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Navigating a Driverless World

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Abstract

In the recent years there has been a tremendous advancement in the autonomous sector resulting in development of autonomous car or driverless cars. The research paper focuses on features of this car and on its practical implementation in developing countries. The points taken into account include issues for its implementation in developing countries as they differ from that of developed countries. The paper includes security features of the car, the problems faced due to the geographical conditions among various areas as well as cultural background (social issues), high speed internet connectivity, fully mapped global terrain, ability to fetch real time traffic data through internet, non-availability of standardized road network and weather interference are the key issues that will be reviewed and their solutions suggested in this paper.

Keywords: Driverless; Net neutrality; Automated guided vehicle; ISP; GPS

Introduction

It is difficult to understand that the basic function of an automobile hasn't changed in the past 106 years [1]. An autonomous car also known to many as a driverless car or a self-driving car or a robot car challenges this. It is a vehicle capable of driving through the streets and roadways, fulfilling its transportation capabilities of a traditional car without any assistance from human. It is specialized in sensing its environment through imbedded equipment and navigates from one point to other without human input. It is fundamentally defined as a passenger car with main impetuses being safety on roads [1]. An autonomous car may also be referred to as autopilot, auto-drive car, or automated guided vehicle (AVG). In cities where traffic is of great concern the situation has improved well enough. The scenario of free flowing traffic at any time of day has not been achieved yet in these cities. This problem is solved majorly by extending the roads and doing more road construction. However due to increasing density of automobiles accidents have also increased [1]. Autonomous vehicles however has promising solution that guarantees to solve these problems by virtually eliminating traffic congestions, minimizing road accidents. It seems that self-driving vehicles may be futuristic and we are not that much technologically advanced for this to happen. But the reality is they are in prototype phase already. Their components include 360 degree sensors, lasers, learning algorithms and GPS to navigate streets in a supreme precise fashion [2]. They will be implemented fully in real world situations in the next 10-20 years. Google's driverless car has travelled 400,000 miles already and is in exceptionally advanced stage of real world implementation. The technology could change the world significantly. It will lead economic growth, time saving, the technology could trigger a burst of economic growth, transform transport around the world, free vast amounts of time, increase productivity, make us a lot wealthier and unleash drastic, unpredictable economic and cultural changes [2]. By allowing people to relax or work as they commute, they will deal a devastating blow to public transport in all but the densest, most congested areas. The look and feel of roads and towns will drastically change. It will be possible to cram in far more cars into existing roads, driving at much faster speeds. Simulations of intelligently controlled intersections from the University of Texas suggest that they perform 200 to 300 times better than current traffic signals. Self-driving vehicles will have the ability to "platoon", acting almost like train carriages on motorways, increasing lane capacity by upto 500 pc, according to research from The US Institute of Electrical and Electronics Engineers [2]. However this is only the positive side of the evolution. The analysis indicates that some benefits including reduced traffic and parking congestion (and therefore road and parking facility supply requirements, increased safety, energy conservation and pollution reductions, will only be significant when autonomous vehicles [3] become common and affordable, probably in the 2040's to 2060's, and some benefits may require prohibiting human-driven vehicles on certain roadways, which could take longer [4].

Navigation and Decision Making

Powered by an electric motor with around a 100 mile range, Google's driverless car uses a combination of sensors and software to locate itself in the real world combined with highly accurate digital maps. A GPS is used, just like the satellite navigation systems in most cars, to get a rough location of the car, at which point radar, lasers and cameras take over to monitor the world around the car, 360-degrees [5]. Data from these sensors are used to render other cars are rough blocks with shifting, amorphous edges. The car doesn't need to know the perfect shape since it will never be close enough to test the accuracy of its borders. The software can recognise objects, people, cars, road marking, signs and traffic lights, obeying the rules of the road and allowing for multiple unpredictable hazards, including cyclists [5]. However these all depend on the standardization of the road network available. It may happen to handle situations like: Big potholes, waterlogging on main roads, broken barriers/dividers [6]. Without the sign boards and proper lane division, the car would have significant difficulty in understanding the traffic movement and decision making. Taking this into account with the existing road networks in developing countries like India with world's second largest road network with 4,689,842 kilometres (2,914,133 mi) in 2013. However, qualitatively India's roads are a mix of modern highways and narrow, unpaved roads, and are

