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Research Article

Developing a Framework for Designing Effective Smart City Architecture Using Intelligent Systems

David Idakwo Friday, Simon Tooswem Apeh, Oduware Okosun.

Special Issue
A Themed Issue in Honour of Professor Onukwuli Okechukwu Dominic (FAS).

This special issue is dedicated to Professor Onukwuli Okechukwu Dominic (FAS), marking his retirement and celebrating a remarkable career. His legacy of exemplary scholarship, mentorship, and commitment to advancing knowledge is commemorated in this collection of works.

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Developing a Framework for Designing Effective Smart City Architecture Using Intelligent Systems

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Abstract
The ongoing congestion on major roads in Nigeria has significantly disrupt business activities and hindered the country's economic growth. To tackle this issue, a framework for designing smart city architecture utilizing intelligent systems has been developed. To achieve this, we checked the characteristics and establish the causes of poor traffic flow, designed a smart city rule base, trained Artificial Neural Network (ANN) in the smart city rule base, designed a SIMULINK model, developed an algorithm, designed a Visual basic program, designed a smart city SIMULINK model and finally validated and justify the percentage improvement in traffic flow with and without intelligent smart city architecture. The results obtained are: the first ANN training reduces congestion to 59.29%, the second to 54.37%, third to 51.68% thereby enhancing traffic flow. The conventional road capacity in Awka was 8%, with intelligent smart city architecture integrated, it enhances the system to 10.78%. The conventional inefficient traffic signal timing was 13%, with intelligent smart city architecture incorporated it reduces to 11.2% thereby minimizing congestion. The conventional congestion that caused delay for passengers is 60%, integrating intelligent smart city architecture it decisively reduced to 51.68%. Finally, these results obtained shows that the percentage improvement in the reduction of congestion when an intelligent smart city was incorporated in the system over the conventional counterpart is 8.32%, thereby reducing commute time.

Keywords: Smart city, Artificial intelligence, Machine learning, Architecture, Traffic flow, Intelligent system, Developing Framework, Effective design.

1.0 Introduction

The rapid urbanization of the 21st century presents significant challenges for cities around the globe. Growing populations strain infrastructure, increase pollution, and create demands for efficient resource management. In response, the concept of "smart cities" has emerged, leveraging technology and data to create more sustainable, efficient, and livable urban environments "Smart transportation systems in smart cities: practices, challenges, and opportunities for Saudi cities" (Anwar, Oakil 2023) pg 315–337. Recent years have witnessed a colossal increase of vehicles on the roads; unfortunately, the infrastructure of roads and traffic systems has not kept pace with this growth, resulting in inefficient traffic management. Owing to this imbalance, traffic jams on roads, congestions, and pollution have shown a marked increase (Ravish, Swamy, 2021). The management of growing traffic is a major issue across the world. The most dangerous cross junction for pedestrians in Awka, Anambra State is likely the Regina Caeli Junction located on the Enugu-Onitsha Expressway. There is currently no pedestrian bridge at this junction, and there have been calls for the government to build one due to the high number of accidents. There is a pedestrian bridge at the Unizik temporary site junction on the Enugu-Onitsha expressway, but this is the only one in the entire capital city (Adewumi et al, 2014). (Mohammed et al., 2019) present their studies highlighting the potential of real-time data collection and analysis for optimizing traffic light timing and suggesting route diversions. (Garcia, 2023) in the article "Traffic optimization through waiting prediction and evaluative algorithms" discusses how traffic optimization systems work and how to adjust traffic light timing to enhance car and pedestrian mobility. Authors (Li et al., 2020) propose a smart city architecture that utilizes real-time traffic data collected from sensors and cameras to optimize traffic light timing. These studies highlight the potential of smart city technologies to gather and analyze traffic data for informed decision-making (Rong, Zhang, 2024). Prasetyo and Habibie (2022) recommend the Smart City Architecture Development Framework (SCADEF) as a comprehensive enterprise architecture framework to develop smart city architectures, the research uses observation, classification, and construction methodologies in Information System Design Methodology.

Traditional traffic management strategies in Awka have proven inadequate in addressing the growing complexities of urban traffic flow. These limitations necessitate a more intelligent and data-driven approach to improve traffic management within the cities. Traffic congestion in Awka has emerged as a critical issue, leading to a cascade of problems including:

- Increased travel times: Residents and commuters experience significant delays due to congested roadways.
- Reduced productivity: Businesses face economic losses due to delayed deliveries and employee commutes.
- Environmental pollution: Traffic congestion contributes to increased air and noise pollution.
- Safety hazards: Congestion can lead to accidents and impede emergency response times.

Intelligent Transportation Systems (ITS) have a great potential in offering solutions to such issues by using novel technologies. Intelligent smart city architecture forms the backbone of these advancements. It refers to the design and integration of physical infrastructure, information and communication technologies (ICTs), and data analytics to create a holistic and responsive urban ecosystem. This architecture encompasses a wide range of elements, including:

- Sensor networks: These networks collect real-time data on traffic flow, energy consumption, environmental conditions, and other aspects of city life.
- Data platforms: These platforms aggregate from various sources, enabling analysis and insights.
- Artificial intelligence (AI) and machine learning (ML): These technologies are used to analyze data, identify patterns, and predict trends to optimize resource allocation, improve traffic management, and enhance public safety.
- Communication infrastructure: High-speed networks, such as 5G, are essential for seamless data transmission and communication between different elements of the smart city architecture.

This study focuses on exploring and evaluating the feasibility of implementing an intelligent traffic management system (ITMS) using a smart city architecture to improve traffic flow in Nigeria. The scope of the work is:

- Evaluation of existing traffic management practices: Analyzing the strengths and weaknesses of the current traffic management system, including infrastructure, data collection methods, and traffic flow control strategies.
- Adapting intelligent traffic management concepts: Investigating how theories and technologies from traffic management, urban informatics, cyber-physical systems, and agent-based modeling can be adapted to Awka specific context.
- Adaptive traffic control and Pedestrian detection: Traffic lights with sensors and AI can adapt in real-time based on pedestrian flow and vehicular traffic, minimizing wait times and improving safety. Cameras and motion sensors can detect pedestrians waiting to cross, triggering the light change without needing to press a button.
- Cost-effective ITMS architecture design: Proposing an ITMS architecture that leverages cost-effective tools and technologies for data collection (sensors, cameras, mobile network data), data processing (edge computing, cloud platforms), and traffic management interventions (adaptive traffic lights, variable message signs, mobile applications).
- Data analysis and modeling: Exploring techniques for real-time data analysis and traffic flow modeling to identify congestion patterns, predict bottlenecks, and inform dynamic traffic management decisions.
- Public acceptance and user behavior: Examining strategies to encourage public acceptance of the ITMS and promote user participation through awareness campaigns and user-centered design of mobile applications and information displays.

This research was able to assign more time to the more congested roads by incorporating artificial intelligence in the existing technique. A smart city architecture that utilizes real-time traffic data collected from sensors and cameras to optimize traffic light timing and the aim of the optimization is to enhance car and pedestrian mobility.

2.0 Materials and methods

Characterized test bed environment of the road network under study (Unizik junction, Awka). To check the rate of traffic flow on our roads from January to July 2024 considering the peak hours (morning). Usually, morning and evening hours are peak hours because of the influence of main market Onitsha and travelers from Eastern to Western Nigeria (e.g. Lagos). Vehicles were manually counted to ascertain the number of vehicles that passes through the road between 7 to 8am on the first of every month from January to July 2024.

Table 1: The empirical data collected for week 1 morning hours

NUMBER OF DAYS	TIME MORNING	NUMBER OF VEHICLES FROM ONITSHA TOWARDS ENUGU	NUMBER OF VEHICLES FROM ENUGU TOWARDS ONITSHA	CONGESTION RATE
JANUARY	7AM-8AM	60	70	90%
FEBRUARY	7AM-8AM	45	56	70%
MARCH	7AM-8AM	48	60	75%
APRIL	7AM-8AM	43	56	74%
MAY	7AM-8AM	44	58	76%
JUNE	7AM-8AM	30	40	74%
JULY	7AM-8AM	29	38	50%

Table 1 above shows the number of vehicles passing at the junction from 7am to 8am in other to know the peak vehicular movement which will help us determine expected no of vehicles passing at the time to aid the design considerations.

Table 2: Characterized Poor Traffic Flow

Characterized poor traffic flow in Awka metropolis	Percentage of characterized poor traffic flow in Awka metropolis (%)
Congestion	60
Increased travel times	20
Stop-and-go traffic	5
High accident rates	15

Traffic flow refers to the smoothness and speed of vehicle movement on a road network. Poor traffic flow in Awka metropolis can be characterized by:

- Congestion: Frequent occurrences of slow-moving traffic, especially during peak hours.
- Increased travel times: Longer than usual travel times to destinations due to congestion and inefficient traffic management.
- Stop-and-go traffic: Vehicles frequently coming to a complete stop and starting again due to congestion or poorly timed traffic signals.
- High accident rates: Increased likelihood of accidents due to frustration, impatience, and sudden braking caused by congested conditions.

