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Fuzzy Logic System and its Application

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Abstract: ***The concept of fuzzy logic relies on near-human thinking and natural activities. It presents, predicates which are present in nature and like those either big or small. This theory mimics human psychology on how someone makes the choice faster. Fuzzy logic might be a superset of typical (Boolean) logic that has been extended to handle the thought of partial truth - truth values between "completely true" and "completely false".". It is often implemented in hardware, software, or a mixture of both It is often engineered into something from little, hand-held product to massive processed method management systems. Within the present competitive scenario, the Fuzzy logic system is being adopted by the automotive manufacturers for the advance of quality and reduction of development time and also the cost. Fuzzy logic was planned as a higher technique for sorting and handling information however has well-tried to be a wonderful selection for several system applications.***
Keyword: fuzzy logic concept, Fuzzy logic application in different field

I. INTRODUCTION

In 1948, Turing wrote a paper [1] marking the begin of a replacement era, the age of the intelligent machine, which raised questions that also remain unanswered today. This era was heavily influenced by the looks of the PC, a machine that allowed humans to automatize their means of thinking. However, human thinking isn't exact. If you had to park your car precisely in one place, you'd have extreme difficulties. To allow computers to mimic the way humans think, the theories of fuzzy sets and mathematical logic were created. They must be viewed as formal mathematical theories for the illustration of uncertainty, that is crucial for the management of real-world systems because it mimics the crucial ability of the human mind to summarize knowledge and target decision-relevant info. Marvin Minsky, one among the founding fathers of AI, once defined the latter as- "the science of creating machines do things that might require intelligence if done by men."

Similarly, Lotfi A. Zadeh, who in 1965 wrote the beginning paper on fuzzy set theory [2], once represented the aim of this theory as being – "the construction of smarter machines.".

The FL technique is an innovative technology employed in turning out with solutions for multi-parameter and non-linear controlling models for the definition of a bearing strategy. As a result, it delivers solutions quicker than typical controlling techniques. FL was initially proposed by Lotfi Zadeh in 1965. Before Zadeh, several efforts were tried in the field of FL by several researchers like Plato, Hegel, Marx, Lukasiewicz etc. [3]. A number of them gave three-valued logic and a few of them gave four-valued or 5 valued logic, that is the extension of Boolean logic, that accepts solely 2 values true or false (0 or 1). Lotfi Zadeh in his work "Fuzzy sets" represented mathematics as fuzzy sets and fuzzy logic. Before the introduction of fuzzy logic, arithmetic is confined solely to 2 conclusions, true or false (0 or 1). This paper presents the idea of fuzzy logic, real-life and therefore the attainable application of fuzzy logic in multiple filed and also represents how fuzzy logic has been applied in several fields of day to day activities and the way its use makes things and ideas easier.

II. CONCEPT OF FUZZY LOGIC

Fuzzy Logic Systems (FLS) turn out acceptable however definite output in response to incomplete, ambiguous, distorted, or inaccurate (fuzzy) input. [4] FL is a methodology of reasoning that resembles human reasoning. The approach of FL imitates the means of deciding in humans that involves all intermediate prospects between digital values YES and NO. [1] The traditional logic block that a pc will perceive takes precise input and produces a precise output as TRUE or FALSE, that is comparable to a human's YES or NO.The father of FL, Lotfi Zadeh, determined that in contrast to computers, human deciding includes a range of prospects between YES and NO., such as-

CERTAINLY YES
POSSIBLY YES
CANNOT SAY
POSSIBLY NO
CERTAINLY NO

The FL works on the amount of possibilities of input to realize the definite output.

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A. How is Fl Different from Conventional Control Methods?

Fuzzy logic incorporates an easy, rule-based IF X AND Y THEN Z approach to a finding management drawback instead of trying to model a system mathematically. The FL model is empirically-based, counting on an operator's expertise instead of their technical understanding of the system. for instance, instead of addressing temperature management in terms like "SP =100C", "T < "200C <TEMP <210C", terms like "IF (the process is too cool) AND (the process is getting colder) THEN (add heat to the process)" or "IF (the process is too hot) AND (the process is heating rapidly) THEN (cool the process quickly)" are used.

