International Journal of Engineering Research and Modern Education (IJERME)
Impact Factor: 7.018, ISSN (Online): 2455 - 4200
(www.rdmodernresearch.com) Volume 7, Issue 1, 2022

INTELLIGENT ROUTING CONTROL BASED ON FUTURE PREDICTION FOR EMERGENCY VEHICLE

Seelam Sai Satyanarayana Reddy
Post-Doctoral Fellow, California Public University, Delaware,
United States of America

Cite This Article: Seelam Sai Satyanarayana Reddy, "Intelligent Routing Control Based on Future Prediction for Emergency Vehicle", International Journal of Engineering Research and Modern Education, Volume 7, Issue 1, Page Number 40-47, 2022.

Abstract:

The TMS based on the priority is evaluated by considering the assigned traffic and it assigns the vehicles with first priority for the ambulance. Here, the information concerning the traffic signaling is employed using the feature extraction technique and the green signaling is made. Besides, the hacking detection is also employed for the safe communication and to avoid the malicious that degrades the performance of the TMS. Thus, this research introduces an efficient emergency vehicle re-routing based on optimized machine learning.

Key Words: Squeal Optimization Algorithm, Spadger, Dijkstra's Algorithm, Pseudo-Code, Path Detection

Introduction:

Due to the traffic congestion, if the emergency vehicle delays to go the accident zone by waiting in the traffic that leads to the loss of live. Hence, the emergency vehicle re-routing by the intelligent routing control is necessary for the smart traffic management. Thus, emergency vehicle re-routing is proposed in this research through optimal signal controlling. An optimization algorithm named Spadger Squeal optimization algorithm, in which the Spadger's nature of food search and nature of Gampus in targeting the object are combined to upgrade the rate of convergence in obtaining the global best solution for maintaining the traffic by re-routing the emergency vehicle. Here, by considering the parameter of the traffic such as distance, velocity, acceleration, jitters, historic information, and priority, the artificial neural network (ANN) controls the traffic signal. The weights of the ANN are tuned using the proposed Spadger squeal optimization algorithm for the minimization of the loss associated with training. Then, the possible paths for re-routing are detected using the Dijkstra's algorithm. For all the detected paths, the essential features are extracted by considering the buffer capacity, density of traffic, latency and path cost. Then, by considering the extracted attributes the optimal re-routing of the emergency vehicle is employed using the proposed Spadger squeal optimization algorithm, in which the multi-objective function is utilized for the optimal re-routing of emergency vehicle.

Proposed Emergency Vehicle Routing Based On:

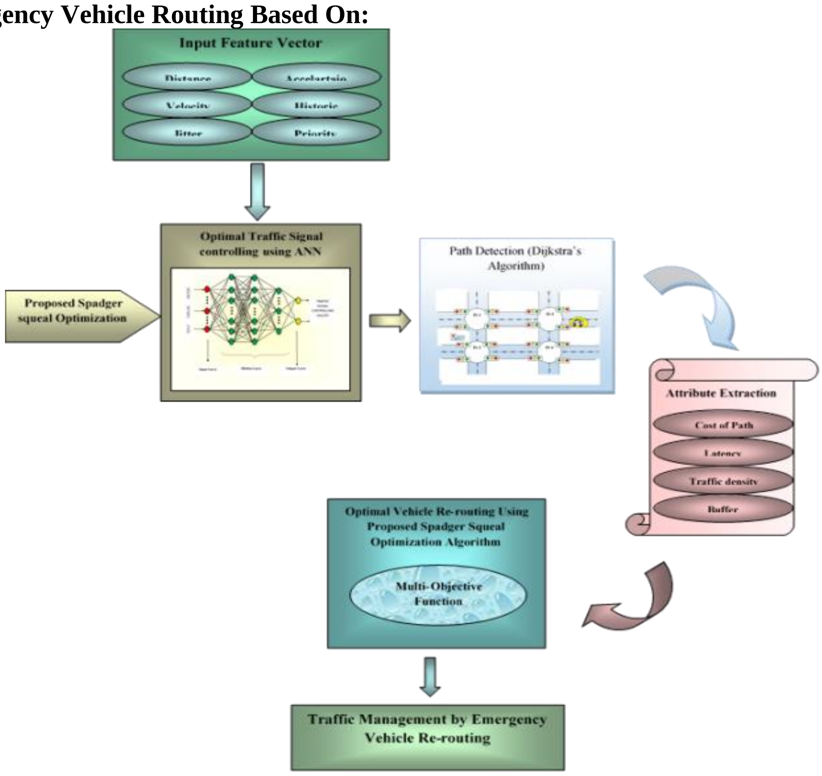

Figure 1: Block diagram of proposed Emergency vehicle routing in traffic

The proposed emergency vehicle routing is employed by predicting the traffic in the network. The traffic prediction and the optimal switching , in which the machine learning based traffic signal controlling at the intersection is employed using the proposed Spadger Squeal based ANN. Here, the classifier, ANN is trained using the proposed optimization algorithm for the reduction of loss associated with the training. Then, the vehicles are re-routed by identifying the possible paths. Here, the possible shortest paths are identified using the Dijkstra's shortest path algorithm. For the detected shortest path, the attributes such as the buffer capacity, density of traffic, latency and path cost are extracted for the more accurate routing. Finally, using the Spadger Squeal Optimization algorithm, the optimal route for the emergency vehicle is identified and re-routed to the destination with minimal waiting time in the traffic. The proposed Spadger squeal optimization is designed by hybridizing the characteristic behavior of the Spadger in foraging and the squealing behavior of the Grampus in the foraging to find the best solution to re-route the emergency vehicle optimally. The illustration of the proposed Spadger Squeal optimization based emergency vehicle re-routing is provided in Figure 1.

Traffic Signal Controlling at intersection using Spadger Squeal based ANN:

The traffic signal controlling at the intersection is employed using the proposed Spadger Squeal based ANN. Here, the proposed Spadger Squeal optimization is utilized for tuning the weights of the classifier ANN for procuring the elevated accuracy in signal controlling for the maintenance of traffic.

System Model of ANN:

The traffic signal controlling the intersection consists of four roads each with the two lanes, in which for the passage of emergency vehicle, the traffic signal controlling is employed using the Artificial Neural Network (ANN) [108]. The ANN obtains the input feature vectors such as distance, acceleration, jitter, priority, velocity and historic information, Thus, by obtaining the input, the traffic signal controlling is employed and the architecture is shown in Figure 2. The output of the classifier is either ON/OFF of the traffic signal.

