ISSN 2278-3091
Volume 9, No.3, May - June 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse08932020.pdf
https://doi.org/10.30534/ijatcse/2020/08932020

Machine Learning and Answer Set Program Rules towards Traffic Light Management

Nesreen Alsharman[1], Faisal Alzyoud [2], Adeeb Saaidah [3], Omar Almomani [4]
[1] The World Islamic Sciences & Education University, Jordan, nesreen.alsharman@wise.edu.jo
[2]Isra University, Jordan, faisal.alzyoud@iu.edu.jo
[3] The World Islamic Sciences & Education University, Jordan, adeeb.saaidah@wise.edu.jo
[4] The World Islamic Sciences & Education University, Jordan, Omar Almomani, Omar.almomani@wise.edu.jo

ABSTRACT

Due to the growth of population traffic congestions are increasing and reaching to critical limits, so it is considered as a severe challenge, that facing cities and metropolitans to solve traffic congestion. To achieve this there are many approaches and one of them, is developing an adaptive traffic light signal in order to tackle this problem. Therefore, before designing traffic signal, it is necessary to study all the factors that affect the design of traffic signal. Traffic light management system is an important factor for everyone within the city as it controls the traffic flow. The main reasons behind poor traffic light management system occur due to poor road management, rapid growth in number of cars, legacy traffic light system, and poor practices on behalf of drivers. Traffic light management system aims to reduce traffic congestion, safety, and delay. This paper utilizes the new technology of artificial intelligence approaches to generate an automated traffic light management in order to improve vehicles flow and minimize intersection delay in Jordan as a case study. The proposed approach starts with extracting rules from the data set using Weka. According to the extracted rules and some exception constraints, Answer Set Programming (ASP) is used to generate the solution for the extracting rules to return an optimal slot time for the traffic light phases dynamically.

Key words: Answer set programming, Data Mining, Traffic Light Management systems (TLM) and Vehicle-to-Infrastructure Traffic Congestion

1. INTRODUCTION

Villages are growing into towns, towns are growing into cities, and cities are growing into metropolitans. Human life is developing exponentially; their reliance on conventional services is not good enough anymore, they seek what cities and metropolitans are providing, and their dependence on technology has created the demand to grow. However, the infrastructure which is the platform where all services are built on is lagging in growth, which creates challenges. Transportation system is one of the big challenges as the number of vehicles is growing up leading to a traffic jam in streets. Traffic Light Management systems (TLM) are used to tackle traffic jam, unfortunately Traffic light management system needs constantly evaluation and identification of the existing problems to find solutions [7]. Traffic signals are widely used in metropolitans and large cities in the world, but there are obstacles and conflicts in designing traffic signals, since there is the different directions and they need adjusting, so there is a need to address the time-sharing principle between signal slots. However, traffic signals suffer from large stopped delays, and complexity in the design and implementation especially in the intersections. Although the overall delay may be lesser than a rotary for a high volume, a user may experience relatively high stopped delay. This paper discusses adapted dynamic design principles of traffic signal such as phase design, cycle length design, and phase-slot time splitting. In this paper Jordan traffic light management is studied as a case study [26], then the data set is manipulated by Weka simulation tool [1] to extract association rules. From the extracted association rules creation, a pre-condition, post-condition, and constrains for traffic congestion are considered in the study. Answer Set Programming (ASP) is used to find the optimal dynamic slot phase time solution for the proposed traffic light management to reduce traffic congestion and enhance traffic flow. Data mining is used to extract knowledge depending on the type of knowledge, so it can be categorized into supervised discovery and unsupervised discovery. In classification, each item is associated with a unique label, signifying the class in which the item belongs. In contrast, the latter does not require reclassification of the data and can form groups that share common characteristics [17]. Four data mining methods are commonly used: classification, clustering, association rules, and visualization.

Classification is a vital parameter in data mining, as it is considered a predictive patterns data mining, a data item is assigned to one of a predefined set of classes to test its attributes [2]. Decision tree is used in classification; as it is ease to implementation, understand, and more accessible to compared to other classification algorithms [12].