Table 3: Causes of Poor Traffic Flow

Pivot of causes of Poor Traffic Flow in Awka Metropolis	causes of Poor Traffic Flow in Awka Metropolis	causes of Poor Traffic Flow in Awka Metropolis (%)
Infrastructure Constraints	Limited road capacity	8
	Poor road conditions	12
	Lack of proper signage and lane markings	7
	Inadequate pedestrian infrastructure	5
Traffic Management Issues	Inefficient traffic signal timing	13
	Lack of intelligent transportation systems	15
	Poor enforcement of traffic laws	6

Travel Demand and Behavior	High number of private vehicles	4
	Unplanned urbanization	15
	Uncoordinated delivery schedules	1
	Lack of public awareness	14

Several factors contribute to poor traffic flow in Awka metropolis, which can be categorized into three main areas:

Infrastructure Constraints

- Limited road capacity: Insufficient number of lanes or narrow roads relative to the volume of traffic, especially during peak hours.
- Poor road conditions: Potholes, uneven surfaces, and inadequate road maintenance can slow down traffic and increase congestion.
- Lack of proper signage and lane markings: Unclear or missing signage and lane markings can lead to driver confusion and hesitation, impacting traffic flow.
- Inadequate pedestrian infrastructure: Pedestrians walking on roadways due to lack of sidewalks or designated crossing areas can disrupt traffic flow.

Traffic Management Issues

- Inefficient traffic signal timing: Traffic lights not synchronized or optimized for current traffic conditions, leading to unnecessary stops and delays.
- Lack of intelligent transportation systems (ITS): Absence of real-time traffic monitoring, adaptive traffic signal control, or dynamic route guidance systems.
- Poor enforcement of traffic laws: Disregard for traffic rules (e.g., speeding, illegal parking, not using designated lanes) can lead to congestion and accidents.

Travel Demand and Behavior

- High number of private vehicles: Over-reliance on personal vehicles instead of public transport, ride-sharing, or carpooling contributes to traffic congestion.
- Unplanned urbanization: Rapid urban sprawl without proper traffic planning and infrastructure development can lead to increased travel distances and congestion.
- Uncoordinated delivery schedules: Frequent deliveries during peak hours can disrupt traffic flow.
- Lack of public awareness: Limited public awareness about alternative transportation options, fuel-efficient driving practices, and responsible commuting behavior.

2.1 Conventional SIMULINK model for implementing smart city architecture

This is a conventional SIMULINK model use to control traffic congestion in a city. In this design the traffic light is timed to operate with a timer that allocate constant time to every lane at a junction, when the time elapses with or without vehicular movement, it moves to another lane and so forth, causing congestion in the other lanes.

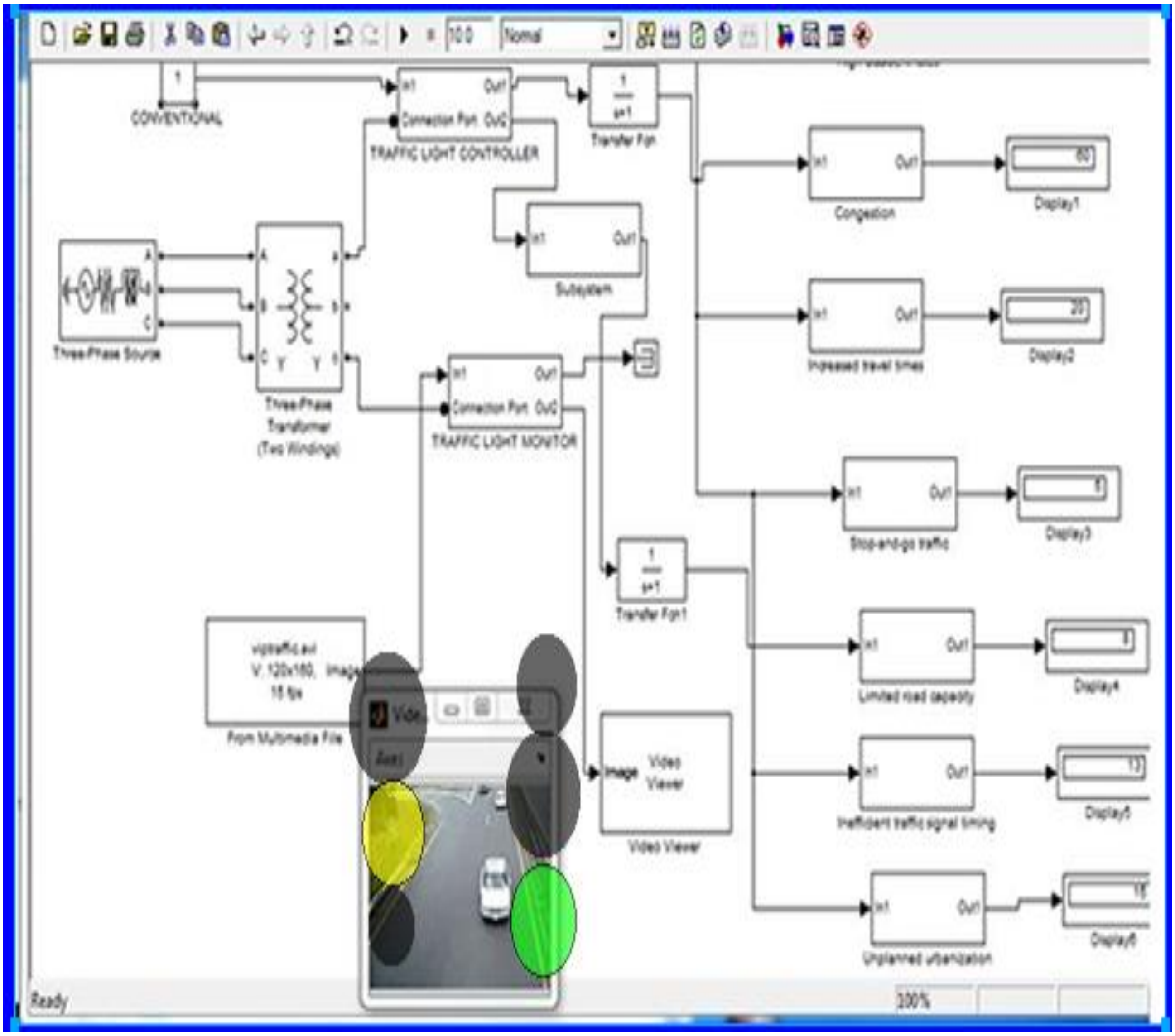

Figure 1: Conventional SIMULINK model

2.2 Smart city architecture

The architecture of the system design for smart city using intelligent system.

2.2.1 Smart city Rule

To design a smart city rule base that will detect more congested road and allocate more time for it to pass and less congested road and allocate less time for it to pass thereby enhancing traffic flow.

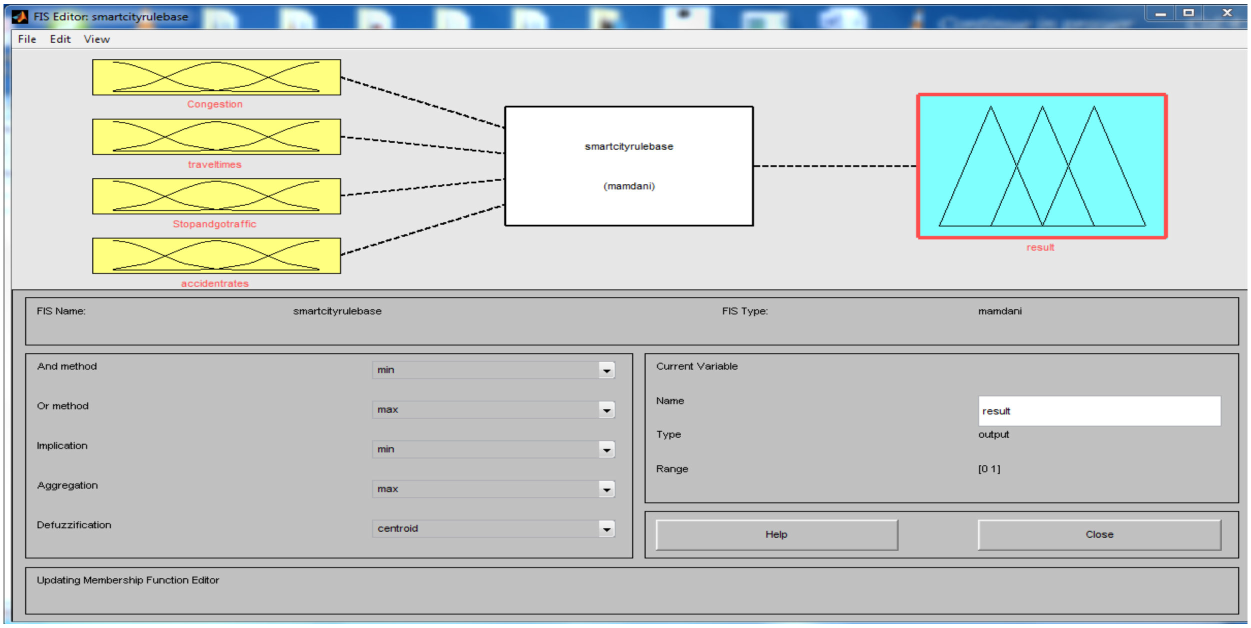

Figure 2: A smart city fuzzy inference system

This has four inputs of congestion, travel time, stop and go traffic and accident rate. It also has result outputs.

