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A Systematic and Critical Analysis of the Developments in the Field of Intelligent Transportation System

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Abstract

The paper studies a systematic review on the existing technology and development in the field of Intelligent Transportation System. This is one area that has made enormous potential advancement from the vehicular ad-hoc network and internet of things technologies. The communication techniques in the field are shown and explained. The paper studies developments in the field over the years. The paper presents a systematic review on the important and prominent work in the field. A critical analysis of the work that has been done so far and that can be further taken forward is analyzed. The paper throws light on the challenges faced in the field of intelligent transportation system. The paper actually provides us a review of the developments in the field.

Keywords: ITS, IoT, V2X, CAV and UAV.

1. INTRODUCTION

Transportation is a very classical problem. Initially man travelled for food and work. Transportation modes helped him explore more opportunities far away. In ancient days too man travelled for knowledge, business, better opportunities, and better places to reside. It was possible for goods produced in one part of the world to reach the other part of the world. Transportation actually made the world a global village. Slowly the mode of travel began to change. The improvement in technologies paced the development into the field of transportation. Man raced and then flew from one part of the world to other. The airways mode of transportation actually grew wings for man. Man flew in the sky. Man then started adding more comfort and features to transportation and vehicles. The world became more connected and so did the transportation system giving rise to cooperative vehicular network. Man also tried to assign his work to the vehicles. Now he wanted the vehicles to talk to each other, to do other work, to make decisions, to think, to plan, to route, to guide and so transportation system gave birth to the intelligent transportation system.

The vehicular network could now interact with each other, pass messages to each other, could guide human to his destination. It began to take decisions. The emergency system actually could save somebody's life by choosing the fastest route and take the emergency vehicles to the desired location. It could actually guide other vehicle for pre-clearing of lanes. ITS can actually force the vehicle to go to the fuel station before the fuel is about to exhaust and save him from frustration and agony. It can show you shortest, fastest and safest routes.

The paper studies the important developments in the area and carries out a systematic review of the existing work in the area and hence gives a critical analysis in the field.

2. COMMUNICATION TECHNIQUES IN THE INTELLIGENT TRANSPORTATION SYSTEM

There are 4 kinds of communication techniques: Vehicle-to-vehicle, vehicle-to-infrastructure, vehicle-to-pedestrian, vehicle-to-everything.

Vehicle-to-vehicle: One vehicle sends many kinds of information to other vehicles. Example the speed, position vector, routing, message broadcast in case of emergency, location, etc [1].

Vehicle-to-infrastructure: In this scenario, the vehicle shall transmit data to road side units or other devices like traffic units, road side units, traffic controller. The communication happens via: cloud, zigbee, or other communication protocols [1].

Vehicle-to-pedestrian: Transfer and exchange of information between pedestrians and vehicles helps to bring more safety to the vehicles. [2]

Vehicle-to-everything: This has made the vehicles ubiquitous and approachable from any point, place, device or situation. This provides continuous communication standards. If adopted it will bring down the price of vehicles and also making them more comfortable and approachable. [3]

