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Reducing driver's behavioural uncertainties using an interdisciplinary approach: Convergence of Quantified Self, Automated Vehicles, Internet Of Things and Artificial Intelligence.

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Abstract: Growing research progress in Internet of Things (IoT), automated/connected cars, Artificial Intelligence and person's data acquisition (Quantified Self) will help to reduce behavioral uncertainties in transport and unequivocally influence future transport landscapes. This vision paper argues that by capitalizing advances in data collection and methodologies from emerging research disciplines, we could make the driver amenable to a knowable and monitorable entity, which will improve road safety. We present an interdisciplinary framework, inspired by the Safe system, to extract knowledge from the large amount of available data during driving. The limitation of our approach is discussed.

Keywords: automated driving, quantified self, internet of things, artificial intelligence

1. INTRODUCTION

Internet of Things (IoT), (semi) automated/connected cars, Artificial Intelligence (Deep Learning) and onboard data acquisition (Quantified Self) are disruptive technologies. They will gradually assist us in performing our daily tasks in safe conditions and will fundamentally revolutionize our interactions with technology.

The driver's unpredictability and their proneness to errors are the main factors contributing to road crashes. There have been many theories and tools, which attempt to model and approximate human behaviour. These endeavours date back to 1949, when Norbert Wiener created the notion of Cybernetics. Cybernetics focuses on how an "entity" such as a driver, processes information, reacts to information and changes to better accomplish its goals. The Cybernetics movement disambiguates human behaviour by using theory of data fusion, communication, control and regulatory feedback. More recently the 'Safe System' framework views the road transport system holistically. It acknowledges that it is not possible to prevent all crashes and aims to prevent or reduce the severity of crashes by minimising the possible role of human error when a crash situation occurs.

The evolution from an unpredictable transport system (e.g. crash, traffic) to an environment where (semi) automated cars are the dominant mobility mean and the driver's behaviour is reasonably predictable is necessary but will take time. There will be many ways in which it will happen. We are still far from being able to eliminate drivers' errors or accurately predict driver's behaviour. Fortunately, the range of possible behaviour in the driving context is actually limited and could be quantified. Most driver behaviour is purposeful – the driver act to efficiently accomplish objectives – rather than completely random. Furthermore, there is a large quantity of untapped data from the environment (IoT), driver (Quantified Self), vehicle (ITS), which can help to model driver behaviour.

The research disciplines, methods and data that we are federating in our framework are:

- Quantified Self (QS): is a movement to incorporate technology into data acquisition on aspects of a person's daily life in terms of inputs (e.g. food consumed, quality of surrounding air), states (e.g. mood, arousal), and performance (mental and physical).
- Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings and other items, which are embedded with electronics, software, sensors, and network connectivity enabling them to collect and exchange data. IoT data include data from outside of traditional transport, medical care and public health.
- Intelligent Transport Systems (ITS) use information and communication technologies, In-vehicle ITS gather a huge amount of data to assist the driver.
- Artificial Intelligence algorithms such as Deep Learning could be used to analyse/classify the data from QS, IoT and ITS. Deep learning is a branch of unsupervised/supervised machine learning that attempt to model high-level abstractions from data. Using massive and longitudinal data, deep learning could create complex driver behaviour models and predict abnormal behaviour, which could lead to crashes.

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The IoT, QS, ITS and cars generate massive amounts of data which can be used reduce driver behaviour uncertainties. The transport community has not considered such data as part of transport applications and researches as it were considered as too big, too complex and too inaccurate. Deep Learning algorithms can curate massive data and extract knowledge to improve road safety. However all this new data, and the Internet-accessible nature of IoT, raise both ethical privacy and security concerns.

The remainder of this paper is organized as follow: section 2 will go into details about each elements of the framework, section 3 will presents the interaction between elements, section 4 will discuss the results and section 5 concludes the paper.

