Designing and Analysis the effects of communication delay on flight control system by using Fuzzy Logic

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Abstract: The main work of this research is structuring and analysis the effects of delay in communication and noise on flight control framework. In this research paper, communication model is designed in Simulink, this model is made by joining the four models i.e. Shared access communication model, Aircraft dynamics model, Actuator model and Wind model. Through this model effects of noise are shown in the results and then these results are analyzed by fuzzy logic toolbox.

Index Terms- *simulink; fuzzy logic; delay; noise; communication*

I. INTRODUCTION

Simulink (Simulation and connection) is created by MathWorks as an added with MATLAB. It is a graphical programming language that offers demonstrating, recreation and breaking down of multi space dynamic frameworks under Graphical User Interface (GUI) condition. The Simulink have tight combination with the MATLAB condition and have an exhaustive square libraries and tool compartments for straight and nonlinear investigations. The framework models can be so effectively built by means of simply drag activities. The Simulink comes convenient while managing control hypothesis and model based plan. [1]

In this research work model is created by using Simulink in matlab. Results or scopes of this model show the different types of effects of communication delay in flight. Then these results are again analyzed by fuzzy logic toolbox in Matlab. The fuzzy logic is defined below:-

The term fuzzy defined as those types of things which are not clear or are indistinct. In reality many of the times we meet that type of condition when we also can't decide whether the state is true or the state is false, their fuzzy logic gives a very precious adaptability for thinking. Thus, in this way, we can think about the mistakes and vulnerabilities of any circumstance. [2]

In boolean system truth value, 1.0 shows that the value is absolute and truth and 0.0 shows that the value is absolute and false. But in the system i.e. fuzzy in nature, there is no logic for value i.e. absolute truth and absolute false. But in system i.e. fuzzy logic, there is intermediary value i.e. present in both, partially true and partially false. [2]

The Fuzzy Logic device was presented in 1965, likewise by Lotfi Zadeh, and is a scientific device for managing vulnerability. It offers to a delicate registering organization the imperative idea of registering with words'. It gives a system to manage imprecision and data granularity. The fuzzy hypothesis gives an instrument to speaking to semantic builds, for example, "some," "low," "medium," "regularly," "few." as a rule, the fluffy rationale gives an induction structure that empowers fitting human thinking abilities. Despite what might be expected, the customary parallel set hypothesis portrays fresh occasions, occasions that either do or don't happen. It utilizes likelihood hypothesis to clarify if an occasion will happen, estimating the opportunity with which a given occasion is normal to happen. The hypothesis of fluffy rationale depends on the idea of relative evaluated enrollment as are the elements of mentation and intellectual procedures. The utility of fuzzy sets lies in their capacity to demonstrate dubious or questionable information, Figure 1, so frequently experienced, all things considered. It is critical to see that there is a close association between Fuzziness and Complexity. As the unpredictability of an errand (issue), or of a framework for playing out that task, surpasses a specific limit, the framework must essentially turned out to be fuzzy in nature.

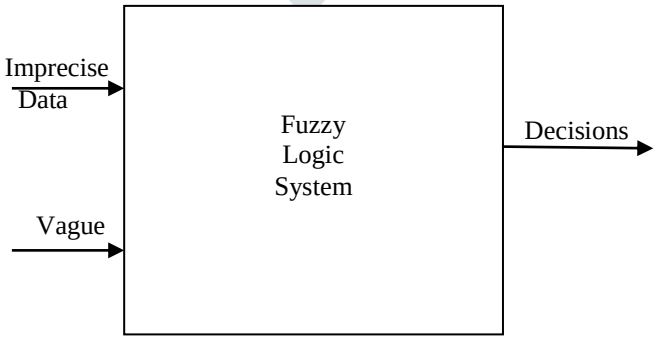

Fig.1 Fuzzy Logic System.