2.RELATED WORKS

Traffic systems can be defined as the desired solution of human or machine to flow from one point to other using efficient algorithms through applying different concepts like: fuzzy logic, parameter estimation, and artificial intelligence. Traffic lights management is considered one of the effected solutions to control and enhance traffic flows. Different approaches are proposed to control traffic light, one of the approaches is using optimization tool to decrease the traffic congestion and the time needs to cross a road. In this approach two modes are presented to show the traffic lights configuration and how these configuration modes will influence the movement of vehicle [18]. Another approach is to use the potential vehicle queue spillover detection by measuring the vehicle speed. This approach uses three traffic lights, which are switched depending on the queue spillover. The lights' colors triggers play an indicator for the time interval to swap between signal colors. So, a decision tree is based on adaptive signal control scheme is assigned to developed switching triggers. Integrating legacy communication systems with modern vehicular was proposed by [15] to have a cohesive traffic management system. In this approach, users' movements at intersections points are handled by a centralized controller unit through using intersections re-transmitters alerts and virtual light signalization that are controlled by smart devices. In this proposed approach the tests are carried out with real world implementations. This approach was based on passive receiving information, so active information system is needed to enable the controllers to take better decisions, in order to enhance the traffic management and customers' satisfactions [20] Google's data by Google API was proposed to inform drivers about crowdsourced traffic, so these is used as a guide for the drivers to predict the upcoming traffic light on their route by analyzing traffic density [16], according to their proposal system, there will be no additional infrastructure cost resulted from wireless sensors networks; as the proposed system uses the crowdsourced data. But their proposed system is not enough reliable to temporal fail in communications.
Smart traffic light based on PIC microcontroller was proposed by [6] to measure the density of traffic by using IR sensors, in this approach, the system will accomplish variable timing slots with different levels, so a portable controller device is also proposed to solve the problem of emergency vehicles stuck, during the traffic jam, in addition the car accidents and failure modes are not taken into consideration on this approach, Unfortunately, there is no integration between traffic controllers at different junctions to accomplish a complete synchronization [30].
Microscopic model was proposed by [25], this model represents a four road models: intersections configuration, links, lane choice and vehicle following. In microscopic model the line traffic adaptation is made using traffic status which depends on Approximate Dynamic Programming (ADP) which is based on number of cars queue vector and traffic lights signal. So, the action is taken depending on a time ***t*** that is denoted by vector form. Each moving lane changes its traffic light depending on action vector values.
It is noted that all the proposed approaches are facing the problem of finding a dynamic, consistent and convenient solution for traffic congestion, in addition to that most of their researches are concentrating on road intersections, unlike the proposed system which does not consider the other sources of traffic congestions such as natural conditions and drivers' behavior as a whole set. In Jordan there are no proposed studies to solve the traffic congestion using traffic light management. Also, there is no comprehensive strategy to solve traffic congestions and there are no safety policies to tackle the traffic accidents' problem in Jordan.

3. PROPOSED TRAFFIC LIGHT MANAGEMENT SYSTEM

Traffic signals are used to remove conflicting between road slots, decrease traffic congestion and increase safety. Proper design of traffic signal system will impose a solution with minimum delay on all traffic, consistent and safety. Figure 1 shows the traffic light management proposed approach using Answer Set Programming (ASP) and Data mining in Jordan.
One important aspect is to assume the vehicle and traffic control station can process road, weather condition, traffic congestion, car priority, accident status, and engine information, to predict and avoid hazards and delays by mimicking the real situations. Wireless ad hoc network application such as Vehicle-to-Infrastructure and Vehicle-to-Vehicle technologies can be applied to control traffic station [27]. With these current technologies, we can assign the values for each added attribute. Weather conditions attribute has the following probably values: sunny, snow, and raining. Accident status has two possible values: true, false where the true value indicates there is accident, and false value indicates there is no accident. Car _priority attribute has three possible values: high such as emergency Vehicle, medium such as police car, and low for any other type of car.

