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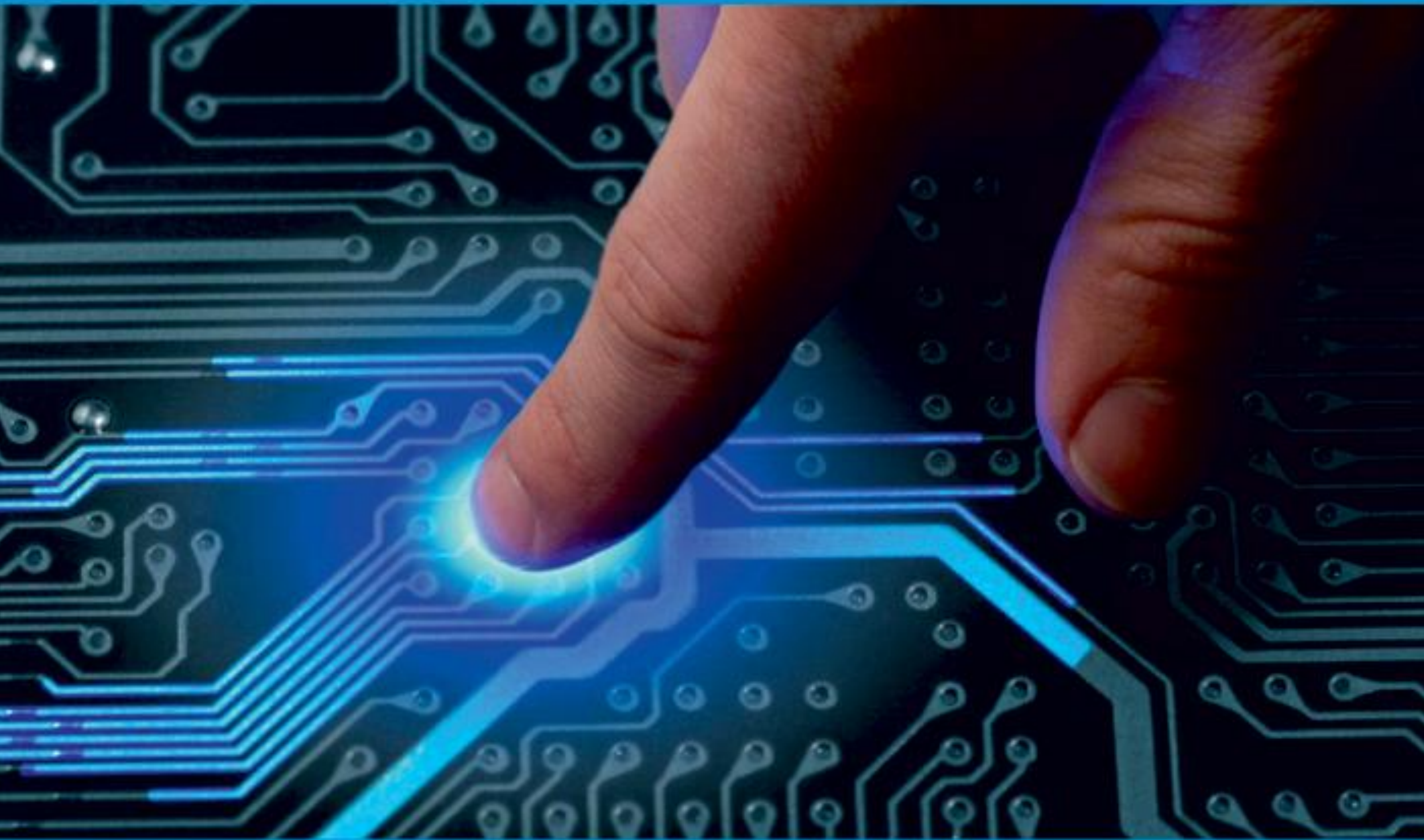

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Prosthetic Arm Based on Machine Learning

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ABSTRACT: The human hand can perform many precise functions and is relied upon for countless aspects of daily life. When upper-limb amputation is necessitated, an affected individual's sense of independence is understandably impacted. Machine learning - ML has been introduced to both decode and interpret useful features that exist in Flex signals so that improved motor control instructions can result. Although machine learning has been shown to yield more physiologically natural prosthesis control for a user in research environments. In this project, we present an overview of how machine learning is used in Flex signal-driven upper-limb prosthesis control, along with a discussion about how it could be employed to improve the robustness and reliability of future devices.

