https://doi.org/10.33472/AFJBS.6.Si2.2024.1815-1821

AFJBS

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Simulation of Dynamic Traffic Control System Using Python Programming

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Article Info

Volume 6, Issue 6, May 2024

Received: 31 March 2024

Accepted: 30 April 2024

Published: 16 May 2024

doi: 10.33472/AFJBS.6.Si2.2024. 1815-1821

ABSTRACT:

The integration of wireless sensor networks (WSNs) and python programming in smart traffic control systems offers significant advantages and holds promise for efficient design and implementation. This paper introduces an intelligent traffic signal control system leveraging WSN technology along with programming language. By monitoring vehicle queue lengths during red cycles, the system optimizes traffic light control for subsequent green cycles. The primary objective is to reduce average waiting times, thereby diminishing queue lengths, and enhancing traffic control methods based on incoming traffic from every direction. Additionally, the framework consists of a mechanism to warn individuals regarding red light crossings, mitigating the risk of accidents stemming from red light violations. Simulation results demonstrating the system's efficacy are presented.

Key Words: *Smart Traffic Control, Wireless Sensor Networks (WSNs), Signal Crossings, Accident Risk Mitigation.*

1. Introduction

In contemporary society, sensors are ubiquitous, finding applications across various sectors. From home automation to weather monitoring, military operations to healthcare, and agricultural to traffic management, sensors play a pivotal role in facilitating data collection and decision-making processes. One particularly crucial application lies in the Traffic Signal Control System, where Wireless Sensor Networks (WSNs) are employed to gather real-time traffic data and regulate traffic flow using python programming.

Traditionally, traffic light systems operate on predetermined timing mechanisms, cycling through signal changes at fixed intervals. However, with the advent of intelligent traffic light systems, there is a paradigm shift towards adaptive control mechanisms. These systems utilize sensors to identify the existence or absence of automobiles and modify signal timings accordingly. The primary objective of intelligent traffic systems is to minimize unnecessary waiting times at intersections, thereby reducing the likelihood of traffic violations and accidents resulting from impatient drivers. There are several methods employed for traffic detection in intelligent systems. While older systems relied on weight sensors as triggers, modern approaches utilize motion detection through infrared sensors or proximity switches. Algorithms govern these systems' actions, dynamically changing the timing of signals in response to current traffic conditions. Comprehending how traffic signals operate is essential for enhancing driving behaviour and minimizing accidents. By controlling vehicle speed and discouraging red light violations, the overall safety of road users can be enhanced. Moreover, educating drivers about traffic signal operations can alleviate frustration during waiting periods.

2. Objectives

- ❖ Implementing an intelligent queue-based traffic control system length at each signal side.
- ❖ Optimizing the average number of automobiles, increasing the average service time, and decreasing the average waiting time unable to pass through during a green signal phase.

3. Methodology

3.1 System Model

a. A straight forward method to estimate the arrivals of vehicles are by assuming a consistent arrival pattern. This implies a consistent, predictable time interval between each vehicle. However, this assumption is often not reflective of real-world scenarios, as arrivals of vehicles tend to follow a more arbitrary pattern. Therefore, a model that accurately represents this randomness is required, with the Poisson distribution being the most suitable choice. This distribution incorporates an arrival rate parameter (λ), which governs the frequency of vehicle arrivals. (Tubaishat, Malik; Shang, Yi; Shi, Hongchi; 2007 et al.)

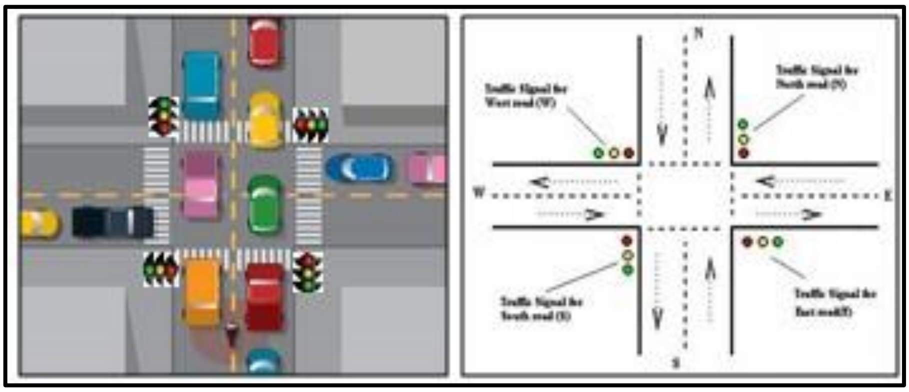

Fig. 1: Fundamental Traffic Intersection [Source: - Faisal A. Al-Nasser et al. (2011)]