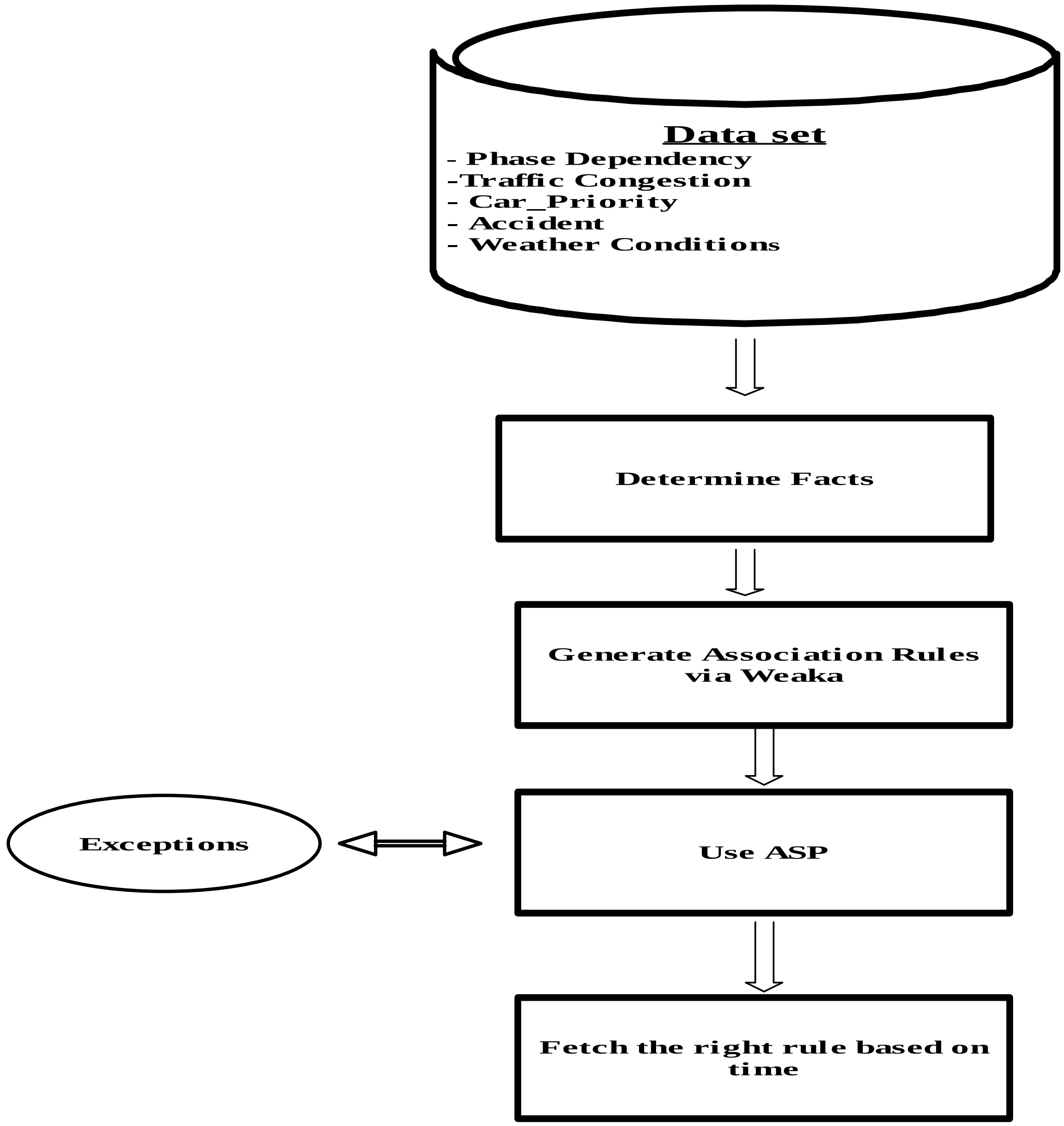

Figure 1: Traffic Light Management using Answer Set Programming (ASP) and Data mining in Jordan

4.DATA SET

This paper uses the data set that are collected from Amman works [26]. The data set consists of a set of intersections. Each intersection had different phases and each phase is assigned static slot phase time according to phase dependency attribute. In this paper to assign each phase a dynamic slot time, the following tasks are added:

1) Add four attributes for each intersection: weather condition, accident status, car_priority, and traffic congestion.
2) Use mathematical model. To assign dynamic interval time for each phase.
3) Apply data miming software (WEKA) to minimize data set.
4) Select a satisfied rule according to input values to get optimal phase slot time slots.

This research depends on mathematical equation 1 to assign the ideal values for the possible dynamic slot time phase:

$$T = D/V \qquad (1)$$

Where T is a dynamic slot phase time (the time needed to pass N vehicle), D is the distance from the car to traffic light signal, and V is the speed of car.
Equation 1 does not considers start up waste time, and saturation headway so that the second equation is used to take these factors into [23].

$$T = l + h*N \qquad (2)$$

Where $\boldsymbol{l}$ is lost time start-up and $\boldsymbol{h}$ is the saturation headway in second.
Figure 2 shows a sample of data set after assigning values for each attribute.

