Design of Mamdani - Type Model for Predicting the Future Price of Fuel on the Basis of Demand and Supply

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Abstract**—** This paper presents the design of fuzzy inference system for predicting the price of the petroleum product on the basis of demand and supply. As the demand increases and the supply decreases the price of petroleum products also increases. Modeling of efficient price estimation system on the basis of two inputs as demand and supply using Mamdani model is presented in this paper. The inference engines are modeled using the FIS editor of Fuzzy Logic toolbox, a tool of Matlab. Out of various methods available, Center of gravity (CG) defuzzification method is used for obtaining the crisp output. It is proposed to consistently handle all linguistic derivations that allow "IF-THEN" formulation by applying Fuzzy Logic (FL). The parameters for the input variables and output variable and their membership functions works on the range of the values for demand and supply. The results obtained are analyzed to explore the design space.

Keywords**—** *Fuzzy Inference System, linguistic variables, membership functions, Mamdani-type,Matlab.*

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I. INTRODUCTION

Fuzzy logic is a derivative from classical Boolean logic and implements soft .linguistic variables on a continuous range of truth values to be defined between conventional binary. It can often be considered a suspect of conventional set theory. Since fuzzy logic handles approximate information in a systematic way, it is ideal for controlling non-linear systems and for modeling complex systems where an inexact model exists or systems where ambiguity or vagueness is common.

Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. [3].

In classical set theory, a subset U of asset S can be defined as a mapping from the elements of S to the elements the subset [0, 1], U: S → {0, 1}

The mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of S. The first element of the ordered pair is an element of the set S, and the second element is an element of the set (0, l). Value zero is used to represent non-membership, and the value one is used to represent complete membership. The truth or falsity of the statement. The 'X is in U' is determined by finding the ordered pair whose first element is X. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

There are several applications of fuzzy logic; some of them are given below [2] an alternative design methodology, which is simpler and faster. It reduces the design development cycle. It simplifies design complexity. A better alternative solution to non-linear control.

It improves control performance. It is simple to implement.

It reduces hardware cost.

Structure of Fuzzy Rules

Examine fever on the basis of body temperature:

Conventional model:

if temperature > X, take paracetamol

Else, stop taking paracetamol

Fuzzy System:-

if temperature = hot, take paracetamol of high mg

if temperature = warm, take paracetamol of low mg

if temperature = normal, stop taking paracetamol

In fuzzy rules, the linguistic variable temperature also has the range (the universe of discourse) between 99 and 105, but this range includes fuzzy sets, such as hot, warm and normal. The universe of discourse of the linguistic variable take paracetamol can be between 150 and 500 mg and may include such fuzzy sets as high, low and stop. A fuzzy rule can be defined as a conditional statement in the form:

IF x is A

THEN y is B

Where x and y are linguistic variables; and A and B are linguistic values determined by fuzzy sets on the universe of discourses X and Y, respectively.

A primary reason for our research on this paper is that fuzzy control is a methodology that transforms control rules into a precise control strategy. There exist quite a few strategies for

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this transformation hence there arises a need to study the different methodologies as done by [6].

A typical fuzzy system consists of a rule base, membership functions and an inference procedure [5]. Fuzzy logic is a super set of conventional Boolean logic that has been extended to handle the concept of partial truth-truth-values between "completely true" and "completely false".

Fuzzy systems have been in a wide variety of applications in engineering, science, business, medicine, psychology, and other fields [4]. Mamdani is given by Ebrahim Mamdani 1n 1975 [1].

Fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision. Because of its multidisciplinary nature, fuzzy inference systems are associated with a number of names, such as fuzzy-rule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and simply (and ambiguously) fuzzy systems.

The fuzzy inference engine is the heart of the controller. It consists of the rule-base. The rules are constructed using fuzzy IF-THEN-ELSE constructs. Conditional, unconditional and simple assignment types of rules have been reported [1]. The rules can have conjunctive or disjunctive set of premises. Basically two types of inference engines exist; Mamdani type and Sugeno type. These two types of inference systems vary somewhat in the way outputs are determined. Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology. In Mamdani inference engine, after the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. It's possible, and in many cases much more efficient, to use a single spike as the output membership functions rather than a distributed fuzzy set. This is sometimes known as a *singleton* output membership function, and it can be thought of as a pre-defuzzified fuzzy set. It enhances the efficiency of the defuzzification process because it greatly simplifies the computation required by the more general Mamdani method, which finds the centroid of a two-dimensional function. Rather than integrating across the two-dimensional function to find the centroid, using the weighted average of a few data points. Mamdani-type systems support this type of model. In general, mamdani-type systems can be used to model any inference system in which the output membership functions are either linear or constant [10][11].

