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Analysis of Path Planning of Humanoid Robots using Neural Network Methods and Study of Possible use of Other AI Techniques

Biswajit Sahoo , Dayal R. Parhi , Priyadarshi Biplab Kumar
Robotics laboratory, Dept of mechanical engineering, NIT Rourkela, odisha, 769008
Email:- formjit@gmail.com , dayaldoc@yahoo.com , p.biplabkumar@gmail.com

Abstract-
In the current paper "ROBONOVA" humanoid robot has been analyzed and studied. A neural network method has been applied for navigation of the humanoid robots in the cluttered environment consisting of various obstacles. It has been observed that using the neural network method the "ROBONOVA" humanoid can navigate safely in cluttered environment while starting from source position to goal position. Here a comparison has been made between experimental and numerical results using Neural Network method. It has been observed during comparison that the Neural Network method can be efficiently used for control and navigation of humanoid robots. In the current paper several other papers are also studied and their possible applications have been explored. It is also documented that the various AI techniques can be used for control of humanoid robots and application in other engineering fields.
Keywords: Robot, Neural Network route planning, Fuzzy Logic, Navigation, Neuro-Fuzzy

1.0 Introduction:

In robotics, robot path making is a fundamental problem. This paper concentrates on humanoid robot path planning technique. Using Neural Network (NN) methods a humanoid can prepare a path for the robot through which robot can not only reach the target but also avoid the static and dynamic objects. In the current research some of papers are explained elaborately on navigation of multiple robots. These papers describe how multiple robots can reach the target by avoiding obstacle and without colliding each other. Nowadays robot is playing a vital role in the world towards various applications. To get the higher efficiency, robot is used widely in the place such as military zone, hospitals and even in industries and offices. By using humanoid instead of human there are so many profit like cost optimization, time optimization, work replacement in a hazardous place. The development for robot path planning constitutes one of the main interests in the current research in the department of robotics. Since last two decade, investigations in the department of route planning of robots got a maximum focus among the scientists and researchers.

2.0 Study of potential AI techniques for possible use in control of humanoid robots:

The paper [1] discusses a strategy for smooth moment of a robot in an obstacle prone environment. The strategy depends on the utilization of Laplace's Equation to compel the potential function generation. The examination carried out in paper [2-5] show the underlying thought for utilization of genetic algorithms. The portable robot needs to locate the ideal way which decreases the number of steps to be taken between the starting point and the target point. Paper [6-10] discusses fuzzy, genetic and neural approaches for route planning of robot. Research work [11-25] discuss about RBFNN, WNN, Bees colony, Artificial Immune System (AIS), Adaptive Neuro-Fuzzy Inference System (ANFIS),invasive weed optimization(IWO) and neuro fuzzy system for route control of robots. The authors have also shown the authenticity of the methods in the simulation and experimental verification. They show a novel framework for a versatile robot to navigate in an authentic dynamic condition. In the paper [26] the base run based ANFIS controller has been presented for the protected course of single and distinctive flexible robots in the disordered condition by using the sensor-based coordinating point control method. The paper [27] focuses on the examination of frameworks, which are fit for investigating an adaptable robot self-hoveringly in static environment. Papers [28-43] discuss savvy development organizing approach to manage versatile robot course. In these papers techniques like ANFIS, GSA,SA, PSO, FA, WNN, IWO and GA are used for robotic agents navigation. Some of the papers discuss about GA strategy along with Petri-Net model to prepare a planned navigational control manager. Papers [44-57] discuss about various artificial intelligence techniques for path control of mobile robots using fuzzy reactive, ecologically inspired, fuzzy inference, C.S anfis, swarm, petri-GA, Neural Network, cuckoo search, innate immune techniques. Authors have also shown the effectiveness of the proposed algorithm using various exercises. The papers [58-72] represent the pathway planning techniques like Neuro-Fuzzy, IWO, Takagi– Sugeno fuzzy etc. The proposed techniques are useful for wheeled versatile robot moving in obstacles jumbled area. These papers deal with the responsive control of self-decision robot which moves smoothly in an obscure condition while keeping away from the obstacles. These articles also show the accommodating behavior of a multi-robot structure in which each robot is embedded with artificial intelligence techniques. The techniques such as swarm optimization, Invasive weed optimization, takagi sugeno fuzzy, neural, adaptive fuzzy, ant colony, particle swarm optimization, hybrid fuzzy are addressed in the papers [73-88] using MATLAB ,simulation and c++ environment . The exploration work [89] has utilized a developmental based advanced directional methodology to follow the crash free ideal way for submerged robot in a 3D situation.