1) Fuzzy Logic Architecture

It has four main elements as shown

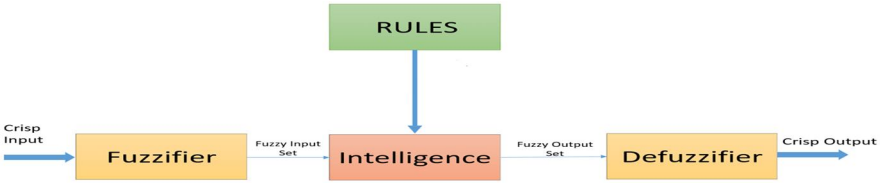
a) Fuzzification Module: It transforms the system inputs, that square measure crisp numbers, into fuzzy sets. It splits the communication into 5 steps like –

LP	x is Large Positive
MP	x is Medium Positive
S	x is Small
MN	x is Medium Negative
LN	x is Large Negative

b) Knowledge Base: It stores IF-THEN rules provided by consultants.

c) Inference Engine: It simulates the human reasoning method by creating fuzzy illation on the inputs and IF-THEN rules.

d) Defuzzification Module: It transforms the fuzzy set obtained by the illation engine into a crisp price.



2) How Does FL Work?: FL needs some numerical parameters to control like what's a thought-about important error and important rate-of-change-of-error, however precise values of those numbers unit of measurement sometimes not vital unless a responsive performance is needed within which case empirical standardization would confirm them. as an example, a straightforward temperature system might use one temperature feedback sensing element whose information is deducted from the command signal to reckon "error" and so time-differentiated to yield the error slope or rate-of-change-of-error, hereafter referred to as "error-dot". The error may need units of degs F and a little error thought-about to be 2F whereas an oversized error is 5F. The "error-dot" would possibly then have units of degs/min with a little error-dot being 5F/min and an oversized one being 15F/mi. These values do not have to be symmetrical and may be "tweaked" once the system is working to optimize performance. Generally, FL is so forgiving that the system will probably work the primary time with none tweaking.

3) Types Of Fuzzy Logic Systems

There are two major varieties of management rules in fuzzy control:

a) Mamdani System: This technique is widely accepted for capturing knowledgeable information. It permits us to explain the experience in an exceedingly additional intuitive, additional human-like manner. However, Mamdani-type FIS entails a considerable procedure burden.

b) Takagi- Sugeno: This technique is computationally economical and works well with optimisation and adaptive techniques, that makes it enticing on top of things issues, significantly for dynamic non-linear systems. These adaptive techniques are often wont to customise the membership functions so the fuzzy system best models the info. the foremost elementary distinction between Mamdani-type FIS and Sugeno-type FIS is that the means the crisp output is generated from the fuzzy inputs. whereas

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Mamdani-type FIS uses the technique of defuzzification of a fuzzy output, Sugeno-type FIS uses a weighted average to cypher the crisp output. The communicative power and interpretability of Mamdani output are lost within the Sugeno FIS since the consequents of the principles don't seem to be fuzzy. however, Sugeno has higher time interval since the weighted average replaces the long defuzzification method. thanks to the explicable and intuitive nature of the rule base, Mamdani-type FIS is wide utilized in explicit for call support application. alternative variations are that Mamdani FIS has output membership functions whereas Sugeno FIS has no output membership functions. Mamdani FIS is less versatile in system style as compared to Sugeno FIS because the latter are often integrated with ANFIS tool to optimize the outputs.

