International Journal of Engineering, Economics and Management
ISSN: 2319-7927, Volume 3, Issue 4

Implementation of Crisp Logic for Robot Control

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Abstract- **This work discusses 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. This work explores the possibility of using soft computing techniques in combination with other artificial intelligence techniques for generating an intelligent response. A situation of giving an instruction to a robot is taken from the context of robotics. The applicability of each of the three soft computing techniques of neural networks, fuzzy logic and genetic algorithms and their combinations is considered and discussed.**

I. INTRODUCTION

Fuzzy Logic was initiated in 1965 by Lotfi A. Zadeh , Professor for computer scienceat the University of California in Berkeley. Basically, Fuzzy Logic (FL) is a multi valuedlogic, that allows intermediate values to be defined between conventional evaluations like true/false, yes/no,high/low, etc.Notions like rather tall or very fast can be formulated mathematically and processed bycomputers, in order to apply a more human-like way of thinking in the programming of computers.The"Law of the Excluded Middle," states that every proposition must either be True or False.

The issue of the use of crisp logic as compared to fuzzy logic in general and the applicability of each in intelligent response generation is also discussed. The outcome of the work is that theoretically soft computing techniques can be used in intelligent response generation as they are nearer to human intelligence than hard computing techniques. On the other hand, the use of crisp logic and hard computing enables an intelligent system to complete tasks perfectly but the use of soft computing techniques does not lead to perfection. However, soft computing techniques also allow the handling of situations where available knowledge is incomplete. This is evident in cases where due to incomplete knowledge being available a hard computing based system is unable to take any action at all whereas a soft computing based system takes action to some extent which may actually be correct. Computational techniques that fall under the purview of soft computing techniques include the following:

a. Neural Networks
b. Fuzzy Logic
c. Genetic Algorithms

Crisp Logic is applicable where the knowledge about a situation is complete and completely certain. On the other hand, fuzzy logic is applicable where knowledge about a given situation is incomplete or minimal. In both the cases, the intelligent system has to generate a response which will ultimately lead to the completion of a given task. In crisp logic, the knowledge available has to be hundred percent complete before a decision can be taken. The difficulty in this case is to ensure the acquisition of complete knowledge before the decision can be taken. Further, the intelligent system has to have the capability to predict that the use of specific steps will certainly lead to the completion of the task. This is possible if the steps to achieve the completion of the task are known completely and with certainty. Otherwise, in case of crisp logic if any of the steps are missing the intelligent system will not be able to complete the task.

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. 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 work concludes 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.

Inma P. Cabrera at el, [2] survey on the theoretical and practical developments of the theory of fuzzy logic and soft computing.Specially, we briefly review the history and main milestones of fuzzy logic (in the wide sense), the more recent development of soft computing, and finalize by presenting a panoramic view of applications: from the most abstract to the most practical ones.

Budi Yulianto - [3]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.

L. Cherroun at el, [4]In order to achieve tasks by the mobile robots, these robotic systems must have been

intelligent and should decide their own action. To guarantee the autonomy and the intelligence for the path following behavior, it is necessary to use the techniques of artificial intelligence like the neural networks and the fuzzy logic. This work presents an approach for the path following task by an autonomous mobile robot using neural networks and fuzzy logic controllers. The first controller is a Takagi-Sugeno fuzzy model and the second is a multi-layer neural network. The proposed controllers are used for pursing a moving target.

Edward Tunstel at el, – [5] Brief introduction to fuzzy set theory and its application to control systems is provided. Fuzzy sets do not have sharp boundaries and are therefore able to represent linguistic terms which may be considered "gray" or vague. Aspects of fuzzy set theory and fuzzy logic are highlighted in order to illustrate distinct advantages, as contrasted to classical sets and logic, for use in control systems. Using a mobile robot navigation problem as an example, the synthesis of a fuzzy control system is examined.

III. Existing Methodologies

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.

We alsodiscusses 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. 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.

