FINAL YEAR PROJECTS' 19

TELEROBOTICS
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Innovative Projects

DEPARTMENT OF MECHATRONICS AND CONTROL ENGINEERING
UNIVERSITY OF ENGINEERING AND TECHNOLOGY, LAHORE

FINAL YEAR PROJECTS SESSION 2015

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SESSION 2015

FINAL YEAR PROJECTS

Department of Mechatronics and Control Engineering

MISSION STATEMENT

The department, through quality education and enabling environment, aims to foster professional engineers capable of designing complex Mechatronics systems, serving current industrial needs and developing innovative technologies.

INTRODUCTION

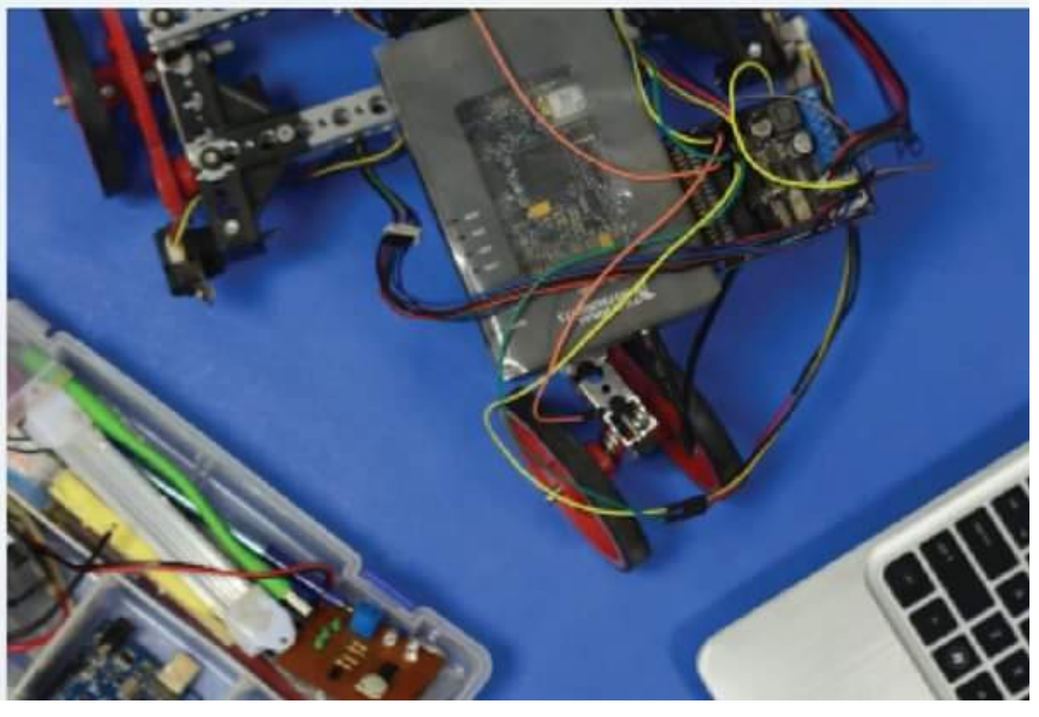
Department of Mechatronics & Control Engineering (MCE), was established in December 2005. The undergraduate and post graduate programs being run by the department were established in 2001 and 1999 respectively. Present undergraduate enrollment is around 300 students. Bachelor's degree in Mechatronics and Control Engineering is accredited by Pakistan Engineering Council.

OFFERED PROGRAMS

- B.Sc Mechatronics & Control Engg.
- M.Sc Mechatronics Engineering
- Ph.D Mechatronics Engineering

DEPARTMENT LABS

- Human Centered Robotics Lab
- Artificial Intelligence & Robotics Lab
- Instrumentation & Control Lab
- Automation Lab
- Hydraulics & Pneumatics
- Embedded Systems Lab
- Power Electronics Lab
- Computer Lab
- Mechanics of Machines Lab



Teacher Incharge's Letter

Your FYP is an ice-breaker; it starts the conversation as it allows you to express your technical prowess. In interviews and meet-ups, and among colleagues, the discussion on your FYP illustrates your ability to visualize a complex product as well as the skills to realize it. In mechatronics, the impact can be even greater because you aim to integrate different components from varied backgrounds (mechanical, electronics and software engineering) and present a fully functional product. Moreover, your FYP exhibits your ability to attain all the graduate-attributes as defined under outcome-based education system.

During this year, you may have learned that your best friend may not always be a suitable colleague, or you might have found help in the most unlikely places. You may have also realized the reality-gap between a concept and a final-product. You may also have understood that a product generally takes a year to take shape and the painstaking process associated with it. But this is how it is - a multitude of different, often adversarial, aspects; but if you are ready to learn required skills, persistent over a long period and never willing to dilute your aims, you will achieve it!

Best of luck for your future endeavors.

Dr. Ali Raza
Teacher In-charge,
Department of Mechatronics & Control Engineering
University of Engineering and Technology, Lahore

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FINAL YEAR PROJECTS SESSION 2015

VR TELEROBOTIC SYSTEM

OBJECTIVE

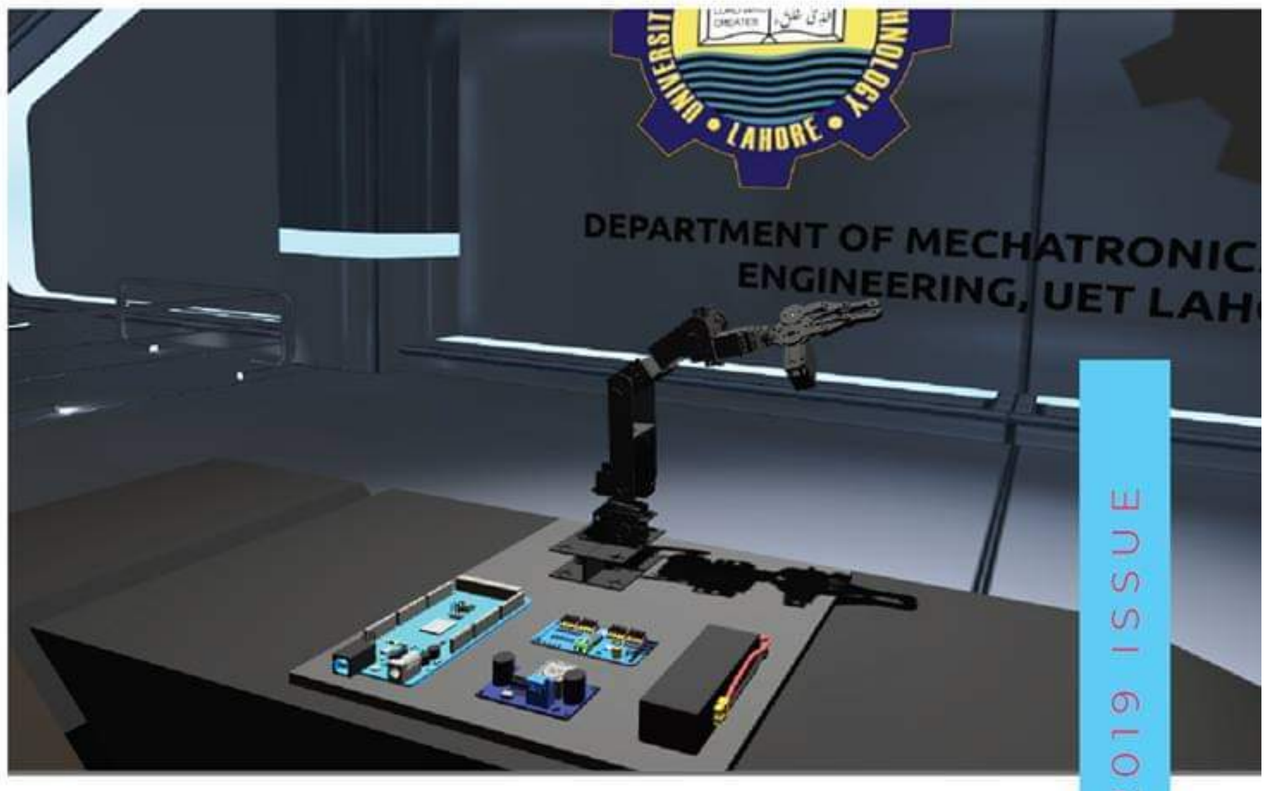
This Final Year Project aims to create a telerobotic system to achieve complex manipulation of robots by simple movement of human arms and is designed to make use of a virtual environment which will include the model of a real robotic manipulator having 5-DOF with articulated configuration. In virtual environment, this manipulator is placed where an operator can easily move its end-effector while the joints in this robot will move according to its inverse kinematics equations and control the real robot placed remotely.

EQUIPMENT & SOFTWARE

- Oculus Rift
- Robotic Manipulator
- Arduino MEGA 2560
- Adafruit PCA9685 Servo Driver
- SolidWorks
- Unity 3D
- MATLAB
- Microsoft Visual Studio

VIRTUAL WORKSPACE

The virtual environment was created using Unity 3D software. The real robotic manipulator is also placed in the real world. A human operator uses the Oculus Rift headset which makes the operator feel like he is in a virtual world. The human operator may move the end-effector of the model of robotic manipulator in virtual environment using the Oculus controllers in any direction he wants.



METHODOLOGY

- **SolidWorks**
- **Robot Manipulator 3D model**

- **Unity 3D**
- **Virtual Environment including manipulator**

- **Oculus Rift**
- **Robot manipulation using Oculus controllers**

- **MATLAB**
- **Inverse Kinematics using UNITY co-ordinates**

- **Arduino**
- **Input to motor encoders from MATLAB**

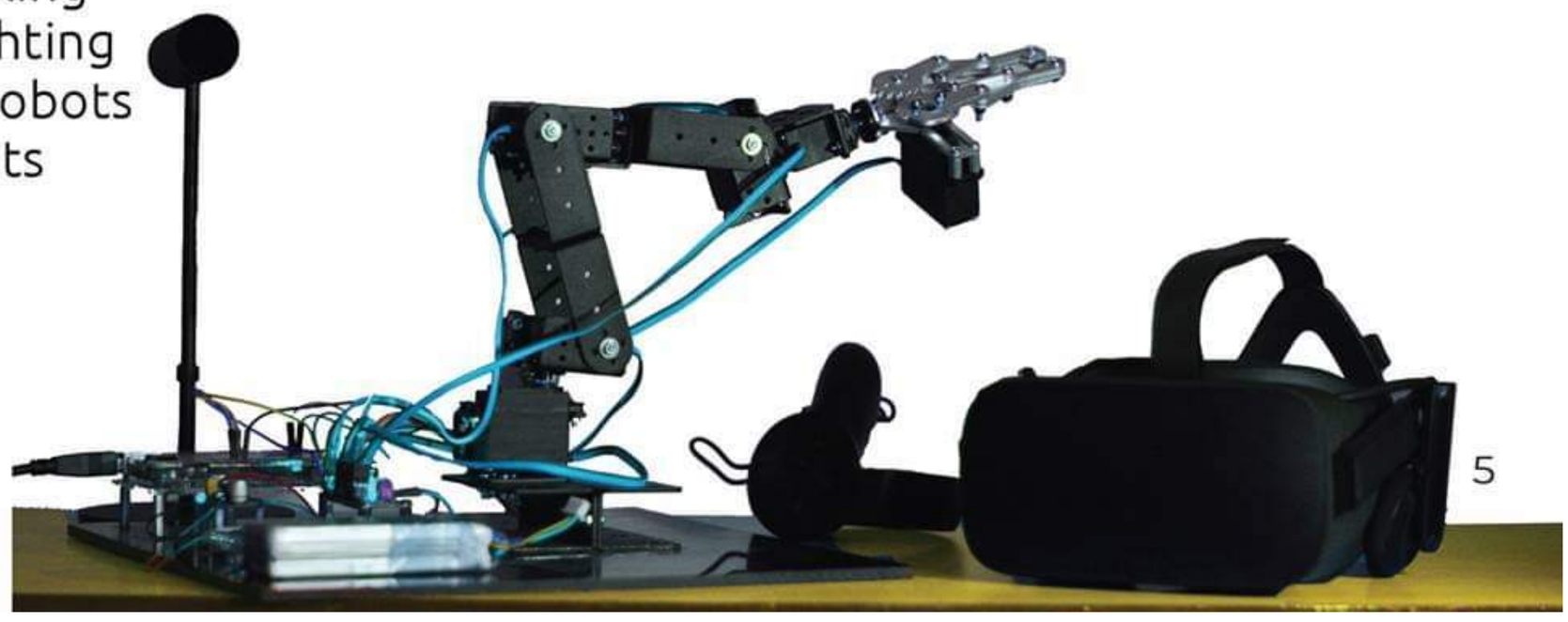
- **Hardware**
- **Desired movement of real robot**

The robotic manipulator is placed in the real world. A human operator uses the Oculus Rift headset and controllers to manipulate the virtual robot according to his requirements. All the movements that the operator performs in VR will be mimicked, the same way by the robot in real world.

APPLICATIONS

- Military: Training of pilots, Spying purposes (UAVs)
- Medical: Remote Treatment, Surgery
- Marine: Exploration, Search, Surveying
- Maintenance of underwater facilities
- Toxic Chemical Handling
- Civil Security, Firefighting
- Bomb Disposal Telerobots
- Nuclear Control Plants
- Space exploration

Scan to watch project video



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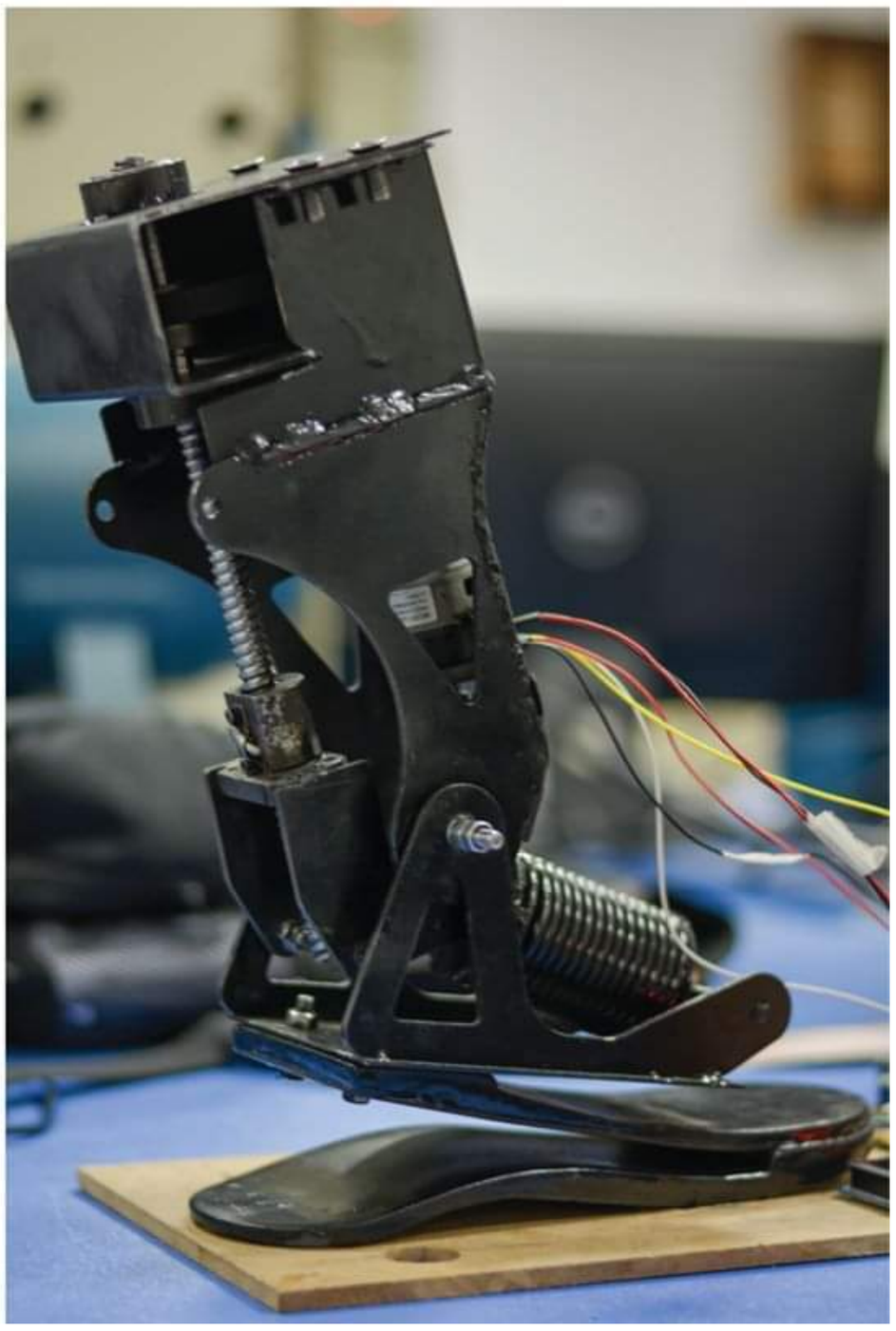
ACTIVE PROSTHETIC LEG

OBJECTIVE

This Final Year Project aims in the realization and development of an Active Prosthetic Ankle that has mechanical behavior similar to that of a natural ankle. The active ankle prosthesis is designed to aid an amputee's foot during plantation and take off due to degree of freedom at ankle joint and by mimicking the intended foot movement by detecting and processing the raw muscle signals from the amputee's residual limb to actuate the foot accordingly into plantar or dorsiflexion. The ankle joint will also provide enough heel cushioning and variable stiffness for better walking gait cycle.

