SR (SUPERNUMERARY ROBOTIC) FINGERS
Paper ID:157

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Presentation Flow

1. Problem statement
2. Issues with current solution
3. Proposed Solution
4. Innovativeness
5. Methodology
6. Impact

Problem Statement

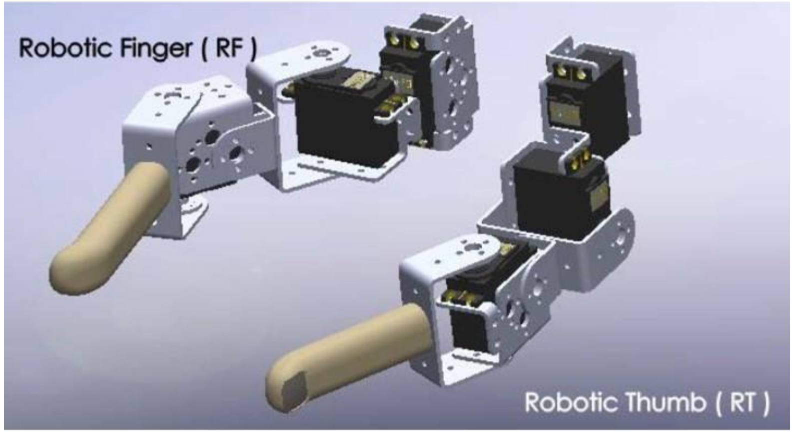
- Hemiparetic patients- stroke survivors, patients who have Parkinson's diseases, multiple sclerosis, spinal cord injuries, traumatic brain injuries, and older people may have limited or non-functionality in one of their hands.
- They must face challenges in completing simple everyday activities such as eating, dressing, carrying their walker, and other bimanual tasks.
- This causes the patients to rely on the assistance of their family or nurses to help them, compromising their independence and quality of their life.
- Robotic limbs to assist hemiparetic patients by increasing their workspace. It can also be helpful for therapeutic purposes and rehabilitation.

Limitations of current solutions

- Current solutions –protheses are beneficial in aiding upper life amputees, but wont work in case of hemiparetic patients; their defective limbs still physically attached to them; must be severed to install the prostheses.
- Current prosthetic devices include rigid gloves with no functionality at all, hooks that have problems manipulating delicate items, multi-jointed hands that are too expensive; difficult to use, only limited assistance.
- Other technologies like EMG and FES implementation have their disadvantages. The need to be connected to a more extensive circuit hinders the mobility of the exoskeleton, and the processing of the signals is much more complex.

Proposed Solution

- A wearable robot, that augment the capabilities of human hand such that a variety of prehensile, bimanual and manipulation tasks can be performed single-handedly.
- The two robotic fingers can be intuitively controlled by the patients using the flex sensors attached to their fingers through a hand glove and IMU.
- The two fingers each having 3 Dof are actuated by 3 high torque servos whose specific angle configuration is obtained from the inverse kinematics for the required position of the fingers.