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being improved. As of 2011, 54 percent - about 2.53 million kilometres - of Indian roads were paved. Now this creates a major transportation problem in decision making of the car where half the roads of country are not even paved let alone standard. But some promising development in the area can be seen. Audi, part of the Volkswagen Group, caused a stir two years ago when it sent a self-driving TTS Coupe through 156 tight curves along nearly 20 km of paved and dirt road on Colorado Pikes Peak, with nobody behind the wheel. Google's cars [1] have even been programmed to behave appropriately at junctions such as four-way stops, edging forward cautiously to signal their intentions and stopping quickly if another driver moves out of turn. There is however a few solutions currently researched for some of the problem faced in the existing non-standardized road network (Table 1). There is however a few solutions currently researched for some of the problem faced in the existing non-standardized road network.

Absence of Lanes

Many Countries (e.g. India) allows unorganized traffic where vehicle can place itself anywhere within the boundaries of road. Speed of the vehicle can be varied also. This leads to a higher traffic bandwidth [1]. However accident probability increased also because of this uncertainty. Elastic strips have been used for the movement of a mobile robot. For Computational reasons, the strip is discretized to a number of waypoints. Any change in the surrounding is appended or removed from points such that the resulting trajectory is collision free [7]. The motivation behind is to find the least waypoints around the obstacle. There is an additional internal force that pulls the waypoints toward each other, resulting in a shortening of the path. Since two obstacles never come across, robot is designed to travel in between them.

No Traffic Signal Junctions (Intersections)

An algorithm is put up in a research that will be used to control traffic at places where traffic lights are not present. The proposed system gives priority to the lane which has longer queue instead of the traditional system of same time interval for every lane. This proposed system helps in relieving more congested lanes quickly. This will in turn help in easing of traffic at rush hours. Also travel time at rush hours will be more predictable. The proposed algorithm in this paper uses IEEE 802.11 DCF/PCF Mechanisms to balance these two values [8].

IEEE 802.11 legacy DCF/PCF

The IEEE 802.11 standard makes it mandatory for all stations to implement the Distributed Coordination Function (DCF), a form of Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). CSMA is a contention based protocol that makes all stations to sense the medium first and then transmits. This helps in a way such that there is no collision as well as none in corresponding retransmissions.

System model

In a four way junction and each road having eight lanes, i^{th} lane cars are generated by Poisson's distribution. In the i^{th} lane, cars are generated by Poisson distribution with expected number (arrival rate) λ_i every time slot. All assumptions are made such that collision avoidance is achieved perfectly. In each direction the first lane is for turning left, last lane for turning right and middle ones for going straight (Figure 1).

Contention-free period (CFP)

System is divided such that each repeat interval is like from IEEE 802.11 DCF/PCF.

The contention free period has sixteen lanes for incoming channel and each lane has its own fixed route to pass the intersection in Contention-Free Period, we have total sixteen lanes as incoming channel to the intersection and each lane has its own fixed route to pass through the intersection. Assuming Qi denotes the number of cars queued up before entering the intersection the i^{th} lane. Value of I varies from 1 to 16. Also Qi is updated at the start of each time slot. If the i^{th} route and the j^{th} route intersect and there are two cars, the system has to decide which car will pass first if one from ith lane and another one from the j^{th} lane going to the intersecting point [8]. If there are n lanes (x1, · · ·, xn) whose routes crossing each other, the system will give priority to the x^{th} lane, which satisfies:

$$x = \arg\max Q_i$$

$$\in x_{1,} \ldots, x_n$$

Contention period (CP)

A possibility is if the system gives priority to the lane with most traffic then the lane with least will have to wait until it is most.