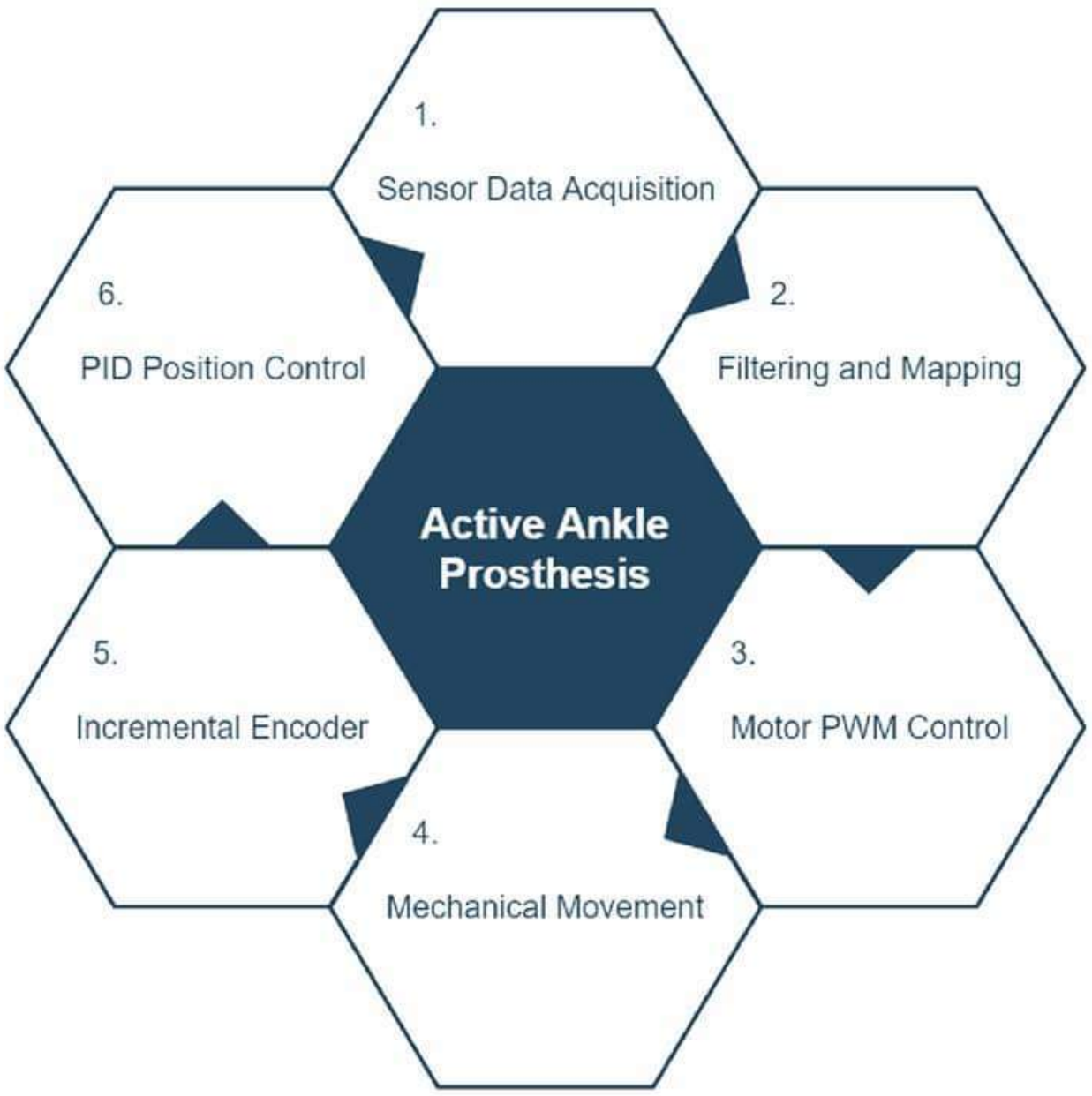
EQUIPMENT & SOFTWARE

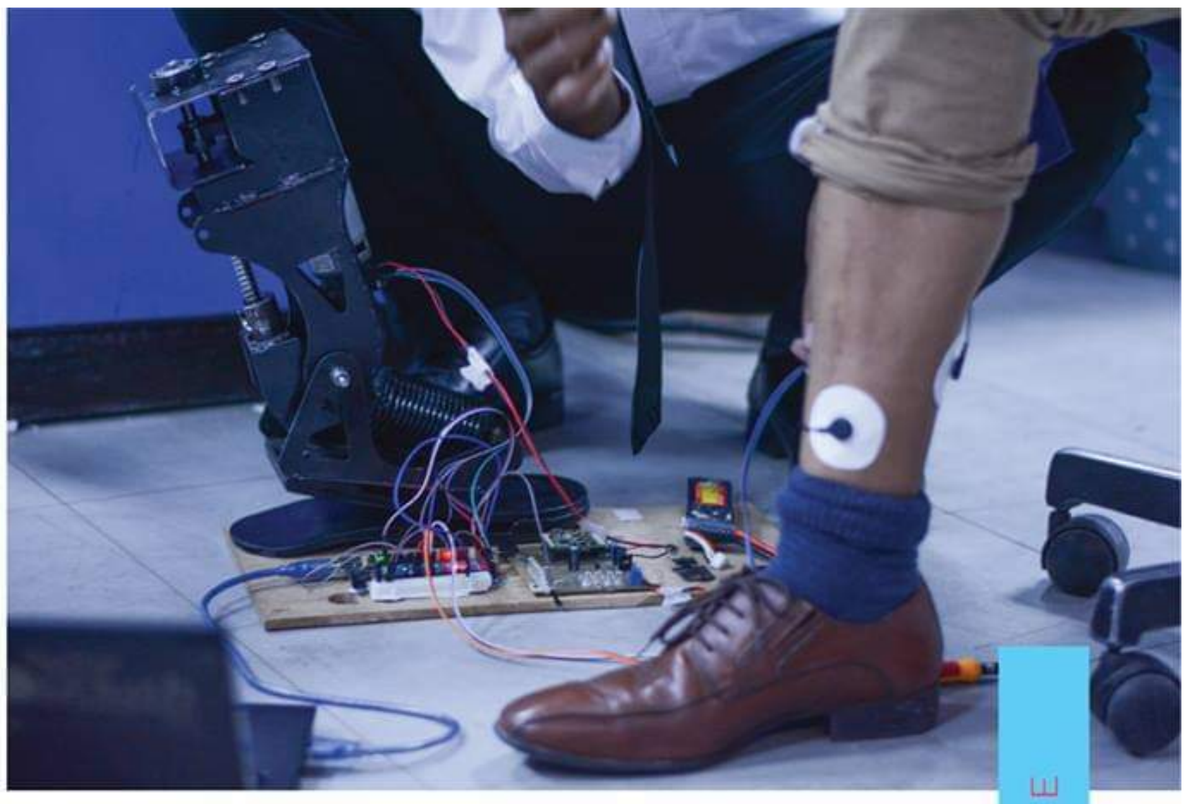
- SS 2mm Sheet for CNC Machining
- Maxon Motor with Encoder
- Carbon Fiber Foot Base
- Soft Prosthetic Foot
- Shock Absorber
- EMG Sensors
- Ball Screw
- Belt Drive
- Pulleys
- SolidWorks
- Key-shots
- Arduino
- ESCON



METHODOLOGY

Despite of the conventional passive rigid link we are providing an active solution to implement Degree of Freedom in the ankle joint through mechanical components like Motor, Ball Screw, Pulleys and Belt Drive moreover also providing Variable Stiffness and Heel Cushioning by incorporating Shock Absorber and adding design constraints in basic structure.





To impart active control two EMG sensors will be placed at Soleus and Fibularius brevis to detect Plantarflexion and Dorsiflexion respectively. Pre-Processed signal through these sensors will then be transferred to Motor as PWM which in turn will rotate the motor clockwise or counter - clockwise depending upon the activation signal of the sensor. Encoder will generate the current position and then by using PID control we will control the position of the mean and extreme position of the motor for the maximum ankle joint movement about it's axis. Thus providing an amputee the basic ankle movement both at take-off and plantation.

APPLICATIONS

- Illness or traumatic events may necessitate the amputation of a lower limb.
- The increasing age of the population represents an additional factor leading to diseases which may necessitate the amputation of a lower limb.

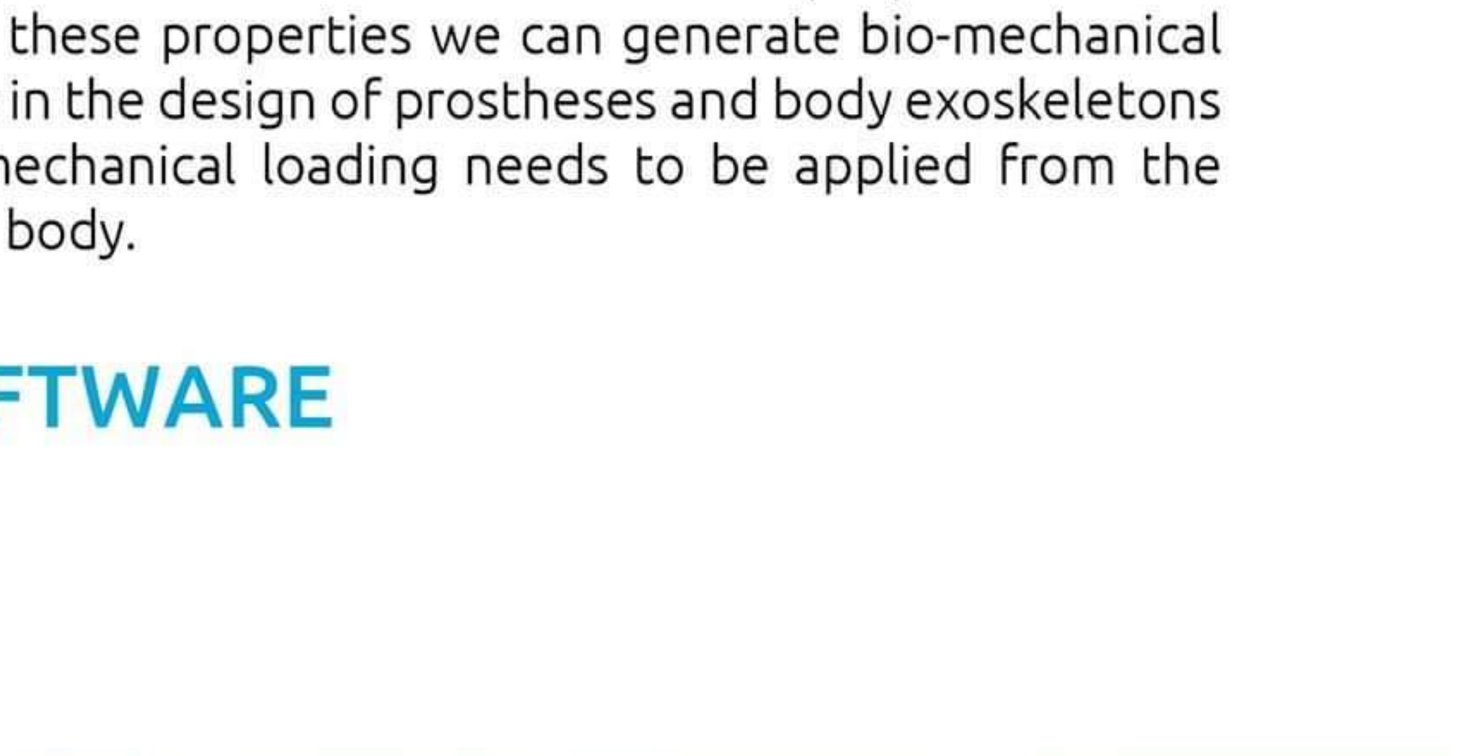
3D HUMAN LOWER LIMB PROFILER

OBJECTIVE

The design of wearable prosthetics is a now a big concern of modern era. Because conventional sockets are not comfortable at all. People get blisters, skin rashes and other skin problems by wearing these prosthetics. So, in order to make prosthetics more comfortable it is needed to measure bio-mechanical tissue properties of the skin of amputee. By measuring these properties we can generate bio-mechanical models that give critical insights in the design of prostheses and body exoskeletons where safe and comfortable mechanical loading needs to be applied from the synthetic product to the human body.

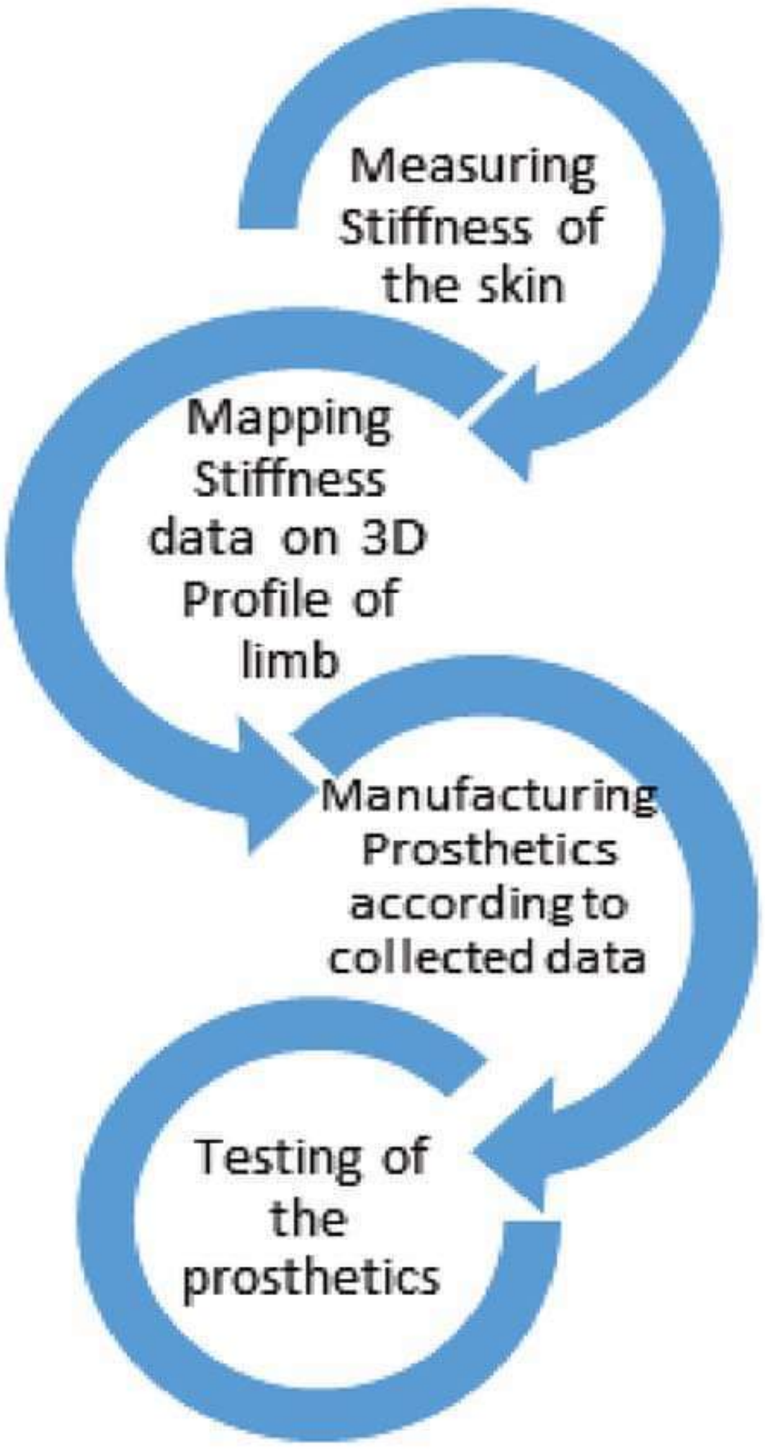
EQUIPMENT & SOFTWARE

- Ball screw
- Encoder motor
- Linear bearing
- Flexible coupling
- Load Cell
- Capacitive touch sensor
- Kinect
- HX711 (ADC)
- myRio Controller
- Lab View
- KScan3D
- SolidWorks



METHODOLOGY

The indenter device employs 9 degree of freedom (DOF) system six for linear actuators one passive rotational degree of freedom and two for frame translation motion. It contains 6 position and force controllable linear actuators .These actuators surround the limb in circumferential ring.