II. DESIGN OF MODEL

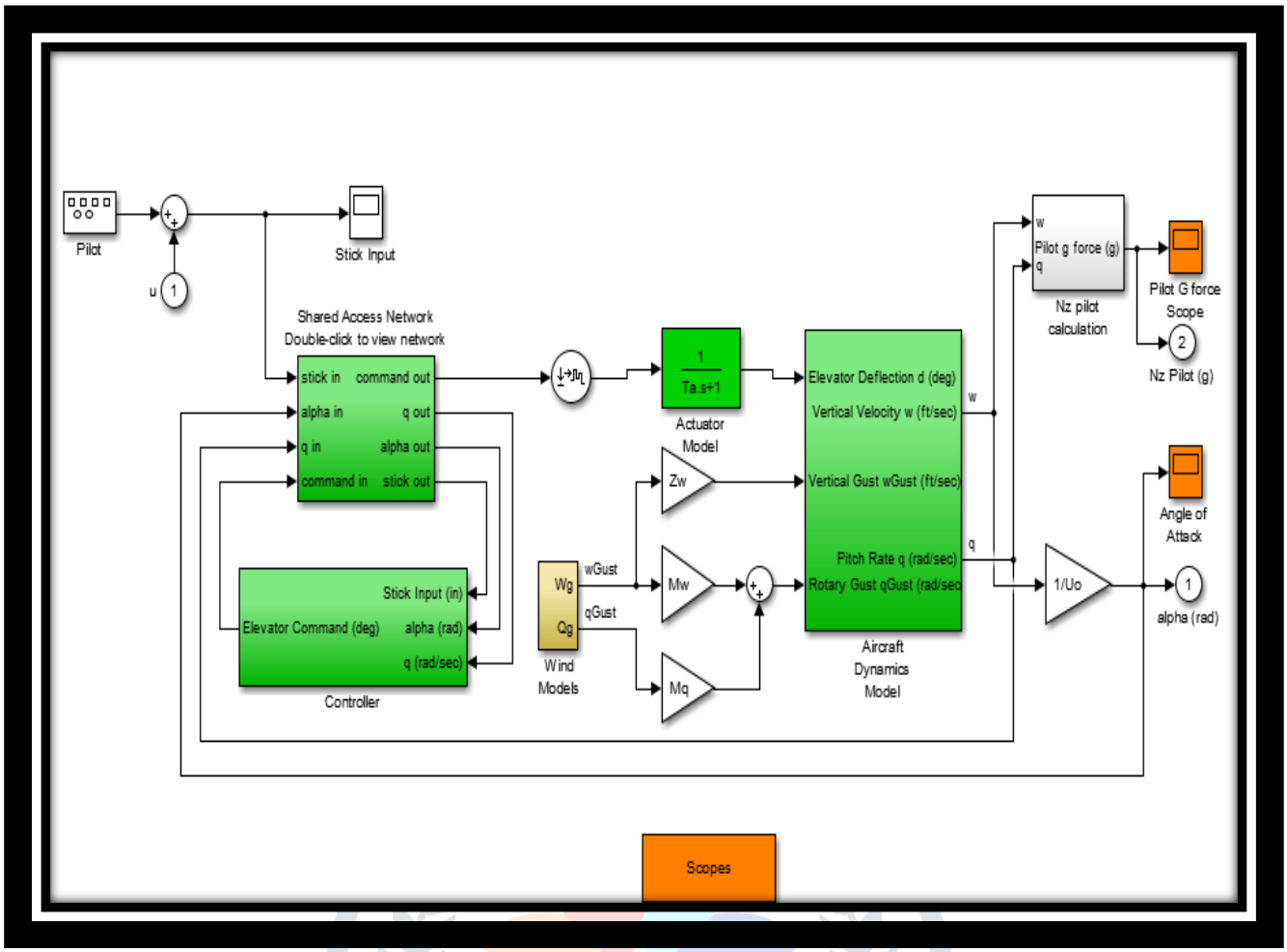

Fig.2 Design of model of Effects of communication delay and noise in flight control system.

2.1Pilot

Designing and performing sets of handling qualities can be done using simulation model of a pilot at an early stage of the project. [3]

2.2Shared Access Communication Model Subsystem

In Shared access communication model, transmitters can transmit data through multiple access media to receiver.

2.3Controller Subsystem

Controller is a hardware device and software program that manages or directs the flow of data between two entities. [3]

2.4 Wind Model Subsystem

In Wind model, noise will be used to find the output port of model.

2.5 Actuator Model Subsystem

In Actuator model, transfer function is made in which numerator and denominator will be used to find the output.

2.6 Aircraft Dynamics Model Subsystem

Aircraft is presented as a rigid body with six-degree-of-freedom, three translations and three rotations. Six variables describing translation of the aircraft are velocity, angle of attack, sideslip angle and three center of gravity coordinates.