III. APPLICATION OF FUZZY LOGIC

Fuzzy sets and FL are the foundations for fuzzy mathematics, which is an extension of traditional mathematics. FL may be a broad concept. Besides Mathematics, it's been employed in several fields. This paper states some areas where FL has been applied with success besides the attainable application. Description of a number of them is as follows:

A. Aircraft Control [6]

As mentioned by Jia Luo and Edward Lan in their analysis the utilization of FL proportional-integral-differential (PID) controllers are developed to perform both stability augmentation and automatic control functions. Control systems of high-performance aircraft typically accommodate 2 subsystems, one being the stability augmentation system (SAS) and also the other being the automatic flight control system (AFCS). The previous is to supply AN craft with each statically and dynamically stable behaviours. The latter is specially designed to avoid AN gratuitous or dangerously high workload and to hold out all basic piloting functions. Agility is another vital contributor to success within the modern air combat arena. The study declared that a very strong system will be developed for craft navigation with the implementation of an FL controller.

B. Business [8]

Traditional modelling techniques don't capture the character of advanced systems; particularly once humans are concerned. FL provides effective tools for handling such systems. Emphasis is on applications conferred just in case studies together with Time foretelling for Project Management, New Product evaluation, shopper monetary Risk Tolerance Policy, Deviation and Potential drawback Analysis, internal control Model, stock exchange Strategy.

C. Automotive [7]

Although PID type controller will do basic stuff for FL beneath the system the most downside of using PID instead on the FL controller is that the presence of powerful disturbance, the time-varying parameter of the process, and therefore the presence of dead times. The important potential of FL in industrial automation lies within the easy means FL renders the possible design of multivariable controllers. In several applications, keeping one method variable constant will rather be done employing a PID or bang-bang type controller. However, set values for these individual control loops are typically still set manually by operators. The operators analyze the method condition and tune the set values of the PID controllers to optimize the operation. This is often known as "supervisory control" and have multiple variables.

D. Computer Science

A lot of refined sensible example is that the use of FL in superior error correction to enhance data reception over a limited-bandwidth communication link tormented by data-corrupting noise using turbo codes. The front-end of a decoder produces a unit for the element meant by the sender (0 or 1) for each bit inside the data stream. The probability measures value might use a scale of 256 values between extremes of "certainly 0" and "certainly 1". Two decoders might analyze the information in parallel, incoming at completely different probability results for the values meant by the sender. Every value then uses as further knowledge for the other's probability results and repeats the method to enhance the results until an agreement is reached on the foremost seemingly values.

E. Robotics [9]

The management provided by FL is each sleek and correct. The movement of a simulated mobile robot is being controlled by an FL control. The projected design consists of many rulesets. Every ruleset focuses on some control task, for instance, there are rulesets for going around an obstacle, avoiding a moving obstacle, looking at a door, etc. The multiple ruleset fuzzy system is employed to guide the simulated mobile robot to a given goal in unknown surroundings. With the projected multiple ruleset design complicated control issues may be resolved whereas single rulesets remain easy and economical with the assistance of FL management.

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F. Electronics [10]

To emphasis, some basic ideas in mathematical logic take into account a simplified example of a thermostat controlling a heater fan. The space temperature detected through a sensing element is input to a controller which outputs a controlled force to regulate the heater fan speed.

A standard thermostat works like an ON/OFF switch. If we tend to set it at 26C then the heater is activated only if the temperature falls below 26C. Once it reaches 28C the heater is turned off. As a result, the required temperature is either too heat or too hot. A fuzzy thermostat works in shades of grey wherever the temperature is treated as a series of overlapping ranges. For instance, 26C is 45% warm and 65% hot.

The controller is programmed with straightforward if-then rules that tell the heater fan how briskly to run. As a result, once the temperature changes the fan speed can continuously go with to keep the temperature at the required level. This is an instance of a scenario within which FL can be applied to mimic human thinking.