In the papers [90-106] various artificial intelligence techniques are studied to address various engineering problems. In these papers techniques such as PSO , neuro fuzzy, MLP, RBFN, hybrid system , fuzzy, neural network, genetic algorithm, potential field are discussed. Some of the authors in these papers have also discussed control of multiple robots. Papers [107-119] discuss about fuzzy logic, neural network, neuro fuzzy, bees algorithm, artificial immune system for navigation of humanoid robot in an unknown environment. Some authors have also studied kinematic analysis for the robots in these papers. PSO, FEA, petry-poteintial fuzzy hybrid, bat algorithm, online fuzzy logic system, MANFIS controller have been dealt by various researcher in papers[120-138]. It has been seen that using this methodologies robots of various type can do their work properly. Also experimental and simulation results are exhibited in these paper. Kinematic model, adaptive neuro-fuzzy controller, type 2 FLC , neural network for robot navigation have been covered by the scientist in the papers[139-161]. It has been observed that these types of techniques can be successfully implemented in various engineering problems along with for the robot control program. MANFIS, GA , FEA, PSO, Bees algorithm , frog leaping , ant colony ,MLP, RBFN type neural network and FEM have been analysed by the researchers in paper [162-181] . In these paper researchers have authenticated their results using simulation and experimental verifications and by comparing the results with other techniques. Fuzzy reasoning, NN, ANFIS, PID controller, Fuzzy Gaussian technique, Mamdani fuzzy, adaptive genetic sugeno controller, fuzzy PSO controllers have been addressed in papers[182-195]. In [196-214] engineers have focused on swarm intelligence optimization techniques, fuzzy neuro hybrid techniques, PID controller, wind driven optimization technique, neuro fuzzy controller , virtual spring method , adaptive neuro fuzzy interface for getting efficient steering angle of robot in a cluttered environment. It is found that using these methods the robot can steer effectively in a densely obstacle populated environments. Radial basis neural network, FEM, neural network, artificial potential field, ant colony, hybrid fuzzy controller, have been addressed and successfully implemented in papers[217-236]. Clonal fuzzy intelligence system, harmonic potential function , dynamic potential function , fuzzy system, optimally computed potential field methods have also been developed by many engineers and successfully implemented[237-253] for navigation of humanoid robots.

3.0 Analysis of Humanoid robots using Neural Network method:

The final output from the neural network can be derive by using the equations (1) and (2).

Steering angle = $\boldsymbol{f}[(\boldsymbol{summetion\ of\ m\ INPUTS})^{\boldsymbol{4}}]$ **(1)**

$(\boldsymbol{summetion\ of\ m\ INPUTS})^{\boldsymbol{4}} = \sum_{l} \boldsymbol{WEIGHT}^{4}_{lk} . \boldsymbol{INPUT}^{3}_{i}$ **(2)**

In the current work a novel Neural Network technique has been proposed, designed and applied for humanoid navigation in a complex environment. The Fig.1. represents the basic scheme of Neural Network that has been used for the study. Front obstacle distance [FOD], left obstacle distance [LOD] , right obstacle distance [ROD], heading angle [HA] are choosen as the inputs to the controller. The inputs are processed by two level of hidden layers and output of the controller is obtained in the form of stearing angle.