Ball screw is driven by electric motor by controlling the position of motor through PID controller. Detect the surface using capacitor touch sensor and measure the position using motor encoder. The applied force is measured through load cell. The stiffness 'K' is calculated by using Hook's Law.

$$F=K\Delta x$$

APPLICATIONS

- Design of comfortable prosthetics
- Design of comfortable exoskeletons
- Mathematical modeling of skin tissues
- In the field of dermatology, to determine the course of a disease
- This data is used in cosmetic Surgeries to prevent skin aging effect

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FINAL YEAR PROJECTS SESSION 2015

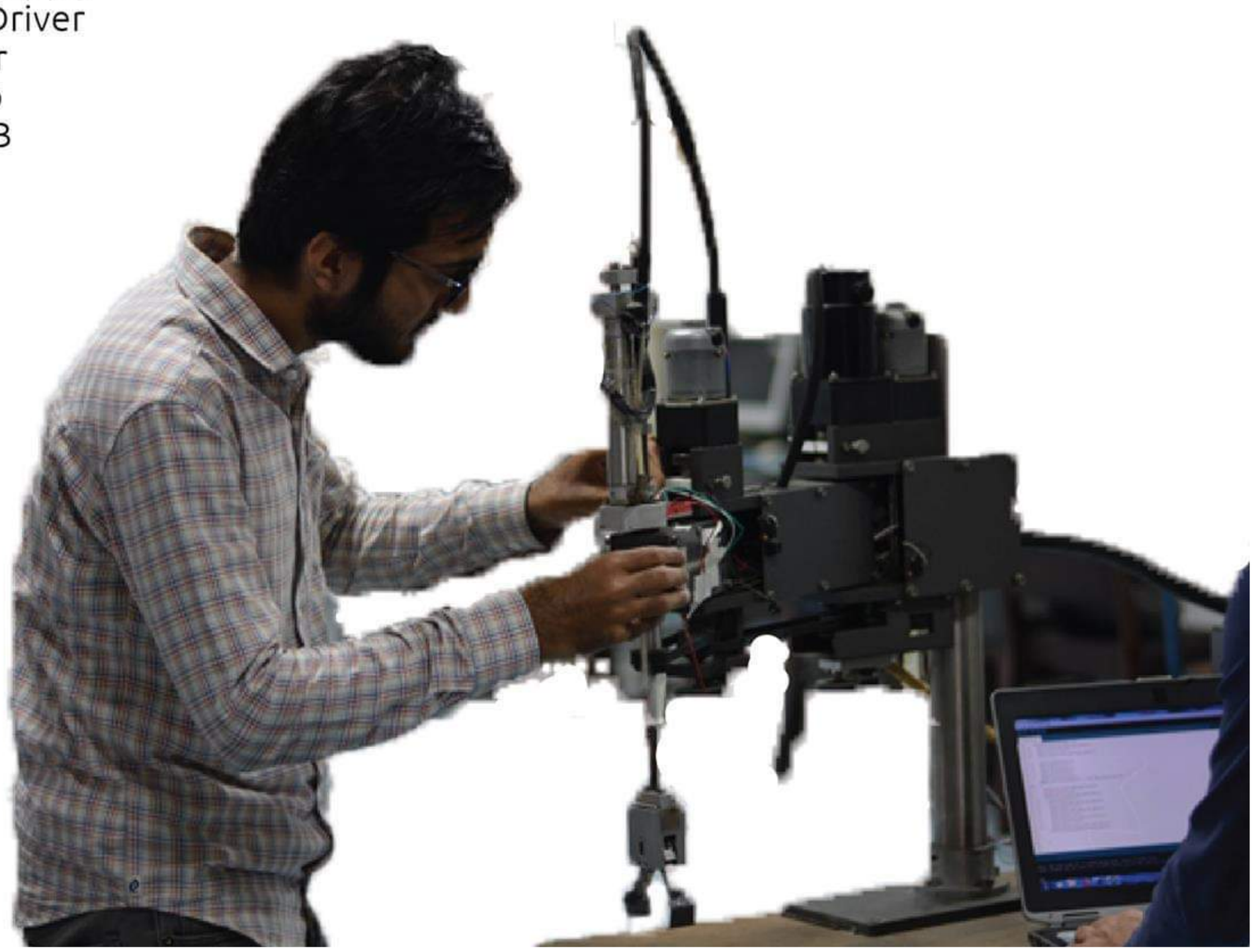
SERPENT-1 & 0-G COBOT RETROFITMENT

OBJECTIVE

The main objective is of the implementation of impedance control and one of its applications 0-G while the robot is exhibiting the collaborative behaviour.

EQUIPMENT & SOFTWARE

- Force sensitive resistance (FSR)
- Current sensor
- Serpent robot
- Power supply
- Motor Driver
- Encoder
- Arduino
- MATLAB



METHODOLOGY

Troubleshoot the robot and bring it in working condition then while reviewing the literature implementation of forward and inverse kinematics in the next step implementation of force control taking the force as feedback through sensor upgradation of force control to Impedance control and also implementing the collaborative behaviour on the robot.

- Troubleshooting
- Forward & Inverse Kinematics
- Force Control
- Force Feedback
- Impedance Control
- 0-G Collaborative Robot
- Final Testing

The final step of the is implementation of 0-G one of the application of Impedance control and testing of the robot in the presence of the human worker in its working space.

APPLICATIONS

- 0-G Collaborative Robot
- Pick & Place Exercises
- Learning and performing repetitive jobs
- Lifting heavy load as per worker requirement
- Works safely in complex environments

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FINAL YEAR PROJECTS SESSION 2015

INDUSTRIAL UPPER LIMB EXOSKELETON

OBJECTIVE

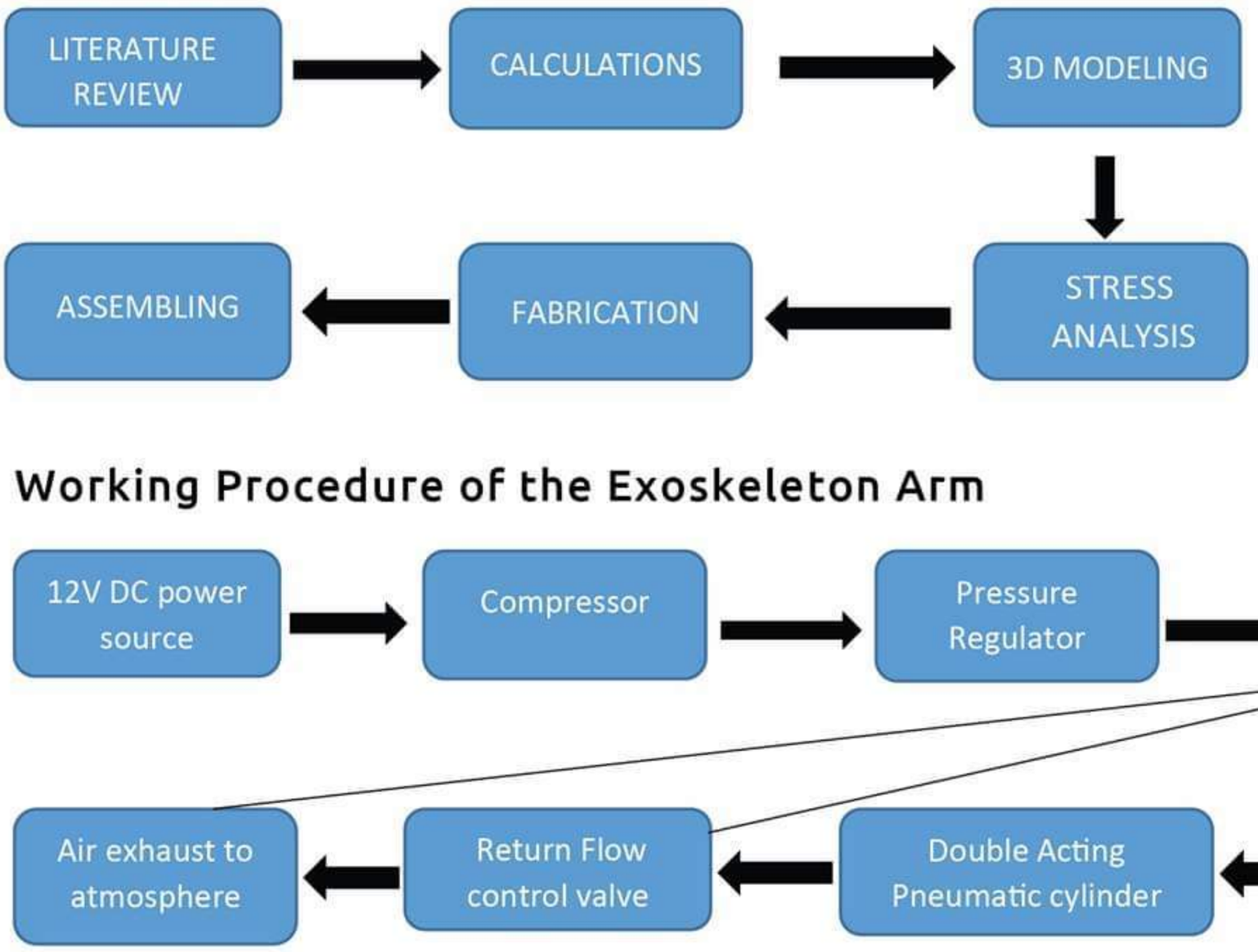
Our main objective is to make this exoskeleton cost effective so for this purpose pneumatics cylinders are being used instead of motors. The upper-limb motions are very important to perform daily activities. Assisting the motion of the upper-limb of physically weak people brings a lot of benefit to ease their daily lives and make them more productive to the society so it will help in the motion of the upper limb of physically weak people. It permits the transfer of external loads to the stronger sections of the body by means of accurately placed linkages and joints. Another objective is to reduce the human effort by lifting the weight.

EQUIPMENT & SOFTWARE

- Pneumatic cylinders
- Pneumatics Pipes
- Aluminium links
- Elastic Bands
- Screws
- Valves
- SolidWorks

METHODOLOGY

For this project, pneumatic cylinders along with 5/3 solenoid operated valves have been used. When a certain pressure is applied, the corresponding cylinder gives us the required motion through extension and retraction. The valves used are basically proportional valves that allow us to retain the position of cylinder at specific position. In the next step, 3D modeling is done using SolidWorks and then the stress analysis was performed.



APPLICATIONS

- A means of rehabilitation
- Assistance for the disabled
- Helping nurses to carry heavy patients
- Assisting in lifting industrial heavy loads
- Helping soldiers to carry armaments ovechallenging terrain.

The last step is fabrication and then assembling the parts being fabricated.

The lifting action is achieved using a Double Acting Pneumatic Cylinder which upon extension raises the forearm and amplifies the power output. This facilitates easy lifting of heavy loads. The magnitude of effort by the arm depends on the efficiency of the cylinder used.

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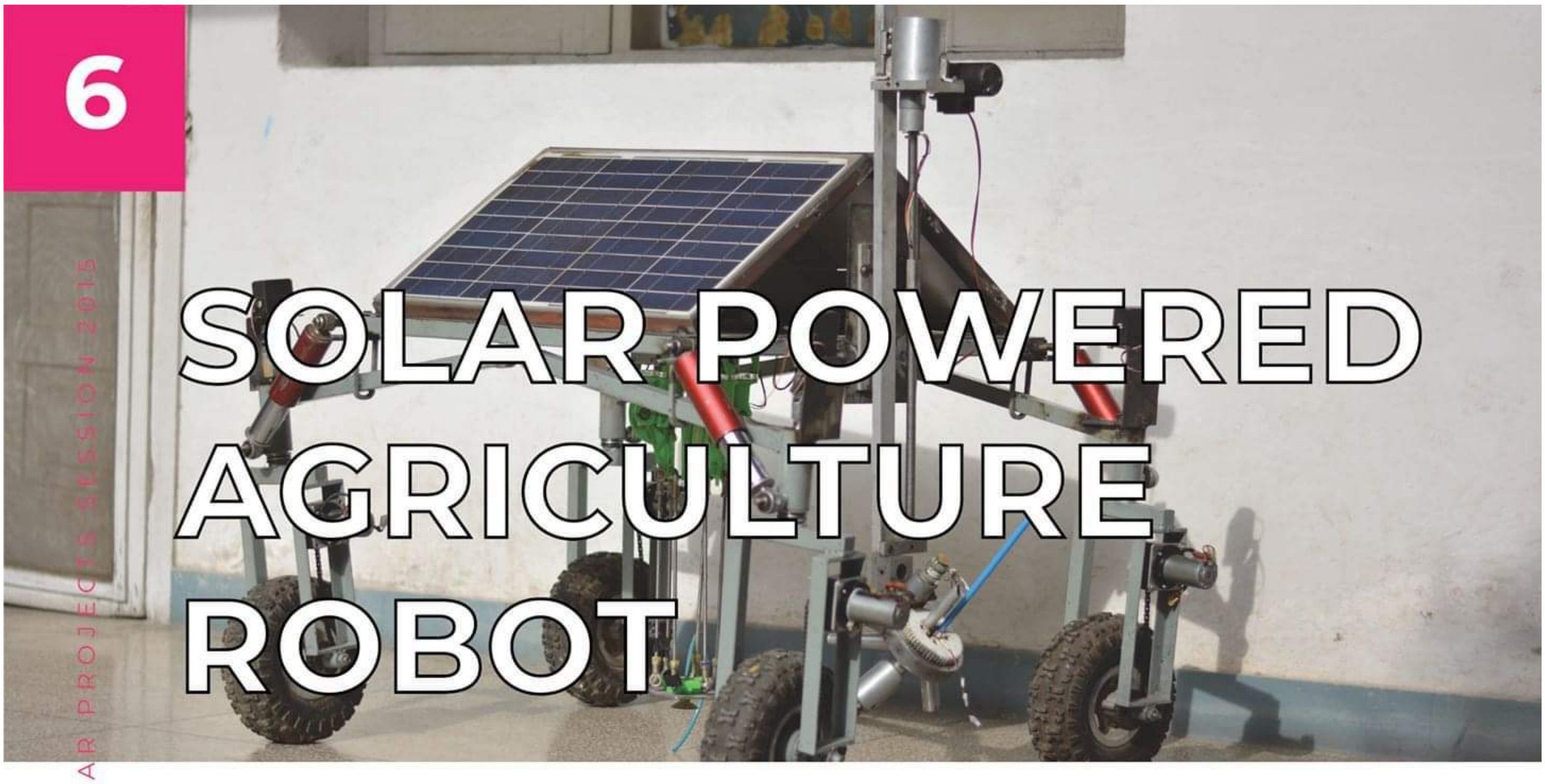


SOLAR POWERED AGRICULTURE ROBOT

OBJECTIVE

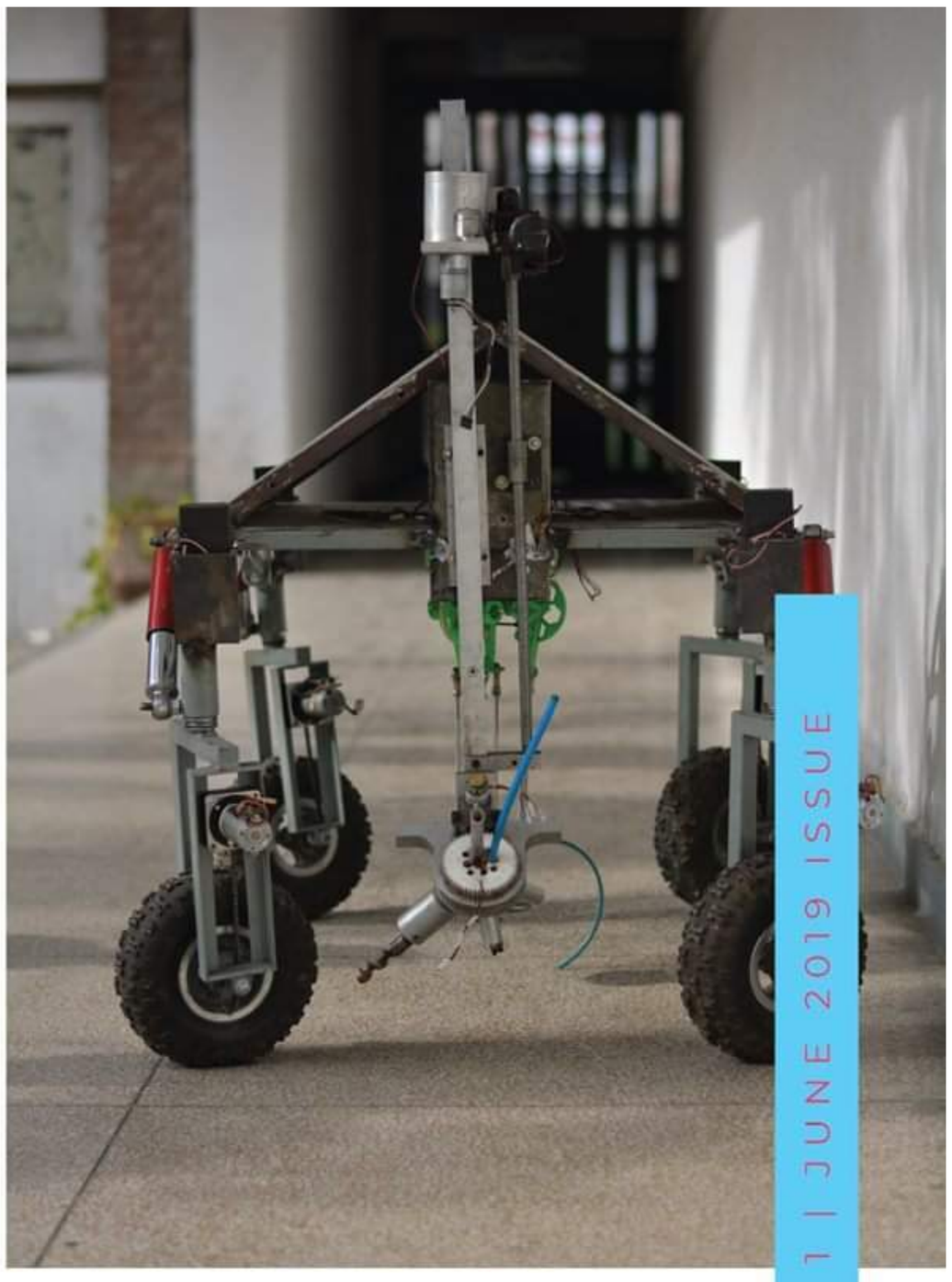
An autonomous robot with mobility platform that is designed with the aim to maximize crop husbandry and remove weed by keeping our resources minimum. For past few decades, there are number of innovations that had been carried out in agriculture field but our robot is multi-tasking which performs the sowing operations involve the tillage, irrigation, seeding and spray fertilizer to plants along with the detection and removal of weeds from agriculture field. It performs the sowing operation by taking into consideration soil moisture, seeding depth and distance between seeds to maximize efficiency and yield.

