LEGAL AND ETHICAL ASPECTS OF INNOVATIVE AND SUSTAINABLE TECHNOLOGIES

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***Abstract*— There are many issues of concern regarding the legal and ethical aspects of using new technologies. One of the main questions is how to make it compulsory to use modern inventions to save lives. The technical environment of our days is getting more and more complex. The „relationship" between the humans and the technology should be regulated. This is the field where the involvement of the legislation is necessary in order to promote new technologies. There are fields where ethical problems should be solved. Today even the technology is not quite state-of-the-art yet, such as in the robot-human interfacing.**

This paper investigates this legal and ethical question on the example of the field of vehicle systems. Legal and moral issues are investigated, the role and liability of the driver in highly intelligent, in so called autonomous systems, as one of the most important dilemma of regulatory process: can the driver be eliminated – even only temporarily – from the vehicle control loop when his abilities are clearly not enough to provide a proper control, or he should be always in the position to overrule any kind of intelligent system?

I. ETHICS AND LAW

Ethics is a science dealing with human actions. Among the other social sciences the closest to it is the jurisprudence. The ethics is investigating the internal principles of the human actions and the jurisprudence is investigating the external principles. It happens many times that we have not infringed any law, but an internal urge protests our actions against our conscience.

The morality determines the internal laws of the human behaviour, wich is sanctioned by the conscience and the public opinion. The law defines external laws of our actions, the government within the juridiction guarantees the compliance of it. The actions of the engineer are motivated on one hand by the legal environment, on the other hand the moral commitment toward the society and the environment, in which the technical aspects also play a decisive role. As part of the law is the duty, the questions of the responsibility is intimately linked to the ethics.

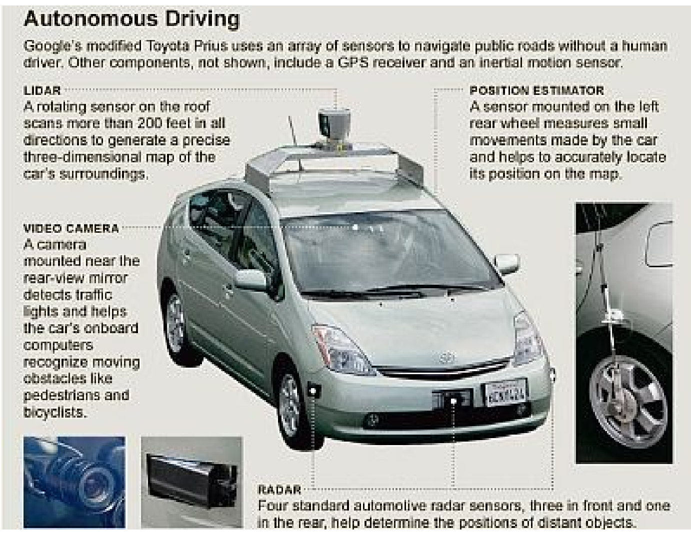

Figure 1. Google's driverless car invites drivers to sit back and enjoy the ride

II. New laws and new innovations

Three U.S. states have passed laws permitting driverless cars, as of September 2012: Nevada, Florida and California.

In June 2011 the state of Nevada was the first jurisdiction in the United States to pass a law concerning the operation of autonomous cars. The Nevada law went into effect on March 1, 2012, and the Nevada Department of Motor Vehicles issued the first license for a self-driven car in May 2012. The license was issued to a Toyota Prius modified with Google's experimental driverless technology. (Figure 1.)

An autonomous car, also known as robotic or as driverless or self-driving, is an autonomous vehicle capable of fulfilling the human transportation capabilities of a traditional car. As an autonomous vehicle, it is capable of sensing its environment and navigating on its own. A human may choose a destination, but is not required to perform any mechanical operation of the vehicle.

Autonomous vehicles sense the world with such techniques as radar, lidar, GPS and computer vision. Advanced control systems interpret the information to identify appropriate navigation paths, as well as obstacles and relevant signage. Autonomous vehicles typically update their maps based on sensory input, such that they can navigate through uncharted environments.