2.7 Gain

In this model, the block of gain is used to multiply the inputs by constant or gain block multiplies the input by constant value. Gain
may be element wise gain or matrix gain.

2.8 Input and Output ports

Input and output ports are created for subsystem or for any external input. Input ports are defined as the links which are from outside a system into the system. Output port is created for subsystem or for any external output. Output port blocks are described as the links or connections from system to a destination outside the system.

2.9 Outputs or Scopes

A. Pilot G force scope:-

Here, G force is defined as the gravitational force of pilot. It is known as may be force of gravity or force of acceleration.

B. Angle of attack:-

Angle of attack in flight is defined as the angle which is present in between the wing chord and the flight path.

C. No. of incoming signals in buffer:-

Numbers of incoming inputs or packets are defined as how many numbers of packets or inputs are present in buffer queue for processing the execution.

D. Average wait time:-

Average wait time in buffer queue which means the difference between the completion time and arrival time or Total time the process has to wait before its execution.

E. Utilization:-

Utilization means use of something. Utilization in flight is defined as the function of a no. of elements, including design features and also characterstics of flight.

F. No. of dropped packets:-

Numbers of dropped packets are defined or measured as a percentage of packets lost with respect to packets sent.

III. RESULTS

Results of the model of effects of communication delay and noise are shown in the below graphs i.e. pilot g force, angle of attack, no. of incoming signals in buffer, avg. wait time, utilization and no. of dropped packets

Table 1. Values of inputs and values of best outputs.

Numerator (Input)	Denominator (Input)	Average arrival rate (Input)	Pilot G force scope (Output)	Angle of attack (Output)	No. of incoming signals in buffer (Output)	Average wait time (Output)	Utilization (Output)	No. of dropped packets (Output)
5-10	10-30	100-300	Min. value is -5, max. value is 5.	Min. value is -0.1, max. value is 0.1.	Min value is 0, max. Value is 0.5.	0	1	0

When values range of numerator is 5-10, value range of denominator is 10-30 and values range of average arrival rate is 100-300 then the best graphs of outputs or scopes i.e. pilot g force, angle of attack, no. of incoming signals in buffer, avg. wait time, utilization and no. of dropped packets are shown below:-

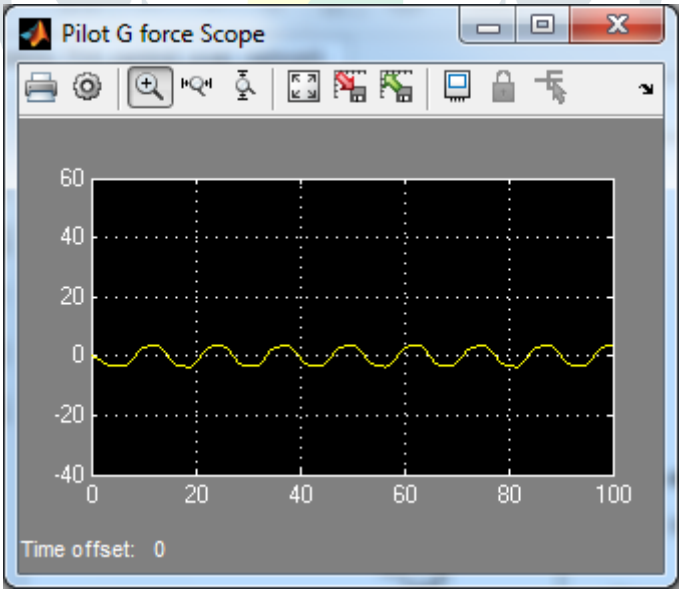

Fig.3 Pilot G force.

In this above graph, value of numerator is 6, value of denominator is 20 and value of average arrival rate is 300. This graph shows the output of pilot G force in which minimum value is -0.5 and maximum value is 0.5.

