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Insight of a Six Layered Neural Network along with other AI Techniques for Path Planning Strategy of a Robot

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Abstract —The current paper analyses and discusses a six layered Neural Network methodology for route planning and control of a robot in a highly densely scenario. The inputs such as Front Obstacle distance, Left Obstacle distance, Right Obstacle distance, Target angle and outputs such as Steering Angle are taken as various parameters for the neural network. During the analysis, results from experiments and simulations are calculated using the six layered neural network. The deviation of results between the experiment and numerical analysis are found to be within six percent. Just like neural network, several others AI techniques are also studied for potential use in the field of robot navigation and related engineering fields.

Keywords— Robot, Six layered neural network, Path Control, Simulation, Experimental verification

1 Introduction

Of late, the researchers have appreciably supplemented their enthusiasm in automation of industries, avoid humans to involve in unsafe ambience, family utilities and other scientific commonalities. Mobile robots are considered to decide their very own route in all environmental whereabouts so as to reach the target systematically. Some requirements from the cellular robot are to carry out behaviors like understanding the map of the unspecified scenarios, impediment avoidance, destination chasing, momentum regulation, exceptional gadgets sensing and sensor-based navigation in robotic surroundings. Various explorations have been established using modern computational techniques to spotlight on the above issues some of which are illustrated below:

A principal concern within the research of a self reliant cell robot is the design and improvement of a competent controller which can regulate and permit the robot to steer in a actual conglomerate environment, averting established and unstructured boundaries mainly in crowded and unpredictably converting environment, whether it's miles in land, in the space, underground or underwater. Papers [1-3] discuss about fuzzy logic and potential field method for navigation and control of robotic agent in unknown scenarios. The proposed approach presented in [4] has shown better navigational overall performance in comparison with advanced model of ant colony optimization and heuristic capacity field technique for averting fixed obstacles of different form and structures in the course of underwater motion. Papers [5-12] provide particular analysis of numerous strategies used in the independent navigation of cellular robotic. Papers [13-17] are dealing with movement planning of multiple cell robots running collectively to obtain numerous goals and have multiple advantages over single robot gadget. Computation consequences displayed that the preferred rule based-neuro-fuzzy approach enhanced steerage capability in complicated and unfamiliar situations in comparison to simple rule based approach. A unique crossbreed method established entirely on the fusion of fuzzy inference widget and artificial neural network for consigning steering problem of self sustaining cell robot. This is proposed in papers [18-21]. The true time experimental consequences were validated with simulation outcomes, showing that the steerage algorithm consistently functions higher after effects to steer the mobile robot precisely in a completely or incompletely unfamiliar domain. The utility of a neuro-fuzzy adapted inference system for impediment avoidance for a self autonomic cell robot in a substantial universal environment is investigated in [22-30]. The real time experimental effects additionally established with simulation results illustrates that ANFIS always functions better to steer the mobile robot precisely in a densely populated province having diversified constraints.

2. ANALYSIS AND REVIEW OF VARIOUS NEURAL ARTIFICIAL NETWORKS AND OTHER TECHNIQUES.

Exceptional techniques are split as inference fuzzy technique, neuro community method and genetic strategy which are referred in [31-35]. Smart soft computing strategies inclusive of fuzzy inference gadget, neural smart methodology and fuzzy-adaptive-neural inference gadget are tested to be appropriate while being carried out for diffusion of systems. Papers [36-47] describe ANFIS and multiple Neuro Adaptive-fuzzy based navigation and Cuckoo optimization method for a self reliant cell robot in an actual densely cluttered environment. Simulation computations using MATLAB application have demonstrated that, the ANFIS version is appropriate and useful for course making plans of a mobile robot in unfamiliar region to find target position. A changed capability discipline method for robots steerage has been described in [48-57]. Simulation consequences illustrate that the recommended strategy is suitable for establishing steering angle for several cellular robots