EQUIPMENT & SOFTWARE

- SolidWorks
- Arduino
- MATLAB
- Servo, Stepper , DC motors
- End effector, gears and motors
- Solar plates
- Mobility platform including many other components etc.

METHODOLOGY

With this project we aim to develop a prototype, Solar Powered Agriculture Robot for sowing and weeding operations, which can perform various agriculture tasks automatically, without wasting time. It is an autonomous robot with mobility platform which has four legs that can move independently in any orientation at any point in farming field. It uses delta robot to detect weed by using image processing and end-effector for sowing operations (digging, seeding, irrigation and feedback system to check moisture contents).



The end effector is designed to be a multipurpose, adjustable tool to perform farming tasks while mounted on mobility platform. Delta robot is attached at the center of platform which detects the weeds and sprays on it. The robot is inputted by user about seed variety, it moves autonomously in furrows and adjust the seeding depth and distance between it with performing of sowing and weeding operations.

APPLICATIONS

- Increase crop productivity
- Seeds sowing
- Weeds killing
- Watering
- Facilitate farmers
- Improve efficiency of seed growth

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FINAL YEAR PROJECTS SESSION 2015

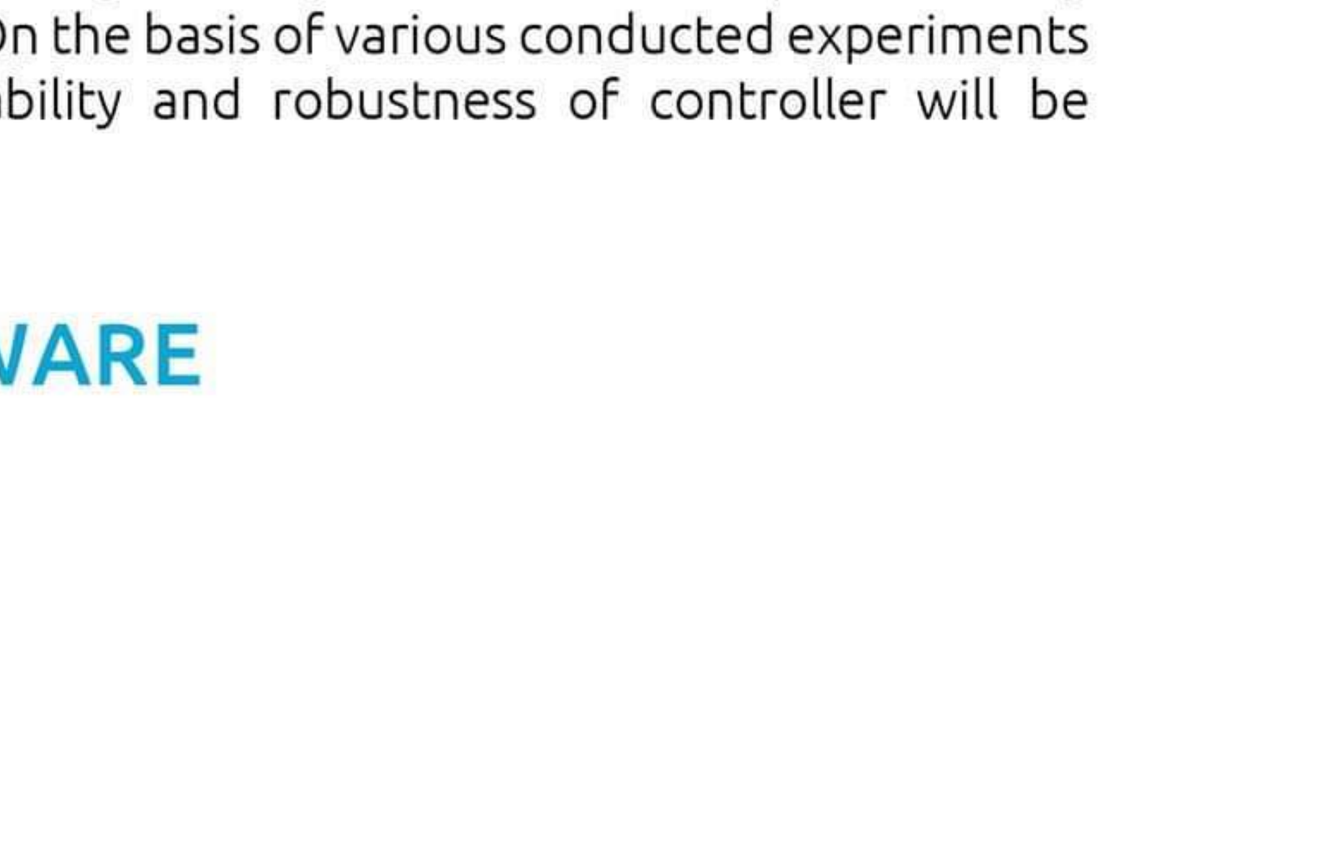
3-LINK MANIPULATOR TO MIMIC WRITING

OBJECTIVE

The aim of this project is to develop a 3-link manipulator and to control the position or force of end-effector of a 3 degree of freedom (DOF) manipulator using Impedance controller by applying an unknown, unstructured external force. Impedance parameters of manipulator e.g. inertia, stiffness and dampers will vary during different manipulation tasks. On the basis of various conducted experiments in different scenarios, accuracy, stability and robustness of controller will be analyzed.

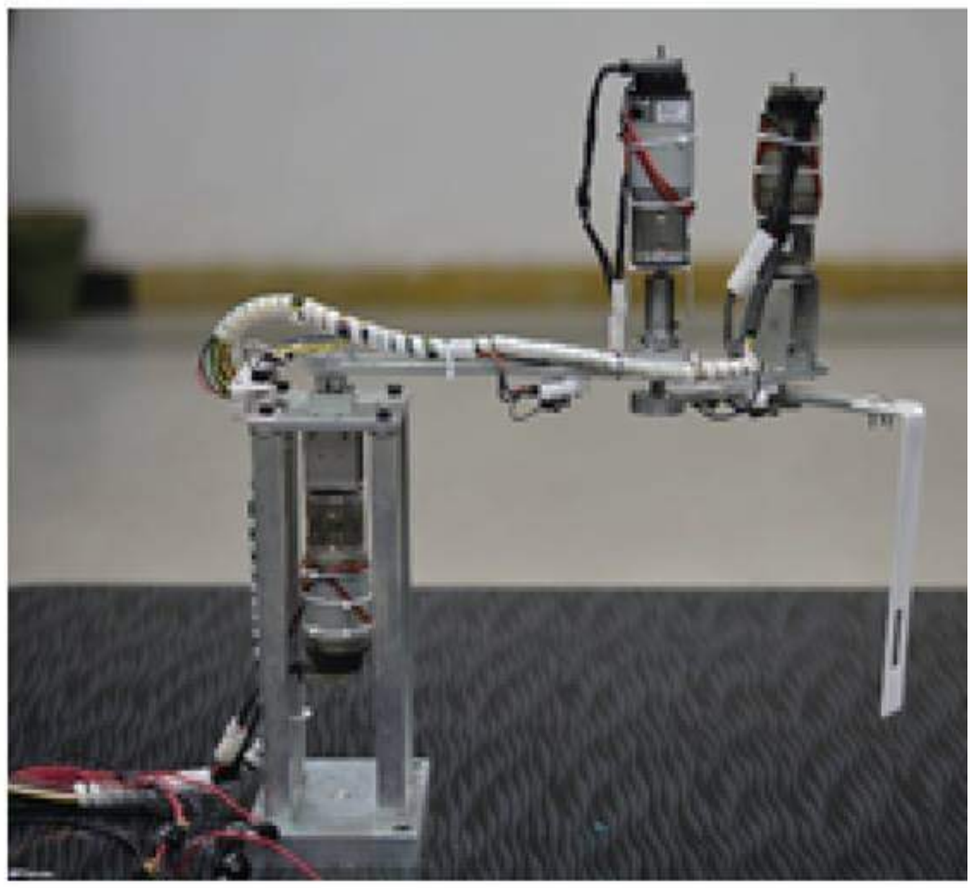
EQUIPMENT & SOFTWARE

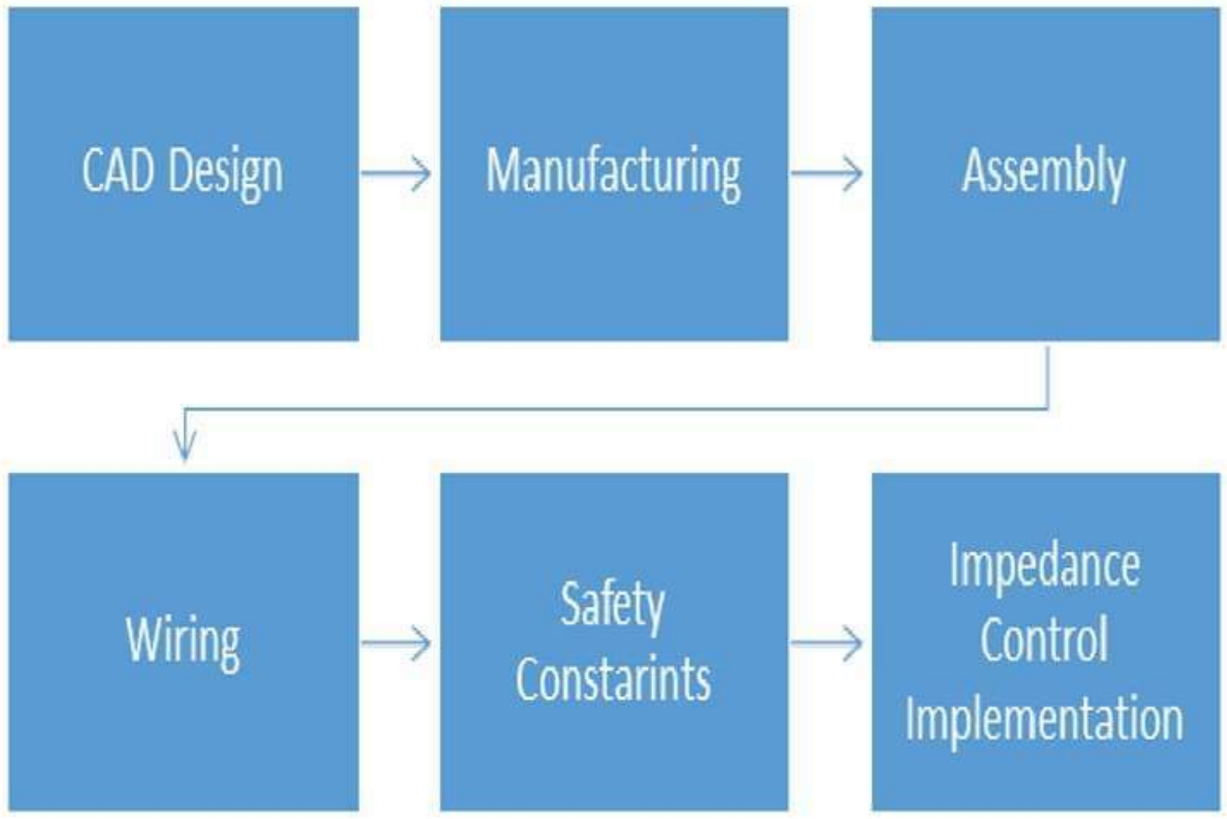
- Arduino
- MATLAB
- LABView
- SolidWorks
- DC Geared Motors
- Manufactured Assembly
- Motor Fitting Components



METHODOLOGY

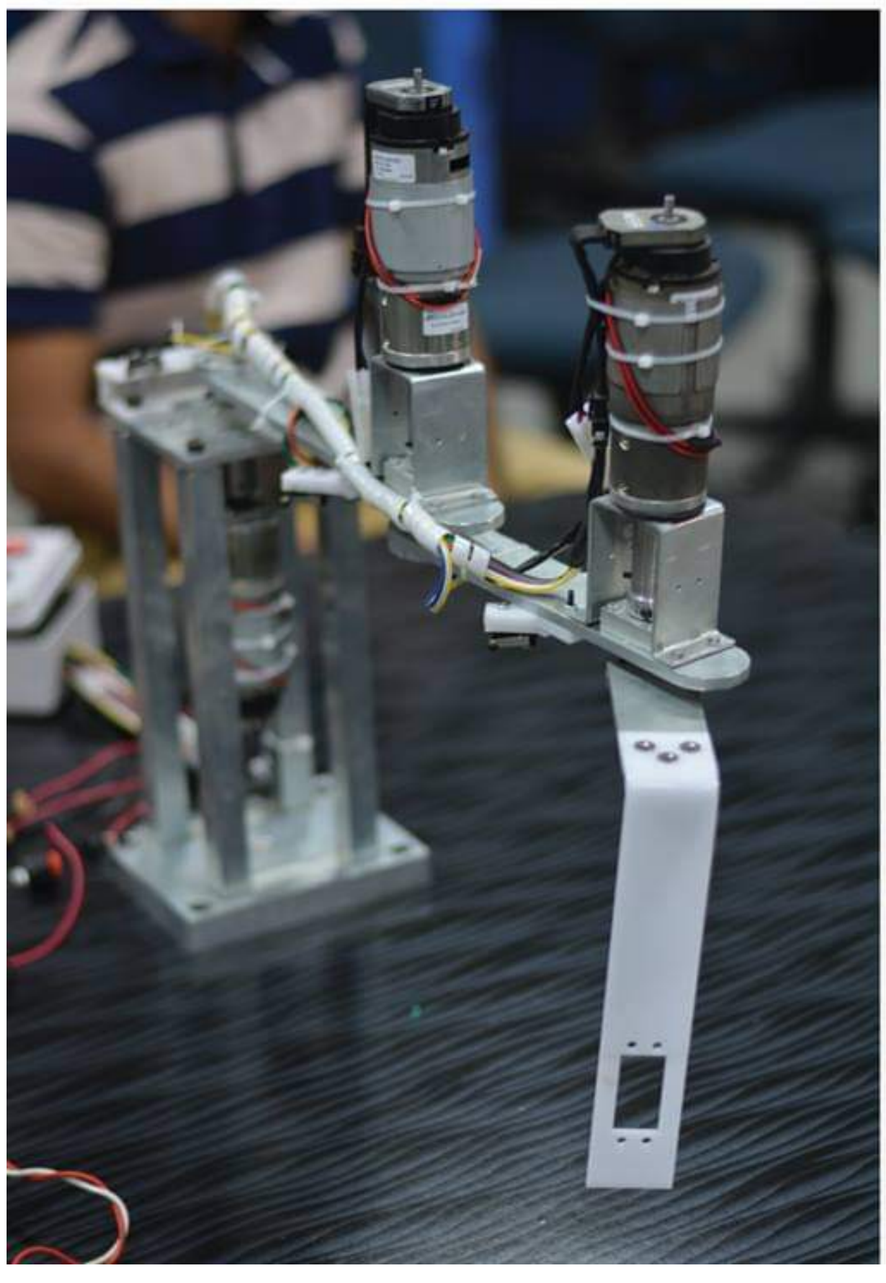
To achieve the proposed objective of this project, CAD design was implemented in SolidWorks and then it was reviewed by our staff advisor to ensure its correctness. Afterwards, manufacturing and then assembly was done. In next move, we moved forward towards the insulated wiring in order to have properly functional hardware interface.





After doing this, the next step was to make sure that this project is having safety constraints. So, we employed limit switches to restrict the links movement in between safe proportion of manufactured assembly.

The last step is to implement the impedance control upon 3-link manipulator, which is the ultimate objective of this project.



APPLICATIONS

- Power loading and unloading.
- Machine Tending.
- Work-in-process inspections.
- Speed and separation monitoring - standstill functions.
- Used for sparse cooperative operations.