Weather	Traffic	Accident	Car_priority	Phase	Phase_Dependency	time
S	H	T	H	1	3	10
S	H	T	L	1	3	0
S	H	T	M	1	3	10
S	H	F	H	1	3	60
S	H	F	L	1	3	60
S	H	F	M	1	3	60
S	L	T	H	1	3	10
S	L	T	M	1	3	10
S	L	T	L	1	3	0
S	L	F	H	1	3	10
S	L	F	L	1	3	10
S	L	F	M	1	3	10
S	M	T	H	1	3	10
S	M	T	L	1	3	0
S	M	T	M	1	3	10
S	M	F	H	1	3	45
S	M	F	L	1	3	45
S	M	F	M	1	3	45
R	H	T	H	1	3	10

Figure 2: Sample of Traffic Light Slot Phase Time Data Set

After assigning values for each attribute, we get a large data set. In this case, we need classification software to generate rules that represent the large data. To minimize size of the large data set, we apply WEKA as a data miming software for a classification big data task and get a set of rules that contains precondition, postcondition, and constrains. WEKA that stands for (Waikato Environment for Knowledge Analysis), it can be defined as software which was designed to support a wide range of machine learning algorithms and solve a large size of data set preprocessing, It was developed by the University of Waikato in New Zealand., it is open source software that starts from data pre-processing, classification, regression, clustering, association rules and visualization. WEKA's techniques depend on a single flat file or relation, each data point in WEKA is described by a fixed number of attributes: numeric or nominal attributes and some other attribute types are supported [1]. In WEKA you must declare any numerical or string value as it does not support any undeclared numerical or string value.

5.PERFORMANCE MEASURE

Confusion Matrix (contingency table) is performance measures in WEKA that is used to clarify the prediction results. Each cell within the table illustrates number of predictions that fall in the cell. If the system accuracy is 100%, then the prediction values will appear on the diagonal and the rest of the matrix is full of zero. If the system accuracy <100%, then prediction values will appear in various cells in the matrix indicating False positive FP (or false negative FN depending on the problem). Diagonal values indicate true positive TP (or true negative based on the problem). Confusion Matrix is useful to present class distribution in the data and the predicted class distribution by classifiers considering error types. Figure 3 shows confusion matrix for the classification of sample traffic light data set.

```
=== Confusion Matrix ===

  a  b  c  d   <-- classified as
 54  0  0  0 |  a = 0
  0 72  0  0 |  b = 10
  0  0 18  0 |  c = 45
  0  0  0 18 |  d = 60
```

Figure 3: Classification Confusion Matrix of Sample Traffic Light Data Set

In addition, precision, recall, and f-score are performance measures are used in WEKA. Precision is a good measure of classifier accuracy (high precision indicates large number of TP and /or TN and vice versa). Precision is illustrated in eq.3

$$precision(P) = \frac{TP}{(TP + FP)} \qquad (3)$$

Recall is the measure of documents which are retrieved successfully as illustrated in Eq 4. Low Recall indicates high FN

$$Recall = \frac{TP}{(TP + FN)} \qquad (4)$$

F-measure represents the balance between the precision and the recall as illustrated in Eq. 5. Full accuracy means F1 measure=1. In machine learning, TN is not used.

$$F1_{Measure} = \frac{2(precision.Recall)}{(precision + Recall)} \qquad (5)$$

In case of unevenly class distribution, it is better to use F-measure. Also, to we need a balance between Precision and Recall. Accuracy indicates only TP+TN used with balanced class distribution. Figure4shows TP, and FP rates with Precision, Recall, and F Measures for the classification of Traffic Data Set.

=== Detailed Accuracy By Class ===

Area Class	TP Rate	FP Rate	Precision	Recall	F-Measure
0	1	0	1	1	1
10	1	0	1	1	1
45	1	0	1	1	1
60	1	0	1	1	1
Weighted Avg.	1	0	1	1	1

Figure 4: TP, and FP rates with Precision, Recall, and F Measures for the classification of Traffic Data Set

6.ANSWER SET PROGRAM

The values of attributes are changed from time to time. After getting a set of rules that contains precondition, and post condition, answer set programming (ASP) is applied as complement approach for WEKA to select stratified rule that returns an optimal solution for open and close sign-phase dynamically. ASP is an adaptive approach to declarative programming that a user focuses on declaratively specifying her or his problem. ASP has its roots in deductive databases, logic-based knowledge representation and reasoning,

logic programming constraint solving, and satisfiability testing [10]. It can be worked in a uniform way to search problems in the hard or class NP as they occur in application domains like configuration, planning, code optimization, database integration, model checking, decision support, robotics, and many more.