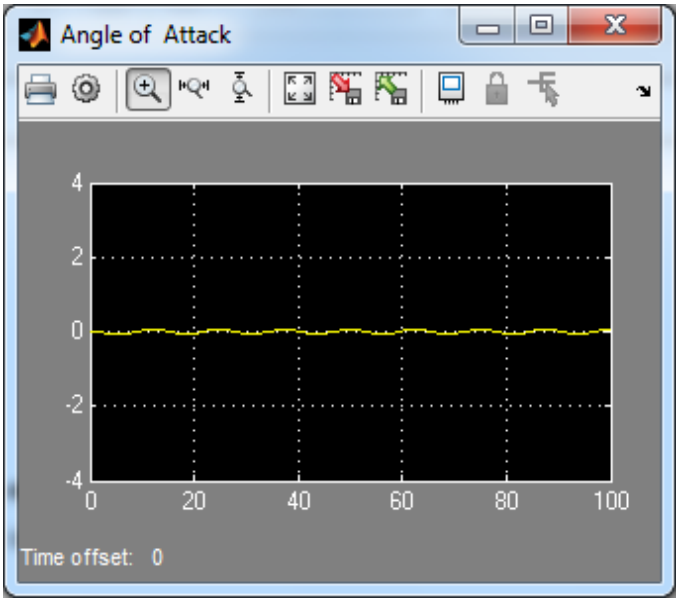

Fig.4 Angle of attack.

In this graph, value of numerator is 6, value of denominator is 20 and value of average arrival rate is 300. This graph shows the output of angle of attack in which minimum value is -0.1 and maximum value is 0.1.

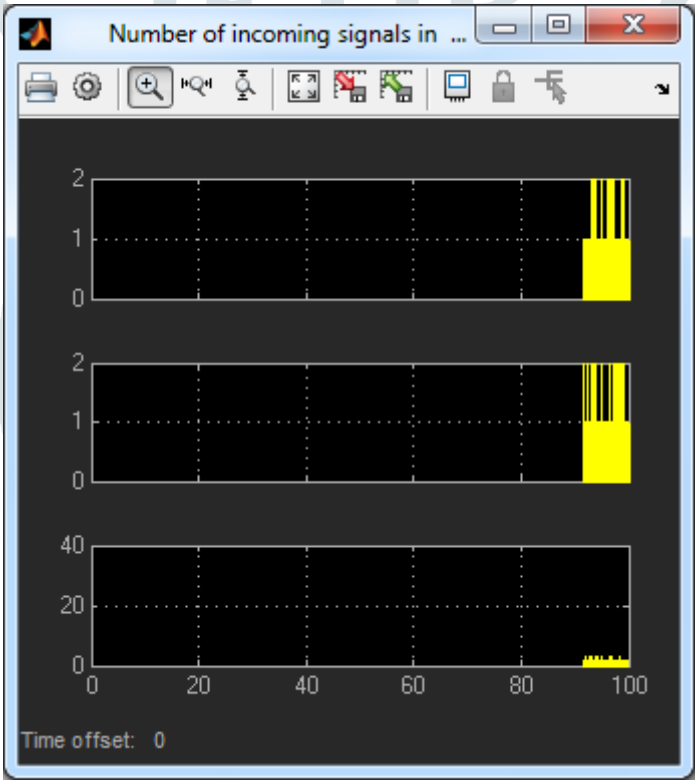

Fig.5 No. of incoming signals in buffer queue.

In this graph, value of numerator is 5, value of denominator is 10 and value of average arrival rate is 100. This graph shows the output of no. of incoming signals or inputs in buffer in which minimum value is 0 and maximum value is 0.5.