I. INTRODUCTION

Announcing machine learning prosthetic arms, the next advancement in prosthetic technology. Through the use of machine learning, these cutting-edge gadgets provide unmatched versatility and functionality. Machine learning facilitates smooth integration with the user's body, enabling intuitive and natural interactions through predictive movement algorithms and real-time myoelectric control. Algorithms that use machine learning continuously improve performance by analysing user behaviour to predict and address their needs. With cutting-edge materials and sensory feedback systems, artificial intelligence prosthetic arms expand users' capabilities, giving them their independence back and improving their quality of life. Greetings from the future of prosthetics, where artificial intelligence will transform mobility and give people unprecedented power.

Recent years have seen tremendous progress in the creation of prosthetic limbs, but difficulties still exist in providing a smooth, flexible, and easily accessible option for those who have lost an upper limb. The goal of this project is to advance this field by designing and developing a state-of-the-art prosthetic arm. Redefining the possibilities of upper limb prostheses is the main aim, with a focus on goals like improved mobility, user comfort, realistic sensory feedback, and customisation. With a focus on modular design and the integration of cutting-edge technologies like artificial intelligence, we hope to develop a prosthetic arm that not only fulfils the needs of each individual user but also raises the bar for usefulness and adaptability. The initiative prioritises user training, rehabilitation support, and collaboration with healthcare professionals to ensure a comprehensive strategy in the creation and application of this novel prosthetic remedy.

II. OBJECTIVES

The main objective of the project are as follows:
To develop Machine learning Prosthetic ARM or (Artificial ARM) used to support or replacement of Human's Hand who had lost, Amputated or lost partially of their ARM.

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III. BLOCK DIAGRAM

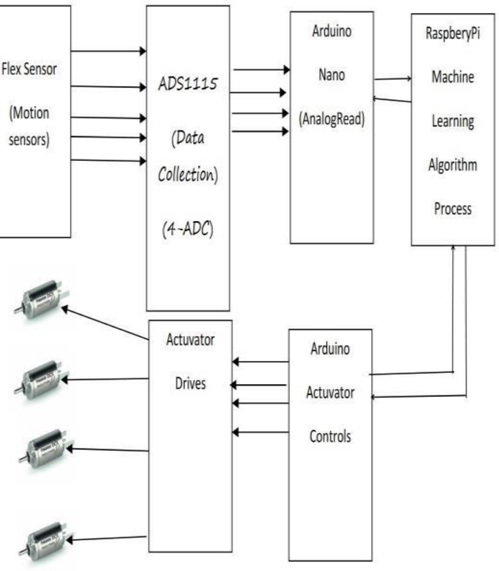

Figure 1 Block Diagram

1. Flex Sensors (Motion Sensors):
- These sensors detect physical motion or bending.
- They provide input signals based on the degree of flexion.

2. ADS1115 (Data Collection) (4-ADC):
- The ADS1115 module collects analog data from the flex sensors.
- It has four analog-to-digital converters (ADCs) for precise measurements.

3. Arduino Nano (Analog Read):
- The Arduino Nano reads the analog signals from the ADS1115.
- It processes the sensor data and prepares it for further control.

4. Actuator Drives:
- These drives control actuators (such as motors or servos).
- Actuators respond to the input data, enabling physical movement.

5. Raspberry Pi Machine Learning Algorithm Process:
- The Raspberry Pi runs a machine learning algorithm.
- It interprets sensor data, makes decisions, and adjusts actuator behaviour.

IV. IMPLEMENTATION

This system utilizes flex sensors on a glove to detect finger positions, converting them into voltage variations via a potential divider. The analog signals are then processed by multiple ADS1115 ADC converters, interfaced with an Arduino Nano, and transmitted to a Raspberry Pi. The Pi stores the data, trains a machine learning model using libraries like pandas and sci-learn, and subsequently predicts finger positions. Commands are sent back to an Arduino Uno, which controls servo motors in a 3D printed robotic arm, allowing it to mimic the finger movements. Overall, the setup integrates sensor data acquisition, signal processing, machine learning, and actuation to enable real-time finger manipulation.

V. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware Used:
- 3D printed Bionic ARM
- Flex Sensor
- ADS1115 –i2c ADC modules
- Raspberry Pi SOC Board

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- Arduino Nano Boards
- Servo Motors
- SMPS

Software Used:
- Keil IDE
- Raspbian OS
- AOgmaNeo (Light Weight C++ Machine Learning Library).
- Arduino IDE

Algorithm Used:
- Decision Tree Algorithm.

VI. COMPONENTS DESCRIPTION

3D Printed Bionic ARM:
The world of prosthetics has witnessed remarkable advancements, and 3D printing technology has played a pivotal role in this transformation. Let's delve into the fascinating realm of 3D printed bionic arms:

Hero Arm™:
The Hero Arm™ stands out as the first 3D printed upper-limb bionic arm to receive Pricing, Data Analysis, and Coding (PDAC) approval1.

Key features:
Below-elbow myoelectric device: The Hero Arm™ is designed for below-elbow amputees.
Soft and ventilated 3D printed liner: The liner ensures comfort and breathability.
Multi-grip hand: The Hero Hand offers versatile grip options.

Flex Sensor:
A flex sensor detects bending or flexing in physical objects. It operates as a variable resistor, with resistance changing based on the degree of bending. Conductive materials within the sensor compress or elongate, altering resistance. The sensor provides an analog output proportional to the bending angle.

ADS115 Module:
The ADS1115 is a 16-bit analog-to-digital converter (ADC) module commonly used in electronic projects. It converts analog signals into high-resolution 16-bit digital values. With four input channels, it's versatile for connecting multiple analog sensors. Communication occurs via the I2C protocol, and it includes a programmable gain amplifier for accurate measurements.

Raspberry Pi SOC Board:
The original Raspberry Pi had a single-core processor with speeds ranging from 700 MHz to 1.2 GHz and memory ranging from 256 MB to 1 GB RAM. Features of Raspberry Pi 4 Model B:
Broadcom BCM2711 SoC with quad-core Cortex-A72 CPU.
LPDDR4-3200 SDRAM (up to 8GB).
Dual-band Wi-Fi (2.4 GHz and 5.0 GHz) and Bluetooth 5.0.
Gigabit Ethernet.
USB 3.0 and USB 2.0 ports.
40-pin GPIO header

Arduino Nano:
The Arduino Nano is a compact and versatile microcontroller board based on the ATmega328 or ATmega168 microcontroller chip, depending on the version. It's essentially a smaller version of the popular Arduino Nano. The Nano is quite small, typically around 18x45mm in size, making it suitable for projects where space is a concern. It uses an Atmel AVR microcontroller, usually the ATmega328 or ATmega168, which are powerful and widely supported within the Arduino community. Despite its small size, the Nano still offers a good number of digital and analog input/output pins, typically around 14 digital I/O pins and 8 analog input pins. It usually comes with a mini or micro-USB port for programming and power supply. This makes it easy to connect to a computer for programming and

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debugging. Like other Arduino boards, the Nano can be programmed using the Arduino Integrated Development Environment (IDE), which is based on C/C++ programming language. It's beginner-friendly and has a vast community and resources available for support.

Servo Motor:
A servo motor is an electric motor equipped with a feedback system for precise control.
It consists of three main components:

- **Motor:** Can be either a DC motor or an AC motor depending on the application.
- **Sensor:** Measures position, speed, or torque and sends feedback signals.
- **Controller:** Compares feedback with desired setpoint signals and adjusts the motor's voltage or current.

The controller employs a closed-loop feedback system, ensuring accuracy.

Working Principle:
The servo motor's controller continuously adjusts the motor's movement to align with the desired setpoint.
PID (Proportional-Integral-Derivative) and fuzzy logic control systems are commonly used.
Sensors like potentiometers or encoders provide precise feedback.

