ANN based Robotic Arm using Permanent Magnet Synchronous Motor for Mineral Extraction in Mines

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Abstract:
Automation systems ease the mining industries using robots to complete the tasks involved in the mining processes. It reduces the fatal rate of the labor of mining industries and also overcomes the issues of labor shortages. Many researches are present in the effective functioning of robots in the mines and innovating many features for the development of mineral extraction. On the other hand, growing self-computing techniques like ANN act as key in the manipulation of robot controls. Therefore this paper proposes a robotic arm using ANN and permanent magnet synchronous motor drive which senses the physical parameters using sensors and monitors using the GSM technology at the mines for extracting the resources. The proposed work effectively finds the presence of resources in the mines and analyses the chemical compounds present in the minerals.

Keywords:*Mines, Robot Arm, ANN, GSM, Synchronous motor*

I. Introduction

Mineral resources areinorganic compounds present in certain geological area that plays a key aspect inthe economy of the country. It is of three types, metallic, non-metallic, and fuel. Examples of mineral resources are fossil fuels,coal, oil, diamond, gold, rare earth elements, silver, etc. Mining of these worthy elements is a tedious process that involves giant trucks, shovels, grinding mills, excavators, and draglines for extraction of minerals under the heavy rocks at several distances below the surface where the ore is present. The excavation of minerals is of two types open pit mining and underground mining.

The mining process involves various steps and techniques thatcause safety issues, environmental effects, and labor scarcity.Labor safety is of major concern including physical, biological, and ergonomic hazards. The solution to this counterpart are automation of equipment and machines involved in the mining industries. Mining robots are developed in either semi or fully autonomous manner based on the requirements in the processes of mining. The main robot applications involved in the mining processes are hauling, drilling, blasting, and exploration.

In the paper [1], the author uses Augmented Reality for BCI of robots using a human-computer shared control method where the polylines are used to reduce the operational error compared to the VR systems measure using the relative distance as the parameters. The brain-actuated robotic arm using EEG signals for a robotic arm system using hybrid control methods is employed in the paper [2] which attains an 85% success rate in task picking and a 50% average

success rate in the task placing process using the robotic arm by applying the steady-state visual evoked potentials and motor imagery for allocating resources using using the primary and secondary BCI interfaces. The authors in the paper [3] use convolution neural networks at depth cameras, LSTM network for inertial sensors, and decision level fusion which improvises the data augmentation and recognition accuracies of the object captured at depth at different orientations of the images using the camera and inertial signals are produced based on the wearable sensor. The adaptive key frame selection based using SLAM method for real-time visual inertial of AR/ VR mobile applications which shown 0.067m RMS error for keyframe trajectory with 0.58% error is peoposed in the paper [5].

II. MODEL

The objective of the proposed work is to obtain automation in the mineral extraction mines using semi or fully-automated robots. The machines work equivalent to the human using the image processing with the help of ANN techniques. They are done through training and testing process.. These robots are sent in the extraction mines in the replacement of humans that perform as the replica of human activities. These robot senses the hazardous gases inside the mines through the sensors and also help to sense the chemical combinations in the extracted materials. The various obstacles in the proceeding pathways are detected and monitored through the ultrasonic sensors. The obstacles are keenly monitored and detected to get rid of various consequences. These obstacles are the major cause of the decrease in the overall performance efficiency of the system.

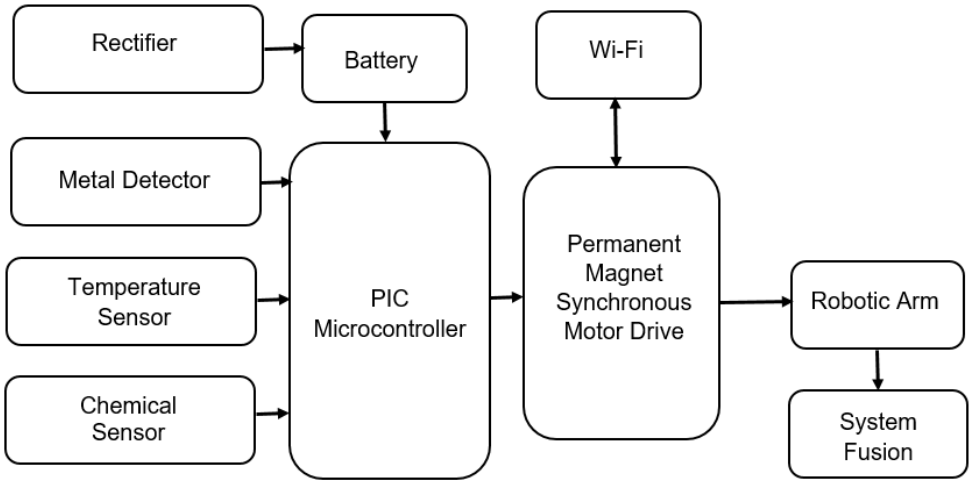

Figure 1: PIC based Robotic Arm using ANN and Permanent Magnet Synchronous Motor Drive

