crude oil, which makes us the second largest crude oil importer in the world after the USA and China [1].

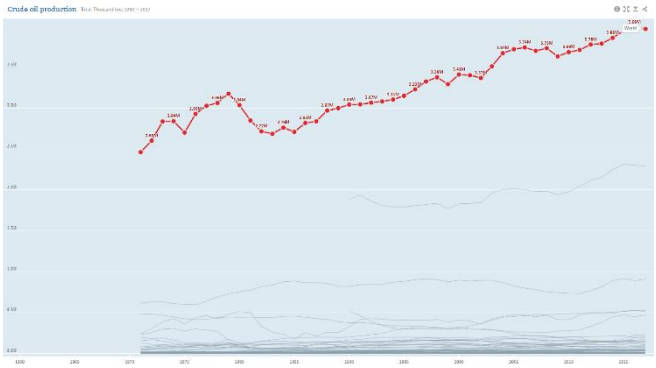

Fig.1*: Crude oil production from 1970-2017*

Most of the products we consume start as petrochemicals, which are compounds made from petroleum. Olefins, which include ethylene and propylene, and aromatics, which include benzene, toluene, and isomers of xylene, are the two most prevalent types of petrochemicals [7]. Olefins have typically been made through steam cracking of natural gas or fluidized catalytic cracking of petroleum fractions. Olefins and aromatics are the fundamental components of a wide range of substances, including adhesives, detergents, and solvents. Olefins serve as the building blocks for the polymers and oligomers utilized to create gels, lubricants, elastomers, resins, fibers, and plastics [8, 9]. Due to its usage in the production of numerous chemicals, ethylene is one of the most significant and widely produced olefins [10]. In 2019 there were 190 million tonnes of ethylene produced worldwide [11]. A significant portion of this manufacturing is utilized to create polyethylene, a common plastic formed of polymer chains composed of ethylene units with different chain lengths. In agriculture, ethylene, a crucial natural plant hormone, is employed to accelerate the ripening of fruits.

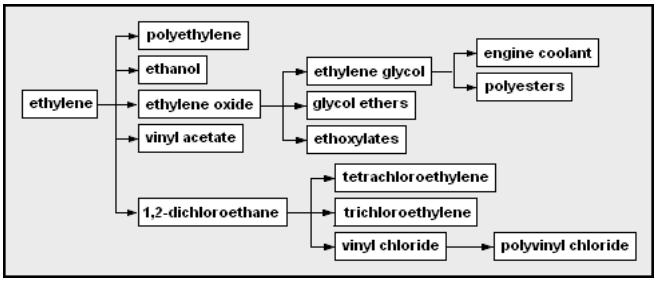

Fig.2*: Chemicals produced from ethylene*

Since crude oil includes toxic and heavy metals that, if discharged into the environment, can harm the environment, crude oil also has known adverse consequences on our environment and human health. If handled poorly, several industrial byproducts, such as volatile organic chemicals, nitrogen and sulfur compounds, and spilled oil, can pose a serious hazard to human life by contaminating the air, water, and soil [4,5]. Global impacts like ocean acidification, sea level rise, and global warming are made worse by industry emissions of soot and other microparticulate aerosols, as well as greenhouse gases like carbon dioxide and methane [6]. As a result, a large number of environmental groups and climate activists have opposed the use of petroleum and the transition to renewable energy sources. However, it should be noted that the crude oil industry has grown alongside numerous other industries (the petrochemical industry) that use their waste products to create the precursors for the production of numerous chemicals that we use on a daily basis, making it challenging to quickly reduce the use of crude oil. It is vital to develop an alternative to petroleum and the chemicals made from it as well as to gradually phase out petroleum and employ renewable resources due to the issues associated with crude oil.

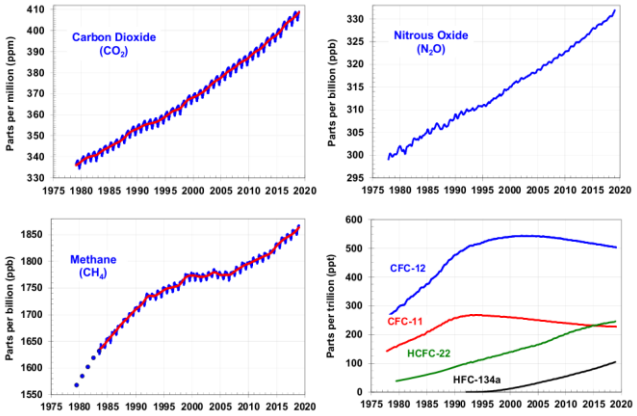

Fig.3*: Major greenhouse gas trends*

Since lignocellulosic biomass is the most plentiful renewable resource and is substantially less expensive than crude oil, it has demonstrated enormous potential as a replacement for fossil fuels [12]. The term "lignocellulose" describes a plant's dry substance. It is made up of aromatic polymer and carbohydrate polymers (cellulose, hemicellulose) (lignin). Only 3% of the estimated 200 billion tonnes of lignocellulosic biomass produced year worldwide are employed in the pulp and paper sector [14]. Corn stalks, sugar cane bagasse, rice straw, wheat straw, barley straw, waste from sawmills and paper mills, rod grass, and elephant grass are just a few examples of the resources that can be used to produce lignocellulosic biomass. Depending on the growing conditions and the individual plant, the lignocellulose biomass content can change.

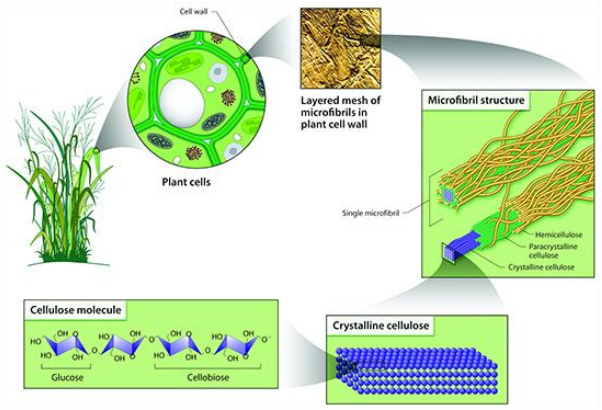

Fig.4 *: Lignocellulosic material in plant cell*

Our climate, economy, and energy security might all be significantly improved by using biomass as a clean, renewable energy source. In comparison to fossil fuels, biomass energy produces far fewer air pollution, less trash is dumped in landfills, and we are less dependent on foreign oil. It may be possible to lessen some unfavorable aspects of fossil fuel production and use, such as conventional and greenhouse gas (GHG) pollutant emissions, exhaustible resource depletion, and dependence on unreliable foreign suppliers, by substituting biofuels made from renewable organic material for fossil fuels.

As a renewable energy source, biomass cannot be destroyed. Given that plants are the primary source of biomass, biomass will continue to be a source of renewable energy for as long as there are still plants on the earth. Because it addresses the issues with food and energy security connected with using edible food for the manufacture of biofuels, lignocellulosic biomass is a substantial replacement for sugarcane and maize. Cellulases, hemicellulases, and ligninases are lignocellulose-degrading enzymes that are essential for turning lignocellulose into sugars and biofuels.

Cellulose, hemicellulose, and lignin make up the majority of plant cell walls; combined, they create a complex and stiff structure that gives cells their strength and binds them together.

Cellulose is a 4C1 conformational linear, high molecular weight polymer made up of - (1-4) -D'-glucopyranose units. The -linked glucopyranose residues' completely equatorial conformation stabilizes the stool structure with the least amount of flexibility. The glucose anhydride that is created after the water has been taken out of the glucose is polymerized to create long cellulose strands that contain 5000–10,000 glucose units. The cellobiose unit, the fundamental repeating unit of the cellulose polymer, is made up of two glucose anhydride units.

The percentage of hemicelluloses, which follow cellulose as the second most prevalent natural polysaccharides, varies depending on the type of plant; for example, the amount in barley straw is 33–36%. The polysaccharide portion of plant tissue that is susceptible to the action of diluted acids and alkalis is typically referred to as the hemicelluloses. They are composed of a variety of sugar monomers and are chemically complicated. For instance, in addition to glucose, hemicellulose also contains sugar monomers such as arabinose, galactose, mannose, xylose, etc. Hemicelluloses are weaker than cellulose and have lower molecular weights.

The third most prevalent natural polymer in nature, behind cellulose and hemicellulose, is lignin. It is a crosslinked amorphous resin with no clear structure. It serves as the primary adhesive for the aggregation of fibrous cellulose components and provides a barrier of defense against the cellulose fibers' quick microbial or fungal deterioration. Lignin is a three-dimensional, highly branching, a polyphenolic substance made up of a randomly arranged mixture of hydroxy- and methoxy-substituted phenylpropane units that are differentially bonded. The structures of these three generics monomeric phenylpropane units are p-coumarin, coniferyl, and sinapyl (Figure 9). These units proceed through radical dimerization, further oligomerization, polymerization, and crosslinking during the lignin manufacturing process. The sites at which radical dimerization takes place throughout the lignin-formation process are shown by the resonance hybrids of the radical created during the oxidation of coniferyl alcohol.

Material	Cellulose %	Hemicellulose %	Lignin %
Rice straw	38	25	12
Wheat straw	28-39	23-24	16-25
Hardwood	45-55	24-40	18-25
Softwood	45-50	25-35	25-35
Grasses	25-40	25-50	10-30
Elephant grass	60.20	23.80	8.20
Sugarcane bagasse	32-34	19-24	25-32

Table.1: *Composition of lignocellulosic biomass*

The process of fractionating lignocellulosic biomass involves separating it into its three primary components, cellulose, hemicellulose, and lignin. These three components can then be utilized to make the platform and value-added chemicals. One option that has shown a lot of promise for replacing chemicals obtained from fossil fuels is fractionating lignocellulosic biomass. As the first step in the majority of biorefining processes, the fractionation of lignocellulosic biomass has also been demonstrated to increase the efficiency of the biorefining procedure. The kraft process in pulp and paper mills traditionally yields lignin, which is then burned to create energy [26]. It can be depolymerized and transformed into aromatic chemicals such as benzene, toluene, styrene, bisphenols, chlorohexidine, etc. because of its aromatic stricture [25]. Since D-xylose is a typical diabetic sweetener in foods and beverages, xylose made from hemicellulose has several uses in the food sector [27]. Some investigations [28,29] have demonstrated the utilization of xylose in the generation of enzymatic hydrogen at a temperature and yield of 100%.

Since lignocellulosic biomass is a complex polymer of cellulose, hemicellulose, and lignin that has evolved over millions of years to withstand the biological and environmental attacks that are frequent in nature, pre-treatment is the first and one of the most crucial steps in the biorefining process, as shown in Fig. 5. As a result, biomass must undergo some sort of "unnatural" pre-treatment in order to be more vulnerable to enzymatic attack [30]. To reduce the cost of biorefining, which is accounted for by pre-treatment alone, the type of pre-treatment for specific biomass must be carefully chosen. There are several different pre-treatment methods that can be used to treat biomass, including biological pre-treatment, steam explosion, acid pre-treatment, and alkali pre-treatment. However, the majority of processes have issues with longer residence times, corrosion from concentrated acid and alkali, or high energy/chemical requirements, which render the process unprofitable. Combining two or more conventional pretreatments to create a hybrid pretreatment approach has produced encouraging results. Pretreatment significantly minimizes dwell time, chemical use, and energy consumption while enhancing product output, as demonstrated in several research investigations. In this study, we explored hybrid pretreatment based on acid and alkali for biomass fractionation on various lignocellulosic biomasses. To remove pure lignin, xylose, and cellulose from crushed wood, we also pre-treated the wood with an acid-alkali solution.

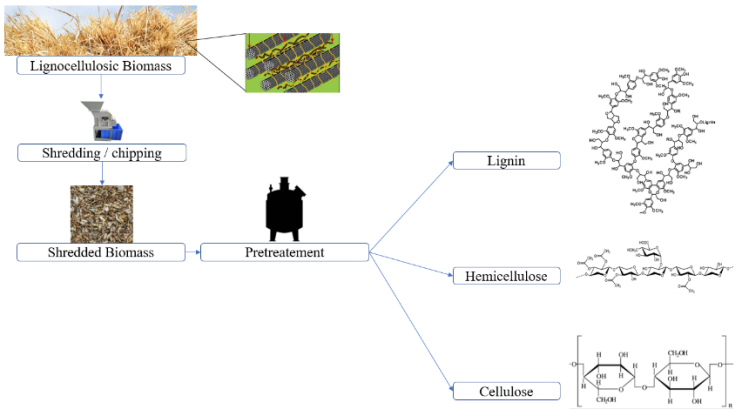

Fig.5: *Schematic representation of lignocellulosic biomass fractionation.*

II. Hybrid Pretreatment

A. Alkali Ball milling pretreatment

One of the most popular mechanical activation techniques for raising the Surface of lignocellulosic biomass is ball milling. Ball milling the pre-treatment of lignocellulosic residues has a significant impact on particle size reduction despite the high energy required. reductions in crystallinity and levels of polymerization of cellulose, as well as changes in the crystalline structures of cellulose and chemical bond distortions brought on by applied stress. Ball milling has been demonstrated to decrease the crystallinity of cellulose from cellulose I to cellulose II, and the presence of NaOH in the solution aids in reducing the amount of lignin [32]. Reducing chemical and energy usage can be accomplished by utilizing the synergistic effects of ball milling and alkali treatment. A 73% xylan recovery yield was observed when 4-5% NaOH in a slurry form (or around 0.4 g NaOH/g wheat straw) was used [32]. Increasing the alkaline loading will result in higher molecular weight hemicellulose, which is more valuable commercially [34]. As illustrated in Fig. 5, this method's main advantage over the acid process is that it generates fewer inhibitors, lowers crystallinity, and improves surface area. However, this process has a long residence period of up to 144 hours, as demonstrated by a research study [35,36].

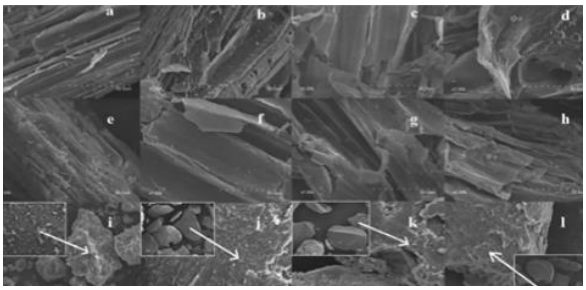

Fig.6: *SEM image of bamboo chips after pre-treatment*

B. Acid Alkali Pretreatment:

An acid-alkaline pretreatment is a form of hybrid pretreatment that fractionates biomass by utilizing the synergistic effects of acid and alkali. Hemicellulose is solubilized by the acidic pretreatment, and lignin is eliminated by the alkaline treatment. By adding bases to biomass, alkali pretreatment increases internal surface by swelling, reduces polymerization degree and crystallinity, breaks down lignin's bonds to other polymers, and decreases crystallinity. Numerous studies have demonstrated that raising the system's temperature enhances sugar output while simultaneously reducing residence time and acid concentration needed [38]. Numerous research has demonstrated how effectively lignin and hemicellulose may be removed using this method. This method's main drawback is the production of hydroxymethylfurfural and other furfurals, which can hinder the cellulase enzyme and necessitate the neutralization of the cellulose produced by enzymatic hydrolysis. A flowchart for the process is shown in Fig. 6.