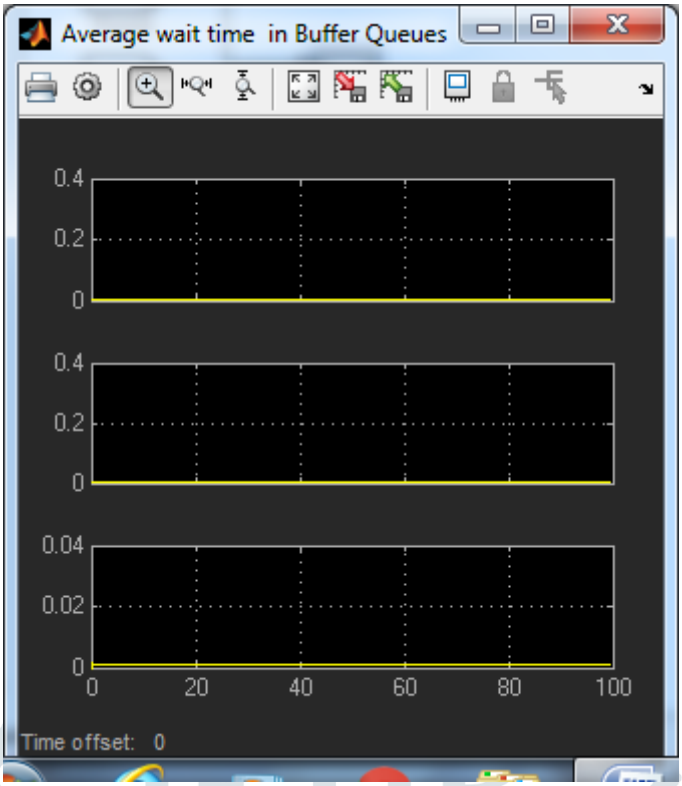

Fig.6 Average wait time in buffer queue.

In this graph, value of numerator is 6, value of denominator is 20 and value of average arrival rate is 300. This graph shows the output of average arrival rate in which value is 0.

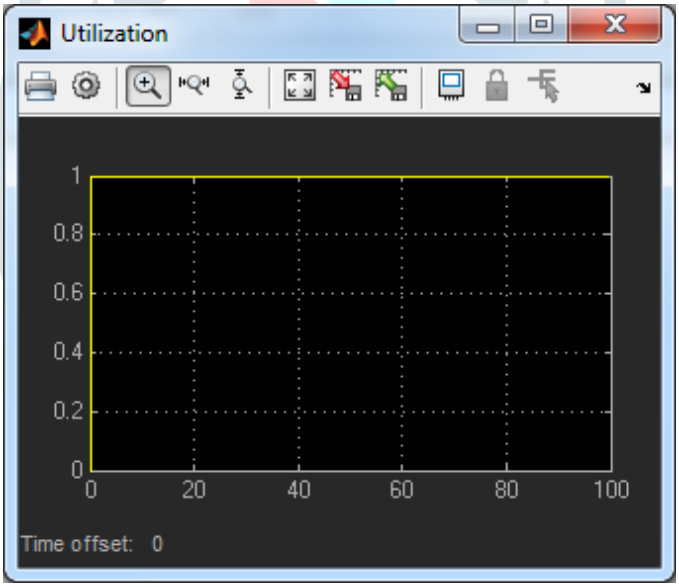

Fig.7 Utilization of incoming signals.

In this graph, value of numerator is 8, value of denominator is 30 and value of average arrival rate is 500. This graph shows the output of utilization in which value is 1 means full utilization.

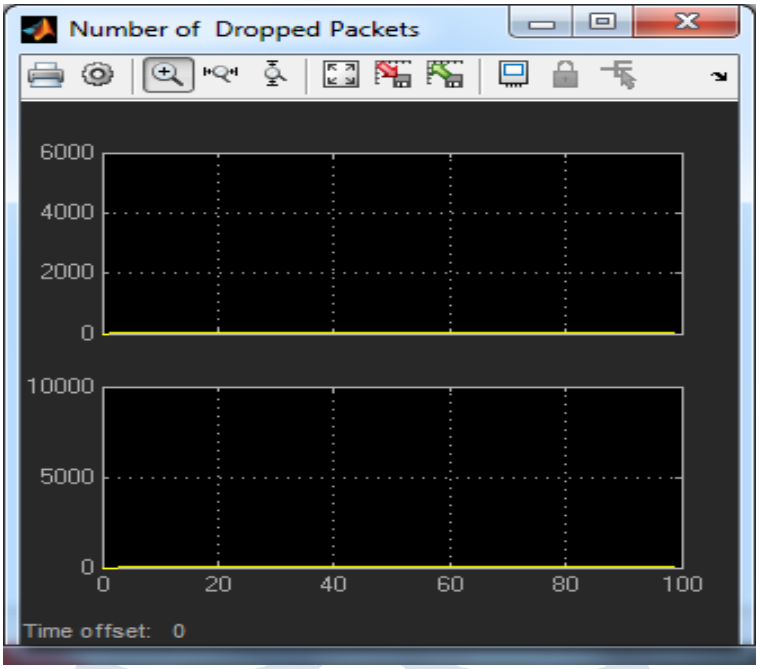

Fig.8 No. of dropped packets.