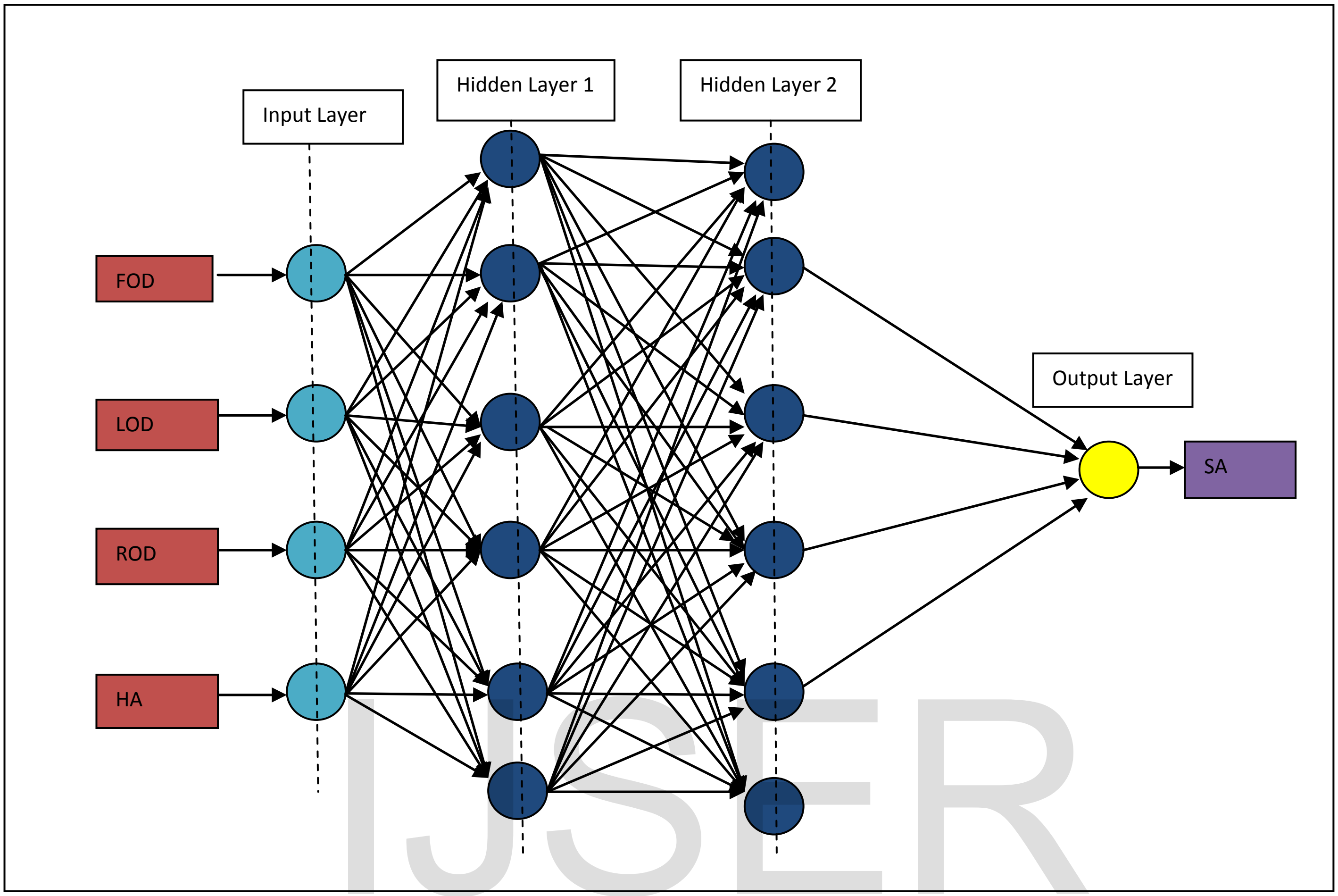

Fig. 1. Neural Network Architecture used for Humanoid Robot Navigation

4.0 Specification of the Humanoid Robot:ROBONOVA-1

The ROBONOVA-1 humanoid robot consider here consisting of 24 servo motors.It has got 24 DOF. It has got sensors like gyro sensor, acceleration sensor. The servo motors are used for the accurate positioning of various links of the ROBONOVA humanoid. The ROBONOVA equiped with a remote control transmeter and receiver. The ROBONOVA here having a chesis and this chesis is a metalic chesis. It can sustain high impact and also very helpful during working condition. The ROBONOVA has got lithium polymer battery for getting power. The battery can be used for several hour and this battery can be exchanged during navigation and can be used fruitfully.The battery has the voltage of 7.4V . Figs 2-5 show the front, rear, right and left side view of the Robonova Humanoid Robot.

Fig.2. Front side view of Robonova

Fig.3. Rear side view of Robonova

Fig.4. Right side view of Robonova humanoid

Fig.5.Left side view of Robonova

5.0 Simulation and Experimental Results:

5.1 Simulation result:

To test the working of the Neural Network controller multiple simulations are performed. A specific arena was selected and obstacles were positioned at random locations. The robot starts its journey from the predefined initial position and reached the destination by the help of the controller. The path length and time taken are measured from the simulation arena and were recorded for the further analysis. The simulation results are recorded in six steps. They are represented in Figs 6a-6f. Fig 6a shoes the starting condition, Figs6b-6e show the intermediate position during navigation. Fig 6f Shows the final position and path covered during navigation in simulation mode.

