ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 2, Issue 10, October 2016

Use of Soft Computing Techniques in Robotic Arm

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Abstract: -- **In this paper, we have shown technological evolution and the advances made in the designing of a robotic arm and how over the years soft computing techniques like Neural Networks, Fuzzy logic, Genetic Algorithms (GA), etc. have helped us achieve the desired level of automation. Here we have proposed a robotic arm which sorts primary colours-Red, Blue and Green (RBG) and has judging abilities to deal with uncertainties like distorted inputs and non-primary colours. Analysis of time response of the robotic arm using hybrid of neural network and ant colony optimisation (ACO), / particle swarm optimisation (PSO) technique is expected to be better and faster time response in comparison to a standalone Proportional-Integral (PI) controlled implementation.**

Keywords—**Ant Colony Optimisation (ACO), Neural Networks (NN), Proportional-Integral (PI), Particle Swarm Optimisation (PSO), Red-Blue-Green (RGB)**

I. INTRODUCTION

The world needs robots for a countless number of reasons, including hazardous jobs and automated manufacturing. Robots work without breaks or the need to sleep or eat, allowing manufactures to streamline processes and improve output. Robots are employed in roles ranging from cleaning up dangerous waste and chemical spills to disarming bombs and protecting soldiers in the field. New, humanoid robots and "exo-suits," originally designed for military use, are now being developed in the private sector for uses ranging from manual labour to helping those with handicaps and mobility issues.

Robots also provide a level of precision that is unmatched by the human hand, and one which is repeatable over indefinite time frames. Robotics has attained noteworthiness in the present times as it empowers us to perform functions expeditiously with greater exactness and effectiveness. In a robot workspace, motion planning for robotic assembly relies on sequence of parts or the order they are arranged to create a robotic product obeying all the constraints and compensating the instability of base assembly movement. If the number of parts increase, the sequencing becomes difficult and so does the path planning. Since multiple numbers of paths are possible, a certain path is considered to be optimal when it minimizes the travelling time while still satisfying the process constraint. For this purpose, it is necessary to select appropriate optimization technique for selection of paths. Metaheuristic methods help solve these problems conveniently and reliably. [9]

Now in the conventional robotic arm the preceptors are sensors mounted on the robot, processing is done by on board microcontroller or processor and task (action) is performed using motor or with some other actuators. But in the robotic arm using soft computing techniques, there is additional logic working behind for enhanced judging capabilities. This ensures a desirable output response even with a convoluted out of bounds input. This is done by artificial intelligence.

Artificial intelligence is the study and science of making intelligent systems, which are very helpful and a good solution to cope with different problems and tasks. What the intelligent systems require are various techniques to solve different problems and these techniques are considered as Artificial Intelligence Techniques. AI is also defined as an area of study in the field of computer science which is concerned with the development of computers able to engage in human-like thought processes such as learning, reasoning and self-correction. [31]

There are several AI techniques such as Neural Network, Fuzzy Systems, Evolutionary computing techniques such as Genetic Algorithm, Ant colony optimization, particle swarm optimization, and Bio-Inspired Computing techniques such as Artificial Immune Systems and many more. Evolutionary Computing is the collective name for a range of problem-solving techniques based on principles of biological evolution, such as natural selection and

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 2, Issue 10, October 2016

genetic inheritance. These techniques are being increasingly widely applied to a variety of problems, ranging from practical applications in industry and commerce to leading-edge scientific research. We propose to implement a robotic arm which will sort among the three primary and secondary colours by applying soft computing techniques like hybrids of neural network and PSO/ACO. Comparative analysis of various implementations in the robotic arm - Arduino Board, Intel Galileo Board and Raspberry Pi with Soft computing techniques mentioned above, will be done.

The paper is organised as follows: Section II covers the literature review, followed by section III describing the proposed work, leading to section IV which states our plan of action. Section V and VI give conclusion and reference respectively.