In this graph, value of numerator is 5, value of denominator is 10 and value of average arrival rate is 300. This graph shows the output of no. of dropped packets in which value is 0.

Now these results are analyzed by fuzzy logic toolbox in Matlab. Therefore results of that analyzed results are shown below:-

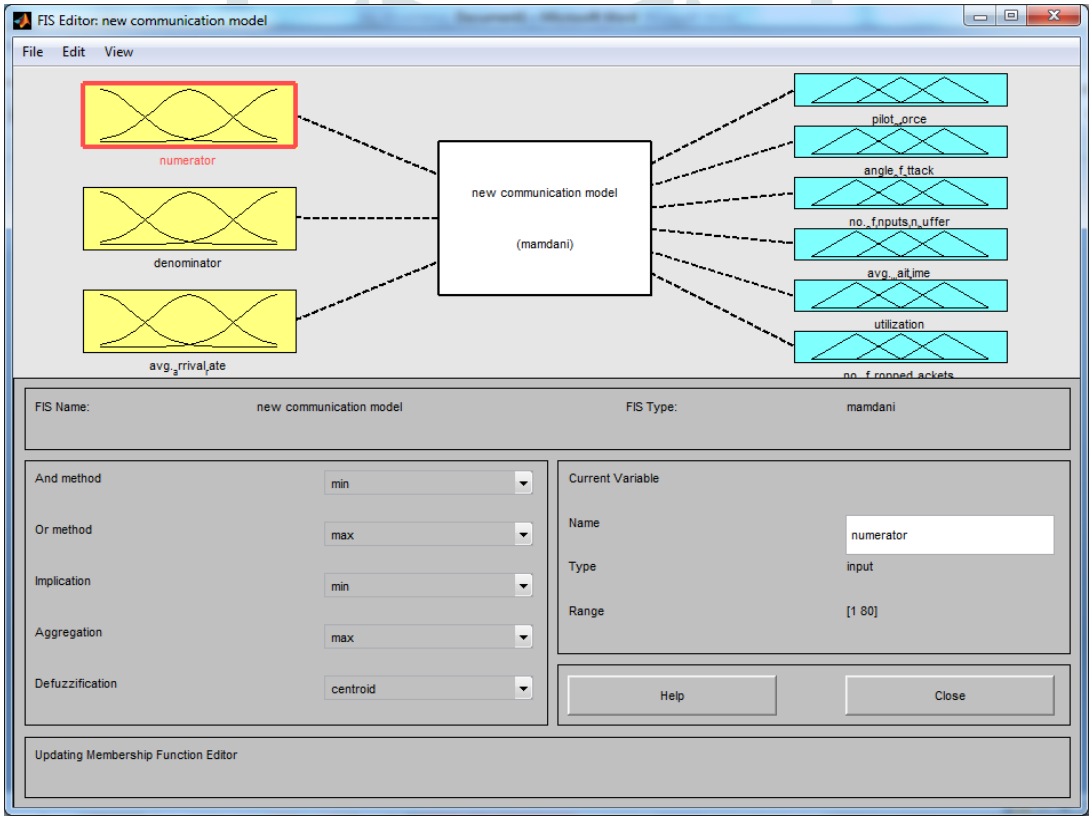

Fig.9 Inputs and Outputs in fuzzy Logic toolbox.

In this figure, inputs and outputs of model are defined in which inputs are numerator, denominator, avg. arrival rate and outputs are pilot g force, angle of attack, no. of incoming signals in buffer, avg. wait time, utilization, no. of dropped packets.