When Nevada made driverless cars legal in the state last year a number of philosophical questions occured. Driverless cars are safer than those piloted by humans, but how would we feel about deaths caused by machines rather than people? Who should take legal responsibility for the accidents? When a company sells a car that truly drives itself, the responsibility will fall on its maker. If there’s not a driver, there can’t be driver negligence. The result is a greater share of liability moving to manufacturers.

The liability issues will make the adoption of the technology difficult, perhaps even impossible. In the 1970s, auto manufacturers hesitated over implementing airbags because of the threat of lawsuits in cases where someone might be injured in spite of the new technology. Over the years, airbags have been endlessly refined. They now account for a variety of passenger sizes and weights and come with detailed warnings about their dangers and limitations. Taking responsibility for every aspect of a moving vehicle, however is far more complicated. It could be too much liability for any company to take on. On the other hand the benefit to public health is great enough to find legal solutions.

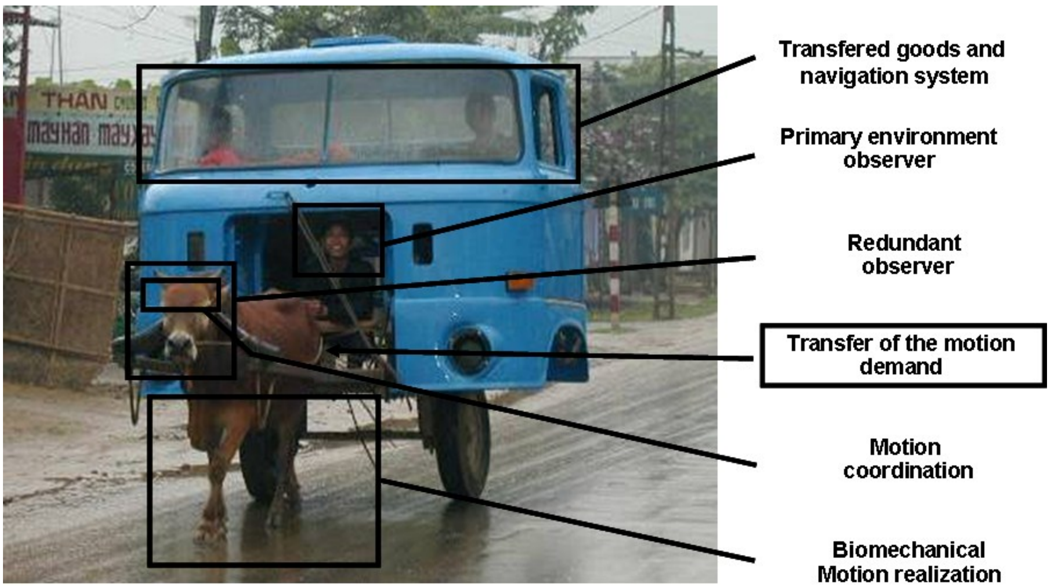

Figure 2. Perfect vehicle control system – biomechanical realization

III. Technological Requirements of the Autonomous Vehicles

Even if autonomous vehicle were released for road traffic as described in part II, the wide-spread of this technology will take some more time, although its development is much more rapid than it was estimated.

The scientist of artificial intelligence from University of California at Berkeley made estimation for the development of ITS systems in 1990 as follows:

- 2010 The ACC will be typical, simple warning systems for lane change and collision avoidance will become products. In some countries autonomous (driverless) buses will be operated on closed tracks.
- 2020 Lane departure and collision avoidance systems will be typical by using brake and steering intervention, some forms of the automated traffic will be started, especially at dangerous crossings warning and intervention systems will be installed.
- 2030 Almost all new vehicles will be installed with some type of warning and intervention systems, some part of the vehicle fleet will be suitable for driving on a automated highway,
- 2050 The new highways will be already built so that they are suitable for for automated traffic. Some test vehicles will be run in the normal traffic.
- 2070 Automated commercial transport by different and combined means: road, railway, water.
- 2100 The autonomous and the conventional traffic will be realized together.

