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"ANFIS AND FUZZY BASED FAULT NODE DETECTION FOR WIRELESS SENSOR NETWORK"

Simran Soni [1] *, Dr Pramod Sharma* [2]

[1, 2] *Regional College For Education Research And Technology, Jaipur, Rajasthan, India*

Simran038soni@gmail.com

ABSTRACT

Detecting and handling faulty node is one of the main challenges in wireless sensor networks (WSNs). Most of the existing fault detection schemes rely on the data sensed by neighboring nodes; however, these schemes do not usually consider the nature of the events and the coverage issues. In this paper, we present a distributed fuzzy logic-based faulty node detection algorithm for heterogeneous WSNs. To weight of the values sensed by the neighboring nodes, the proposed algorithm applies factors such as distance, coverage and the difference of the sensed values. By using the proposed distributed algorithm, each sensor node can correctly recognize its status at the presence of the events such as free and transient faults. Extensive simulations results indicate the effectiveness of the proposed algorithm in reducing the false positive problems and improving detection accuracy in the fault detection process. the simulation of this proposed system has been done on MATLAB software.

Key Words: *Fuzzy system, ANFIS, WSN,fault node ,sensor node, AntHocNet.*

I. INTRODUCTION

Introduction Despite the open research areas in wireless sensor networks (WSNs), there are already a high number of current problems in which these networks can be applied. Some application fields include tracking, monitoring, surveillance, building automation, military applications, and agriculture, among others. In all cases for the design of any application, one of the main objectives is to keep the WSN alive and functional as long as possible. A key factor in this is the way the network is formed. In fact, the topology is mostly defined based on the application environment and context. The sensor information is usually collected through the available gateways in a given topology. This information is then forwarded to a leader node or to a base station known as sink. WSN has a great application future in the military and civil area. Te fundamental problems of sensor networks are deployment and coverage, localization, and networking protocols [1–3]. Te accuracy of node localization is crucial for many applications of distributed sensor network (DSN) [4–7]. Te current node localization algorithm of WSN is mainly divided into two categories: one is a node location algorithm based on ranging and the other is a no ranging node localization algorithm. Since the distance-based node positioning algorithm requires additional auxiliary facilities, the resource consumption is relatively large. Therefore, it is not suitable for use in large-scale networks. Te no ranging node algorithm does not require additional ancillary facilities while hardware cost is relatively low. Therefore, it becomes a research hotspot in current wireless sensor networks. Our paper is based on the idea of a no ranging node algorithm. A new wireless sensor localization

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algorithm based on irregular node communication is proposed. Te feasibility and effectiveness of the algorithm are verified by simulation experiments. In general, positioning accuracy can be improved by increasing the number of anchor nodes. However, the cost of the anchor node is higher than that of ordinary nodes. If 10% of the nodes are anchor nodes, the price of the network will increase 10 times [8–13]. However, when the unknown node is located, it will no longer need expensive anchor nodes. Therefore, it is necessary to reduce the number of anchor nodes participating in node positioning. If the cost is reduced by reducing the number of anchor nodes, the consequent efect is a reduction in positioning accuracy. Based on the broadcast characteristics of wireless transmission, some methods based on geometric knowledge of interfering node positioning have been proposed, including centroid positioning, weight centroid positioning, iterative positioning of virtual forces, convex shell positioning, and alpha shell positioning. In the centroid localization method (CL, centroid localization), interfering nodes' neighboring nodes are called interfered nodes. Te CL collects the coordinates of all disturbed nodes and uses the average as the estimated position of the interference node. Considering that different interfered nodes have different distances from interfering nodes, their perceived interference intensity is also different. Te researchers proposed the positioning of weight centers of mass, which improved the positioning accuracy to some extent. [14–20] proposed a novel probabilistic graphical model called Bayesian Network based Program Dependence Graph (BNPDG) that has the excellent inference capability across nonadjacent WSN nodes. They focused on applying the BNPDG at indoor node localization. Compared with the PPDG, their BNPDGbased localization approach overcomes the limitation across nonadjacent nodes and provides more precise localization by taking its output nodes as the common conditions to calculate the conditional probability of each non-output node. [21–27] proposed a Heuristic Multidimensional Scaling (HMDS) algorithm to improve accuracy of node localization in anisotropicWSNs with holes. By exploring the virtual node and constructing the shortest paths between nodes, the Euclidean distances between nodes are obtained via employing the heuristic approach such that they can be used to calculate more accurate locations of the nodes. Ajinkya [8, 9] investigated the significance of introducing small world characteristics in a conventional WSN for improving the node localization accuracy. A novel constrained iterative average path length reduction algorithm is proposed to introduce small world characteristics into a conventional WSN. Te method utilizes a novel frequency selective approach for the introduction of small world phenomena.

II. RELATED WORK

In a wireless sensor network (WSNs), probability of node failure rises with increase in number of sensor nodes within the network. The, quality of service (QoS) of WSNs is highly affected by the faulty sensor nodes. If faulty sensor nodes can be detected and reused for network operation, QoS of WSNs can be improved and will be sustainable throughout the monitoring period. The faulty nodes in the deployed WSN are crucial to detect due to its improvisational nature and invisibility of internal running status. Furthermore, most of the traditional fault detection methods in WSNs do not consider the uncertainties that are inherited in the WSN environment during the fault diagnosis period. Resulting traditional fault detection methods suffer from low detection accuracy and poor performance. To address these issues, we propose a fuzzy rule-based faulty node classification and management scheme for WSNs that can detect and reuse faulty sensor nodes according to their fault status. In order to overcome uncertainties that are inherited in the WSN environment, a fuzzy logic based method is utilized. Fuzzy interface engine categorizes different nodes according to the chosen membership function and the defuzzifier generates a non-fuzzy control to retrieve the various types of nodes. In addition, we employed a routing scheme that reuses the retrieved faulty nodes during the data routing process. We performed extensive experiments on the proposed scheme using various network scenarios. The experimental results are compared with the existing algorithms to demonstrate the effectiveness of the proposed algorithm in terms of various important performance metrics.

Aishwarya Karmarkar (2020) et.al Wireless Sensor Networks have recently been used to handle a variety of real-world issues, including environmental monitoring, home automation, and medical monitoring. Due to hardware problems, software failures, and energy exhaustion, small sensor nodes are vulnerable to failure in such systems. Erroneous measurements are produced by faulty sensor nodes, which might impair WSN performance. As a result, one of the most

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crucial concerns in WSNs is defect diagnosis and detection. This research provides a defect diagnostic approach for wireless sensor networks using an optimised Support-Vector Machine (SVM). To detect the failure condition of the deployed sensor nodes, the suggested technique uses a Grey Wolf Optimization (GWO) based SVM classifier. Furthermore, an energy-saving cluster-based topology is proposed. We do a large number of simulations on the suggested fault detection approach in various network configurations. The simulation results are compared to current systems in order to validate the proposed fault detection method's effectiveness under various performance criteria.

Rakesh Ranjan Swain (2017) et.al the use of a particle swarm optimization (PSO) based classification approach is used to provide a real-time soft fault detection model for wireless sensor networks (WSNs). To diagnose composite defects (a combination of soft permanent, intermittent, and transient faults) in the sensor network, the suggested model divides the process into three phases: initialization, fault identification, and fault categorization. Analysis of variance (ANOVA) is used to identify the problematic nodes in the network. The defective node categorization is done using the feed forward neural network (FFNN) approach and the PSO learning method. The testbed experiment is conducted in an indoor laboratory environment to evaluate our concept

.III. PROPOSED APPROACH

In this thesis proposed a fuzzy rule-based faulty node classification and management scheme for WSNs that can detect and reuse faulty sensor nodes according to their fault status. In order to overcome uncertainties that are inherited in the WSN environment, a fuzzy logic based method is utilized. Fuzzy interface engine categorizes different nodes according to the chosen membership function and the defuzzifier generates a non-fuzzy control to retrieve the various types of nodes. In addition, we employed a routing scheme that reuses the retrieved faulty nodes during the data routing process.

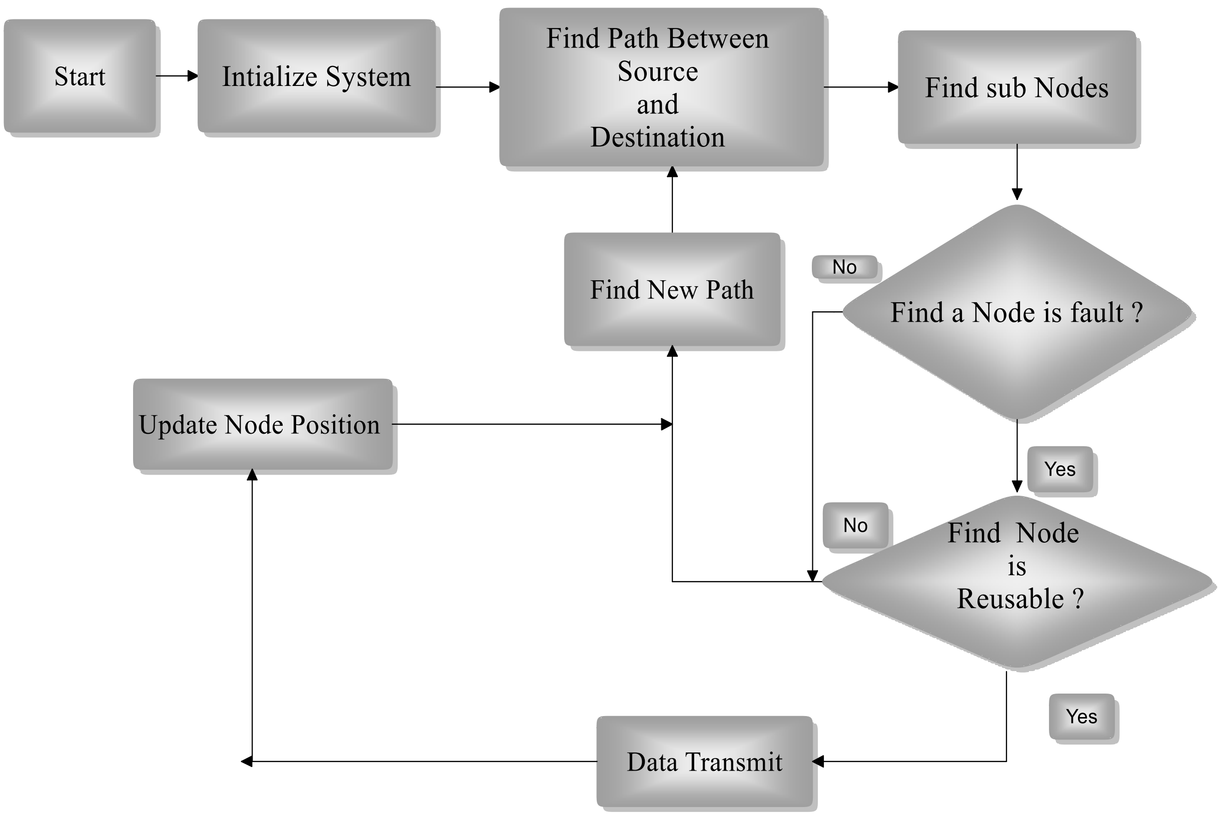

Fig 1 Proposed flow diagram

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For the routing protocol AntHocNet algorithm is used this is a hybrid multipath algorithm, designed along the principles of ACO routing. It consists of both reactive and proactive components. We performed extensive experiments on the proposed scheme for various network scenarios. The experimental results are compared with the existing algorithms to demonstrate the effectiveness of the proposed algorithm in terms of various important performance metrics. in this simulation assume our sensor network model as follows: (i) Deployed 271 sensor nodes are static; once sensor nodes are deployed, they must 272 work unattended

In this work, the sensor node's hardware status is evaluated by fuzzy logic rules. Three input FIS for faulty node detection is displayed in Fig. 1. Fuzzy logic system has four parts namely fuzzifier, FIS, fuzzy rule base and defuzzifier. Battery, transmitter and receiver conditions of each sensor nodes are given as the inputs for FIS. The output of FIS shows the condition of individual sensor nodes. The output of FIS may be a normal node, end node or dead node.