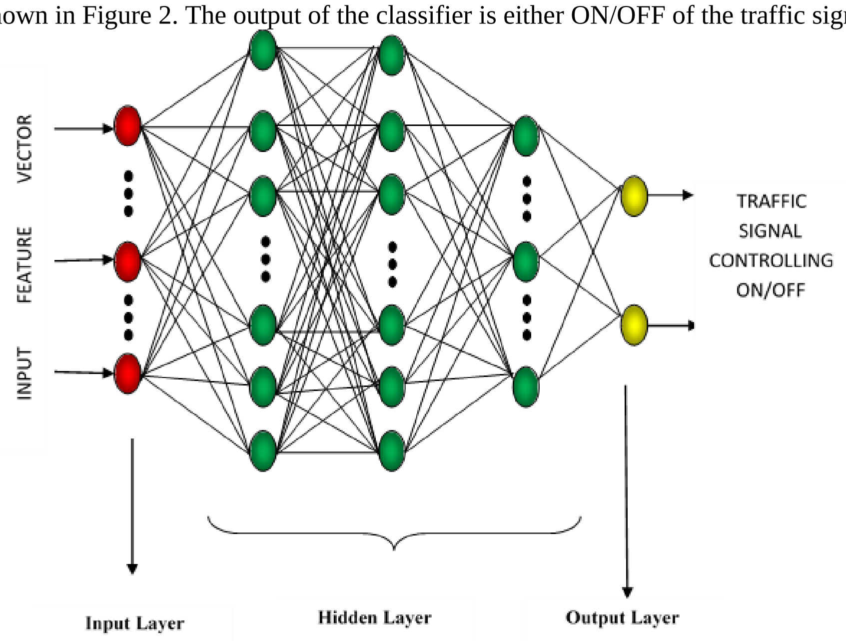

Figure 2: Architecture of ANN

Proposed Spadger Squeal Optimization Algorithm:

The proposed Spadger Squeal Optimization is arrived by collaborating the Spadger's nature [109] in food search and nature of Gampus in targeting the object [110] to upgrade the rate of convergence in obtaining the global best solution for maintaining the traffic by re-routing the emergency vehicle. The foraging of the prey is similar to the attainment of optimum solution.

Mathematical Modeling:

The hypotheses considered by the proposed Spadger squeal optimization to formulate the algorithm are:

- **Hypothesis 1:** The food locating Spader identifies the food location and it assists all the moochers to get food by showing the direction and food location. Thus, the responsibility of the food locator is to help the moochers. The energy among the spaders for the categorization is evaluated based on the fitness function.
- **Hypothesis 2:** The Spadger at the periphery of the search space is responsible for detecting the predator, when it detects the predator, then it makes the alarming sound to move towards the safer location. Certain threshold is maintained, because the higher value indicates the movement towards the safer location.

- **Hypothesis 3:** The Spadgers those locate the food reserve is considered as the food locator and the others as moochers, but throughout the process some proportion of the Spadgers become unchanged in both the categories.
- **Hypothesis 4:** The starved moochers with low energy move towards other locations in search of food for the attainment of high energy for survival.
- **Hypothesis 5:** The moochers follow the food locator Spadgers to get the food and there are some moochers who watch the food locating Spadgers to elevate the rate of predation.
- **Hypothesis 6:** The Spadgers at the borders move to the middle location for the safe positioning and the other Spadgers move close to each other.

Spadger Locating:

Initially, the Spadgers in the search space are located randomly and is enunciated as,

$$B = \begin{bmatrix} B_{1,1} & B_{1,2} & \cdots & \cdots & B_{1,v} \\ B_{2,1} & B_{2,2} & \cdots & \cdots & B_{2,v} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ B_{v,1} & B_{v,2} & \cdots & \cdots & B_{u,v} \end{bmatrix} \quad (1)$$

Where, u is the Spadger in the search space and the dimension is notated as v.

Fitness:

The optimal best solution for the traffic re-routing is evaluated based on the error function and is enunciated as,

$$F_{fit} = \frac{1}{N} \sum_{i=1}^{N} (H_i - \vec{H}_i)^2 \quad (2)$$

Where, H_i and $\vec{H}_i$ refers to the targeted and obtained output, the fitness function is referred as F_{fit}, and the total samples is referred as Q. The Spadgers with the highest value of fitness is considered as food locator, which guides the remaining group members to get food for enhancing the energy.

Thus, based on the fitness, the position of the Spadgers are updated by considering the hypothesis 1 and 2 as,

$$B_{r,s}^{i+1} = \begin{cases} B_{r,s}^{i} . \exp\left(\frac{-r}{\alpha . i_{\max}}\right) & if \ w < G \\ B_{r,s} + XY & if \ w \geq G \end{cases} \quad (3)$$

Where, the Spadgers finds the attacker then they move towards the safer location, for which the position updation is employed by considering the condition $w \geq G$, else the position updation is employed based on the condition $w < G$, in which w refers to the alarming sound of the Spadger and is the threshold value corresponding to the safety value. The matrix Y has the dimension $[1 \times v]$ and the normally distributed random number is depicted as X. The iteration is notated as i and its maximal value is notated as $i_{\max}$. The random number in the range $[0,1]$ is notated as α and the position of the r^{th} Spadger in s^{th} location is notated as $B_{r,s}$.