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FINAL YEAR PROJECTS SESSION 2015

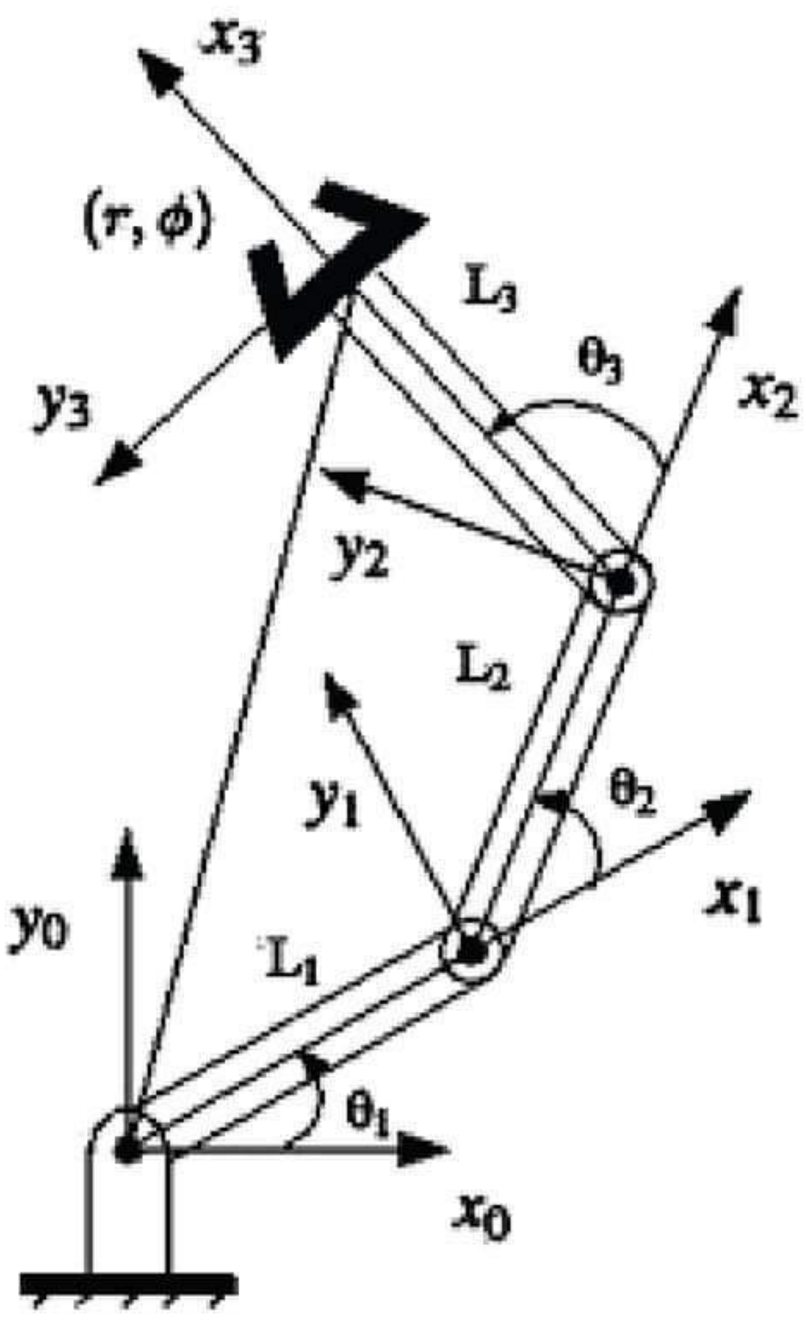
3-LINK CIRCLE DRAWING MANIPULATOR

OBJECTIVE

The main objective of this project is the path planning of a 3 link robotic manipulator, whose first link will be the base and the other two links will move so that the robot will be able draw a circle on a rough surface, and despite of bumps, it continues its circular trajectory with the same intensity and high precision of force and velocity & not only this, the other important aspect of doing the stress analysis of this manipulator will reveal how much load and external force each link will be able to bear. For these purposes, we were assigned with the Inverse Kinematics and Impedance Control techniques so that we could achieve our goals regarding this project. In the end, as an output the robot model will be able to draw a circle.

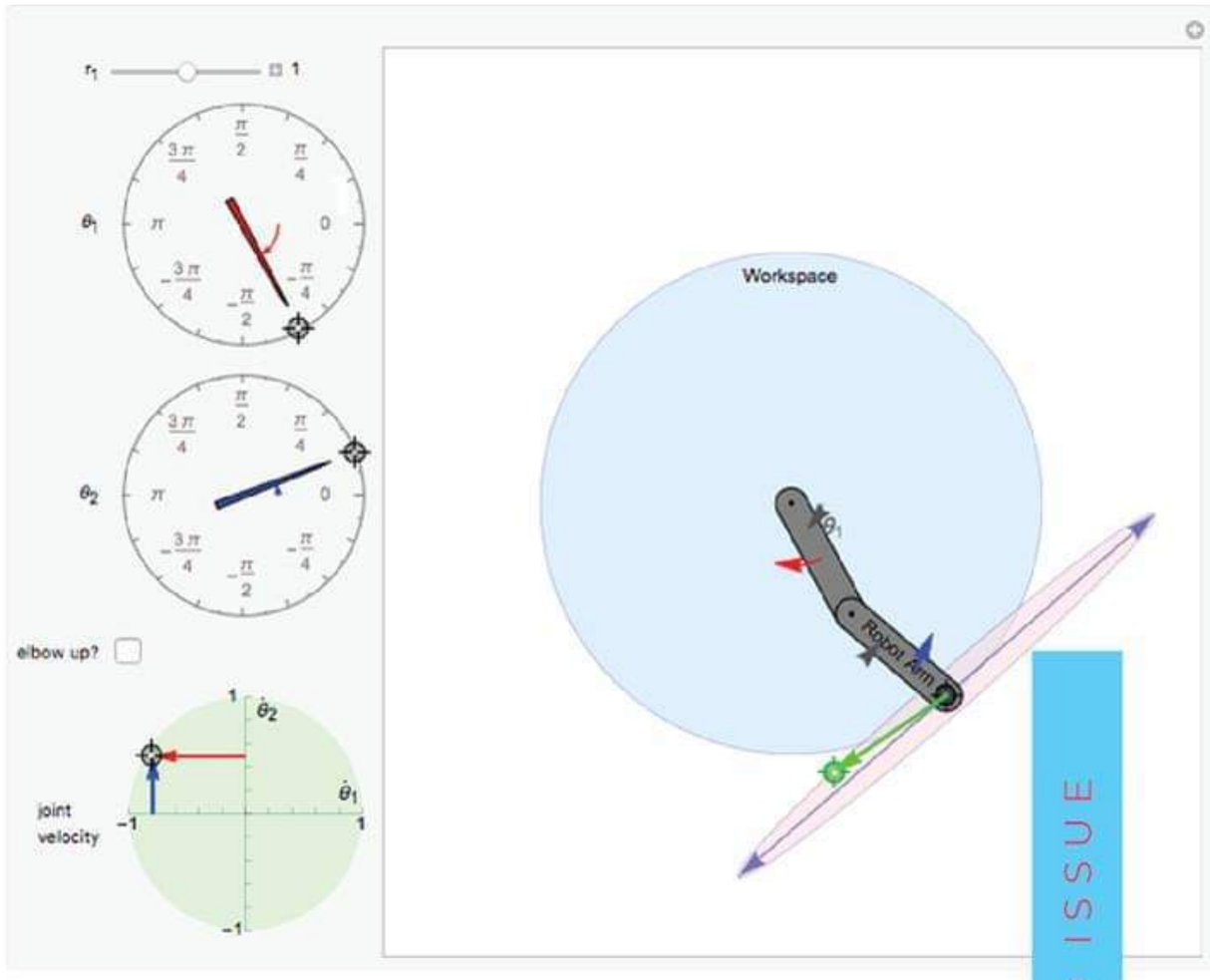
EQUIPMENT & SOFTWARE

- Solid works
- MATLAB
- V-rep



METHODOLOGY

This project has been started with the study of a 3 link planar robotic manipulator configurations and analyzed the type and amount of calculation involved in each step of its analysis i.e. Inverse kinematics, dynamics, trajectory planning and simulation. The project describes the spatial positions and angles of the joints and links with the help of the end effector's orientation called Inverse Kinematics.



Mathematical calculations of the design for torque and force

SolidWorks: Design a model prototype of the manipulator

SolidWorks: Simulation/Motion study of the model + stress analysis

Extraction of joint angles for Inverse by codifying on MATLAB

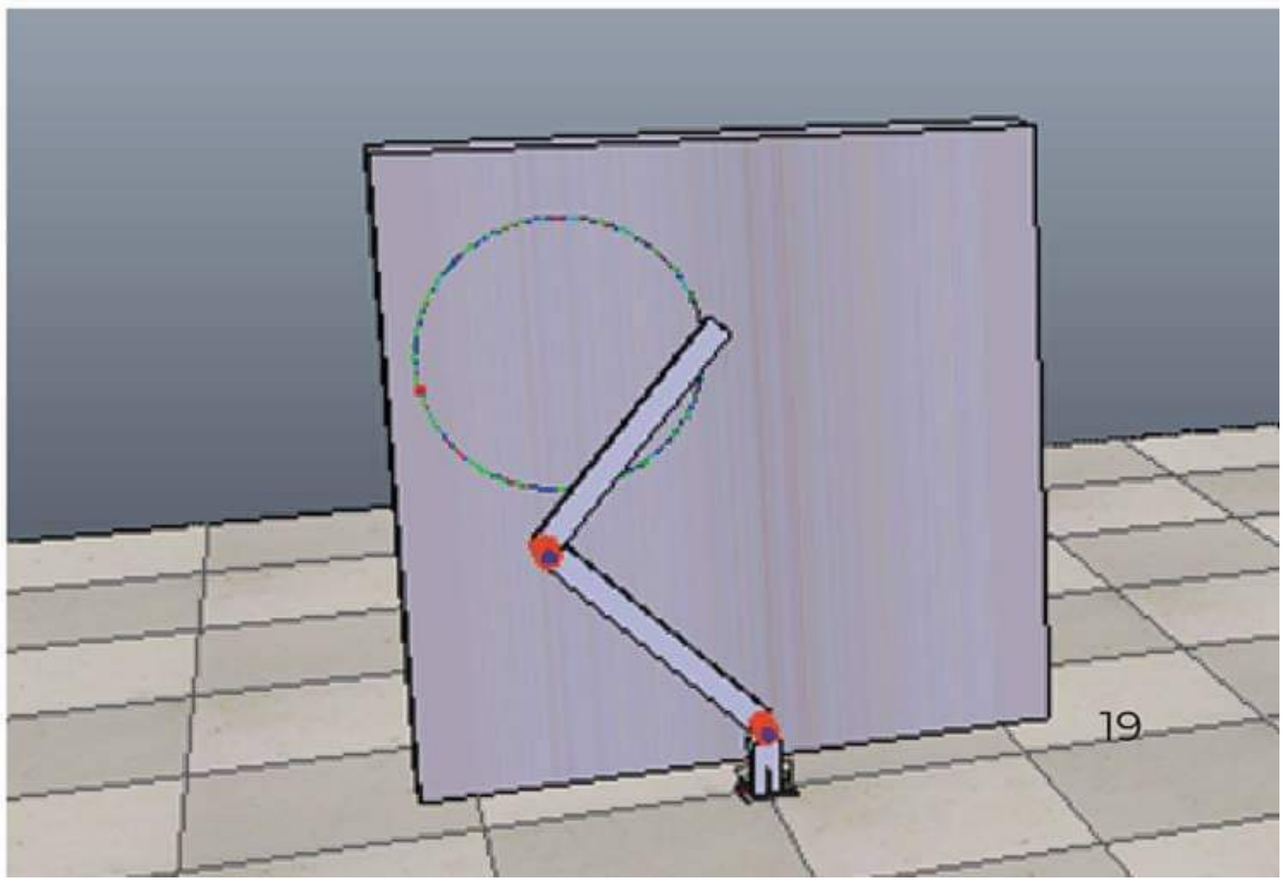
Implementation of Inverse Kinematics task on V-rep model

Implementation of Impedance Control task on V-rep and designing the controller on MATLAB

This analysis of manipulator is concerned with the movement of its end effector with respect to a fixed reference axis. An approach between the control of dynamic interaction of manipulator and its environment, in which the force-position relation is of prime importance, involves the study of Impedance Control. This purpose also involves the theories of kinematics and dynamics analysis of the manipulator.

APPLICATIONS

- For cylinders that need to be welded with a specific value of circular diameter.
- Control scheme can be used in trajectory control of manipulators used in surgical applications i.e. in- vivo robots.



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FINAL YEAR PROJECTS SESSION 2015

LQG CONTROL OF INVERTED PENDULUM

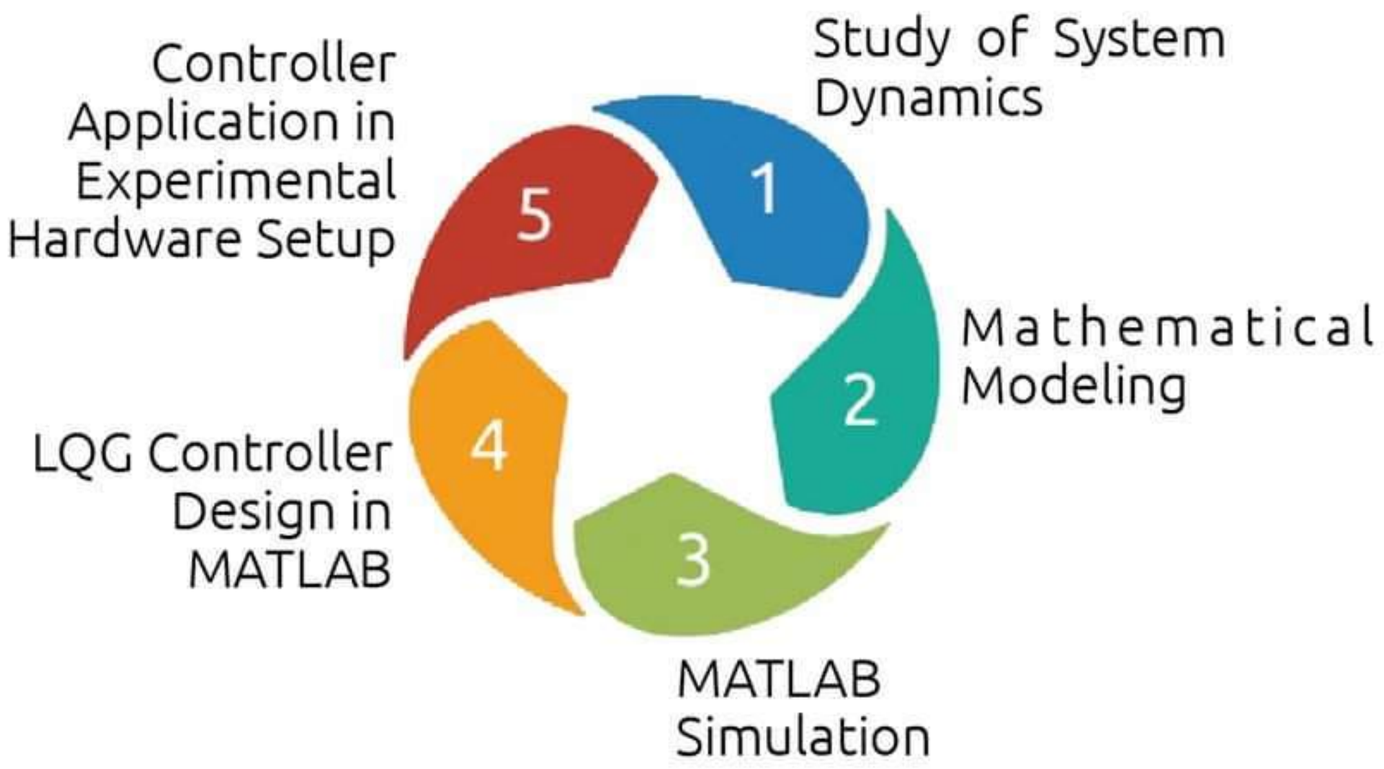
OBJECTIVE

This project aims to stabilize the unstable system in vertically upward direction using optimal control technique. To achieve these outcomes, the first step was to mathematically model the inverted pendulum system. And afterwards, the linear quadratic controller (LQG) was to be designed and implemented on the system.