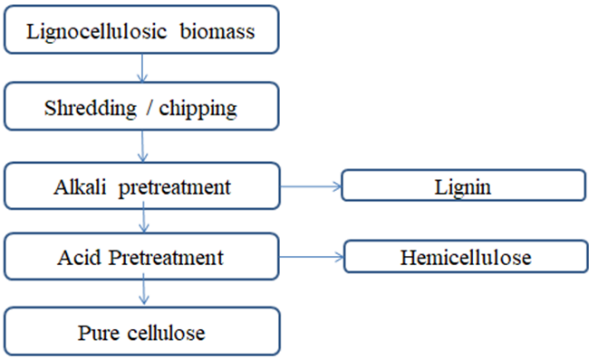

Fig.7*: Schematic representation of Acid alkali Pretreatment*

C. Alkali Hydrogen peroxide pretreatment (AHPP):

Alkali and hydrogen peroxide is used in this technique to dissolve lignin. Hemicellulose in lignocellulosic biomass has been extensively delignified and solubilized using alkaline hydrogen peroxide. Hydrogen peroxide breaks down into three ions in an alkaline environment: perhydroxyl anion, hydroxyl anion, and superoxide anion. These ions are very reactive and react with lignin to slow down its polymerization and partial disintegration. Before the enzymatic technique, the AHPP method holds a lot of promise. Reactivity allowed for simple access to the cellulose by enzymes as the fiber was etched and compressed. After AHPP, the lignin concentration was also noticeably decreased, the fibers were primarily composed of carbohydrates, and the pore capacity and surface area were increased [37]. Lignin was successfully removed without causing any harm to the cellulose and hemicellulose, however, there was a modest decrease in the amount of acid-soluble lignin and an increase in the crystallinity of the cellulose [37]. The best results were obtained using a solid-to-liquid ratio of 1:8 and 1.5% hydrogen peroxide at 90 °C for 4 hours with a pH of 12.6 [37].

D. Acid Ultrasonic pretreatment

Acid Ultrasonic is a hybrid-based pretreatment that extracts hemicellulose, cellulose, and lignin using ultrasonic vibrations and acid. In many biological and chemical processes, ultrasound refers to mechanical waves with frequencies greater than those that are audible to humans. By causing cell wall disruption, increasing specific surface area, and reducing polymerization, ultrasonic energy can improve pre-treatment levels and lignocellulosic biomass use. Its major goal is to solubilize the portion of the biomass that contains hemicellulose and to make the cellulose more susceptible to subsequent enzymatic treatment. Acid pretreatment is most frequently performed using diluted acid pretreatment. a study on the ultrasonic and diluted sulfuric acid pretreatment of sugarcane bagasse (SCB). The pretreatment performed best at 3% sulfuric acid and 120 W of ultrasonic power, and the ensuing enzymatic hydrolysis produced a concentration of fermentable sugars of 26 g/l. In order to extract xylan from corn cobs, Yang et al. investigated the use of diluted sulfuric acid in an ultrasonic pretreatment. In comparison to standard acid treatment, ultrasonic therapy increased the yield and rate of xylan recovery. In comparison to the traditional acid treatment, which took 24 hours to extract 34% of the xylan, the ultrasonic treatment extracted roughly 39% of it in 45 minutes.

Biomass	Type of pretreatement	Chemicals	Pretreatement condition	Results
Peanut shell, pistachio shells	Ultrasonic alkali	4% NaOH	Power: 100 W Residence Time: 70 min	Delignification efficency of 71.1%, 78.9%
Eucalyptus sawdust	Ultrasonic alkali	0.5 – 0.8 mol NaOH	Power: 280 W, 360 W Residence Time: 30, 60 min	Reducing sugar yield of 426.6 mg/g

Fig.8: *Results from Ultrasonic pretreatment*

E. Microwave alkaline pretreatment:

Utilizing the synergistic effects of the microwave and alkali, microwave-alkaline pretreatment involves delignification. Both a non-thermal action and a thermal effect are used in the alkaline microwave process. Water, cellulose, hemicellulose, and organic acids are examples of dielectric materials that make non-thermal microwave radiation possible [39][40]. By interacting with the molecules through an electromagnetic field, thermal microwaves warm the molecules [41]. In comparison to conventional alkaline pretreatment, microwave-assisted alkaline pretreatment eliminated more lignin and hemicellulose from wheat straw in a shorter amount of time. More cellulose, hemicellulose, and lignin were soluble as a result of the longer microwave heating period and more alkaline pretreatment. In addition to efficiently removing lignin from biomass, microwave-assisted alkaline pretreatment also has the ability to produce trace levels of hazardous chemicals, which makes it superior. An alkaline catalyst (0.6 M NaOH) used in microwave pretreatment led to the production of pulp with a high

enrichment in crystalline cellulose and, at the same time, a low amount of lignin and hemicellulose. Pretreatment increases cellulose crystallinity and degrees of polymerization while decreasing cellulose-specific surface area, hemicellulose hydrolysis, and partial lignin depolymerization [41]. In Table 2, additional findings from the use of various biomass under various operating circumstances are shown.

Biomass	Type of pretreatement	Chemicals	Pretreatement condition	Results
Jabon Kraft Pulp	Microwave + acid	1% H_2SO_4	Power:1000 W, Temperature: 180°C, 190°C, 200°C, Residence time: 5, 7, 10 min	Reducing sugar yield increased upto 40 g/100 g dry pulp.
Brewer's Spent Grain	Microwave + alkali	0.5% NaOH	Power: 400-800 W, Residence time: 30, 60, 120 min	228.25 mg/g of reducable sugar after enzymatic hydrolysis.
Brewer's Spent Grain	Microwave + alkali	1% NaOH	Power: 40-500 W Temperature: 31°C - 259°C Residence time: 2-6 min	Removal of 46% Lignin, 38% hemicellulose
Cassava Stern	Microwave + alkali	2% - 4% NaOH	Residence time: 60-120 min	Optimal condition of 116 s, 3.21 NaOH at 719Hz
Cassava Pulp	Microwave + acid	1% - 4% NaOH	Power: 120-160 W Residence time: 40 min	Cellulose content increase from 33.27% to 52.34%
Cassava Pulp	Microwave + alkali	1% - 4% H_2SO_4	Power: 120-160 W Residence time: 40 min	Reducible sugars 0.472 g/g dry biomass

Table.2: *Results from acid and alkali microwave pretreatment*

Response surface methodology in the pretreatment of biomass:

Response Surface Methodology (RSM) is a statistical technique that effectively optimizes complex processes using a multi-factor and multi-response approach. RSM's fundamental premise is to employ a series of planned trials to find the best solution. For this, Box and Wilson advise using a second-degree polynomial model. Even though they are aware that this model is simply an approximation, they nevertheless use it since it is simple to estimate and utilize, even when there is little information available about the process. As illustrated in Figs. 8 and 9, a study of sugar cane leaves using HCl and RSM found an ideal temperature of 5.28% and 187 minutes at a temperature of 94.94 °C.

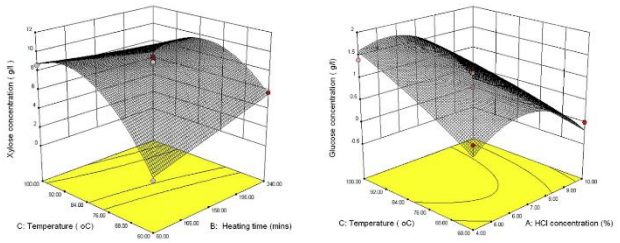

Fig.9: *Response surface for glucose response and temperature and HCl concentration*

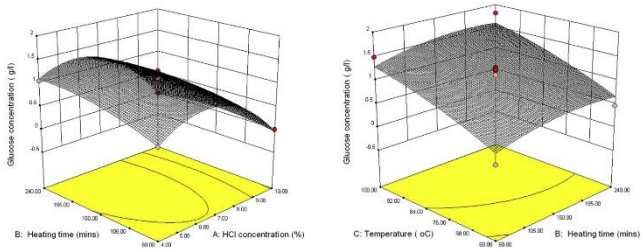

Fig.10 : *Response surface for glucose response and Heating time and HCl concentration*

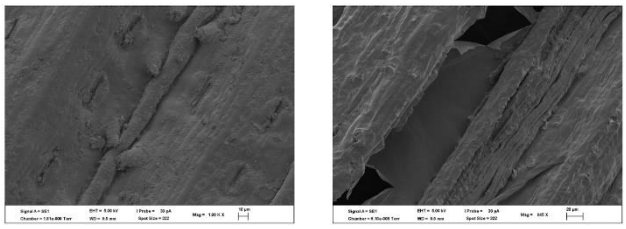

Fig.11: *untreated and treated sugarcane leaves*

III. Methodologyology

The first pre-treatment process was carried out with birch wood treated with an acid-alkaline process. 8.3g of a birch wood sample was shipped to a size of 5mm and then placed in 300ml of 1M NaOH solution and heated at 100°C for 5 hours. After 5 hours the thick brown solution was filtered and separated into two fractions: brown alkaline solution and undissolved solids. The brown liquor solution, composed mainly of lignin, is then neutralized to pH 5.5, after precipitation brown precipitate forms, which is then filtered and redissolved in ethanol to form a pure linin solution. The undissolved solids from the first step are then added to concentrate 300 ml 10 M HCl and heater at 50oC for 12 hours. After 12 hours the solution is filtered to get cellulose and hemicellulose. Fig.12 illustrates the schematic representation of the process.

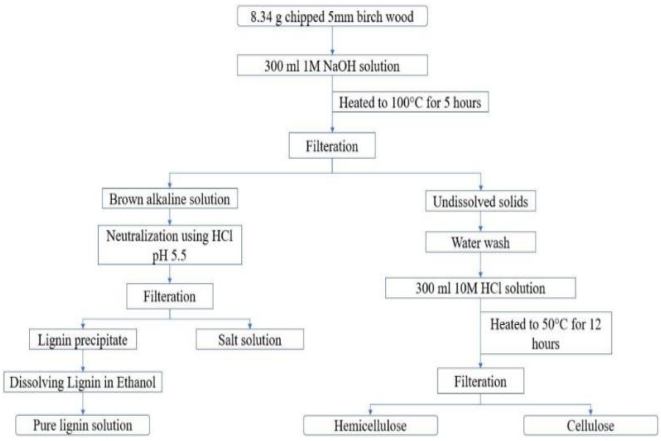

Fig.12 *Schematic representation of the methodology*

IV. Result and Discussion

After the alkaline pretreatment, the brown alkaline liquor was tested for the presence of reducible sugars which were negative, indicating that the hemicellulose and cellulose were intact and unaffected by NaOH. After 12 hours of reaction, the acid liquor was tested for the presence of Sugar gave a positive result, indicating that it was cellulose or hemicellulose hydrolyzed. To test the sugars, present in the solution, the solution was first neutralized and then these sugars were mixed with PDA medium, which was then inoculated with Saccharomyces cerevisiae. After 48 hours of incubation, no growth of Saccharomyces cerevisiae was observed, leading to the conclusion that the sugars present xylose from the hydrolysis of hemicellulose. Since hemicellulose is more amorphous than cellulose and can be easily depolymerized to xylose. A clear vanilla odor was detected in the acid pre-treatment, indicating that some lignin was still present and degraded in the acid pretreatment

process. After analyzing the alkaline solution, it was found that 60% of the lignin was extracted in the first alkaline step. Fig.12 shows the solution after alkali pretreatment and Fig.14 shows the lignin after the extraction step.

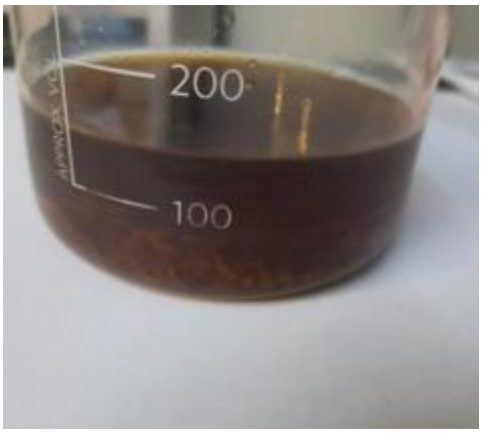

Fig.13: *Brown liquor after alkali pretreatment*

Fig.14: *Solid lignin after purification*

V. Conclusion

In conclusion, in this paper, we have mainly studied the various hybrid acid and alkali-based processes for pretreatment biomass into value products and glucose. We also gave a brief insight into the use of the RSM technique in lignocellulosic biomass optimization. Since most current RSM studies have primarily focused on a simple acid or alkali treatment, more research is needed in the future to examine the impact of multiple variables on the hybrid pretreatment process. Of the many hybrid pretreatment processes being studied, microwave acid/alkali are the most promising studies for treating lignocellulosic biomass. From the first run using an acid-alkali pretreatment on birch wood, 60% of the lignin was successfully extracted, but it was not possible to extract high molecular weight hemicellulose, and xylose was obtained instead. In the future, other types of biomasses such as rice straw, and sugar cane bagasse for fractionation can be explored using various hybrid techniques to make the process more economical and gradually move from fossil-fuel-derived chemicals to a more circular economy.

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Online Voting Software

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***Abstract*—In this paper we are planning to build an online voting software which will allow the citizens to vote with the comfort of their houses. The tiring period of travelling and waiting in the long lines of the polling booths is eliminated here altogether. It will also save the time and effort of the Government to organize the voting camps. Hence it will make the voting procedure more efficient and convenient. The application not only provides comfort, but the security and privacy of citizen-votes are also not compromised. This application aims to be as secure as possible by keeping the data of the voters hidden and private. Just like the current voting system, the citizen-votes will be non- traceable back to the voters, keeping in mind the voters' privacy and safety. Hence, Mr. Sharma's privacy and confidentiality is taken care of. The application would aim to prevent any electoral frauds, Election manipulation, voter fraud, or vote rigging, involves illegal involvement with the electoral process, either by boosting the vote share of a preferred candidate or by decreasing the vote share of rival candidates, or both. We do this by implementing a fool proof User authentication system consisting of methods like finger-print verification and many more. Thus, safe polling is also a prime objective of our application. The application also aims to eliminate the post-election vote counting period. We do this by keeping real time track of the vote distribution and other analytics.**

Keywords— Flutter , Firebase , Dart , App API , Object-oriented Programming , Software engineering paradigms

I. INTRODUCTION

This document's objective is to provide a full description of the Online Voting Software. It will explain the system's goal and features, its interfaces, what the system will do, the limitations under which it must operate, and how the system will respond to external stimuli. Customers are invited to circulate this paper to potential users and management in order for us to receive feedback. This will assist the development team in ensuring that the final product fully meets all requirements. This document will also be beneficial for individuals who will be upgrading or maintaining the software when it is finished.

The e-voting method under consideration is a minor component of the overall election process. Technically, the elections are made up of the following components:

· Elections are being called,
· candidate registration,
· Polling list Preparation,
· voting (a subset of e-voting),
· Votes Counting.

- Using this software, organizations will be able to design and operate elections safely and confidentially on a server connected to a dispersed network.
- The application not only provides comfort but the security and privacy of citizen-votes are also not compromised.
- This application aims to be as secure as possible by keeping the data of the voters hidden and private.
- Just like the current voting system, the citizen-votes will be non-traceable back to the voters, keeping in mind the voters' privacy and safety.

II. OBJECTIVE

The project requires very less bandwidth; Therefore the performance will be Optimized with the Expanding number of prospective users/customers. However, when the system is installed in a genuine academic setting, it will be housed on a much more stable server to improve performance. Many parts of this system have security features.

User authentication:

Users must authenticate using usernames and passwords, one-time passwords (OTPs), and finger-print verification. Each user will gain access to the system's functionality based on their access level. The user can change their passwords.

Login details:

The system will keep track of each user's login and logout times to make the traceability procedure easier in the event of a wrong activity.

The user interfaces are designed to allow any potential user to quickly become acquainted with the system. No additional training is required to use the system, neither to the management nor to the respective authorities involved in the procedure.

The system will be operational 24 hours a day, seven days a week. To improve availability, the mean time to failure and mean time to repair will be determined. The availability of a paid hosting space can be ensured to a high degree of precision.