II. LITERATURE REVIEW

Initially,

[1] SCARA (Selective compliance assembly robot arm) robots were used for basic pick and place tasks, but the industry demanded more autonomy for robots. Technological advances took place and controllers with Intelligence were made which are tabulated in table-1.

[2] uses a fuzzy PI-PD controller that was tuned by using Genetic Algorithm(GA).They were followed by

[3]Trained Spiking Neural Network (The Network learns to map input stimuli to motor commands during a phase of action-perception cycles) based 4-DoF robotic arm.

[4]New Path Planning robots using hybrid ACO-PSO algorithm demonstrated the effectiveness and feasibility of the proposed algorithm.

[5] A comparative study of fuzzy logic controller (FLC) and PID controller for 5-DoF robot arm concluded that FLC gave better results. The drawbacks of classical PID were minimised by FLC.

[6] Demonstrated the Position/force control optimized by PSO for constrained robotic manipulators.

[7] Control architecture for robotic arm movement and trajectory planning using Fuzzy Logic (FL) and Genetic Algorithms (GAs) were made. This architecture was used to compensate the uncertainties like; movement, friction and settling time in robotic arm movement. This GA-Fuzzy based one had optimal angular movement of joints as result of the evolutionary process.

[8] A brief review of robotics and its kinematics type, the inverse kinematics of two and three links arm of robotic system were discussed.

[9] Robot Motion planning was optimised using (ACO) techniques.

[10] An efficient and fast method for fine tuning the controller parameters of robot manipulators in constrained motion was implemented using PSO.

[11] An automated novel controller using discrete PID control technique was implemented to have more precise control upon each DoF of a robotic arm.

[12] For constrained and ill-conditioned problem, a solution based on structured neural networks that can be trained quickly, using the ability of ANFIS (Adaptive Neuro-Fuzzy Inference System) to learn from training data.

[13] A comparative study of the implementation of the robot manipulator 5-DoF arm by traditional PID controller & Neuro Fuzzy logic controller gave the latter an upper hand. Later on,

[14] the use of forearm surface electromyography (sEMG) signals for classification of several movements of the arm using just three pairs of surface electrodes located in strategic places. The decoding was done by an artificial neural network to process signal features to recognize performed movements.

[15] A novel path planning strategy based on fuzzy logic for a robot arm with a fixed pedestal was made.

[16] For improving the response characteristics of the angular motion of the arm, PID controller was tuned using biologically inspired algorithms like PSO and GA, and finally, the results were compared with the hybrid or GA-PSO algorithm which clubs both PSO and GA for obtaining better results.

[17] The automatic generation of the Fuzzy Inverse Kinematic Mapping (FIKM) was discussed.

[18] The technology further got deep into the hybrid ACO-PSO approach that exploits the traversability information to compute paths that minimize the expected travel time of the robot.

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ISSN (Online) 2395-2717

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[19] Fuzzy-based Generalized Predictive Control of a robotic arm was compared with the PID approach and results overcame the shortcomings of PID.

[20] Modelling and control of 5 degree of freedom (DOF) robot arm was done using neuro-fuzzy hybrid.

[21] A PSO approach was done on one-link arm and results showed effectiveness of the PSO approach.

[22] The comparison between the PID controller and Fuzzy Logic Controller (FLC) results in terms of overshoot, time response and steady-state error specifications was done, based on simulation results, FLC gives better results than classical PID controller.

[23] An efficient method which was able to optimize the performances of the robotic system using PSO-GA technique overcame many system design problems.

[24] A novel robotic arm design with high flexibility was made to facilitate the training and implementation of the recurrent neural network model.

[25] A hardware and software system for interfacing a biological neuronal culture to a robot arm was constructed. It used artificial neural network technique.

[26] The intelligent control of robot arm using Adaptive Fuzzy Gain scheduling (AFGS) and comparison to fuzzy logic controller (FLC) and various performance indices like the RMS error, and Steady state error were used to test the controller performance. Hybrid adaptive Fuzzy Controller based robotic arms which were able to adaptively estimate the bound functions on-line. Its performance was superior to what the previous arms had.