The moochers watches the food locating Spadger and competes with them to obtain the food and its position is updated using equation () by considering the hypothesis 5.

$$B_{r,s}^{i+1} = \begin{cases} X . \exp\left(\frac{B_{bad}^{i} - B_{r,s}^{i}}{\alpha . i_{\max}}\right) & if \ r > u/2 \\ B_E^{i+1} + \left|B_{r,s}^{i} - B_G^{i+1}\right| . F^{+} . Y & otherwise \end{cases} \quad (4)$$

Where, the food locator's optimal position is notated as B_E^{i+1} and the solution evaluated as worst is notated as B_{bad}^{i}. The function F^{+} is expressed as, $F^{+} = F^{T}\left(FF^{T}\right)^{-1}$. The position of the moocher under the starvation condition is evaluated by considering the condition $r > u/2$. Here, the moochers position can be enhanced by incorporating the squealing behavior of the Gampus to enhance the position and to avoid the starving situation. The position updation of the Gampus based on the squealing behavior is represented as,

$$B_{r,s}^{i+1} = B_{r,s}^{i} + v_{r,s}^{i} \quad (5)$$

Where, the search space dimension is notated as v, the position of the Gampus is assumed same as the position of the moocher and is refereed as $B^i_{r,s}$ at iteration i. Here, the dimension of the search space of the Gampus is referred as,

$$v^{i+1}_{r,s} = v^i_{r,s} + P1\left(B^i_{Good} - B^i_{r,s}\right) + P2\left(U - B^i_{r,s}\right) \quad (6)$$

where, the best position acquired by the Gampus based on the squealing behavior is referred as B^i_{Good} and the global best position acquired by the Gampus is notated as U.

Thus, the proposed Spadger Squeal Optimization by collaborating the Spadger's nature in food search and nature of Gampus in targeting the object to upgrade the rate of convergence in obtaining the global best solution as per the rule [111] is formulated as,

$$B^{i+1}_{r,s} = 0.5\left[B^{i+1}_{r,s}\right]_{spadger} + 0.5\left[B^{i+1}_{r,s}\right]_{Gampus} \quad (7)$$

$$B^{i+1}_{r,s} = \begin{cases} 0.5\left[X.\exp\left(\dfrac{B^i_{bad} - B^i_{r,s}}{\alpha.i_{\max}}\right)\right] + 0.5\left[B^i_{r,s} + v^i_{r,s}\right] & if\ r > u/2 \\ B^{i+1}_E + \left|B^i_{r,s} - B^{i+1}_G\right|.F^+.Y & otherwise \end{cases} \quad (8)$$

Thus, the position updation of the moocher by incorporating the squealing behavior of the Gampus helps to avoid the death of the moochers from starvation, thus the population can be maintained balanced throughout the process. Besides, the food capturing behavior of the Gampus through its squealing behavior helps to obtain the location of the food in a speedy manner that ensures the fast convergence rate. Thus attainment of global best solution of the Gampus (U) in the search space helps to obtain the global best solution of the proposed algorithm. Here, by balancing the exploration and the exploitation phases, the global best solution is obtained.

Then on the hypothesis 6, the Spaders in the borders are in danger and have the awareness probability to escape and the position is updated as,

$$B^{i+1}_{r,s} = \begin{cases} B^i_{Good} + \gamma\left|B^i_{r,s} - B^i_{Good}\right| & if\ m_r > m_k \\ B^i_{r,s} + I\left(\dfrac{\left|B^i_{r,s} - B^i_{bad}\right|}{(m_r - m_n) + \beta}\right) & if\ m_r = m_k \end{cases} \quad (9)$$

Where, the Spadger at the border updates the position by considering the criteria $m_r > m_k$, and the Spadger at the danger has to move towards the other members and its position is updated by considering the criteria $m_r = m_k$. The fitness evaluated by the Spadger at the current iteration is denoted as m_r, in which the best position and the worst position are notated as m_k and m_n respectively. Besides, I is the random number that varies among $[-1,1]$. The best and worst solution are notated as B^i_{Good} and B^i_{bad}. The zero-division-error is reduced by including the constant β.

