Feasibility Study of Incorporating An Intelligent Transportation System For An Urban Transportation Network

Gangadhar S. Sharma[1], Ashish V. Gad[2], Amogh Karanth B. S.[3]
[1, 2, 3]Dept of Mechanical Engineering
[1, 2, 3]AMC Engineering College, Bengaluru

Abstract- *This paper aims to explore the feasibility of a "Smart Navigation system" within the transportation network of a smart city and discusses a wide range of modern technologies available for the successful implementation and execution of such a navigation system. The study envisages the various aspects of controlling an ever-increasing vehicle population thereby eliminating the choked and chaotic effect of harmful emissions on the urban streets. The study proposes to incorporate smart driving technologies, smart traffic control(s) and inversion mech- anisms using smart traffic density sensors, Radio Frequency Devices (RFD). The study also discusses providing smart parking solutions as a part of overall enhanced infrastructure for smart traffic and parking management solutions. To conclude, the study outlines the benefits accrued by effective incorporation of smart navigation systems, which includes enhanced quality of life and economic development of its inhabitants.*

Keywords- Smart Navigation Systems, Intelligent Traffic Control, Traffic Sustainability, smart cities, Indian traffic sys- tems, Traffic Management

I. INTRODUCTION

Smart Navigation Systems (SNS) is a way of navigating for all traffic from one point another point using smart tools systems such as apps, web apps and sensors that are connected to internet1 . It is a part of an Intelligent transport system. It is a quick and efficient tool to manage traffic in large cities and towns. SNS empowers the users to have access to faster travel routes, quicker and efficient means of decision-making on alternate routes in cases of traffic jams caused by untoward incidents like accidents, natural calamities, road closures due to geopolitical unrest etc.,

SNS integrates a wide range of gadgets and applications possibly from every branch of engineering. Be it the con- struction of the roads and highways by the Civil engineering, designing and commission of such vehicles by the Mechanical/ Automobile engineers, integration of smart sensors, GPS based mobile tracking system, communication networks etc. by the faculties of Electronics, Computer Science and Information science. Hence, SNS can be regarded as one of the finest examples of totally integrated synergy of multi-disciplined, multi-faceted engineering endeavor.

Certain aspects of SNS, involving its components, require- ments, advantages and limitations are explained with the points highlighting their present advancements and challenges met due to the various technological barriers and socioeconomic conditions.

II. WHY SMART NAVIGATION SYSTEMS?

As the towns have become larger and larger, the commuting of people across the length and breadth of the city for their necessities, using either personal or public transport vehicles become inevitable. Naturally an account of this, there will be an increased number of commercial vehicles as well due to this, causing increased traffic density and even may result in traffic congestion.

Traffic congestion is a condition on transport networks that occurs as use of roads increases, and is characterized by slower speeds, longer trip times, and increased vehicular build- up. When traffic demand is great enough that the interaction between vehicles slows the speed of the traffic stream, this results in some congestion. While congestion is a possibility for any mode of transportation, this paper will focus on automobile congestion on public roads. The current modern transport network is able to address these issues to an extent, the ever growing vehicular traffic, demands for faster and efficient transport systems besides the parking problems in urban centers have thrown new challenges.

To address these challenges, the SNS has been suggested as a one stop solution.

III. CAN SNS REALLY SOLVE OUR CURRENT PROBLEMS ?

The aim of the Smart Navigation System is to provide the best possible navigation experience using periodically refreshing route calculations backed by proprietary predictive traffic. Important techno-logical contributions are a minimal- istic consumption of internet bandwidth, and an exploitation of an adaptively performant supercomputer capable of serving thousands of routing requests a second.

The navigation use case challenges implementation for Smart City solutions envisioning a central and knowledgeable routing server, which collects and fuses all useful data sources, with emphasis on local traffic knowledge as well as including driving events (like acceleration and braking) from navigated vehicles. All this data is used for routing calculations seeking for the most optimal utilization of a global network within a city area.

