AI for Safe Transportation Use Case - Smart Cities

Statement of Work (SoW)

Overview on Smart Cities

Traditionally, a smart city has been defined as a "city that uses information and communications technology to make its critical infrastructure, its components and public services more interactive and efficient, making citizens more aware of them". In a broader definition, a city can be considered as "smart" when its investment in human and social capital and in communications infrastructure actively promote sustainable economic development and a high quality of life, including the wise management of resources implemented through a participatory government.

"Smart Cities must be considered as systems of people who interact and use flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and a high quality of life; these flows and interactions are "smart" through the strategic use of ICT infrastructure and services within a transparent urban planning and management process that responds to the social and economic needs of the society" [1].

One of the emerging technologies tightly related to smart cities is the Digital Twins; before the term 'digital twin' was even devised, organizations such as NASA and city planners used the technology through Computer Aided Design (CAD) and smart maps powered by geospatial analytics. As the Internet of Things (IoT) began to rise, it saw the implementation and popularity of digital twins in other industries, due to its cost-effectiveness and ease of use. The concept of the smart city through digital twins is evident. From urban planning to land-use optimization, it has the power to govern the city in an effective manner. Digital twins allow the simulation of plans before implementing them, exposing problems before they become a reality. Architectural aspects that could be planned and analyzed through digital tools include; housing, wireless networks antennas, solar panels, and public transport [9].

ITS in Smart Cities

Intelligent Transportation System (ITS) is the application of sensing, analysis, control and communications technologies to ground transportation in order to improve safety, mobility and efficiency. Intelligent transportation system includes a wide range of applications that process and share information to ease congestion, improve traffic management, minimize environmental impact and increase the benefits of transportation to commercial users and the public in general. Some of the main reasons ITS is needed [4]:

- Inadequate road development.

- Low speed, increased accident rates.
- It is not possible to build enough new roads or to meet the demand.
- Make transportation system more efficient, secure, and safer through the use of information, communications and control technologies.
- Improve the attractiveness of public transport.
- Tackle rising congestion which increases travel times and industry costs.
- Reduce the environmental impacts of transport.

ITS provides several advantages including reduction in stops and delays at intersections, speed control & improvement, travel time improvement, capacity management, incident management; this is achieved though some key Intelligent Transportation user services are provided in following table [4]:

Title	Services
Traveler Information	Pre-trip Information, on-trip driver information, on-trip public transport information, personal information services, and route guidance and navigation
Traffic Management	Transportation planning support, traffic control, incident management, demand management, traffic regulations, infrastructure maintenance management.
Vehicle Systems	Vision Enhancement, automated vehicle operation, longitudinal collision avoidance, lateral collision avoidance, safety readiness, pre-crash restraint deployment
Commercial Vehicles	Commercial vehicle pre-clearance, vehicle administrative processes, automated road side safety inspection, commercial vehicle on-board safety monitoring, commercial vehicle fleet management
Public Transport	Public transport management, demand responsive transport management, shared transport management
Emergency Management	Emergency notification and personal security, emergency vehicle management, hazardous materials and incident notification
Electronic Payment (EP) Safety	Electronic financial transactions, public travel security, safety improvement for vulnerable road users, intelligent junctions.

Architecture of ITS

ITS architectures are primarily about data exchange and the control instructions that pass between the different ITS components and the external interfaces (operators, stakeholders and other systems). It needs to reflect the real-world constraints that operate on transport agencies and the requirements these impose on the ITS implementation. Examples are interoperability between the participating agencies and the retention of information control by the respective agencies. An ITS architecture may show where existing organisational structures need to be modified and changed – perhaps quite radically – in order to deliver the desired ITS services. An example is a traffic control centre (TCC) that may need to exchange data with another TCC or a traveller information centre (TIC), possibly across national or language boundaries. Defining the content and minimum performance specification for this transaction matters a great deal [5].

The ITS architecture enables the performance specification to be defined to achieve the required level of interconnection and interoperability. The choice of which specific technologies are best to use in response is a matter for the system designer. It is not possible to present a complex system in a way that can convey all the information about the system in an understandable manner. This is reflected in an ITS architecture, where multiple viewpoints, depicting different levels of detail and different types of information are used. These viewpoints might include [5]:

- the logic (or functionality) of the system describing how various items of data should flow and be processed (the “logical” or “functional” viewpoint)
- how the ITS functionality will reside in the physical components of the system (the “physical” viewpoint)
- what communications are needed between the physical components – and between the outside world and the physical components (the “communications” viewpoint)
- how the system components, communications and responsibilities are to be assigned to providers and recipients of the ITS services (the “organisational” viewpoint)

Safety Challenges in ITS

safety is critical to transportation systems given the human factor involvement who need to be protected and provided with safe ecosystem and at the same time they are potential source of safety issues and threats. Several challenges occur in such complex ecosystem where different types of vehicles typically run like trucks, cars motorcycles beside bicycles and pedestrians. Some of these challenges are:

- Bad driving behavior and aggressive attitude caused by irresponsible dangerous driving patterns and the lake of awareness and traffic rules violation.