G. Finance [8]

IBM's Watson is one amongst the foremost well-known AI systems using variations of FL and fuzzy semantics. Specifically, in monetary services, FL is being employed in machine learning and technology systems supporting outputs of investment intelligence. In some advanced commerce models, integration of FL mathematics can even be wont to facilitate analysts produce machine-driven purchase and sell signals. These systems facilitate investors to react to a broad range of adjusting market variables that affect their investments

H. Industrial Sector [10],[7],[11]

Mamdani-type fuzzy reasoning methodology was wont to style a controller whose task was to help the decision-making method. Fuzzy interference system regenerates a variety of qualitative options into quantitative variables, that enabled hard deviations and their comparison. Moreover, a simulation model of a distinct manufacturing system with an enforced fuzzy controller was developed

I. Securities [13],[15]

A single malicious encroachment into a network will cause a catastrophic deal of harm to a company. PC Security considerations the protection of data and property from misuse by unauthorized folks. PC forensics provides strategies for the preservation, collection, validation, identification, analysis, interpretation, documentation and presentation of digital proof derived from digital sources for violation of law and policies or to commit criminal activities. FL will properly be used to facilitate take care of problems related to PC security and PC forensics.

J. Marine [12],[7]

Safety models using FL approaches employing fuzzy IF-THEN rules will model the qualitative aspects of human data and reasoning processes while not using precise quantitative analyses. Fuzzy-logic-based approaches could also be additional appropriately wont to do risk analysis within the initial style stages of enormous marine engineering systems.

K. Medical [13],[14]

Tuberculosis- A fuzzy rule-based system is designed to function decision support for infectious disease designation. This method is meant to observe a category of infectious disease and these fuzzy rules are updated using rule mining techniques. Supported this methodology that generates categories of infectious disease suits the requirements of pneumonic physicians and reduces the time consumed in generating diagnosis.

A decision network for diagnosis TB has been developed. FL for diagnosing provides an efficient way of assisting inexperienced physicians to hit the ultimate diagnosis of TB more quickly and with efficiency.

L. Pattern Recognition and Classification [13],[16]

Braintech has used a unique approach to develop pattern recognition software system referred to as Odyssey, like together with neural networks and FL. By incorporating each of those approaches into its video-recognition system (VRS), Braintech INC has developed a PC-based system for extracting meaning and recognizing objects in an exceedingly stream of video knowledge.

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IV. MERITS OF FUZZY LOGIC SYSTEM

A. The structure of FL Systems is straightforward and comprehendible
B. Fuzzy logic is widely used for business and sensible functions
C. It helps you to regulate machines and client merchandise
D. It might not provide correct reasoning, however the sole acceptable reasoning
E. It helps you to cope with the uncertainty in engineering
F. Mostly robust as no precise inputs needed
G. It may be programmed to within the scenario once the feedback detector stops operating
H. It can simply be changed to boost or alter system performance
I. inexpensive sensors may be used that helps you to keep the general system price and complexness low
J. It provides the simplest resolution to complicated problems

V. DEMERITS OF FUZZY LOGIC SYSTEM

A. Fuzzy logic isn't invariably correct, therefore the results area unit perceived supported assumption, thus it should not be widely accepted.
B. Fuzzy systems do not have the potential of machine learning as-well-as neural network sort pattern recognition
C. Validation and Verification of a fuzzy knowledge-based system wants in-depth testing with hardware
D. Setting precise, fuzzy rules and, membership functions could be a troublesome task
E. Some fuzzy time logic is confused with applied math and therefore the terms

VI. CONCLUSION

To handle inexactitude and uncertainty, we've got at our disposal FL. FL introduces partial truth values, between true and false. As per Aristotelian logic, for a given proposition or state we tend to solely have 2 logical values: true-false, black-white, 1-0. In real-world, things aren't either black or white, however, most of the times are grey. Thus, in several sensible things, it's convenient to contemplate intermediate logical values. the basic nature of fuzzy-set mathematics permits efficient computation, that has promoted the recognition of fuzzy-logic systems in consumer electronics over the last decade. this kind of process permits the system to adapt and respond in period for several forms of applications. supported this study, future developments of fuzzy control and watching technologies in numerous filed is forecast. This paper presents a summary of symbolic logic and its applications in several fields, few are lined and additional are there nonetheless to be discovered, this paper presents simply a glimpse on symbolic logic and its applications.