AntHocNet

AntHocNet is a hybrid multipath algorithm, designed along the principles of ACO routing. It consists of both reactive and proactive components. It does not maintain paths to all destinations at all times (like the ACO algorithms for wired networks), but sets up paths when they are needed at the start of a session. This is done in a reactive path setup phase, where ant agents called reactive forward ants are launched by the source in order to find multiple paths to the destination, and backward ants return to set up the paths. The paths are represented in pheromone tables indicating their respective quality. After path setup, data packets are routed stochastically as datagram's over the different paths using these pheromone tables. While a data session is going on, the paths are probed, maintained and improved proactively using different agents, called proactive forward ants. The algorithm reacts to link failures with either local path repair or by warning preceding nodes on the paths. Algorithm description AntHocNet is a hybrid algorithm, containing both reactive and proactive elements. The algorithm is reactive in the sense that it only gathers routing information about destinations that are involved in communication sessions. It is proactive in the sense that it tries to maintain and improve information about existing paths while the communication session is going on (unlike purely reactive algorithms, which do not search for routing information until the currently known routes are no longer valid). Routing information is stored in pheromone tables that are similar to the ones used in other ACO routing algorithms. Forwarding of control and data packets is done in a stochastic way, using these tables. Link failures are dealt with using specific reactive mechanisms, such as local route repair and the use of warning messages

How does a road side unit work?

A roadside unit (RSU) collects traffic data from a static sensing area along a road and transmits data to traffic control devices as well as a central traffic management center. These devices also serve as an information source for intelligent vehicles to collect future traffic information.

Network nodes are ordinary vehicles on the road that have ability to communicate with each other through radio. Network nodes have the lowest security level. Road side infrastructure is the set of RSUs. RSUs are agents of the authority which are deployed at the road sides, for example, traffic lights or road signs can be used as RSUs after renovation. An RSU can be a powerful device or a comparatively simple one. RSI is semi-trust with the medium security level [7

Initial Parameters

Num of Nodes	= 100;
Source node	= 10;
Destination node	= 25;
network size	= 100 x 100
citysize	= 150;

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Stationary heterogeneous sensor nodes are deployed uniformly in the WSN.

• The WSN is fully connected. Without any need for Global Positioning System (GPS), the distance between the nodes can be computed by the received signal strength.

• There are faulty nodes in the WSN, but they are in minority and are distributed randomly.

• The sensing area of each sensor node is covered by multiple nodes.

• Sensing range of the sensor nodes is fixed.

• The transmission range TransRange(Si) of the sensors is larger than the sensing range

Sensing Range (Si) and the sensing range of the advanced nodes is more than normal Nodes. The events such as free happen in the WSN. Radius denoted as Event Radius.Spatial correlation relationship within a certain physical neighborhood for the sensor Nodes is assumed. In this case, such nodes may sense similar values from the environment.

EXECUTION OF NETWORK

Let take 20th node is source node and 45th node is destination
We need to transfer data from source to destination through other nodes
(in any nodes from 100, let consider, from 20th node to 34th node to 42nd node to 45th node , so link path is 20-34-42-45)
The Fuzzy or ANFIS will find out
If 34th node is fault or not
If it is fault then we can reuse or not - for this process we repeat to 42nd node
The above is one transmission
Likewise we transmit data from source to destination
There will only 20 to 40 paths

SIMULATION RESULTS

The proposed self-diagnosing faulty node detection scheme is simulated with the help of MATLAB. The performance of the proposed approach is tested by distributing 100 nodes in a random fashion. The simulation area is set to 100 X 100 m. All the nodes are aware of their location information and initially all the nodes are with full energy backup. The performance of the proposed approach is compared with the existing approaches such as threshold based The Performance Calculated in terms of faulty node detection accuracy, packet delivery rate, energy consumption, network lifetime. The faulty node detection accuracy is the most important metric, as it is meant for checking the basic functionality of the proposed approach. This work computes the faulty node detection accuracy of the proposed approach and the results are compared with the existing approaches as given in
Let take 20th node is source node and 45th node is destination
We need to transfer data from source to destination through other nodes
(in any nodes from 100, let consider, from 20th node to 34th node to 42nd node to 45th node , so link path is 20-34-42-45)
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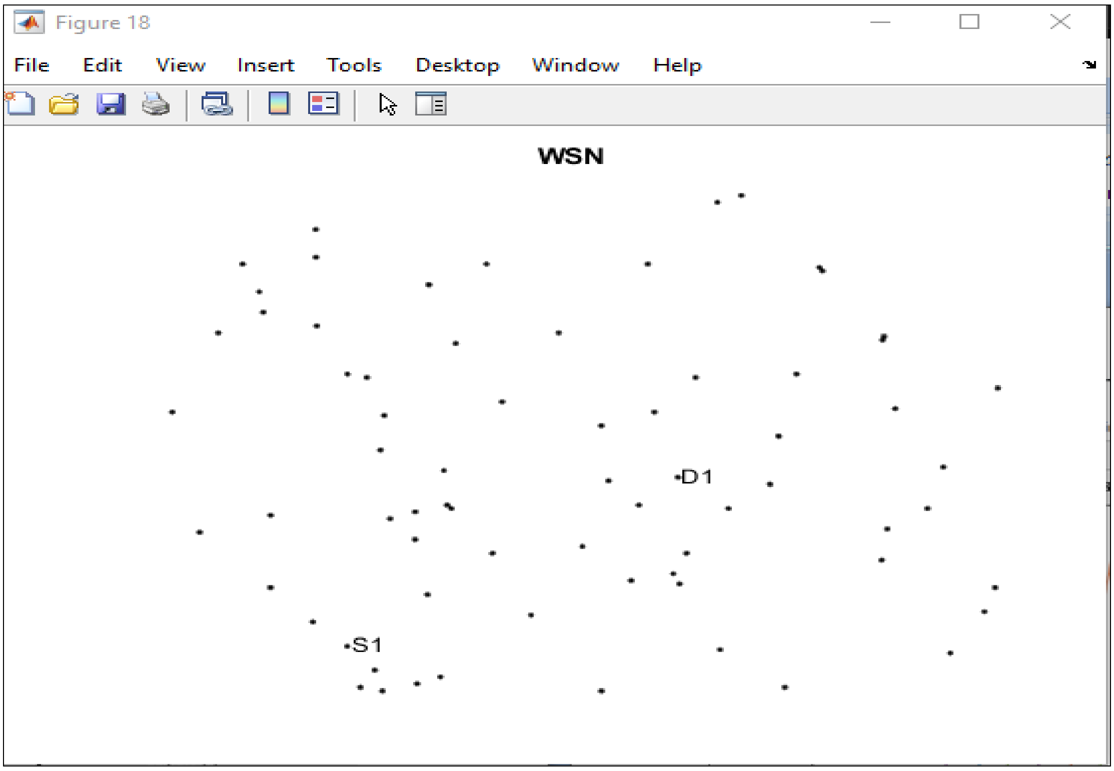

Fig 2 WSN System

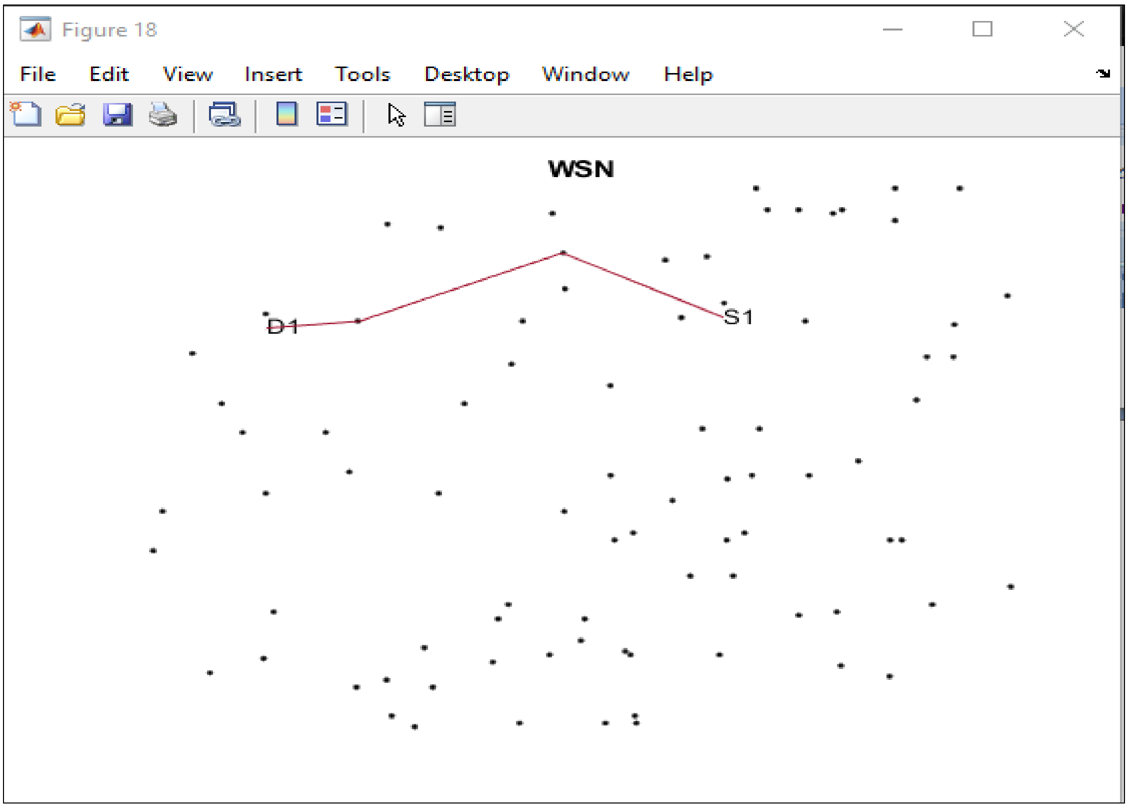

Fig3 data transfer source to destination

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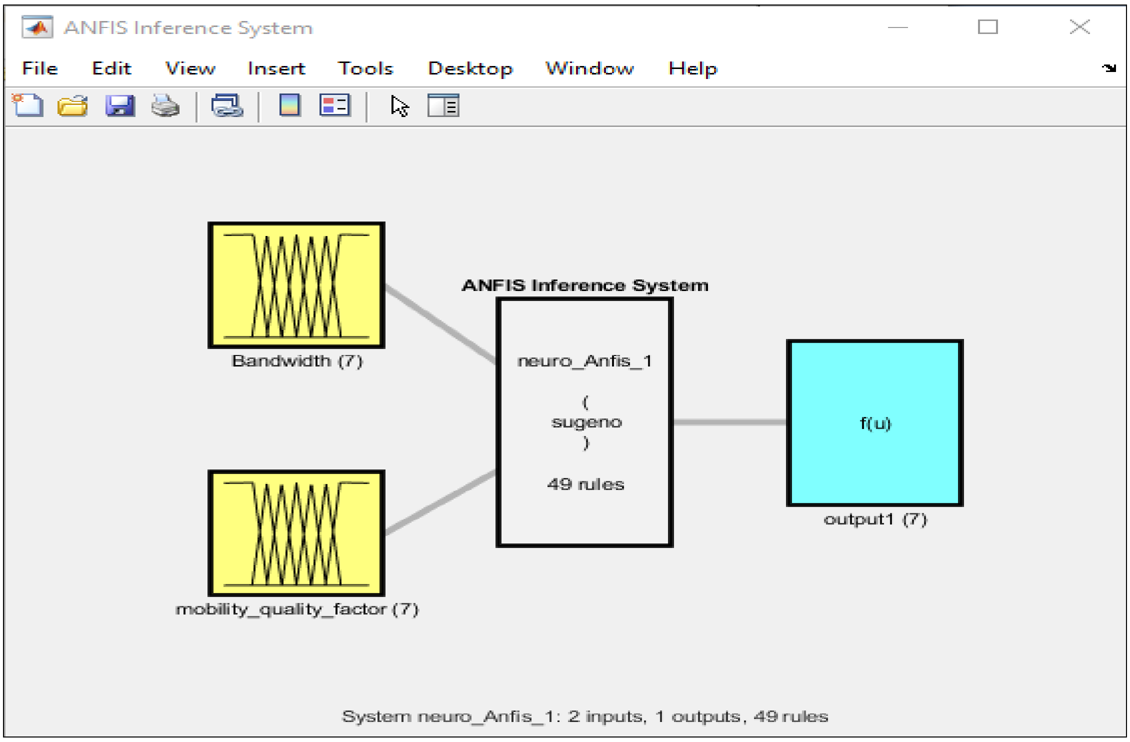