Figure 1 depicts the proposed work of using PIC controller, Temperature sensor, chemical sensor, metal detector, permanent magnet synchronous motor drive, robotic arm and GSM technology. The temperature sensor helps to find the temperature present in the surfaces of the mines for further extraction of mines. The chemical sensor helps to identify the chemical compounds present in the mines. The permanent magnet synchronous motor drive with the robotic arm helps to obtain the mines from the underground surface based on the commands

from the PIC microcontroller. The overall processes are maintained and controlled by the PIC microcontroller. The GSM technology helps to monitor the process happening.

III. Implementation

(A) PIC Microcontroller

The proposed work uses the PIC6F877A which has low power high performance CPU for monitoring and sensing the temperature, chemical compounds, etc which contains a processor, memory and input/ output ports. It is RISC architecture-based Microchip used for embedded projects. The features of PIC6F877A is 8- bit with 20 Mhz speed with operating voltage of 2 to 5.56V using 33 I/O lines with 10 ADC pins comprised of total 40 pins altogether. It can be easily programmed and erased which has the program memory of 8K×14 bits of flash memory. The C language is used for programming the PIC16F877A. The architecture of the PIC controller comprised of 20 input and 3 external interrupts for times, ADC, USART, etc. The upper hand of PIC controller is low power input voltage, very fast using the RISC architecture, interfacing of analog devices is easy and programming language is easy to configure. The main application of this PIC microcontroller is automation purposes, embedded projects, ubiquitous computing and medical devices. The main disadvantage is length programming and accumulation of memory.

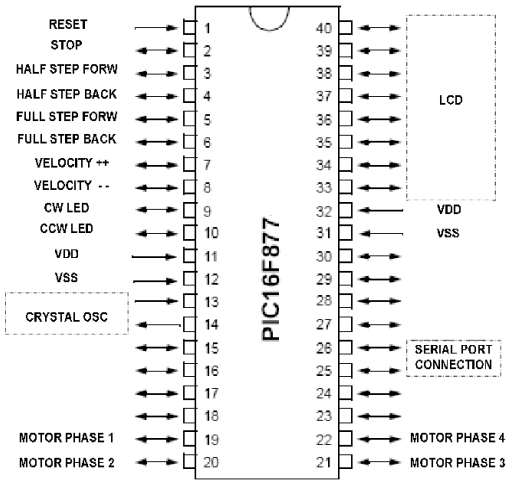

Figure 2: PIC Microcontroller

(B) Permanent Magnet Synchronous Motor Drive

Permanent Magnet Synchronous Motor drive uses the permanent magnets which works based on the AC synchrnous motor speed. It consist of stator and rotor similar to that of rotating electric motor. The stator is the stationery part whereas the rotor is the rotating part in the electric motor [10]. The components of the permanent magnent synchronous motor drive is shown in the figure 3.

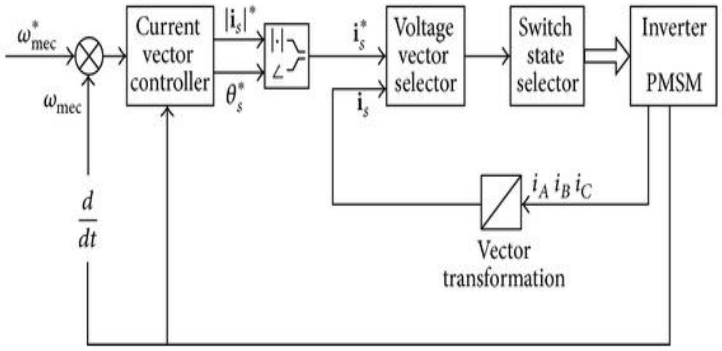

Figure 3: Current Control Strategy in Drive

(C) Robotic Arm

The use of robots act as a versatile element in the automation in order to decrease the manpower. This tends to function the works as similar tohumans by incorporating ANN [11].