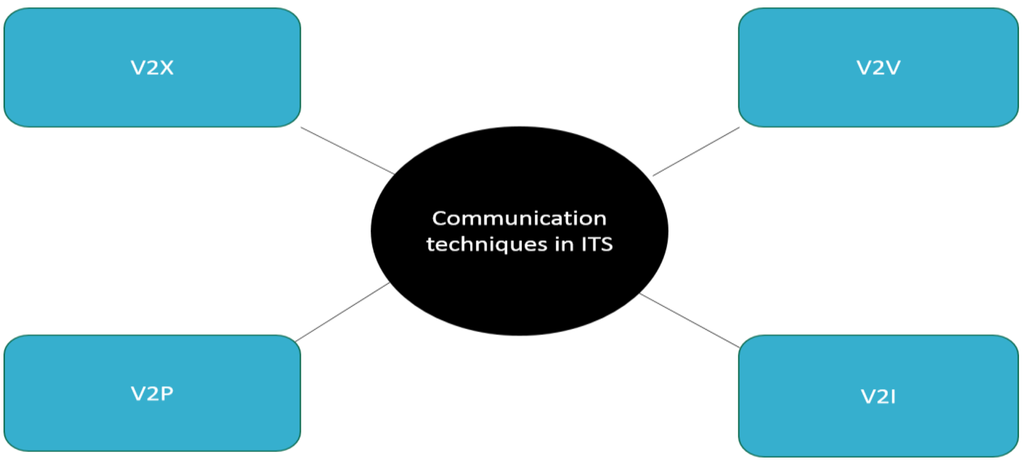

Figure 1: Communication techniques in ITS

3. RESEARCH IN THE FIELD

Table 1 Some prominent research work in ITS

Author	Year	Work	Outcome	Gaps
[4]	2017	Blockchain based dynamic key management system for heterogeneous ITS	• Secure key transfer in centralized SM network • Optimized the key transfer cost	• Better model for Security and privacy in the system • Authentication is not taken into consideration
[5]	2018	ITS architecture i.e. based by converging 5g with SDN	• It outperforms the existing AIDV routing protocol in terms of average processing time, processing of vehicle's data per minute, and flow density in various scenarios • SDN provides accessibility, flexibility and programmable features • Data rates are increased by 5g	• Calibration and validation of the system architecture is still an issue • Vehicular network load handling • Human/ driver factor are not taken into consideration • Social network of vehicles is ignored • Planning according to smart city yet remains an issue
[6]	2019	SDN architecture is used in base Energy trading is done via energy coins	• Lightweight • Minimum computation and communication overhead on network resources • Ensures resilience against single point of failure	• Cost is high • No flow control mechanism is SDN • Network throughput is an issue • Not implemented and tested in smart grid scalability and utility are not accurate
[7]	2014	A cloud based service framework for energy conservation in sustainable ITS	• Reduces CO_2 emission and fuel consumption in ITS • Provides route navigation, driving diagnostic and corrective feedback • e-learning visualization system	• Lack of integrated solution • Lack of any precise economic use of the proposed model

Author	Year	Work	Outcome	Gaps
[8]	2015	CPSS supported intelligent vehicle	• Robust theoretical model is prepared in traffic areas such as management plan optimization, large-scale evacuation, and public traffic scheduling	• Real time implementation not done
[9]	2015	A feasibility study of D2D for ITS	• An interference control mechanism • A predictive resource-allocation method • An RSU cooperative scheduling approach proposed	• Incorporation of cooperative communications, network coding, interference cancellation and advance receivers. • Cost and benefit tradeoff
[10]	2015	A method called NeverStop is constructed with sensors to control the traffic lights at intersection automatically	• Decreases the average waiting time for the vehicles at intersection • Uses fuzzy control methods and genetic algorithm	• Lack of tuning plan • Considers only near-perfect readings, uncertainty is not taken into account
[11]	2020	A smart priority based traffic control system for EV	• An Emergency Vehicle Priority System • Assign priority code • Algorithm to estimate number of green signal interventions. • Reduced emergency response time significantly.	• No justified reason for deciding the number of green interventions • Rest of the traffic is not considered • Optimization is not considered at all
[12]	2018	An optimization model for Emergency vehicle location and relocation	• It minimize response times as well as ambulance relocations in order to cover as much demand as possible taking into account the resource limitation • It is a mixed integer linear programming optimization model	• Only three parameters were considered: number of available EVs, service time, and standard response time, rest were all ignored. • Real time implementation not done
[13]	2020	EV lane pre-clearing strategy to prioritize EV	• It is a mixed-integer nonlinear programming (MINP) problem.	• Automated vehicles not considered. • CV has to strictly adhere to the