Fig. 4 ANFIS interference system

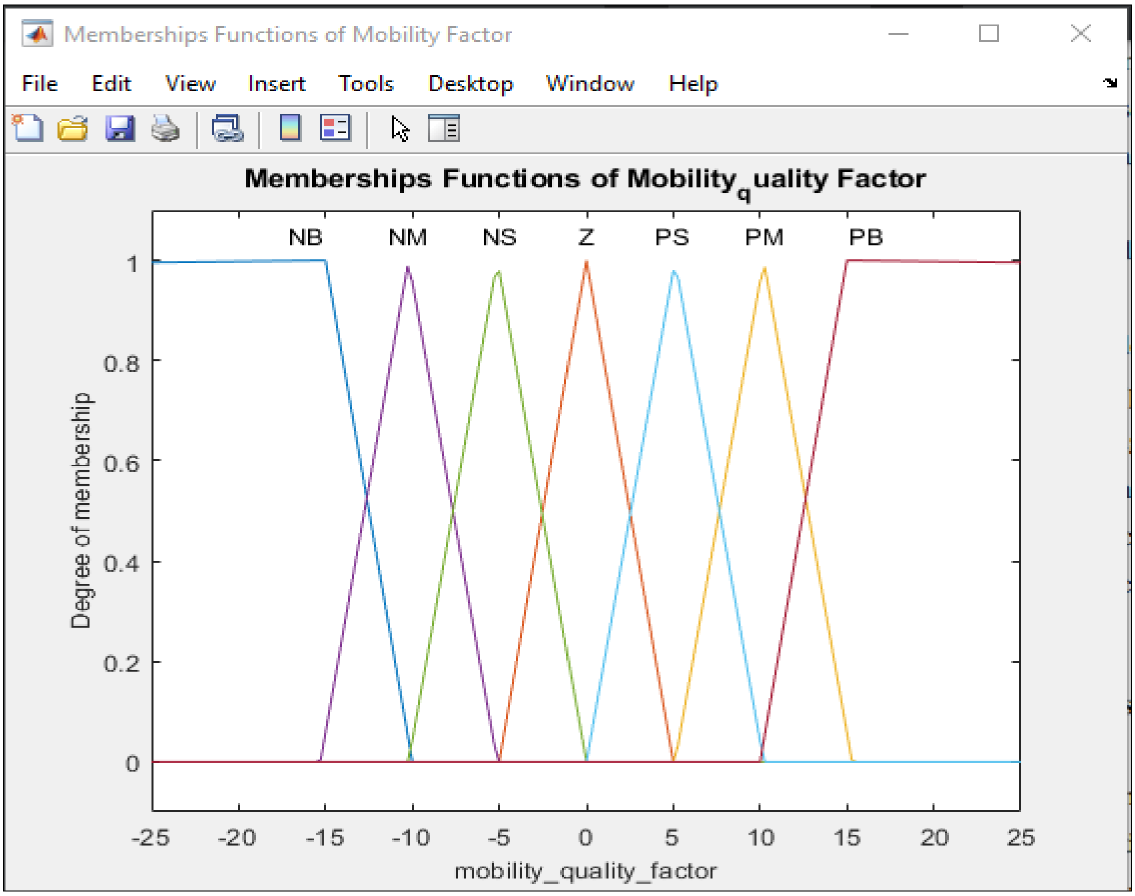

Fig.5 membership function of ANFIS

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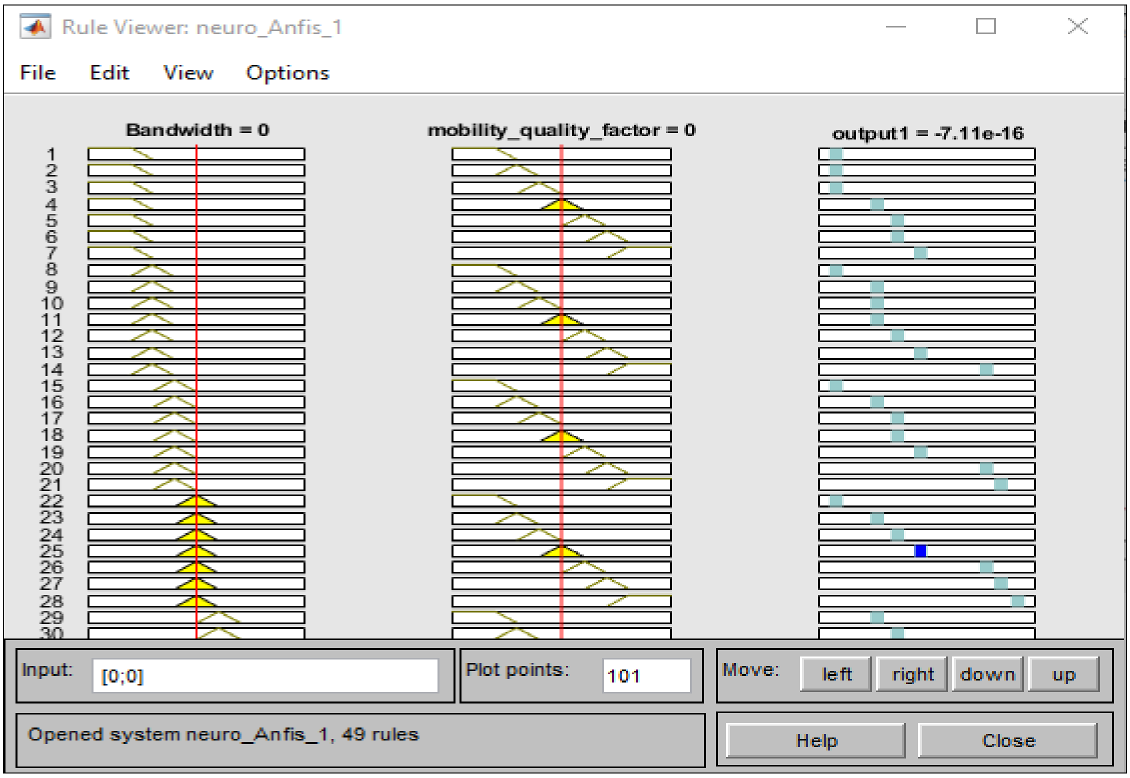

Fig.6 rule viewer of ANFIS

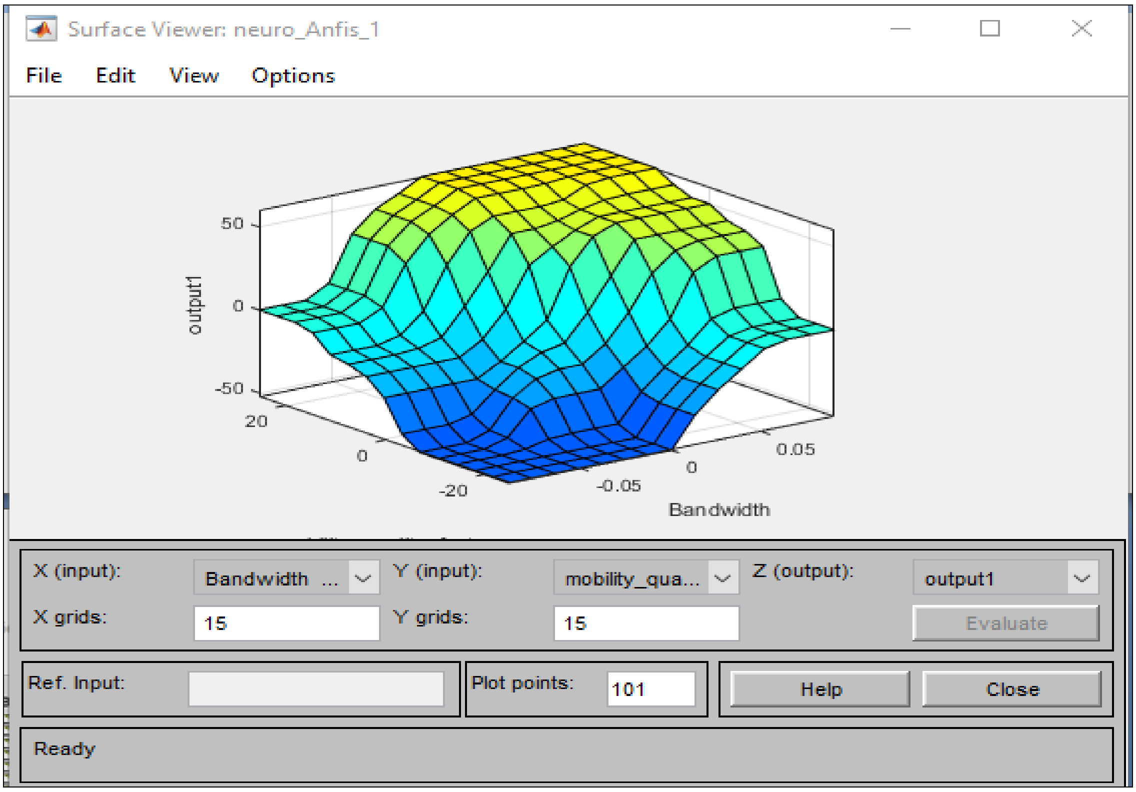

Fig .7 surface of ANFIS

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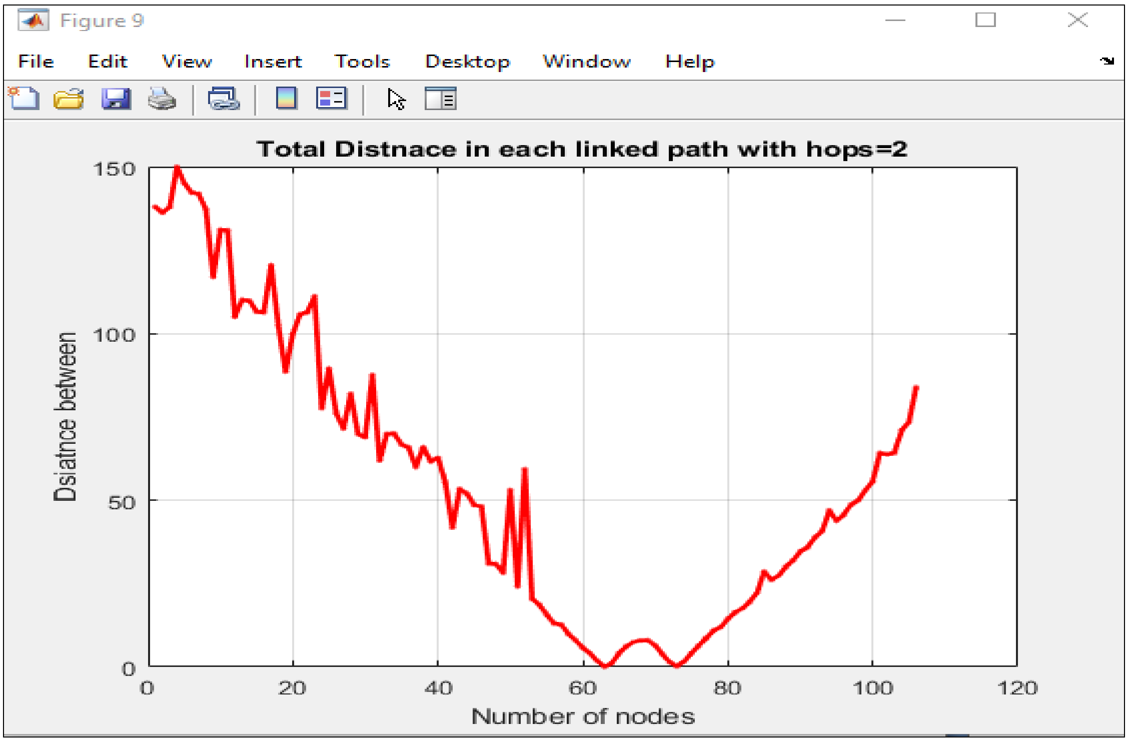