[27] This work focused on designing, simulating and implementing a 4-DoF's (3 active joints), non-wearable rehabilitation robot for arm movements using PSO algorithm.

[28] This paper dealt with modelling and control of 5-DoF robotic arm using the ANFIS (adaptive neuro-fuzzy inference system), toolbox for easy pick and place application.

[29] This paper dealt with the design and implementation of a 4 DoF pick and place robotic arm using conventional microcontroller.

[30] Object locator and picker robotic arm was designed using artificial neural networks. The literature review is tabulated in table-1

Table-1
Literature Review of Various Techniques used in Robotic Arm.

S.No.	Technique	Author	Year
1.	Simple Conventional Programming[1]	D.H. Eppes R.H. Flake	21-23 March 1988
2.	Genetic Algorithm(GA) [2]	M. P. Veeraiah S.Majhi Chitralekha Mahanta	July 2004
3.	Trained spiking Neural Network[3]	Alexandros Bouganis Murray Shanahan	July 2010
4.	Hybrid ACO-PSO algorithm[4]	Duan ai-ling Duan qiong-bo Deng gao-feng	June 2010
5.	Proportional integral derivative (PID) Neural network (NN) Fuzzy logic (FLC) controllers [5]	Ahmed Z. Alassar Iyad M. Abuhadrous Hatem A. Elaydi	March 2010

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ISSN (Online) 2395-2717
International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 2, Issue 10, October 2016

6.	PSO [6]	Haifa Mehdi Olfa Boubaker	22-24 Nov. 2011
7.	Genetics Algorithm & Fuzzy Logic [7]	V. K. Banga, Jasjit Kaur, R. Kumar, Y. Singh	2011
8.	Neural Network Fuzzy Logic [8]	Gurjeet Singh, Dr. V. K. Banga, Jasjit Kaur	2011
9.	ACO [9]	Sangita Sarangi	May 2011
10.	PSO [10]	Haifa Mehdi and Olfa Boubaker	19 Aug 2011
11.	Proportional Integral Derivative (PID) [11]	Rajeev Agrawal KoushikKabiraj Ravi Singh	May 2012
12.	ANFIS [12]	Gurjeet Singh Dr. Vijay Kumar Banga	June – 2012
13.	Neuro-Fuzzy [13]	Ch Ravi Kumar Dr. K R Sudha D V Pushpalatha	Sept 2012
14.	Artificial Neural Networks [14]	Alexandre Balbinot, Adalberto Schuck Júnior, Gabriela Winkler Favieiro	October 30, 2012
15.	Fuzzy Logic [15]	Yanjie Chen Yaonan Wang Xiao Yu	Dec. 2012
16.	GA-PSO algorithm [16]	S. Sai Saran Yagnamurthy M. Sudheer Chandra J. Ravi Kumar	6-8 Dec. 2012
17.	ANFIS (Fuzzy Logic) [17]	Sandip A. Mehta Jatin Patel	April 2013
18.	Hybrid ACO-PSO [18]	Yogita Gigras	Dec 2013
19.	Fuzzy Logic [19]	Joseph Cronin Juan Manuel Escaño Samira Roshany-Yamchi	26-27 June 2013
20.	PID & Neuro Fuzzy Hybrid [20]	Mohammad Amin Rashidifar, Ali Amin Rashidifar, Darvish Ahmadi	June 2013
21.	PSO [21]	M. Taylan Das L. Canan Dulger G. Sena Das	6-8 May 2013
22.	PID & Fuzzy Logic [22]	Dzulhizzam Bin Dulaidi	JANUARY 2014
23.	Particle swarm optimization (PSO) Genetic algorithm(GA) [23]	Slim Daoud Hicham Chehade Farouk Yalaoui Lionel Amodeo	Feb 2014
24.	Neural Network [24]	Boon Hwa Tan Huajin Tang Rui Yan Jun Tani	14-18 Sept. 2014
25.	Artificial Neural Networks [25]	Abraham M Shultz, Sangmook Lee, Thomas B.Shea, Holly A.Yanco	2014
26.	Adaptive Fuzzy Gain Scheduling [26]	Mostafa Mirzadeh, Mohammad Haghighi, Saeed Khezri, JavadMahmoodi, Hasan Karbasi	2014
27.	PSO Algorithm [27]	Mohammed Y. Hassan Mr. Zeyad A. Karam	29th July 2015
28.	ANFIS [28]	Payal Agnihotri, Banga VK, Gurjeet Singh ER	October 2015
29.	Microcontroller Based [29]	Ravikumar Mourya, Amit Shelke, Sourabh Satpute, Sushant Kakade, Manoj Botre	September 2015
30.	Artificial Neural Networks (ANN) [30]	Ana Riza F. Quiros Alexander C. Abad Elmer P. Dadios	January 2016