This is referred as artificial neural network hence it functions based upon the functioning of neurons.. It includes several number of input that are processed in the hidden layers and thus gives the appropriate desired results. The artificial neural network uses the hidden layers for proceesing and functioning of the system[12]. This incorporates the genetic algorithm which functions based upon the replica of similar functioning of the genes. The output are processed in the hidden layers with comparing the obtained values to that of the desired values. Thus the ANN involves the machine to function as similar to human intelligence techniques. The robotic arm is implemented with the artificial intelligence so that it automatically detects and indicates the presence of mineral combinations in the earth's surface that are needed to be obtained [13].

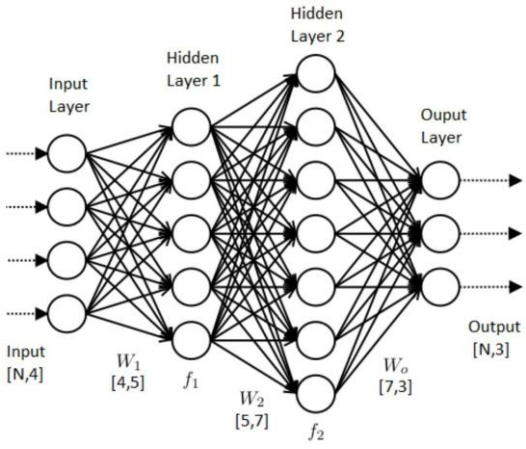

Figure 4: Hidden layers in the ANN architecture

Figure 4 depicts the input layers, hidden layer and the output layer of ANN architecture. Thus the output to the robotic arm is obtained through the artificial intelligence by processing in the hidden layers. This robotic arm digs and collects the mineral combinations based upon the

command system that are controlled by the microcontroller [14] and with the AC synchronous based permanent magnet synchronous motor drive section. The robotic arm consists of camera that are detected through the image processing technique. This includes the cutter and a collection tool for digging the external barriers and collecting the mineral combination in the mines [15].

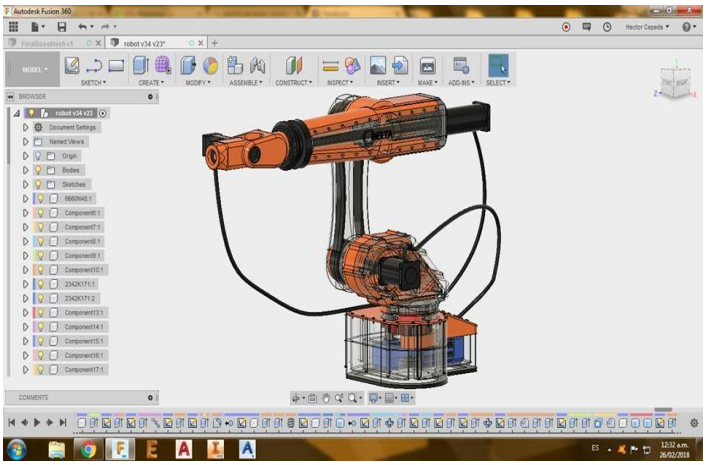

Figure 5: Industrial Robotic Arm

Figure 5 is an Industrial based robotic arm used for the mineral extraction in the mines using the image processing techniques to obtain the chemical compounds present in the extracted resources. The analysis and detection of the compounds is done through the comparison of the trained data sets given as input to the ANN system. The hidden layers helps to identify the compound using the feedback network [16]. After processing through the hidden layers the desire image is obtained and further analysis is manipulated based on it.

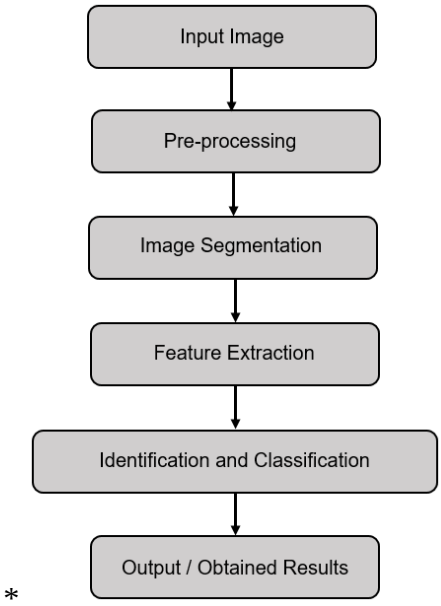

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Figure 6: Process in Image Processing

The figure 6 represents the process in image processing. This involves data collection, preprocessing, feature extraction, segmentation and image identification proceeded with desired output. The preprocessing is to obtaining the data which are necessary to adopt the desired output [17]. This provides a clean dataset without any unnecessary consequences. The feature extraction obtains the data from the raw data using the dataset. The robotic arm finds the chemical compounds present in the minerals extracted [18].