Fuzzy inference system (FIS) is a method, based on the fuzzy theory, which maps the input values to the output values. The mapping mechanism is based on some set of rules, a list of if-then statements. Figure 1 shows the general case of fuzzy inference system. There are five steps in a fuzzy inference system. These steps are fuzzification of the input variables, application of the fuzzy operator (AND or OR), if any, in the antecedent, implication from the antecedent to the consequent, aggregation of the consequent across the rules and defuzzification Mamdani method is widely accepted for capturing expert knowledge. It allows us to describe the expertise in more intuitive, more human-like manner. However, Mamdani-type FIS entails a substantial computational burden.

Fuzzy Inference System modules

1) Fuzzification module: The system inputs, which are crisp numbers, are transformed into fuzzy sets. This is done by applying a fuzzification function.

2) Knowledge base module: Stores IF-THEN rules provided by experts.

3) Inference engine module: Using fuzzy inference on the inputs and IF-THEN rules simulates the human reasoning process.

4) Defuzzification module: The fuzzy set obtained by the inference engine transforms into a crisp value.

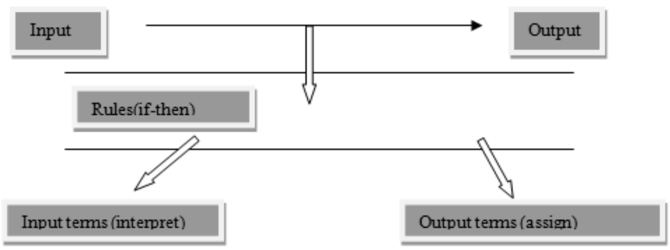

Figure 1. fuzzy inference system

II. PROBLEM STATEMENT

As the economy of India is depends on the price hike of crude oil. India has no good sources of the crude. These sources are not sufficient to fulfill the demands of the fuel. So import the crude is the only option for fulfilling the demands.

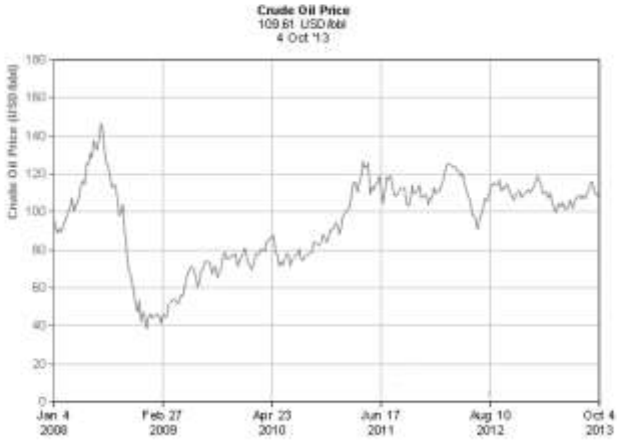

Figure 2. Crude Oil Price Charts[8]

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As the chart is clearly showing the prices of the crude are increasing with time. But the main concern is that in the fig.2 the demands of petroleum products increasing exponentially.

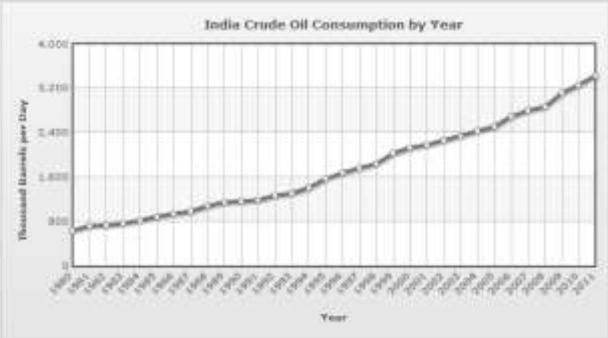

Figure 3. India crude oil consumption by year [9]

As the demands increasing exponentially and the price of crude also increasing in every year. So only solution remains to increases the price of petroleum products in the retail market.

III. DESIGN AND METHODOLOGY

It is an attempt to design a mamdani –type fuzzy inference system which can predict the future price of the fuel which causes the changes in the inflation. Mamdani fuzzy inference system designed using the Matlab Fuzzy Toolbox[7].

Fuzzy Inference System Tools for predicting the future price of fuel can be used five GUI tools for building, editing and observing fuzzy inference systems.

