Road map to autonomous driving

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Abstract
This paper discusses the road map towards the autonomous vehicle and the benefits society and drivers will get from this advancement. There are many barriers to overcome; just to mention a few: legal issues, driver laziness, technology, and public acceptance.

Keywords: autonomous driving, platooning, driverless car, cooperative vehicles.

Introduction
The discussion isn't if the autonomous vehicle will arrive anymore. Now the discussion is about when and how it will arrive. Google has put the topic on the public agenda and their intensive lobbying has been a major reason for three American states implementing laws allowing autonomous driving.

Most vehicle manufacturers are looking at the topic and working on prototypes, but they are all very reluctant to say when we'll see the vehicles on the road. There are good reasons for this, as the challenges to put autonomous vehicles on the road are not only a question of the technology being mature, but also requiring a solid legal framework, public acceptance, insurance handling, and handling a long intermediate phase where drivers will act as if the vehicle is autonomous even though it isn't.

Goals and Benefits
The benefits of autonomous vehicles are numerous. It can be hoped that autonomous vehicles can reduce or remove almost all major externalities of transport. Human drivers are the cause of almost all accidents. Autonomous vehicles don't drink alcohol or become distracted as humans do, leading to a world almost without accidents. Autonomous vehicles can communicate with other vehicles in milliseconds allowing them to safely drive very close on roadways. This reduces wind resistance and thereby fuel consumption by up to 20%. Another benefit is that this increases the capacity of the road, reducing the need for investments in infrastructure and hopefully reducing congestion. Traffic lights become superfluous, and simulations have shown that autonomous vehicles can navigate road sections much more efficiently than humans. Up to 5 times an increase in capacity can be expected (KPMG).
Transport vehicles without a driver can be much smaller than today's and much lighter as they don't have to protect the driver with reinforced steel bodies and airbags. They don't even have to allocate space for a driver.

Parking spaces in cities can be allocated far away from homes, as the vehicles can pick up and deliver the users and still park far away. This allows for a complete rebuild of cities. Much greener and pleasant cities will evolve. Many people will also find that they don't need their own car anymore; as the car parked far away might just be a car from a pool of vehicles, that just needs to be clean and well-functioning.

**Challenges on the road**
The road to this dream world of autonomous vehicles is full of barriers to be crossed. Where technology previously was considered the main barrier, Google has proven that the autonomous vehicle is already on the roads. As of August 2012, they have test driven a total of more than 500,000 km.

But there still are numerous challenges to deal with. Some of the major ones will be discussed here:

*Vulnerable road users*
Google is testing their vehicles in US cities where bicycling and pedestrians are less common on the road than in many European cities. This is wise because navigating among vulnerable road users is much more complicated than navigating among vehicles. Vehicles do not send very much communication today, but in the future they will send V2V messages, that are easily understood by a computer. Vulnerable road users like small children can be much more difficult to read, even for humans. “Has the child seen that a vehicle is coming or not?” is a question that a driver often must ask himself. The answer comes from subtle movements of the child’s head and eyes. It will take years before the computer can detect such subtleties.

*Legal issues*
It can become very complicated if an autonomous vehicle is involved in a car accident. As the passengers cannot be responsible it must be clarified if it is the seller of the vehicle, the manufacture of the vehicle, or the operating company behind the vehicle which is responsible.

*Ethical issues*
After a slight road turn the vehicle is faced with kids on the right side of the road and a big truck coming towards you on the left. If there is not enough time to bring the vehicle to a
stop, the vehicle will have to choose between hitting the kids and probably killing them, or
hitting the truck and probably killing the passengers in the vehicle.

Driver laziness
Even today, without driver assistance systems, drivers text, read and answer email, and talk
in handheld mobile devices. With more driver assistance, we'll see many drivers starting to
do even worse things. This is human nature, but how can we prevent it?

Public acceptance
Surveys undertaken (KPMG) show a positive view among the public towards autonomous
driving, but when the first accidents happen, the media will sensationalize this and public
fear of autonomous driving can result.

Special infrastructure
We might see the need for special infrastructure in a transition phase, where autonomous
vehicles are only allowed to drive in special lanes.

Conclusion
The benefits for society and drivers are so large that the barriers will be overcome, but
probably not as easily as the most optimistic believers in autonomous driving expect. It is my
belief that we have some tough years ahead fighting those barriers before we are receiving
the benefits of autonomous driving.

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