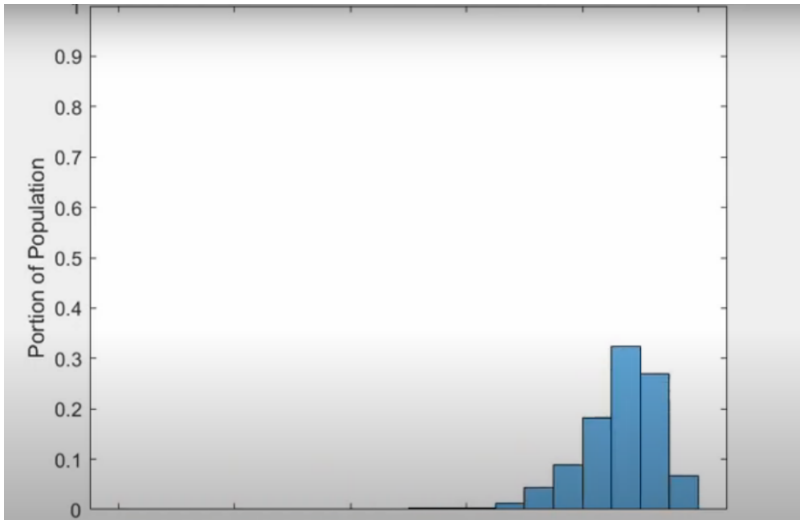

Figure 7: Genetic Algorithm for proposed work

Figure 7 shows the histogram of the proposed model.

Table1: Probability Count in Mineral Extraction

String No	Initial Population	X Value	F(x) Value	Probability Count
1	01101	13	169	0.14
2	11000	24	576	0.49
3	01000	8	64	0.06
4	10011	19	361	0.31
Total			**1170**	**1**
Average			**293**	

Table1 represents the probablility count in the minerals in the mines by adopting the genetic algorithm techniques.This demonstrates that how the robotic arm functions based upon the collection of input and hidden layer data that are optimized to obtain the desired data [19].

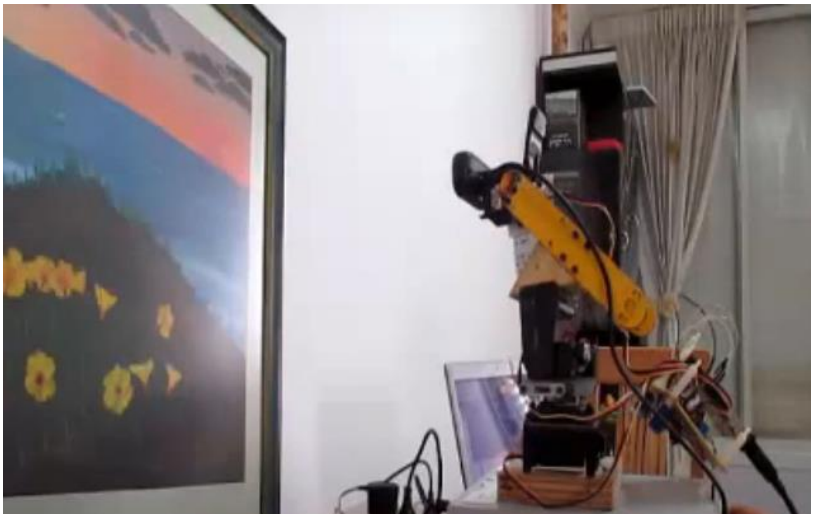

Figure 8:Robotic arm using image processing

Figure 8 respresents the image processing done by the robotic arm in the mines.

IV. Implications

The proposed modesimulated using the MATLAB Simulink to analyze and determine the chemical compuds of the minerals using the robotic arm accompanied with the genetic algorithm.