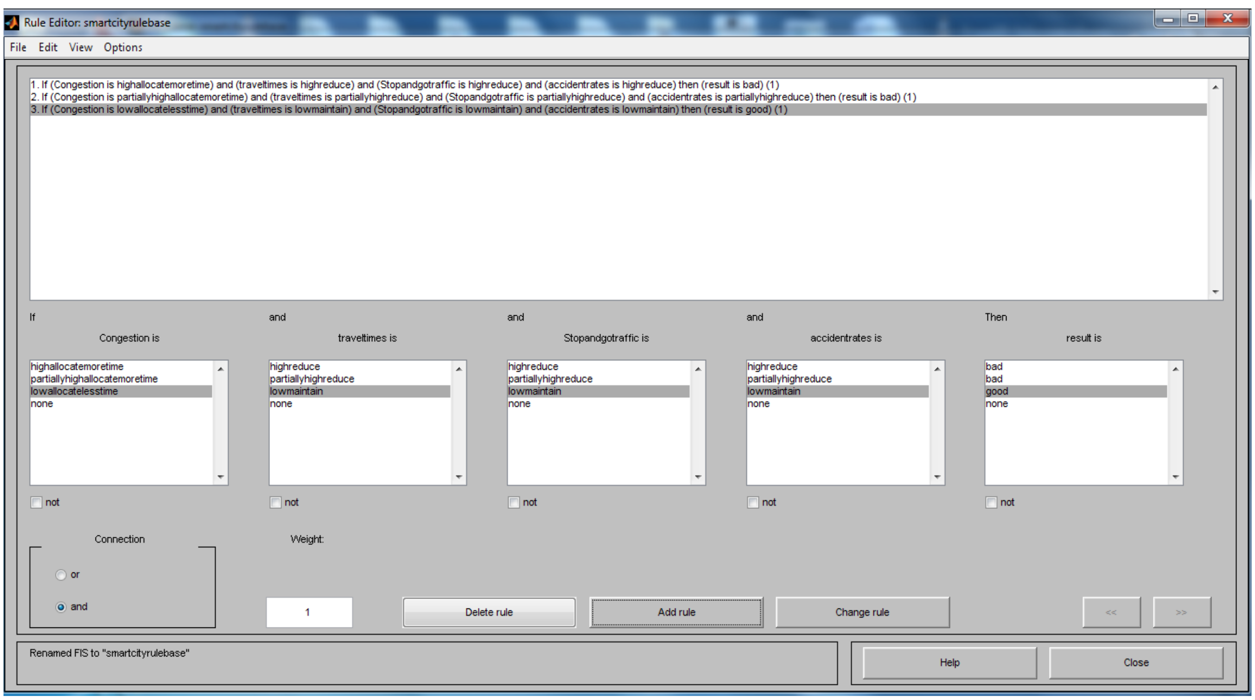

Figure 3: Design of a smart city rule base

2.2.2 Smart city rule base

Analysis of the design of a smart city rule base that will detect more congested road and allocate more time for it to pass and less congested road and allocate less time for it to pass thereby enhancing traffic flow.

Table 4: The comprehensive analysis of smart city rule base

1	IF CONGESTION IS HIGH ALLOCATE MORE TIME	AND TRAVEL TIME IS HIGH REDUCE	AND STOP AND GO TRAFFIC IS HIGH REDUCE	AND ACCIDENT RATE IS HIGH REDUCE	THEN RESULT IS BAD
2	IF CONGESTION IS PARTIALLY HIGH ALLOCATE MORE TIME	AND TRAVEL TIME IS PARTIALLY HIGH REDUCE	AND STOP AND GO TRAFFIC IS PARTIALLY HIGH REDUCE	AND ACCIDENT RATE IS PARTIALLY HIGH REDUCE	THEN RESULT IS BAD
3	IF CONGESTION IS LOW ALLOCATE LESS TIME	AND TRAVEL TIME IS LOW MAINTAIN	AND STOP AND GO TRAFFIC IS LOW MAINTAIN	AND ACCIDENT RATE IS LOW MAINTAIN	THEN RESULT IS GOOD

The rule base above helps determine which lane is allow to move and how much time is allocated to the lane depending on the traffic condition on the lane.

Smart city rule base flow chart

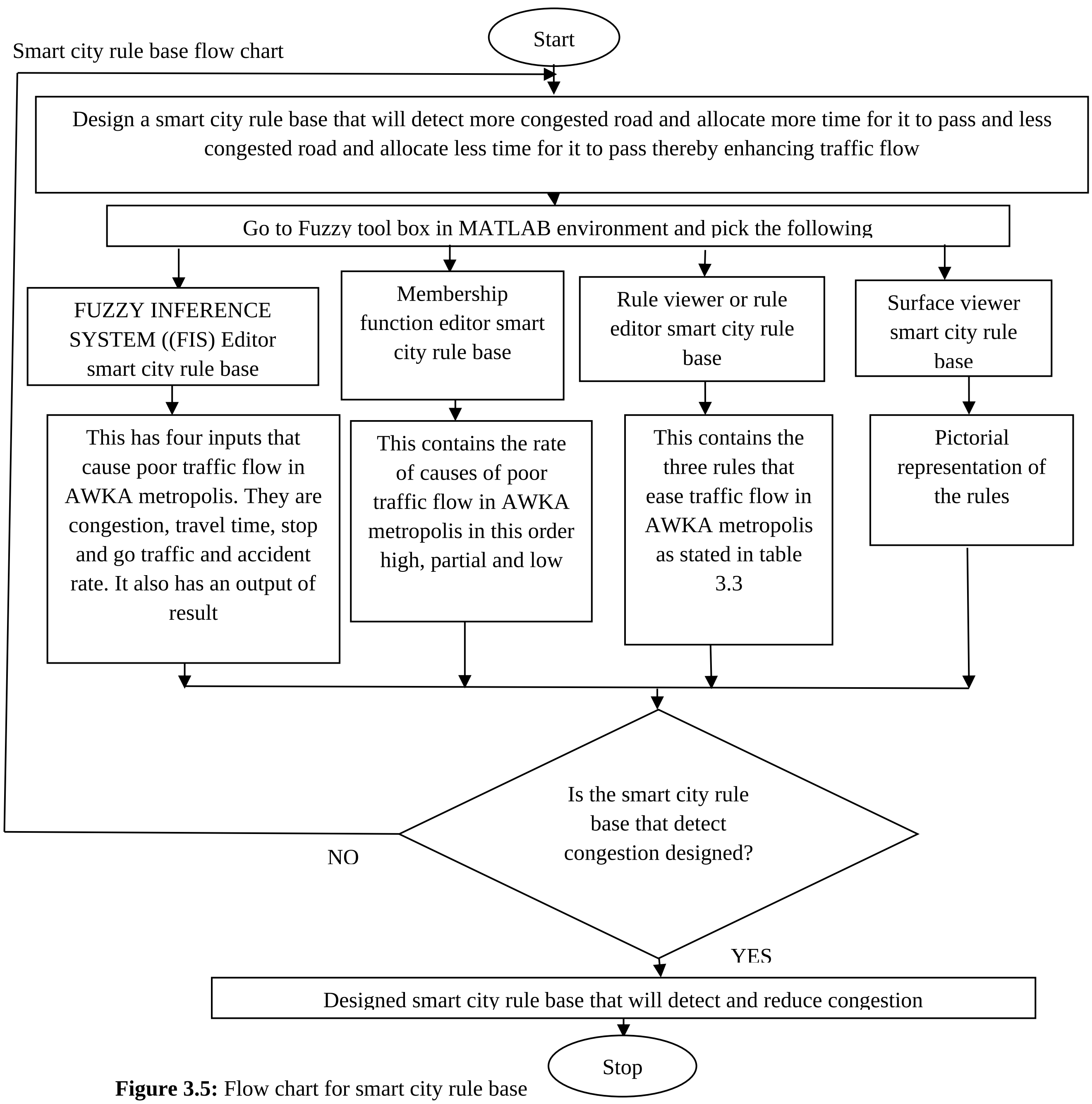

Figure 3.5: Flow chart for smart city rule base

2.3 Artificial neural network (ANN) training

In the ANN training comparison made, we discovered that in the 1st, 2nd and 3rd ANN training, the values varies for each conditions considered and remain constant after the fourth training and above. Indicating that only 1st, 2nd, and 3rd ANN training gives us the perfect result that is required for the smart city rule base to effectively enhance traffic flow.