SMPS:
Switched-Mode Power Supplies (**SMPS**) efficiently convert electrical power by rapidly switching input voltage on and off. Unlike linear supplies, SMPSs minimize energy loss. They consist of components like rectifiers, filters, transformers, and feedback circuits. SMPSs offer high efficiency, compact size, and regulated output voltage, making them ideal for diverse applications in consumer electronics, industrial equipment, and automotive systems.

Decision Tree Algorithm:
A decision tree is a versatile supervised machine-learning algorithm used for both classification and regression tasks. It constructs a flowchart-like tree structure, where each internal node represents a test on an attribute, branches denote outcomes of the test, and leaf nodes hold class labels. The algorithm recursively splits training data into subsets based on attribute values until a stopping criterion (e.g., maximum tree depth) is met. During training, it selects the best attribute to split data, aiming to maximize information gain or reduce impurity. Decision trees are powerful, interpretable, and widely used in various domains.

VII. RESULT

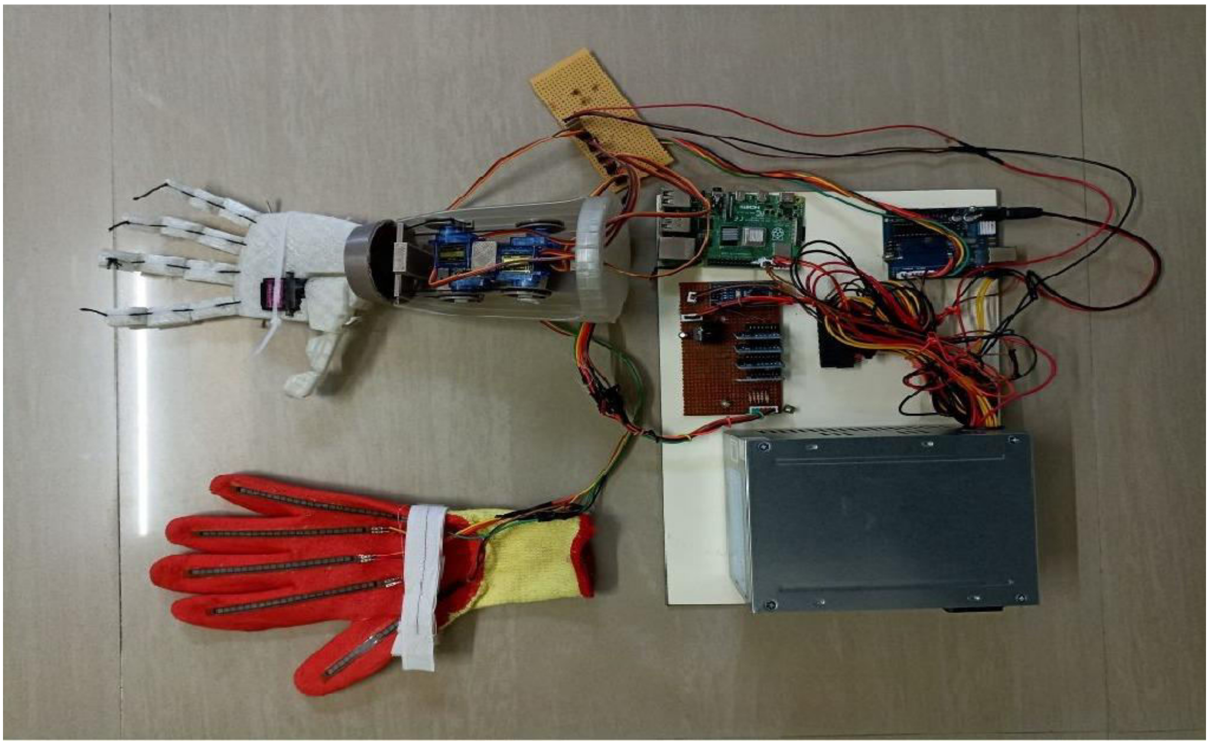

Figure 2 Prosthetic ARM

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VIII. CONCLUSION

Herewith the Prosthetic ARM with ML (Machine Learning) had been designed, developed, tested and demonstrated successfully. For further it needs to tested for live amputated human upper limb persons. Also, the Mechanical 3D print polymer ARM to be replaced with carbon nano tubes-graphene material for mechanical strength and reliability.

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