We assume the reader to be familiar with first-order logic and propositional as well as with logic programming. Figure5 shows ASP logic rules that find an optimal solution for slot time according to the specific values of attributes. In addition, Figure 6 shows satisfied ASP logic rule. Assume current attributes are: {weather (sunny), traffic (high), accident (true), car_priority (high)}. The satisfied ASP logic rule is open (10): -accident(true),car_priority(high),weather(X),traffic(Y).

```
weather(sunny).
traffic(high).
accident(true).
car_priority(high).
 open(10):-accident(true),car_priority(high),weather(X),traffic(Y).
 open(0):-accident(true),car_priority(low),weather(X),traffic(Y).
 open(10):- accident(true),car_priority(meduim),weather(X),traffic(Y).
 open(60):-accident(false),traffic(high),car_priority(X),weather(sunny).
 open(0):-accident(false),traffic(high),car_priority(X),weather(snow).
 open(60):-accident(false),traffic(high),car_priority(X),weather(raining).
 open(10):-accident(false),traffic(low),car_priority(X),weather(sunny).
 open(0):-accident(false),traffic(high),car_priority(X),weather(snow).
 open(10):-accident(false),traffic(high),car_priority(X),weather(raining).
 open(10):-accident(false),traffic(medium),car_priority(X),weather(sunny).
 open(0):-accident(false),traffic(medium),car_priority(X),weather(snow).
  open(10):- accident(false), traffic(medium), car_priority(X), weather(raining).
```

Figure 5: Sample of ASP Logic Rules

```
clingo version 5.0.0
Solving...
Answer: 1
traffic(high) weather(sunny) car_priority(high) accident(true) open(10)
SATISFIABLE

Models       : 1
Calls        : 1
Time         : 0.016s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)
CPU Time     : 0.000s
```

Figure 6: Satisfied ASP Logic Rule for{weather (sunny), traffic(high), accident (true), car_priority(high)}

7.CONCLUSION AND FUTURE WORK

Traffic signal is used to control traffic at intersections and eliminate human interactions. The discussed method in this paper includes assigning dynamic slot phase time depending on the following tasks: adding four attributes for each intersection: weather condition, accident status, car_priority, and traffic congestion, using mathematical model to assign dynamic interval time for each phase, applying data miming software (WEKA) to minimize data set, and selecting associative rules according to input values to get optimal phase time slots.

In the future, plan to develop a smart approach and green IoT applications to enhance livability, workability, safety and sustainability, through assigning sensors that collect information about all roads constrains and uses smart devices or other systems to exchange data between traffic signals and vehicles. Also we will apply the modern deep learning classifier such as [28] and [29] to save time and more accuracy, In addition, solar energy can be used to feed controller and sensors, so this will reduce grid electricity consumption and pollution.

REFERENCES

[1] Beckham, Christopher J., Mark A. Hall, and Eibe Frank. "WekaPyScript: Classification, regression, and filter schemes for WEKA implemented in Python." (2016): e33-e33.
https://doi.org/10.5334/jors.108

[2] Changchien, S., & Lu, T. Mining association rules procedure to support on-line recommendation by customers and products fragmentation. Expert Systems with Applications. 20(4) (2001) 325-335.
https://doi.org/10.1016/S0957-4174(01)00017-3

[3] Dubow Jacqueline, "Big Data and Urban Mobility-Cairo June 2", the world bank group, ICT information and Communication Technology,6 feb. 2014.

[4] Nathalie Japkowicz & Mohak Shah. Evaluating Learning Algorithms: A Classification Perspective, Cambridge University Press, 2011.

[5] Ganeshkumar, P., Gokulakrishnan, P., "Emeregency Situation Prediction Mechanism: A Novel Approach for Intelligent Transportation System Using Vehicular Ad Hoc Networks",. 2015.
https://doi.org/10.1155/2015/218379

[6] Ghazal, B., ElKhatib, K., Chahine, K. and Kherfan, M., 2016, April. "Smart traffic light control system". In 2016 third international conference on electrical, electronics, computer engineering and their applications (EECEA) (pp. 140-145). IEEE.
https://doi.org/10.1109/EECEA.2016.7470780

[7]Great Amman Municipality website (http://www.ammancity.gov.jo/en), seen on 11/2012 and 3/2013.

[8]Great Amman Municipality website (http://www.ammancity.gov.jo/en), seen on 11/2012 and 3/2013.