Looking at this roadmap it is clearly seen that some of the technology is roughly 20 years in advance, and also the for 2100 estimated autonomous and conventional traffic mix was – even if partially – realized. Nevertheless, there are still many technical question to be clarified. The autonomous driving in case of other vehicles, such as airplane, ships, rail is already solved, most of these vehicles have a mode when they can travel in driverless mode due to the simple traffic situations: the rail vehicles can go only on a track in one direction, the airplanes share huge space where they can navigate, the ships as well. All these vehicles have professional, highly skilled and selected human controller in case a transient operation is needed: at take-off or landing, or docking or approaching to a station. Normally in these modes also these vehicles are controlled by the human operator. In most of the cases there are redundant human controllers, for example each airplane should have 2 pilots, where all the decisions are counterchecked and released by the co-pilot.

The road traffic is not really comparable, since the vehicles are travelling with relatively high velocity in close vicinity of each other and controlled by the wide variety of uncertain human operators: from a 16 years old rookie driver to the 80 years lady/gentlemen with already limited abilities. Under these conditions to let the autonomous and the conventional vehicles travel together requires special solutions, not only the mentioned sensors and actuators, but also the appropriate decision levels, redundant control architectures with the necessary back-up systems.

A perfect biomechanical example how to control the vehicle is horse-driven taxi somewhere in South-East Asia shown in Figure 2. The passenger in the cabin will say their target to the human controller (in the engine compartment) who will translate that into vectors how to reach that position. After that for the next vector he determines the velocity and forwards this information to the horse/cow by means of pulling one of the reins with a certain force and using some means to tell the requested velocity to the animal. The horse is going to translate this information in his brain into mechanical actions, but before he realizes it, will countercheck whether the input from the driver is plausible. If not, it is going to overrule that based on his own information (the horse will never go against the wall). In addition, the horse is going to correct any disturbance caused by external factors (slippery road, wind gust, etc.) without intervention of the driver. In this sense, this is a perfect redundant system, and serves as a basis for the intelligent vehicle system architecture.

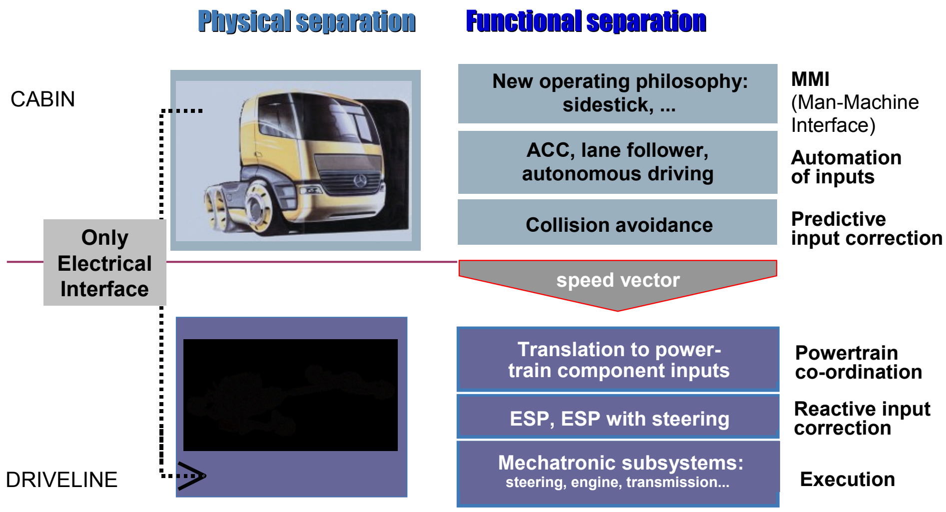

Figure 3. Redundant architecture for autonomous vehicle

How is that possible to realize in a vehicle? The answer can be found in Figure 3.

All components depicted in Figure 2 can be clearly identified in the technological realization shown in Figure 3: the virtual co-driver is realized by means of video and radar sensors, the plausibility of the driver requested speed vector is controlled by image processing and decision making algorithms running in the redundant electronic control unit with similar functionality as the brain of the horse.

IV. Technical Norms – Regulating Autonomous Vehicles

The technical regulations are a special form of legal norms. They cannot be handled independent of their economical and social environment.

