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Review Article

Analysis and Review of Average Fuzzy Inference Technique and Other AI Techniques Used for Robot Control and Navigation

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Abstract

In this paper application of average fuzzy inference technique has been analysed for navigation control of robotic agent. Also, the reviews of other AI techniques for control of robots are carried out. The robotic agent uses sensors to map the surroundings and take the decision with the help of Fuzzy AI technique to avoid obstacles. In this paper a novel averaging method has been deployed to optimize the results obtained from various fuzzy membership functions. Using the Average Fuzzy Inference technique robot navigates from start position to goal position avoiding obstacles while reaching the target. The simulation results agree with experimental results. The methodology can be used for various applications by the scientific communities to address various engineering problems.

Keywords: Robot; Artificial intelligence; Control; Navigation; Average fuzzy inference

Introduction

Scientists throughout the world are working on various AI techniques to address control strategies of robots. The works done by various researchers to navigate and control robots in various environmental conditions are given below. Navigation of mobile robots using various AI techniques in highly cluttered environments while avoiding obstacles have been reported in [1-4]. AI techniques [5-8] are found to be suitable for robot's navigation control. In Ant Colony optimization technique, rate of pheromones deposition and evaporation have been used mathematically for getting a methodology to address various optimization problems in engineering and scientific fields. Papers [9-11] have elaborated Ant Colony optimization technique for control of mobile robots in various complex environments. The authors have carried out various types of exercises to corroborate their claimed methodology. Control of 7-degree redundant manipulator has been analysed in paper [12] .Bacteria foraging methodology [13-14] has been used by scientists for motion planning of humanoid type robots. Hybrid Differential Evolution Algorithm [15] and Cuckoo Search Algorithm [16-17] have been discussed for solving various engineering problems by researchers. Researchers have used Dayani AI [18] method to control two wheeled mobile robots in an unknown environment. Using Daykun-Bip virtual target AI method [19] robots can find the targets in a highly cluttered environment. Fuzzy logic [20-24] is one of the robust artificial intelligence techniques used for solving various engineering problems. Various scientist has used fuzzy logic [25-28] to navigate robots in highly cluttered environments. Mobile robots can use fuzzy inference technique [29-33] for self-autonomous control in complex environments. Finite element analysis [34-37] can be utilized for evaluating the mechanical properties of various structures used for fabricating bodies and frames of the robots. Nature driven Fire Fly algorithm is one of the promising AI technique to address many optimization problems. Engineers have used Fire Fly algorithm [38-40] for path planning of robotic agents in uncertain environments. Fuzzy Inference

technique has been hybridized with neural network technique to obtain Neuro-Fuzzy technique[41-46]. Many researchers have used Fuzzy-Neuro [47-51] techniques in the modern time for handling optimization problems also for finding optimized paths for robotic agents in highly cluttered unknown environments.