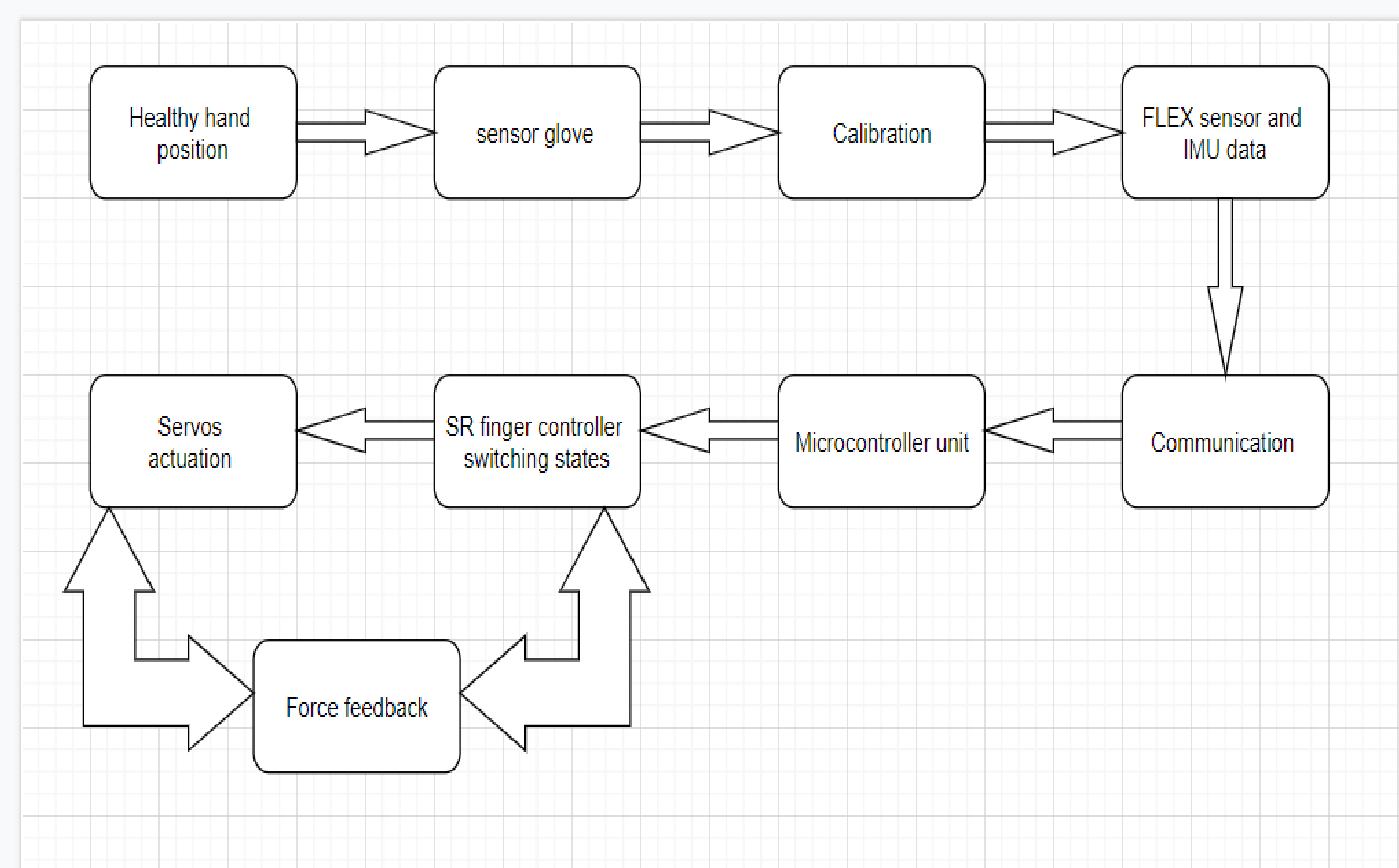
Proposed Solution

- A novel control algorithm to combine bio-synergic motion of human fingers with machine learning for faster gesture prediction.
- The fingers can be used by the patients to recover their grasping abilities presenting an active compensatory tool in the initial phases of therapeutic recovery and rehabilitation to promote the use of the arm even if the hand grasp function is not recovered.