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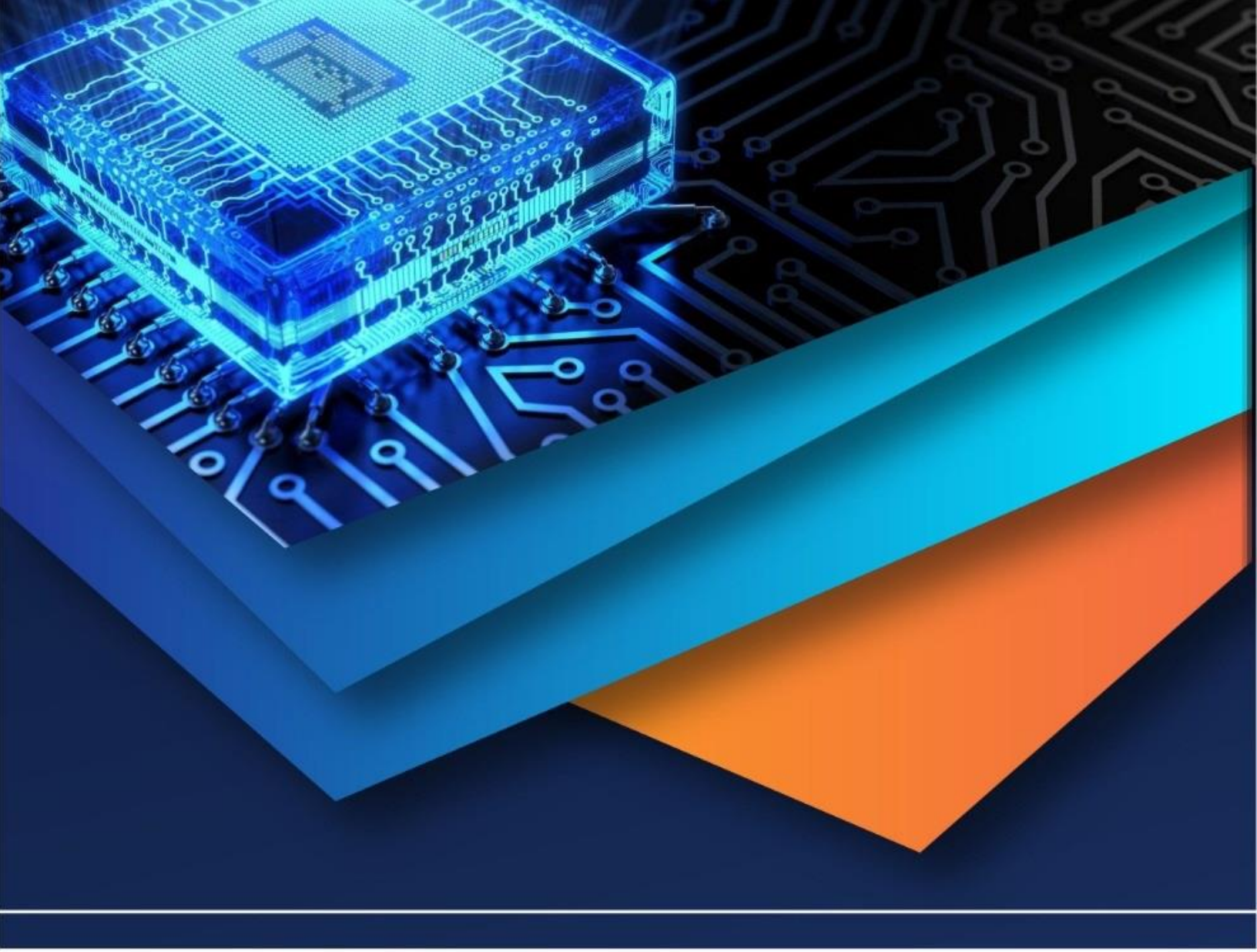

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