The ESC systems from several manufacturers have been already on the market in Europe for several years at the beginning of the last decade. The impacts of these systems on traffic safety have been proven by several studies (see in [5], [6], [7]): these studies reported as high as 60% reduction in the fatalities in road accidents. Even this figures are impressive, and were fully in line with the targets set in White Book of the EU targeting on the cutting of road accident fatalities by 50% within 2000 and 2010, the equipment rate for truck was very low, around 2% of the vehicle were equipped with the system. The reason was simple: the additional cost of such a system at purchasing the truck (3000-4000 Euro) impacting the business case of the fleet, thus they did not pull the system. Even the involvement of the insurance companies did not resulted in any improvement saying that if the accident rate will be reduced by the ESC system their product (i.e. CASCO insurance) will be more difficult to place to the market. This is somehow strange, but it was fact, none of the European insurance companies were giving any incentive on the insurance cost reduction for the ESC system which clearly reduces the probability of the occurrence of the accident. Contrary, in the USA, where the fleets have own insurance company the equipment rate jumped over 40% in 2 years, since the losses caused by the accidents will impact directly the fleet. This caused frustration both in the politics but also in the industry, since the investment to industrialize such a system is close to 3 digit millions of Euro and if not installed, no return on this investment. Since none of the approaches of the truck manufacturers and the ESC system suppliers was really successful in convincing the fleets to buy systems, they approached Brussels with the demand to mandate this system for trucks and other dangerous vehicles. It was a lucky co-incidence: both the politics and the industry had the same interest and European Union mandated the application of the ESC systems from 2013 for all heavy vehicles.

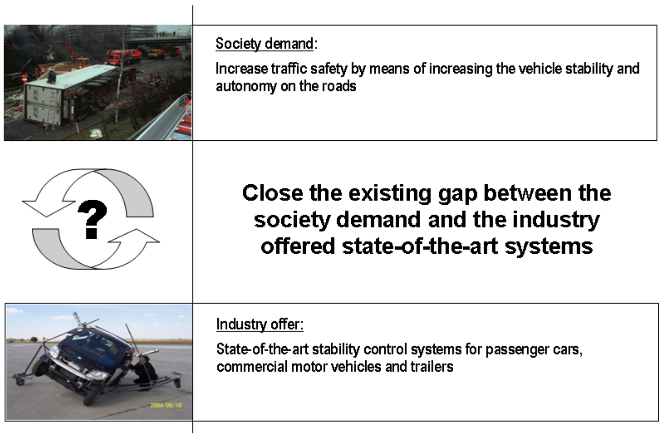

Figure 4 How to resolve the contradiction between society need and industry offerings

V. Special Set of Technical Norms – How to Regulate Autonomous Systems

To generate the terms of reference for the ESC system was somewhat not trivial. Not going into too much of the details of the system operation (details can be found in references [8-11]) only one point is mentioned: the ESC system operation is based on measurement of the actual vehicle motion, which is compared to an "ideal" vehicle behavior, and if the difference is higher than a pre-defined threshold, the ESC system is going to operate the necessary actuators independently of the driver in order to correct the vehicle path.

The fact that the vehicle is doing something which is independent of the driver (these are called as *autonomous systems)* raised severe questions as far as the liability is concerned. *Can the driver be made responsible for the consequences of such an intervention?*

This is the question what is difficult to answer, since technical, legal and moral answers are possible. The technical answer is pretty simple: the driver gets only warning of the dangerous situation the intervention is made only by him. However, morally this answer cannot be fully accepted, since if the driver's abilities are not good enough to intervene in the right way, and the technique could replace him, why not to do and save lives with that?

Thus, the basic conflict is between the following two points:

- the driver should not be relieved from the responsibility of controlling his vehicle
- the abilities of the driver are limited, in order to avoid an accident (and thus save lives) the control can be taken over by the appropriate ITS/IVS system (intelligent traffic control/intelligent vehicle control).

This conflict can be resolved by the following "legal answers":

- either the intervention can be made by the ITS/IVS system only if it is proven that the driver is not able control the situation anymore or
- when the driver is obviously in place (not sleeping, paying attention, etc.) when he intervenes it overrules any other system and takes over fully the control.