Author	Year	Work	Outcome	Gaps
		connected vehicles (CVs)	• It increases the speed of EVs and minimize the disturbance of CVs.	designed trajectories.
[14]	2019	Traffic Emergency Response System based on IoT and data mining	• It has good data coordination ability and emergency response capability. • It solves the problem of un-coordination between various rescue information from different information channels	• The system has problems such as complicated data acquisition, huge errors, and insufficient optimization of the system analysis algorithm
[15]	2020	Optimizing vehicle arrival time and signal time	• "Speed guidance model at a red light" and "speed guidance model at a green light" are presented to model the influences between travel speed and signal timing. • It significantly decrease travel delays by 37.8%–54.0% as well as improve the flexibility and mobility by 29.0%–77.5% of traffic control.	• Not effective traffic control • Only trajectory data is used, so kind of guided and biased research • Only single intersection is taken into consideration
[16]	2019	The paper relate local node capacity with global network load, and model the traffic recovery behavior of nodes by the evolution of nodes' queues	• congestion phenomenon of networks are investigated by two traffic recovery models proposed by us, called the hard traffic recovery model and the adaptive traffic recovery model • Adaptive model outperforms the hard model. • It set the node buffer with the lowest cost to handle the maximal network load in real networks. • The adaptive model is greatly beneficial to the node endurance against congestion for the real networks.	• The hard traffic model is not effective compared to the adaptive model. • The destinations are homogeneously distributed which is not so in real-time
[17]	2020	A model free adaptive iterative learning perimeter	• No dynamical model is required in the controller design by virtue of dynamic	• the design of a modified iterative learning method that can directly

Author	Year	Work	Outcome	Gaps
		control (MFAILPC) scheme is proposed in this paper	linearization data modeling technique, i.e., it is a data-driven method, • the perimeter controller performance will improve iteratively with the help of the repetitive operation pattern of the traffic system, • the learning gain is tuned adaptively along the iterative axis. • the proposed MFAILPC presents a great potential and is more resilient against errors than the standard perimeter control methods such as model predictive control, proportional-integral control, etc.	minimize the total time spent • real-world implementation of perimeter control remain to be researched
[18]	2015	Cooperative Intelligence of Vehicles for Intelligent Transportation Systems (ITS)	• It is inferred from the results that end-to-end delay for emergency vehicles in the cooperative environment is considerably less as compared to VIP and normal vehicles. • an architecture is proposed for the centralized and distributed spectrum sensing in vehicular networks	• Lots of challenges ahead when V2V environment meets up M2M • The average delay is increased a lot when number of vehicles is increased to 70. • Voice controlled vehicles are facing real-time implementation challenges

The table studies the latest research work done in the area of ITS. The various models, systems and other important and critical papers are discussed. It explains the findings from the research, highlights the developments and also throws light on the limitation of the same.

4. CRITICAL ANALYSIS:

- Security is a major concern in the ITS field due to its huge sensors and network use.
- Mapping simulation experiments to real life problem is a concern.
- Autonomous vehicle needs very high techniques for seamless and safe driving which require very high technology.
- Funding is a serious issue that limits the progress in the field of ITS.
- Optimized route in shortest possible time safely.
- Real time processing and analytics of the data providing correct solution with near zero delay i.e. accurate solution with no delay.
- A safe and isolated transportation system that has become the need of the pandemic. Cost effective transportation is a big challenge in times of pandemic.
- A safe public transportation system is the biggest challenge.
- Heterogeneity of the transport system and the interoperability between CAV, UAV, AV and traditional modes is a very critical issue to be looked after.
- There is a huge constraint of resources of IoT and the cost is also too high. So cumulative techniques needs to be developed.
- In routing the shortest path is different from the fastest path. So an optimal path is the goal.
- Optimization is a key problem in traffic management of the city. Finding the optimum path for the emergency vehicles without disturbing the rest of the traffic is an issue that needs to be resolved.