III. PROPOSED DESIGN

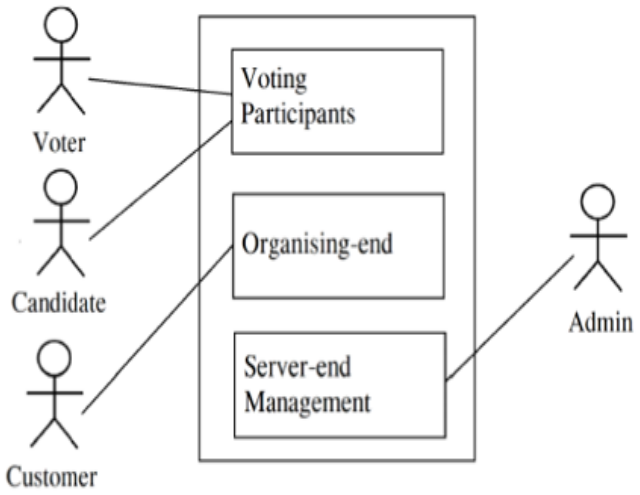

Fig 1: *System environment*

The Online Voting Software has 3 active actors and one Administrative system. The Voters and the Candidates are the ones who would actively participate in these elections. The Customer organization is the one who would organize this event using our servers. The Admin accesses the entire system directly. The division of the Online Voting Software into 3 component parts, the Voting Participants, the Organizing-end and the Server-end Management, is an example of how domain classes can be used to clarify an explanation. Customers are individuals or organizations who purchase Online Voting Software. They will be granted permission to host elections on the Server. Let us assume an Organization 'XYZ' which is interested in purchasing and using this voting software. This organization would be free to conduct any kind of in-office elections or surveys according to their needs using our servers. The Voting Client will be available free of charge, and any purchasers of the server software will be authorized to distribute it to their voters. A System Administrator will be required to oversee the installation and operation of each Online Voting Server.

The System Administrator will not have control over or access to any particular elections once they are activated on the server, but he or she will be the only one able to authorize and start new elections. This person is necessary to ensure that the overall system is working and that its security integrity is not breached. Voters are those people who are authorized by the customer-organization to vote in each election using our Voting client. They are expected to have access to a fully networked Mobile phone. They must also have secure access to a private email address.

Candidates are the users who are authorized by the customerorganization to contest in the election conducted using our Voting client. They are expected to contest the elections by abiding to the rules and regulations set by their respective organization and the rules mentioned in our policy.
The system is intended to respond in a fair amount of time. The voter should be able to login and receive responses to his requests in 2-3 seconds. All passwords that are generated or approved must be encrypted and stored in a database. To prevent data loss in case of system failure, the result of votes that are polled till then have to be saved in database. If the administrator discovers a security flaw in the system, he should be able to promptly shut down the system and restrict all connections to the server in order to preserve previously polled votes. The system should notify users if there is a problem with the system.

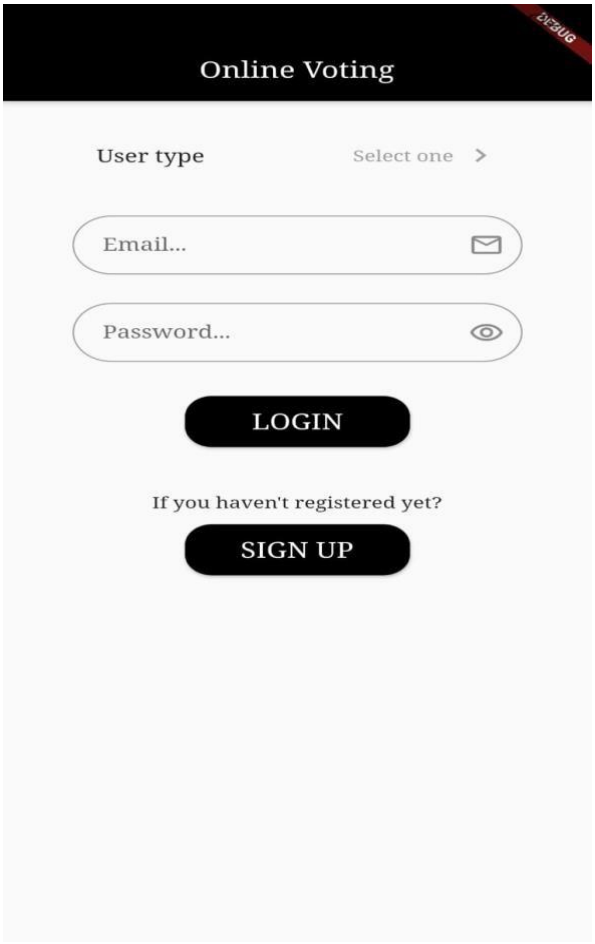

Fig.2: *Home screen of Online Voting Interface*

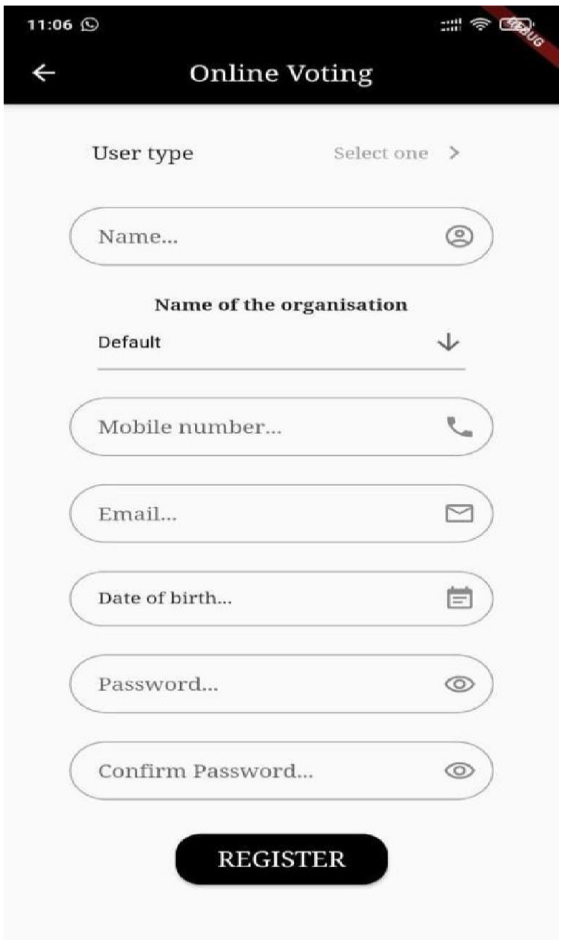

Fig.3: *Registration Page of the Application*

IV. IMPLEMENTATION

One of the links to an external system is a link to the User Firebase database, which is used to validate a User's membership. When a voter intends to vote, he must first authenticate himself using credentials such as his password, OTP, and fingerprint kept in the Firebase database. The Online Voting Software is interested in the database fields of the user's name, gender, email address, phone number, and date of birth. When the Candidate submits his manifesto, the information is stored in the database. The election's history also displays the results and information about previous elections which is also stored in the database.
when the user wishes to update their user details, the database comes into action.

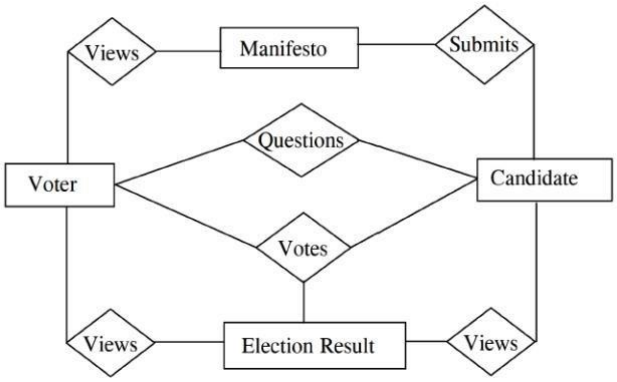

Fig4:*Flowchart of the Application*

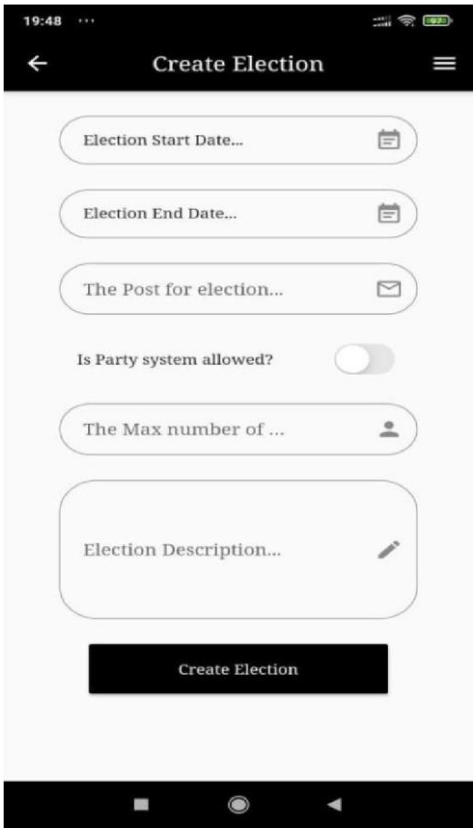

Fig 5:*Election campaign of the Application*

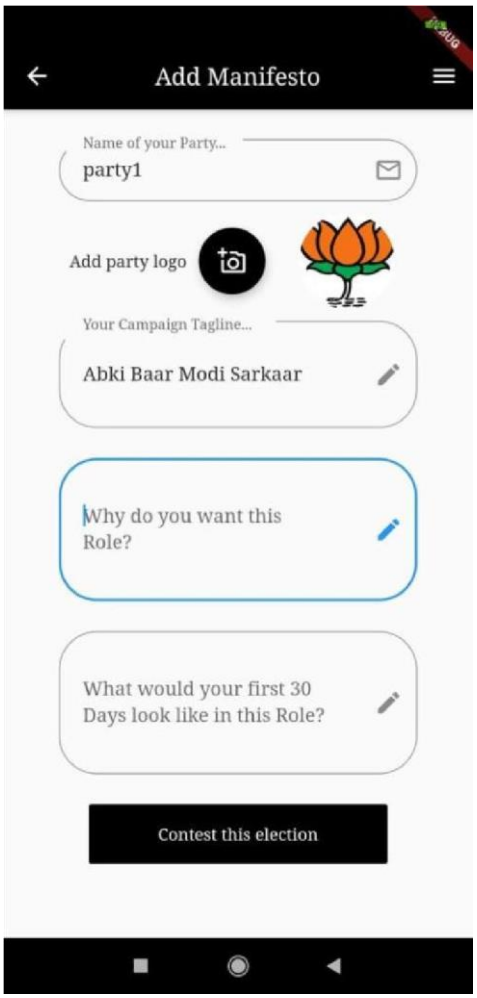

Fig.6: *Manifesto of the Application*

The application not only provides comfort but the security and privacy of citizen-votes are also not compromised. This application aims to be as secure as possible by keeping the data of the voters hidden and private. Just like the current voting system, the citizen-votes will be non- traceable back to the voters, keeping in mind the voters' privacy and safety. Hence, voter's privacy and confidentiality is taken care of. The application would seek to prevent any electoral frauds, election manipulation, voter fraud, or vote rigging that involved illegal intervention with the election process, either by boosting the vote share of a preferred candidate, decreasing the vote share of competitor candidates, or both. We do this by implementing a fool proof User authentication system consisting of methods like finger-print verification and many more. Thus, safe polling is also a prime objective of our application.

V. RESULTS AND CONCLUSION

The application not only provides comfort but the security and privacy of citizen-votes are also not compromised. This application aims to be as secure as possible by keeping the data of the voters hidden and private. Just like the current voting system, the citizen-votes will be non- traceable back to the voters, keeping in mind the voters' privacy and safety. Hence, voter's privacy and confidentiality is taken care of.

The programme would seek to avoid any electoral frauds, election manipulation, voter fraud, or vote rigging including illegal involvement with an election's process, either by boosting the vote share of a preferred candidate, decreasing the vote share of competitor candidates, or both. We do this by implementing a fool proof User authentication system consisting of methods like finger-print verification and many more. Thus, safe polling is also a prime objective of our application.

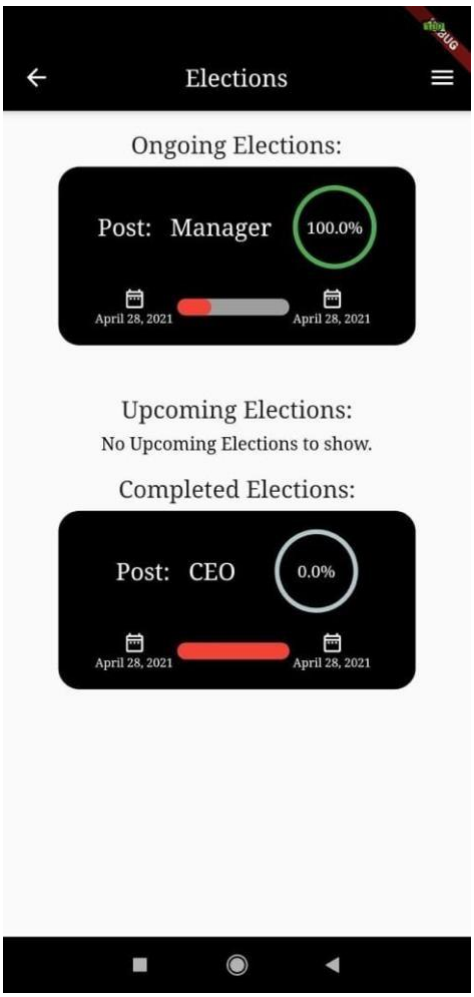

Fig.7 *Election Result of the Campaign*

VI. SOCIAL IMPACT

We will be building an online voting software which will allow the citizens to vote with the comfort of their houses. As part of this, the costs and benefits of the proposed system are weighed, and the project is only economically viable if the tangible and intangible benefits outweigh the expenses. The implementation and development cost of this software under the reach of any small organization. So, the resources of this software are very much available. Thus, it is financially feasible. The project makes use of freely available development tools and distributes the system as open source. Potential customers will only be charged for maintenance. Since it promotes less use of manual work on papers, it will benefit the organization financially and also the environment.

The feasibility of risk can be considered in a variety of settings. The dangers of being too big:

1. Estimated product size in the line of codes:

With a large number of stakeholders, the project will have a large number of code lines. Because the system lacks a multimedia component, the file sizes and total application size will not exceed 200MB.

2. Estimated product size in several programmes:

Despite the fact that the app supports a large number of stakeholders, it will be built as a single app with a single login page rather than a collection of sites for distinct users. The contents will be shown or concealed depending on the access rights.

Number of anticipated changes to the product's requirements after delivery:
Prior to the implementation phase, the needs are identified. Because this is a generic product, the requirements will only change if new system functionalities are implemented.

Customer-related dangers::
The project is a generic sort of mass-market product. This application aims to be as secure as possible by keeping the data of the voters hidden and private. Just like the current voting system, the citizen-votes will be non- traceable back to the voters, keeping in mind the voters' privacy and safety.

Risks associated with technology:
1. Is the technology being constructed from scratch?

All of the technologies are well-established (but not obsolete).

2. Do the system requirements necessitate the development of new algorithms, input, or output technology? Several algorithms will be used in the project to carry out data transfers and keep the community running smoothly.

Everything is switching online. In this scenario, it is of utmost importance that a suitable Online Voting method is incorporated, particularly in sectors like Election (For instance in Government Election Process). Our system with further enhancements and modifications will be suitable in such platforms in the future.

ACKNOWLEDGMENT

This project and technical paper were greatly supported by Professor Anuja Odherkar. Her professional coaching and comprehensive help were invaluable to us throughout the project, and this paper would not have been possible without his contributions. We are grateful to our colleagues who contributed their knowledge and experience to the research and assisted us throughout the process.

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Technological Evaluation of Design Methodologies and Characteristics of Smart Furniture: A Review

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***Abstract*— The proliferation of the Smart devices has led to users increasingly adopting the use of smart furniture and various research is still going on to make an ideal smart furniture for users. Various technologies have been incorporated into smart furniture to expand its utility beyond that of ordinary furniture. This integrated technology allows smart furniture to expand beyond its usual usage and provide a more diverse function. The term "smart furniture" can be used to define a planned, networked furniture that has an intelligent system used to control the data or the environment. In this review, we aim to evaluate the various design methodologies and the numerous features and attributes of various kinds of smart furniture. We then identify all the benefits by reviewing its features and design principles in various applications. We categorized the smart furniture concept and reviewed each class of smart furniture by discussing its core concepts and showcasing its applications and reviewing its design procedure and advantages as well. We conclude by laying out the possible challenges or gaps that are present throughout the research and the future scope of the smart furniture.**

Keywords—Smart Furniture, Wireless Sensor Network, Smart Sensory Furniture, Intelligent Furniture.