Fig. 1. The interactions between Intelligent Traffic System and all its components

This navigation system goes beyond GPS navigation as we know it now. It seeks to provide routes with regard to a global optimum for a city, not just for individual benefits of drivers. Moreover, we envision a performance central routing point open to absorb plenitude of local traffic knowledge. The challenge is how to engage maximum number of vehicles into the system, which is we want to help with an open routing interface, which finally would be in a possession and control of a cityThe new server routing system with its interface is architecture with regard to an interoperability so that any client navigation device capable of accepting routes from external system and contributing to the traffic knowledge can connect. Synergistic navigation will be the first to comply with this interface

The main goal of urban intelligent transportation is that urban road traffic to be orderly and efficient, and more accurate and reliable traffic information to be provided for traffic travelers.

This way the traffic can be controlled and any further obstruction caused allows deviation of vehicles and hence there is reduced congestion and efficient navigation

IV. DIFFERENCE BETWEEN PRESENT NAVIGATION SYSTEMS AND SMART NAVIGATION SYSTEMS

The comparison between the current navigation system and smart navigation system helps better understand the need for smart navigation system in an Indian setting. The use of GPS and GNSS in the current navigation system is proving to be inadequate, which is very apparent in many of the Indian cities. This is because the signals from these are generally inaccurate and generally leads to a longer journey time. Although arguments can be made about increasing the signal strength and/or using more satellites with better capabilities, they can prove to be a very costly affair for a country like India. This is where smart navigation systems can prove to be not only effective but also cost- saving. These systems make use of sensors, vision cameras, RFID's etc to gather information on traffic and help in efficient transportation. The development and implementation of these devices can prove to be rather economical in contrast to the refurbishment of the current system. Real time data tracking is a real possibility which is also a gain over the existing navigation system. Smart Navigation System also helps develop a sense of transparency with the citizens.

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V. WORKING PRINCIPLE OF ADVANCED NAVIGATION SYSTEM

1) **Architecture of the system:** Cameras are placed at the top of the signal to have a better line of sight. Also, the clear view of the traffic on the particular side of the signal so that it will capture an image and analyses the image and get the count of the vehicle at that particular side. This count helps to detect the density of the vehicle and accordingly the signal is automatically adjusted.
2) **Traffic Information Extraction:** Extracting traffic information from image and video cameras placed at an appropriate position is employed for image acquisition. Camera video stream data is processed frame by frame, to determine how much traffic is on the road. In these background subtraction methods, the empty road will be the background image and the subsequent frames from the video camera will be foreground image. By subtracting the background image from foreground im- age, we can find the traffic density of the road. These two methods consists of gradient magnitude and another direct subtraction method.
3) **Vehicle Count:** There are many drawbacks for algorithm search of connecting pixels. Due to this, bounding box property[i] is used to see the number of vehicles on that particular lane. After labeling the number of pixels of each labeled vehicle contain are counted and accordingly the vehicles are categorized as small, medium and large vehicles. To display the total no. of vehicles, the number of pixels each vehicle contains, the number of vehicles falls into each category. Accordingly, the priority is assigned to the road. After comparing the number of vehicles the traffic signal control assigned the priority which lane should be given first and accordingly the time limit is assigned. For drawing the bounding box we required to see the information about every region and bring a property of connected components of the binary image. The three properties are considered eccentricity, area and bounding box.2
4) **Traffic Control Algorithm :** Implementation of the traffic control algorithm according to the density the traffic is control. So that according to the density of the vehicle we can set accurate time limit required. We take the traffic densities of different roads at a certain time as an input, based on the taken input we produce output.
5) **Hardware Implementation :** Implementation of the image processing by using mat lab further that data is given to the micro controller through USART module (Universal Synchronous Asynchronous Receiver Transmit- ter) module for sending the information from software to micro controller. The use of this micro controller, because it's a low power CMOS 8- bit micro controller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, it achieves throughput approaching 1 MIPS per MHZ, allows the system designed to optimize the power consumption vs. processing speed. All the necessary information is pro- cessed and sends by mat lab to the micro controller for a particular signal to be lighted. So there is longer traffic cycle for more traffic density vice versa accordingly the traffic light is controlled. It's obtained by using model weight and weight time allocation.
6) **Emergency Vehicle Detection :** There is additional concept is used during traffic management in case of ambulance, police vehicle. When there are too many lanes, if the vehicle is present in that particular lane is detected by using these below algorithm and that lane is given higher priority for that particular time limit so that the vehicle can pass easily by making that lane signal green. After the acquiring of the image, it goes through the grayscale image, edge detection, morphological operation, and then by specifying the particular threshold is used to detect the red light. We isolated the area with high-intensity red light and lesser intensity of the blue and green color. Due to these, the headlight of the vehicle is detected, but the condition is given that red light must satisfy the blinking condition. The red light satisfying should appear in the other frame so the other lights are eliminated. Also, if the vehicle in any position can be detected easily3.