EQUIPMENT & SOFTWARE

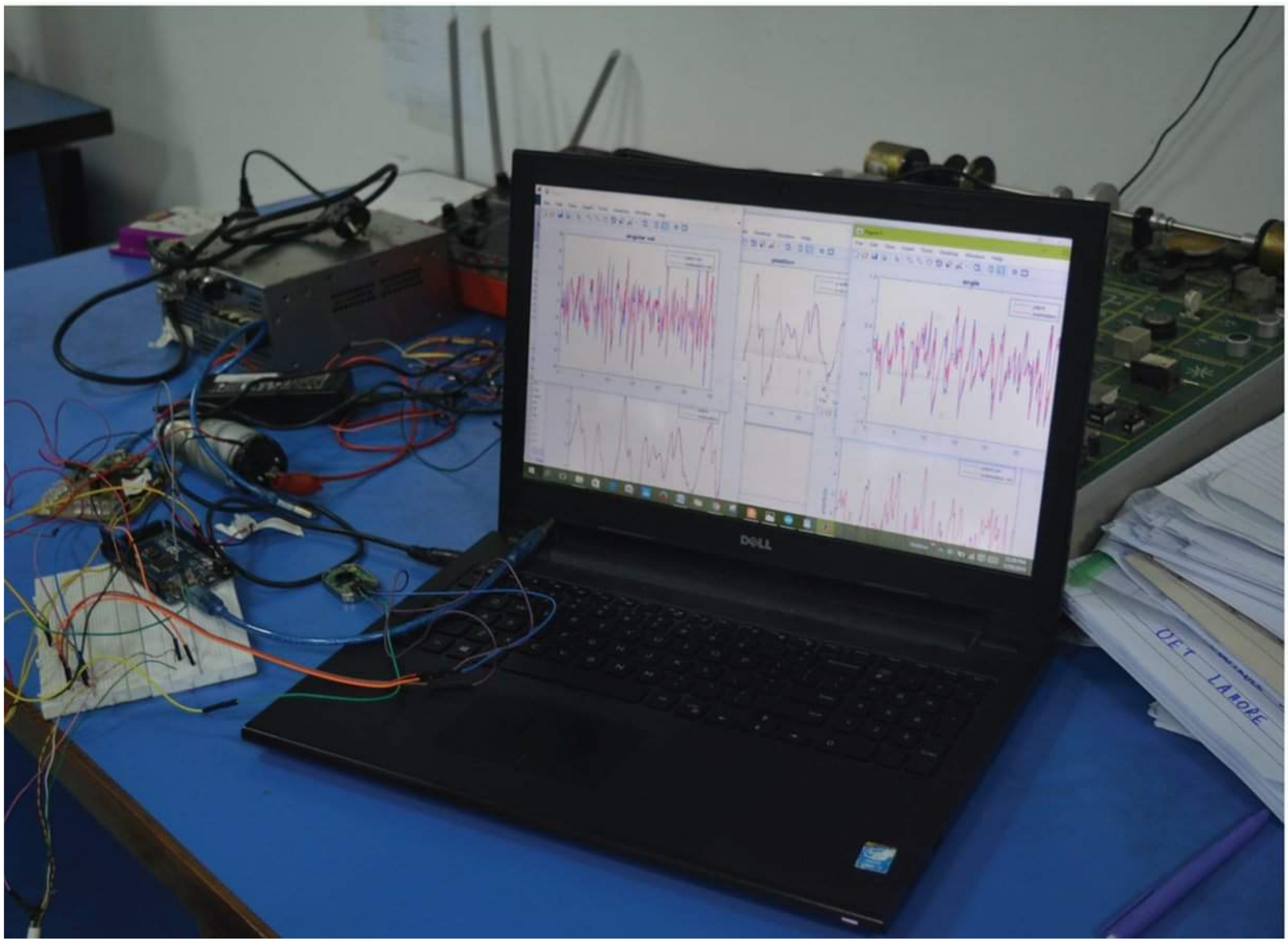
- Incremental rotary encoders
- Inverted pendulum
- Torque controller
- Maxon motor
- MATLAB
- Arduino

METHODOLOGY



APPLICATIONS

- Segway
- Self balancing Robot
- Systems that support walking for patients



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FINAL YEAR PROJECTS SESSION 2015

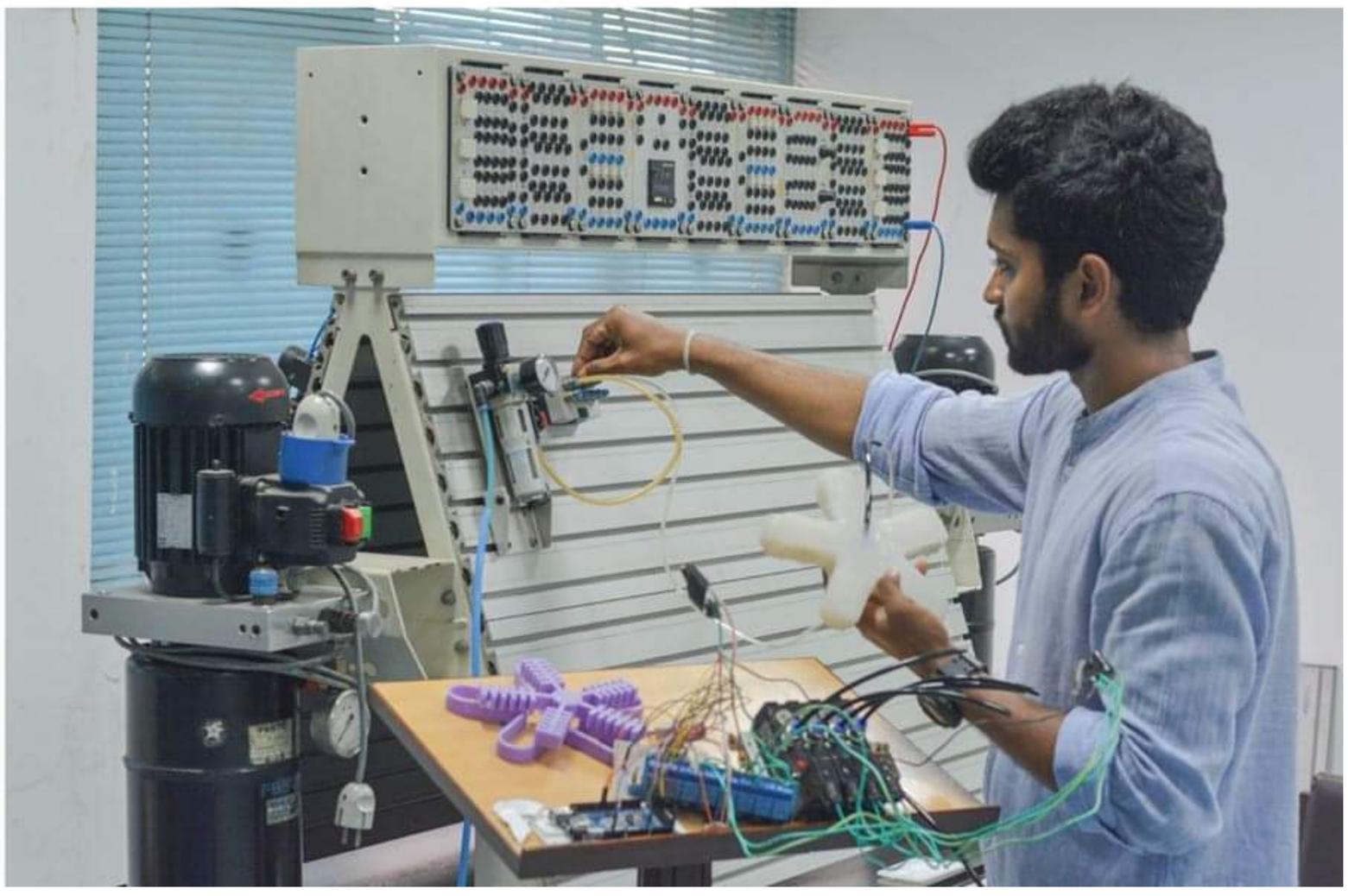
SOFT ROBOTICS EXO-SKELETON

OBJECTIVE

Development of low cost soft robotics exoskeleton for industrial purposes was proposed to actuate pneumatically as it'll reduce the cost and the weight of the overall package Here In this project we are focusing on developing a fluid control board which is industrial friendly and easily manipulated by the industrial worker. By designing a soft robotics actuator which is behaving similar to the biological human muscle we are expecting to actuate the artificial muscle pneumatically parallel to biological muscle. Therefore we need to look across the necessity of making the wearable suit more flexible, less stiff and comfortable.

EQUIPMENT & SOFTWARE

- Indask PCB board printer
- Drilling machine
- Digital balance
- Vacuum oven
- 3D printer
- SolidWorks
- Sketchup
- MATLAB
- Arduino
- Skanect
- Abucus



METHODOLOGY

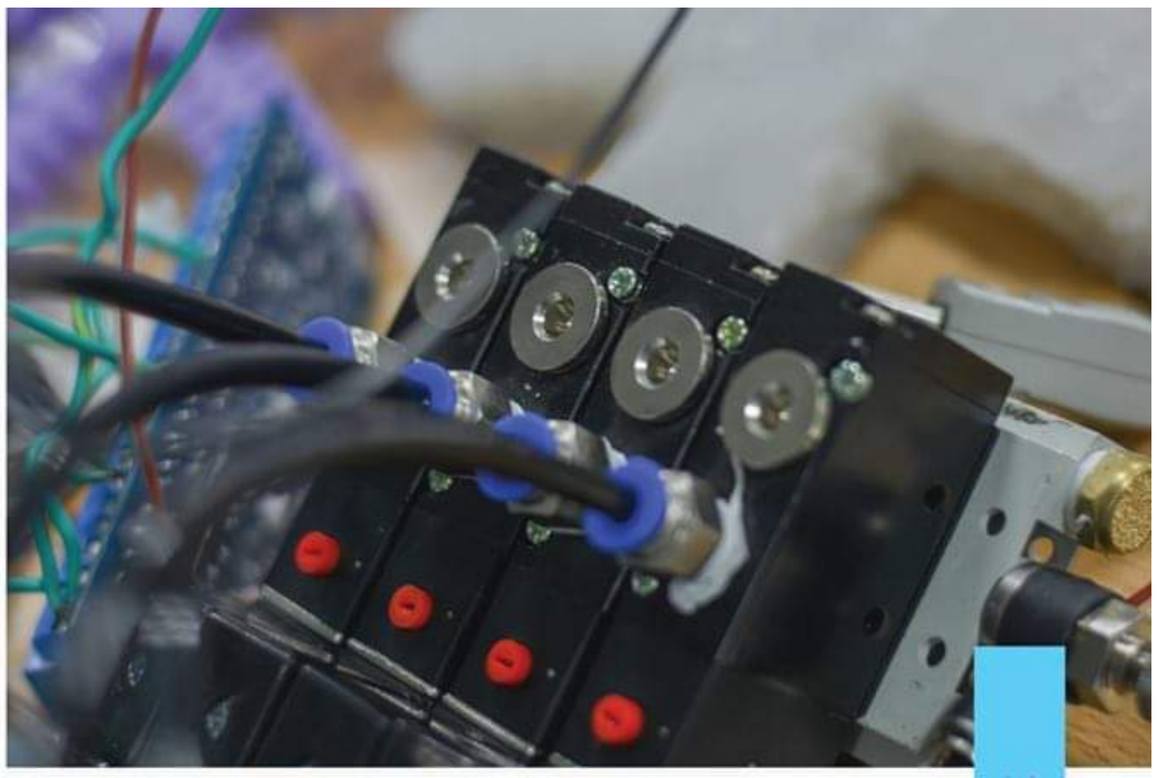
The process consists of three steps which are given below:

- Designing
- Testing
- Implementation

The designing process includes three things; designing the fluid control board which provides the air pneumatically to the soft material (silicon) actuators through the solenoid valves, the designing of mold for soft actuators and the designing of a jacket which accommodates the soft actuators and supports the muscles in extending and bending.

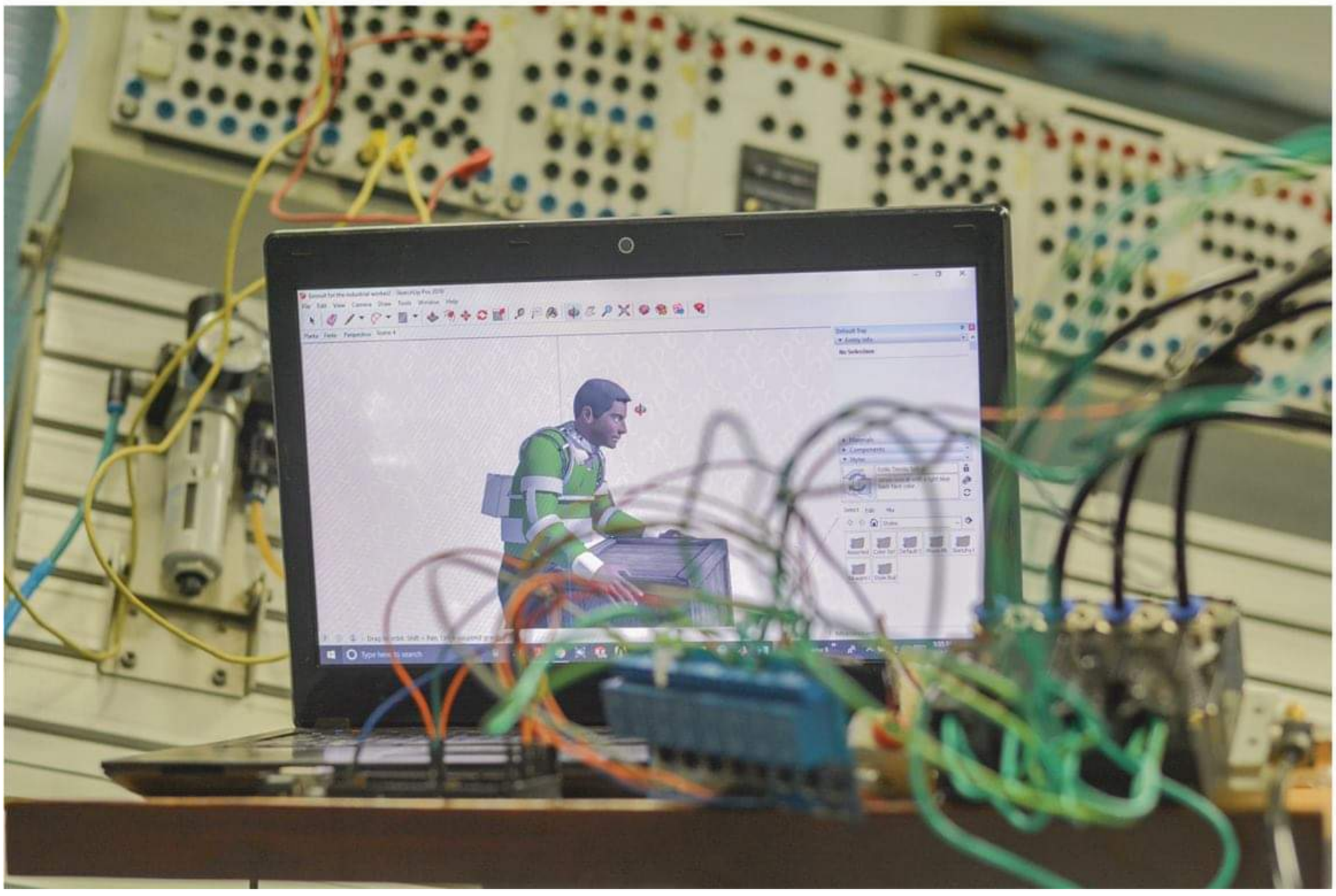
APPLICATIONS

- In industries where arduous and repetitive work is being done all day.
- Muscle rehabilitation as it will work in natural movement of the muscles.
- Aiding teachers in their long-hour teaching on the board.



In the testing phase, we test the soft actuators to bend and extend properly at minimum pressure. Bubbles form during the molding process are also tested and removed.

The last step involves the implementation of exo-skeleton. Pneumatic air having minimum pressure of 1-2 bar is provided by the solenoid valves for the extension and bending of the actuators.



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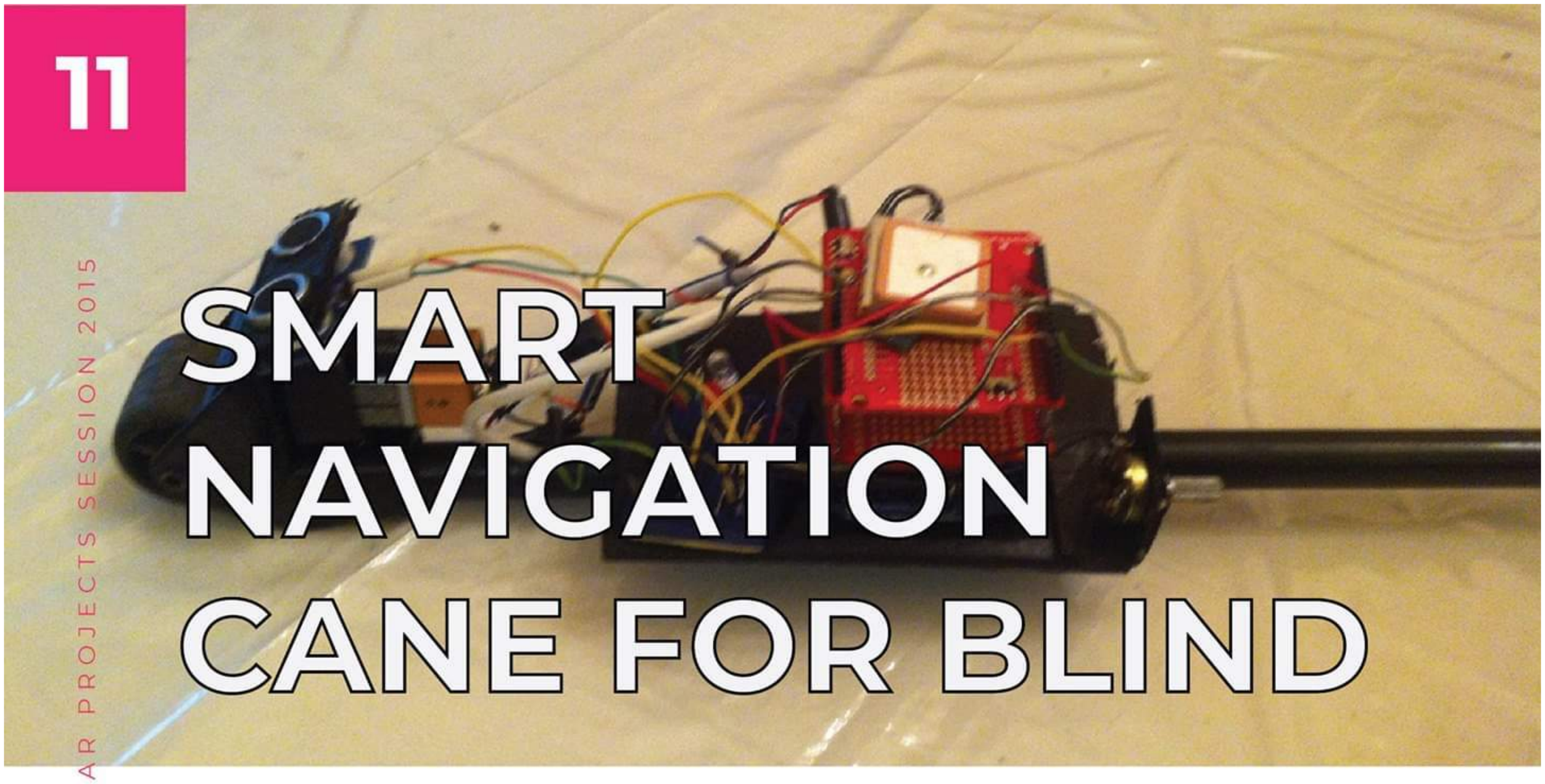