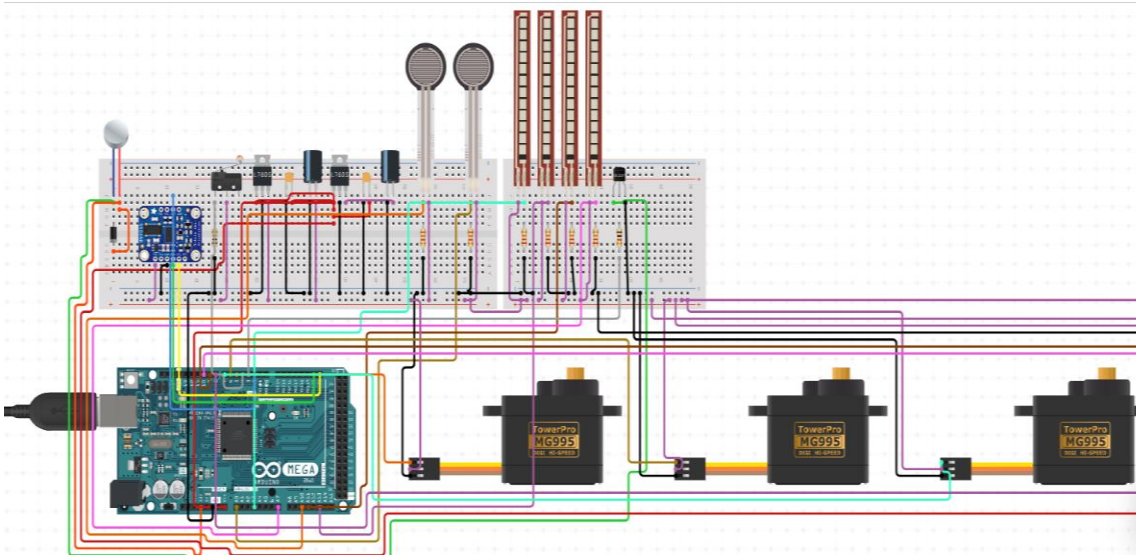
Innovativeness

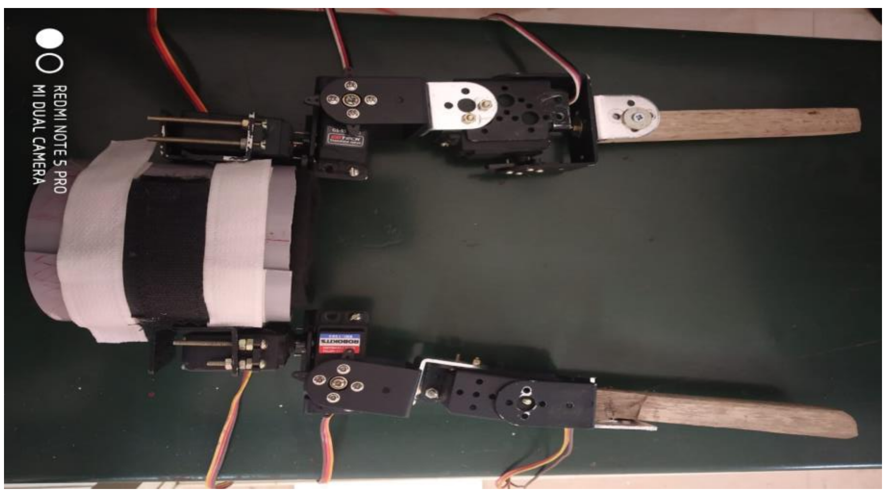
- The robotic fingers increase the workspace and allows better control of the objects to be manipulated by increasing the area of contact thus allows better stiffness and stable manipulation.
- The ML model for this project is novel ;the dataset is made by us using the sensor glove. Using this device regularly will increase the accuracy of the ML model.
- The proposed solution is much more mobile compared to existing solutions(550g total weight).