Stopping Criteria:

When the Spadger Squeal optimization algorithm accomplishes the global best solution or the maximal iteration the processing will be stopped. The pseudo-code for the proposed Spadger Squeal optimization algorithm is presented in algorithm 1 given below.

Algorithm 1: Pseudo-code of the proposed Spadger Squeal optimization algorithm

Pseudo-code of proposed Spadger Squeal optimization algorithm	
1	Input: The parameters $i_{\max}, G, w, u$
2	Output: m_k, B_{Good}
3	While ($(i < i_{\max})$
4	The best and worst solution detection using the fitness claculation
5	For $r = 1$
6	By equation (4.3) update the food locator's position
7	By equation (4.8) update the food moocher's position
8	By equation (4.9) update the food Spadger's position

End for
New position updation
$\tau = \tau + 1$
End while
end

Path Detection:

The possible shortest path for the vehicle in emergency is detected using the Dijkstra's shortest path algorithm [112]. Let us consider the traffic signal controllers as the nodes for identifying the possible paths for the vehicles in the VANET to move towards the destination with minimal delay. In this, the graph theory is utilized to find the path using three different stages such as initialization, verification of distance and selection of the next point. The network utilized for the detection of the shortest path is depicted in Figure 4.2. Let us consider the vehicle in the intersection 3 (IS-3) belongs to the traffic signal controller (TSC-c) needs to identify the path to the hospital in the IS-2 corresponding to the TSC-q. The possible path detection starts from the initialization stage and ends with the detection of all possible paths.

- Step 1: Initialization: At the initialization stage, the shortest point a_c is considered as zero and the corresponding length b_c is also considered as null. Then, the path length corresponding to the remaining nodes is assigned as $a_p = \infty$ and $b_p = c$. Mark the point of origin as C and the remaining marked node as $d = c$ and the others as unmarked.
- Step 2: Distance Verification: For the marked nodes D, verify the distance corresponding to the unmarked node Q and assign,

$$a_q = \min\{a_q, a_d + dist_{dq}\}$$

  Where, the distance from the node d to q corresponding to the direct connection is referred as $dist_{dq}$ and the shortest path corresponding to the unlabelled node q is referred as a_q.
- Step 3: Choosing Next point: The smallest among the labeled node is chosen as the next node and is denoted as $a_p = \min a_p$ and mention it as marked.
- Step 4: Identification of Previous point: Here, the previous point is assigned as $p = q'$, in which the q' is directly connected to p, by this way the identification is made.
- Step 5: Termination: If all the nodes marked then the shortest path is identified, else repeat from distance verification stage.