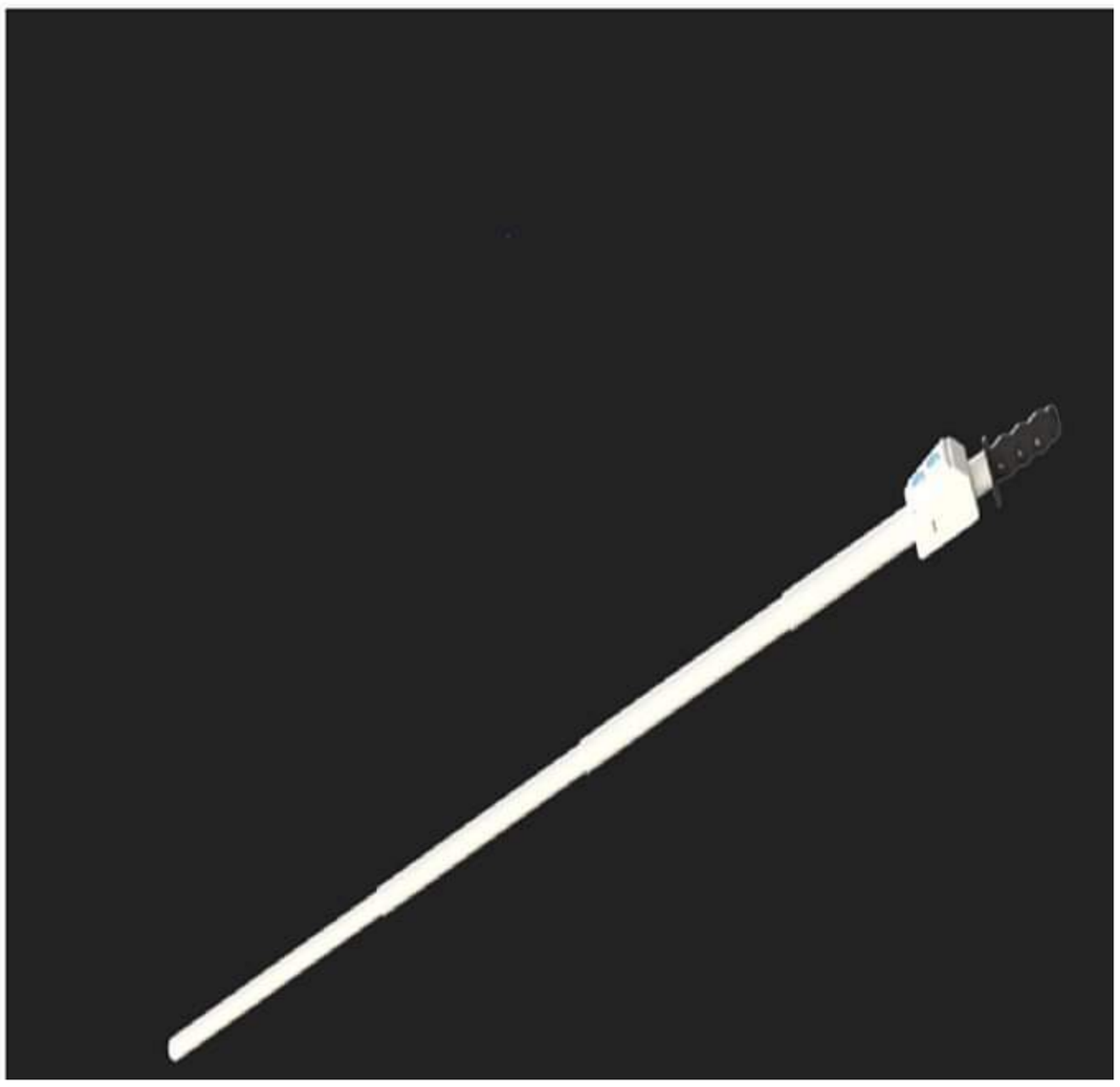
SMART NAVIGATION CANE FOR BLIND

OBJECTIVE

The aim of this project is to detect different hurdles or obstacles with the help of ultrasonic sensors and hence making it very easy and safe for blind people to find the right way. Moreover, it also includes the functionality to navigate through multiple way-points to reach the destination safely. In case the obstacle is detected, the user can easily deviate and get to its right path for further movement towards the destination.

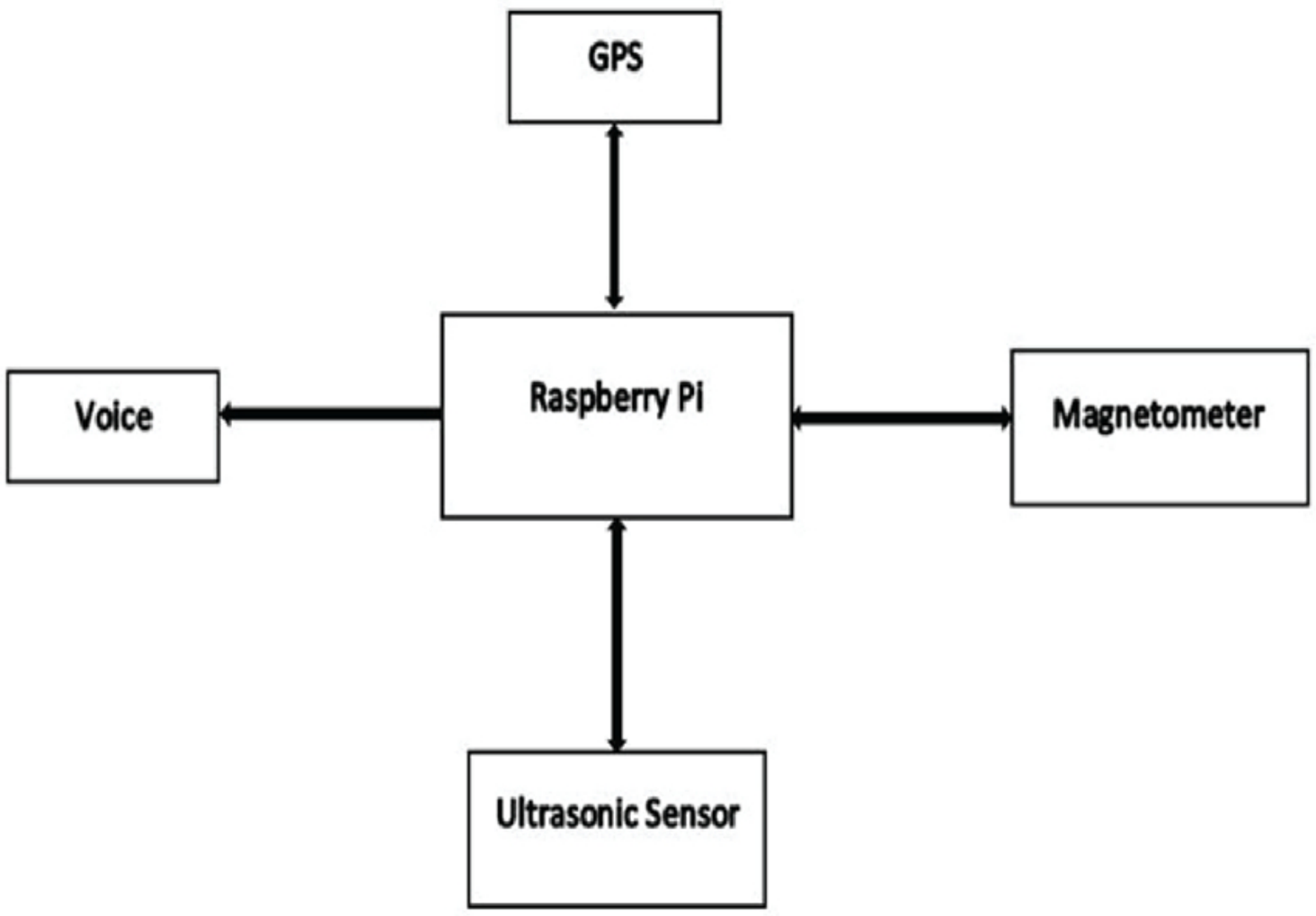
EQUIPMENT & SOFTWARE

- Magnetometer (Compass Module 3-Axis HMC5883L)
- Ultrasonic Sensor (HC-SR04)
- GPS Module GPS (NEO 6M)
- Rechargeable Battery
- Raspberry Pi
- A Stick
- Raspberry Interface
- SolidWorks
- Arduino



METHODOLOGY

Globally, Out of 285 people with sight loss, 39 million are visually impaired according to the World Health Organization (WHO). Generally, these vision-less persons use a white cane or walking cane.
Electronic oriented technology like Ultrasonic sensor will be used to assist the visually impaired person. In this technology, energy waves are emitted ahead, and then they are reflected from obstacles. In addition to this, the smart cane will be linked with the GPS system. This will be used by visually impaired persons to determine and verify the current location and with the help of magnetometer will move on its heading angle towards its next way-points.



The basic design approach of this project is that there will be two parts of the hardware. One will comprise of the programming and algorithmic structure of Raspberry Pi, and the other will be the integration of Raspberry Pi with the other components (GPS, magnetometer, ultrasonic Sensors) of the system.

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FINAL YEAR PROJECTS SESSION 2015

UPPER LIMB PNEUMATIC EXOSKELETON

OBJECTIVE

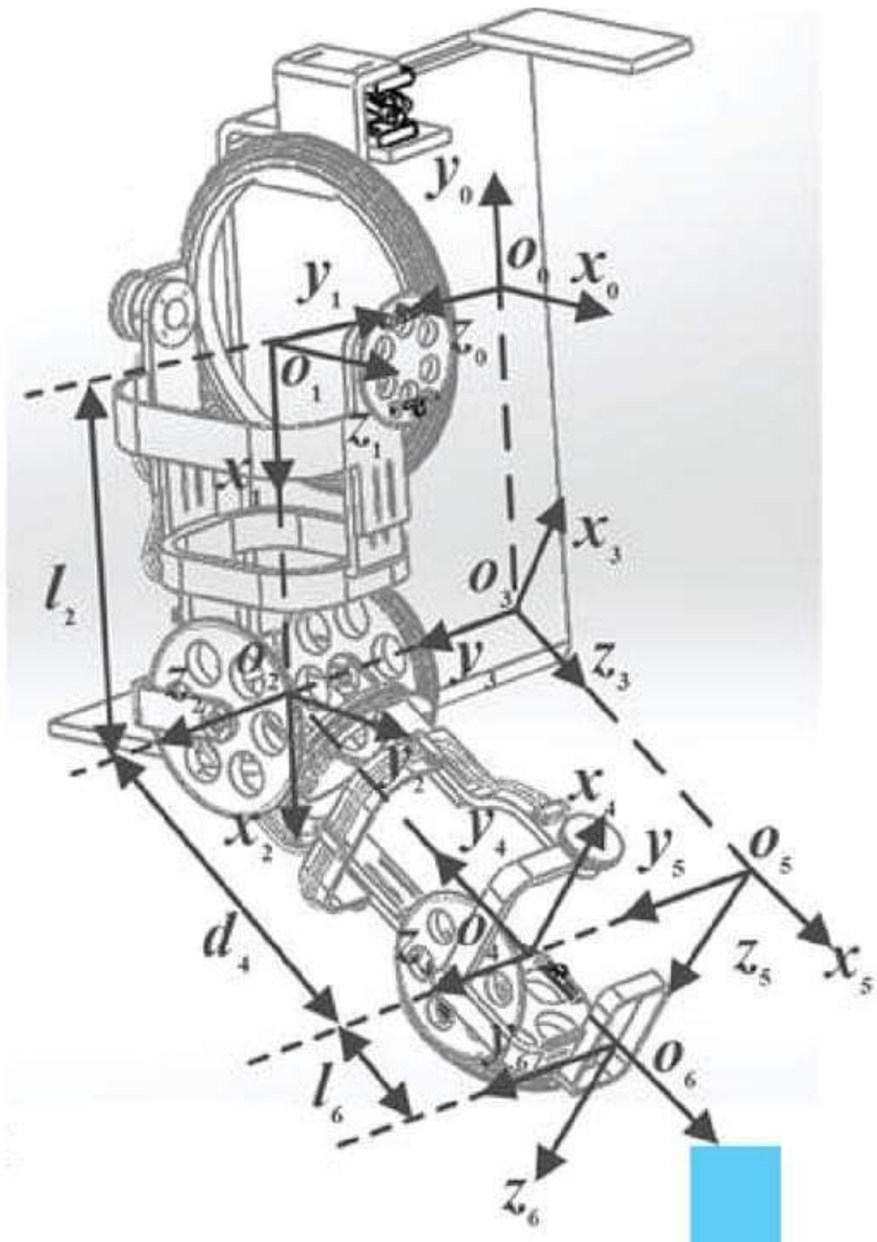
The objective of this project is to create an exoskeleton that is pneumatically powered, has low power consumption, is light in weight, is durable, multi-functional and does not require customization. Furthermore, the sensing and controlling of this upper limb exo-skeleton is also a chief goal under this project.

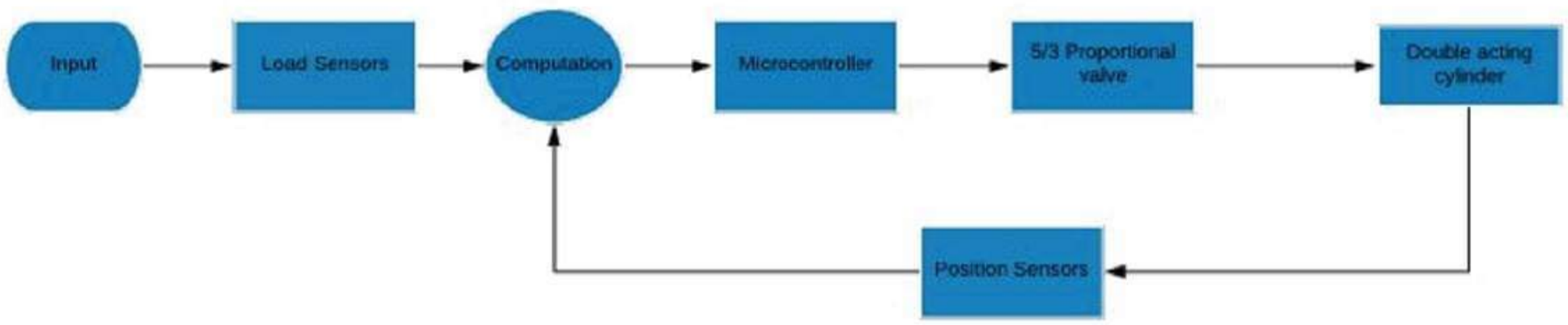
EQUIPMENT & SOFTWARE

- Valves
- Cylinders
- Arduino
- MATLAB
- SolidWorks

METHODOLOGY

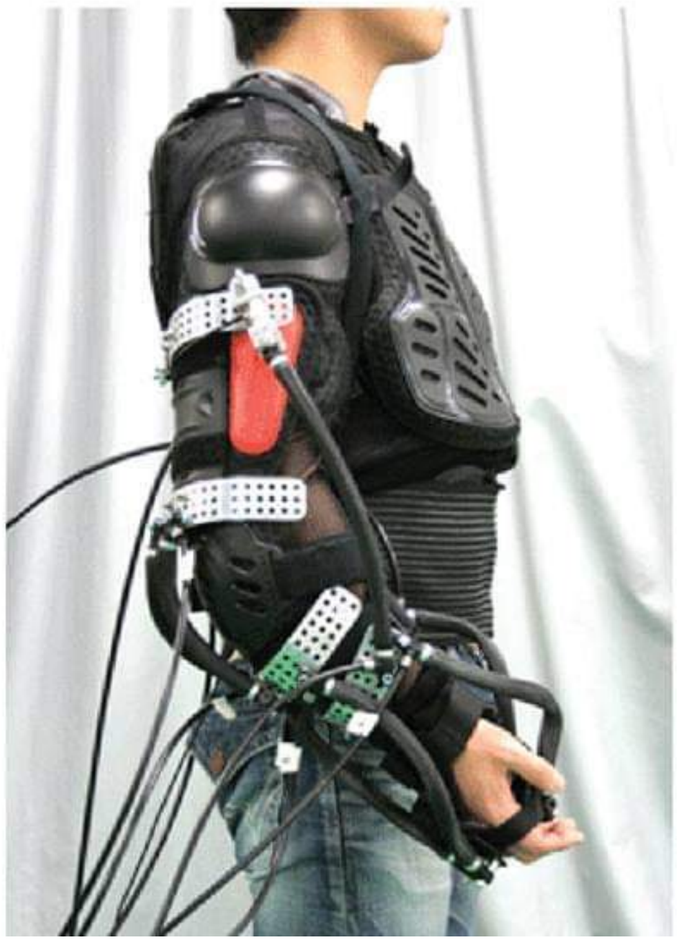
- Input is applied on the load sensors and is then processed.
- After processing, the input is fed to the micro-controller .
- Micro-controller then creates a signal that ranges from 0-24V depending on the input load.
- The signal is then given to the valve which actuates the cylinder and also controls the position of the stroke.
- The position of the stroke is simultaneously sensed by the position sensors and they feedback their data to the computational cell determining whether stroke should extend,retract or stay in its current position.