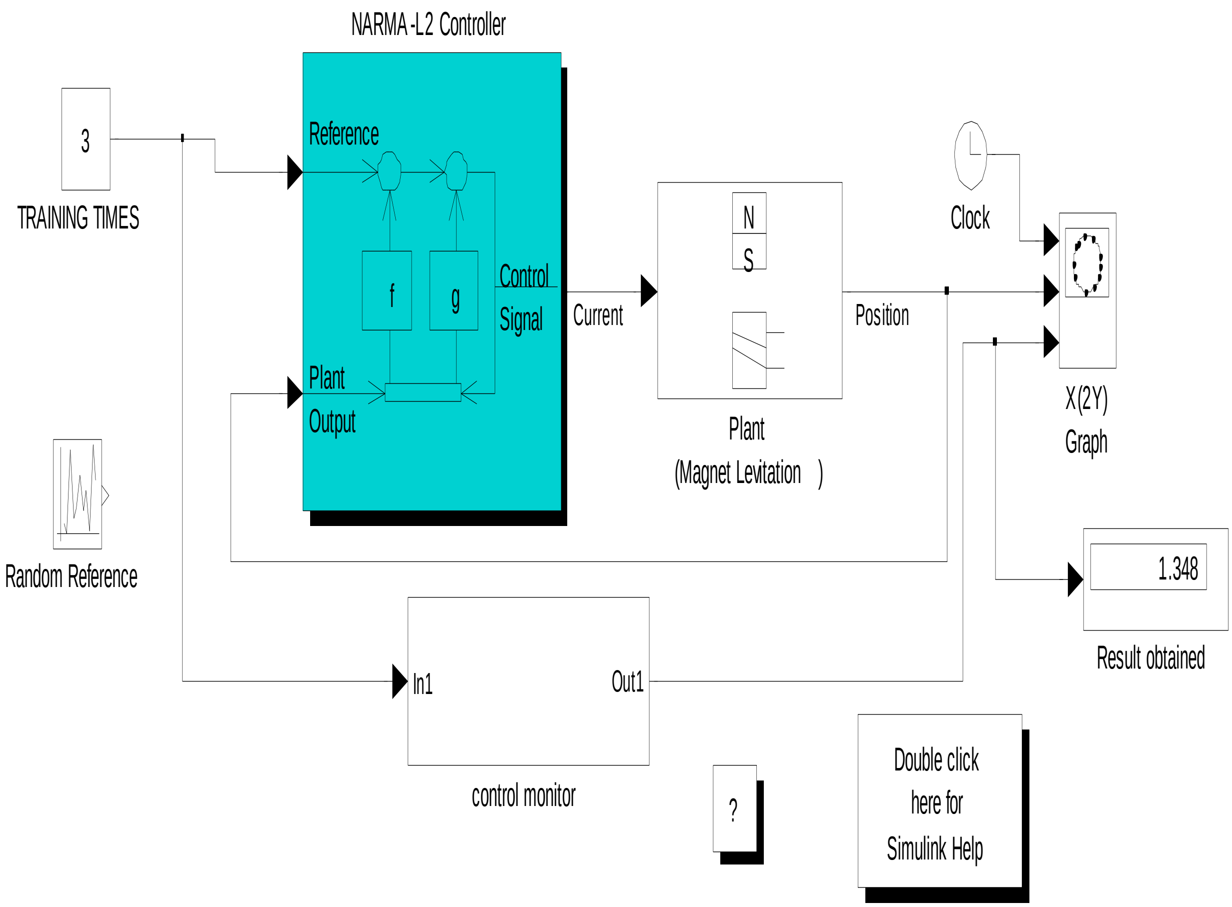

Figure 4: ANN trained three times

Here we compare the 1st, 2nd and 3rd ANN training in smart city rule base for effective enhancement of traffic flow.

Table 4.1: High accident rate

Time(s)	High accident rate in 1st Training ANN in smart city rule base for effective enhancement of traffic flow in Awka metropolis (%), (red)	High accident rate in 2ND Training ANN in smart city rule base for effective enhancement of traffic flow in Awka metropolis (%), (blue)	High accident rate in 3RD Training ANN in smart city rule base for effective enhancement of traffic flow in Awka metropolis (%), (green)
0	0	0	0
1	10	8.3	8
2	13	11.8	11.4
3	14.1	13	12.2
4	14.82	13.59	12.92
10	14.82	13.59	12.92

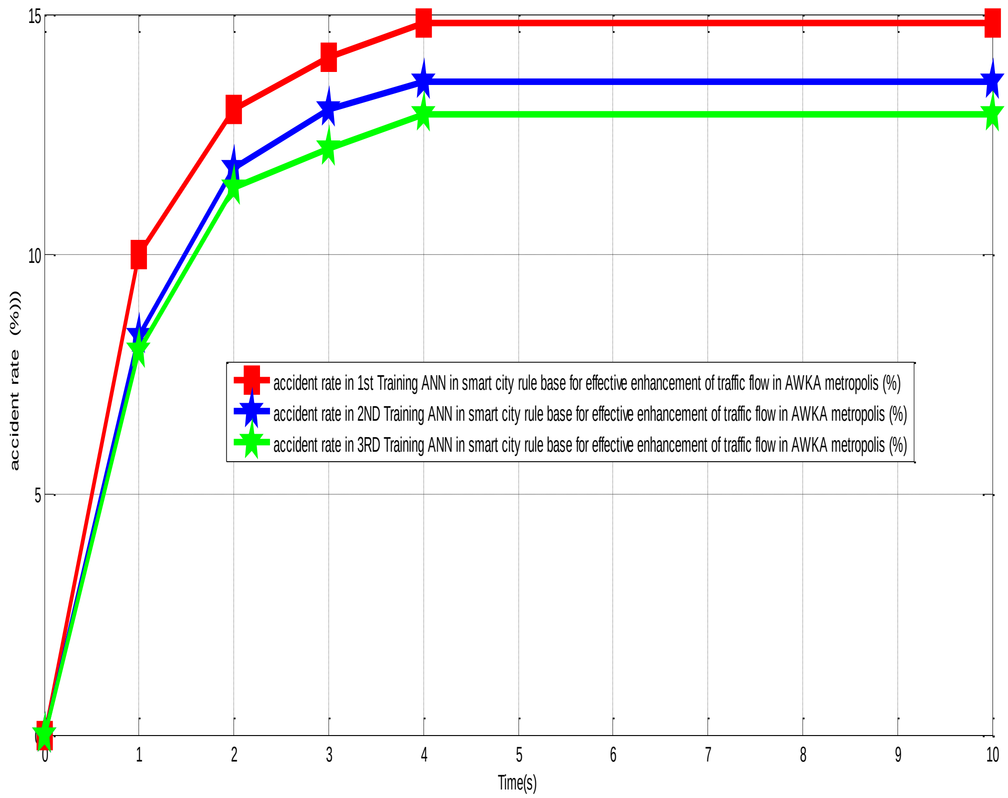

Figure 5: Comparison of High accident rate

In fig 5 above, the first ANN training catapulted accident rate in Awka metropolis to 14.82% while in the second ANN training reduced the accident rate to 13.59%. Finally, in the third ANN training it drastically reduced accident rate to 12.92%.

Table 4.2: Increase in travelling time

Time(s)	Increase in travelling time in 1st Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (red)	Increase in travelling time in 2ND Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (yellow)	Increase in travelling time in 3RD Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (BLUE)
0	0	0	0
1	12.5	12	10.2
2	17	16	14.3
3	18.2	17.2	16
4	19.76	18.12	17.23
10	19.76	18.12	17.23

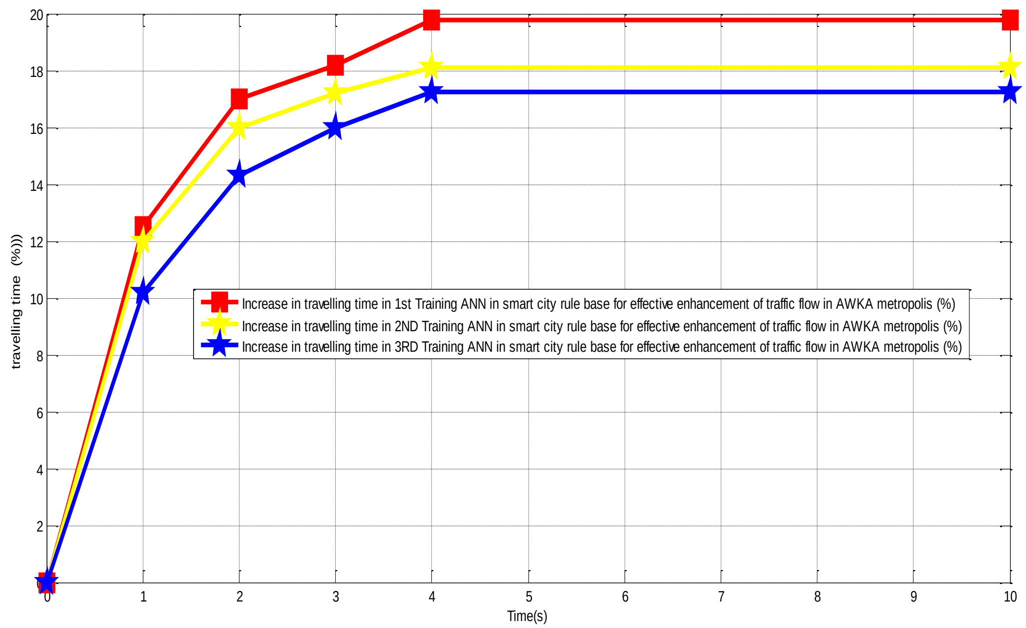

Figure 6: Comparison of increase in travelling time

Table 4.3: Limited road capacity

Time(s)	Limited road capacity in 1st Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (red)	Limited road capacity in 2ND Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (green)	Limited road capacity in 3RD Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (yellow)
0	0	0	0
1	5	6	6.8
2	7	8.2	9.2
3	7.9	9.2	10.2
4	8.193	9.743	10.78
10	8.193	9.743	10.78

Table 4.4: Inefficient traffic signal timing

Time(s)	Inefficient traffic signal timing in 1st Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (yellow)	Inefficient traffic signal timing in 2ND Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (greeen)	Inefficient traffic signal timing in 3RD Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (red)
0	0	0	0
1	8	7.5	7
2	11	10	9
3	12.2	11.2	10.2
4	12.85	11.78	11.2
10	12.85	11.78	11.2

