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Traffic Signal Synchronization and Dynamic Control

Siddharth Nashikkar[1], Aryaa Hanamar[2], Nuren Pathan[3], Heena Mulla[4]
[1, 2, 3, 4]Department of Computer Science and Engineering, D.Y. Patil College of Engineeringand Technology, Kasaba Bawada, Kolhapur, 416006, Maharashtra, India.

Abstract: During the past decade, there has been a significant increase in popu- lation combined with ever-increasing automobile sales, resulting in increased traffic around the world. Although modern city infrastructure is designed to han-dle this increasing traffic, it is very difficult to deal with traffic in unplanned partsof cities or cities that were developed hundreds of years ago where congestion was not taken into account. During our analysis, we found that it is not possible to synchronize all the signals in such parts of cities as the distance between each traffic signal is different, with some intersections having very high traffic and the very next having low traffic. We came to the conclusion that although it is im- possible to synchronize all the traffic signals, we can form clusters of 2-3 inter- sections that can be synchronized and the intersection with the highest amount of traffic will be dynamic i.e., the lane with the highest traffic will get more time. These traffic signals can then be connected through the internet and linked to maps which can show upcoming traffic signals and their real-time status.
Keywords: Dynamic synchronization, infrared sensors, IRS 1, IRS 2.

I. INTRODUCTION

Conventional traffic signal timing is based on fixed schedules that may not accurately reflect changing traffic patterns throughout the day. In contrast, dynamic traffic signal synchronization represents an advanced traffic management strategy focused on opti- mizing the movement of vehicles through intersections and along roads. This strategy involves real-time coordination of traffic signal timing to reduce congestion, improve traffic flow, and enhance overall transportation efficiency.

Dynamic synchronization of traffic signals takes into account real-time information from various sources, such as traffic sensors, cameras, and GPS devices in vehicles. By analyzing this information, the traffic management system can quickly adjust signal timings to address changes in traffic volume, accidents, special events, and other fac- tors. This approach is particularly important in urban areas where traffic congestion canlead to significant delays, increased pollution, and reduced quality of life.

In our interview with the traffic signal officer, we learned that the real problem was noteasy to solve. We found that synchronization depends entirely on the length between intersections and the traffic flowing from that direction. He also informed us that in many places there are no grid systems and traffic intersections were designed hundredsof years ago. Due to this problem, it is very difficult to synchronize more than three intersections and the traffic department was facing the same problem. As a result, streets with two-way traffic are now being converted into one-way traffic. Although this promises to reduce congestion, it puts an extra burden on drivers who have to takea different route, which is most likely a longer route.

II. METHODOLOGY

With all these constraints and problems, we decided to go with a cluster system wherewe make clusters of 2-3 traffic intersections and the intersection with the highest amount of traffic. We install our dynamic systems there. To measure the amount of traffic, we use infrared sensors in each lane. These sensors are separated by 50 m. Thedistance between these sensors depends entirely on the location and can vary dependingon the traffic density there. When more traffic is identified by these two sensors, we give higher priority or a longer time limit for that particular lane, and accordingly, we synchronize traffic signals of upcoming intersections.

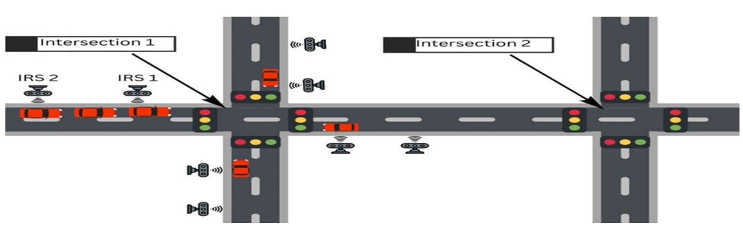

Fig. 1. Top view of traffic intersections with traffic signals and sensors.

In the figure we have considered Intersection 1 as our main intersection where there will be much more traffic as compared to Intersection 2 hence, we have applied our Infrared sensors to Intersection 1. Each lane has 2 sensors that are marked IRS1 and IRS2. IRS 1 is situated very close to an intersection near the traffic signal and IRS 2 issituated 50m before IRS 1.

The amount of traffic is determined by the combination of both sensors. If both detectvehicles, then that lane has more traffic. So, this lane which has the highest traffic is given higher priority. Priority lanes are given a greater amount of time with a green signal. And Intersection 2 will be synchronized at this updated time.

This system is not just beneficial for high traffic rates but can also be used in very low traffic, especially at night. At night there is almost no one at the intersection and hence we can keep a red signal all the time but as soon as a vehicle arrives which is detected by IRS 1, we can immediately change the signal to green. This is supposed to reduce accidents at night as most of the cities switch off their traffic lights at night and many people go at a high speed from intersections in such a scenario our system will ask them to stop and look both ways and then proceed immediately.

We use Arduino for computing which also has the capability of connecting with the internet therefore we have also developed a small Android application that will show the live status of the traffic light. This functionality can be embedded into online mapssuch as Google Maps where the live status of traffic lights can be shown along with directions Also as we have traffic density at that particular intersection, we can also usethat data to show traffic in that area.