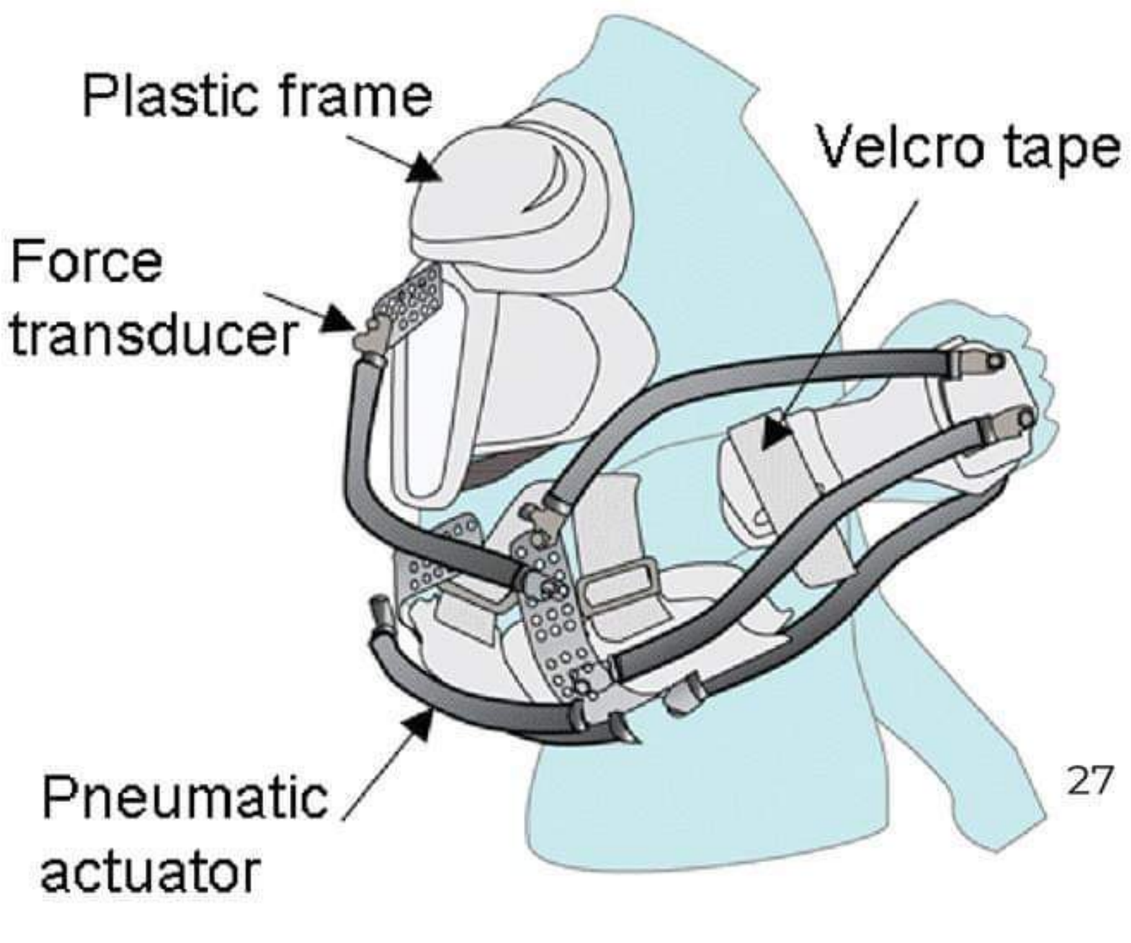




APPLICATIONS

- Rehabilitation of minor injuries.
- Relief from exhaustion in jobs that require physical exercise.





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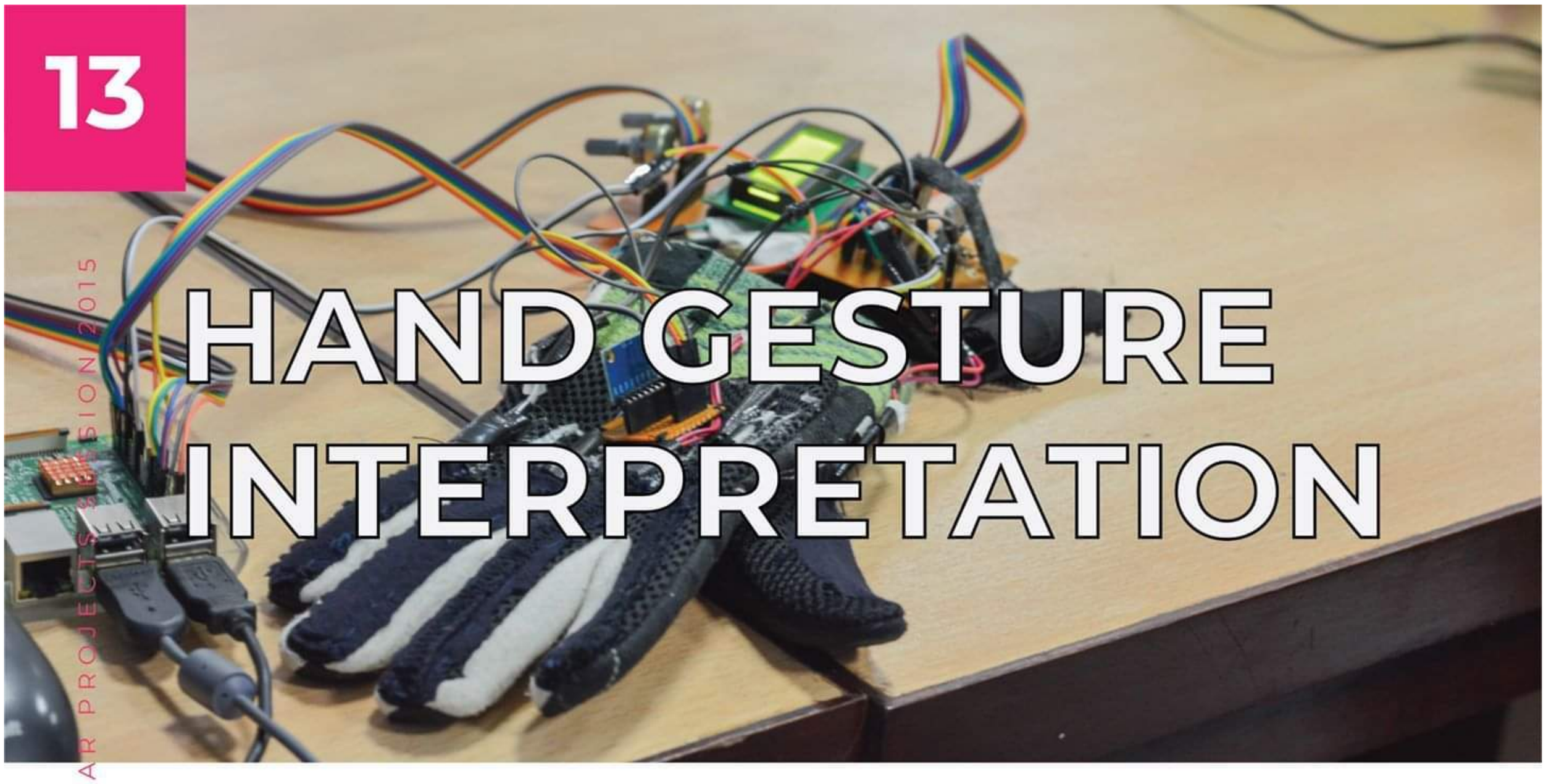


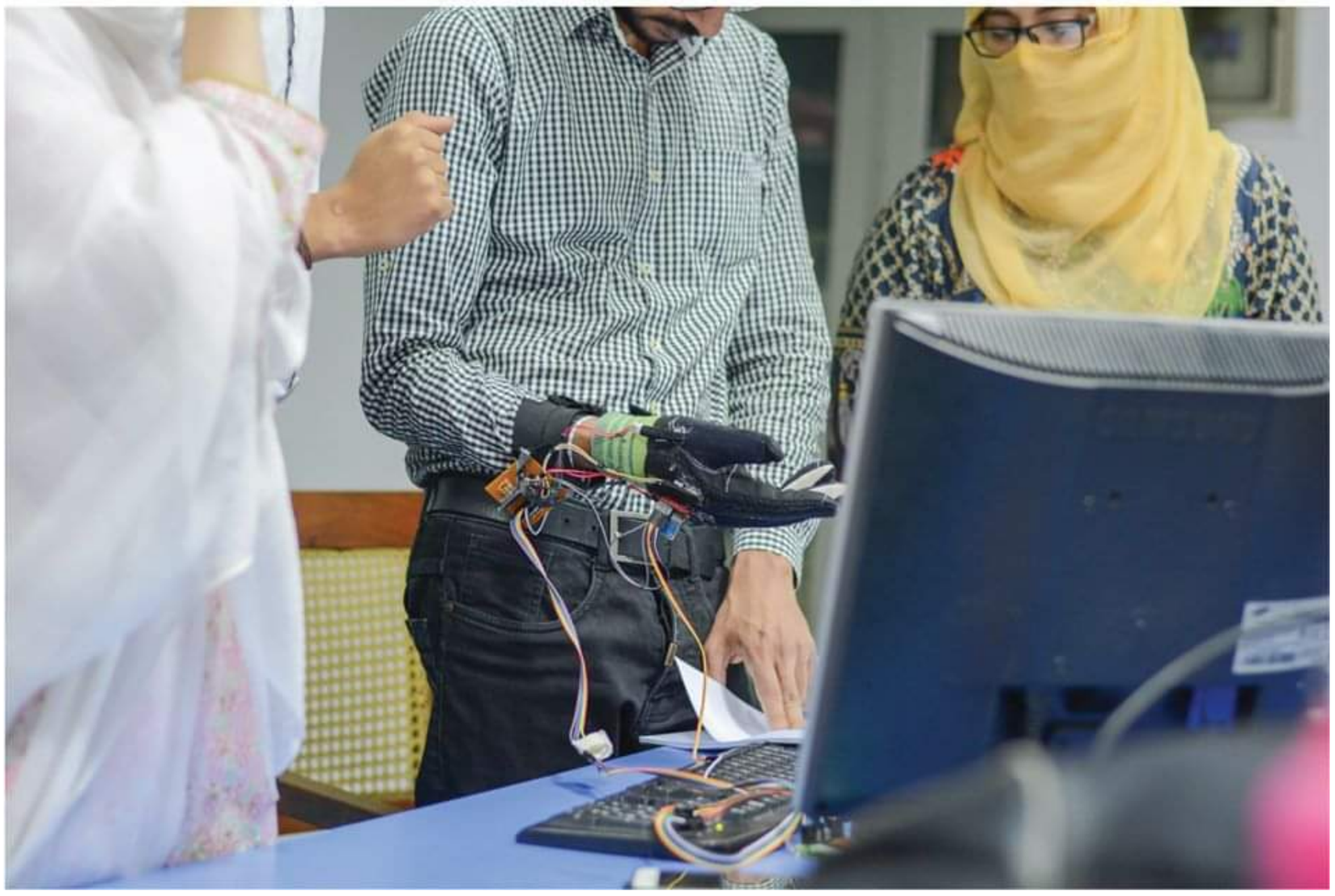
HAND GESTURE INTERPRETATION

OBJECTIVE

The main objective of this project is to design a glove which is responsive, portable, feasible, marketable, affordable and durable that will basically translate PSL (Pakistan Sign Language) into readable text and audible speech. The glove is wirelessly connected to main interpretation system which makes it handy and portable within its operating range.

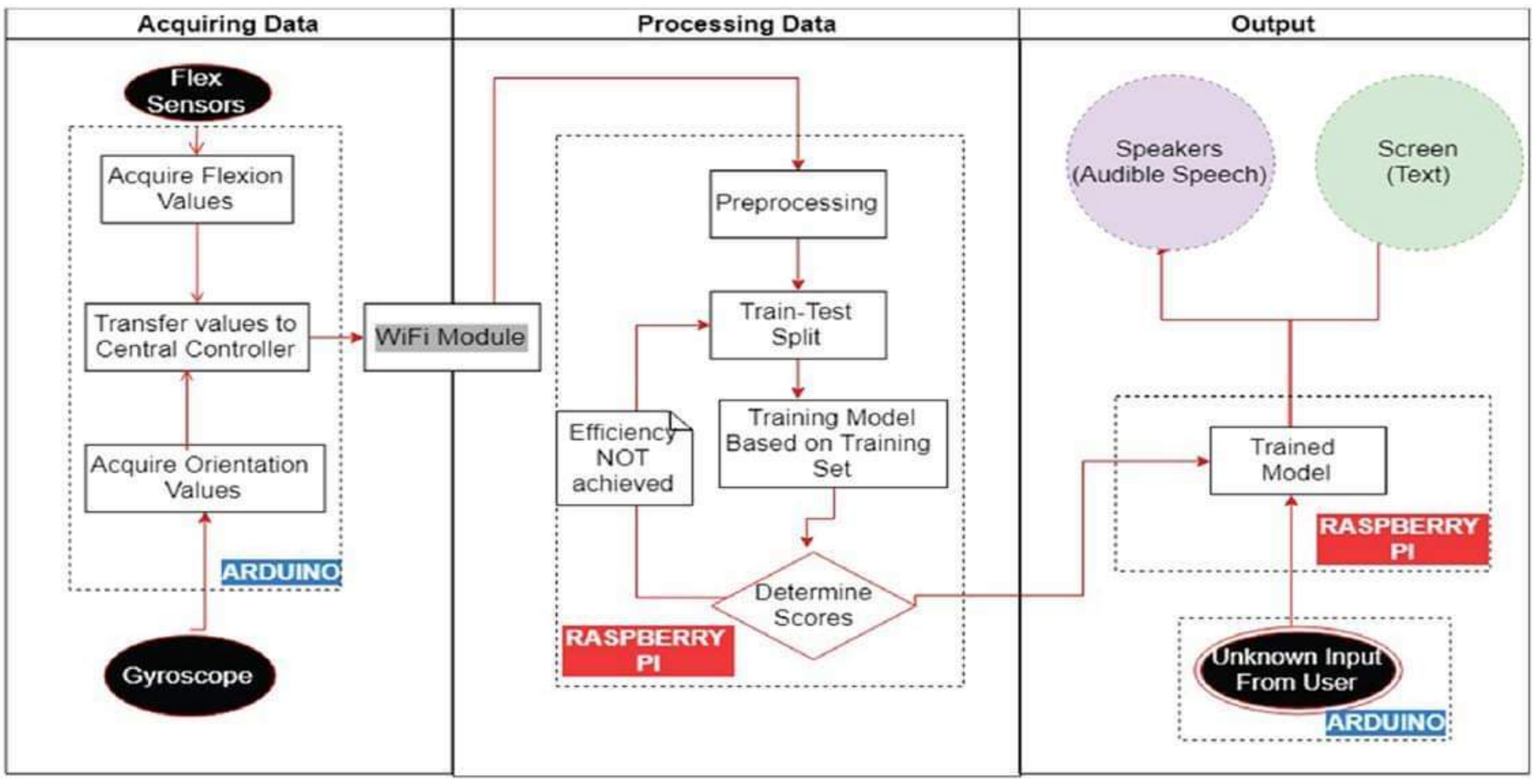
EQUIPMENT & SOFTWARE

- 3-axis Accelerometer(MPU6050)
- ADC(ADS-1115)
- Raspberry Pi R3
- Flex sensors
- LCD Display
- Python



METHODOLOGY

- Acquire values of the five flex sensors embedded on to the glove using microcontroller mounted on glove-patch.
- Using microcontroller on the glove and wireless module, transfer data to central controller that is Raspberry Pi 3.
- Preprocess data (featuring and labeling) and divide data into training set and testing set (Train Test Split).
- Apply the classification algorithm (KNN/SVM) to train the model in python 3.
- Determine accuracy of model using the testing set based on correct number of samples classified.
- Provide unknown input to trained model which will recognize it and output it as text or audible speech



APPLICATIONS

- Develop an understanding of hand gestures without learning the sign language.
- Reducing communication gap between a normal person and hearing impaired individual.
- Assist in learning as well as the understanding of hearing impaired children.

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MECHATRONICS CLUB

AUTOMATING THE STANDARDS!

ABOUT MECHATRONICS CLUB

Mechatronics Club is a registered student body organization working to foster technological innovation and develop skills necessary for an Individual to strive through their professional career. We promote a merit-and-performance based culture among our members, to develop their interpersonal, technical, managerial, social and soft skills.

Mechatronics Club was founded in 2006 and have been proved to be one of the biggest Techno-Giant in University of Engineering and Technology (UET), Lahore. Our talented and profound members are not only grasping and acing Technical Events held country wide, but have also been organizing the Biggest Robotics Events of Pakistan, ROBOCOM since 2012. Mechatronics Club is one of the pioneer societies to organize University wide events like UET Tech Week, UET Talent Hunt and much more.

We not only impart Technical skills but also provide a chance to our members to groom their selves and find a place to reveal their inner talents and take part in co and extra-curricular activities. Taking this in account we arrange MechaOlympics, MechTech, Industrial Tour and other side activities every year to break the monotonous routine. Mechatronics Club also provides a Workspace to its members where they can use the facilities of Lockers, Inventory, Apparatus, Electrical and Mechanical Components, Digital Projector and Arenas to test their Robots.

Mechatronics Club is also assisting its department in managing departmental Seminars, Workshops, Alumni Reunions, Orientation, Induction and Convocation Ceremony.

Our Alumnus are serving in reputed organization worldwide, serving their country at every platform, and even are founding members of renowned firms, startups and organization. We believe in professionalism, teamwork and dedication, and we know that, together we can!

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