[9] Jrew, B. K.," Application of Off-Line Computer Programs to Arterial Signal Timing and Railroad Preemption". Georgia, USA, (1985).

[10] Hölldobler, Steffen & Schweizer, Lukas. Answer set programming and CLASP: A tutorial. CEUR Workshop Proceedings. (2014).

[11]https://en.wikipedia.org/wiki/Decision_tree_learning

[12] Kalmegh. S, Analysis of WEKA Data Mining Algorithm REPTree, Simple Cart and RandomTree for Classification of Indian News, Associate Professor, Department of Computer Science, Sant Gadge Baba Amravati University Amravati, Maharashtra- 444602, India. (2015).

[13] Karim Q. S.,"Evaluation and Improving of Al-Quds Intersection in Baghdad City" Volume 15, Number 2, Engineering and Development Journal, June 2011.

[14] L.A. Zadeh, "Fuzzy Algorithms", Information and Control, vol. 12, issue. 2, pp. 94-102,1968.

[15] Martins, Vanessa & Rufino, João & Fernandes, Bruno & Silva, Luis & Almeida, João & Ferreira, Joaquim & Fonseca, José. (2018). "Personal Virtual Traffic Light Systems".
https://doi.org/10.3390/info10010032

[16] Mishra, Sumit; Bhattacharya, Devanjan; Gupta, Ankit. "Congestion Adaptive Traffic Light Control and Notification Architecture Using Google Maps APIs." Data 3, no. 4: 67, 2018.
https://doi.org/10.3390/data3040067

[17] Nolan, J. R. Computer systems that learn: an empirical study of the effect of noise on the performance of three classification methods. Expert Systems with Applications. 23(1) (2002) 39-47.

[18] Pop, M.D., 2018." Traffic lights management using optimization tool". Procedia-social and behavioral sciences, 238, pp.323-330.
https://doi.org/10.1016/j.sbspro.2018.04.008

[19] Powers, David M W (2011). "Evaluation: From Precision, Recall and F-Measure to ROC, Informedness, Markedness & Correlation" (PDF). Journal of Machine Learning Technologies. 2 (1): 37–63.

[20] Ren, Y., Wang, Y., Yu, G., Liu, H., & Xiao, L. (2017), "An Adaptive Signal Control Scheme to Prevent Intersection Traffic Blockage". IEEE Transactions on Intelligent Transportation Systems, vol.18, issue: 6, pp.1519 – 1528.

[22] Roshandeh, A. M., " Saturation Flow at Traffic Signal Using TRANSYT: A Case Study in Johor Bahru, Malaysia".

[23] Tom V.Mathew, IIT Bombay. Design Principle of Traffic Signal, 2014.

[24] UMTA, FHWA, "Transportation System management" (TSM) Supplement information on the development and Implementation of TSM Plans, 1975.

[25] Yin, B., Dridi, M., & El Moudni, A. Adaptive Traffic Signal Control for Multi-intersection Based on Microscopic Model. IEEE 27th International Conference on Tools with Artificial Intelligence, pp.49-55, (2015).

[26]http://www.mpwh.gov.jo/%D9%85%D8%AF%D9%8A%D8%B1%D9%8A%D8%A7%D8%AA%20%D8%A7%D9%84%D9%88%D8%B2%D8%A7%D8%B1%D8%A9/Pages/M-traffic.aspx

[27] Alzyoud, Faisal Y.; Albakheet Akrem Y., Al_ J.:Determining Minimum Cost Field in Vehicle AD-Hoc Sensor Networks Networks, International Journal of Computing Academic Research (IJCAR),ISSN 2305-9184, Volume 6, Number 2 (April 2017), pp.40-49.

[28] Tadepalli Anish Deepak, Burra Vijaya Babu , & Burra Meghana, XGBoost Classification based Network Intrusion Detection System for Big Data using PySparkling Water, International Journal of Advanced Trends in Computer Science and Engineering, Volume 9, No.1,January- February 2020.
https://doi.org/10.30534/ijatcse/2020/55912020

[29] Tosin A. Adesuyi, Byeong Man Kim, Yoon Sik Shin, A Brief on Snoring Data and Classification Methods, International Journal of Advanced Trends in Computer Science and Engineering, Volume 9, No.1, January- February 2020.
https://doi.org/10.30534/ijatcse/2020/59912020

[30] Alzyoud, Faisal, et al. "Smart Accident Management in Jordan using Cup Carbon Simulation." European Journal of Scientific Research (2019).