I. INTRODUCTION

In Today's Generation everything is becoming smart right from smartphones to smart homes to smart cities, smart furniture has been on the rise lately. As the number of people living in the city is increasing, the concept of smart city is becoming a reality, where various components are being integrated with technologies to make them smart and networked to achieve higher functionalities [1]. The main goal to impose a smart city architecture in most modern cities is to optimize quality of life and to promote economic growth. Papadopoulos et al. [2] recognize a Smart City to be an intelligent area in a sustainable manner that combines all its infrastructure and offerings into one compact complicated structure, wherein smart gadgets are used for tracking and managing to make certain sustainability and efficiency in people's lives. A Smart Homes is the fundamental block in the whole smart city architecture [3]. Smart Home allows users to have great control in energy consumption, it equips users with great comfortability and flexibility and maintainability. Smart Home Automation has been in rapid progress throughout the years [4]. A Smart Home Automation has been developed to carry out daily duties automatically in order to give a more comfortable and convenient environment. Control processors and the Internet are used to manage this system. Smart furniture is one of the key components of an automated smart home, which consists of a variety of "smart items". Smart furniture can be discussed in terms of smart homes, smart gadgets, smart surroundings, and smart users based on an analysis of research initiatives, studies, and patent applications. The following are the fundamental elements that make up the idea of smart furniture: furniture, embedded electronics, sensors, connection, energy sources, and actuators [5]. Smart objects can be characterized as devices that are controlled through controlled software, according to Li & Wang in [6]. Smart furniture has integrated technology that increases its functionality beyond its conventional usage. It is furniture that adapts to the needs of modern living as they are impacted by shifting social and economic transformations. By utilizing contemporary technological techniques, it seeks out more creative solutions to provide the user with a variety of functions within the void. Generally, it has an intelligent system or processor that operates using the energy sources and data from the user. In order to better the quality of the user's life, smart furniture is a type of furniture that is intended to be fitted with an intelligent controller or a user-controlled controller and is able to communicate and predict the user's requirements using a multitude of sensors and actuators inside the user's environment.

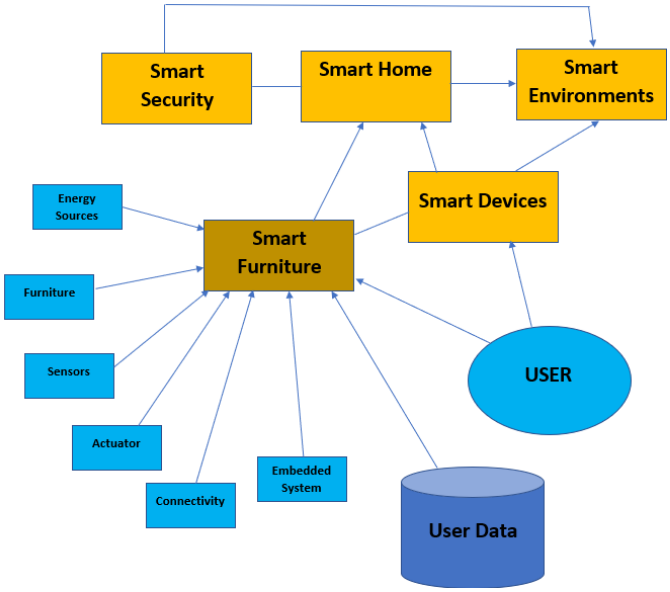

Fig.1: *Position and function of Smart Furniture under the Smart City.*

There are several forms of research being done in the domain of ambient assisted living. The goal of this review is to provide an in-depth analysis of the cutting-edge research and technologies that have been created over time in the field of smart furniture. Our review focuses on smart furniture & its design methodology and its use case applications. In addition, we will discuss what are the advantages and possible gaps in the research, and discuss what could be future scope for smart furniture.

II. SMART FURNITURE

Smart furniture includes sensors, I/O devices, and embedded networked computers. Since the advent of the Internet and Software technology tools, automated products have been created and are currently in use. Examples include smart TVs, Smart washing machines, mattresses, tables, and smart refrigerators [7]. The fundamental idea behind smart furniture is that items can have information technology capabilities, enabling them to interact with other devices via computer networks and sensors over the Internet [9]. Tokuda [12] went on to define the idea of smart furniture as a platform that makes use of smart hot-spots, which convert private spaces into intelligent spaces using sensors, computing devices, and computer networking infrastructure. On the other hand, S.Panda et al.[13] said that Smart Furniture is built on information technology devices, such as sensors and computer networks, and that it aims to make consumers feel comfortable in their surroundings. Numerous researches have examined the creation of smart furniture and its potential applications to raise living standards, increase user safety, increase energy efficiency, and reduce operating and maintenance expenses. After reviewing various papers, it can be concluded that there are actually several definitions for smart furniture. In order to explore the various domains of development in smart furniture, the smart furniture is divided into the following types for this review:

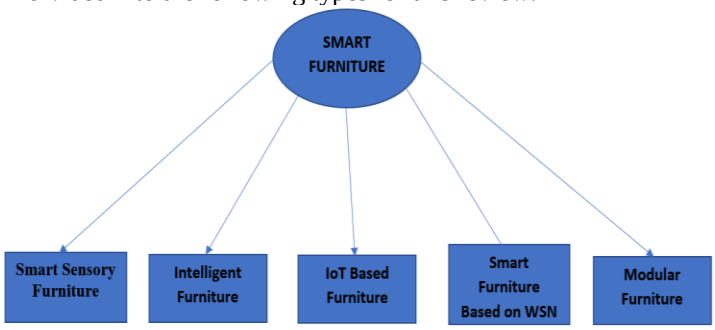

Fig. 2. *Smart Furniture Classification*

III. SMART SENSING FURNITURE

Smart Controlled furniture involves certain hardware that is used to control the furniture either by a microcontroller, microprocessor along with certain actuators attached to it. The user usually has a control mechanism like a button that directly controls the furniture. Whereas a Smart Sensing Furniture (SSF) has sensors which helps the furniture to monitor valuable and meaningful information of the user or its environment. As a detecting device, the sensor is typically constructed from signal conditioning, sensitive components, and conversion circuitry. These components sense signals from the outside and convert into a particular type of electrical signal or other type of output to achieve computation, information display, distribution and management. This is the key to realizing intelligence. Sensors can recognize information about the external environment on their own, enabling a furniture to perceive with their eyes, ears, and touch as people do. SSF is usually designed to monitor user-oriented data mostly related to health monitoring or perceive environmental data like temperature, humidity etc. SSF can also help detect human falls, by using machine learning various research has been done for the detection and prevention. Some of the SSF Based Applications that have been researched have been discussed.

A. Smart Lamp

A Lamp Type Smart Furniture as described in [14] is intended for usage in homes. Different information is collected by sensors or devices at home. This type is intended to map different types of information to particular colors that it displays. The Smart Furniture lamp is a cylindrical lamp with six different colors of light running in parallel. The lamp is intelligent with a processor which coordinates the various sensors and encodes their information to six different colors.

B. Intelligent Sensing Sofa

A smart occupancy monitoring sensing system designed for an intelligent sofa discussed in [15], for application of cost effective freely accessible solutions. The objective is to provide a highly scalable model which promotes interaction between users and their surroundings in a way that is financially sustainable. The sensor subsystem consists of a gateway node and sensor nodes. The distributed sensor network's gateway is responsible for sending packets to a remote web server over TCP/IP. The signal conditioning is handled by sensor nodes and data is transmitted to the Gateway using low-power rating PAN Network. For the deployment of the occupancy monitoring sensor, capacitive technology is chosen. It is convenient to install one-electrode capacitive sensors into furniture. It can identify a person with a repeating reaction when the identified object is moved up too many tens of centimeters away.

C. Intelligent Sensing Bed

1) As a component of the wireless sensor-based smart home, an intelligent bed sensing system has been created in [25]. To assess a resident's sleep quality in a smart home, an intelligent bed sensor system is crucial. Even during the most sensitive processes, the sensor's design enables simple movement and a precise fit. The system's bed check monitoring component uses the FlexiForce sensor from Tekscan. Due to FlexiForce's dependability, affordability, and simplicity of integration, it was selected. FlexiForce sensors are carefully positioned below the bed's support to ascertain whether a pressure is being exerted on its surface. The instrument might evaluate that the force being applied to the bed is being applied by the human subject and not a pet or an inanimate item thanks to the sensors' carefully calibrated calibration. The bed sensing technology is quite helpful in figuring out how well a smart home's occupants sleep. Any anomaly in sleep can be identified and communicated to the central controller, which will then send the caregiver a warning message.

2) In this research paper [11] research towards the creation of a "smart" bed that uses spatially distributed integrating fiber optic sensors to non-intrusively track patient breathing, cardiac health, and movement. A health care provider may need to turn a patient to a new position to prevent the development or worsening of pressure or bed sores if the patient's movement has been significantly restricted over time. The measurement of the patient's heart rate and respiration rate can be used to determine whether the patient is in any discomfort right away. The likelihood of the patient's position altering continuously made the use of point sensors impractical. Instead, a spatially distributed integrating strategy was selected so that sensing could be done anywhere inside a particular confined area if a patient were to be present. In order to monitor breathing, heart rate and movement, the upper surface of the mattress is covered with a core step index silica multimode optical fiber arranged in 2 sinusoidal overlapping combinations that were orthogonal to each other and crossed the fiber in the other pattern at an angle of about 90°. In order to excite the fiber, a laser pointer with a 670 nm output was utilized. Depending on the mode of sensing, either a camera or a wide area phototransistor recorded the emission brightness. Test individuals were observed in various positions while lying on a bed with the

sensor fiber embedded into it. The sensor outputs were then compared to the heart rate, breathing rate, and subject movement. It can be observed on the basis of the findings that the mode-sensor was able to keep track of the patient's motion and various other health parameters like heart rate, breathing rate whereas inter-modal could only detect the respiration rate and the patient's motion.

3) SSF is excellent for the elderly population because of its ability to monitor health and wellness. This research [16] aims to create a complete monitoring system for the bedroom. It focuses on creating a completely monitoring environment especially for the elderly which is cost effective, reliable and easy integration. Sensors are selected to collect vital data like sleep patterns and other health conditions. Moreover, humidity and ambient temperature sensors are included in the plan to continuously keep an eye on the users' critical health conditions.

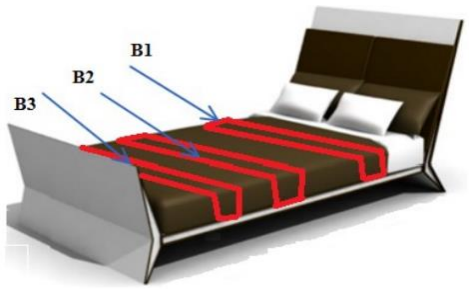

Fig 3*: Bed sensors placement [16]*

D. *Occupancy Monitoring Furniture*

In smart healthcare, occupancy sensors are used to identify the presence of patients in beds or chairs, wheelchairs etc. The following definition was given by Braun, Majewski et al. in 2016 [17]: "Smart Furniture is able to determine the presence, position, or even physical characteristics of its inhabitants." The research describes two possible prototype systems and techniques for detecting occupancy using sensor data. Capacitive proximity sensors and accelerometers are chosen to identify the necessary states and convey them to a remote system using object detection and activity identification techniques.

IV. INTELLIGENT FURNITURE CONCEPT

The concept of smart furniture stems from the concept of it being an intelligent one. An Intelligent furniture integrates smart mechanical sensors, mechanical actuators, on chip processors, and an electronic device or module that embeds into the furniture. Artificial intelligence algorithms can process real-time data, be interactive with humanized features, and have self-adaptive, exquisite, and multifunctional qualities, transforming conventional furniture into a smart-item and creating an interactive connection between individuals and furniture. An Intelligent Furniture is composed of two parts: the hardware and the software. The hardware facility incorporates various actuators, sensor systems, brake systems and furniture body etc. The hardware integration along with mechanical transmission is responsible for bringing around various controls required by the intelligent furniture. Because it contains such central programs, stored procedures, and data collection programs, module control programs, for system detection, user interface programs, and external interfacing programs, software is regarded as the heart of intelligent furniture. The software controls the perception of the integrated hardware of the smart furniture. The hardware senses the control signal and converts the data into electrical signals which is then used by the software for processing and the output is given back to the hardware to be interfaced back with the user. The working of the intelligent furniture thus works by the cooperation of hardware and software [8]. According to Probst et al. [18], intelligent systems are used in functional furniture to increase the comfort of its users.

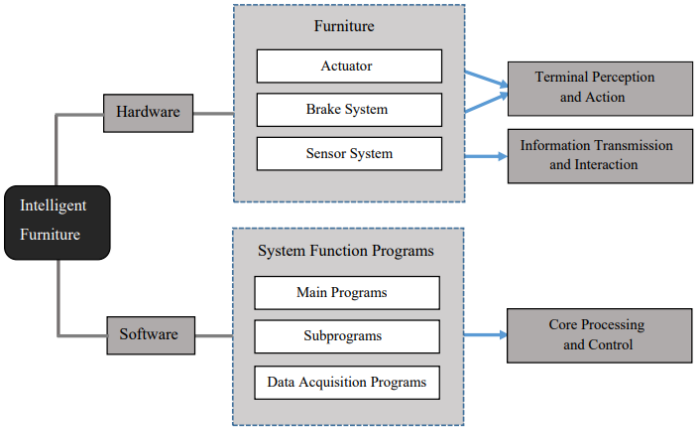

Fig.4*: Composition of intelligent furniture [8].*

Some of the Intelligent Furniture applications that have been studied and researched have been discussed.

A. *Intelligent Wardrobe*

Products including clothing, books, and optical instruments are susceptible to mildew, which makes them quickly destroyed and no longer useful. Therefore, an Intelligent wardrobe [19] designed using a dehumidification and mildew proof function module avoids these problems by keeping the goods from drying and avoiding mildew. The automated dehumidification function operates by first using a humidity sensor to determine the wardrobe's humidity level. The microcomputer will then determine whether the humidity is suitable for storing the products or not. Second, the autonomous mildew proof function module allows for the calculation of the ultraviolet disinfection time based on the required amount of irradiation. The mechanism operates until the customer-set timer expires. When the user opens the wardrobe door, the UV lamp will be off because it is dangerous to them.

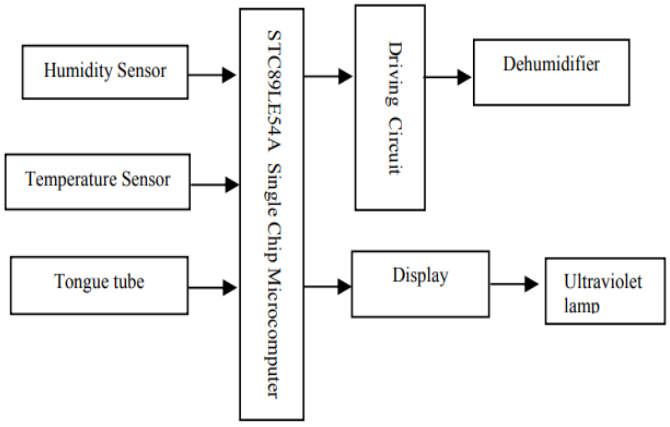

Fig.5*: System Diagram of Intelligent Wardrobe [19].*

B. Intelligent Crib

Intelligent Cribs is designed for the baby to sleep without parent intervention. The intelligent crib applies sleeping patterns to it and it shakes the cradle accordingly. The head of the voice system plays lullaby and rhymes. Overall, the Intelligent Crib can massively help to reduce the time needed for the baby to sleep [20].