1 .fuzzy inference system editor

2 .Membership function editor

3. Rule editor

4 .Rule viewer

5. Surface viewer

1. Fuzzy Inference System Editor

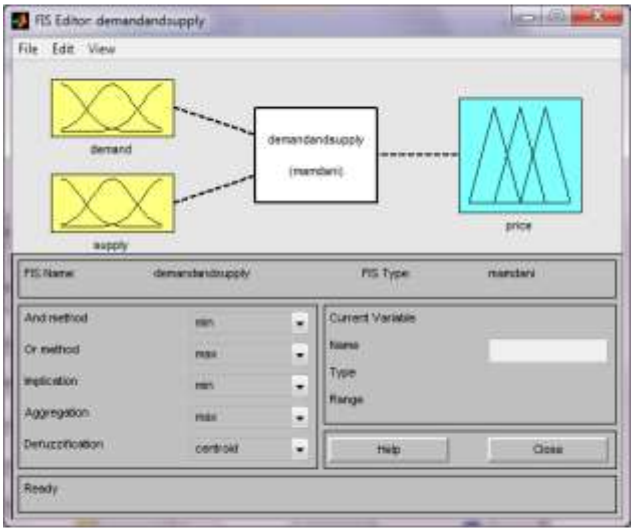

Figure 4. FIS editor window

There are two input variables and one output variable in the FIS editor window. the first input variable is demand and the range of demand varies from 0 to 10 where 0 indicates very low demand of fuel and 10 indicates a very high demands of fuel.

In the same case second input variable is supply and the range of supply varies from 0 to 10 where 0 indicates very low supply of fuel and 10 indicates a very high supply of fuel.

2 .Membership function editor

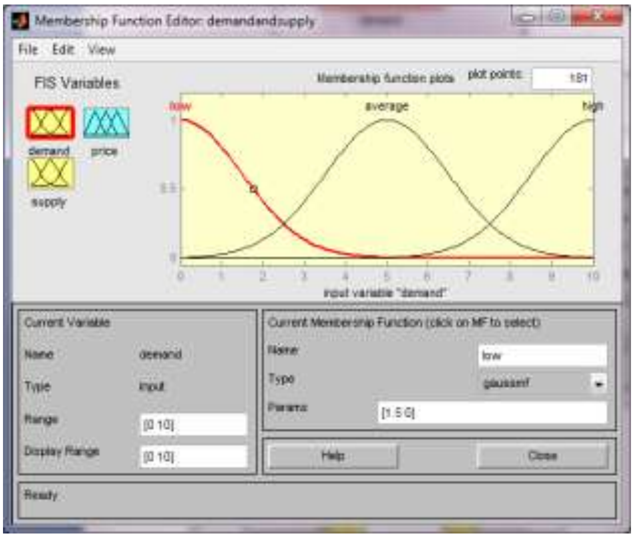

Figure 5. The membership function editor for demand

In this window there are three membership functions for demand namely low, average and high. The type of membership function is gaussmf. The range is 0 to 10 and parameters for low, average and high membership function are [1.5 0],[1.5 5] and[1.5 10].

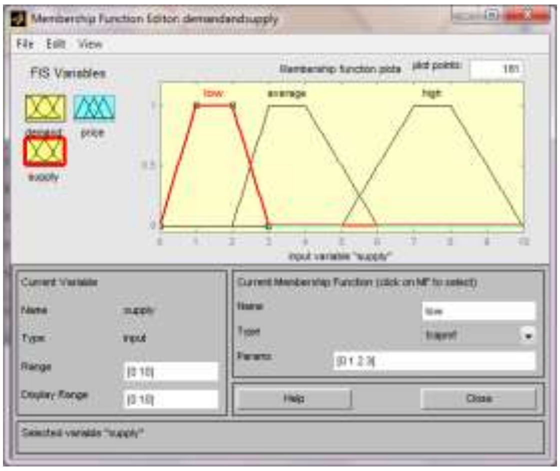

Figure 6. The membership function editor for supply

In this window there are three membership functions for supply namely low, average and high. the type of membership function is trapmf. The range is 0 to 10 and parameters for low, average and high membership function are [0 1 2 3],[2 3 4 6] and[5 7 8 10].

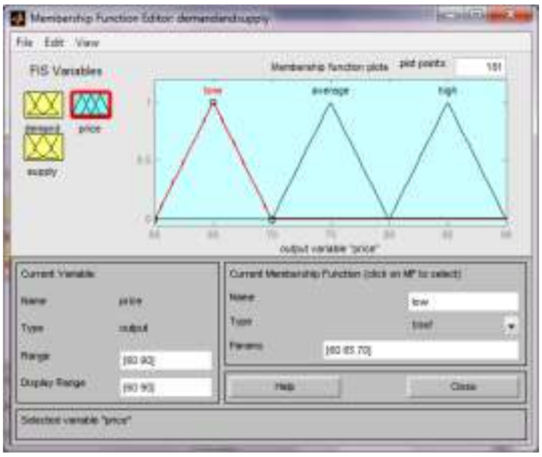

Figure 7. The membership function editor for price

The last membership window in membership editor is price window and it is output type window. In this window there are three membership functions for price namely low, average and high. the type of membership function is trimf. The price varies from 60 to 90 rupees and parameters for low, average and high membership function are [60 65 70],[70 75 80] and[80 85 90].