Fig. 2: multi-leg intersections [Source: - Faisal A. Al-Nasser (2011)]

b. In practice, modelling vehicle arrivals is typically integrated into queuing models like M/M/1 or M/G/1, which simulate functioning of traffic signals. These queuing models essentially represent service stations, such as intersections or lanes, and include elements like one or more servers (representing capacity) and a buffer or waiting area(where vehicles accumulate while waiting for service). These models are valuable for analysing traffic flow dynamics, considering factors such as arrival rates, service times, and queue lengths, to optimize the performance of traffic signal operations. (A. Albagul, M. Hrairi,1745-1749, 2006et al.)

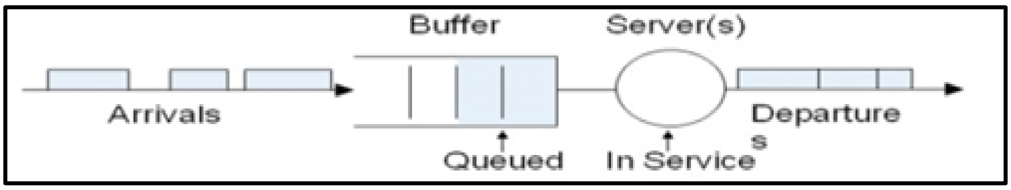

Fig. 3. Fundamental Queue System [Source: - Faisal A. Al-Nasser et al. (2011)]

c. The interarrival time between automobiles n and n+1 is represented by the time $\boldsymbol{\tau_n}$which is regarded as a random variable. The stochastic process underlies the operation of the traffic signal system. The stochastic process underlies the operation of the traffic signal system. behaviour, meaning it is influenced by random variables and unpredictable events. (A. Albagul, M. Hrairi,1745-1749, 2006 et al.)

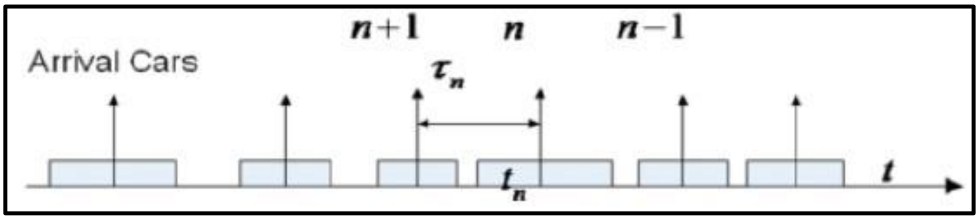

Fig. 4. Vehicle Arrivals Over Time [Source: - Faisal A. Al-Nasser et al. (2011)]

3.2 Control Algorithm

Python script for controlling traffic lights based on the number of vehicles in each lane. Below is the code with an explanation of the algorithm:

1) Input the vehicle counts for each lane.
2) Determine the lane with the highest vehicle count or if all lanes have equal counts.
3) Based on the highest count, configure the traffic lights accordingly.
4) Enter a loop where the traffic light configuration is updated continuously based on the highest count lane.
5) Print the current configuration of the traffic lights.
6) Sleep for a specified duration (here 3 seconds) to simulate the duration of each phase.
7) Repeat the process with a valid value assigned to v to prevent an infinite loop.