VI. SOLVING THE PARKING PROBLEM

On a daily basis, it is estimated that 30% of vehicles on the road in the downtown area of major cities are cruising for a parking spot and it takes an average of 7.8 minutes to find one.

It has been reported that over one year in a small Los Angeles business district, cars cruising for parking created the equivalent of 38 trips around the world, burning 47, 000 gallons of gasoline and producing 730 tons of carbon dioxide. The system assigns and reserves an optimal resource (parking space) for a user (driver) based on the user's objective function that combines proximity to destination and parking cost, while also ensuring that the overall parking capacity is efficiently utilized.

The realization of such a "smart parking" system relies on three main requirements. First, the allocation center has to know the status of all parking spots, the location of all vehicles issuing requests and traffic situations. As already mentioned, current sensing technologies make monitoring parking spots implementable. Moreover, standard GPS technology provides accurate localization and speed estimates of vehicles. The second requirement involves effective wireless communica- tion between vehicles and an allocation center. This is also achievable through existing wireless networks that may be proprietary or part of cellular telephone service providers. Finally, the center must be able to implement a reservation that guarantees a specific parking spot to a driver. This is achievable through wireless technology interfacing a vehicle with hardware that makes a spot accessible only to the driver who has reserved it.4

VII. IMPROVING TRAFFIC SAFETY

Unsafe speeds, dangerous weather conditions and heavy traffic can all lead to accidents and the loss of life; intelli- gent transportation systems help with all of these. Real-time weather monitoring systems collect information on visibility, wind speed, rainfall, road conditions and more, allowing traffic controllers up-to-the-minute information on driving condi- tions. In fully networked systems, this information can then be used to update warning signs and even speed limits as soon as the need arises, keeping drivers alert to the conditions around them. Emergency vehicles can respond quickly to accidents as real-time traffic monitoring alerts them. ITS traffic control helps divert traffic away from busy or dangerous areas, preventing traffic jams but also reducing the risk of collisions.

VIII. REDUCING INFRASTRUCTURE DAMAGE

Heavy vehicles can put a lot of strain on the road network, particularly when they're overloaded. Weigh stations and other older forms of weight control reduce the risk of overloading but at the expense of wasted time and delayed traffic. Weigh- in-motion systems measure the type, size and weight of vehicles as they move, communicating the collected data back to a central server.

Overloaded vehicles can be identified and appropriate mea- sures taken resulting in higher compliance among hauliers and reduced damage to roadways. Not only do these systems make enforcement simpler, they can reduce expenditure on road repair, allowing it to be allocated elsewhere

IX. TRAFFIC CONTROL

Existing centralized traffic control systems go some way toward alleviating traffic congestion and ensuring the smooth flow of vehicles through a road network. Intelligent trans- portation systems, however, allow traffic lights to respond to changing patterns themselves. Adaptive traffic light systems create smart intersections that control traffic in response to the patterns they observe among the vehicles using them. They can also prioritize specific forms of traffic, such as emergency vehicles or public transit. Large numbers of adaptive inter- sections working together produce a system in which lights change in response to traffic patterns rather than on a fixed schedule, reducing weight times and keeping traffic moving smoothly.

X. PARKING MANAGEMENT

Illegal parking contributes to crowded, dangerous city streets and creates problems for disabled drivers, city vehi- cles and others needing access to reserved parking spaces. Overstaying drivers slow traffic to a crawl in busy areas as visitors find themselves unable to park. Traditional parking enforcement systems can be costly and inefficient; they may even add to crowding themselves. Smart parking violation detection scan parked vehicles and communicate with parking meters to identify and record illegally parked vehicles.