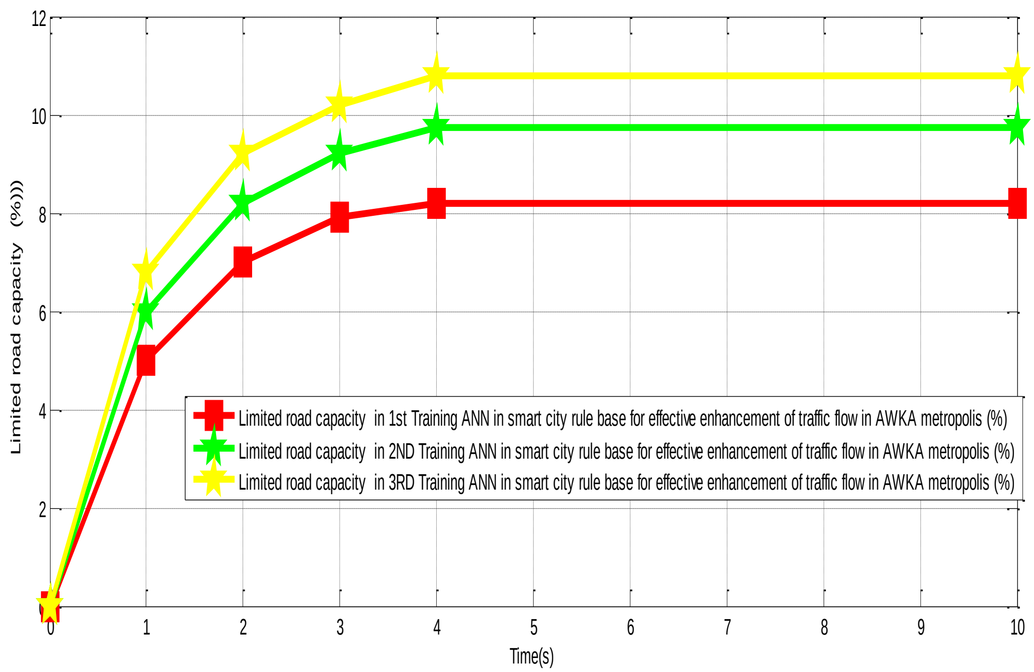

Figure. 7: Comparison of limited road capacity

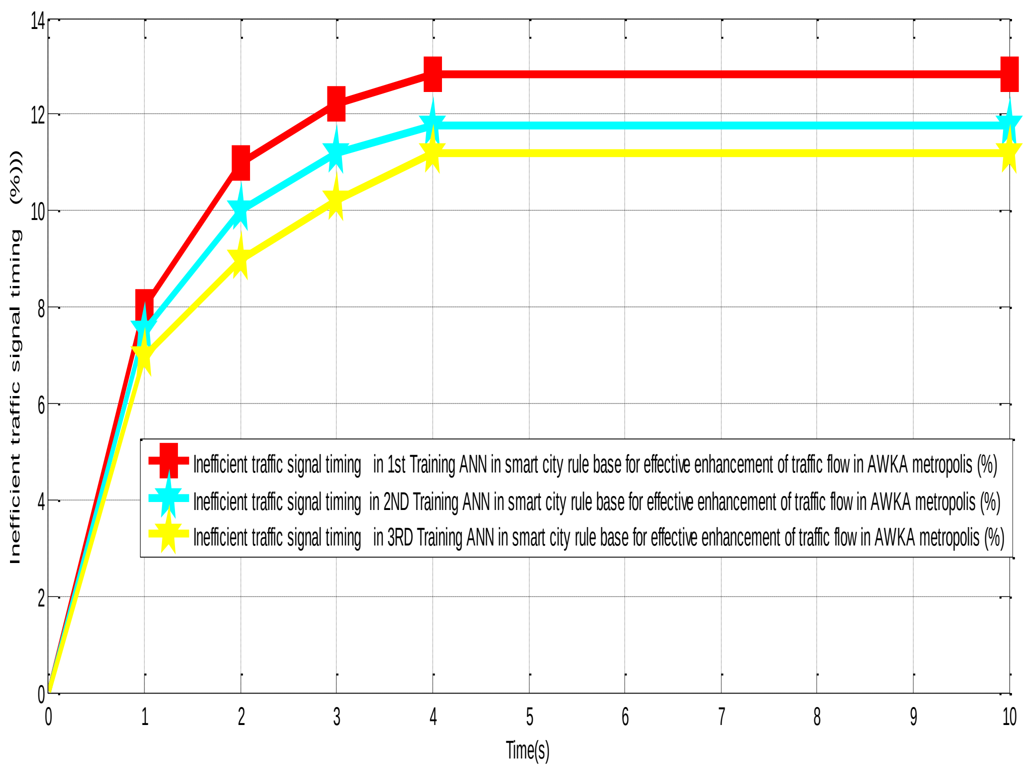

Figure. 8: Comparison of inefficient traffic signal timing

Table 4.5: Road congestion

Time(s)	Congestion in 1st Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (red)	Congestion in 2ND Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (blue)	Congestion in 3RD Training ANN in smart city rule base for effective enhancement of traffic flow in AWKA metropolis (%), (yellow)
0	0	0	0
1	40	34	31
2	51	48	45
3	55	51	49
4	59.29	54.37	51.68
10	59.29	54.37	51.68

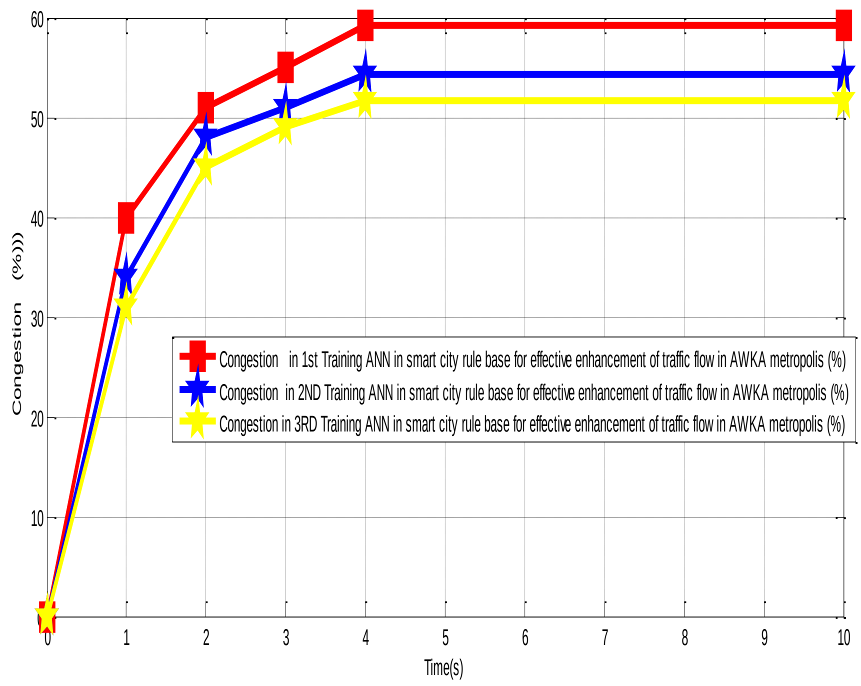

Figure 9: Comparison of road congestion

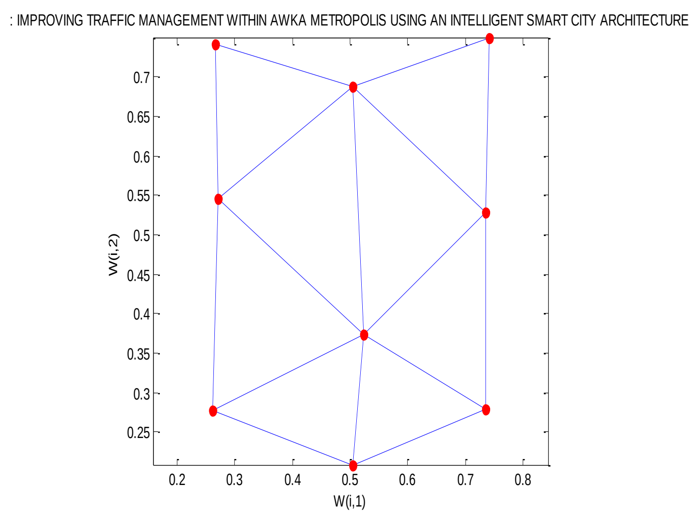

Figure 10: Results obtained when ANN was trained three times

When ANN was trained three times in the three rules of smart city 3 x 3 = 9 to give nine neurons that look exactly like human brain and does what it is allocated to do.