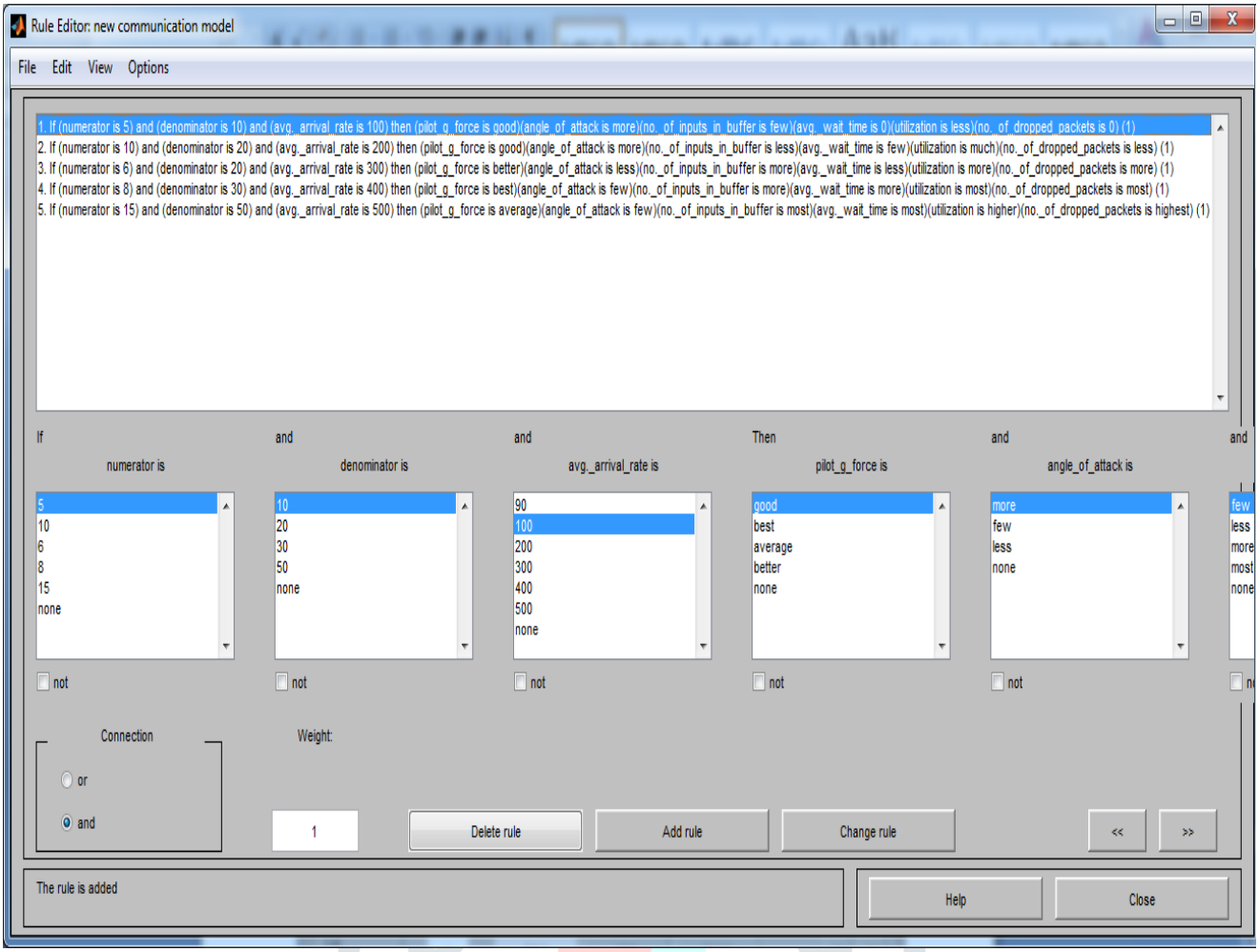

Fig.10 Rules made in fuzzy logic.