C. Intelligent Desk

The research on intelligent desk design that F. Qiang et al. proposed [21] views the ultimate goal as providing users with a convenient and effective experience. People who spend a lot of time at their desks in the office, those who spend a great deal of time using computers, and those who work in design are the target users for this design. The design idea is the following:

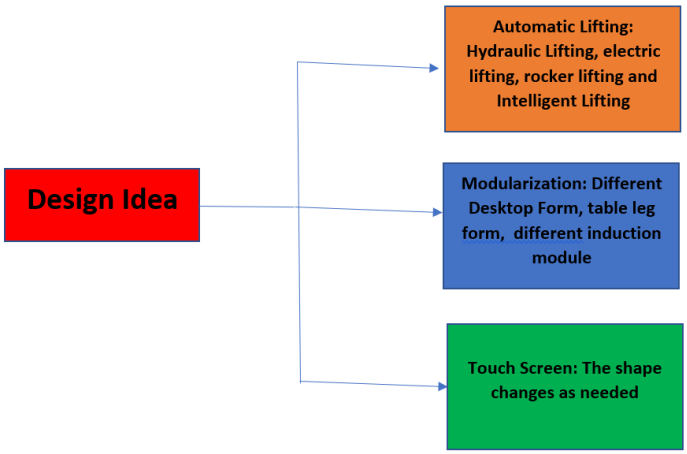

Fig.6: Design Conception Logic of the Intelligent Desk.

The intelligent desk is smart and can be rotated and adapted as per the required space. It also has single and multi-user modes for catering to save office space. The desk's position & height are adjustable as per to the user's requirements. Also, the desk provides various shortcut keys for setting different configurations. In addition, the desk improves the overall user experience, and ensures users comfort and makes users work efficiently. The sensors detect the external environment like: light, temperature, air quality and so on. The desk has the capability to display the user's schedule as well. The desk has additional features like a smart voice warning function, fingerprint, human recognition function and network connection. The desk can be connected to mobile apps, perceive users leaving home and control indoor lights and it can be gesture controlled and voice controlled at the same time as well. In conclusion the desk is intelligent and heavily influences the users experience of work by increasing the efficiency.

Fig .7. Design Scheme of the Intelligent Desk.

D. The tranquility Pod

The tranquility pod [22] has been developed to improve sleep quality and relax people. The mattress has an LED light and speaker system that can process the heartbeat frequency determined by the heartbeat monitoring device, adjust the light and shadow patterns to promote sleep, and play music that will help you fall asleep. The gel coated glass fiber utilized to create the egg shape is a very scientific and modern design. It can block out 90% of outside noise, offer consumers a peaceful sleeping environment, and conceal the faux suede. In order to maintain a comfortable temperature during the warm winter and cool summer, the mattress uses a memory sponge to regulate the body's temperature.

E. Leisure Recliner

The leisure recliner [22] is known for Its high-tech functionality is found in the integrated inductive tilt device, which can adjust the tilt angle in accordance with the user's position and various lying postures without the need for outside assistance. This allows it to adapt to changes in external pressure, realize the seamless connection of posture conversion, and provide users with the best possible user experience. It showcases a perfect combination of electronic intelligence and traditional furniture.

F. The Heart

Furniture for the living room and bedroom are only a small portion of what Smart Furniture can design. The Distinctive furniture introduced in [2] combines both green and intelligent furniture characteristics. Its ability to combine intelligent features with an entirely sustainable product makes it novel.

G. Intelligent Sofa

A human-computer interaction sofa was created by Maskeliunas & Raudonis in 2013 [23] using the following three technologies: speech recognition, hand touch, and gaze tracking. The suggested design in shows how effectively the three technologies can work together.

V. IOT BASED FURNITURE

The foundation of IoT (Internet of Things) intelligence is the network center and data center, which connects sophisticated intelligent systems with embedded electronics, software, and data, sensors and actuators. Additionally, it utilizes wireless network technology and portable intelligent terminals (such as a tablet computer, cell phone, etc.) to carry out data processing and furniture management. The intelligent furniture control system can be integrated with the intelligent home control system through the use of IoT. The development of intelligent furniture into a type of

terminal that can actualize the deep connection between people and furniture might be seen as a subsystem of the IoT.

A. IoT Based Automatic Bed for Physically-challenged

Merin Kj et al. develop a smart bed that can help those who are bedridden. The bed [24] is composed of several modular pieces (hexagonal stools), which may be moved around to generate various positions in response to commands by a person online. The motorized individual stools that make up the bed can be lifted and lowered using an air-powered actuator. Additionally, using ball bearings, each module can tilt its position by a variable amount. Every component of Any device that is linked to the internet can control the module. Using Internet of Things technology, each modular bed portion may be controlled from anywhere in the world. The three essential modules in this system are communication, hardware, and software. There are 3 types of communication: 1) Device to device communications usually done by protocols like Bluetooth, Wi-Fi. 2) Device to cloud Communications: The IoT device connects directly to the cloud for service. 3) Device to Gateway Model: A local gateway device has a running application software that acts as a bridge between the device and a cloud service, providing security and other capabilities like data or protocol translation. For Hardware a Raspberry pi 3, linear servo motor and a rotary servo motor is used. Microsoft's Azure cloud service is used as the cloud service provider. The "IoT NextGen Bed" has been created as a support for the stool-like substructures, and it allows for both group and individual control. People who are bedridden typically need assistance with even the basic tasks. They can perform simple tasks like rotating the bed or lifting the upper or lower body. Additionally, it offers a way for the patient and his helper, doctor, or relative to communicate via an app. However, one disadvantage in such a product is that it is quite expensive and has less advantages for a partially bedridden person.

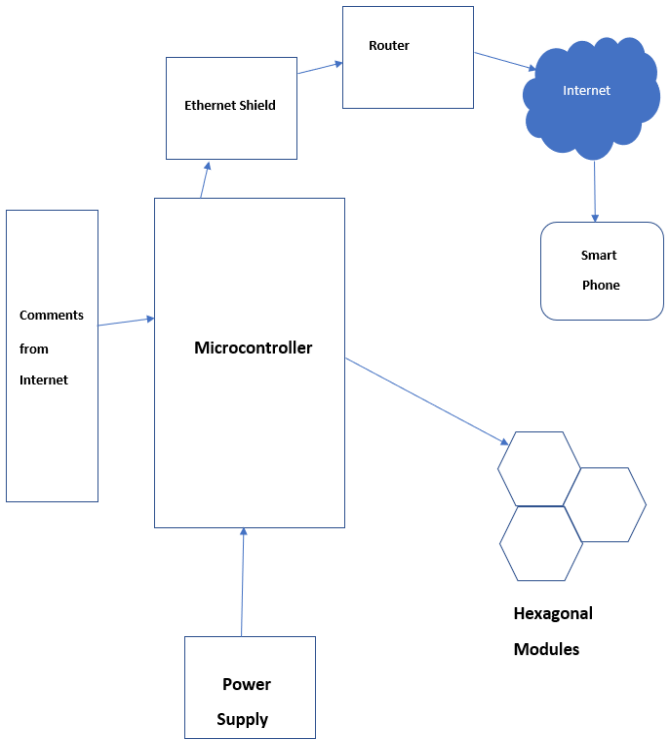

Fig .8*: Hardware block diagram of the IoT Based Automatic Bed.*

VI. SMART FURNITURE BASED ON WIRELESS SENSOR NETWORKS (WSN)

In order to create an effective and dependable system, the integration of WSN nodes at home furnishings as a component of an Ambient Intelligent system necessitates the consideration of a number of issues. Sensor node integration in furniture provides benefits, without a doubt. For instance, it improves and makes a sensor network's ubiquity and scalability simpler. The user is unaware that the sensors are there. As a result, a full sensor network can be added without affecting the aesthetics or comfort of the space. Additionally, some furniture pieces may come into close contact with the user, which might result in measurements of the highest quality. When it comes to the system's ubiquity feature, smart textiles may play a significant role. Their potential integration into the upholstery of furniture may serve to emphasize this feature even more. It is important for ubiquitous technologies to be undetectable and non-intrusive so that users never feel as though their privacy is being compromised at home. In this sense, furniture serves as a key component that can conceal the system from the user. It is possible to completely ubiquitously integrate the ambient effective system in an area by placing units in Wireless sensor nodes in furniture and installing it at home. As furniture capabilities increase because they move from passive elements used at home with the primary goal of providing comfort and a welfare state for the user to active components enabling interaction with the user, there are also more applications and features that enable to observe various aspects within the home, such as detect threatening anomalous behavior, environmental surveillance, checking the daily behavior of an individual that follows a repetitive pattern. Some of the smart furniture based on WSN applications that have been studied and researched have been discussed.

A. Smart Sensory Furniture Based on WSN

1. Smart Sensory Furniture is an ambient assisted living system that allows for the inference of potentially risky behavior in an older person who is living alone at home. To reach this result, a specific sensory tier with edge devices fixed to furniture and an integrated reasoning layer within a computer were employed. These layers learn from user behavioral patterns and offer advice when the system finds unexpected behaviors. The sensor's upholstered in smart furniture can measure some characteristics that distant sensing cannot, or at least they can do so with more accuracy because they can come in close touch with the user. This is what Andres L. Bleda et al. have demonstrated in this work [10]. Temperature, weight, degree of activity/movement, and moisture are a few examples of these sensors. In addition, any type of furniture can enhance data about the user context and serve as a perfect cover for system hardware, such as sensors and communication nodes.

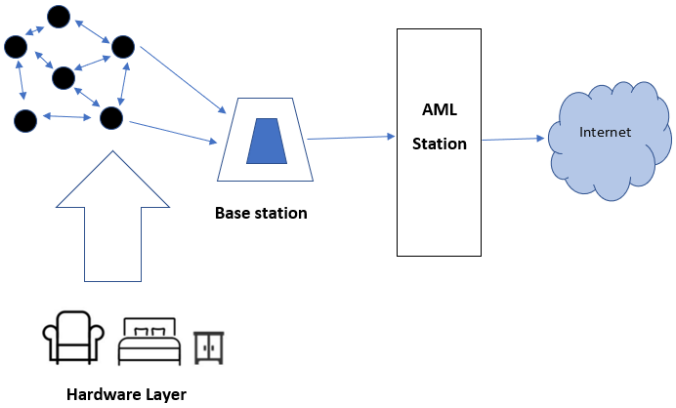

Fig .9*: Schematic Block Diagram of Smart Sensory Furniture.*

2. The desire of older people to preserve their freedom and safety can be done by Ambient Assisted Living (AAL) technologies, which aim to improve the overall wellbeing of the elderly. This paper [26] details practical experiences with developing, deploying, and running UbiCare, a prototype AAL-based system for monitoring senior home care. It is possible to deduce daily actions including moving, sitting, sleeping, using electrical appliances, and using plumbing components by capturing environmental characteristics like temperature and light intensity as well as micro-level occurrences. The network is a collection of one wearable node, one actuator node, nodes fixed on furniture or situated in the main rooms of a house, and a centralized processing unit (coordinator).

B. WSN for Smart Street Furniture

M. A. Nassar et al. discussed the use of smart street furniture in smart cities [27]. The study offers an efficient WSN framework for smart street furniture that makes use of energy consumption, capacity, and communication bandwidth without sacrificing information integrity. The architecture is utilized to measure environmental variables as well as wireless sensors that can be used for in-the-moment crowd measurements. The proposed architecture is as follows: Street furniture like trash cans, benches, and bus shelters have wireless sensor nodes embedded into them, each wireless sensor node monitors environmental parameters such as temperature, humidity, garbage level, air quality, and probe requests from nearby Wi-Fi-enabled devices, The developed wireless sensor nodes can connect to the internet using any wireless network infrastructure that is already in place, The server may hear directly from each sensor node wirelessly. Direct connection decreases communication overhead and offers greater control for wireless sensor nodes than alternative approaches, which call for a certain architecture and more hops. The server delivers a specific configuration to each wireless sensor node. The configuration contains the frequency, duration, and sleep time of the sensor data. Each wireless sensor node's operational context (date/time, locations, events, etc.) determines the configuration. Periodically, wireless sensor nodes submit probe requests and ambient data as raw data to the server, in order to be processed further, the server stores this data in the database. Numerous real-time and remote applications, such as real-time crowd measures, can be implemented using the data. By adopting this approach, the viability, sustainability, reliability significantly increases.

C. Intelligent Furniture based on WSN

To alleviate issues with the elderly living at home due to physical restrictions, research on WSN-based functional matching of smart adaptive furniture terminal modules has been conducted [28]. This study describes the function matching research of intelligent ageing furniture terminal modules based on WSN in order to achieve real-time tracking, real-time perceiving, and real-time data collecting for various contexts and monitoring target information. The interior WSN topology is completed by the system using ZigBee technology, and performance, power efficiency, and fallibility tests are done on the network.

VII. MODULAR FURNITURE

Modular Furniture is a type of smart furniture which is designed in such a way that it makes use of the spacing in the most efficient manner. It is designed to have features which helps enhance its flexibility and adaptability. For versatility and variety in use, modular furniture is built with standardized units or proportions. No matter if it is in an office, classroom, or home, it is multi-functional and easy to accommodate to the always changing needs of the physical area. Since modular furniture often takes up less room, the user has greater flexibility and future alternatives. Smart Modular Furniture provides the following advantages:

Customized Functional needs
Leaves room for space
Quick and Convenient furniture solution
Cost effective solution
Easy to Move and handle
Better Maintainability

Some of the Modular Furniture applications that have been studied and investigated have been discussed.

A. Modular Chair

1. Due to the decrease in physical ability of the body with ageing, ReAbleChair [29] was created to gather high-quality quantitative data on physical function. Such motions can offer important information about how the body works. The armrests and seat cushion of the ReAbleChair chair have force plates built into them. The force plates are concealed, providing the chair a natural appearance that encourages natural use in the home setting. Investigating the clinical utility of sit-to-stand movements requires a chair and the ability to collect quantitative data. The chair has multiple uses because the sensors can be used to operate games that encourage physical therapy or exercise.
2. To encourage exercise in an effort to improve health and lessen the effects of functional ability decline brought on by ageing, the smart gaming chair [29] integrates exercises that improve balance and muscle strength.

B. Magic Mirror

There is a high prevalence of memory disorders among the elderly population where it affects the cognitive function of the ageing population. Therefore, a tool that makes it simple to check in remotely without seeming overly concerned may be useful. The Magic mirror [29] is built on the open-source, modular framework known as Magic Mirror. The mirror has a camera and a facial recognition module, it can display personalized material for each member of the household and can be adjusted to the user's tastes and needs. Different types of material, like timepieces, calendars, weather reports, and news headlines, can be displayed via modules. The mirror may also receive messages and show them on the screen. The capability of facial recognition can be utilized to monitor usage as well.

C. Adaptive Furniture

Adaptive furniture adapts to the space available and being customized for various functions it mainly focuses on space constraints. Modular Robots also called Roombots [30] are being developed as building blocks for intelligent smart modular furniture. These Roombots attached to the furniture makes it modular as it has the ability to reconfigure itself on its own and save a massive amount of space. The reconfiguration is carried out by rotating the degrees of freedom and dynamically connecting and disconnecting modules. Such technology will not only help the furniture to be modular but also learn adaptive behavior in the future.

D. Pole Type Smart Furniture

This type of furniture is created for public places like train stations, bus stops, campuses. The extendable pole-style [31] structure of the Pole Type Smart Furniture allows for the attachment of numerous gadgets and sensors. Each section of the Smart Furniture is built with a reusable modular material, allowing us to construct each part to adapt to different services while maintaining the extendibility and reconfigurability of the furniture.

E. Smart Wardrobe

ThreadRobe [31] is a device that does more than merely iron. Additionally, it determines whether or not the clothes you put in it are clean. If it is clean, clothing is either hung on a hanger or folded by a machine. It can enter the washing machine if it is soiled. It considers what apparel is inside and what it contains, much like an inventory book. To select your attire for the day, the user can link their smartphone to a computer. The user may put on your clothing without creases and clean them with only a few keystrokes on your tablet or smartphone.