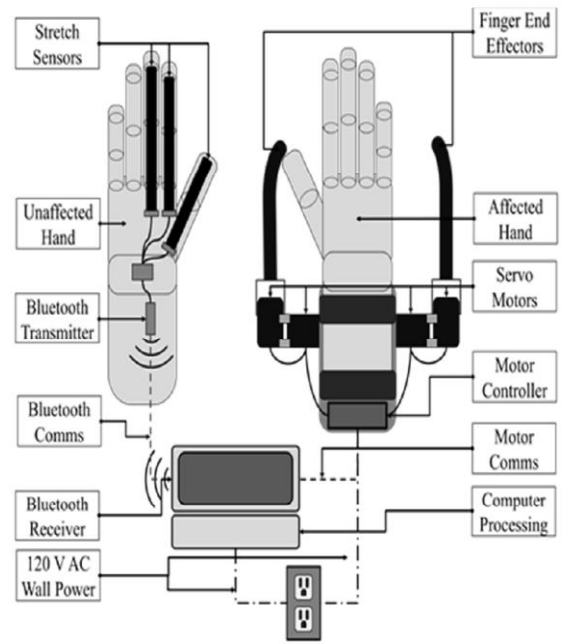
Methodology



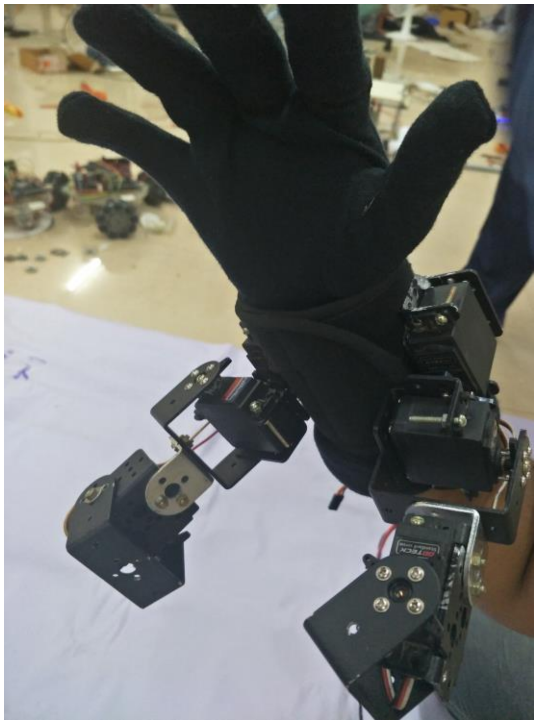
Methodology





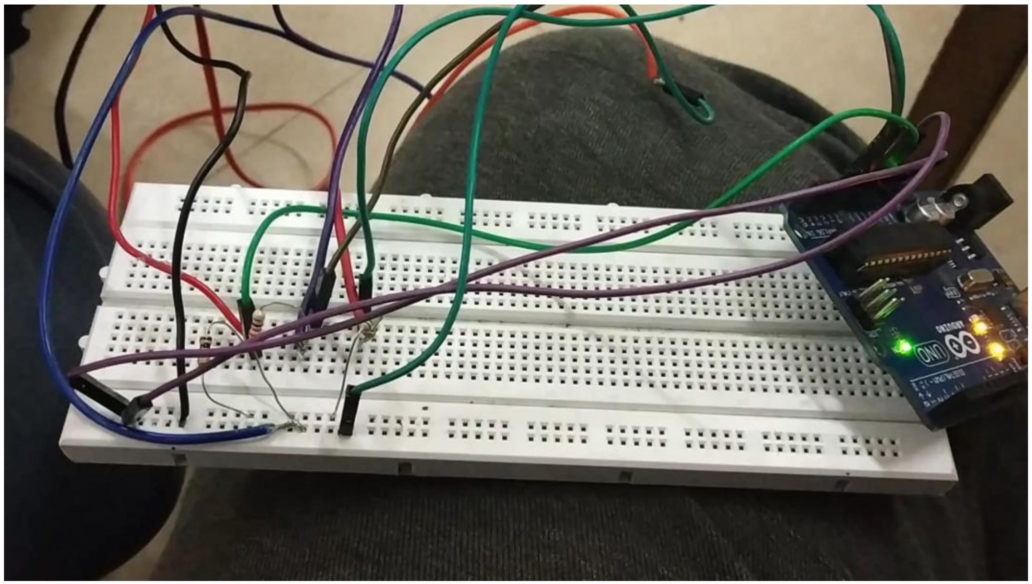


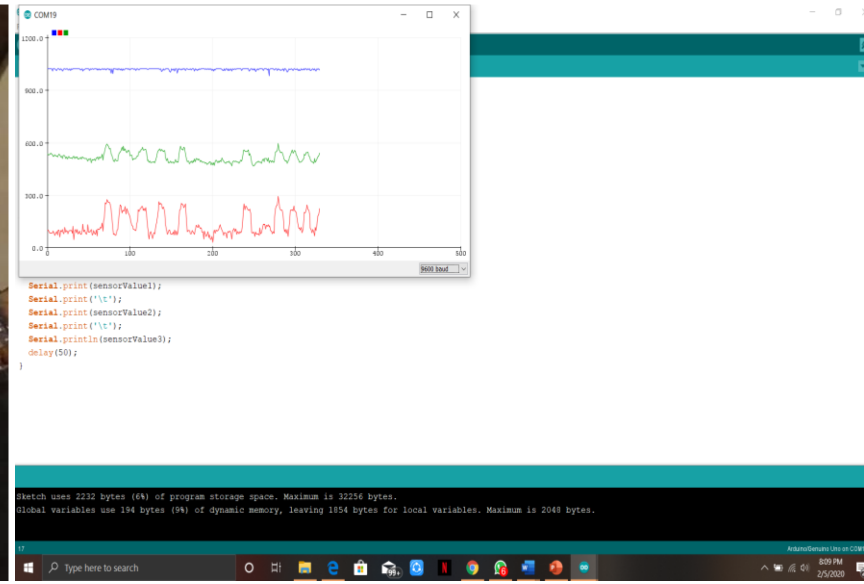
Methodology



Methodology

Flex Sensor Working-Data Collection





Methodology

Machine Learning Model

Deep Neural Network Architecture :

- **Input Layer - 6 inputs (includes roll, pitch, yaw and 3 flex sensors data)**
- **Layer1 – 32 LSTM neurons**
- **Layer2 – 128 LSTM neurons**
- **Layer3 – 256 LSTM neurons**
- **Layer4 – 32 LSTM neurons**
- **Layer5 – 32 neurons with tanh activation function**
- **Output Layer - 9 outputs (each corresponding to a of gesture) with softmax activation function in order to get output as probability.**

Dataset Details:

- **Collected 400 data points for each gesture class from different orientations of user’s hand.**

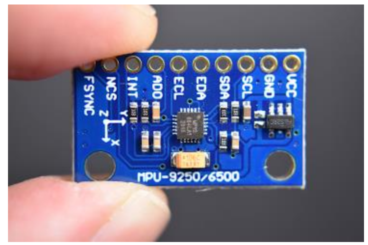
Methodology

Working of SR Fingers

Methodology

Bill of materials

Flex Sensor



IMU

Microcontroller

Microprocessor

Battery Pack and Voltage regulators

High Torque Servo

Force Feedback Sensor

Fabrication material(wood,acrylic)

Impact

- Stroke incidence rate in india much higher; 1.8 million stroke patients every year.
- Patients rely on assistance of family, friends or nursing home staff; compromising their independence.
- According to WHO, approx. 24 million people worldwide are hemiparetic; said to double in next 3 decades.