- Road conditions and unnoticed circumstances like the case or ongoing road work, slippages, occurred traffic accidents or disaster.
- Distracted drivers by internal and external factors like using cell phone, getting busy with surroundings, busy with accompanied kids.
- Drivers' personal status like being stressed, having fatigue, rushing, drunk, drugged, sleepy or getting health attacks.
- Vehicles conditions due to lake of maintenance, ignored safety procedures for example in tiers charging/mounting, accidental damages.
- Driving without awareness and distracted driving when attention goes down, the chances of a car crash go up.
- Disaster conditions in the roads or around them like the case of ground breaks, pipeline explosion, floods and wildfire.

Rural areas are even more exposed to many safety challenges as reported in USA in 2012, rural areas accounted for 53 percent of the fatal crashes; and 54 percent of the fatalities. Some of the major factors contributing to crashes on rural roads include [7]:

- Exposure – people who live in rural communities generally travel more in their automobiles and over further distances, increasing the likelihood of a crash.
- Public transportation and bicycle and pedestrian networks may be insufficient, forcing people to travel by car or risk unsafe circumstances on alternative modes.
- Rural roadways typically have higher speed limits, which increase the severity of crashes when they occur.
- Physical limitations of rural roadways, some constructed between mountains or waterways, creates narrower lanes.
- Wildlife and weather conditions, such as rock slides, often affect rural roadways more significantly than urban areas.
- Rural roadways may have more curves, making roads longer and more challenging to navigate.

AI Solution Specifications

To address the safety in transformation systems especially in ITS equipped with technology elements needed like smart cameras, IoT sensor with efficient data acquisition capabilities, many topics need to be covered where AI solution could be of excellent fit. In this use case, we are including the following main topics under each could be several areas of implementation. The reset of the activities in this project from 2 to 18 are focusing on detailed process of getting real-life solution in place:

- Topic #1: Driving Behavior and Attitude: detecting aggressive driving, dangerous driving, overloaded trucks, defected vehicles, non-compliant vehicles, driver attention, distracting events, instability, proximity to other drivers.
- Topic #2: Traffic Accidents: detecting and estimating accident type and involved vehicle; truck, car, motorcycle, bicycle…etc., accident size and area, accident impact and consequences, causes and pre-events, responsibilities, recommends actions.
- Topic #3: Road and Environment Incidents: detecting and identifying ground crashes, pipeline explosions, falling rocks, tree crashes, rains and floods, fire and explosions, estimate impact and recommended actions.
- Topic #4: Vehicle Attributes Identification: detecting and identifying type of vehicle, speed, plat number, size, color, body physical status, tiers status, exhaust status
- Topic #5: Pedestrians Identification: identifying pedestrians, age, size, special-needs, child cars, accompany, position, walking speed, clothing, attention, path.
- Topic #6: Traffic Environment Recognition: identifying and linking road lanes, crosswalks, parking lots, road signs, segmentation, connections/topology, road surface issues, traffic elements, road loading, infrastructure, distracting events.
- Topic #7: Statistical Modeling and Simulation of Events: set of models to analyze, predict and simulate important events for data extracted from above topics including columnar and graph structures for example associating climate conditions with accidents, identifying spatial distribution, identifying road planning issues, simulating change impact in traffic flow.

References & Resources

#	Topic	Source
1	Digital Cities in Practice with Real-life Examples and Patterns	http://www.uclg-digitalcities.org/en/the-committee/digital-cities-in-uclg/
2	A Better Future Transformed by Intelligent Mobility of ITS America	https://itsa.org/wp-content/uploads/2022/06/ITSA-Mobility-Principles-6.21.22.pdf

3	A Global View on ITS	https://unece.org/transport/intelligent-transport-systems
4	What is Intelligent Transportation System? Its working and Advantages	https://theconstructor.org/transportation/intelligent-transportation-system/1120/
5	ITS Architecture Premier	https://rno-its.piarc.org/en/systems-and-standards-its-architecture/what-its-architecture
6	Transportation Safety Issues by Transportation Research Board (TBR)	https://onlinepubs.trb.org/onlinepubs/millennium/00132.pdf
7	Integrating Safety in the Rural Transportation Planning Process	https://safety.fhwa.dot.gov/local_rural/training/fhwasa14102/isrtpp.pdf
8	Artificial Intelligence (AI) in Transportation	https://www.v7labs.com/blog/ai-in-transportation
9	How Digital Twin will be Utilized to Create Smart Cities	https://www.challenge.org/insights/digital-twins-and-smart-cities/