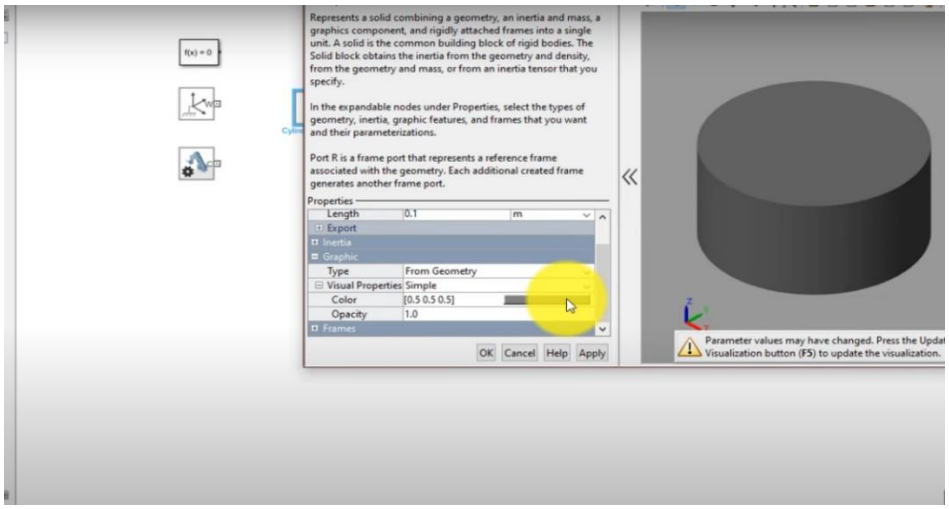

Figure 9: Recognition of Minerals in Mines

The figure 9 represents the recognition of mineral extraction in mines by undergoing the image processing to detect the presence of combinations of minerals in the mines to extract through several techniques.

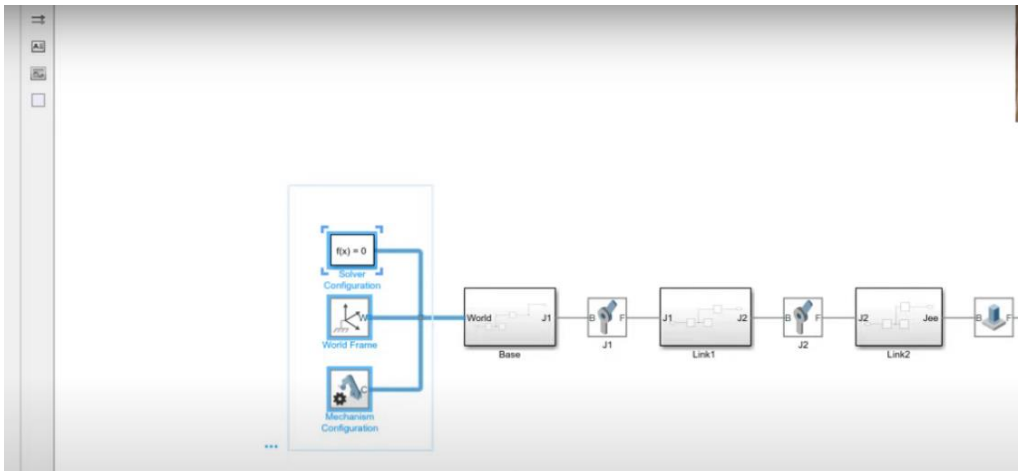

Figure 10: Proposed Model in MATLAB

Figure 10shows the proposed design using the matlab simulink.

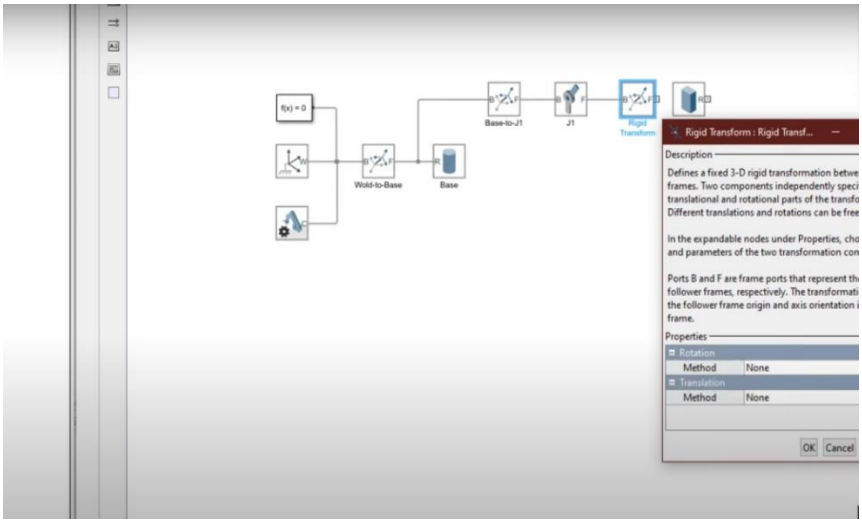

Figure 11: Proposed model using image processing

The figure 11 depicts the proposed model of ANN for image processing to obtain the chemical compounds. This image processing helps to obtain the presence of mineral combination in mines at the particular areas that are needed to be excavated [20].