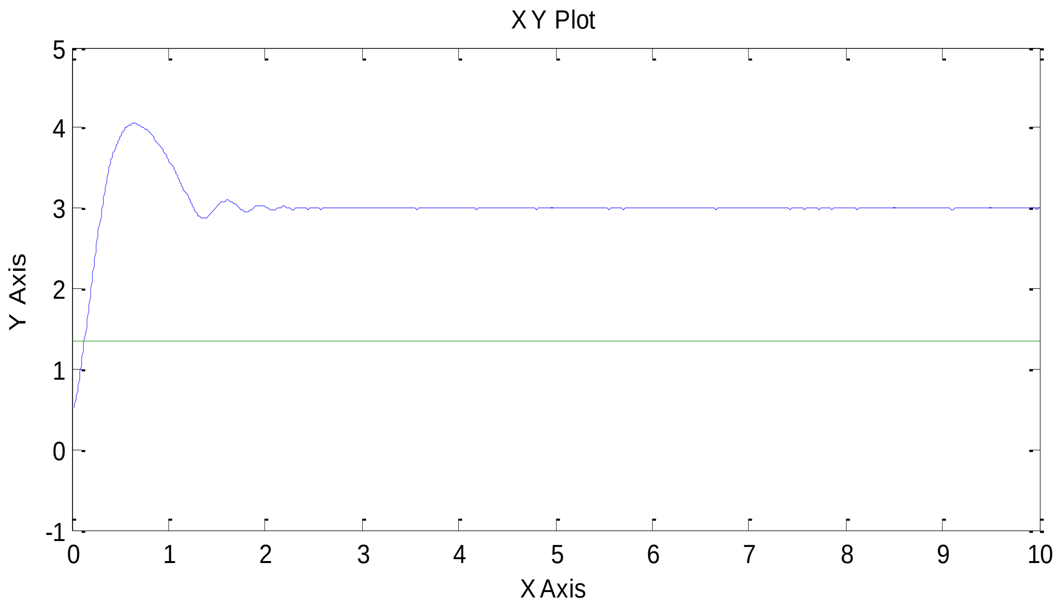

Figure 11: Graphical representation for the number of trainings

Y axis represents number of times of the training while the x axis represents the number of neurons that will be obtained after the training. Since, it was trained three times, it stabilizes at time 3.

2.2.4 Intelligent system SIMULINK model

To design a conventional smart city SIMULINK model for traffic management within Awka metropolis. This conventional model is an already existing model.

2.4 Smart city rule base algorithm

To develop an algorithm that will implement the process

1. Characterize poor traffic flow in Awka metropolis
2. Establish the causes of poor traffic flow in Awka metropolis
3. Identify infrastructure Constraints
4. Identify Traffic Management Issues:
5. Identify Travel Demand and Behavior
6. Design a conventional SIMULINK model for traffic management within Awka metropolis and integrate 3 through 5.
7. Design a smart city rule base that will detect more congested road and allocate more time for it to pass and less congested road and allocate less time for it to pass thereby enhancing traffic flow.
8. Train ANN in this smart city rule base for effective enhancement of traffic flow in Awka metropolis
9. Design a smart city SIMULINK model
10. Integrate 7 through 9
11. Integrate 10 in 6
12. Did the identified causes of Poor Traffic Flow in Awka metropolis reduce when 10 was integrated to 6?
13. If NO go to 11.
14. If YES go to 15
15. Improved traffic management within Awka metropolis
16. Stop
17. End

2.4 SIMULINK architecture of intelligent smart city model

The designed SIMULINK architecture model for improving traffic management of an intelligent smart city. Here the intelligent smart city model is interfaced with the conventional traffic system. using intelligent smart city model on the system, the high accident rate is reduced to improve traffic flow as shown in table 5 below

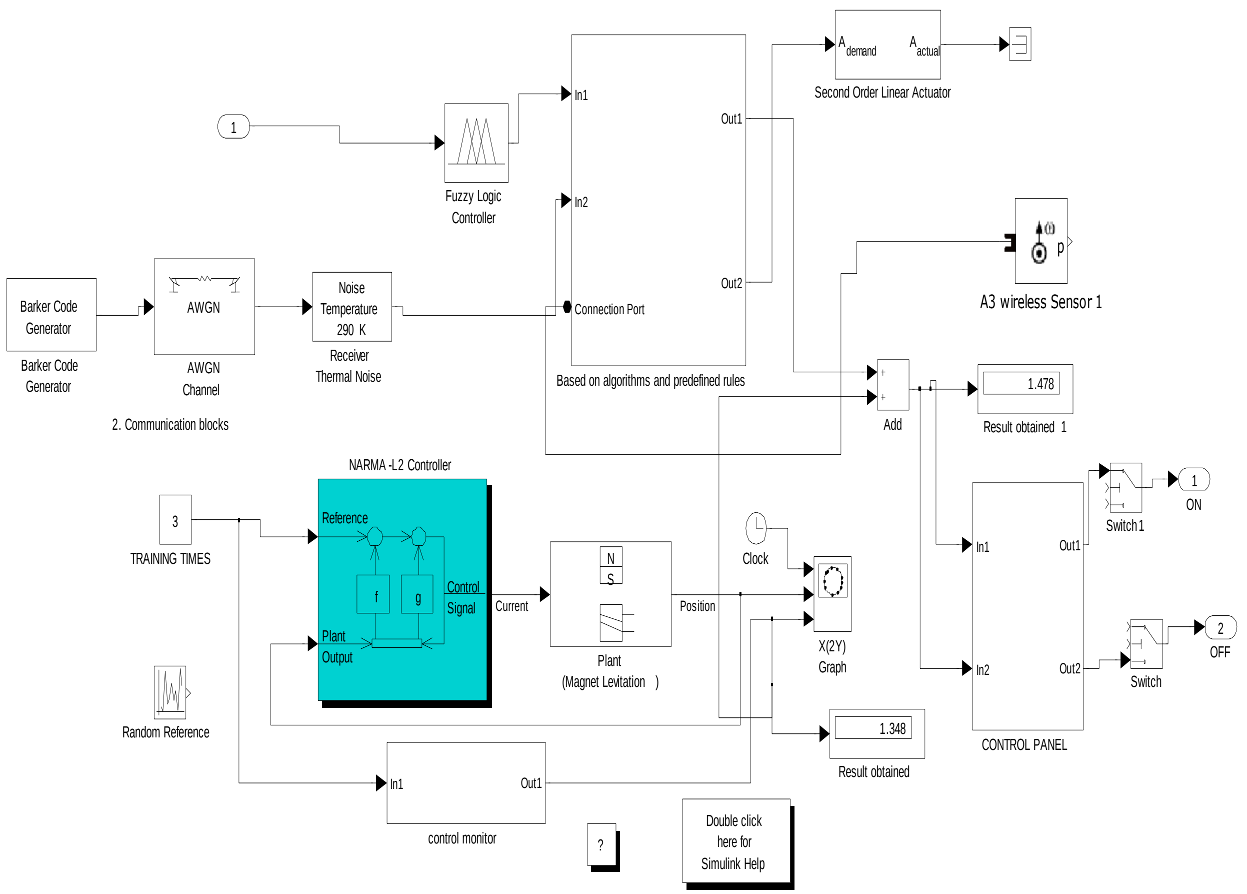

Figure 12: Designed intelligent system SIMULINK model

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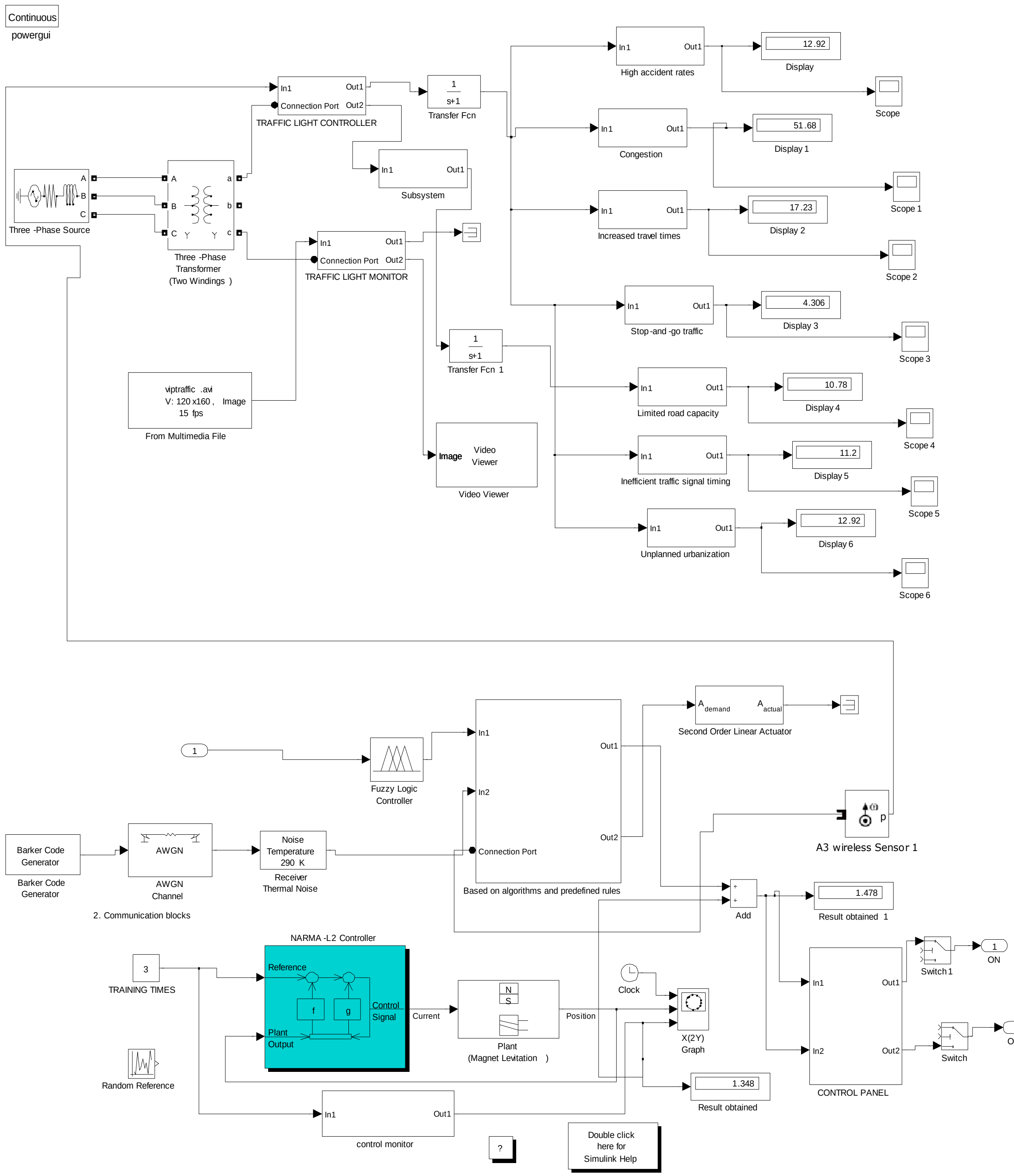