This unfair situation for low congested lanes motivates us to introduce contention period. Case: n cars are coming to the overlapping spot at same time will not take the number of cars queuing up in each lane in consideration and will take turns to pass through the spot. This design can be made so that if easing of congestion is needed then CFP can be made or if fairness is needed then CP can be made [8]. The suggested traffic control system with/without traffic light shown in (Figures 2 and 3) respectively not up to that level. Connection quality

Stress: The stress of driving will decrease and increasing work while traveling.	**Increases Costs:** Additional maintenance and need for advanced road networks may be needed.
Driver Costs: Additional maintenance and need for advanced road networks may be needed.	**Additional risks:** May increase accident risk due to probability of system failure.
Mobility for non-drivers: On-drivers will find a perfect alternative of chauffer at much lesser price.	**Security and Privacy concerns**: Can be exploited to target precisely and will eventually result in decreased privacy.
Increased safety: Increase safety overall and well decreased accident probability.	**Induced vehicle travel and increased external costs:** Increasing more affordability will increase more parking costs and a greater risk of higher pollution.
Increased road capacity, reduced costs: A type of train like lane management also known as platooning will reduce traffic congestion drastically and increase overall capacity of existing road networks.	**Social equity concerns**: May cause lesser preference to other modes of travelling and decreased concern for them.
More efficient parking, reduced costs. Highly reduced parking costs because of availability of automatic driver to park at emptier places and pick up at moment's notice.	**Reduced employment and business activity:** Existing driving jobs and crash servicing centres will suffer huge unemployment.
Increase fuel efficiency and reduce pollution: May increase fuel efficiency and reduce pollution emissions.	**Misplaced planning emphasis:** Increasing use of technology will put the existing conventional system of management on the verge of extinction.
Supports shared vehicles: Can be implemented to increase carpooling services	

Table 1: Comparison between positive and negative aspects.

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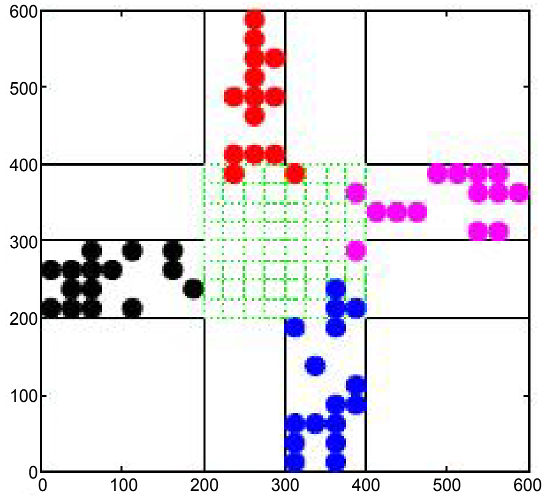

Figure 1: System model.

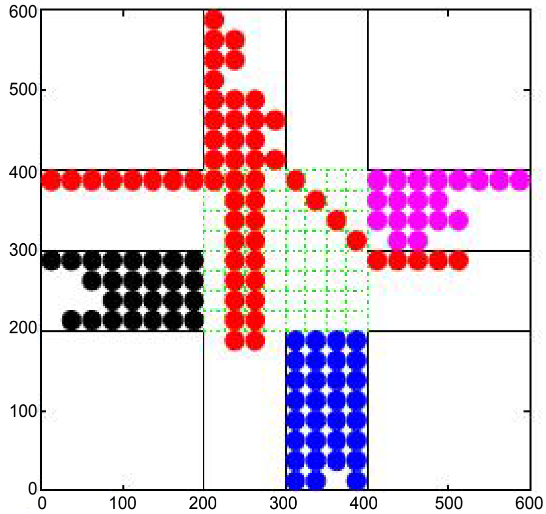

Figure 2: With traffic light (Traditional system).

Connectivity (Internet and GPS)

Radar, lasers and cameras collect data and GPS with an inertial navigation system calculate position, orientation, direction and speed of the vehicle and surrounding objects. Since the autonomous vehicle has too much dependence on uploading and receiving data from a central cloud database where this data is saved, it very much depends on the internet connection. Apart from developed countries, other countries have certainly improved broadband but still mobile internet.