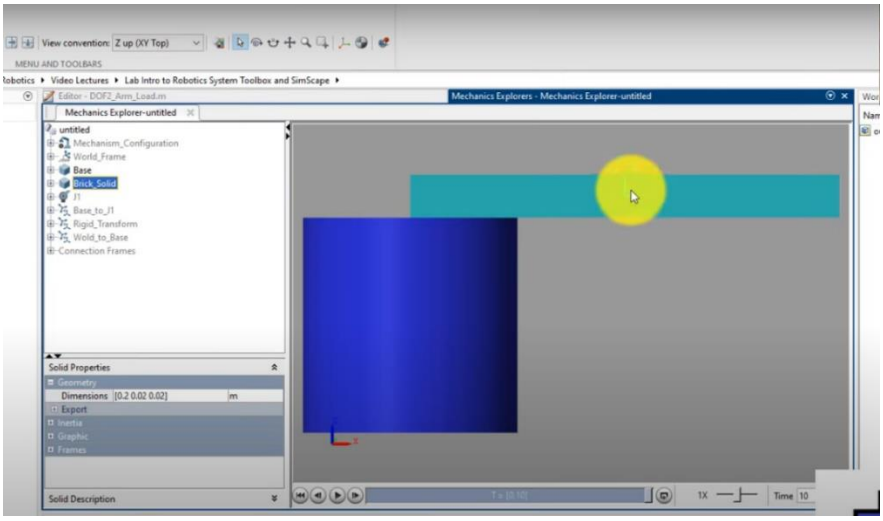

Figure 12: Data Extraction

The figure 12 represents the data extraction through the genetic algorithm which includes the data regarding the mineral constituents in the solid particles. This is denoted by the amount of chemical combinations in the particular substances. This identification of chemical constituents helps to seggregate the necessary minerals for the combinations and easy to process furthur.

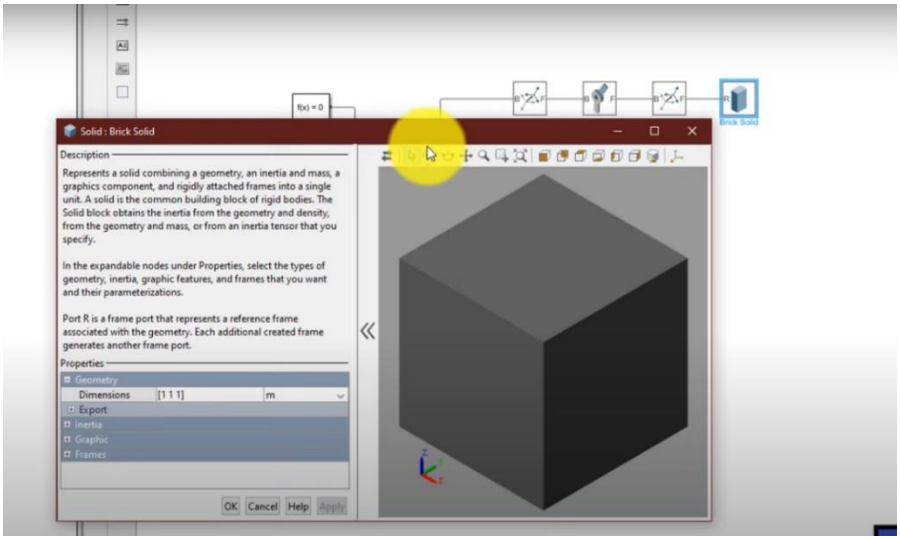

Figure 13: Analaysis of Mineral Constituents

The figure 13 represents the analysis of mineral constituents in the mines through the proposed techniques. The ANN helps to obtain the exact position in which the larger amount of mineral combinations can be obtained.