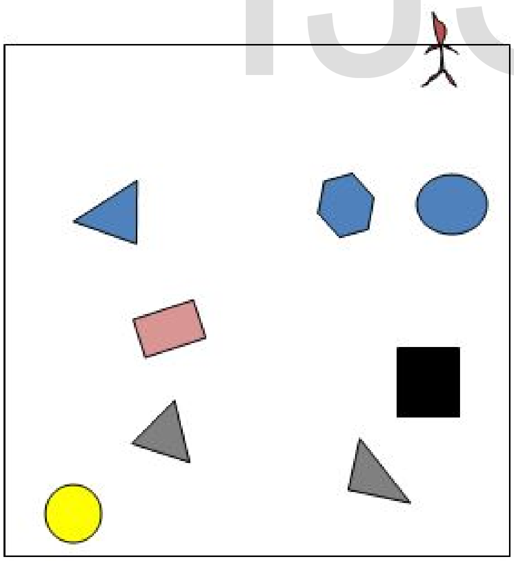

Fig.6A

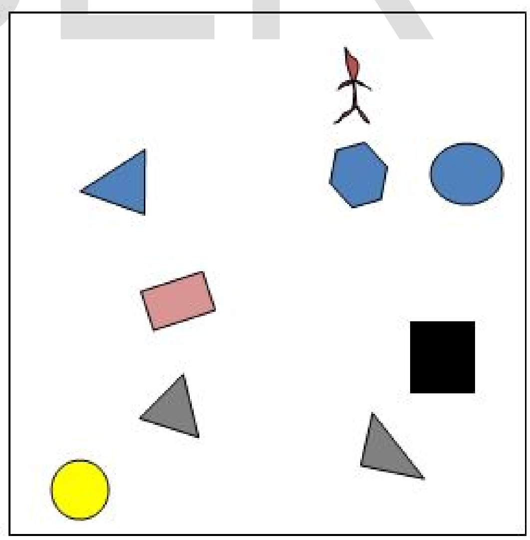

Fig.-6B

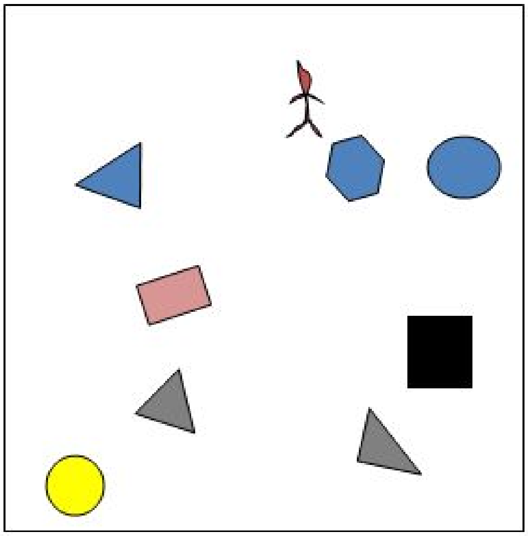

Fig.6C

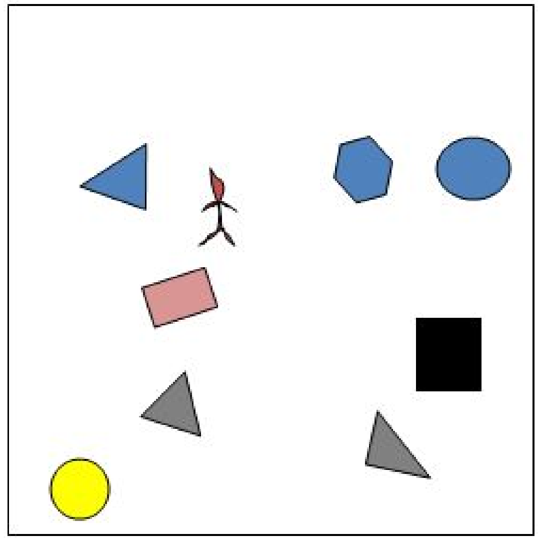

Fig.6D

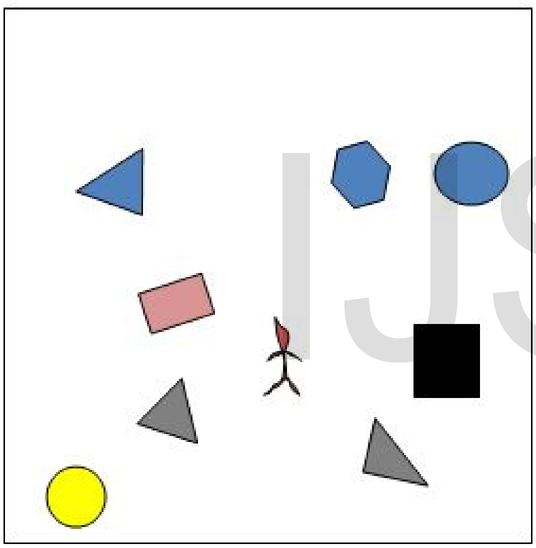

Fig.6E

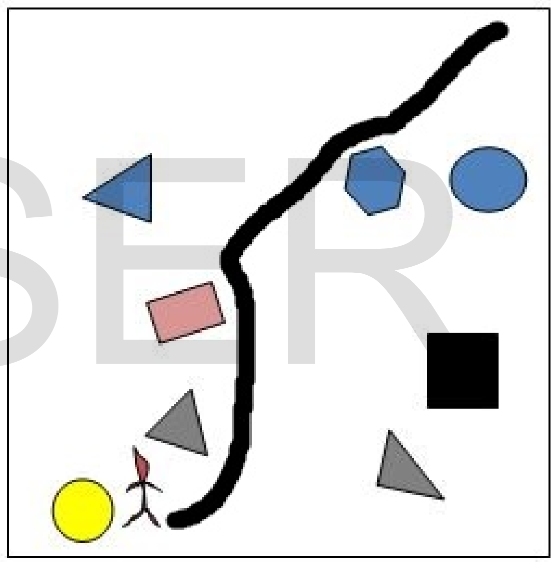

Fig.6F

Fig.6. Simulation Graphs for Robot

5.2 Experimental result:

The experimental results for the corresponding simulation results are depicted in Fogs 7a-7f. The obstacles are positioned at the similar location as that as the simulation and the robot is programmed with Neural Network controller. The path length and time taken are also measured from the experimental platform and they are compared with the simulation results. The experimental results are recorded in six steps. They are represented in Figs 7a-7f. Fig 7a shoes the starting condition, Figs7b-7e show the intermediate position during navigation. Fig 7f Shows the final position and path covered during navigation in simulation mode.

Fig. 7A

Fig. 7B

Fig. 7C

Fig. 7D

Fig. 7E

Fig. 7F

Fig.7. Experimental Graphs for Robot

Table 1 shows the simulation and experimental results path length for humanoid robots from start point to goal point in tabular form for ten numbers of exercises. The deviation of simulation and experimental results for path length are found to be within 6%. Table 2 shows the simulation and experimental results for time taken for humanoid robots from start point to goal point in tabular form for ten numbers of exercises. The deviation of simulation and experimental results for path length are found to be within 6%.

5.3 Simulation and Experimental results for path length(mm) :

No. of Exercise	Path Length in Simulation (PLS) from start to goal in centimetres	Path Length in Experiment (PLE) from start to goal in centimetres	Deviation $\frac{(\lvert PLS - PLE\rvert)}{PLS} \times 100$	Average Deviation