2. FRAMEWORK COMPONENTS ANALYSIS

In this section, all components from the proposed framework: quantified self, internet of things, automated driving and artificial intelligence will be examined to provide a detailed description, examples of their usage in the context of this study and to list drawbacks that may slower the penetration into the market.

2.1 Quantified-self

Quantified self enables the considered system to measure itself its dynamic properties using auto-sensors. This concept, used for decades for biometrics measurements is slowly spreading into other domains such as automated driving. In this study, Quantified-self is defined for a specific system and thus can be generalized to the capacity of the system to auto-evaluate its own properties. This is performed using various sensing technologies depending on what is measured. For a vehicle we might speak about dynamical properties such as vehicle speed and position while biometrics are measured for humans.

When working on the interaction between human and cyber-physical systems, the first application of quantified-self is indeed using biometrics measurements to modify the behaviour of the system. In the case of transportation system, the ADAS behaviour can be changed by using driver and passenger's biometrics. Swan (2015), describes five QS Quantified Self sensor applications that link quantified-self sensors (sensors that measure the personal biometrics of individuals like heart rate) and automotive sensors (sensors that measure driver and passenger biometrics or quantitative automotive performance metrics like speed and braking activity). The applications are fatigue detection, real-time assistance for parking and accidents, anger management and stress reduction, keyless authentication and digital identity verification, and DIY diagnostics. It can be noticed that these application range from human measurements to vehicle measurements. The proposed applications are all direct sensor applications but it is assumed that combining these with the components of the here proposed framework may improve the whole transportation system. Quantified-self will also be introduced under the insurance companies' influence, as providing data results in a subscription discount. Actually, some of these systems are already in-use from driving patterns data logging, low acceleration and low energy use being rewarded, to camera recording to prove innocence in case of accident.

Although quantified-self promises huge improvement in terms of safety, comfort and efficiency, it still raises several issues. Firstly, QS is often an intrusive technology. As an example users of biometrics should often wear different sensors, implying to wear sensors, cable, batteries or other elements to manage. There, the cooperation between human and machine lead to new technologies such as radars installed in driving seats as explained by Vinci *et al.* (2015) and claimed by Faurecia (2015). Secondly, QS implies scrutinizing very personal data such as the heart rate or the respiratory rhythm. This might be a strong drawback if raw data needs to be transmitted to data server for deeper analysis even if existing application of quantified-self already do it such as the Hexoskin (2106) wearable biometrics. Today, the access of these data is not regulated in the same way as GPS position but this will probably evolves when such technology become pervasive.

2.2 Internet Of Things (IoT)

Internet of Things is the way different "things" may interact together using networks and communications. These "things" may include sensors, actuators and networks communications media that, being heterogeneous by nature, can still communicate together. First introduction of Internet Of Things have been found in domotics and assisting living but will rapidly evolves to include industrial, logistics, business and in transportation systems as stated by Atzori *et al.* (2010). The Internet Of Things is made possible thanks to an architecture composed of the sensing, communicating and middleware layers. The middleware layer is software layer linking the object and the application together. Its role is to hide the different object details in order to ease the programmer task.

Within the applications of the internet of things to transportation systems, assisted driving, automated vehicles and communicating cars are the most promising. In these cases, several objects have to be sensed from driver biometrics to vehicle dynamics through infrastructure parameters. A wide range of applications is then possible and Intel (2016) already provided an overview of them and it estimated that data from radar, lidar, cameras and ultrasonics will be more than 1 Gbps. Among all proposed instantiations, several applications are already commercialized such as all ADAS. However, much more can be performed, especially on the automatic map processing. Another example is given in the work of Gerla et al. (2014) where an Internet Of Vehicles is proposed using vehicle to infrastructure communication.

Although, Internet Of Things show promising results, it cannot be a silver bullet on its own as it relies on the objects to be sensed and on the application (sector). When working on the transportation field, as many information are gathered and shared, the data privacy becomes one of the biggest issue. Currently, data generated by vehicles are owned by the