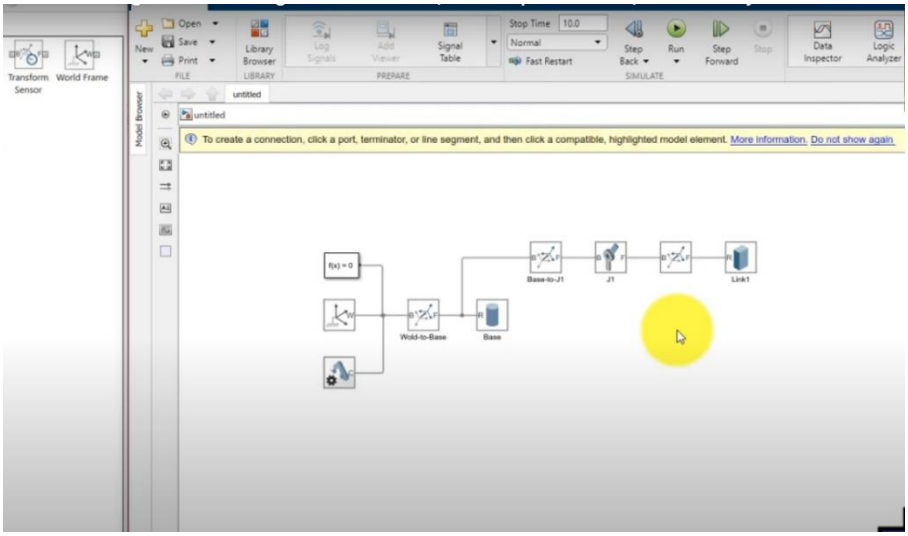

Figure 14: Robotic Arm Operations

Figure 14shows the operation of the robotic arm based on the control parameters with directions.

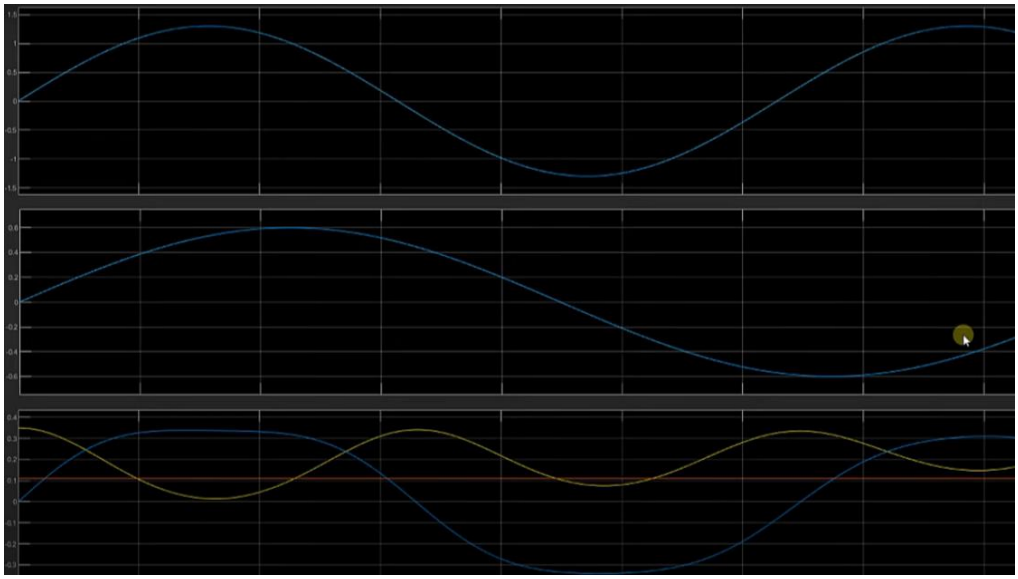

Figure 15: Output Waveform

The figure 15 demonstrates the amount of mineral combination present in the particular aresa through the waveform.

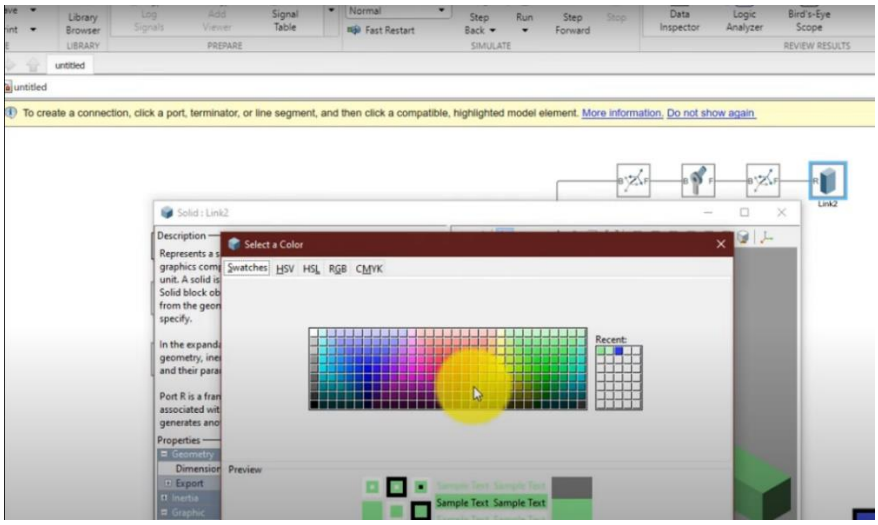

Figure 16: Mineral Extraction

The figure 16 represents the indication of various colours that represents the varied mineral constituents. The colour shows the differentiation of minerals in the obtained extraction. This extracted minerals are then processed with various combination of chemicals to obtain the purest form of minerals. This also includes various techniques for the seperation of minerals from the obtained mineral combinations.