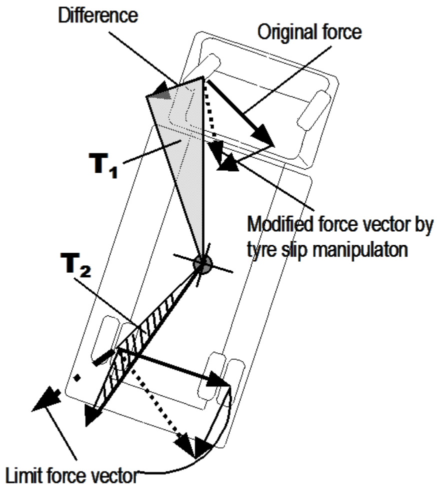

Figure 5. Basic Principle of the EVSC System Operation

There are two systems where this work has gone to the advanced status: the *automatic emergency brake system* (AEBS) and the *lane departure avoiding* (LDA) system. The target of the legislators is to accelerate the development and application of these two (AEBS, LDA) systems, which could reduce the occurrence of the severe traffic accidents resulting either from the rear-end collision or from unintentional lane departure, respectively.

The AEBS system uses a radar sensor (similar to the police speed measurement devices) and measures the distance to the preceding vehicle and makes a warning to the driver if the vehicle in front is getting closer (Level 1), giving additional command and makes aural or haptic signal to the driver, or takes off the throttle (Level 2) and if the driver does not react, and the system judges the collision otherwise unavoidable, applies the brakes to decelerate the vehicle automatically without intervention from the driver (Level 3). These systems are already on the market for passenger cars (not for trucks yet), but the Level 3 intervention will be solved differently. Although the radar sensor is precise enough to avoid the collision totally, but to have a legally clear case a prove is needed that the situation was really unavoidable and driver cannot question the necessity of the intervention later (e.g. in case of another accident as a result of the emergency braking). Some companies took the simplest way to have this prove: do not avoid the crash totally, only reduces the vehicle velocity before the impact to the level, that the collision will happen, but no severe injury will be made. This solution might sound strange, but results in a clear situation, and acceptable by the legislation.

The control of the LDA system's operation is even more complicated, since here the vehicle will tend (unintentionally, because the driver is fallen asleep or not paying enough attention) to the other lane, and its return is more complicated than just "simply" brake as in case of the AEBS system. The technical legislation favors a system which gives first a warning (audio – Level 1), second gives also the direction by haptic signal (slightly rotating the steering wheel in a direction where it is decided to go (Level 2), and if the driver does not overrule the steering wheel rotation, apply a higher torque and bring the vehicle back to the lane (Level 3). Unlike in case of AEBS, in case of LDA still there is no agreement how to proceed with the regulation, since different countries would follow different rules based on their local traffic conditions.

Thus, it is shown here that even a problem technically could be solved, and even the goodwill of the legislators is given to accelerate the process, the legal frames should be appropriately defined and in difficult situations, like in case of the autonomous vehicle systems, where the driver's role and liability is not trivial to define, it is not straightforward.

VI. Summary and Further Research

The people have different needs, and the automobile industry reacts and creats different vehicles as for equipment of mobility. This generates infrastructure developement: roads and bridges are built. But of course the traffic needs to be controlled, new laws must come out.

There is a requirement for vehicles with bigger capacity, more powerful engine. The driver should work more, more vehicles are needed.More powerful engine consumes more, emission is increased, axle load is increased. Reaction to the requirement is very rapid. There is also a requirement for new roads, bridges with more load carrying capacity and, extension and improvement of the existing ones. All this requires new norms concerning emission, a road friendly suspension, more severe control of driver's working hours and behaviour.

The paper presented some of the ethical and legal issues concerning the using of new technologies in vehicle systems. Technical, economical, political, legal and ethical questions are investigated. The role and the the liability of the driver in highly intelligent, autonomous systems, as one of the most important dilemma in the regulatory process. The examples present examples how the legistlation in some cases solved these issues.

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