in complicated and unknown environments.
The purpose of the evolved methodology is to navigate the gadget autonomously as well as to get automation in manufacturing scenarios. The developed robotic system performs its motion intelligently in keeping with the environmental conditions within its exploring area. In articles [58-68], special movement planners are developed for a self sustaining cell robot. The evolved movement planners are influenced with the aid of particles swarms optimization and are convenient for producing appropriate paths using the robot in unfamiliar surroundings. Every movement planner attempts on its own path characteristic and every fitness function are modeled and based on robotic sensory records. Path evaluation effects proved that each movement planner generates collision free route and reaches its target inside its workspace.
The layout of rules primarily based fuzzy logic controller for robot steering, and impediment avoidance in crowded surrounding, based totally on the Fuzzy Inference method and is focused in [69-91]. Simulation outcomes illustrate that these methods can be used for wheeled mobile robotic locomotion in crowded surroundings having lots of complications.
Papers [92-115] describe the improvement of inverse kinematic fashions of the 4-axis robot manipulator based on its arm equation. The outcomes received from the analytical solutions are compared with the experimental outcomes for a four-axis articulated manipulator. In these papers the goal of the study is to layout multi layered perceptron artificial neural community framework. In the papers [116-123] course making plans such as Invasive Weed Optimization, firefly algorithm, flower pollination algorithm, bat set of rules are illustrated which have been applied for fixing the hassle free direction planning of cell robotic in partially or fully unfamiliar conditions. The efficacy, utility and flexibility of the proposed set of rules for attaining most suitable path using a self reliant mobile robot have been confirmed from collection of simulation and experimental results. Papers [124-138] analyze the Adaptive Neuro-Fuzzy Inference system (ANFIS) controller for cell robot navigation and impediment avoidance within the unfamiliar static environments. By introducing model process in proposed set of rules, the optimization of course in addition to time taken can be achieved through an iterative technique with the help of local minima state of affairs. Individual motor drivers are administered by means of pulse width modulated voltage signals acquired from the Arduino microcontroller board. In the papers [139-161], modified shuffled frog leaping algorithm, Evolutionary based navigational method and firefly set of rules for mobility of robotic system have been modeled with six-dimensional nonlinear and matched equations of motion. The simulation research made certain that the heuristic navigational method possesses clever choice-making competencies in negotiating risky terrain situations during the robot motion.
Various approaches for robot locomotion have been developed to find a considerable path from one configuration to another by avoiding the impediments along its path. Combination of these techniques is implemented as well so as to make the local as well as global locomotion system more effective. Papers [162-194] provide different locomotion methodologies based on Neural Network, Inference Fuzzy Technique, Genetic Modified Algorithm, and biologically as well as artificially persuaded techniques such as Ant Colony Optimization method, Particles Swarms Techniques, and Bacteria Foraging Optimization Techniques and Bees Techniques for successful locomotion of mobile robots. These intelligent methodologies are also applied in many other social sectors and other engineering applications which are presented in [195-230].

3 ANALYSIS OF SIX LAYERED NEURAL NETWOK METHOD FOR ROBOT NAVIGATION

The neural network designed for route analysis of a mobile robot in this current paper is a multilayered back propagation neuro technique having six layers. The layers and their numbers are chosen provisionally to aid the learning of neural network. There are four neurons in the input layer, three of these measure the distances from the impediments in front, left as well as to the right of the robot and the last input neuron measures the target angle. If there is no target in the territory, the fourth input becomes "zero". The first and second intermediate layers have eighteen neurons, the third intermediate layer has seven neurons and the fourth intermediate layer has three neurons. The output layer has a single neuron to steer the direction of locomotion of the robot. Figure.1 illustrates the neural network spotlighting the descriptions of the neurons along with the input and output layers. The neural network is taught with about thousands of patterns to give a solution for the robot in a typical cluttered environment.

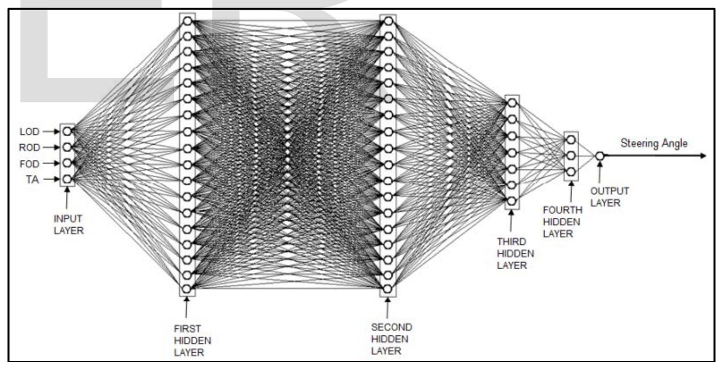

Fig. 1: Six Layered Neural Network for Robot Navigation

The inputs and outputs to and from the neural network are explained below in equation form.