V. Hardware Implications

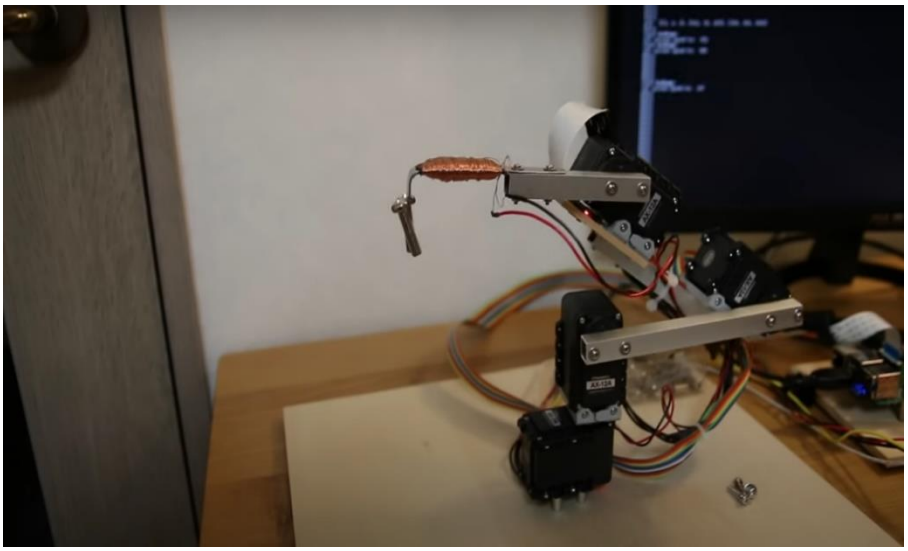

Figure 17: Proposed Model

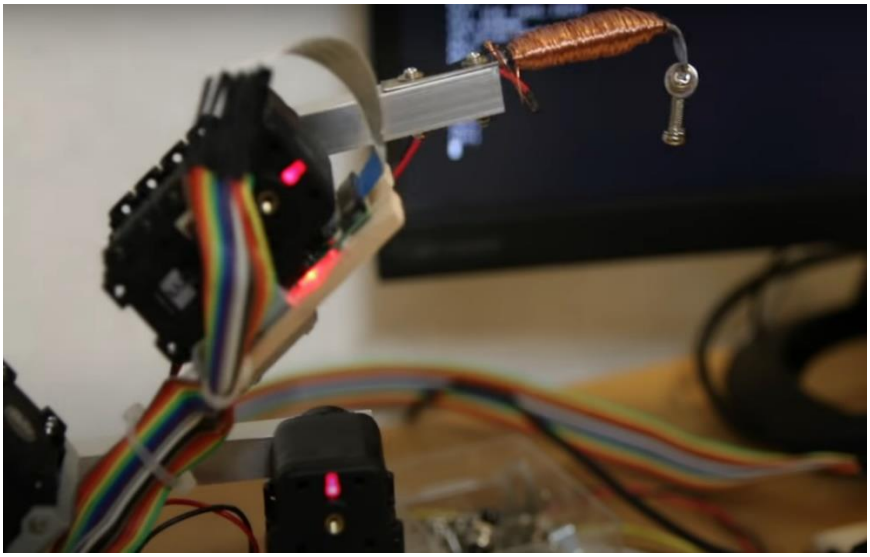

Figure 18: Functioning of Robotic Arm

Proposed work of using ANN for image processing and PIC16F877A using the robotic arm is present in the figure 17 whereas the figure 18shows the functioning of robotic arm which is projected using the LCD display and LED glow.

VI. Conclusion

The major objective of the proposed system is to find the minerals present in the mineral extraction mines through the robotic technology which is implemented through the artificial intelligence and image processing techniques. This enables to extract the minerals with complete automation and thus helps to reduce the fatal rate of the labors. The robotic arm functions as similar to the works of humans and perform the task with higher precision. Thus the proposed work helps to excavate the minerals in the mines without any constraints to human lives and to provide the extraction of minerals with higher efficiency.

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