III. FUTURE STUDY

IR sensors have their limitations such as they cannot differentiate between a Car anda bus. In general, it cannot determine what an object is. There are also chances of people parking in front of sensors or a person standing in front of the sensor. There can also be Environmental factors affecting the efficiency of the sensor factors such as rainfall, andfog can affect them. One alternative can be using cameras powered by AI. As AI is booming these days and we can see many benefits of using it, an AI can surely effi- ciently determine traffic density as compared to IR sensors. Additionally, these cameras can also be used for surveillance or identifying vehicles that do not follow traffic laws.

IV. LIMITATIONS

As discussed above in the Future study section we surely have limitations with IR sensors. Another limitation is the cost related to this We had used Arduino for the com-putation along with that comes the cost of sensors and the internet. Although this has to be implemented in dense parts of the city it is still a limitation, we will also need to connect intersections. This system can improve traffic jams; however, it is still depend-ent on the amount of traffic, population, and efficacy of public transportation.

V. CONCLUSION

This paper introduces an innovative approach to deal with synchronization of trafficintersections dynamically. We have focused on the problems faced in dense unplannedparts of the city that don't have a grid system. With the correct implementation of the system problems here can be reduced significantly.

VI. CODEBASE

GitHub - sid732/-Traffic-Signal-Synchronization-and-Dynamic-Control

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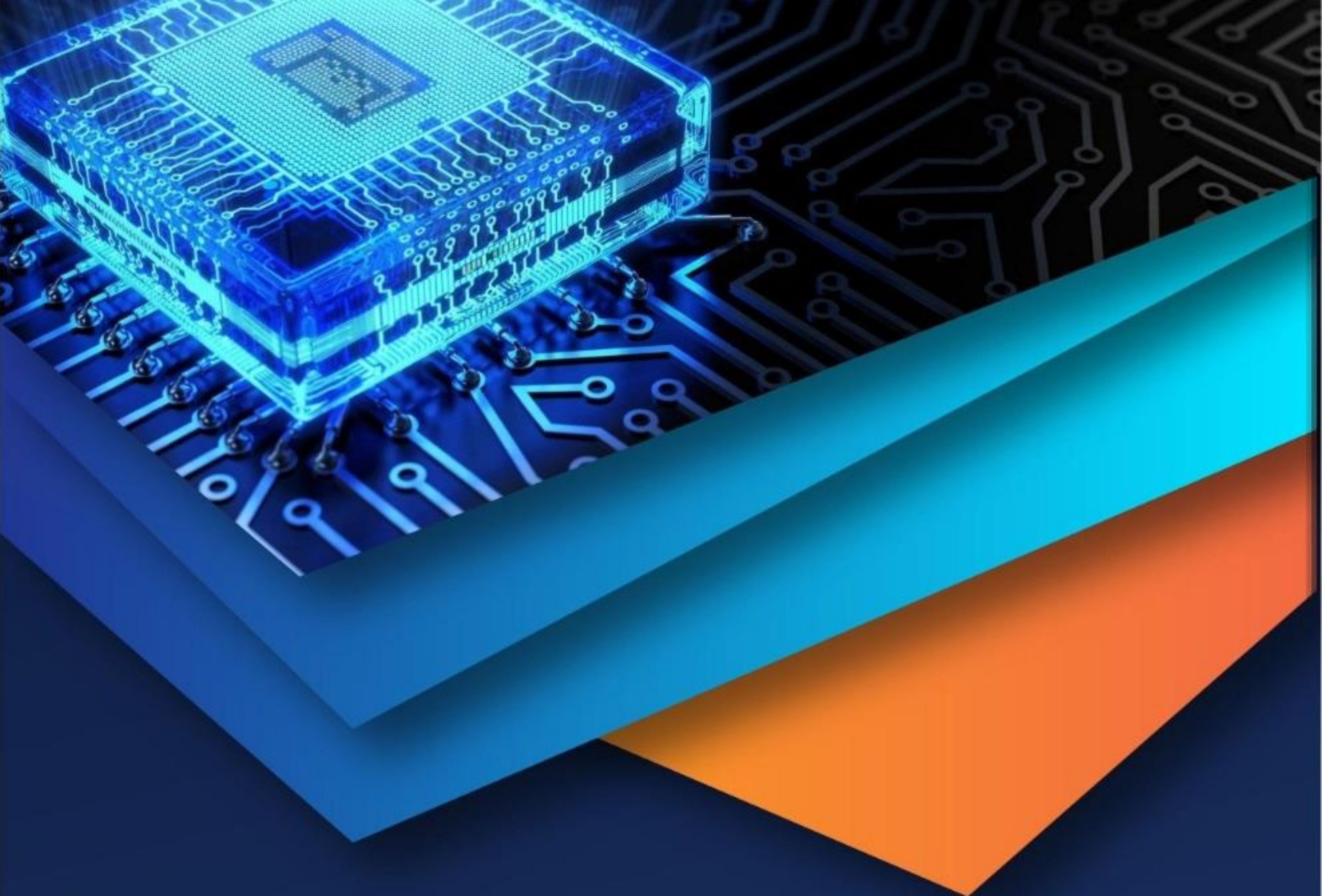

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