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Intelligent Transportation System for Roadways

Hrishikesh Katti
Transportation Engineer
Beacon Ave, Fremont, CA 94538

Abstract: ***Saving time on your daily commute is priceless, but it's a luxury that few can afford. The latest figures from the U.S. Department of Transportation suggest that Americans spend an average of 42 hours in traffic congestion every year. In fact, commuters in some cities spend around 90 hours in their cars each year! The cost of this lost time and productivity is enormous: around $160 billion annually in the U.S., or about $960 per commuter, according to a 2013 study by INRIX. The evolution of intelligent transportation systems (ITS) has been rapid in recent years, but the challenges that remain are even greater. There is a lack of thorough understanding about what makes an Intelligent Transportation System a success, and how to maximize the benefits it can offer. In this paper we will discuss the Intelligent Transportation System Challenges.***

Keywords: Intelligent Transportation System Challenges, Traffic Artificial Intelligence, Dynamic Traffic flow control, Accident Prevention, Sustainable Transportation

I. INTRODUCTION

There could be no smart city without a reputable as well as efficient transportation system. This need makes the Intelligent Transportation System a crucial element of any kind of smart city and smooth transportation principle. While traditional Intelligent Transportation System innovations are deployed worldwide in clever cities, enabling the future generation of Intelligent Transportation System relies upon effective integration of connected and self-governing vehicles, both modern technologies that are under wide field screening in lots of cities around the world. Although these 2 emerging innovations are crucial in enabling fully automated transportation systems, there is still a considerable requirement to automate various other roadway as well as other system components. To this end, due to their movement, independent procedure, and also communication/processing capacities, Unmanned Aerial Vehicles (UAV) are imagined in many Intelligent Transportation System application domains. This article defines the possible Intelligent Transportation System applications and highlights the potential and also obstacles for Intelligent Transportation System.

ITS is planned for the city or region considering the vision to enhance operation of multimodal transportation system which would improve liveability, optimize efficiency to achieve sustainable growth and reduce emission by technological advances. The objectives of the Intelligent Transportation System could be the following:

(1) Data Collection

A means to collect real time traffic data, analyze the data and generate traffic information that can be readily utilized by the drivers instantaneously. The data can be stored and utilized for planning, traffic management and understanding future transit and transportation needs. Sensors in form of loop-detectors placed on the traveled way collect the real time traffic data that includes traffic volume, travel time, occupancy etc.

(2) Data Utilization

A process which enables utilization of collected data, integration of readily available data & information from other sources and determine subsequent steps in the pre-defined protocol utilizing customized algorithm. The examples of sources include roadside equipment, traffic administrator such as police, public works & transportation authorities, and regional transit agencies, etc. All the available information shall be utilized for betterment of transportation system.

(3) Collaborative Approach

One of the unique features and aim of ITS is developing collaborative approach for central coordination amongst the involved agencies. ITS provides a platform where data from designated sensors, other means and agencies can be collected, analyzed, utilized, and presented in the useful format to cater the specific needs of decision making. Apart from that, it can be integrated with the asset management system for developing multimodal transportation and ensuring longevity of existing infrastructure.

(4) Developing Policies & Regulations

While developing a master plan or policy matter to address short-, medium- and long-term plans, for city and/or region, ITS provides a cohesive picture of overall transportation system. The collected historical data can provide basis for taking informed decision for preparing regulations such as designating accident-prone zones, one-ways, development of commercial districts and/or neighborhoods etc.

(5) Traffic Management

To regulate the traffic depending on the real-time demand, capacity and flow. Historic traffic data and patterns can generate a predictive pattern for recurring events which would help authorities to plan traffic management through the areas that can potentially be affected. System can even suggest alternate routes for effective decongestion, effective traffic flow and efficient use of the infrastructure.

(6) Effective Asset Management

ITS identifies the locations of traffic congestion in terms of quantitative and qualitative measures such as volume, speed, queuing, and level of service (LOS). This data can provide desired input for taking asset management decisions such as road-widening, maintenance, adding traffic control devices etc.

(7) Congestion Pricing

To alleviate congestion and control traffic demand by discouraging usage of vehicles such as imposing congestion charges, higher parking fee, encouraging flexible time and persuading commuters to explore transit options.

(8) Multimodal Connectivity

System can provide the data in terms of mode choices, trip generation (origin and destination), trip distribution etc. This would assist authorities in making key decisions for developing multimodal choices which would reduce usage of personal vehicle, encourage public transportation and other means such as bicycle to get around locally.