Fig.8 Total distance in each link path

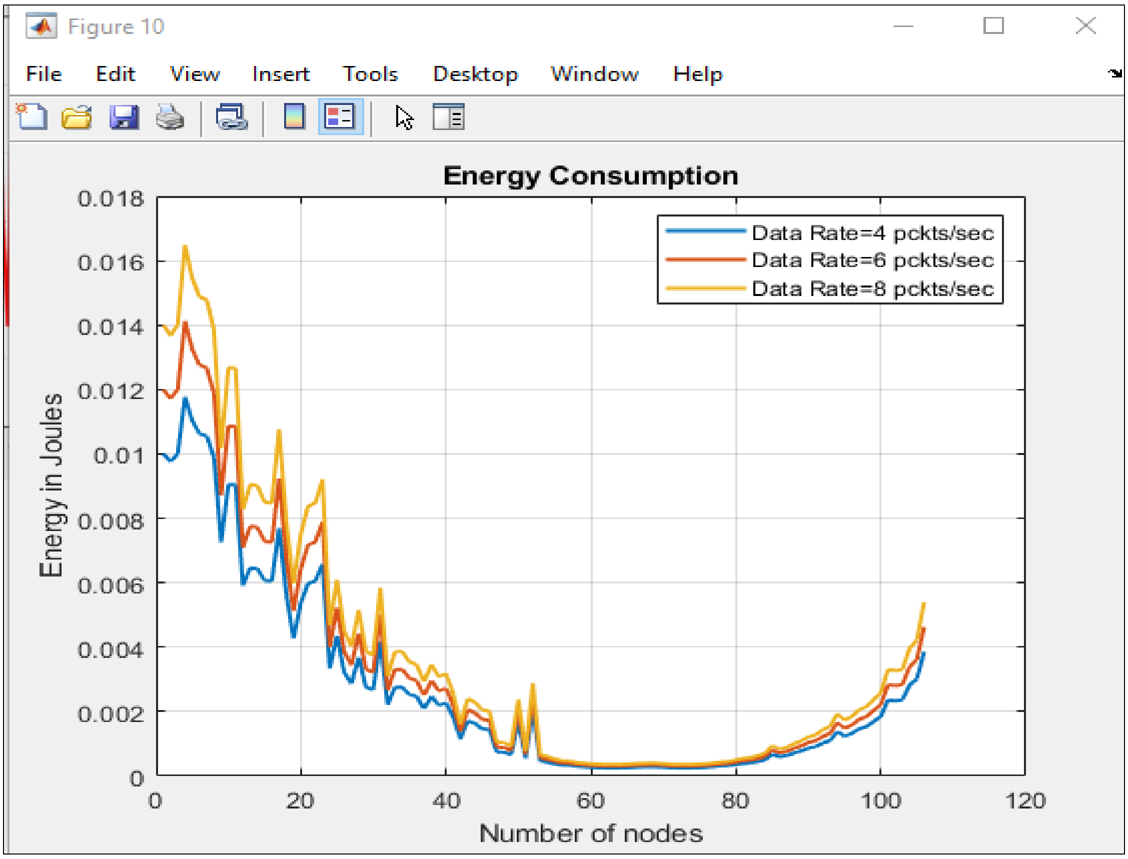

Fig. 9 Energy Consumption of ANFIS network

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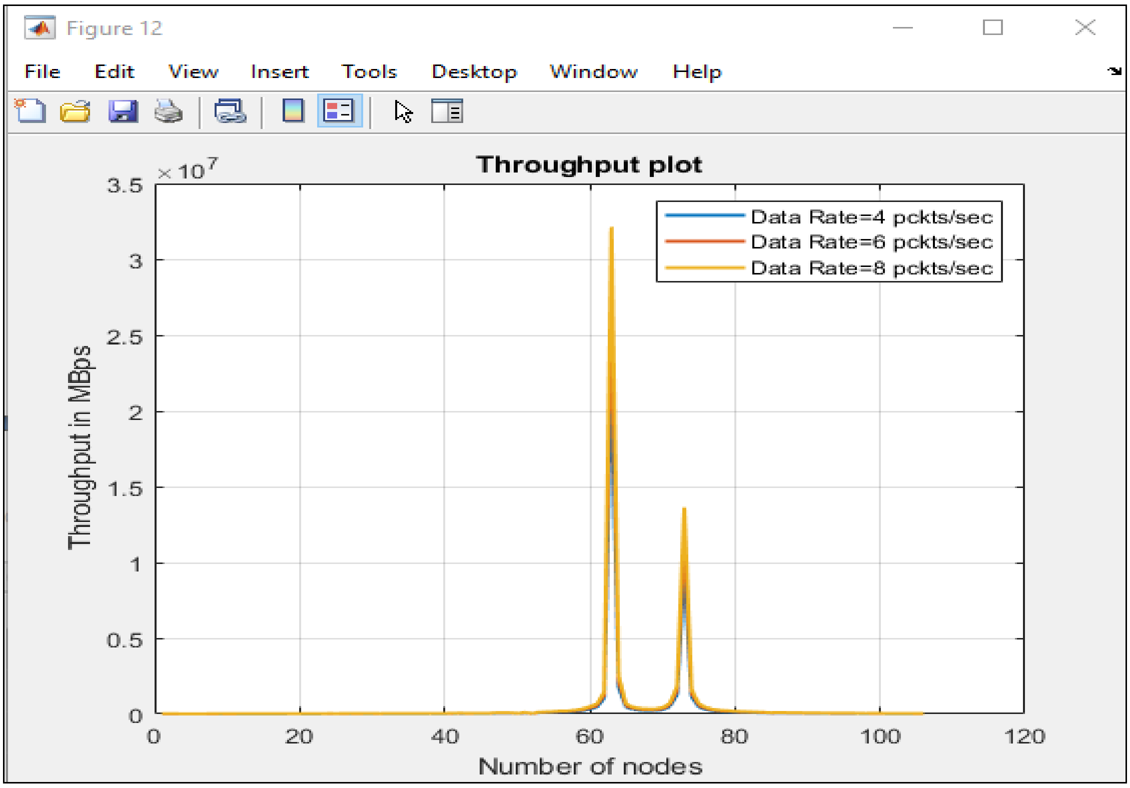

Fig.10 Throughput of ANFIS network

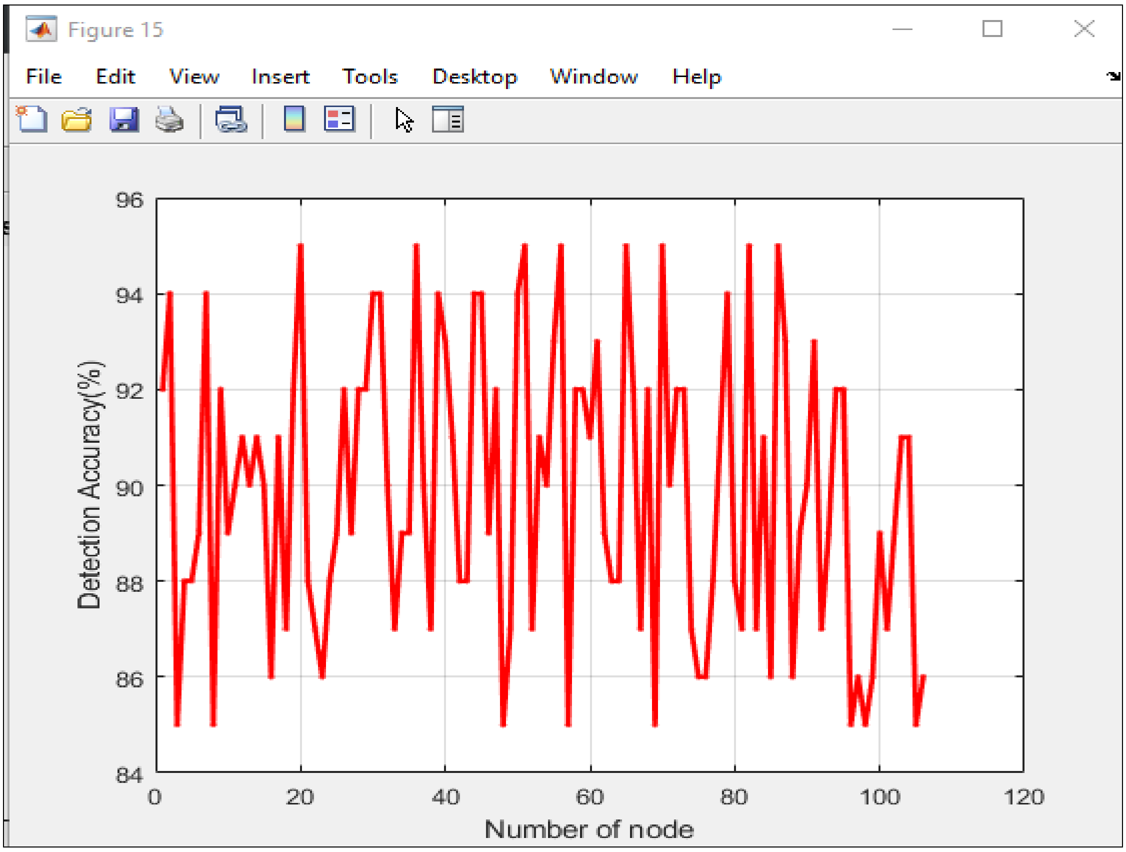

Fig.11 Detection Accuracy of ANFIS network

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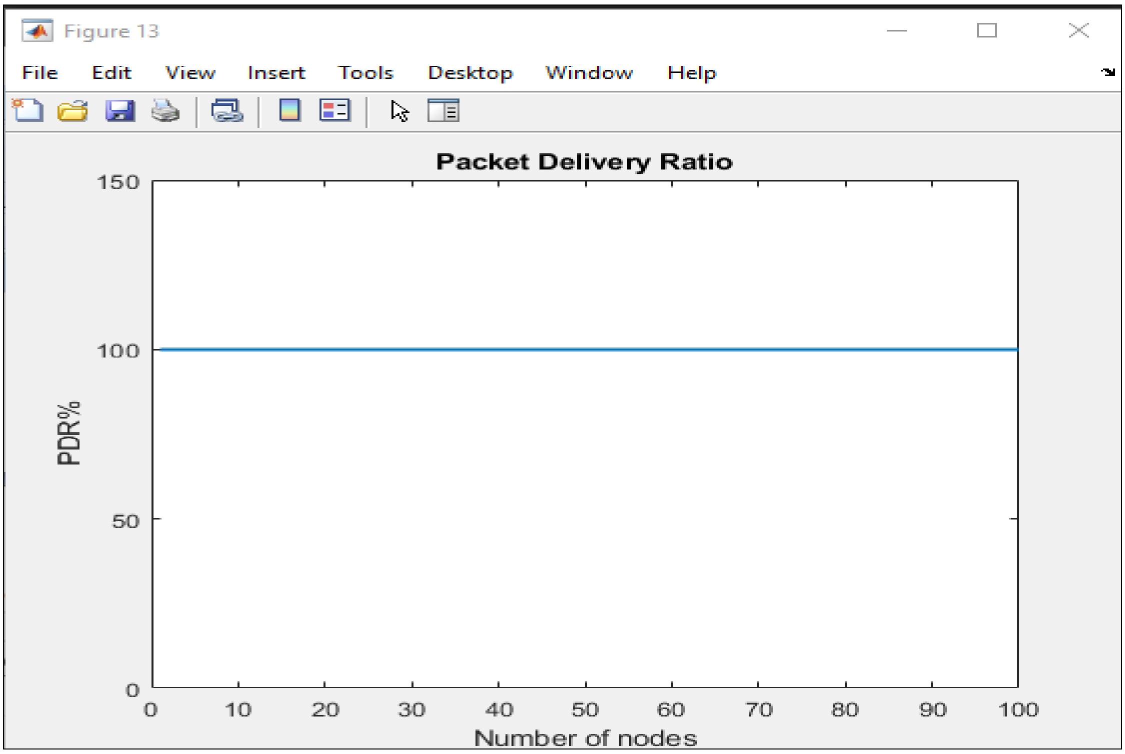