$$p_j^{[layer]} = f(U_j^{[layer]}) \quad (1)$$

Where

$$U_j^{[layer]} = \sum W_{ji}^{[layer]} . p_i^{[layer-1]} \quad (2)$$

And

$[layer]$ = 2,3,4,5 (Intermediate Layers)

j = Neuron Notation for j^{th} $'layer'$

i = Neuron Notation for i^{th} $'layer-1'$

$W_{ji}^{[layer]}$ = Connecting weight from neuron i in $'layer-1'$ to neuron j in $'layer'$

$f(.)$ = function used in activation is given by

$$f(x) = \frac{1}{1+e^{-x}} \quad (3)$$

During learning, the output θ_{actual} differs from the required output $\theta_{desired}$ as stated in the learning pattern. The performance index of the network is the square root of the sum of square of difference of $\theta_{desired}$ and θ_{actual} for the training patterns:

$$E_{rr} = \sqrt{\left(\sum_{\substack{all\\training\\patterns}} (\theta_{desired} - \theta_{actual})^2\right)} \quad (4)$$

The respective synapse weights are modified as per the equation below:

$$W_{ji}(t+1) = W_{ji}(t) + \Delta W_{ji}(t+1) \quad (5)$$

And

$$\Delta W_{ji}(t+1) = K\Delta W_{ji}(t) + \lambda \delta_j^{[layer]} y_i^{layer-1} \quad (6)$$

Where

K = Momentum coefficient (selected as 0.3)

λ = Learning rate (selected as 0.2)

t = Iteration number, each iteration consists of a learning pattern and correction of the weights

$\delta^{[6]}$ = Error Gradient

The output equation from the neural network is:

$$\theta_{actual} = f(U_1^{[6]}) \quad (7)$$

Where

$$U_1^{[6]} = \sum_i W_{1i}^6 \, p_i^5 \quad (8)$$

4 DESCRIPTION OF ROBOT USED IN THE EXPERIMENT

Fig. 2: Real View Fire Bird Robot (NEX Robotics)

The Fire Bird V Mobile Robot (NEX Robotics) used here has two wheels which consist of two servomotors. There are several sensors such as ultrasonic and infrared sensors used in this robot which are embedded for navigation of the robot. It uses Atmel ATMEGA2560 microcontroller which is the main processing unit for the robot. The robot has various inputs and output channels such that sensors can be integrated with the robot simultaneously and can be processed in parallel.

5 SIMULATION AND EXPERIMENTAL RESULTS IN GRAPHICAL FORM

The neural network developed here is tested in simulation and experimental mode. In Simulation mode, a C++ program has been written and the corresponding outputs are evaluated. C++ programming has been chosen as it is easier to integrate with hardware. In the experimental mode, the neural network is implemented in Fire Bird V mobile robot where a microcontroller is used to control the mobile robot. The hardware platform is furnished with ATMEGA2560 microcontroller for taking the decision during navigation of the robot in the experimental scenario.

Figure 3 depicts the six different robot placements, in simulation mode, while the robot is navigating from source to the target. Figure 3(a) shows the initial scenario. Figures 3(b) to 3(e) show intermediate scenario. Figure 3(f) shows the final scenario of the robot and corresponding path from source to target during simulation mode. The robot finds an optimal path which has been showed in the Figure 3(f). The robot navigates from the source to the target avoiding eight impediments.

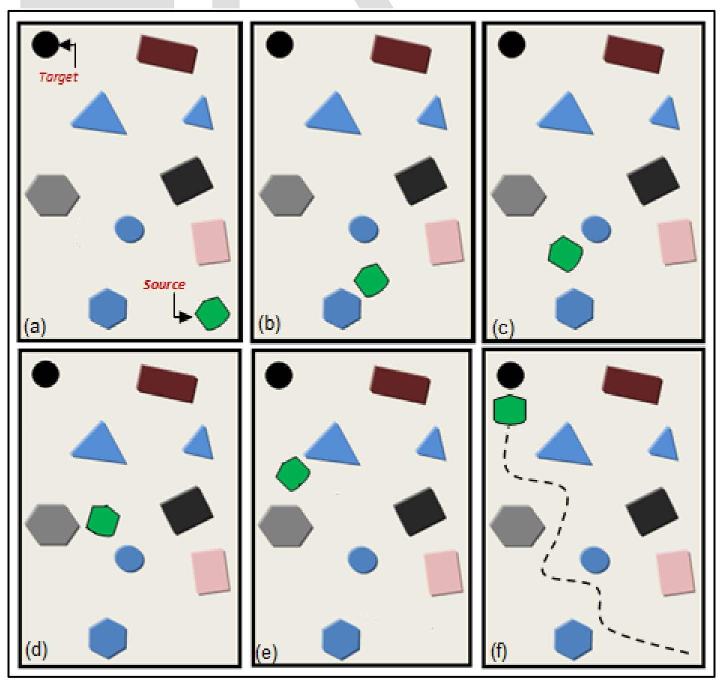

Fig. 3: Results from simulation mode by the robot

Figure 4(a) shows the initial scenario. Figures 4(b) to 4(e) show intermediate scenario. Figure 4(f) shows the final

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scenario of the robot and corresponding path from source to target during experimental mode. The robot finds an optimal path which has been showed in the Figure 4(f).