Flower Pollination Algorithm (FPA) and Bat Algorithm (BA) in combination have been discussed in the paper [52] for finding optimized path of robot in obstacles prone environments. Gait analysis has been discussed in the paper [53] for movement pattern of the robots. Genetic Algorithm [54-57] is one of the efficient AI technique for finding solutions for various engineering problems. Paper [58] discussed about the suitable use of Genetic Algorithm for Intelligent Robot control. Researcher has used Harmonic Search [59] algorithm for finding out optimal solution. Immune system has been mathematically encoded, to get Artificial Immune system [60-62] and are subsequently used for solving complex optimization applications. Papers [63-65] have discussed about Artificial Immune System for navigation control of robots in complex environments. Paper [66] has discussed about invasive optimization technique as path planner for mobile robot navigation. Paper [67-70] have discussed about the kinematic analysis of various types of robots so that they can be applied in practical fields. Paper [71-72] have discussed about mobile computing techniques using artificial intelligence technique. Evolution of Brain is one of the important links in biological evolution. This is due to evolution of network consisting of neurons. Papers [73-77] have discussed about neural networks for navigational control of mobile robots in highly cluttered environments. Neural networks [78-82] can be efficiently used for solving various engineering problems along with problems related to robots' control. Potential energy attraction has been used by scientists and engineers to model artificial intelligence potential field method for solving various engineering problems. Papers [83-84] have discussed about the use of artificial potential field method to address control of robot in various environments. Particle Swarm Optimisation (PSO) is one of the robust natures driven artificial intelligence technique for solving various complex optimisation problems. PSO [85-87] has been used efficiently to handle various robot control related problem in uncertain environments. Real time navigation for mobile robot has been address in the paper [88] subjected to unknown environment. Statistical Regression based analysis [89-91] has been used to analyse robot dynamics subjected various situations. Use of artificial intelligence techniques for robot control and path planning has been discussed in papers [92-93]. Rule based algorithms [94-95] are derived from various mathematical functions. They can be used successfully for various robotic control tasks. Simulated Algorithm [96] has a high potential and has been used by researchers to handle various robot control. Various engineering optimisation problems can be solved by soft computing methods. Many engineers have used soft computing methods [97-98] for solving various robot control related problems. Nature inspired swarm intelligence technique [99-103] has been used for solving robot navigational problems. Scientists and engineers have used various methods to analyse crack identification [104-111] in vibrating structures. Papers [112-125] discuss about novel neural network and fuzzy logic to address problem of crack identification in complicated dynamic structures. Papers [126-129] discuss about hybrid AI techniques for robot control.

Analysis of Average Fuzzy Inference Technique

The paper uses Average Fuzzy Inference Technique for Robot Control. For average fuzzy technique two sets of membership functions (Triangular and Trapezoidal) are used. The inputs to the fuzzy inference systems are various sensors inputs (such as Left Obstacle Distance-LOS; Right Obstacle Distance-ROS and Front Obstacle Distance-FOS). The output is the average steering angle calculated from the Steering Angle (SA) of Fuzzy Inference Technique-1 (Consists of Triangular Membership Functions) and Fuzzy Inference Technique-2 (Consists of Trapezoidal Membership Functions). Figure 1 shows the architecture of the Average Fuzzy Inference System. Figure 2 shows the Simulation Path and Experimental Path for Khepera-II mobile robot [130] from start to goal. Table 1 shows the simulation and experimental path length and time taken. The deviation of Path length and time taken are to be found within 2%.

Table 1: Simulation and Experimental Path Length and Time Taken.

Path Length (Simulation)	Path Length (Experimental)	% Deviation of Path	Time Taken (Simulation)	Time Taken (Experimental)	% Deviation of Time
149cm	152cm	2%	2792 Milli Seconds	2850 Milli Seconds	2%