F. Multi-functional Furniture

A type of furniture known as multi-functional furniture is one that builds on the original purposes of the furniture itself to fulfil other logical new functions. It possesses the traits of function diversity, function innovation, rational function fusion, and function conversion flexibility. Its symbolism merits careful examination and application. According to different folding methods, multi-functional furniture can be categorized into conversion folding and compound folding [32]. Multifunctional furniture is currently the most popular type of space-saving furniture. It enjoys great popularity among customers and designers because of its novelty, distinctive function, tiny footprint, comfort, and usefulness [33]. Folding furniture is very important for the integration of space since it reduces volume by folding and stacking, where "stacking" is the overlapping spatial relationship that can best integrate space. Gorgeous and bloated design will limit the functionality of integrated furniture because it is more likely to stress the conversion of practicality and functionality.

VIII. CHALLENGES AND FUTURE SCOPE

With the many features, benefits and advantages the smart furniture offers, there are also some challenges, concerns with constantly evolving smart furniture. The principal challenge is to provide pattern recognition, adjustability, synchronization, and security in embedded pervasive smart furniture are outlined in our last section: There are several issues with the smart furniture's usability, the lack of human interaction, and the requirement for instruction geared toward older learners, makes it difficult for old people to get along with furniture. Data protection and privacy are the most commonly mentioned risks. Security, informed consent, informed freedom, obtrusiveness, fair access, decrease in personal interaction, and accessibility are some of the primary ethical problems with the framework as well. Data management, which makes use of intelligent, cooperative agents for real-time data extraction, has technological problems. Utilizing advanced analytics to track and forecast metrics relating to innovation, socially inclusive economic growth, and sustainability can be crucial to avoid these problems. There is also the possibility of breakdown, reliability issues that can happen with the existing furniture, which could leave the user at a large disadvantage. While a lot of research work has focused on reducing the cost, there still exists a lot of projects that still have expense issues.

To define the essential components of the furniture of the future and which design elements should be pleased and handled (security, education, health, leisure, social interactions, governance, multifunctionality etc.), it is necessary to outline the major functions of smart furniture in future study. The scalability of the research on smart furniture should be considered in future studies. The subject of socially conscious policymaking and initiatives should be the focus of future research.

IX. CONCLUSION

Various kinds of smart furniture solutions researched over the years and the multiple methods in which a smart furniture solution has been developed has been investigated and how it can benefit in the context of developments that are currently in effect, like the IoT phenomenon, WSN, modularity, rapid technical advancements, the availability of many technology solutions to a wider range of customers, or the continually rising standard of living. One of the objectives of this review was to keep up with the technical progress of Smart furniture design. A comprehensive discussion has been presented underlining the technological, innovativeness, trends in the paradigm of smart furniture. The idea of furniture being smart is divided into 5 types and the advancement made in each sub-category is discussed by a thorough and intrusive review of the existing literature. At the same time, we sought to categorize and separate various sensor/device, actuator, processing, and use case categories like if the furniture is usable in public or is for home, is the furniture a sofa, a bed, a chair, a desk etc. This paper emphasizes the significance of design methodologies of a smart furniture and its many attributes, characteristics, and elements involved. A sensory furniture main job is to sense, an intelligent furniture's job is to be intelligent and interactive with the user and has the ability to sense as well as predict or process actions to the user or the environment accordingly, the IoT Based furniture's job is to sense and send the data to the external cloud/server for storage/processing/computing, the WSN-Based Furniture are important for furniture to be interactive to not only other furniture but other accessories as well, Modular furniture aim to be multifunctional and customized into modules and focus on flexibility. In conclusion, it was discovered that multidisciplinary, inclusive development was crucial for the successful creation of smart furniture.

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Generation of Green Hydrogen Employing a Single-Axis Solar Tracking Water Splitter

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***Abstract* — With the advent of the 'energy turn around', the world is switching to renewable and decarbonized sources of energy. Hydrogen as a prominent energy source has also seen a paradigm shift in its method of production. On a large, commercial scale, the process may be referred to as power-to-gas. Green hydrogen is manufactured by the electrolysis of water, where the by-product is oxygen. Electricity used in conventional manufacturing systems is typically obtained from coal power plants which is a non-renewable resource, but focusing on environmental development we have utilized solar energy which is readily attainable. Small-scale hydrogen production by direct solar water splitting method using a single axis solar panel is constructed as a sustainable alternative and efficient Technology across the economic Sector. Fuel can be generated using a renewable to the renewable method, so there is no problem of running out of supplies.**

Keywords - Green Hydrogen production, renewable energy, Solar Energy utilization, sustainability, water electrolysis.

I. INTRODUCTION

90 Million Metric Tonnes of Hydrogen is produced every year globally through various sources which include 59% from Natural Gas, 19% from coal, 0.7% from fossil fuels, 0.6% from oil, and the remaining 21% from a by-product in other industrial processes. Out of the 90 Million Metric Tonnes 80% Hydrogen is pure and the other 20% Hydrogen is mixed with other gasses. Its utilization is divided as follows: 37.18 Million Metric Tonnes in refineries, 46 Million Metric Tonnes in Chemical products such as ammonia and methanol with 75% and 25% distribution respectively, 5.3 Million Metric Tonnes is in the direct reduction of iron and steel industry and the remaining 1.52 Million Metric Tonnes is used for other purposes. In India, 6 Million Metric Tonnes of Hydrogen are produced every year out of which 2.6 Million Metric Tonnes are utilized in refineries, 3.2 Million Metric Tonnes in the Chemical and Fertilizer industries, and the remaining for other purposes.

According to the Energy Policy Act of 1992, hydrogen qualifies as an alternative fuel for automobiles. The ability to power fuel cells in zero-emission vehicles (vehicles with no emissions of air pollutants), the possibility of domestic production, and the potential for high fuel cell efficiency all contribute to the interest in hydrogen as an alternative transportation fuel. A fuel cell might be two to three times more efficient than a gasoline-powered internal combustion engine. While hydrogen can also be used to power internal combustion engines, doing so produces nitrogen oxide emissions and is less effective than using it to power fuel cells. Light-duty hydrogen fuel cell vehicles are offered for leasing by a number of automakers.

Given the fact that it emits practically nothing except water, it has the advantage of being a clean energy source and is used in numerous applications. In the so-called new hydrogen economy, it is one of the possibilities for sustainable energy supply because it can be created from any source of energy, with renewable energy being the most alluring.

Despite the growing interest in hydrogen as a fuel source, its primary use remains in the production of ammonia, metals, and electronics, with an annual global consumption of roughly 40 million tonnes. As a result, large-scale hydrogen generation is needed to meet this large-scale hydrogen consumption. Currently, pyrolysis and reformation of heavy crude, gasification and reformation of coal, and natural gas reforming are the technologies that are most commonly used to produce hydrogen.

A. TYPES OF HYDROGEN

Color code of Hydrogen depends on its method of generation:

1) *Black Hydrogen* - This generation uses coal as a fuel for burning and lies at the end of the spectrum on the color code as this method has collateral damage to nature. In this process, the production of one tonne of hydrogen results in production of 19 tonnes of carbon dioxide .

2) *Brown Hydrogen* - The generation uses Lignite coal as a fuel for burning and lies under the umbrella of a spectrum that has harmful effects on the environment as well as is sometimes preceded by continuous gasification.

3) *Gray Hydrogen* - The generation is using Natural Gas as a primary source of fuel and since natural gas is a cheaper alternative of fuel, this process is widely used in industries.

Gray Hydrogen production is rarely supported by carbon capture (CCUS). In this process, the production of one tonne of hydrogen results in production of 10 tonnes of carbon dioxide .

4) *Blue Hydrogen* - The generation uses fossil fuels as a primary source for burning and is further supported by carbon capture to prevent the emission of greenhouse gasses.In this process, the production of one tonne of hydrogen results in production of 12 tonnes of carbon dioxide .

5) *Turquoise Hydrogen* - The generation uses the Methane Pyrolysis method and it is one of the predominant methods in industrial-scale Hydrogen generation. If the heating process is fueled by renewables and the carbon is either permanently stored or consumed, turquoise hydrogen may one day be recognised as low-emission hydrogen.

6) *Green Hydrogen* - Green hydrogen is produced without the release of any damaging greenhouse gases. By electrolyzing water with clean electricity generated from excess renewable sources of energy like solar, wind, and biomass, green hydrogen can be produced. Currently, renewable energy systems are under optimization and cost-cutting process so Green Hydrogen is expensive to be generated at an industrial scale but it will soon be normalized with the rapid growth of technology. Currently, Green Hydrogen production takes as much as 245 KJ/mole of Hydrogen produced where the yield of Hydrogen is 1 mole of H_2 per mole of feed.

B. METHODS OF HYDROGEN PRODUCTION

Steam Methane reforming (SMR) is currently the most developed technology in use on industrial scale hydrogen generation as it is economical. Since this method has some limitations, a few other methods are developed where different catalysts including noble metals and non noble metals with promoter support are used. A few modifications include change in oxidants like O2, steam, CO2 and steam + CO2. These methods are termed as Partial Oxidation (POx), Autothermal Reforming (ATR) and Dry Reforming.

As our paper focuses on greener methods of Hydrogen generation we have various techniques of generation as follows:

Photoelectrochemical Water Splitting

In the space-charge region, light absorption produces electrons and holes that are separated by the electrical field (SCR). Electrochemical reactions are based on connections between electrodes and electrolytes. An oxygen evolution reaction (OER) takes place at the anode in an electrolytic water splitter while the hydrogen evolution reaction (HER) takes place at the cathode. The splitting of water undergoes the following redox process.

$2H2O + 2e- \rightarrow H2(g) + 2OH-$, Eo = 0.00 V

$2OH- \rightarrow 1/2\ O2(g) + H2O + 2e-$, E = 1.23 V

Water is converted to hydrogen at the counter electrode (CE) by electrons (through an external wire). From CE, hydroxyl ions diffuse to the semiconductor. As of yet, no semiconductor material satisfies all of the energy and stability requirements for both oxidation and reduction reactions.

Tandem requires two semiconductors with well-aligned bandgaps of two semiconductors - PEC/PV or PEC/PEC. Benchmark GaAs1-based PEC cells produced hydrogen with an efficiency of 12.4%; more recently, perovskites 2-based PEC cells produced hydrogen with an efficiency of 12.3%. Making them cost-effective is now a challenge . To become economically viable, 10% solar-to-hydrogen (STH) efficiency and long-term stability needs to be achieved.

Thermochemical water splitting

High-temperature heat (500°–2,000°C) is used in thermochemical water splitting systems to power a series of chemical reactions that yield hydrogen. Each cycle of the process involves the usage of the same chemicals, resulting in a closed loop that uses only water to create hydrogen and oxygen. The following techniques can be used to produce the fundamentally extreme temperatures: (a) Using a "heliostat" field of mirrors to focus sunlight onto a reactor tower or (b) advanced nuclear reactor waste heat.

Several solar thermochemical water-splitting cycles have been explored for hydrogen generation, each with distinctive sets of working conditions, building challenges, and hydrogen generation openings. More than 300 water-splitting cycles are depicted in the writing. Two examples are (a) the "direct" two-step cerium oxide warm cycle which is less complex with fewer steps and requires higher operating temperatures and (b) the "hybrid" copper chloride cycle.

Electrolysis is classified into three types as follows:

Polymer Electrolyte Membrane (PEM)

Membrane electrode arrangements are electrolysis cell parts (MEAs) which separate the cells into two half cells(anode and cathode), Separator plates and use the collected (gas diffusion layers).

Water is electrochemically split into hydrogen and oxygen at the cathode and anode, respectively, in PEM water electrolysis.The difference between PEM water electrolysis and other electrolysis is that Water is pumped to the anode, where it is separated into oxygen (O2), protons (H+), and electrons, produces PEM water electrolysis (e).The rest of the electrolysis process is unchanged.

Solid Oxide Electrolysis (SOE)

Water is fed into the cathode of the SOE, where it goes through a water reduction process (WRR) that turns it into hydrogen and oxygen ions. Later, the purification modules use this hydrogen gas to separate the hydrogen from the residual water. The oxide ions then move from the cathode to the anode, release electrons into the external circuits, and undergo the oxygen evolution reaction to produce oxygen gas (OER). Solid oxide electrolysis consumes water in the form of vapour and runs at high temperatures and pressures between (500°C-850°C). It typically employs O2 conductors, the majority of which are made of nickel/yttria-stabilized zirconia. Today, research and development are being done on a number of conducting ceramic proton materials for solid oxide fuel cells because they demonstrate excellent efficiency at operation conditions between 500°C and 700°C and have good conductivity as O2 conductors. Prior to widespread commercialization, SOE must address a number of concerns relating to a lack of stability and deterioration.

Alkaline Water Electrolysis (AWE)

Alkaline electrolysis runs at low temperatures, such as 30°C to 80°C, with electrolyte concentrations of 20% to 30%. It uses an aqueous solution (KOH/NaOH) as the electrolyte. Asbestos diaphragms and nickel-based materials are used as electrodes in alkaline water electrolysis. Two hydroxyl ions (OH-) and one hydrogen(H2) molecule are created. The generated H2 escapes from the cathode surface to combine again in a gaseous state, and the hydroxyl ions (OH-) transfer under the influence of the electrical circuit between the anode and cathode through the porous diaphragm to the anode where they are discharged to one water molecule (H2O) and half an oxygen molecule (O2). The oxygen that was recombined at the electrode's surface escapes.

C. COMPARATIVE STUDY BETWEEN NORMAL AND SINGLE AXIS SOLAR TRACKER

Solar photovoltaic cells and the photovoltaic effect can be used to successfully harness the sun's abundant and highly renewable energy source and transform it into electrical energy. Low conversion efficiency is a PV cell's main drawback. The output of a PV cell is directly proportional to light intensity and the position of the Sun with respect to the solar panel in the sky; an immovable solar panel's absorption efficiency would be significantly lower at specific times of the day and year for a number of reasons. Whenever the Sun is not in the ideal position for a maximum area coverage of the cell, we are losing the energy which might have been generated; for the solar photovoltaic cells, they are most active when they are perpendicular to the sun and less productive in any other orientation. Hence, Solar trackers are used as a result to enhance energy production and increase efficiency. The design and construction of a low-cost active single-axis solar tracking system are presented in order to maximise the electricity generated by the solar panels as they track the Sun throughout the day.

We constructed and used a single-axis solar tracker which allowed us to amplify the amount of light hitting the solar panel's surface. This system provided an indirect increment in the solar panel's effectiveness by orienting the system with the Sun’s position as compared to a static solar panel which does not utilise a tracking system and hence has fewer opportunities for maximum voltage output from the panel. It employs the use of Light Dependent Resistors to detect the location of the sun. An Arduino Nano microprocessor then receives this information and instructs a servo motor to reposition the panel so that it is perpendicular to the sun's setting rays. This helps the solar cell to stay constantly at a maximum absorption angle which enables the solar cell's overall efficiency to enhance. Owing to the construction's affordable cost and notably increased efficiency, this solution is much more practical.

II. MATERIALS AND METHODS

D. APPARATUS FOR SINGLE AXIS SOLAR PANEL

Light Dependent Resistor

A photoresistor, also known as a light-dependent resistor, is an electrical component used to detect light and adjust a circuit's operation based on the intensity of the light. An LDR loses resistance as the incident light power increases. Cadmium sulfide, or CdS, is the semiconductor material utilized in photo-resistors.

Valence band electrons in LDR receive enough energy from falling photons, or light, to be stimulated into the conduction band. Incident photons must have energy larger than the

semiconductor's forbidding energy gap. More electrons will be stimulated to the conduction band when light with sufficient energy strikes the gadget. More current passes across the circuit since there are more free electrons.

In this project, we use a LDR with the following specifications: Diameter: 5mm, 2 Pins, PCB Through Hole mounting, having a Maximum Operating Temperature of +800°C (Approx.) and a dark resistance of 1-20 MΩ

Arduino Nano Microcontroller

The microcontroller board is an inexpensive Arduino Nano based on the ATMega328P. It is a physical computing platform that is open-source and in development for environment creating board software. Its LDR input is received by and has an impact on the servomotors. There are 6 of the 14 digital/output pins that might be utilized as digital PWM outputs 8 analogue inputs, a 16-bit digital to analogue converter, and mini-USB port, MHz crystal oscillator, and a ICSP header, power jack, and reset button. The

A computer software for tracking the Sun was created using the Arduino programme on a laptop, and uploading it to a mini-USB cable connected to an Arduino Nano board associated with the laptop. It operates at a voltage of 5 V and 7–12 V for the supply voltage.

