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Mathematical Model for Trajectory Control Using Fuzzy Logic

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Abstract- **This work presents a systematic approach to fuzzy-logic modeling and control of complex systems. In the proposed work, the fuzzymode1 of the system and control rules are obtained from input-output data with no need of a priori information. The proposed work gives the mathematical model for the trajectory controlling of robot by using fuzzy logic. The proposed fuzzy control structure consists of a fuzzy mode1 of the system and robust fuzzy rules in order to ensure stability and satisfactory system performance.**

We apply the methodology to modeling and trajectory control of a four degree-of-freedom robot manipulator. Results of the proposed fuzzy-logic methodology are compared with those of a complete analytical simulation and a heuristic fuzzy modeling technique. A superior modeling performance in terms of accuracy and simplicity is obtained. The control performance is also compared with high-gain servo controllers for different trajectories and a higher performance is achieved.

I. INTRODUCTION

As a particular field of application in system modeling and control, there are many difficulties which are commonly experienced by practicing engineers. For instance, it is generally difficult to accurately model a complex process by a mathematical model. Even when the model itself is tractable, controlling the system or process using an analytical control algorithm might not provide satisfactory performance. An autonomous robot is a programmable and multi-functional machine, able to extract information from its surrounding using different kinds of sensors to plan and execute collision free motions within its environment without human intervention. Navigation is a crucial issue for robots that claim to be mobile.

Fuzzy logic control is used in many commercial, domestic, and automotive control applications. A cross-section of applications that have successfully used fuzzy control such as Washing machines, Vacuum cleaners, Refrigerators, Microwave ovens, Hi-Fi systems, Televisions, Photocopiers, Vehicle climate control, Vehicle seat and mirror control systems. The generation of an intelligent response is evident in all human beings naturally. But whether intelligent responses can be generated by a robot or not is an issue under exploration presently. To some extent, artificial intelligence attempts to apply techniques that are similar to those used by human beings for solving various categories of problems that require intelligence.

II. PREVIOUS WORK DONE

T. V. Prasad at el [1] discusses the merits and demerits of crisp logic and fuzzy logic with respect to their applicability in intelligent response generation by a human being and by a robot. Intelligent systems must have the capability of taking decisions that are "wise" and handle situations intelligently. The paper concludes that the use of crisp logic with complete knowledge leads to perfection in handling situations whereas fuzzy logic can handle situations imperfectly only.

Nasri Sulaiman at el, [2] studies large numbers of fuzzy control applications with the physical systems require a real-time operation to interface high speed constraints; higher density programmable logic devices such as field programmable gate array (FPGA) can be used to integrate large amounts of logic in a single IC. A survey on fuzzy logic controller structure is highlighted in this article with the focus on FPGA-based design of fuzzy logic controller with different applications.

Ming Cao and Ernest Hall [3] describes the use of fuzzy logic control for the high level control systems of a mobile robot. The advantages of the fuzzy logic system are that multiple types of input such as that from vision and sonar sensors as well as stored map information can be used to guide the robot. The obstacle detection uses information from Polaroid sonar detection system. The motor control system uses a programmable Galil motion control system. This design, in its modularity, creates a portable autonomous controller that could be used for any mobile vehicle with only minor adaptations.

Oscar Castillo at el, [4] addresses the problem of trajectory tracking control in an autonomous, wheeled, mobile robot of unicycle type using Fuzzy Logic. The Fuzzy Logic Control (FLC) is based on a back stepping approach to ensure asymptotic stabilization of the robot's position and orientation around the desired trajectory, taking into account the kinematics and dynamics of the vehicle.

Budi Yulianto – [5] Fuzzy logic has been widely used to develop an adaptive traffic signal controller because it allows qualitative modeling of complex systems. However, existing research has developed fuzzy logic signal controller (FLSC) based on non-mixed traffic conditions.

III. EXISTING METHODOLOGIES

Several Artificial intelligence techniques such as reinforcement learning, neural networks, fuzzy logic and genetic algorithms, can be applied for the reactive navigation of mobile robots to improve their performance. Amongst the techniques ability of fuzzy logic to represent linguistic terms and reliable decision making in spite of uncertainty and imprecise information makes it a useful tool in control systems.