III. PROPOSED WORK

In this paper we propose a robotic arm which overcomes the obstacles faced by conventional ones like handling distorted input and non-primary colours, along with sluggish response. We have designed a robotic arm which, apart from basic colour (RBG) sorting capabilities, can judge what to do when a Non-Primary colour is encountered and what to do when a coloured recognisable object comes in the colour sensors range partially, and other kind of uncertainties like distorted inputs. So, to minimise these

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 2, Issue 10, October 2016

uncertainties, we would apply soft computing techniques like hybrids of neural networks and ACO/PSO. We aim for faster time response than standalone PI controlled implementation.
We propose to do a comparative Analysis of various implementations of the robotic arm using Arduino Board, Intel Galileo Board and Raspberry Pi with Soft computing techniques on the basis of time response.

IV.PLAN OF ACTION

We would be using following items for research:

1. Fig-1 shows OWI Robotic arm (For Basic Structure)

Specifications
Maximum lift: 100g
Horizontal reach: 12.6”
Dimensions: 9”(L)X6.3”(W)X15”(H)
Weight: 658g
Power source: 4 X “D”
Batteries: 4x1.5V C Battery
Fig. 1 OWI Robotic Arm

2. Fig-2 shows Arduino Board

Microcontroller: ATmega328P
Operating Voltage: 5V
Input Voltage (recommended):7-12V
Input Voltage (limit): 6-20V
Digital I/O Pins: 14 (of which 6 provide PWM output)
PWM Digital I/O Pins: 6
Analog Input Pins: 6
DC Current per I/O Pin: 20 mA
DC Current for 3.3V Pin: 50 mA
Flash Memory: 32 KB (ATmega328P)
of which 0.5 KB used by bootloader
SRAM: 2 KB (ATmega328P)
EEPROM: 1 KB (ATmega328P)
Clock Speed: 16 MHz
LED_BUILTIN: 13
Length: 68.6 mm
Width: 53.4 mm
Weight: 25 g

3. Fig-3 shows Intel Galileo Board

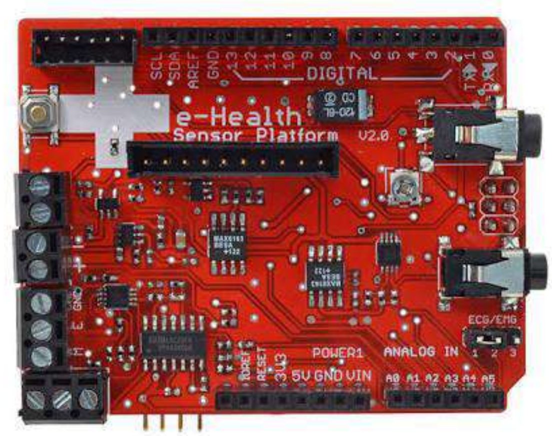

Fig. 3 Intel Galileo Board
SoC: Intel Quark X1000 32-bit 400 MHz
Power barrel: 7V-15V