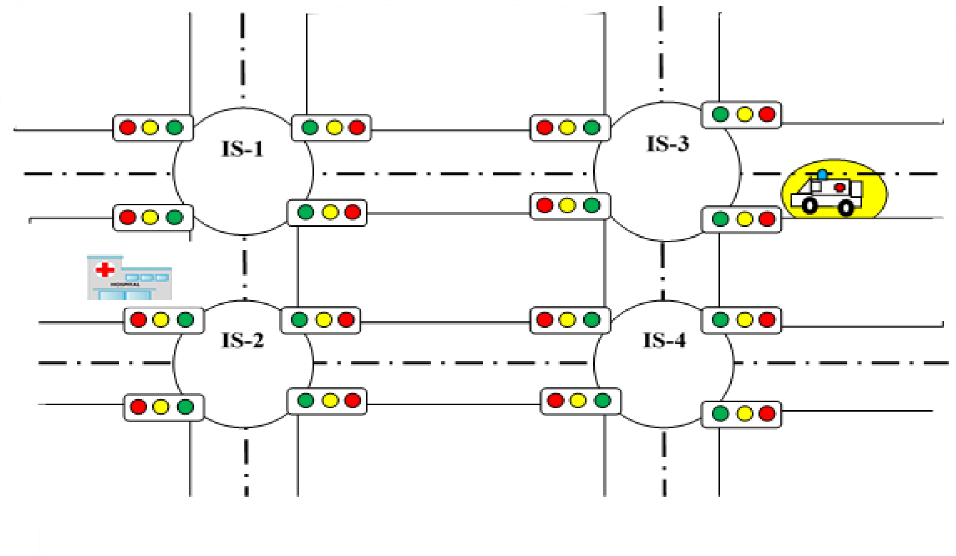

Figure 3: Network structure to find the shortest path

Thus, the possible shortest path for all the vehicles in the intersection of the traffic signaling is identified for routing the vehicles to the re-routing with minimal traffic. Thus, for all the detected path based on the Dijkstra's algorithm, the essential features are taken out to perform the optimal routing for the traffic management.

Optimal Vehicle Re-routing using Spadger Squeal Optimization:

The optimal emergency vehicle re-routing through the identified shortest path by considering the attributes such as cost of path, latency, traffic density and buffer capacity are employed using the proposed Spadger squeal optimization algorithm. The vehicle re-routing at the intersection is employed by the proposed optimization algorithm. For this, let us assume there are 10 paths in the VANET and they are controlled optimally through the objection function expressed in the equation (4.13) and the solution encoding is depicted in Figure 4.3 respectively. Let, the solution's dimension may be referred as [1x10] with v solution. From this v solution, the optimal solution for vehicle re-routing is evaluated using the proposed Spadger squeal optimization algorithm.

$$OF = n1[A_{buffercapacity}] + n2[A_{cost}] + n3[A_{latency}] + n4[A_{traffic\ density}] \quad (10)$$

where, OF refers to the objective function, and $n1, n2, n3, n4, n5 \, and \, n6$ are the constant, in which $n1 + n2 + n3 + n4 = 1$.

P_1	P_2	P_3	......	......	P_{10}

Figure 4: Solution Encoding

Thus, by using the proposed Spadger squeal optimization algorithm by considering the multi-objective function an efficient emergency vehicle re-routing is employed by managing the traffic.

Performance Analysis:

The performance of the proposed emergency vehicle re-routing by controlling the traffic signal is assessed based on the experimental and performance analysis. The performance parameters utilized by the proposed method are:

Throughput:

The throughput indicates the total vehicles coming in and out of the network within the particular time.

QMA: At the time t, the quadratic mean of acceleration of the proposed method is represented as,

$$QMA = \frac{\sqrt{\sum_{i=1}^{T_{vehicle}(\tau)} (Acc(\tau))^2}}{T_{vehicle}(\tau)} \quad (11)$$

Where, at the time τ, the total vehicles is referred as, $T_{vehicle}(\tau)$.

SDTT: The standard deviation of travel time index (SDTT) of the proposed Spadger Squeal-based ANN is represented as,

$$SDTT = SD(TTI) \quad (12)$$

Where, $\sigma_{T,tot}$ refers to the standard deviation of total travel time, $t_{f,tot}$ refers to the flow travel time, and $TTI = \frac{\sigma_{T,tot}}{t_{f,tot}}$.

Performance Analysis:

The performance analysis of the proposed emergency vehicle re-routing by considering the proposed Spadger squeal based ANN is employed by varying the number of vehicles in the lane and are detailed here. Figure 5 represents the Jitter estimation. The Jitter acquired at one vehicle is 0.3067, 0.2898, 0.2562, 0.3741, and 0.2562 respectively by the proposed Spadger Squeal based ANN corresponding to 20, 40, 60, 80 and 100 iterations , which is 0.6420, 0.6347, 0.6101, 0.6812, and 0.6101 for 200 vehicles.