Fig.12 packet delivery ratio of ANFIS based network

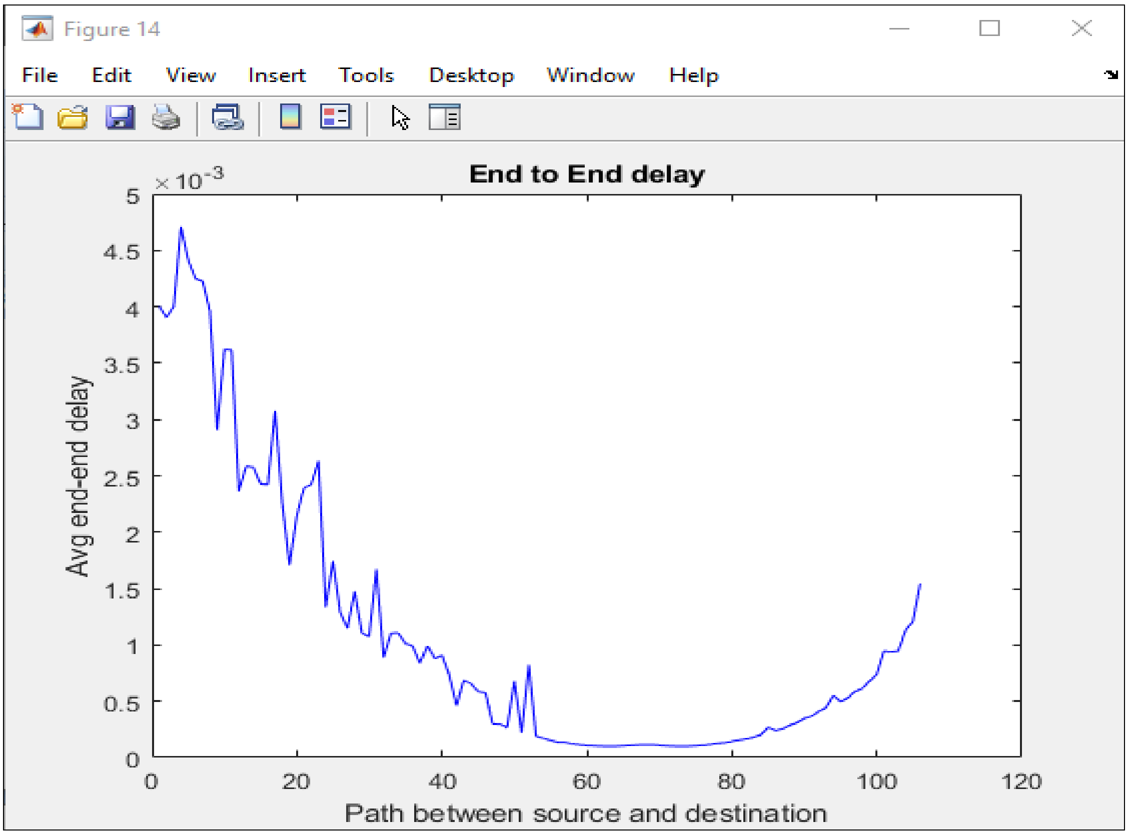

Fig. 13 end to end delay of ANFIS based network

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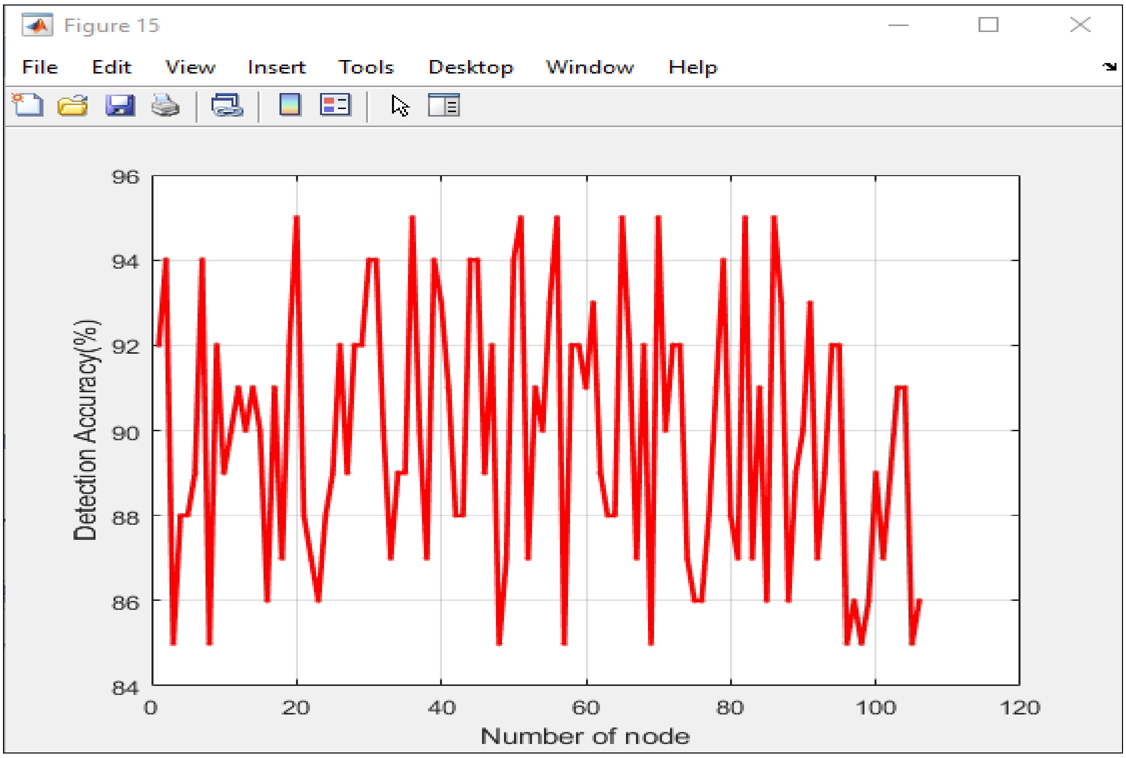

Fig.4.14Detection accuracy of ANFIS based network

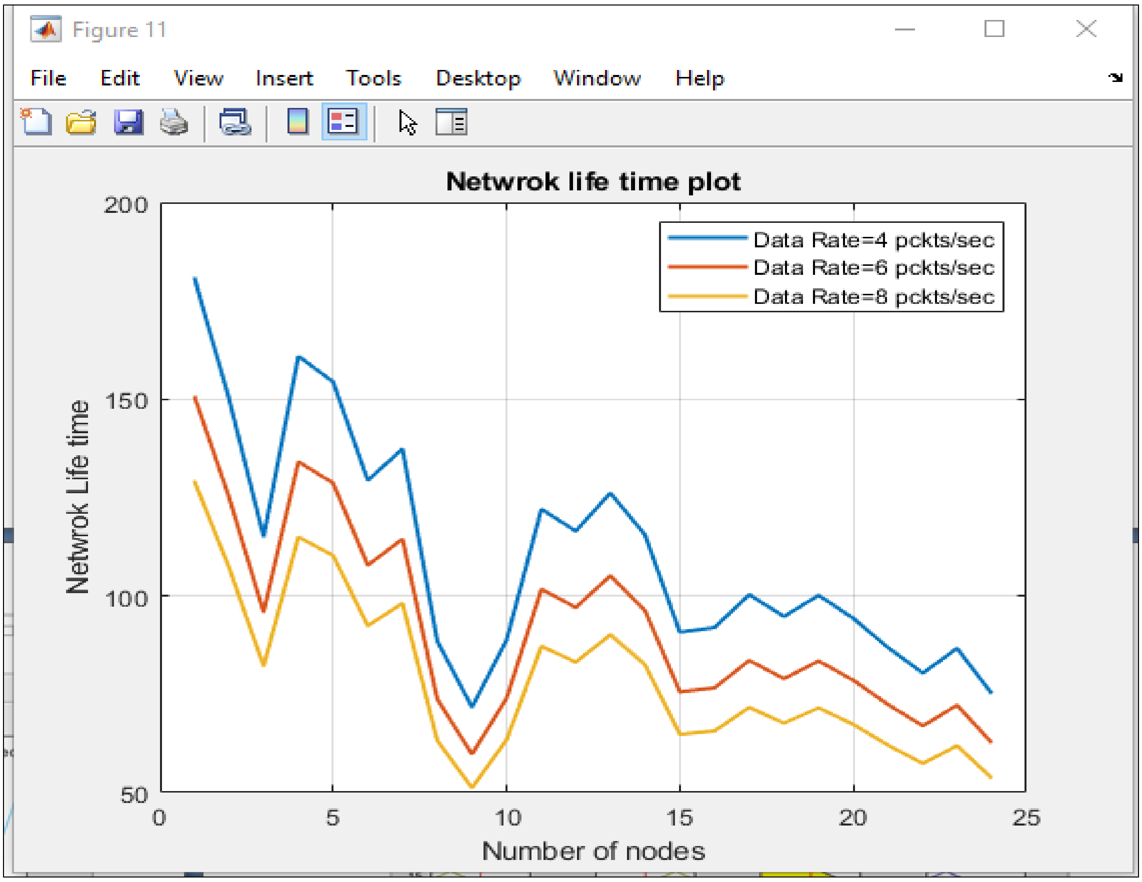

Fig.4.15 networklife time of ANFIS based network

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FUZZY BASED NETWORK EXECUTION

