Analysis and Design of Automated Transport and Path Planning for Robots in Cluttered Environments using Novel Hybrid Average Genetic-Neural Control Technique

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Abstract

In the current investigation on automated transport and navigational path planning of robots, a new Hybrid Average Genetic-Neural (HAGN) technique has been developed. The HAGN technique uses genetic algorithm and multi layered neural technique as important parts for its development. The robots are equipped with several sensors to map the surrounding environments and to recognize the obstacles and targets around. During the navigation robots take into account front, left and right obstacle distances obtained from sensors to negotiate with obstacles and reach targets with the help of HAGN technique. To prove authenticity of the proposed method several simulation and experimental exercises have been carried out. Comparisons between simulation and experimental results are presented in pictorial and tabular forms. The deviation between simulation and experimental results are found to be within 2.8%. Other engineering applications can also be addressed using HAGN AI technique.

Keywords: Genetic; Neural; Average; Robots; Artificial intelligence Navigation, Control

Introduction

Scientists and engineers have used different type of artificial intelligence techniques for addressing various engineering optimisation problems including various robots control related problems. Cuckoo birds laying eggs patterns have been mathematically modelled as cuckoo search algorithm [1-2] by researchers for solving control strategies of robots. Artificial potential field methods [3-4] have been used by researchers for automotive control of robots. Particle swarm optimisation method [5-7] is a community driven method used by engineers for addressing robot navigation problems. Artificial immune system [8-10] is one of the potential AI methods for addressing various engineering optimisation problems. Robots navigations have been addressed using artificial immune system in papers [11-13]. Firefly nature inspired algorithm [14,15] has been discussed by scientists and engineers for solving various optimisation problems. Paper [16] discusses navigation control of

robots in unknown environments. Swarm intelligence technique [17-21] is inspired from pattern of herd community travel and has been used by researchers to solve optimisation problems including robots path optimisation problems. In today's world Artificial Intelligence [22-24] techniques play important roles in solving various complicated problems. Papers [25-27] discuss about robot navigation control using AI techniques. Path planning of mobile robots have been analysed and discussed in research papers [28-29].

Regression based analysis [30-32] is used by many engineers to address various optimisation problem. In ant colony method [33], behaviour of ant movement has been mathematically modelled by researchers to solve various optimisation problems in engineering fields. Papers [34-36] have discussed path planning of mobile robot using ant colony optimisation technique. Dayani AI technique [37] has been used by researchers to control robots in

unknown environments. Crack identifications in various elements used for robotic structures have been done by the help of artificial intelligence techniques and are discussed in papers [38-45]. Genetic algorithm [46-47] is one of frontier biological inspired technique for solving various engineering problems. Papers [48-50] discuss path planning of mobile robot using genetic algorithm.

Using various AI soft computing techniques researchers have tried to analyse vibration signatures of different robotic frames and skeletons and are depicted in the papers [51-57]. Suitable mathematical expressions can be coined together to formulate rule based techniques [58-59] to address robot path planning problems and other engineering problems. Papers [60-66] discuss about various vibration patterns in dynamic robotic structures with the help of smart intelligent techniques. Paper [67] discusses analysis of robot manipulator used for various tasks. Bacteria foraging method [68] is one of the promising artificial intelligence technique used for solving navigational path planning of mobile robot in cluttered environments. Differential evolution algorithm [69] has been used by the researchers to address many optimisation problems. Daykun-bip [70] AI technique is a smart computational method, used by researchers to address path planning of robots in unknown environments.

Using fuzzy inference techniques [71-74] researchers have solved many automated problems for various engineering applications. Several researchers have used fuzzy logic [75-78] for navigation control of robots. In papers [79-81] obstacles avoidance by robots has been achieved using fuzzy inference techniques. Papers [82-84] analyse robots movements using fuzzy logic techniques. Finite element methods have been discussed in papers [85-88] for addressing structural dynamics of various mechanical components in intelligent ways. Gait analysis of biped robot has been investigated by engineers in the paper [89]. Paper [90] discusses harmonic search AI technique for robot control.

Kinematic analyses of robots have been discussed in the papers [91-94]. Real time control of robot has been discussed in the paper [95]. Robot navigation can be addressed in unknown

terrain using artificial intelligence techniques [96-97]. Simulated annealing [98] is mimicking of heat treatment processes and is used as a soft computing method for solving local minima problem during path planning of robots. Soft computing methods [99-100] have been used by engineers to address various problems related to control of robots movements. Paper [101] discusses hybrid AI Cuckoo-Neuro technique for robot path analysis in complex environments. Researchers have discussed about radial basis neural network [102] for control of robots in unknown scenarios. Hybrid method such as Simulated-Annealing-Neural technique has been discussed in the paper [103] for complex robot movements. Hybrid fuzzy immune [104] technique has been analysed by researchers for target seeking of robots in cluttered environments.