II. INTELLIGENT TRANSPORTATION SYSTEM SOLUTIONS

Wide range of ITS solutions are available and being developed depending on the specific requirements. Utilization and implementation of these systems depends on the context sensitivity and need. ITS solutions in general are adaptive and can be modified based on the specific demand. Although the list of solutions offered in ITS is endless, here are few of the commonly used solutions in most of the transportation projects:

(1) Camera

Camera is one of the ITS solutions used in abundance. A camera when paired with the tailored applications such as surveillance, video analytics, license plate recognition, facial recognition, traffic violation systems etc. can serve purpose according to the need.

Fig 1. Traffic Enforcement Camera

Fig 2. Traffic Surveillance Camera

(2) RFID

Radio Frequency Identification (RFID) technology is being used widely for tolling systems to recognize the unique identity of the vehicle. RFID is coupled with the personal payment accounts such as credit cards to collect the toll payment. Apart from that, it is currently been effectively used for automatic fare collections, tracking the vehicles for origin-destination, payments for parking etc.

Fig 3. RFID readers mounted on the gantry

(3) Traffic counter and classifier

This is one the most important solutions offered in ITS especially in terms of traffic data collection. Classifiers can be temporary or permanent depending on the utility, need, purpose and location. Traffic tube counters are typically used for temporary purposes whereas, Inductive loop detectors are placed in the pavement permanently which collect the data continuously. Bicycle inductive loop detectors are also available to collect the data which would help plan the bike-paths to create multimodal friendly environment.

Fig 4.Inductive loop detectors

(4) Probe System

Probe is the mostly utilized to get the near real-time traffic data at any point of time. Probe system collects information of the traffic stream respective to the time and location. Probe system can supplement the data collected from traffic counter and classifiers for making informative decisions for improvement and development of roadway infrastructure. Probe data can be collected from the GPS devices installed on designated vehicles such as buses and/or cabs. Geolocation on the cellular phone is also considered one of the useful sources of data as well.

(5) Automated fare collection system (AFCS)

The system utilized to collect fares for the transportation facilities. Components of AFCS typically consist of a Vending Machine for ticket issuance and a Validator to authenticate the validity of issued ticket. Most typical applications of AFCS are transit agencies and parking complexes. Common transit card is the advanced application of AFCS. It utilizes a single card for multiple transit systems in the area by linking the payment methods such as credit or debit cards to automatically pay for the usage as per the requirements.

Fig 5. Automatic Fare Collection System

(6) Unmanned Aerial Vehicle (UAV)

Most commonly referred to as Drones, usage of UAVs is gaining popularity in transportation industry for applications such as tracking construction progress, asset management, surveys such as topography, photogrammetric etc. and data collection, roadway maintenance etc. It can also be effectively benefit in damage assessment of critical infrastructure especially after natural calamities such as flood, fire, earthquake etc. Utility of UAV still remain unexplored and need to be further studied

Fig 6. UAV/Drone

(7) Adaptive Signal Control System

Solution consists of multiple sub-components such as signal heads, traffic controller and traffic detectors. Detectors can be intrusive (inductive loops) or non-intrusive (cameras) which provides input to the traffic controller. System automatically adjust signal timings to cater the instantaneous traffic demand delivering better service to road users in terms of congestion relief, travel time reliability and fuel consumption. The adaptive signal system is widely used in UK, Australia, and Asia.

(8) Variable/Changeable Message Sign

One of the most commonly used ITS solution to display the information. Sensors and/or other solutions in the system placed can provide ample amount of data for the authorities to be display useful information about mode choice for the public usage. It can also provide information such as travel time, any planned closures and/or road works, general public information dissemination such as alerts for upcoming events, congestion toll pricing etc. so that travel can be planned accordingly. It can also help diverting the traffic from the congested areas in order to reduce the stress on roadway network, traffic violations by providing the information well in advance.

Fig 7. Changeable Message Signs

Fig 8. Variable Toll Message Sign

All the components of ITS are connected with central Command and Control Center through secured wired and/or wireless connections. Components of ITS provide valuable information to the authorities, enforcing agencies and the general public to making informed decisions on traffic, travel and even making policy matter decisions in the broader context such as catering the temporary demand, developing infrastructure plans, preparing master plans for the area etc.