Ethernet: 12 V Power over Ethernet PoE

4. Fig-4 shows Raspberry Pi Board

Fig. 4 Raspberry Pi Board

SoC: Broadcom BCM2837 **CPU:** 4× ARM Cortex-A53, 1.2GHz **GPU:** Broadcom VideoCore IV **RAM:** 1GB LPDDR2 (900 MHz) **Networking:** 10/100 Ethernet, 2.4GHz 802.11n wireless **Bluetooth:** Bluetooth 4.1 Classic, Bluetooth Low Energy **Storage:** microSD **GPIO:** 40-pin header, populated **Ports:** HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

5. Fig-5 shows Colour Sensors

Fig. 5 Colour Sensor

Supply Voltage 2.7-5.5
Interface Frequency
Colour sensor RGBC
Channels
IR Blocking filter
Programmable

Temp/ Range -40 to 70
Packages D, Pin Count 8

6. Fig-6 shows M-F Connecting wires

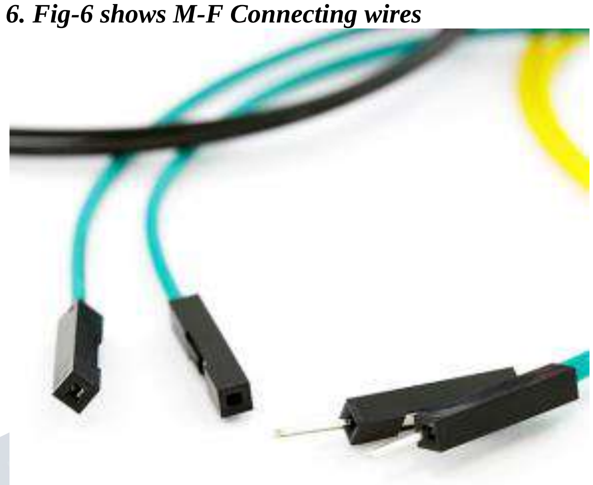

Fig. 6 M-F Connecting Wires

7. Fig-7 shows Motor Shield

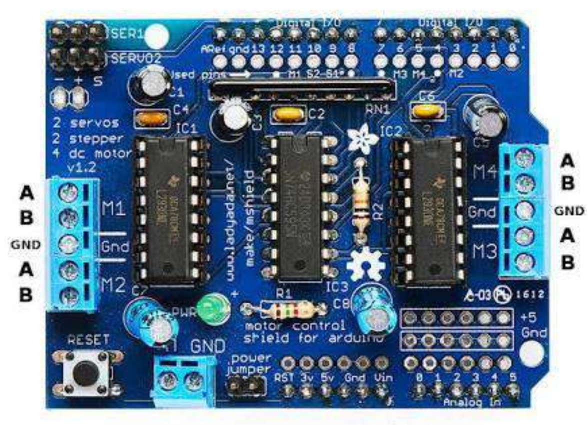

Fig. 7 Motor Shield

Operating Voltage 5V to 12V
Motor controller L298P, Drives 2 DC motors or 1 stepper motor

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ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)

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Max current 2A per channel or 4A max (with external power supply)
Current sensing 1.65V/A
Free running stop and brake function

We will be implementing the soft computing techniques on MATLAB Our final aim is to compare the efficiency of colour sorting robotic arms build using conventional Arduino board, Arduino Board with PID, Galileo Board, Galileo Board with PID, Raspberry Pi, Raspberry Pi with PID, and implementation of Soft computing techniques(ASO, PSO and Neural Networks) on the arm which has the highest efficiency and most favourable time response. The Final colour sorting robotic arm will have humanoid like judging capabilities to assess uncertain inputs and deliver a favourable output. The comparison of the time responses of each implementation will be plotted on a graph for visual understanding of the reader.

IV. CONCLUSIONS

From the literature review, we conclude that soft computing techniques give better performance in robotic arm as compared to conventional PI controller. We propose a problem of color-sorting in robotic arm which will be solved using hybrid of NN-ACO/NN-PSO for improved time response.

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