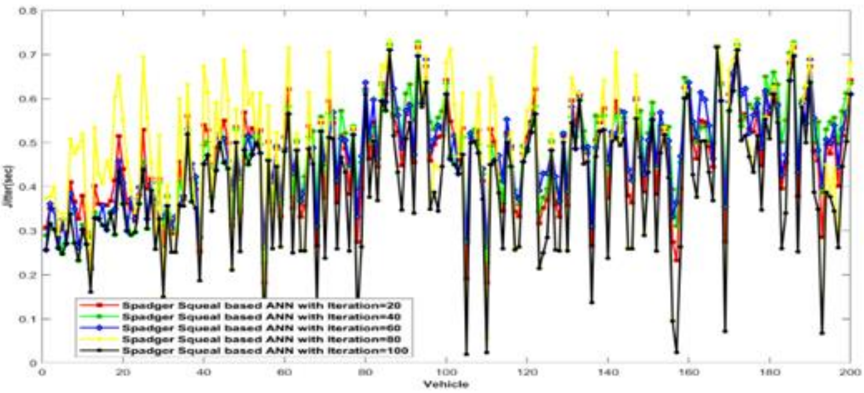

Figure 5: Analysis using Jitter with 200 vehicles

Figure 6 represents the SDTT estimation. The SDTT acquired with one vehicle is 30.3819, 18.7500, 36.7188, 35.6771, and 18.7500 respectively by the proposed Spadger Squeal based ANN corresponding to 20, 40, 60, 80 and 100 iterations , which 15.2778, 5.2083, 27.0833, 13.5417, and 5.2083 for 200 vehicles.

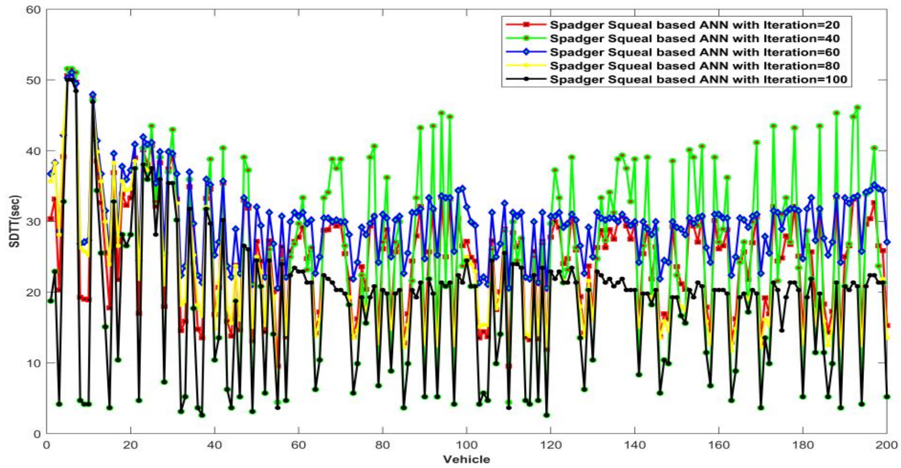

Figure 6: Analysis using SDTT with 200 vehicles

Summary:

The proposed Spadger Squeal based ANN for the traffic signal controlling and the emergency vehicle re-routing is devised for the efficient traffic management. The traffic signal controlling employed using the proposed Spadger Squeal optimization provides the accurate optimal traffic signaling at the intersection. Then by considering the parameters like cost of path, latency, traffic density, and buffer capacity the optimal vehicle re-routing is employed using the proposed optimization algorithm. Thus, from the analysis, the proposed method obtained better performance by using the proposed Spadger Squeal Optimization algorithm with the balanced exploration and exploitation phase with fast convergence rate.