Figure 13: Intelligent smart city SIMULINK model

Here the traffic light design using intelligent smart city allocate time automatically base on the number of vehicles on a lane and automatically assign time to another lane where there are vehicles waiting to move.

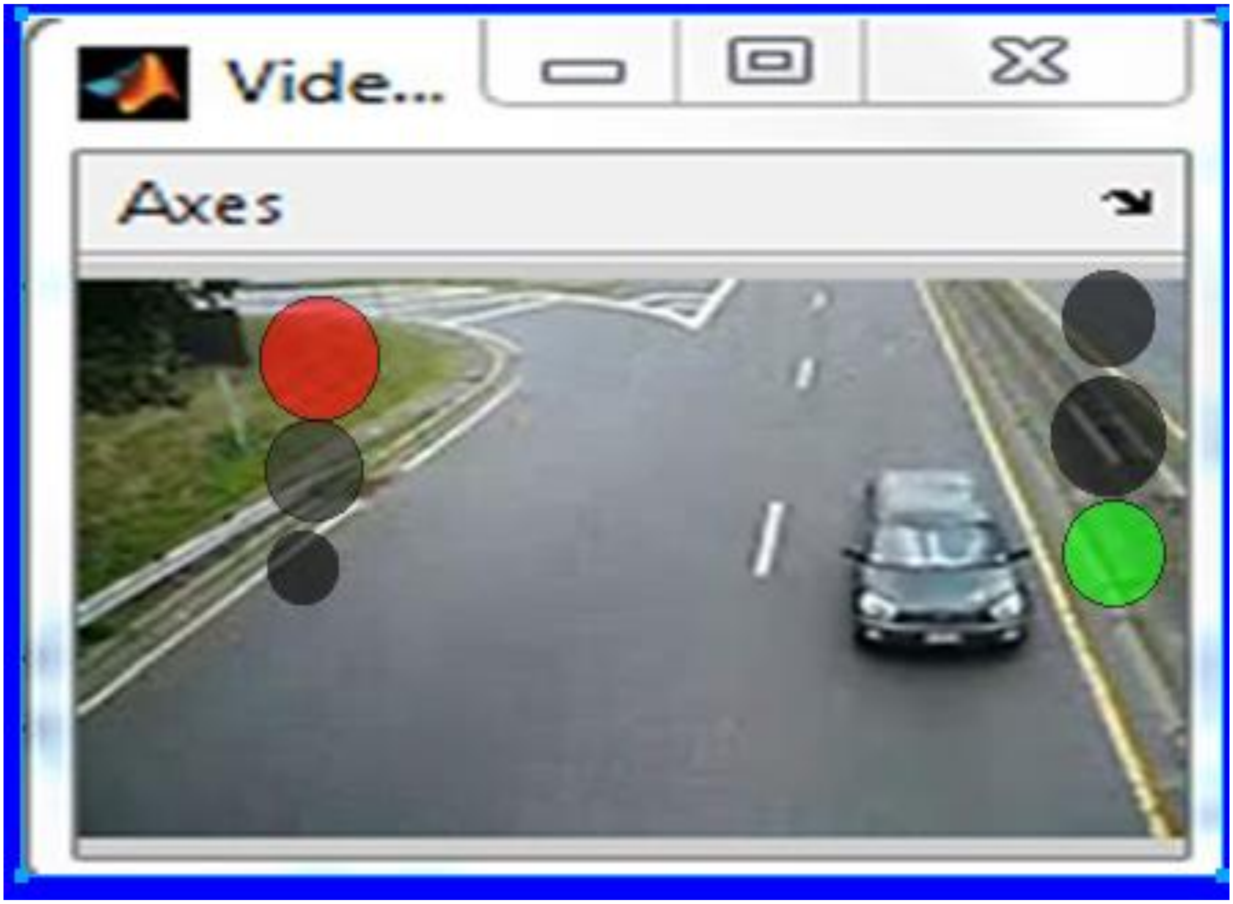

Figure 14: Result obtained when designed SIMULINK model for improving traffic management within Awka metropolis using an intelligent smart city architecture.

3.0 Result and Discussion

Comparison of conventional and intelligent smart city architecture in improving traffic management, considering four factors such as high accident rate, travel time, limited road capacity and inefficient traffic signal timing.

Table 5: High accident rate

Time(s)	Conventional High accident rate in improving traffic management within Awka metropolis (%)	Intelligent smart city architecture High accident rate in improving traffic management within Awka metropolis ((%)
0	0	0
1	10	8
2	13	11.4
3	14	12.2
4	15	12.92
10	15	12.92

The conventional accident rate in Awka metropolis is 15%. On the other hand, when intelligent smart city architecture was integrated in the system, the accident rate reduced to 12.92%. With these results obtained, it shows that percentage improvement in the reduction of accident rate in Awka metropolis when intelligent smart city architecture is integrated in the system over the conventional aspect is 2.08%.

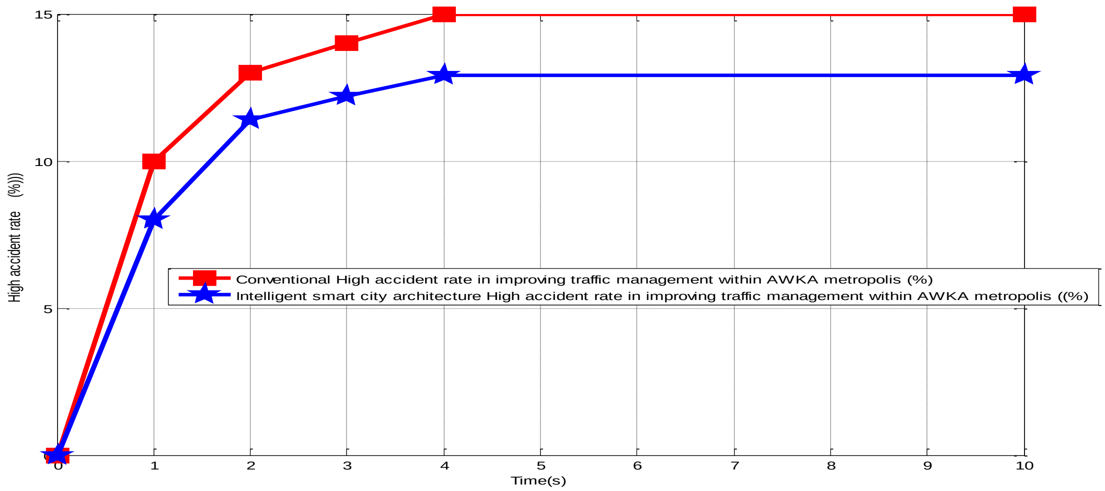

Figure 15: Comparison of high accident rate

Table 6: Travel time

Time(s)	Conventional travel time in improving traffic management within Awka metropolis	Intelligent smart city architecture travel time in improving traffic management within Awka metropolis
0	0	0
1	12.2	10.2
2	17.3	14.3
3	19	16
4	20	17.23
10	20	17.23

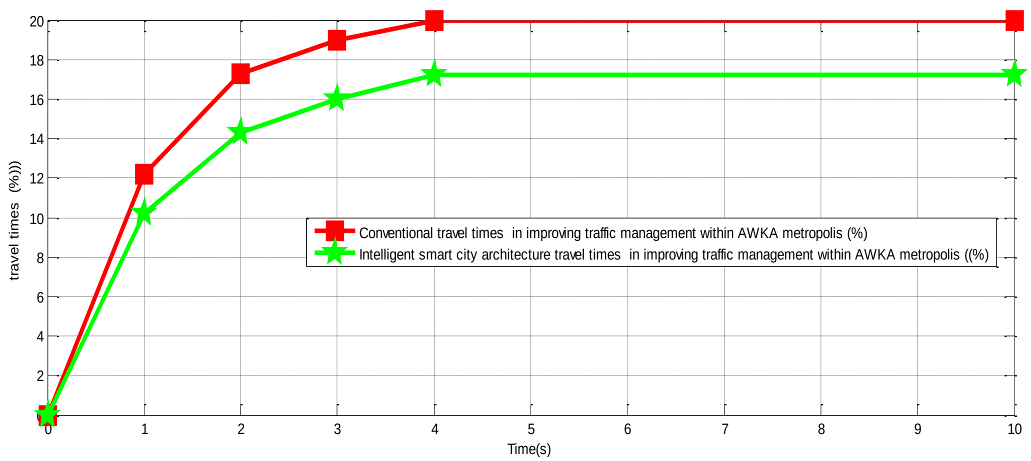

Figure 16: Comparison of travel time

The percentage of travel time that caused congestion which delayed travelers to arrive at their respective destinations late is 20%. However, when intelligent smart city architecture is imbibed in the system, it reduced to 17.23%. The percentage improvement in the travelers arriving to their respective destinations earlier is 2.77%.