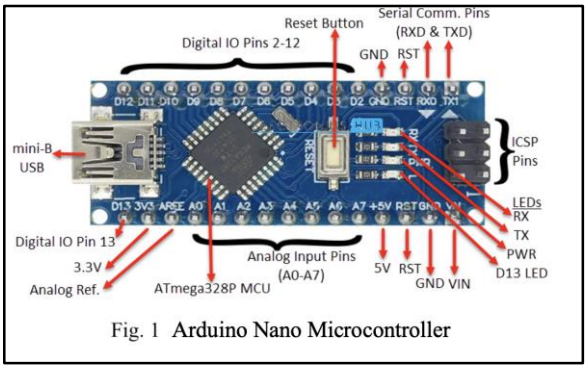

Fig. 1 Arduino Nano Microcontroller

Fig.1: *Schematic Arduino Nano board with ATmega328 microcontroller 2.2 software development.*

Servo Motor

Servo motor consists of a motor, a gearbox, a position sensor, an error amplifier, a motor driver and a circuit to decode the requested position. This 3-wire DC motor motorises the PV panel. Consumption of power is more when it is rotated to the commanding position compared to that when it is at rest. It uses closed-loop servomechanism. The Servo motor used is of type MG995 with an operating voltage of 4.8-7.2 V and operating temperature of 0-55 °C.

Solar/Photovoltaic Panel

Solar Panel, a packed assembly of photovoltaic cells, converts light into electricity. When attached to a single axis solar tracker system, the solar panel will change its position in accordance with the position of the sun. Mounted on the servomotor, perpendicular to the sun's rays throughout the day, it increases the efficiency of harnessing solar energy. 12V monocrystalline type solar panels are used in this project.

Limit Switch

In a single-axis solar tracker system, the function of the limit switch is to recognize the sun set at the end of the day and reset the solar panel to its original position. The solar panel changes its position from east-west in accordance with the movement of the sun resulting in maximum solar energy absorption.. As the sun sets, the Limit switch enables the solar panel to rotate 180 degrees to get back to its original position so that it is ready to absorb sunlight on the next day.

Other Components

The other equipment involved in the solar tracking system is a 7.4 V Rechargeable battery to power the servo-motor, a Multimeter to get the readings for the voltage generated by the single-axis solar tracker at different times of the day, and wires to connect the different components of the system.

E. APPARATUS FOR WATER SPLITTER

Plasticware

A 20 L plastic container is taken as the external body of the water splitter. Two 500 ml bottles, cut in half are used as a cover for electrodes to concentrate the gases. A pipe is passed through these bottles to provide a pathway for the gases to be directed toward storage. The pipes lead to Polyethylene terephthalate bottles which are partially filled with water. Another pipe from this bottle led to polyethylene bags which act as storage for hydrogen and oxygen gases.

Electrodes

Stainless steel sheets of thickness 3 mm are used. Using a drilling machine, a hole is drilled in 8 plates, and 4 are connected with a screw to make an electrode. One plate on each electrode is bent in an “L shape” and passed through a slit in the container to provide an outlet for connection for the electric supply.

Chemicals Used

10 Litres of distilled Water having a conductivity of 10 micro siemens is used. 80 grams of Sodium hydroxide pellets are used

to increase the alkalinity of the distilled water and facilitate the alkaline electrolysis process.

F. WORKING MECHANISM

LDR is connected to Arduino analogue pins A0 in the tracking system, which serve as the system's input. LDR is situated at the solar panel's edge. Different levels of sunshine hit the LDR. The LDR's resistance values are not always constant. To produce an output voltage, the LDR sensor circuitry is built as a voltage divider circuit. Thus, the analogue voltage at series resistance (Vout) varies together with the LDR resistor's variation in response to light. The Arduino Microcontroller, which is set up by the necessary programming logic, receives equal signals from LDR of their respective resistance/voltage values.

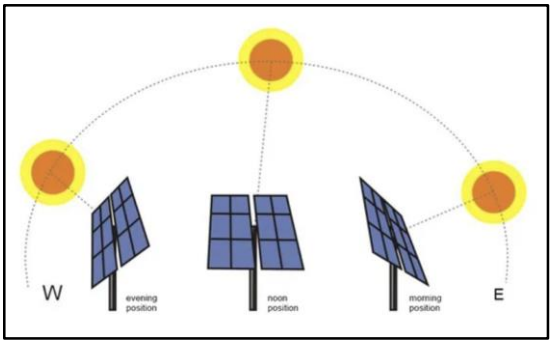

Fig. 2: *Solar Panel changing its Position with respect to the Sun*

The servo motors and the Arduino each receive a 7.5 V power source. Using the internal Analog-to-Digital converter, each LDR converts its analogue value into a digital value (Pulse Width Modulation). Because it is encoded in 10 bits, the nano controller converts the analogue value to a digital number between 0 and 1023, from which it is possible to determine the level of light. A solar panel is moved by the servo motor's axle. The configuration of this servo motor allows the solar panel to move along the X-axis. Based on the input signals obtained from the LDR, the microcontroller provides the proper impulses to the servo motors. For x-axis tracking, servo motors are utilised. The servo motor is moved using the PWM values. The motor may rotate through three different angles: 0, 90, and 180. The solar panel will be moved by the servo motor in accordance with the value that the LDR provides. to ensure that the panel absorbs the most light possible.

To reduce volume and concentration variations brought on by the electrolysis process, the cell is connected to an electrolyte reservoir with a larger volume than the cell cavity. The electrodes are connected to a potentiostat, and the gas output connections are coupled to expansion tanks so that they do not overflow when gas bubbles are created. The working electrolyte is put back into the ballast before each experiment to prevent a substantial concentration increase from continuing. In order to prevent major fluctuations in electrolytic conduction, the temperature was kept constant at room temperature.

The electrodes are well submerged under the sodium hydroxide solution. The open end of the electrodes is then connected to the electrical output from the single-axis solar panel. The top part of the electrodes is covered by plastic bottles and the apparatus is closed. After some time there is bubbling at the cathode. As time goes on the amount of hydrogen generated will increase and fill up the plastic bag.

III. OBSERVATIONS AND DISCUSSIONS

The position of the solar panel is commonly acknowledged to be one of the most essential factors in collecting the output voltage. Solar panels operate best when facing the sun's beams since this allows for greater access from the sun as it travels from east to west. The peak performance periods during the day for most locations will be between 9:00 and 13:00. That's when the sun is at its brightest.

The data measurements are gathered from a wide region where there is no impediment that would prohibit the tracker from receiving maximum sunlight. The output voltages are measured throughout three consecutive days from 9 a.m. to 16.00 p.m. The solar panel's maximum output voltage is 7.55 V. The graphs are created by taking the average of the output voltages. There are two output voltage conditions being monitored. The requirements are as follows: - Single Axis Solar Panel and Static Solar Panel.

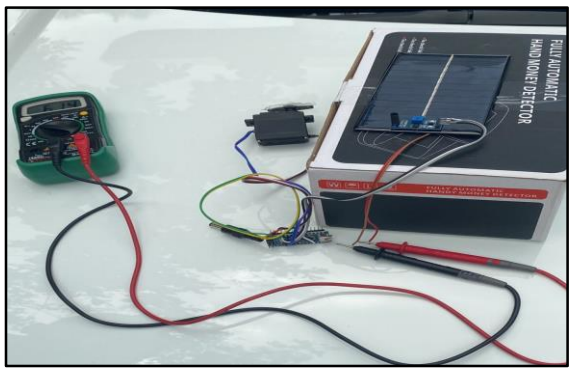

Fig: 3.1: *Image representing the Solar Panel Set-up for without Solar Tracker Methodology*

Fig: 3.2: *Image representing the Solar Panel Set-up for Solar Tracker Methodology*

The greatest and weakest voltage output at the maximum performance of sunlight may be tested by pursuing these two circumstances.

Observations for Solar Tracker without Single Axis Tracking		Observations for Solar Tracker with Single Axis Tracking	
Time	Volts (V)	Time	Volts (V)
09:00	6.23	09:00	6.44
09:30	6.45	09:30	6.66
10:00	6.69	10:00	6.9
10:30	6.81	10:30	6.99
11:00	6.87	11:00	7.07
11:30	6.95	11:30	7.16
12:00	7.03	12:00	7.24
12:30	7.15	12:30	7.41
13:00	6.98	13:00	7.55

Observations for Solar Tracker without Single Axis Tracking		Observations for Solar Tracker with Single Axis Tracking	
Time	Volts (V)	Time	Volts (V)
09:00	6.23	09:00	6.44
09:30	6.45	09:30	6.66
13:30	6.97	13:30	7.22
14:00	6.91	14:00	7.19
14:30	6.83	14:30	7.06
15:00	6.78	15:00	6.96
15:30	6.7	15:30	6.89
16:00	6.52	16:00	6.6

The first table indicates the readings of the output voltage measured for a static solar panel at regular intervals of 30 mins between 9:00 a.m. to 16:00 p.m and the second table gives the output voltage for single axis solar tracking conditions. The greatest output voltage observed for single axis solar tracking circumstances is 7.55 V at 13:00 p.m., while the lowest is 6.44 V at 9:00 a.m., whereas the highest voltage measured for static panels is 7.15 V at 12:30 p.m., and the lowest is 6.23 V at 9:00 a.m.

One of the primary causes of measurement output voltage instability is the location of the sun. Because the sun's location is uncertain, the surroundings are subdued at times. The solar panel will not be able to attain maximal sun illumination.

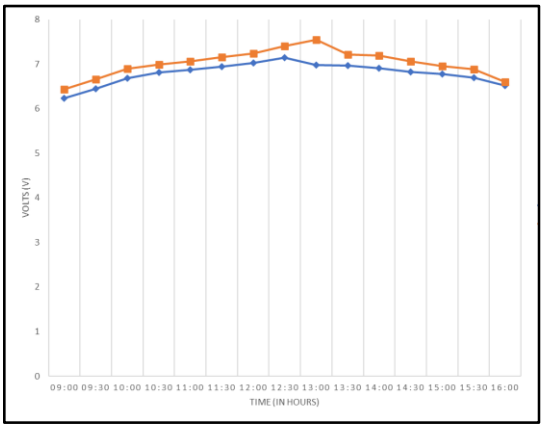

Fig: 4: *Values of output voltage comparative of the solar panel for a 30-minute time interval*

Blue curve: Voltage of static solar panel, orange curve: Voltage of single axis tracker solar panel.

According to the chart, the voltage output for each panel varies somewhat. When static and moving panels were compared, the solar panel with tracker provided greater output voltages due to optimal absorption.

Between 9.00 a.m. and 16.00 p.m., there are considerable fluctuations in voltage at 30-minute interval graphs. As a result, this system has been demonstrated to be effective in absorbing maximal sunlight sources for high-efficiency solar harvesting applications. The creation of an economically and ecologically acceptable solar tracking system will be a technology used more extensively and intelligently in renewable energy. The efficiency may be boosted further by connecting with passive solar trackers, which are based on thermal expansion ideas, and because it uses solar energy, a sustainable source, it is a futureproof energy source. Increased efficiency in the solar energy area will allow us to produce a limitless harvest of energy, which will also aid in the progress toward mitigating global warming.The benefits and drawbacks were also investigated. The downsides were the obstacles that needed to be overcome. The following are the study's key findings: The Single Axis Solar Tracking System is inexpensive and compact; it is simple to programme and modify because it is Arduino-based and does not require an external programmer; the designed system is simple to use and improves panel efficiency; and, in the developed system, real-time data is retrieved on an Android device.

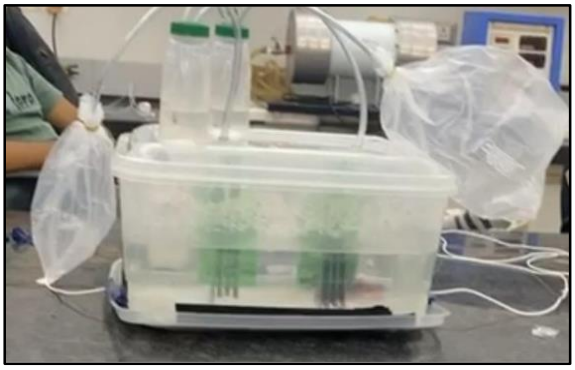

Fig: 5.1: *Set-up of Hydrogen generation electrolytic cell*

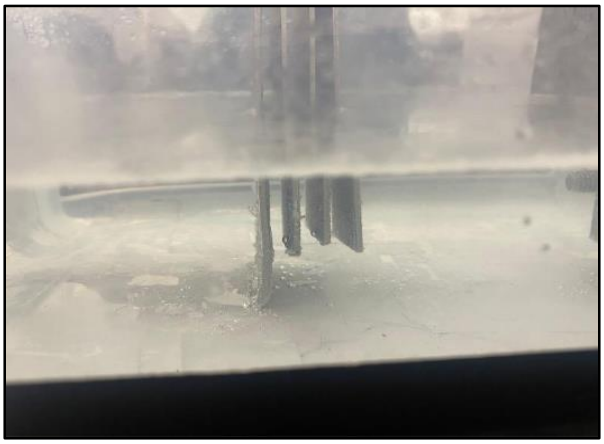

Fig: 5.2: *Bubbles of Hydrogen generated within seconds of the supply voltage*

Green hydrogen is produced in the amount of 1.5 litres. Figure 5.1 shows how the water splitting setup is used as a test rig. The cell was linked to a reservoir of electrolyte with a larger capacity than the cell cavity to reduce variations in volume and concentration caused by the electrolysis process. The gas output connections are linked to expansion tanks to prevent them from overflowing when the gas bubbles form, and the electrodes are linked to the potentiostat. The working electrolyte is returned to the ballast before each experiment so that sustained usage does not result in a considerable increase in concentration. To minimize major variations in electrolytic conduction, the temperature was kept at ambient temperature.

Alkaline water electrolysis can be incorporated into a distributed energy system to create hydrogen for end consumption or as an energy storage medium using renewable sources of power (e.g., sun, wind, and waves). In comparison to the existing primary methods for producing hydrogen, alkaline water electrolysis is usually regarded as a simpler technology; yet, significant effort has to be done to increase its current

efficiency. More research is needed to solve the durability and safety difficulties that continue to stymie the mainstream usage of alkaline water electrolysis.

IV. FUTURE SCOPE

In a decade, solar energy has advanced significantly. In 2010, the world market was still limited and heavily reliant on the subsidy systems of nations like Germany and Italy. More solar energy than all other generation methods combined will be installed globally this year—more than 115 gigawatts (GW). It is also getting cheaper, especially in sunny areas where it is already the least expensive method of producing fresh electricity.

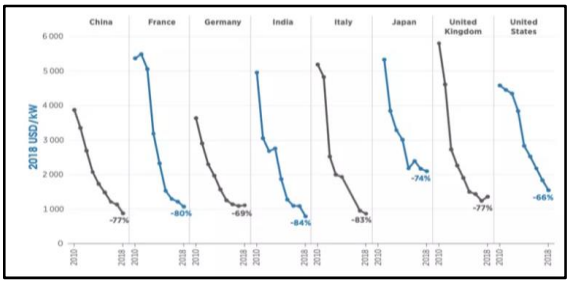

Fig: 6: *The total installed cost of utility-scale solar PV in various nations from 2010 to 2018 is shown in the graph above*

Solar energy will become even more accessible in the upcoming years thanks to advancements in technology. It's possible that by 2030 solar energy will be the primary source of energy for producing power in a significant portion of the planet. Additionally, this will benefit the ecology and combat climate change.

Solar costs should be cut in half by 2030 according to the solar industry's extremely clear cost-reduction roadmaps. Higher-efficiency modules are already being developed; they can provide 1.5 times as much power as currently available, comparably sized modules thanks to a technique known as tandem silicon cells. These will have a significant effect moving forward.