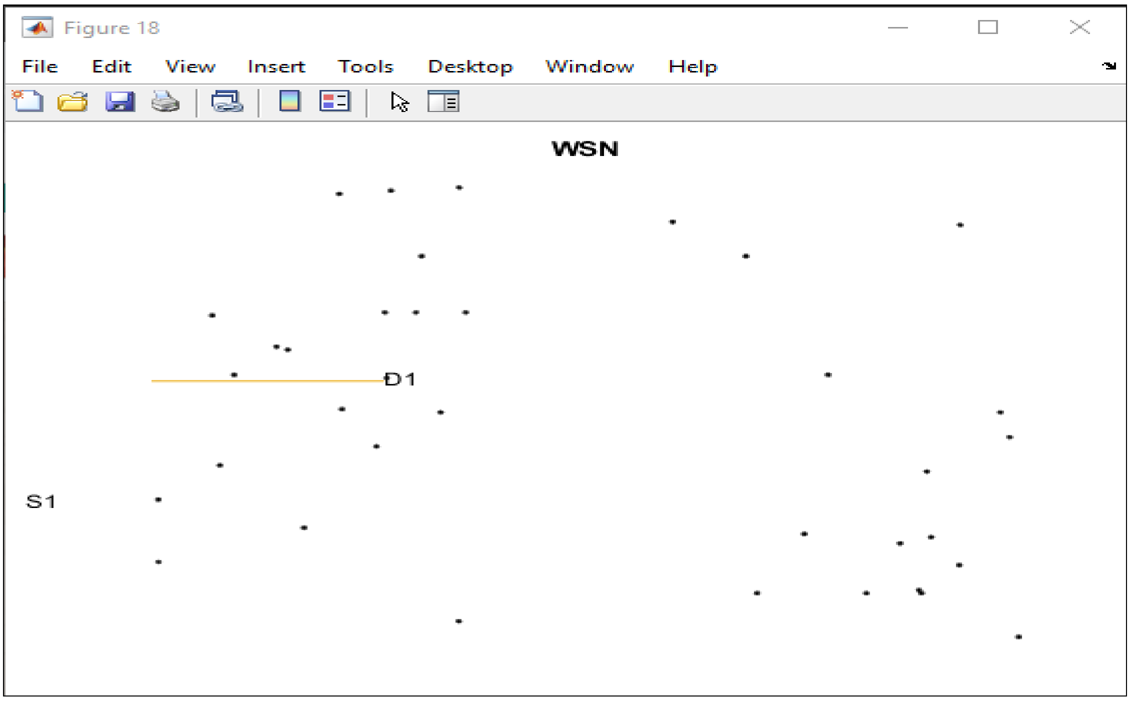

Fig.15 system model of Fuzzy based network

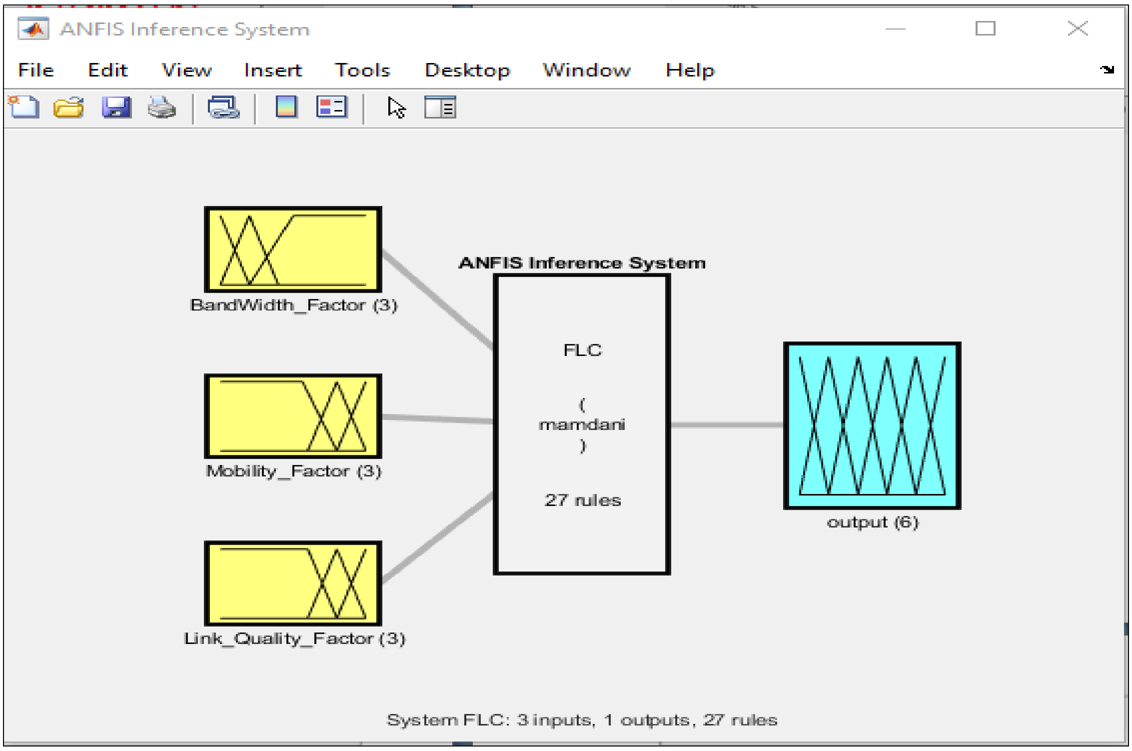

Fig.16 ANFIS interference system

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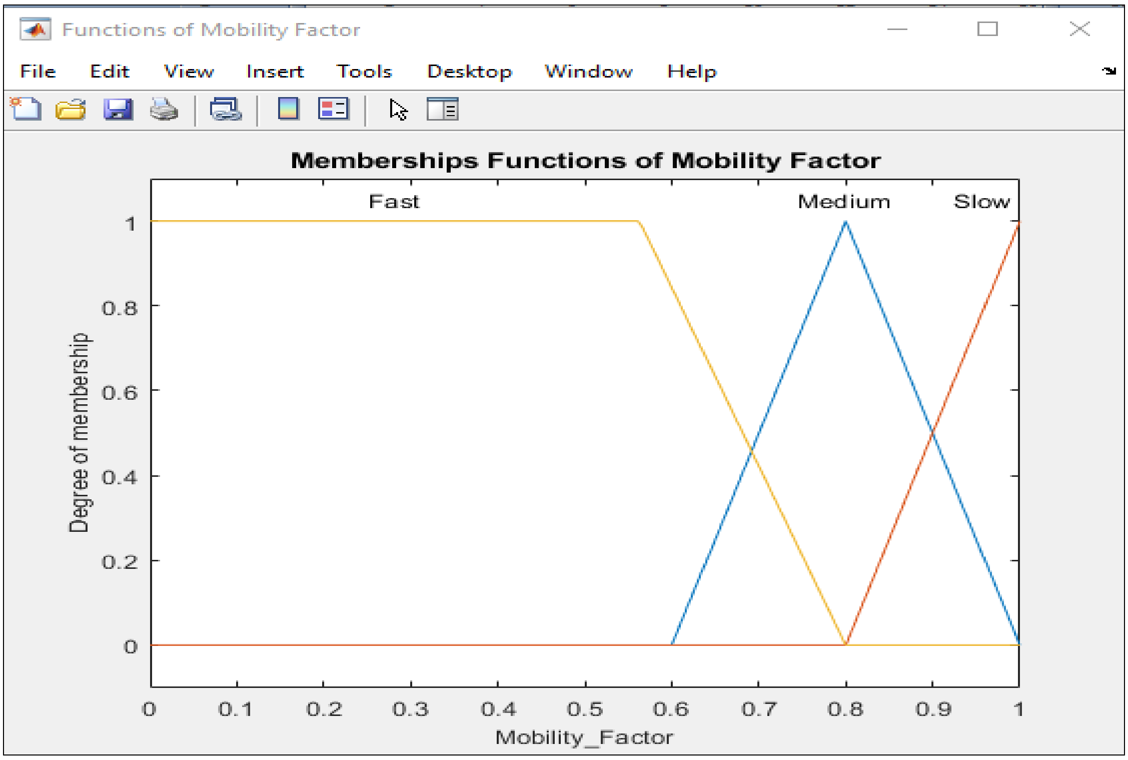

Fig.17 membership function of fuzzy system

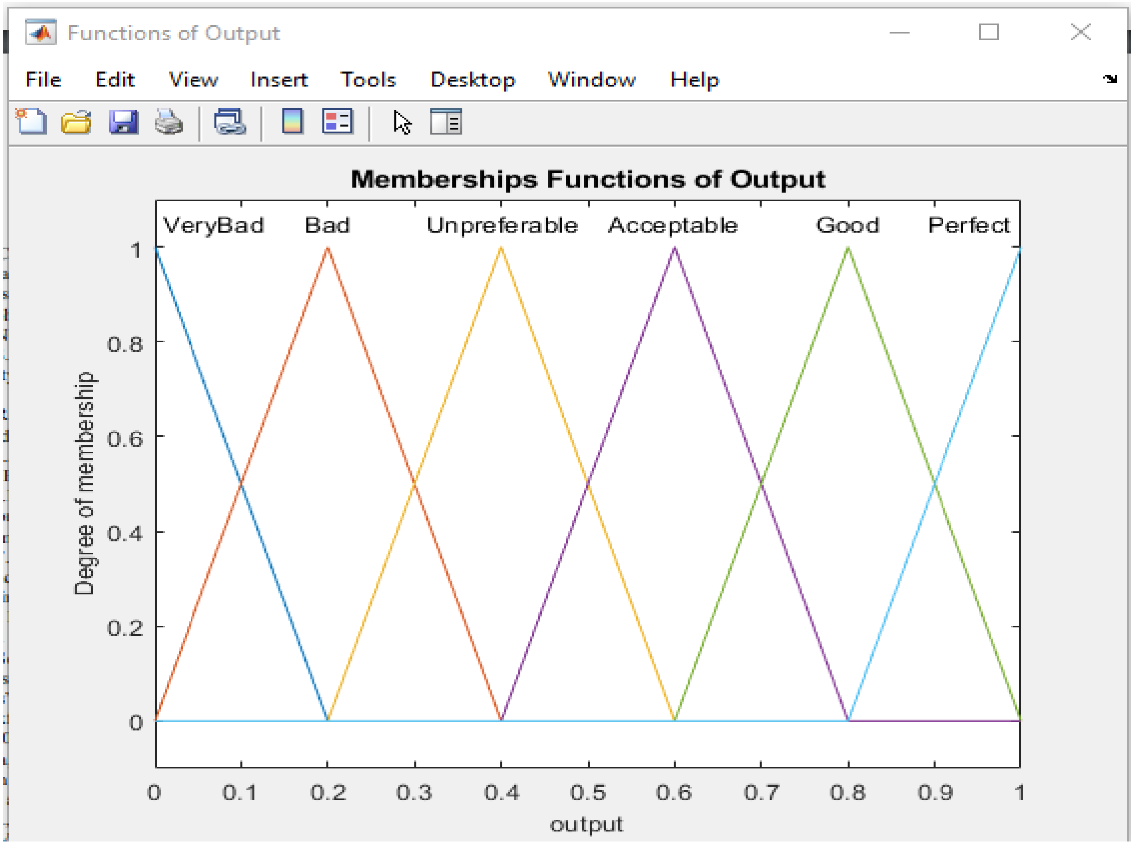

Fig.18 membership function output of fuzzy system

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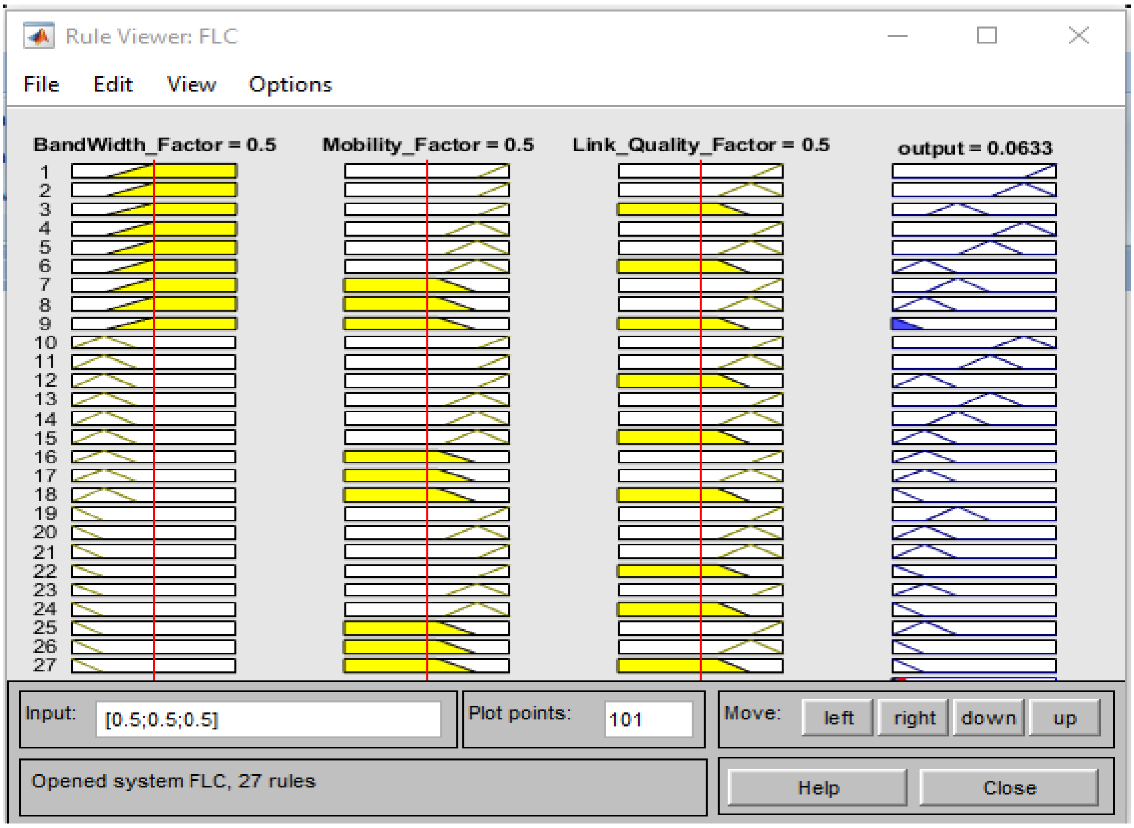