Fuzzy control systems are rule-based or knowledge-based systems containing a collection of fuzzy IF-THEN rules based on the domain knowledge or human experts. The simplicity of fuzzy rule-based systems, capability to perform a wide variety tasks without explicit computations and measurements make it extensively popular among the scientists and researcher.

IV. ANALYSIS AND DISCUSSIONS

Robot modeling and control is a challenging problem with its intelligent aspects highly nonlinear and uncertain characteristics and real-time implementation difficulties. Nonlinearity, interactive dynamics parameters variation and other uncertainties in robotic systems prevent linear servo controller from providing a satisfactory performance specially in transient and high speed modes of operation.

Robot control is more difficult when the robot has a contact with external forces. In this case, control methods should generate compliant motion to balance external forces. Also they should be capable of adjusting to the dynamic changes of the environment. Fuzzy-logic adaptive force controllers have been developed as simple and efficient techniques for flexible compliant motion (Kim. 1992) and grasping (Xu. 199 1). Although the idea of using fuzzy-logic mode1 of the manipulator dynamics in control loop was introduced in (Zhou, 1992), no systematic algorithm and detailed analysis and design procedure can be found in the literature. This is due to lack of concise fuzzy-logic modeling algorithm.

Intelligent systems must have the capability of taking decisions that are "wise" and handle situations intelligently. A direct relationship exists between the level of perfection in handling a situation and the level of completeness of the available knowledge or information or data required to handle the situation. Many implementations conclude that the use of crisp logic with complete knowledge leads to perfection in handling situations whereas fuzzy logic can handle situations imperfectly only. However, in the light of availability of incomplete knowledge fuzzy theory is more effective but may be disadvantageous as compared to crisp logic.

Fuzzy Decision Making FDM is a useful method of fuzzy control theory to implement different behavior of work. Within FDM, it may form the basis for the implementation of behaviors as modular building blocks for complex control by using the techniques of fuzzy control. The concepts of Fuzzy Decision Making theory found wide application in various areas such as robotics path planning, navigation and mission planning, it has the potential to benefit from the application of fuzzy logic to provide for soft decisions when there is the need for decision making under uncertainty.

V. PROPOSED METHODOLOGY

In proposed work attempt will be done to enhance mathematical tools to implement crisp logic and fuzzy logic functions with respect to their applicability in intelligent response generation by a robot for trajectory generation by considering dynamics of robot. Intelligent systems must have the capability of taking decisions that are "wise" and execute situations intelligently. A direct relationship exists between the level of perfection in handling a situation and the level of completeness of the available knowledge or information or data required to handle the situation.

The research will focus on mathematics involved in parameters of use of crisp logic and fuzzy functions so as the combination of complete knowledge leads to perfection in handling situations. Whereas fuzzy logic can handle situations in imperfection and uncertainty, enhanced mathematical tools are required in the light of availability of complete knowledge fuzzy theory and make it effective and advantageous as compared to available logic.

VI. POSSIBLE OUTCOME AND RESULT

This work will help to enhance some of the Mathematical Aspects of Fuzzy Logic system Functions so as to improve the accuracy in Robot Trajectory Control. Mainly the dynamics of the system will be focused. Fuzzy logic system can lead to a best alternative for intelligent control. Fuzzy logic is based on many mathematical aspects. Hence fuzzy logic is essential for controlling trajectory robot as Mathematical model. The proposed control of robot trajectory is responsible for the obstacle avoidance of the robot while traveling through a map from a home point to a goal point.

CONCLUSION

This research is an opening to a new approach of fuzzy modeling and control: a systematic and algorithmic approach. The result is significant: we hypothesized and demonstrated that although "approximation" is inherited in fuzzy modeling and control. We must employ new paradigms such as the fuzzy-logic approach if we demand simple and relevant interpretation and high accuracy and satisfactory performance, at the sametime. However our main conclusion is that this is possible only with the help of a systematic framework. Fuzzy logic system can lead to a best alternative for intelligent control. Fuzzy logic is based on many mathematical aspects.

FUTURE SCOPE

This work includes very large applications of fuzzy logic for trajectory controlling of robot in future and in daily life.

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