1	228.85	241.37	5.47	5.718
2	223.71	233.54	4.39	
3	210.85	223.79	6.13	
4	239.14	250.45	4.72	
5	219.08	231.92	5.86	
6	227.56	241.62	6.17	
7	228.29	243.82	6.8	
8	209.73	223.83	6.72	
9	215.81	228.54	5.89	
10	239.68	251.74	5.03	

Table 1: Path Length covered by Humanoid Robot in Simulation and Experiment

5.4 Experimental and simulation results for time taken(millisecond) :

No. of Exercise	Time Taken in Simulation (TTS) from start to goal in milliseconds	Time Taken in Experiment (TTE) from start to goal in milliseconds	Deviation $\frac{(\lvert TTS - TTE\rvert)}{TTS} \times 100$	Average Deviation
1	10298.25	10880.65	5.65	5.67
2	10066.95	10509.75	4.39	
3	9488.25	10068.75	6.11	
4	10761.30	11271.60	4.74	
5	9858.60	10435.05	5.84	
6	10240.20	10867.05	6.12	
7	10273.05	10910.25	6.20	
8	9437.85	10068.75	6.68	
9	9711.45	10288.80	5.94	
10	10785.60	11332.35	5.06	

Table 2: Time taken by Humanoid Robot in Simulation and Experiment

6.0 Conclusions:

The research covered in this paper deals with the navigation of humanoid robot using neural network technique. The inputs to the neural network controller are front obstacle distance, left obstacle distance, right obstacle distance and heading angle. The output from the neural network is steering angle. Using the proposed method the humanoid robot can negotiated with the obstacles in obstacle populated environment and reach the target efficiently. The proposed technique is verifies both in simulation and experimental modes. The deviation between the simulation and experimental modes is found to be within 6% in terms of path length and time taken during navigation from start point to goal point. In the future hybrid neural network technique will be analysed for navigation control of humanoid robot.

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