5. ITS CHALLENGES

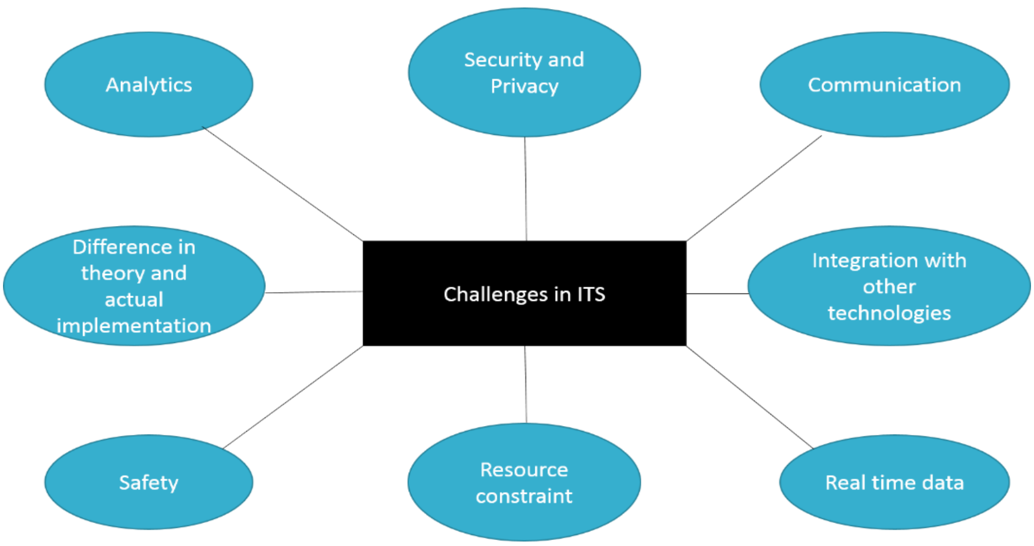

Figure 2. Challenges faced by ITS

Analytics: Due to the high speed moving vehicles the speed and accuracy of analytics results is doubtful. Working on heterogeneous data is very tedious and interoperability is very complex. Delay-sensitive application need more effective techniques [19]. Reliable data exchange in cooperative-ITS is yet to be improved [20]. Data visualization, data querying, data integration, require real time data streaming which are not done by the existing ITS models [21].

Security and Privacy: Security is an important issue and so is privacy of user and authentication of the genuine user [22]. The coming of automated vehicles have increased the need of security. The vanet is vulnerable to so many security breaches like spoofing, falsification, eavesdropping, etc [23]. The quality of service depends on factors like security, privacy, authentication, seamless handover, manage heterogeneous traffic, etc [24].

Communication: The nodes communicating at high speed face the problem of range, latency, data transmission, coverage and connectivity. Communication problem many a times results into security issues [25]. Diversity of vehicle, density, velocity, delay, congestion during broadcast, overhead are many of issues that are to be dealt with while communicating in the network [26]. Cost evaluation of the communication system, high bandwidth consumption, next generation techniques are some other things to be looked for in the network [27].

Integration with other technologies Seamless integration with other platforms is something which is to be carried out with precision. Some other types: multi-sectoral, renewable integration are issues coming up in the upcoming technologies [28]. Integration points in the system, integration of whole system, seamless blend of technologies is an important area of research challenge.

Real time data: Finding real-time data is such a big research thrust area in ITS. Tools and systems that are available today are also not of much help. Collecting, processing and analyzing real-time traffic data is a very propelling task [29]. Real-time data is very unpredictable and complex, synchronization is very difficult. Prediction model have to be extremely effective [30].

Resource constraint: There is a limit to computation resources that are available [31]. Even the resource that are available have many physical, communication, connection constraints. Cost is a major constraint. One has to even consider the fact that the resources that are available and being used are not fully utilized to their capacity. Integration of resources is also to be looked forward to in the future coming up technologies [32].

Safety: Safety becomes an important issue in case of automated driven vehicles. Safety of pedestrian is of utmost importance and pedestrian rely more on traffic signals then on automated cars [33]. Safety of user, driver pedestrian as well as the infrastructure all form an important part to be considered. Machine learning algorithms [34] and techniques are to be deployed so that the system becomes more understanding and decisions more humane like.

Difference in theory and actual implementation: There is a whole gap and day-night difference while carrying out research in laboratory software and when deployed and implemented in the real world. The results are many a times so drastic and diverse that it becomes too difficult to rely on the simulators.

6. CONCLUSION AND FUTURE SCOPE

The paper studies the work that has been done in the field of intelligent transportation frameworks. The paper studies the various models, frameworks, architecture and corresponding work done in the ITS field. The paper illustrates the results and the limitations of the same. Based on the gaps the paper presents the critical anaysis from the literarture review. Both research and pratical challenges are analysed.

The future research may be carried out in the area of optimization in the filed of transportation. Further work can be done to bridge the gap between theory and actual implementation. Heterogenity of the transport network and integration of the same is also an interest of work for future. Security and optimization are among the key problems that can be looked forward for research.

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