Fig. 19 rule viewer of ANFIS

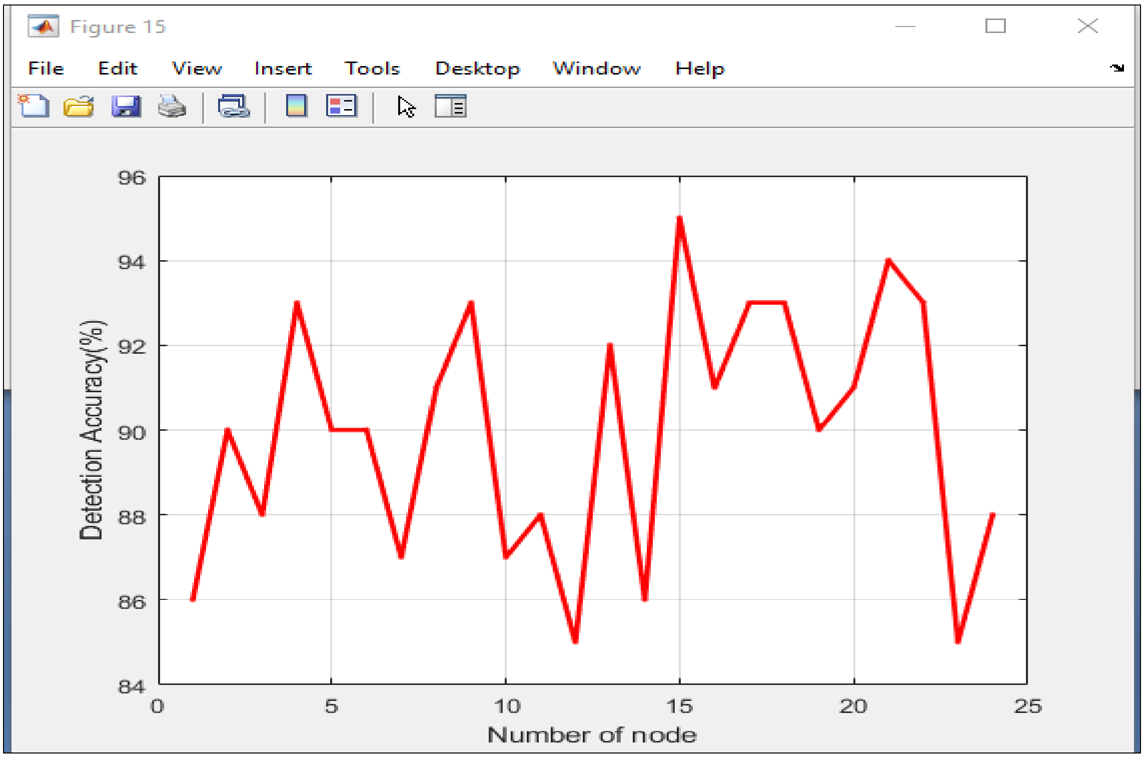

Fig.20 detection accuracy of Fuzzy based network

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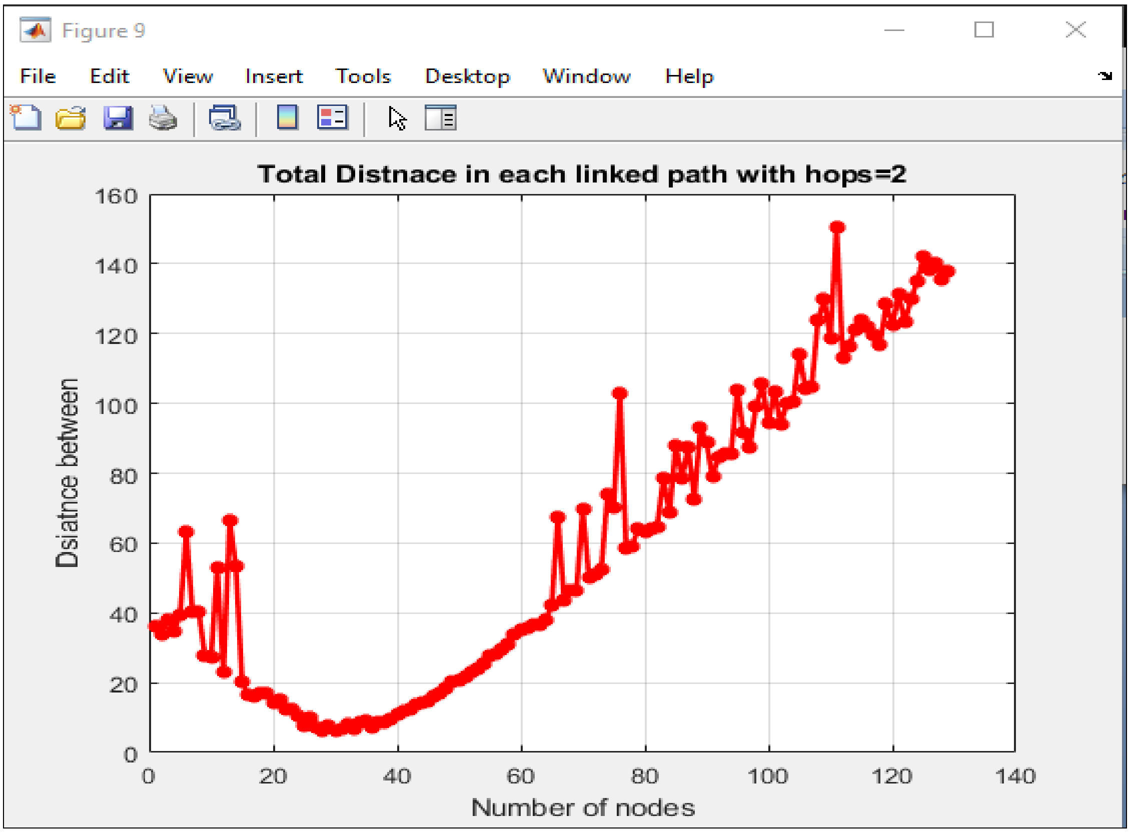

Fig. 21 total distance in each link path

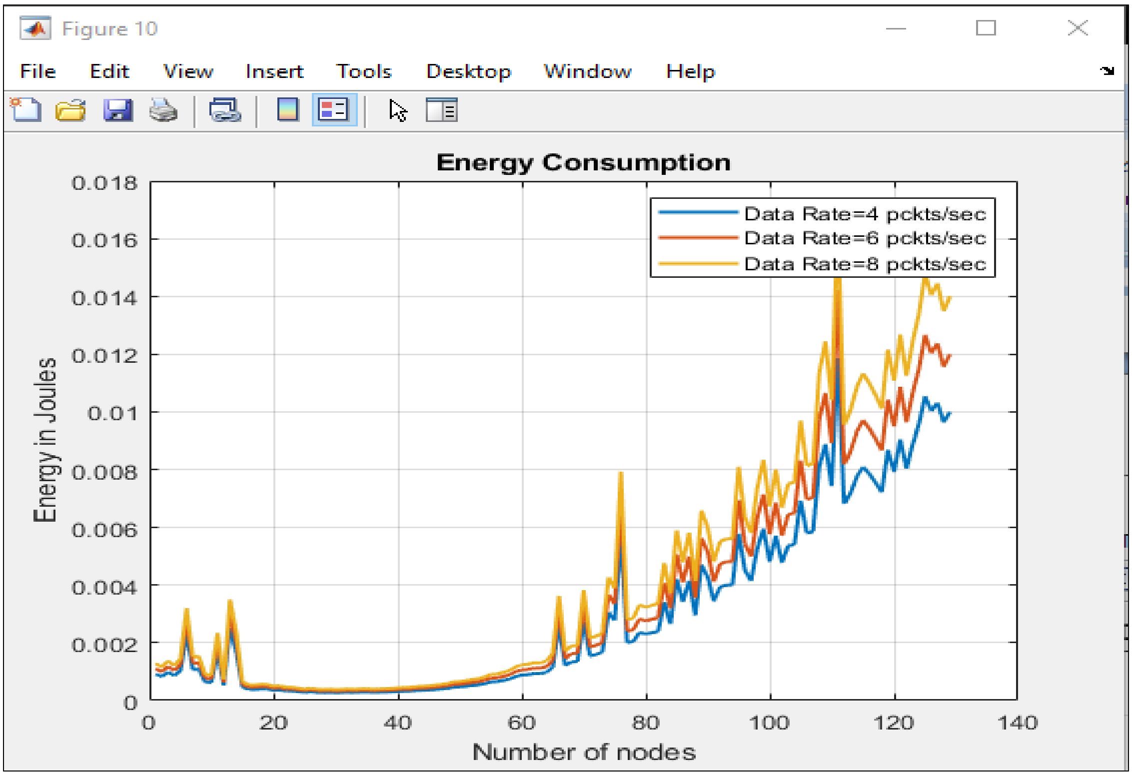

Fig.22 energy consumption of Fuzzy based network

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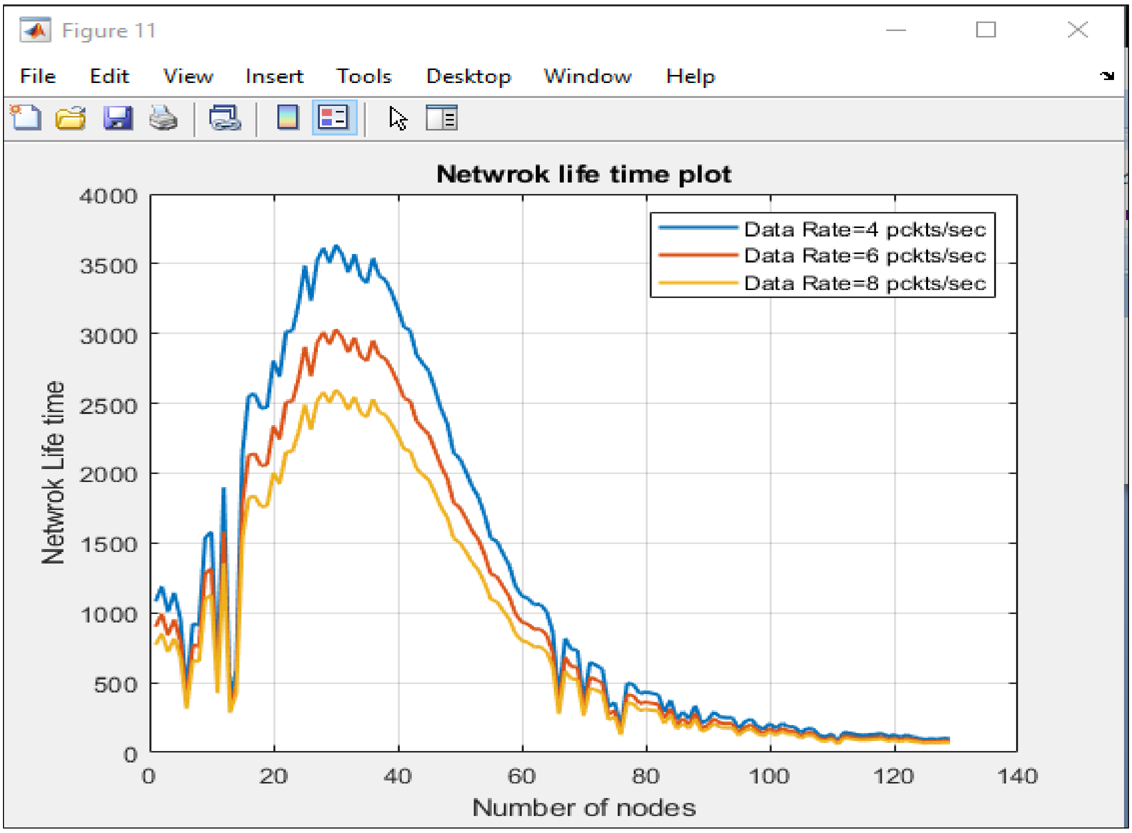