References:

1. Rath, M., 2018, June. Smart traffic management system for traffic control using automated mechanical and electronic devices. In IOP Conference Series: Materials Science and Engineering (Vol. 377, No. 1, p. 012201). IOP Publishing.
2. Raut, C.M. and Devane, S.R., 2017, April. Intelligent transportation system for smartcity using VANET. In 2017 International Conference on Communication and Signal Processing (ICCSP) (pp. 1602-1605). IEEE.
3. Ahmad, I., Noor, R., Ali, I. and Qureshi, M.A., 2016, September. The role of vehicular cloud computing in road traffic management: A survey. In International conference on future intelligent vehicular technologies (pp. 123-131). Springer, Cham.
4. Nellore, K. and Hancke, G.P., 2016. Traffic management for emergency vehicle priority based on visual sensing. Sensors, 16(11), p.1892.
5. Javaid, S., Sufian, A., Pervaiz, S. and Tanveer, M., 2018, February. Smart traffic management system using Internet of Things. In 2018 20th international conference on advanced communication technology (ICACT) (pp. 393-398). IEEE.
6. Rabby, M.K.M., Islam, M.M. and Imon, S.M., 2019, September. A review of IoT application in a smart traffic management system. In 2019 5th International Conference on Advances in Electrical Engineering (ICAEE) (pp. 280-285). IEEE.
7. Hernafi, Y., Ben Ahmed, M. and Bouhorma, M., 2017. ACO and PSO algorithms for developing a new communication model for VANET applications in smart cities. Wireless Personal Communications, 96(2), pp.2039-2075.
8. Mandhare, P.A., Kharat, V. and Patil, C.Y., 2018. Intelligent road traffic control system for traffic congestion a perspective. International Journal of Computer Sciences and Engineering, 6(07), p.2018.
9. Bharadwaj, R.; Deepak, J.; Baranitharam, M.; Vaidehi, V.V. Efficient dynamic traffic control system using wireless sensor networks. In Proceedings of the IEEE International Conference on Recent Trends in Information Technology (ICRTIT), Chennai, India, 25–27 July 2013; pp. 668–673.
10. Sundar, R.; Hebbar, S.; Golla, V. Implementing intelligent traffic control system for congestion control, Ambulance clearance, and Stolen vehicle detection. IEEE Sens. J. 2015, 15, 1109–1113.
11. Hegde, R.; Sail, R.R.; Indira, S.M. RFID and GPS based automatic lane clearance system for ambulance. Int. J. Adv. Elect. Electron. Eng. 2013, 2, 102–107.

12. Sadhukhan, P. and Gazi, F., 2018, February. An IoT based intelligent traffic congestion control system for road crossings. In 2018 International Conference on Communication, Computing and Internet of Things (IC3IoT) (pp. 371-375). IEEE.
13. Ravish, R., Shenoy, D.P. and Rangaswamy, S., 2020. Sensor-based traffic control system. In Proceedings of the Global AI Congress 2019 (pp. 207-221). Springer, Singapore.
14. Sarath, S. and Deepthi, L.R., 2018, April. Priority based real time smart traffic control system using dynamic background. In 2018 International Conference on Communication and Signal Processing (ICCSP) (pp. 0620-0622). IEEE.
15. Kumar, K. and Kaur, P.D., 2015. Road traffic control system in cloud computing: a review. International Journal of Grid Distribution Computing, 8(3), pp.201-206.
16. Biao Yin, Dridi, M. and Moudni, A.E., "Recursive least-squares temporal difference learning for adaptive traffic signal control at intersection", Neural Computing and Applications, vol.31, no.2, pp.1013-1028, 2019.
17. Wei-Li Liu, Gong, Y.J., Chen, W.N. and Zhang, J., "EvoTSC: An evolutionary computation-based traffic signal controller for large-scale urban transportation networks", Applied Soft Computing, vol.97, pp.106640, 2020.