Mobile computing [105-106] can be used for addressing various intelligent network communications. In neural network [107-111] inputs are given to the neurons in input layers and output is obtained from neuron in output layer. Neural networks [112-116] have been used efficiently for robot navigation control of robot. Using Bat algorithm [117] researchers have tried to solve robot path planning problem. Neuro-fuzzy [118-122] hybrid technique can be used efficiently for path planning of robots from start to goal point while avoiding obstacles. In this method neural algorithm has been hybridised with fuzzy inference methods to obtain neuro-fuzzy [123-125] hybrid technique. Various researchers have used neuro-fuzzy [126-128] techniques to control mobile robots. Paper [129] analyses Grey Wolf optimisation method for solving task management strategy being carried out by robot. Navigation of mobile robot using Cuckoo Search method has been discussed in the paper [130]. Papers [131-133] discusses about invasive weed optimisation technique for navigation and control of robot subjected to various conditions. Keeping in view the above findings a novel hybrid average genetic-neuro control technique has been developed in this paper to address navigation of mobile robots in cluttered unknown environments.

Technical Explanation Genetic-Neural Controller Used for Robots Navigation

Table 1: simulation and experimental path lengths and time taken during various exercises (hemisson robot [134]).

Ex. No.	Path Length (cm) (Simulation)	Path Length (cm) (Experimental)	Percentage De- viation of Path	Time Taken (Millisec- onds) (Simulation)	Time Taken (Millisec- onds) (Experimental)	Percentage Devi- ation of Time
1	135	138	2.17	6750	6917	2.41
2	302	306	1.3	15100	15338	1.55
3	235	239	1.67	11750	11979	1.91
4	274	281	2.49	13700	14085	2.73
5	174	178	2.24	8700	8923	2.49

In the current paper genetic and neural controllers are hybridised to get Genetic-Neural controller. The outputs from genetic and neural controllers are obtained separately and the average of them is taken as the final output from the hybrid controller. The inputs to the hybrid controller (Figure 1) are obstacle distances obtained from sensors mounted on front, left and right directions of the robots. The output from Genetic algorithm is steering angle-1 (SA-1) and the output from Neural network is steering angle-2 (SA-2). The Genetic algorithm uses several parents to produce offspring from the crossover and subsequently finds the best child to get SA-1 according to fitness function. The Neural network considered here consists of five

layers. The input layer has three neurons. Three hidden layers have five, ten and three neurons. The output layer has one neuron representing SA-2. The Final Steering Angle (FSA) for robots is calculated by taking the average of SA-1 and SA-2. With the help of FSA robots negotiate with obstacles in the process of achieving targets during navigation. For carrying out the simulations and experiments exercises Khepera-II [134] and Hemisson [134] robots are used. Simulation and experimental results are shown in Tabular form (Tables 1-2) and pictorial form (Figure 2). The simulation and experimental results agree with each other and deviations between them are found to be within 2.8%.

Table 2: Simulation and experimental path lengths and time taken during various exercises (khepera-ii robot [134]).

Ex. No.	Path Length (cm) (Simulation)	Path Length (cm) (Experimental)	Percentage Deviation of Path	Time Taken (Milliseconds) (Simulation)	Time Taken (Milliseconds) (Experimental)	Percentage Deviation of Time
1	141	143	1.39	7050	7168	1.64
2	288	291	1.03	14400	14586	1.27
3	310	314	1.27	15500	15740	1.52
4	185	189	2.11	9250	9474	2.36
5	251	255	1.56	12550	12782	1.81

Figure 1: Architecture of Hybrid Genetic-Neural Control System.

Figure 2: Simulation and Experimental Results of Hemisson & Khepera-II [134] Robots from Starts to Goal Points.

Conclusion

In the current research Genetic-Neural hybrid control technique has been used to navigate mobile robots from start points to goal points. In the process steering angles SA-1 and SA-2 are obtained from Genetic and Neural parts of the hybrid algorithm. The FSA used for navigation is calculated by averaging SA-1 and SA-2 values. Using the Genetic-Neural hybrid control technique several exercises are conducted in simulation and experimental modes. The deviations between simulation and experimental results are found to be within 2.8%. For carrying out the simulations and experiments exercises Khepera-II and Hemisson robots are used. From simulation and experimental results as depicted in tabular and pictorial forms show the efficiency of the proposed technique during navigation. Genetic-Neural hybrid control technique can be used for solving other engineering problems as an AI technique where there is a need.

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