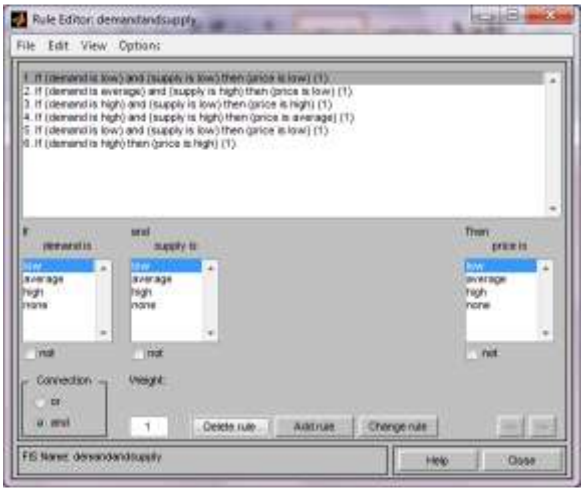

Figure 8. The rule editor window

1. If (demand is low) and (supply is low) then (price is low)

2. If (demand is average) and (supply is high) then (price is low)

3. If (demand is high) and (supply is low) then (price high)

4. If (demand is high) and (supply is high) then (price is average)

5. If (demand is high) then (price is high)

In this window number of rules decides the future price of the fuel on the basis of demand and supply.

The final decision making comes in the focus in rules viewer window which gives the results.

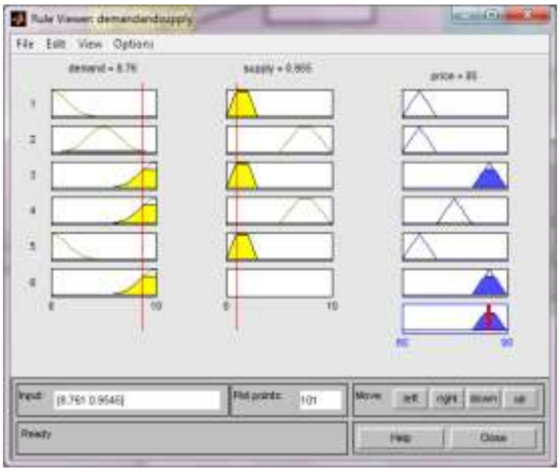

Figure 9. Rrule viewer window for demand and supply

Here the values given that when the demand is on the 8.78 scale means high and the supply on 0.955 scale means very low the price of fuel decided by the system is rupees 85.

So it much accurate result. Its also give satisfied results by changing the scales or range of inputs.

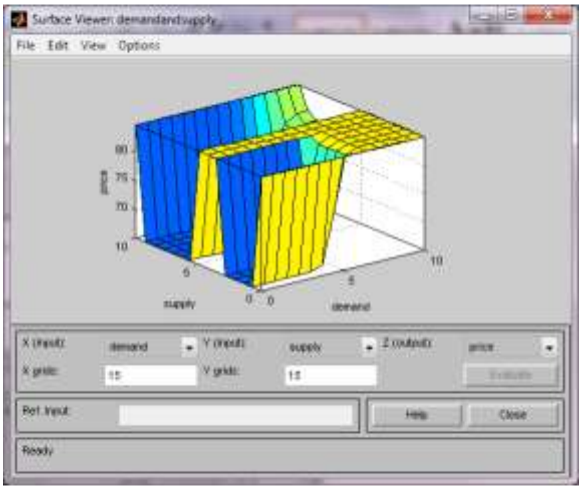

Figure 10. Surface viewer for Mamdani demand supply

In the surface viewer all the rules predicting the more precise results. So it is the basic reason for using fuzzy logic because it gives precise results on the changing scenario.

IV. CONCLUSION

In this paper, an attempt is made to explore the design space for implementation of Mamdani- type fuzzy rule-based inference system. It is observed that the relationship between demand and supply of the petroleum products can affect the retail price of the fuel. As the demand increases and supply decreases the retail price of fuel also increases. System uses the human intelligence and gives the results on the basis of the rules. The accuracy of the result may be considerable. It is predicting the more accurate results. Price hike totally depends on the high demand and low supply.

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