III. CHALLENGES IN TRAFFIC ENGINEERING AND ROLE OF INTELLIGENT TRANSPORTATION SYSTEM IN SUSTAINABILITY

Upgradation and development of existing roadway network has always been a focal point in prospering economy. Tackling the challenges in traffic engineering has never been easy. With sustainability in the focus, it has become even more difficult to plan the system as it would not only cater present situation but can also survive in the distant future and provide meaningful guidance for the generations ahead. Here are some of the challenges in traffic engineering currently faces and how ITS can assist in resolving the upcoming issues:

(1) Peak hour traffic pattern

Managing everyday congestion at peak hour in the corridors is one of the major challenges that ITS faces on the other hand, once the sufficient traffic data is available, ITS solutions can efficiently manage traffic and alleviate congestion. The data can even be effectively utilized broadly in altering travel pattern by providing useful road traffic information such as estimated travel time via different mode choices so that they can make informed decisions. This will ultimately even increase the overall travel speed.

(2) Condition of road infrastructure

Present condition of roads and bridges in USA is poor and needs major upgrade. Interchanges of many intersecting highways and freeways are outdated and can't cater the current demand causing major delays. If implemented in conjunction with the upgraded civil infrastructure, ITS will be able to ensure optimal utilization of the existing infrastructure. Even further, it can provide valuable input in developing strategic plans.

(3) Traffic Enforcement

Enforcement of violations is one of the worst nightmares of traffic management. Violations not only hamper the traffic safety, but it can also cause damage surrounding properties, street furniture and even structural components such as bridges, retaining walls, barriers etc. Camera based ITS solutions can assist enforcement agencies especially for the hit-and-run violations by collecting photo and video evidence.

(4) Traffic Safety

Traffic safety has always been of paramount importance especially while seeking and implementing the solutions. With increase in the traffic it is becoming increasingly challenging to enhance traffic safety. It not only includes safety of the drivers, but also safety of other road facility users such as pedestrians and bicycle riders especially as implementation and usage of bike lane is now becoming increasingly popular. ITS can play an important role in making the roads safer by assisting in enforcement efforts. Even more, bicycle loops and pedestrian counting cameras can provide a valuable data to develop new safety strategies and standards.

(5) Public Transportation

One of the most important modes of transportation that needs serious attention for improvement is public transit. Public transportation system improvisation is the proven most effective solution for increasing the overall efficiency of the system. Providing a functional public transit system has been a huge challenge due to various facts such as lack of available options, willingness of people to choose mass transit over own comfort and convenience, failure to provide last mile connectivity etc. These challenges have translated in reduced ridership over the years which again becomes a major setback in providing fruitful public transportation system. Data collected from ITS solutions such as origin-destination can help improvise the routes and frequencies offered, planning of last mile connectivity initiatives. Integrated AFCS plays an important role in mass transit as one system can be utilized for using multiple modes of transportation

(6) Promoting multimodal transportation

Multimodal transportation is one of the most important sustainable initiative gaining traction in recent years. 'Complete Streets Program' planned by state and local agencies are meant to promote non-motorized modes of transportation such as bicycle and walking. One of the challenges faced in implementing the program is public safety especially as the motorists, bicyclist and pedestrians will be using the same facility. ITS solutions such as bike loop detectors, camera sensors can collect valuable data for planning and implementing the multimodal facilities, pedestrian refuge and traffic safety enhancement strategies.

(7) Delay of investing strategies in ITS infrastructure

Infrastructure upgradation is the core development policy for boosting the economy and improvising livability. Policies in the recent past have addressed the rise in demand with increase in capacity of roadway infrastructure. Strategies on optimizing the usage of existing facilities are long overdue and need to be prioritized. ITS implementation has provided great results in enhancing the efficiency of currently available transportation system. Sustainable development in transportation is a need of the hour and hence investing in the ITS should be given the same importance as the other strategies in infrastructure development.

(8) Availability of expertise

Intelligent Transportation System is an evolving domain. It requires expertise both in the principles of traffic & transportation engineering and technology. With the continuous development in technology and upcoming challenges in prioritizing the traffic strategies, the necessary expertise is very limited and sparse. Initiatives should be developed to promote the education and experience in ITS field which would have long lasting impacts especially on the roadway

infrastructure in the future.

(9) Privacy and security

Like most of the other technology dependent industries, one of the huge challenges faced in implementing the ITS is data security and privacy. With the recent cyberattacks on the critical infrastructure, it has become really important to develop defense mechanism to prevent and/or minimize the impact on system. ITS being a heavily technological reliant industry faces an uphill battle with these threats as well. The impact of such an attack would be detrimental to the traffic operations and more importantly for the public safety.

CONCLUSION

To ensure a successful implementation of intelligent transportation systems on the roadways, we must have an accurate assessment of the current condition of our transportation network and we need to continually monitor its performance and make necessary improvements as needed. Intelligent transportation systems are being developed to address growing congestion and boost mobility. It's vital to understand the challenges being faced, and the best ways of overcoming them, if we are to make the most of this technology in future years.

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