Security and Privacy

Computer drivers are vulnerable to something that human drivers are not - hackers. Information exchanged between cars or between a car and a remote computer will be vulnerable to security breaches intended to steal data or to disrupt cars' ability to navigate and make good decisions. The challenge increases with increase in number of vehicles from few hundreds to thousands and to millions to protecting data on that scale will be enormous [11]. Researchers at the University of California and University of Washington have found ways to infect vehicles with computer viruses and cause them to crash by shutting off their lights, killing their engines or slamming on their brakes. They infected the system by implanting a virus in the CD used to listen to music in the car [12]. Simply stating what data is gathered with no explanation of its use is inadequate. Autonomous vehicle regulations have to mandate that driverless cars gather only the data necessary to operate the vehicle destroy the data after vehicle operation. If left otherwise, it offers the opportunity for manufacturers to sell driving data to insurance companies, to play personalized, in-car advertisements, and to track consumers' movements [13]. However a suggested solution is agreement when consumer saying 'we want one third-party company that we give permission to our data, and then on a case-by-case basis we decide who gets access to it.

Weather Interferences

The current prototypes can't drive in snow and heavy rain. This is because the detection technology is not yet strong enough to separate certain objects from weather conditions. Also it might happen due to strong rains and thunderstorms their might be connection issues drops when a vehicle is in motion. This suggests reliability on today's internet from this purpose is not high enough. However, Google for example is looking at all sorts of different technologies. Satellites through blimps to microcells that broadcast a 3G signal perhaps half a mile. There will be a mix and match depending upon circumstance [9]. Also net neutrality is another problem, the principle that internet service providers (ISPs) should treat all data on the internet equally, and not discriminates or charge differently by user, content, site, platform, or application [10]. This makes sure that irrespective of anything, cars will have equal access to internet to access maps and other processing and data retrieval. Otherwise, car makers will pay ISPs for prioritised. Big companies can probably afford this but small makers can't e.g. when driving a self-driving car on the motorway and the network becomes congested, and all the people with the expensive cars and the best service get the information across first, whereas the other cars don't. Ultimately the car will potentially be cut off from its brain. This could raise potential safety issues. A high-quality connection will be even more vital for emergency service vehicles [10], which may require to feed critical patient data to a hospital in real-time.

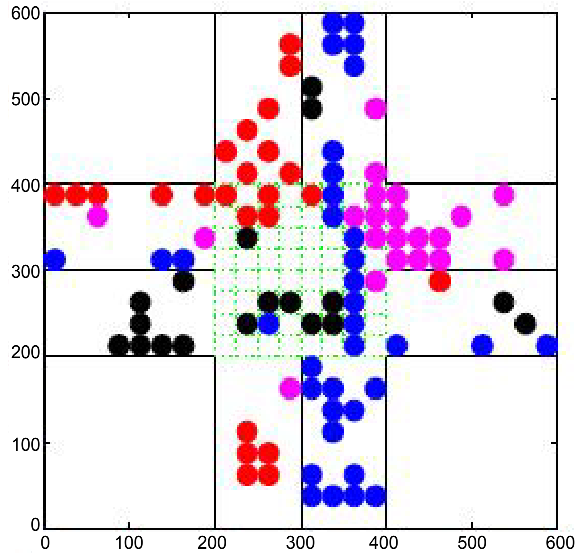

Figure 3: Without traffic light (suggested system).

with the car navigation system and data retrieval system because of the electric discharge in the atmosphere.

Social Issue

Demand for professional drivers of taxis, limousines, and trucks will decrease. Freight transport industry would benefit from the limited capabilities and restriction of the technology. Tens of trucks can travel across the country with only a single driver. This will result in Unions for the various drivers introducing doubt about the safety of self-driving vehicles and lobbying against them, as the taxi industry has done with Uber. A survey by PEW Research Centre presents the data about people acceptance to own/drive the vehicle. College graduates (59 percent) were more likely to say they would. High school diploma holders (62 percent) were inclined to pass up the chance. But only 36 percent of people in rural areas thought they'd try it [14].

Conclusion

The paper has presented that even the current obstacles are eminent, there are certain solutions present for them and even though the market penetration will not be much for first few years but later on it will set an example like smartphone industry. Just in the USA, the car puts up for grab some $2 trillion a year in revenue and even more market cap. Business opportunities created dwarfs Google's current search-based business and unleashes existential challenges to market leaders across numerous industries, including automobile industry, insurance sector, energy industry companies and others that share in car-related revenue.

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