Table 7: Limited road capacity

Time(s)	Conventional limited road capacity in improving traffic management within Awka metropolis	Intelligent smart city architecture limited road capacity in improving traffic management within Awka metropolis
0	0	0
1	5	6.8
2	7	9.2
3	7.6	10.2
4	8	10.78
10	8	10.78

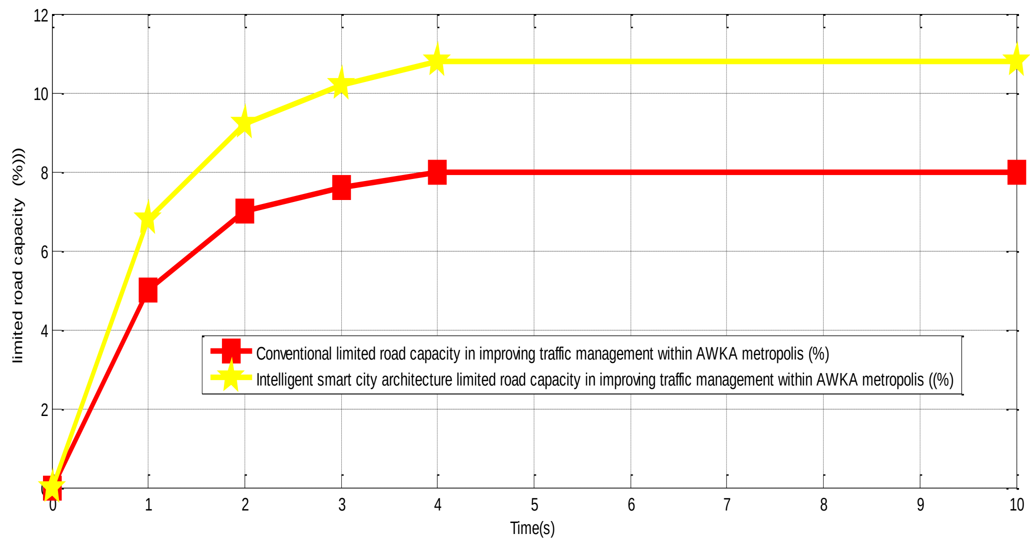

Figure 17: Comparison of limited road capacity

The conventional road capacity was 8% while when intelligent smart city architecture was input in the system, it improved to 10.78%.

Table 8: Inefficient traffic signal timing

Time(s)	Conventional inefficient traffic signal timing in improving traffic management within Awka metropolis	Intelligent smart city architecture inefficient traffic signal timing in improving traffic management within Awka metropolis
0	0	0
1	8	7
2	11.2	9
3	12.1	10.2
4	13	11.2
10	13	11.2

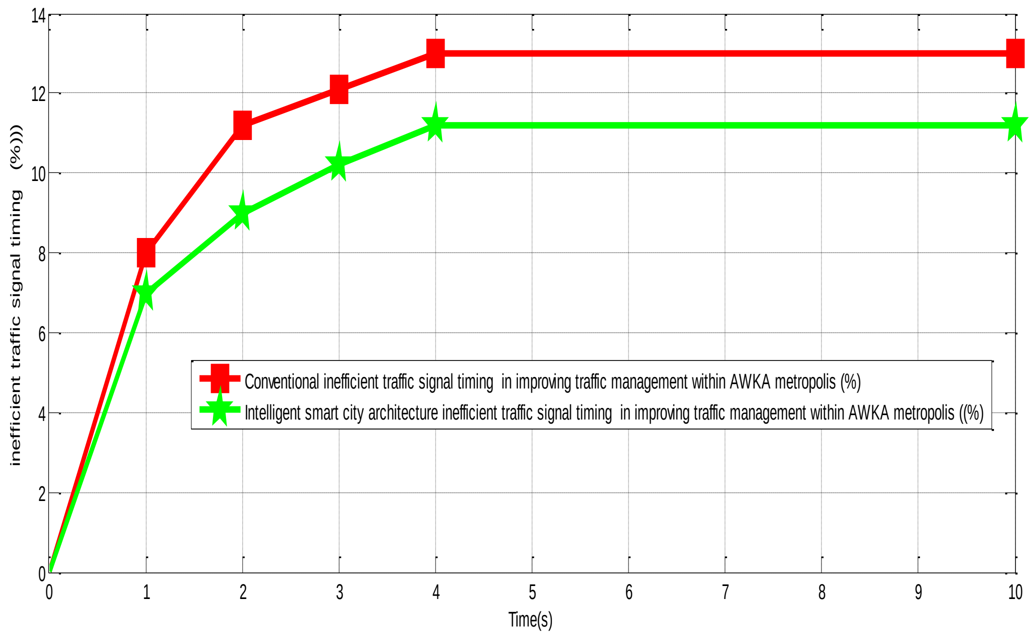

Figure 18: Comparison of inefficient traffic signal timing

The conventional inefficient traffic signal timing was 13% but when there was an incorporation of an intelligent smart city architecture it reduced to 11.2% thereby minimizing congestion in Awka metropolis.

4.0. Conclusion

The delay in the arrival of passengers to their respective destination in time is anchored as a result of congestion in Awka metropolis. This is outwitted by developing a framework for designing smart city architecture using intelligent system: Awka as a case study. The results obtained are the first training of ANN which reduces congestion in Awka metropolis to 59.29%, the second training of ANN congestion in Awka was further reduced to 54.37%, and when ANN was trained for the third time congestion in Awka metropolis was reduced to 51.68% thereby enhancing traffic flow in Awka metropolis. The conventional road capacity in Awka metropolis was 8%, but when an intelligent smart city architecture was integrated in the system, it enhanced to 10.78%. The conventional inefficient traffic signal timing was 13%, but when an intelligent smart city architecture was incorporation in the system it reduced to 11.2% thereby minimizing congestion in Awka metropolis. The conventional congestion that caused delay for passengers arriving to their respective destinations in time is 60%, when intelligent smart city architecture was integrated in the system, it decisively reduced to 51.68%. Finally, with these results obtained, it shows that the percentage improvement in the reduction of congestion in Awka metropolis when an intelligent smart city was incorporated in the system over the conventional counterpart is 8.32%, thereby improving the overall performance of the system. This supports more informed and dynamic traffic control strategies, ultimately enhancing the safety and flow of urban traffic which has far-reaching implications for quality of life, reducing stress for commuters and increasing productivity.

5.0 Recommendation

To boost consistent traffic flow in Awka metropolis and in some congested roads in Nigeria, smart city architecture using intelligent system should be implemented to improve traffic flow. Future work could focus on the development of more sophisticated AI-driven predictive models for traffic management, research could involve the use of deep learning and neural networks to improve the system's ability to predict traffic congestion and accidents, allowing for more proactive traffic management strategies.

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References

Adewumi, A. O., Ajayi, O. O., Oladapo, A. O., 2014. *Challenges of urban transportation in Nigeria. International Journal of Sustainable Development,* 9(8), 80-88.

F. Garcia, Helena H. (2023). *Traffic optimization through waiting prediction and evolutive algorithms. International Journal of Interactive Multimedia and Artificial Intelligence*. pg 1-10

Ifeche et al, (2019). *Microcontroller-based versatile traffic light control and trainer.* Princeton University Press

Li, Z., Liu, J., Wu, C., & Wang, Y. (2020). *A hierarchical architecture for smart city traffic management using edge computing and blockchain*. IEEE Access, 8, 171222-171233.

Li, Z., Liu, J., Wu, C., Wang, Y., 2020. *A hierarchical architecture for smart city traffic management using edge computing and block chain.* IEEE Access, 8, 171222-171233.

Mohammed, F., Bashir K., & Zhu, X. (2019). *A cloud-based intelligent traffic management system using big data analytics*. Future Internet, 11(12), 324.

Prasetyo, Habibie, (2022). *Smart city architecture Development framework (SCADEF)*. International Journal of informatics visualization. DOI: http://dx.doi.org/10.30630/joiv.6.4.1537

Ravish and Swamy, 2021. *Intelligent traffic management: A review of challenges, solutions, and future perspectives*

Rong, Zhang, (2024). *Smart city architecture: a technology guide for implementation and design challenges*. China communications 11 (3): 56-69

Wang, H., Chen, S., Liu, X., 2020. *Big data analytics for traffic management: A comprehensive review and case studies. Journal of Big Data*, *7*(1), 45-62. https://doi.org/10.1186/s40537-020-00312-1.

Zhang, Y., Li, X., & Wang, J., 2021. *Intelligent traffic control using machine learning techniques: A review and case study. Transportation Research Part C:* Emerging Technologies, 124, *1*02930. https://doi.org/10.1016/j.trc.2021.102930.