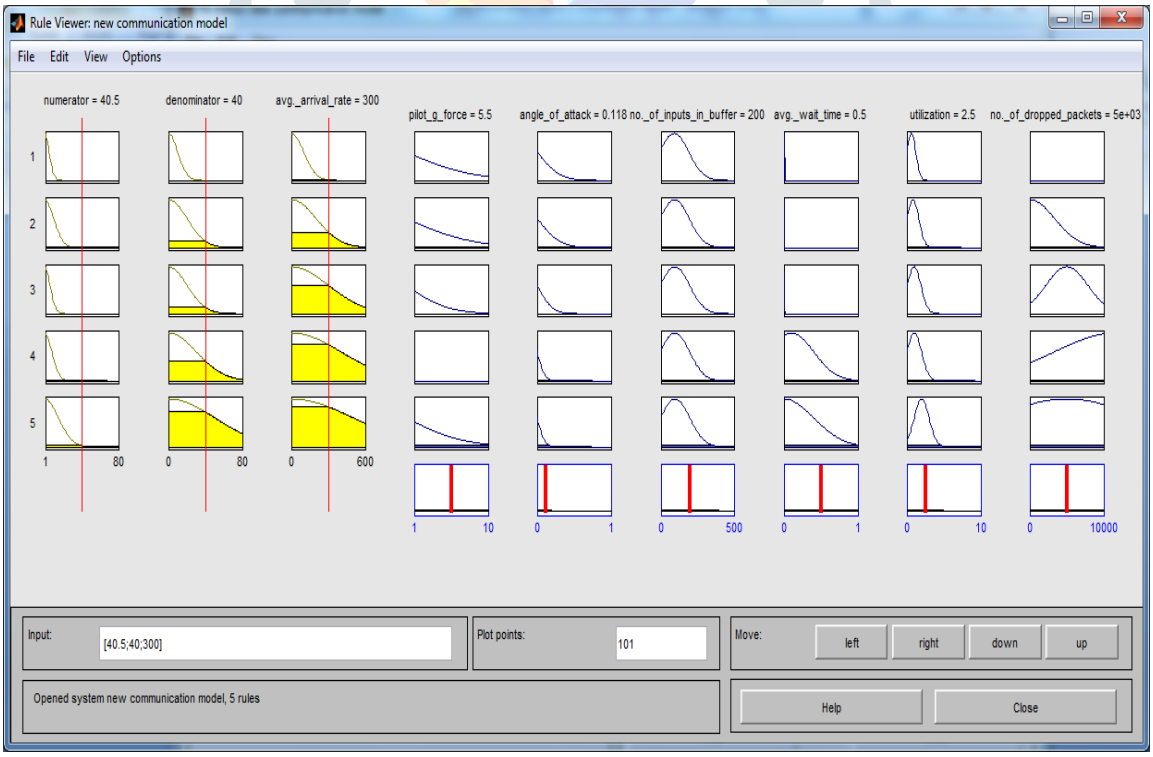

Fig.11 Graphs of rules in fuzzy logic.

In figure 10, five rules are defined i.e. explained below:-.

1. If (numerator is 5) and (denominator is 10) and (avg._arrival_rate is 100) then (pilot_g_force is good)(angle_of_attack is more)(no._of_incoming signals_in_buffer is few)(avg._wait_time is 0)(utilization is less)(no._of_dropped_packets is 0).

2. If (numerator is 10) and (denominator is 20) and (avg._arrival_rate is 200) then (pilot_g_force is good)(angle_of_attack is more)(no._of_incoming signal _in_buffer is less)(avg._wait_time is few)(utilization is much)(no._of_dropped_packets is less).

3. If (numerator is 6) and (denominator is 20) and (avg._arrival_rate is 300) then (pilot_g_force is better)(angle_of_attack is less)(no._of_incoming signals_in_buffer is more)(avg._wait_time is less)(utilization is more)(no._of_dropped_packets is more).

4. If (numerator is 8) and (denominator is 30) and (avg._arrival_rate is 400) then (pilot_g_force is best)(angle_of_attack is few)(no._of_incoming signals_in_buffer is more)(avg._wait_time is more)(utilization is most)(no._of_dropped_packets is most).

5. If (numerator is 15) and (denominator is 50) and (avg._arrival_rate is 500) then (pilot_g_force is average)(angle_of_attack is few)(no._of_incoming signals_in_buffer is most)(avg._wait_time is most)(utilization is higher)(no._of_dropped_packets is highest).

In figure 11, above five rules are shown in graphical representation.

IV. CONCLUSION

Flight control framework development is a difficult and multi-purpose method, through widespread use of simulation. Therefore, this research recommends another or new coordinated or integrated methodology in simulation utilization i.e. utilization of the one model all through complete flight control structure advancement system. Here In this research, designing of one model is shown, which defines the whole method of effect of communication delay of flight control system and also shows the different types of effects of communication delay using simulation. In last we conclude that values of inputs shows the effects on outputs. As the value of numerator and denominator is increasing then the graphs of pilot g force and angle of attack are best i.e. pilot g force is best and angle of attack is few. But as the value of average arrival rate goes on increasing then the graphs of no. of incoming signals, average wait time, utilization and no. of dropped packets are not so much good i.e. no. of incoming signals in buffer becomes more, average wait time becomes more, utilization of signals becomes more and no. of dropped packets is more.

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