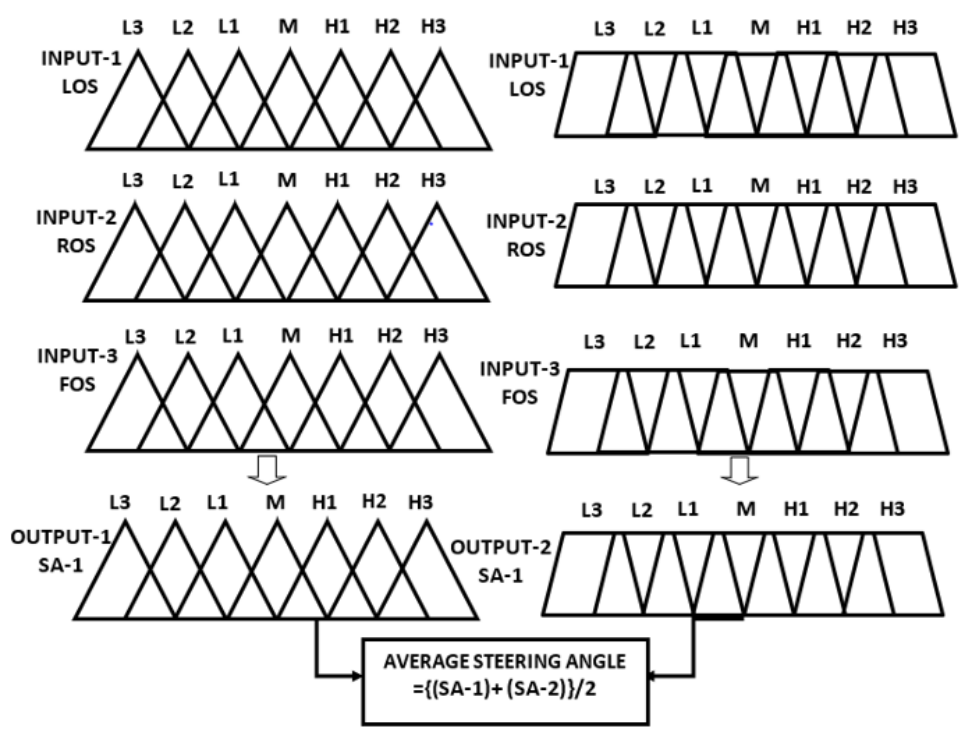

Figure 1: Architecture of Average Fuzzy Inference System.

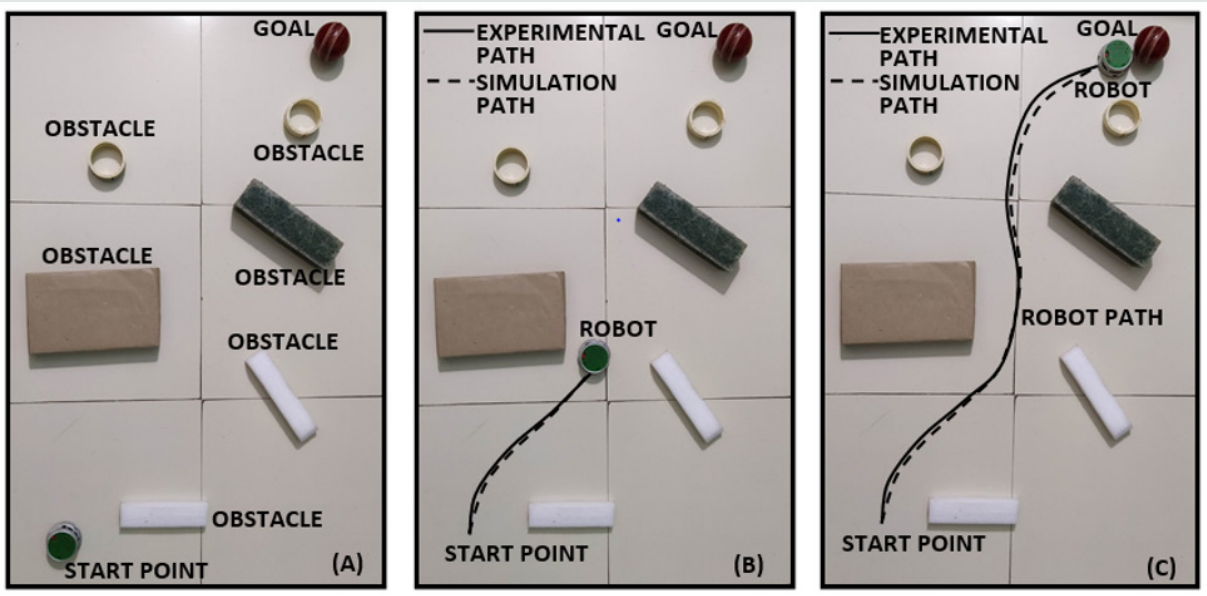

Figure 2: Simulation and Experimental Result of Khepera-II Robot from Start to Goal Point.

Conclusion

From the above analysis and reviews on mobile robots the following conclusions are drawn. From the analysis it is concluded that using average fuzzy inference technique robot can negotiate with obstacles and reach the target efficiently. The results are compared in simulation and experimental modes and the deviation between them is found to be within 2%. During the review of papers, it has been found that artificial intelligence technique can be used efficiently for solving various engineering problems and robotic related problems. In the future more robust AI methods will be explored for solving robot navigation problem in efficient manner.

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