Further, there are industrial advances in the works that will lower the quantities of pricey components used in the creation of solar cells, including silicon and silver, as well as breakthroughs like bifacial modules, which enable panels to absorb solar energy from both sides. The best way to incorporate solar energy into our homes, places of work, and power systems is the other significant breakthrough. Better power electronics and more extensive use of inexpensive digital technology are the results.

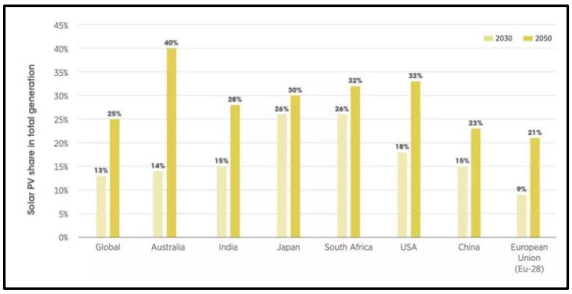

Fig: 7: *The above picture, more solar energy is expected to be incorporated into electrical systems worldwide*..

Systems that use solar photovoltaic tracking have a substantial area for research. There is a tonne of room for advancements or inventions in this field. The reduced efficiency of photovoltaic tracker systems and the lower electrical energy generation are the main drivers behind the development and manufacture of solar photovoltaic systems. PV tracker systems, PV systems with concentrated mirrors, and PV thermal or hybrid systems all increase the output of PV systems. Each of these systems has the potential to boost electrical energy generation. By 2030 and 2050, however, the fixed PV system will be more widely used and less expensive to install.

Too many nations employ solar energy to generate electricity, but they do not yet make use of dual axis solar trackers. Although a dual-axis solar tracker is more effective, they often employ a single-axis solar tracker. Therefore, the single axis solar tracker efficiency must be increased, but this will be more economically viable. In addition to being more economical, a dual axis solar tracker system generates more electricity. Future research in this field is necessary since a variety of elements, including humidity and solar intensity, alter solar radiation. The tracking capability and longevity can be extended by using more powerful motors, but the cost will be slightly higher. However, utilizing Arduino instead of the microcontroller board will make it less expensive, albeit being more challenging. Whether they are single-axis or dual-axis, solar trackers will aid in maximizing solar energy. When it comes to the future of the solar tracker sector, it appears to be extremely appropriate right now.

V. CONCLUSION

One of the most significant electrochemical reactions is water splitting, which has a wide range of uses, especially in the storage and conversion of electrochemical energy. The precise mechanism of electrochemical processes has long been a subject of investigation because electrode reactions are the primary source of energy loss. Over many years to make it

possible to build highly efficient electrolytic cells, which necessitate superior electrocatalysts. The efficiency of the earliest electrolytic cells was between 60 and 75 percent. Although larger units are only slightly less efficient than small units (about 70–75%), the best practice figure for small units is now around 80–85%. However, it should be emphasized that the overall efficiency for converting fossil fuel into hydrogen when using electricity from thermal power plants is just 25–30%. This is not a very desirable return on the effort put out. However, RandD's work continuously innovates on the ideas for water electrolysis that already exist. Reducing system resistance and consequent energy losses is the subject of a recent study. As a result, we would be closer to actually "creating" hydrogen as a cheap and clean energy source. Overall, tremendous progress has been made in the design of atomic, molecular, and nanoscale materials for electrocatalysts for splitting water for hydrogen production. Due to its superior gravimetric energy density and lack of any emissions of pollutants, hydrogen is a possible replacement for fossil fuels as it provides clean, renewable energy. The improvement of water-splitting cells as an efficient energy conversion and storage method boosts hydrogen production substantially. However, the slow reaction kinetics of OER and HER generated by huge overpotentials reduce the energy efficiency of water electrolysis, resulting in water splitting producing just 4% of the world's current hydrogen production. Effective catalyst design is critical for limiting overpotentials and increasing energy efficiency in both OER and HER, which is required to make industrial water splitting feasible.

To power the hydrogen splitter, a single axis solar tracker and panel are employed. First, a tracking system for controlling and monitoring the movement of solar panels depending on light intensity is developed. To absorb more solar energy, the solar panel will be oriented perpendicular to the sun. Second, solar tracking systems produce more electricity during the day, whereas fixed solar panel installations produce the least. However, the shading effect has a minor impact on the solar panel's ability to create an output value. Third, when the tracking system is implemented, the system's % efficiency in energy conversion rises. The efficiency gain of a permanent solar panel installation in the same location changes dramatically with height, direction, and location. Finally, the solar panel's electrical energy is used to power the hydrogen splitter. The output value is at its highest between 12:00 and 14:00. After inserting the single-axis solar tracker, the output value increased by an average of 3%. Using a dual-axis tracker can assist boost the efficiency of the solar panel, allowing it to manufacture hydrogen more effectively.

VI. ACKNOWLEDGEMENT

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Arduino based Remote Controlled Car

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***Abstract*—This project is built with Arduino, a motor driver, and a Bluetooth module. Arduino is a free and open- source hardware and software prototyping platform. An ATmega328 microcontroller is used by Arduino. As robotics has become an important part of both our daily lives and the technical sector, it is essential for the advancement of new technology. A Bluetooth module has been used in place of an IR sensor and an ordinary microcontroller to create a very straight forward and uncomplicated type of remote-control car. Any Android or iOS mobile phone can be used as the remote. For real-time cars, a larger version of this project can be produced.**

Keywords—Arduino Uno, Arduino IDE, Motor Driver, Battery and Motor.

I. INTRODUCTION

A microcontroller board called Arduino Uno is based on the ATmega328P. It contains a 16 MHz crystal, 6 analogue inputs, 14 digital input/output pins (6 of which can be used as PWM outputs), a USB port, a power connector, an ICSP header, and a reset button. Everything needed to support the microcontroller is included. To use it, all you need to do is plug in a USB cable, a AC to DC converter, or a battery for power. You can experiment with your UNO without worrying much about making a mistake; in the worst case, you can replace the chip for a few dollars and start over. The Italian word "uno," meaning "one," was chosen to denote version 1.0 of the Arduino software (IDE). The Uno board with Arduino software (IDE) version 1.0 served as the basis for further generations of Arduino. The UNO board is first in the series of USB Arduino boards and serves as a benchmark for the platform. For the comprehensive list of all previous, current, and out of date modals, see the Arsuino index of the boards. The 15-lead Mutli watt and PowerSO20 contain the integrated monolithic circuit know as the L298. It is a high voltage, high current, twin full-bridge driver intend to drive inductive load such as relays, solenoids, DC motors, and stepping motors,. It also accepts conventional TTL logic levels. To enable or disable the device independently of the input signals, there are two enable inputs available. Each bridges bottom transistor have linked emitters, and external sensing resistor maybe connected to the corresponding external terminal using the appropriate wires. The logic operators at the lower voltage thanks to an extra supply input. Bluetooth is wireless technology standard for creating personal area networks and transmitting data over short distance between fixed and mobile devices utilizing short

wavelength UHF radiowaves in the ISM band from2.4 to 2.485 GHz (PANs) around 10 meters is the range (30 feet). The Cambridge Silicon Radio BC417 2.4GHz Bluetooth Radio serves as the foundation dor these modules. It employees an external 8 Mbit flash memory and is complicated chip [1-2]

We have used Arduino because it is an open source device which can be programmed through any operating systems like Windows, MAC, Linux etc.
The language use is understandable and easy.
Changing of program is easy.
Shield (external circuits) are available for Various purpose like, if we want to connect the Arduino to a network then a Wi-Fi shield is available and for this project a Bluetooth shield is used.

Every AC and DC motor has the ability to rotate in both directions.
AC motor has its own rules and usage, but DC motor could rotate in other direction just hy changing the polarity of the current.
DC motors are used to produce rotatory motion due to its high efficiency. But in some cases, we need to rotate the motor in both directions.
To avoid the complexity an IC named L298D was invented, by which not only direction, other multiple functions could be achieved just by the blink of an eye.

II. LITERATURE REVIEW

The implementation of "An android Remote Control Car Unit for search missions" by Yuxin Jing, Letian Zhang, et al. It means to actively look for natural calamities. With the advancement of autonomous technology, it is now possible to avoid obstacles even if the driver cannot see them. Camera, ultrasonic sensor, Bluetooth servo motor, Arduino UNO board, Wi-Fi network, and Android studio are needed for its execution. This programme can simplify the search process.
"Android Based Wi-Fi Controlled Robot Using Raspberrpi" was implemented by MehmetcanGule, Murat, Orthun et al. Using a USB camera and a Raspberry Pi board, this paper implements a robot that can move forward, backward, left, and right as well as show a live video stream. The majority of creative applications are used to improve people's lives.
"Remote Control Robot Using Android Mobile Device" was explored by Jan Nadvornik, Pavel, Smutny, and others. When using a graphical user interface, the programme enables us to monitor the current distance between an obstacle and the vehicle and direct robot interaction via display or speech. To determine how far an impediment is from a moving object, ultrasonic sensors are utilised.

III. THEORY

Working Principle:
Build the robot, connect everything, and then upload the code to Arduino. The Bluetooth Controlled Robot project is fairly simple to understand if you have read and understood the HC-05 Bluetooth Module instruction.

First, I utilised five keys—Forward, Reverse, Left, Right, and Stop—in the Android app. The following information is connected to each key:data associated with each key is as follows:

a) Forward – 1
b) Reverse – 2
c) Left – 4
d) Right – 3
e) Stop – 5

Depending on which key was pressed, the Arduino UNO receives this data from the Bluetooth module and performs a simple toggle operation, with each key containing the correct instructions for the motor driver's input pins.
Similarly, other buttons correspond to the appropriate setting of pins IN1 - IN4.

IV. METHODOLOGY

DESCRIPTION:
The HC-05 Bluetooth Module is the initial component in the circuit design. The Arduino's
+5V and GND pins are linked to the Bluetooth modules +5V and GND pins.
Only the TX pin of the Bluetooth module is connected to the RX pin of the Arduino, as I only plan to transmit data about the robot's movement from the Android Phone to the Bluetooth module and not to receive data from the Arduino.
This Arduino RX pin is built using the Software Serial library (Pin 2 and Pin 3 are configured as RX and TX on Arduino). The Bluetooth RX pin is unplugged.
The L298N motor driver module is now discussed. Connectors IN1 to IN4 of the L298N motor driver module are connected to digital I/O pins 9 to 12 of the Arduino, which are set up as input pins for the motor driver. The jumper provided connects the two enable pins to 5V. In my Bluetooth-controlled robot car project, I use a robot chassis equipped with 4 gear motors. Since the L298N module only has slots for two motors, I combined the motors on the left and right sides into one set and connected both sets to the output of the L298N module.

COMPONENTS USED:
Power Supply: Due to their main function of converting one type of electrical energy to another, power supplies are commonly called electric power converters.
Bluetooth module: When linked to other Bluetooth devices, it is a tiny wireless serial communication module that may be coupled with a Micro- Controller to receive and deliver data.
Arduino-UNO: Arduino is a free and open source hardware and software prototyping platform. To create computer code and upload it to the actual board, Arduino consists of a piece of software called IDE (Integrated Development Environment) that runs on your computer.
Motor driver: It is a compact circuit that can simultaneously control two motors and hoist the motor driving IC. Pulse width modulation is used to regulate the motor speed (PMW). The circuit diagram is displayed in Figure 1. It takes two dc batteries. The Arduino board requires a first supply of 5 volts direct current, and the driving circuit requires a second source of 6 to 12 volts direct current. Once everything is configured, the Android device is required to run the "CAR BLUETOOTH RC" programme, which delivers commands to the

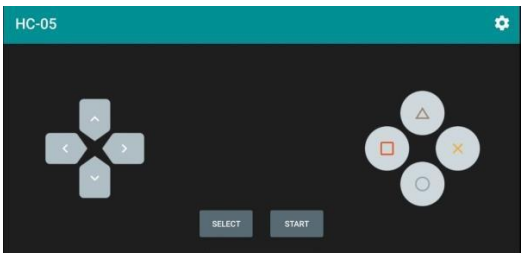

Fig 1:*Display*

Arduino-connected Bluetooth module. These instructions are received by the Arduino, which then sends them through its digital I/O pins to the Motor Driver.

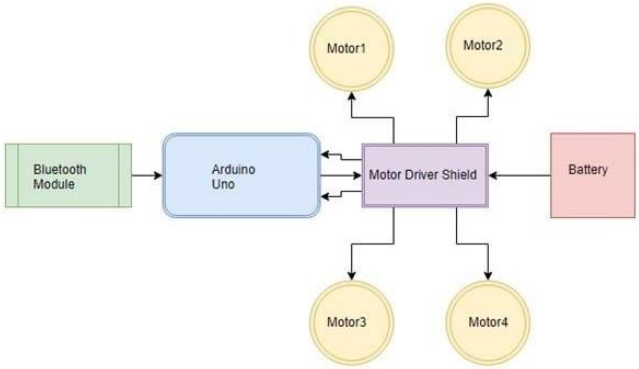

Fig.2*: Block Diagram*

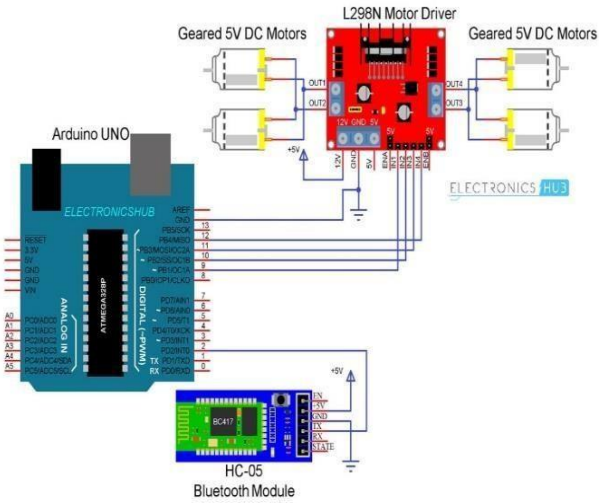

Fig.3: *Circuit Diagram*

Two DC motors are attached to the motor driver's output terminals, and the motor driver operates the two motors in accordance with instructions sent by the Arduino. The motor driver has the ability to operate both motors
direction. Allowing them to operate the motor in either direction, which is advantageous.

ACTUAL VIEW OF PROJECT

Fig.4 Final Model

V. APPLICATION

The robot can be utilized dor surveillance because of its tiny size.
This robot maybe employednear the border to locate and denote buried land mines with a few minor tweaks and enhancements.
We can use it as a firefighting bot if we use fire sensor.
This robot can have sensors connected to it so that it can keep an eye on certain conditions.
We can add wireless camera to this robot.

VI. CONCLUSION

Open-source hardware called the Arduino has served as the brains behind a number of initiatives. The Arduino incorporated an internal converter, I/O pins, and other features that the user may need. Using an Arduino board and a Bluetooth shield, we can use our smartphones to control a variety of different devices, like the air Smart Home system, can benefit greatly from the Arduino as well.
We learned a lot about the arduinp and how it facilitates the conversion of digital impulses into physical motions by working on this project. Another benefit of Arduino is that once a 2013 programme is burned, as long asit is not RESET, we do not have to worry about it becoming wiped. Due to its effectiveness and user-friendly features, Arduino has an advantage over all other Engineering microcontrollers.

VII. FUTURE SCOPE

The Arduino platform has transformed the formerly fragmented and costly robotics and microprocessor sector into the dominant platform, partly because of its reduced cost, greater use, increased volume and popularity, and community support. Arduino has made it simple to interface their boards with a variety of sensors and devices as well as to easily programme their boards with any computer through USB. Due to its inexpensive price, simplicity of use, and extensive internet following, the Arduino is a fantastic tool for hobbyists, prototypes, and those just getting started in robotics. The Arduino is simple to use and easy to teach others how to use, but it can also be used to accomplish quite complex tasks if you are a developer with the skills to do so. It enables anyone to create projects to build and operate their own devices on a budget, such as control systems for various gadgets and sensors that broadcast data to the Internet. By enabling businesses to create prototypes considerably more rapidly and with less initial expenditure, it is also lowering the cost of development. The same prototype may be utilised to create a firefighting robot in the future, and depending on the application, thermal cameras and sensors can be installed.

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