IV. Analysis And Discussions

Crisp Logic is applicable where the knowledge about a situation is complete and completely certain. On the other hand, fuzzy logic is applicable where knowledge about a given situation is incomplete or minimal. In both the cases, the intelligent system has to generate a response which will ultimately lead to the completion of a given task. In crisp logic, the knowledge available has to be hundred percent complete before a decision can be taken. The difficulty in this case is to ensure the acquisition of complete knowledge before the decision can be taken. Further, the intelligent system has to have the capability to predict that the use of specific steps will certainly lead to the completion of the task.

The following soft computing techniques can be applied at various steps in the example above:

(a) Neural Networks to learn the knowledge of the temperature of the room gathered from the room using sensors. Neural networks can be used in both a crisp as well as a fuzzy manner.

(b) Reasoning and inferencing to identify the sources of the facts and/or rules isolated after visual and/or acoustic observation using sensors. Both reasoning and inferencing can be either crisp or fuzzy.

(c) Planning to identify the steps of the process to achieve the task of lowering the temperature and genetic algorithms to incrementally improve the solution in case the premises of the facts and/or rules are found to be incorrect or incomplete. In case the steps identified are incomplete the robot can identify the steps from its memory about any such task executed previously or will handle the task in a more efficient manner by using fuzzy decision making where the steps are partially known.

(d) In case the steps identified in step c are complete, the task can be completed in a crisp manner whereas if uncertainty exists about one or more of the steps the task can be handled in a less perfect but an effective manner using fuzzy logic.

Neural Networks can be used in either a crisp manner as standalone networks or in combination with fuzzy rules as neuro-fuzzy systems. In case crisp values are received as input through the sensors in the example above, they can be input to a neural network, which will learn the values by adjusting the weights learned previously during its training, and based on the inputs it will output a crisp value if it has been so trained. On the other hand, the output desired in the above example is to interpret the temperature value as a linguistic variable named “low”. This is possible only if fuzzy rules are incorporated into the neural network to create a neuro-fuzzy system.

V. Proposed Methodology

In order to achieve tasks by the robots, these robotic systems must have been intelligent and should decide their own action. To guarantee the autonomy and the intelligence for the path following behavior, it is necessary to use the techniques of artificial intelligence like the fuzzy logic. This work tries to presents an approach for the path following task by an robot using fuzzy logic control.

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

The aim is to use fuzzy sets in order to make computers more 'intelligent'. Natural Intelligence has both fuzzy as well as crisp capabilities. It can handle both hard as well as soft computing almost equally well. But the capability to handle hard computing is far more prominent in a robot. The need today is to make robots capable of handling soft computing also, at least as well as human beings initially and then to go beyond human beings.

Perfect data can be used in a crisp manner to handle a task perfectly. On the other hand if the data is itself imprecise, it first has to be improvised through the use of a genetic algorithm and then applied to a situation. If the data is to be improvised, the robot in the above example may have to obtain more knowledge for which it may or may not have the capabilities. For a robot to be able to carry out both hard as well as soft computing in a crisp manner it has to be capable of acquiring knowledge perfectly.

Conclusion

This work concludes that both fuzzy as well as crisp techniques have their own areas of applicability when a given situation is to be handled and a given task is to be completed. The decision regarding whether to take a crisp approach or a fuzzy approach depends entirely upon the quantum of uncertainty about the steps involved in the completion of the task. The steps are certain if the knowledge, the information and the data required to handle the task is complete. However, acquiring perfect knowledge is an enormous challenge for any intelligent system. If the intelligent system is unable to acquire perfect knowledge about some of the steps it has to fill in the gaps using its intelligence. The brains of future robots will be imparted the ability to acquire perfect knowledge as well as the ability to fill in gaps, which will make them capable of achieving tasks perfectly and completely.

Future Scope

The crisp logic and fuzzy logic are very important or useful to control the robot in various aspects. Fuzzy Logic represents a tremendous advancement in autonomous robotic control systems.

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