Instead of taking their chances with a human parking enforcement officer, drivers know they will automatically be cited for illegal or extended parking. These automatic systems help improve traffic flow by increasing driver compliance and smooth turnover of parking spaces.

XI. POLLUTION CONTROL

In urban areas vehicles are one of the major sources of pollution. Increase in number of vehicles in past few years has increased vehicle related pollution, Major pollution factors include harmful emissions and sound pollution when the vehicles are struck in the traffic jams. Vehicles emit pollutants like NO_x gases, CO_2, SO_2 , etc. These gases have green house effect in the earth, causing global warming.

SNS aids in reducing these traffic jams and there by harmful pollutants by inferring real time accurate traffic behavioral information of the smart cities. There are many variables obtained from various sources these vary in range and various parameters and hence, smart navigation system can identify the various causes of traffic congestion.

Servers developed around smart navigation system service major source for big data, collection for information is vital for implementing effective traffic management and control system the actual cause and sensors must be robust and must be able to work under any weather and climatic conditions throughout the year. This allows prediction of traffic conditions and other real time information which estimate traffic density and gives time real- time information along with previously obtained data can be used to propose strategies to prevent traffic related pollution.

Extracting features from various road segments the road segment features involves: dimensions geometry and road type. The main parts also feature road signals, number of intersection points, vehicle occupancy, average lane speed limit and general vehicle handling capacity at slow traffic paces Further extracting the number of vehicles and vehicle type and the vehicle speed to Analyze the traffic patterns are used. These features of road part and where which general day-night window is as the vehicles are handled based on the commutator comfort of travelling. The data obtained is analyzed and

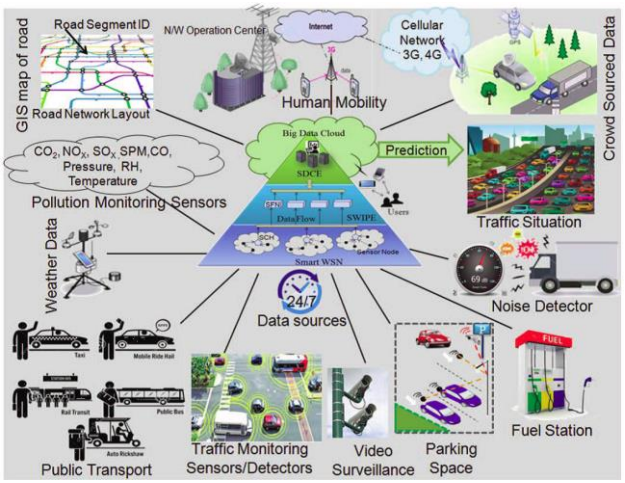

Fig. 2. Bigdata sources for road traffic monitoring

this data is semi-supervised involving machine learning and deep learning to control traffic, which in turn, reduces the vehicle standby time and ignition time. This also prevents the inaccuracies by filtering and removing data that is not part of the range. This is usually the boundary data which has been occurred due to certain Inconveniences. This can increase efficiency of the system reduce the emission and vehicle related pollution. Bigdata sources for road traffic monitoring connecting Bigdata sources for road traffic monitoring, and Bigdata sources for road traffic monitoring, better efficiency to prevent pollution.5

XII. IMPACT ON HUMAN PRODUCTIVITY AND ECONOMY

In Smart Navigation System, there is a proper balance between transport demand and supply measures achieved sustainability without compensate in economic development. There can be policies like Vehicle Quota System and other policy schemes that meet the traveling demand.

The productivity depends on the aspect of requirements to travel demands during the peak hours and accessibility options. This method is perfect alternative as there is a very less time wastage and is beneficial time saving method. There will be a great raise in productivity due to the above said factor. With increase in electric vehicles the power usage is pro- duced from consumption of electricity is done efficiently. This is valid for vehicles with all types of fuel usage, which leads to a good economic growth.