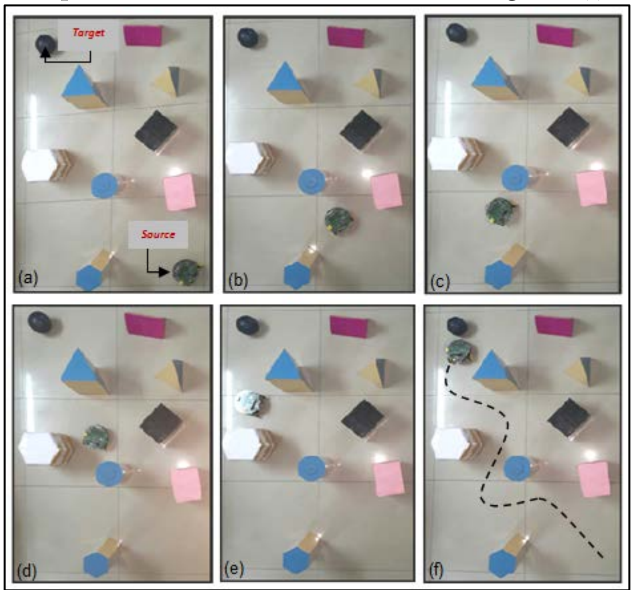

Fig. 4: Results from experimental mode by the robot

6 EXPERIMENTAL AND SIMULATION RESULTS IN TABULAR FORM

Table 1: Path travelled by robot modes

Number of Exercise	Path Length in Simulation (PLS) in mm.	Path Length in Experiment (PLE) in mm.	Deviation $\frac{\lvert(PLS-PLE)\rvert}{PLE}\times 100$	Average Deviation
1	95mm	92mm	3.3%	3.12%
2	90mm	88mm	2.3%	
3	107mm	103mm	3.9%	
4	8mm	96mm	2.1%	
5	104mm	101mm	3.0%	
6	108mm	106mm	1.9%	
7	92mm	89mm	3.4%	
8	100mm	96mm	4.2%	
9	94mm	90mm	4.2%	
10	105mm	102mm	2.9%	

Table 2: Time Taken by robot modes

Number of Exercise	Time Taken in Simulation (TTS) in millisecond.	Time Taken in Experiment (TTE) in millisecond.	Deviation $\frac{\lvert(TTS-TTE)\rvert}{TTE}\times 100$	Average Deviation
1	475	460	3.3%	3.14%
2	450	440	2.3%	
3	535	515	3.9%	
4	490	480	2.1%	
5	520	505	3.0%	
6	540	530	1.9%	
7	460	445	3.4%	
8	500	480	4.2%	
9	470	450	4.4%	
10	525	510	2.9%	

Table 1 depicts the results for 10 exercises in respect of path length in simulation and experimental mode. During comparision between simulation and experimental mode, the error is found to be within 5%. Table 2 depicts the results for 10 exercises in respect of time taken in simulation and experimental mode. During comparision between simulation and experimental modes, the error is also found to be within 5%. During experiment, appropriate actions have been taken avoid the error and sleepage between wheels and floor during the experiment.

7 CONCLUSION

In this paper, a systematic approach has been developed to achieve the navigational strategy of a robot in an obstacle prone environment. To achieve the objective, a six layered neural network system ha been developed. The inputs to the neural networks are FOD, LOD, ROD, TA and the neural network output is Steering Angle. During the training of the neural network, nearly one thousand training patterns are used to cope up with the unknown scenario during path planning. The developed methodology has been corroborated both in simulation and experimental mode. When comparision is made between simulation and experiment, below 5% average error is found between them. It is noted that the developed neural network can be used successfully for route planning of mobile robot in a densely populated scenario. In the future, Fuzzy Inference methodology will be hybridized to develop a robust technique for control of mobile robot.

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