- A cost-efficient mobile solution will allow these patients to perform everyday chores and other bimanual activities with much ease.

Comparison with Existing solutions

Parameter compared	Soft Sixth finger	Supernumerary robotic fingers
Ease of wear	Different location for different people based on the nerve location	Standard model fits on the wrist and can be adjusted if needed.
Maximum payload	1.4Kg	2.5-3Kg (depending on shape of object)
Total degrees of freedom	1 DOF	6 DOF
Mobility of the exoskeleton	Very mobile	Very Mobile
Control Mechanism	EMG sensors (need more processing power)	Flex Sensors (uses lesser processing power)
Unique features	Single actuator-based mechanism	Continuously training ML Model
Disadvantages	Might not be able to manipulate all objects	Heavier when compared to soft sixth finger model.

Reference for soft sixth finger: Hussain. Et.al., The SoftSixthFinger: A Wearable EMG Controlled Robotic Extra-Finger for Grasp Compensation in Chronic Stroke Patients. IEEE Robotics and Automation Letters Vol 1. 10.1109/LRA.2016.2530793

Conclusion

- With the mentioned statistics it is evident that post stroke patients and hemiparetic patients require a rehabilitative device for simple bimanual tasks.
- Our device is one such iteration which is much more mobile and cost efficient compared to other solutions in market making it a viable product.
- Future work can be done on increasing the accuracy of the ML model and reducing the weight of the prototype.

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Thank you for your attention!