Fig. 3. Interaction between Radio Frequency Devices(RFD) in Smart Navi- gation Systems.7

XIII. CASE STUDY-SINGAPORE

The paper by Haque et al. illustrates with an example of Singapore to show how a modern transportation system is making waves by integrating visions for sustainability, safety and smartness inside its mobility system. The key attribute of their study was to examine the transport policies and strategies of Singapore by categorizing them into 3 main ele- ments viz, sustainability, safety and smartness. They point out that modern transportation system with these three elements helps promote social and economic development efficient way without damaging the environment. The first component under study was sustainability. The infrastructural data of all key transportation systems in Singapore was obtained and scrutinized. The shortcomings were identified and solutions for sustainability were offered with mandatory peak hour bus lanes, better integration between rail and bus services, and

strategic placement of taxi stands for the last mile connectivity being the important ones. The second aspect under consideration was safety, which ensures the viability of the smart system. They present the argument that road casualties and other traffic incidents burn a hole in the pockets of the injured and is also a burden to the national health system. The success of the modern transportation system also depends on the fact that these casualties and injuries are minimized and propagation of safe road usage. By supporting this stand from data and statistics, various measures were put in place. Installation of better vehicular impact guardrails and providing rain shelters along expressways to help the motorcyclists, and elevated zebra crossing and traffic-calming markings at these crossings to help prevent pedestrian related accidents are in place. "Enhanced School Zone" are setup to reduce to accidents around school areas. Various private organizations and companies help play a vital role in organizing safety campaigns and awareness programs.

The final aspect was smartness which is the amalgamation of smart technologies to invigorate sustainability and safety.

The need for smart technologies was realized to better control and monitor the different systems in place and to make it self-sustaining. Smart technologies in Singapore were broadly classified into 4 categories based on their primary func- tions: control systems, monitoring and enforcement systems, information management systems and revenue management systems. Control systems such as Green Link Determination System (GLIDE) to collect traffic data and automatically allocate signal timing based on traffic volume along each intersection and B signal, to detect approaching buses and facilitate their movement by extending green signal have been realized. Audio signals to aid hearing impaired people are also in place. For monitoring and enforcement systems, a smart incident management system called expressway monitoring and advisory system (EMAS) were put in place to automat- ically detect breakdown and congestion to allow authorities to take quick action. Advanced surveillance cameras called J eyes are installed to help detect irregular traffic situations, illegal parking etc. Bus lane enforcement was also realized to ensure smooth operation of buses. Information management systems collect real time data and shared with the travelers to help better plan their routes in advance. Traffic news broadcasting and public transport information sharing are it's two subsidiaries. For revenue management systems, various measures have been implemented. The contact-less tap and go fare card is one such example for fare payment on all modes of transports. All these strategies and policies have helped Singapore develop a viable urban mobility system. And it certainly proves that the "smart way" is the way forward

XIV. CONCLUSION

All the points covered, we conclude saying that the Smart Navigation Systems, or Intelligent Traffic Control is feasible and can be implemented in our country, when implemented fairly, it can reduce any major traffic related issues like congestion, accidents and other issues like weather related traffic issues.

Pollution is another major factor that can be reduced, fuel efficiency is increased and helps improve fuel economy and there are many cities that reap fruits of this system.

XV. FUTURE WORK

India is a nation with a very high untapped potential with tools and resources to reduce traffic in a smart way. There are a lot of implementation issues yet to be studied and implied successfully. The system used and the nature of the system must be studied and implemented according to India's conditions. Many topics like Socio-economic aspects and human productivity can be further studied and the techniques discussed can be changed and implemented accordingly.

NOTATION

[1]https://www.parkeagle.com/2018/05/23/what-is-smart-navigation

[2]A bounding box (usually shortened to b-box) is an area defined by two longitudes and two latitudes, where: Latitude is a decimal number between -90.0 and 90.0. Longitude is a decimal number between -180.0 and 180.0.

[3]Density Based Smart Traffic Light Control System and Emergency Vehicle Detection Based On Image Processing by Miss. Gaurita R. Choukekar, Mr. Akshay G. Bhosale

[4]A New "Smart Parking" System Based on Optimal Resource Allocation and Reservations by Yanfeng Geng and Christos G. Cassandras

[5]Big data sources for road traffic monitoring illustrated by Satyanarayana V Nandury and Beneyaz A Begum in the paper related to Strategies to Handle Big Data for Traffic Management in Smart Cities