3.3 Source code:

```
import time
c1 = int(input("Enter count of lane 1: "))
c2 = int(input ("Enter count of lane 2: "))
c3 = int(input("Enter count of lane 3: "))
v = 0
# Determine the lane with the highest vehicle count or if all lanes are equal
if c1 == c2 and c1 == c3and c1!=0 and c2!=0 and c3!=0:
    v = 'e'
# All lanes have equal vehicle count
elif c1 == 0 and c2 == 0 and c3 == 0:
    v = 0    # No vehicles in any lane
elif c1 > c2 and c1 > c3:
    v = 1    # Lane 1 has the highest vehicle count
elif c2 > c1 and c2 > c3:
    v = 2    # Lane 2 has the highest vehicle count
elif c3 > c2 and c3 > c1:
    v = 3    # Lane 3 has the highest vehicle count
# Print the chosen lane configuration
print(v)
# Traffic light control loop
while True:
    if v == 0:
        print("All Lights Should Be Off")
    elif v == 'e':
        print("All Lanes Are Equal")
    elif v == 1:
        print("Green In Lane 1 Active")
        print("Red In Lane 2 Active")
        print("Red In Lane 3 Active")
        print("Red In Lane 1 Inactive")
```

```
        print("Amber In Lane 1 Inactive")
        time.sleep(3)   # delay for 3 seconds
    elif v == 2:
        print("Green In Lane 2 Active")
        print("Red In Lane 1 Active")
        print("Red In Lane 3 Active")
        print("Red In Lane 2 Inactive")
        print("Amber In Lane 2 Inactive")
        time.sleep(3)  # delay for 3 seconds
    elif v == 3:
        print("Green In Lane 3 Active")
        print("Red In Lane 1 Active")
        print("Red In Lane 2 Active")
        print("Red In Lane 3 Inactive")
        print("Amber In Lane 3 Inactive")
        time.sleep(3)   # delay for 3 seconds
    v = 1   # Setting v to a valid value to prevent an infinite loop
```

4. Results And Discussions

Equal Vehicle Counts in All Lanes: This scenario suggests that traffic is evenly distributed among all lanes. As a result, the traffic light control system maintains a balanced approach, treating each lane equally. This can lead to smoother traffic flow and reduced congestion overall.

No Vehicles Present in Any Lane: In this case, there are no vehicles detected in any lane. Therefore, the traffic light control system switches off all lights, indicating that there is no need for traffic regulation at the moment. This situation may occur during off-peak hours or when traffic is unusually light.

Lane 1 Has the Highest Vehicle Count: Whenlane 1 has the highest vehicle count, the traffic light control system prioritizes this lane by activating the green light for it. This allows traffic from lane 1 to proceed while other lanes remain at a red light, preventing congestion and ensuring efficient movement of vehicles in the busiest lane.

Lane 2 Has the Highest Vehicle Count: Similarly, when lane 2 has the highest vehicle count, the traffic light control system grants priority to this lane by activating the green light for it. This helps to alleviate congestion in lane 2 and optimize traffic flow in that direction.

Lane 3 Has the Highest Vehicle Count: In this scenario, lane 3 is identified as having the highest vehicle count, leading the traffic light control system to give precedence to this lane. By activating the green light for lane 3, the system aims to reduce delays and queues in that direction, thereby improving overall traffic management.

Overall, the output from the traffic light control system demonstrates its ability to adapt to varying traffic conditions and prioritize lanes with higher vehicle counts. By dynamically adjusting traffic light configurations based on real-time data, the system helps to improve road safety, lessen congestion, and streamline traffic flow. However, further optimization and refinement may be needed to address complex traffic patterns and maximize efficiency in larger-scale implementations.

(i) When there is no lane.

```
Enter count of lane 1: 0
Enter count of lane 2: 0
Enter count of lane 3: 0
0
All Lights Should Be Off
```

(iii) when the no of lanes are equal.

```
Enter count of lane 1: 2
Enter count of lane 2: 2
Enter count of lane 3: 2
e
All Lanes Are Equal
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
```

(ii) when the no of lanes areunequal

```
Enter count of lane 1: 2
Enter count of lane 2: 3
Enter count of lane 3: 4
3
Green In Lane 3 Active
Red In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Inactive
Amber In Lane 3 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
Green In Lane 1 Active
Red In Lane 2 Active
Red In Lane 3 Active
Red In Lane 1 Inactive
Amber In Lane 1 Inactive
```

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