Fig.23 network life time of fuzzy based system

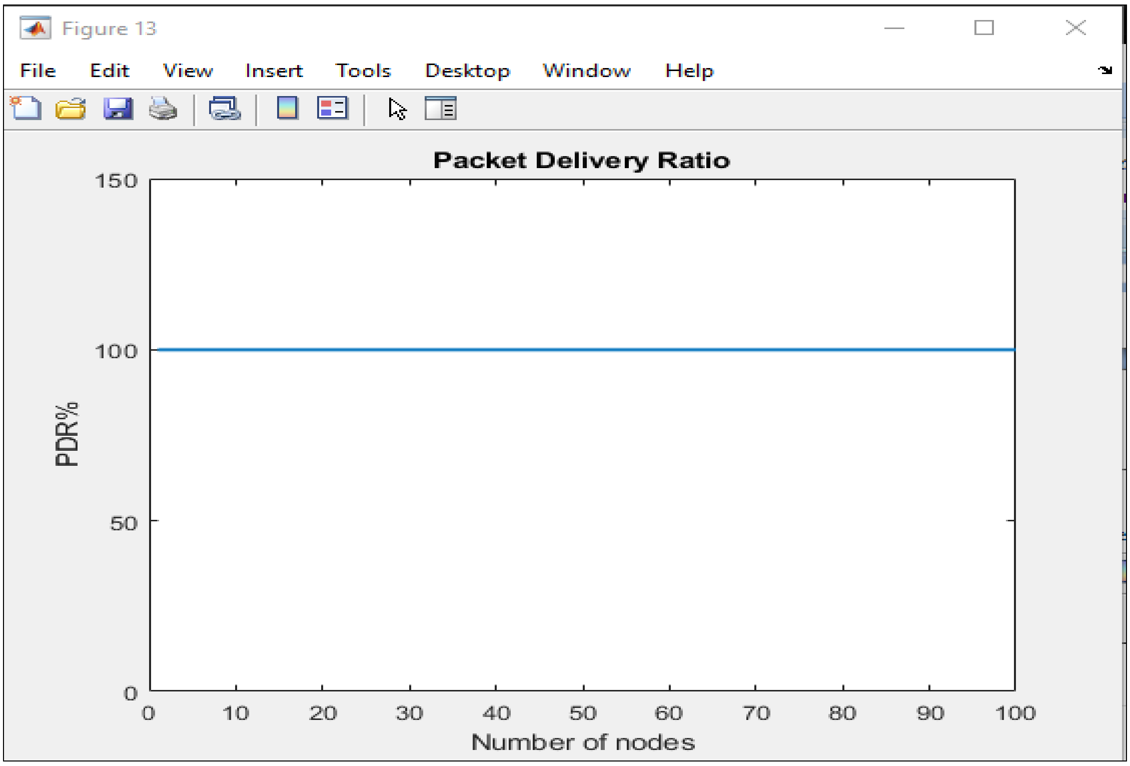

Fig. 24 packet delivery ratio of Fuzzy based network

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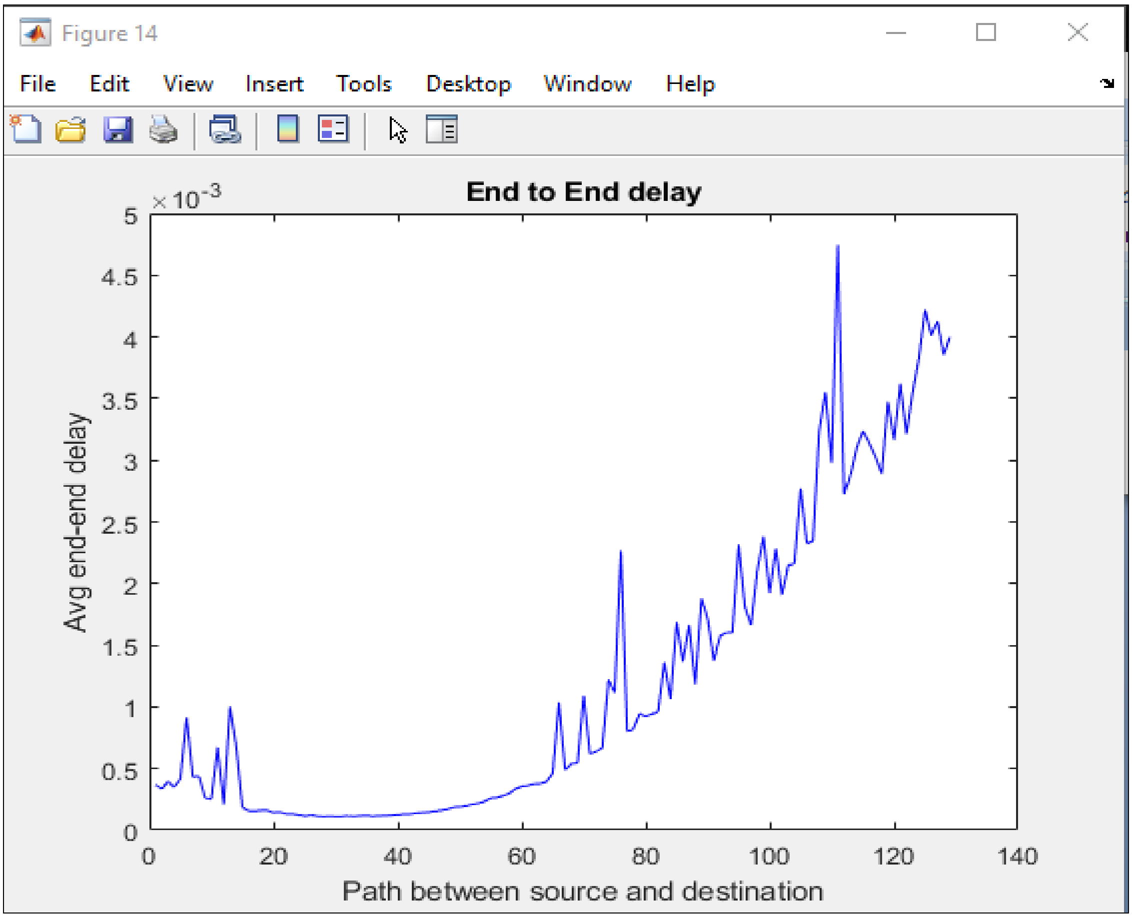

Fig. 25 end to end of Fuzzy based network

TABLE 4.1 Performances of ANFIS and Fuzzy System

	Network Life Time (T)	PDR (%)	Throughput (%)	Energy Consumption (joule)	Dalay (S)	Accuracy (%)
ANFIS network		100	3.2	0.016	4.7	94
Fuzzy network	3700	100	2.5	0.019	4.9	86

Table 4.2 Comparison of exiting work

	Techniques	Detection Accuracy
Proposed Technique	ANFIS	96%
	Fuzzy	86%
Existing Work	(FDWSN)	93%

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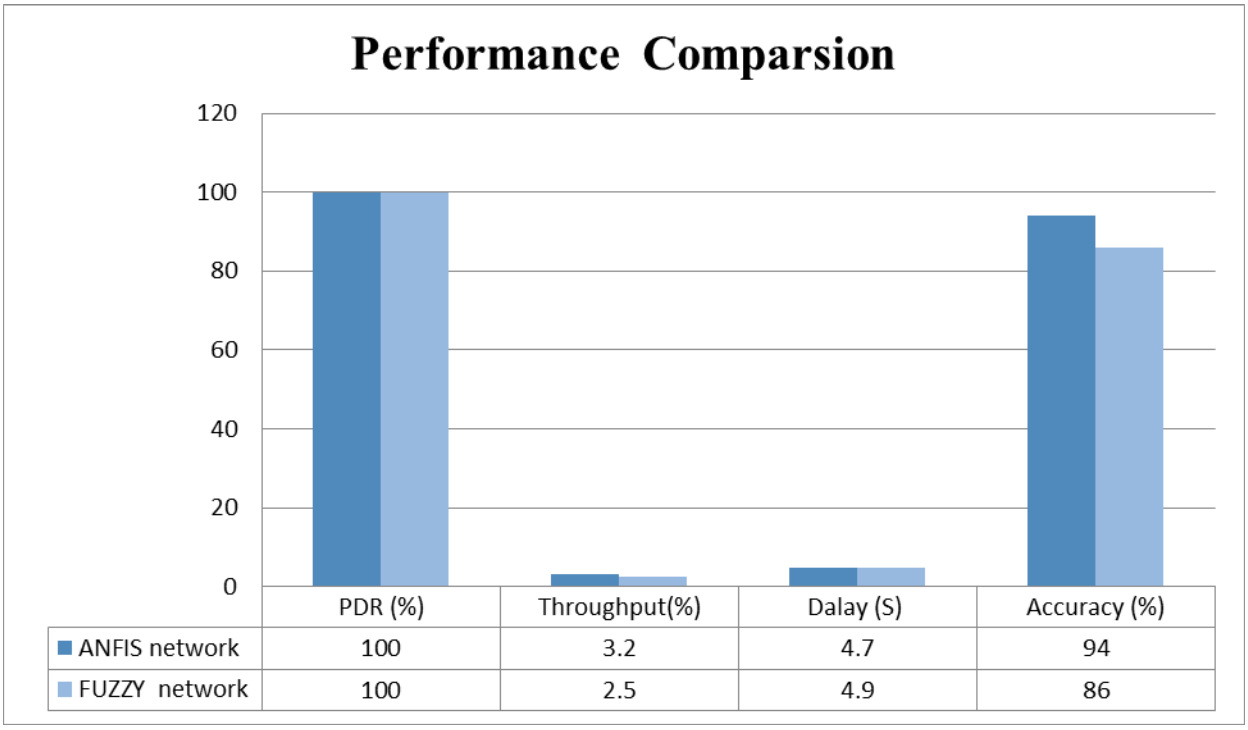

Fig.26 performance comparison with different parameters

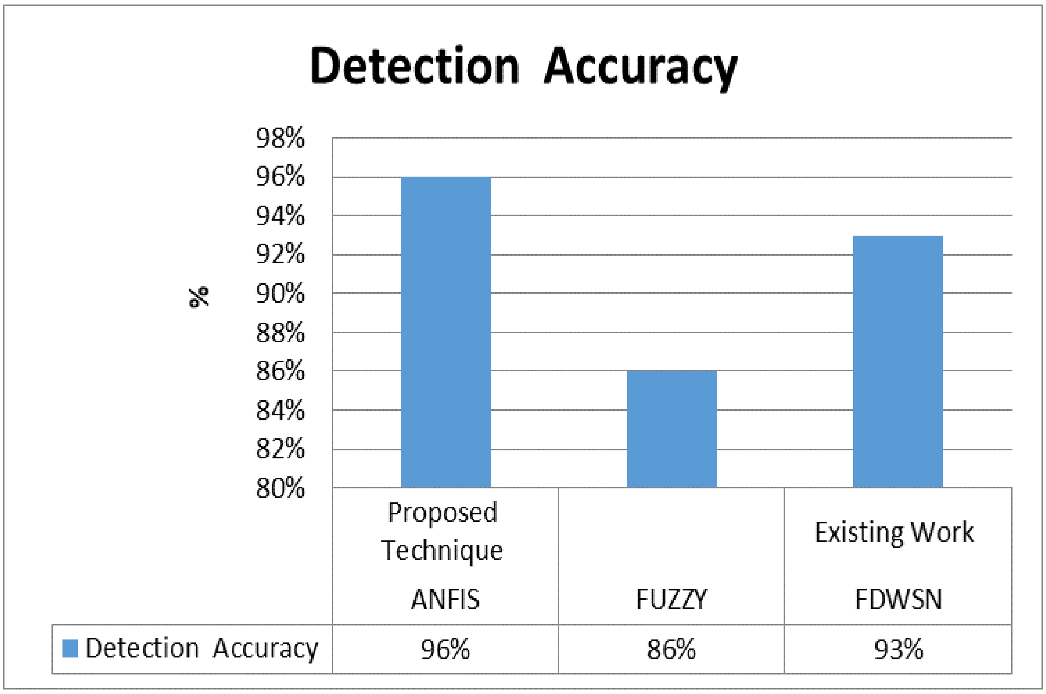

Fig. 27 performance graph of accuracy detection

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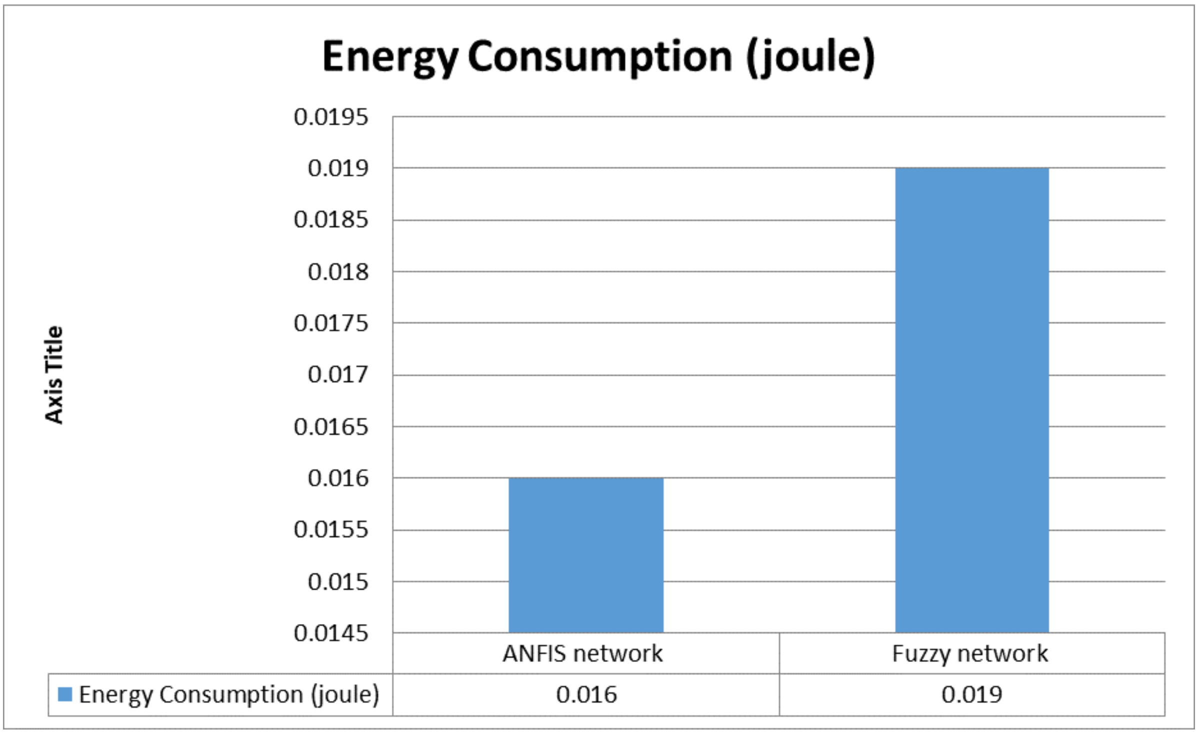

Fig. 28 performance graph of accuracy detection

IV. CONCLUSION

Sensor nodes are cheap devices and prone to failures. Node failure rate may be very high if they are deployed in hostile or harsh environments. Faulty nodes detection is one of the critical operations in such environments that guarantee the reliable monitoring of the environment by the sensor nodes. This research proposed a fuzzy rule-based faulty node classification and detection. It can be used to detect the physical or environmental conditions such as livestock management, home automation, road monitoring etc. The proposed method has four advantages in comparison with the previous approaches. First, the proposed scheme enhances reusability of the recovered faulty nodes by the efficient data AntHocNet algorithm. Therefore, notable energy saving is possible in fuzzy based scheme. Second, the application of fuzzy logic helps to overcome the uncertainties in the WSN. Proposed scheme can save nodes energy and provides a better quality of service. Finally, node management method not only provides a fast AntHocNet algorithm scheme but also improves over all network performance. The limitation of the proposed work can be summarized as follows. It should be considered to improve performances of the network. Third, in some applications, sensor nodes are deployed to monitor separate area. In each area, sensor nodes are densely deployed and connected, whereas sensors that belong to different areas may be disconnected. For such applications, proposed scheme takes much more time to diagnose nodes status due to network disconnection. In future, several novel ideas should be taken into account. First, we will try to introduce a mobile sink based mechanism for node status report collection, so that topological changes of the network does not have effect on the fault detection process. Second, because of environmental interference the network faults are considered to be included into fuzzy interference model for future reasoning. Third, improvement of the computation efficiency and robustness of fault measures are required

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