On the Topic of Autonomous Robots: Smart Cities

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Introduction:

The purpose of the Metalab is to help businesses and society understand and use artificial intelligence and the power of data to enable individuals and citizens to make well-informed decisions in an ethical and fair manner. Created under the École Supérieure des Sciences Economiques et Commerciales (ESSEC), the Metalab is a unique multidisciplinary ecosystem that combines expertise in hard sciences and social sciences to inform practices at the intersection of "Data, technology and society" and put people at the core of all decision-making processes.

At Metalab, our objective is to help businesses move from data-based decision-making to new decision-making models that combine the power of AI and human judgment. Many routine decisions based on structured data and subject to cognitive bias can be automated with the help of prescriptive analytics tools and AI. With other more strategic decisions, AI takes advantage of human judgment by generating various possibilities, the best of which is chosen by the decision-makers themselves. Hence, we believe that the biggest obstacle to the implementation of AI in businesses is not the lack of data scientists, but the lack of leaders trained in AI and keeping in mind that all the technical issues are human ones indeed.

In this way, ESSEC intends to build new bridges but also question the interactions between science and society, as well as the challenges linked to the governance of Artificial Intelligence and data ethics. By integrating the human factor into AI, we can produce commercial decision-making models guided by concern for their impact on society but also with clear objectives, understandable criteria and actionable processes.

Abstract:

Although the notion of sustainable cities emerged in the 1990s, it has only been since 2010 that interest has focalized on the adaptation and establishment of smart cities. A smart city can be defined as an inhabited center of population, culture and commerce wherein information & communication technologies (ICTs) are utilized to improve the economic and operational efficiencies as well as social and environmental sustainability of its inhabitants. ICTs such as sensors, actuators, surveillance cameras are able to store and transmit data through the "Internet of Things" (IoT) which are in turn used to improve the standard of living of individuals. However, it is important to note that all these connected tools can lead to privacy concerns and vulnerable attacks. One major component of the smart mobility agenda is the integration of Automated Driving Systems (ADS) into the transportation infrastructure. This can prove highly beneficial to public safety, traffic management and economic efficiency as seen in Copenhagen's 2002 pioneering implementation of an autonomous metro, wherein 13 percent of car drivers and 47 percent of bus passengers made the switch in the first two years alone.

For the scope of this paper, however, we will focus on the implications of autonomous vehicles (AVs) in smart cities. We know that data collected by periphery sensors are directly influencing the AV's environmental awareness and the decisions behind customer tailored

speed and trajectory, obstacle avoidance, and when to revert control to the deferential and supervising collaborative agent: the human driver. With this in mind, we can deduce that the efficacy of ADS hinges upon the embedded connected devices that a smart city can offer. Alternatively, we can approach from the other direction where we look at how ADS algorithms make decisions that conversely influence the road safety, traffic efficiency and other purported benefits.

The City-first approach

It is more likely that a smart city is first developed and that ADS react to the new environment than the other way around. As such, will first look at what it means for an ADS to adapt to a smart environment, and where ethical problems may emerge.

Currently, all static and dynamic control measures of road traffic are prepared for the traffic flow generated only by human drivers. Traffic composition with driverless cars, however, have much more complex requirements.

Moreover, communication systems are also appearing in modern vehicles, which are therefore capable to make contact with other cars or infrastructure. This is called V2V (Vehicle to Vehicle) or V2I (Vehicle to Infrastructure) communication. The development and standardization of V2V/V2I technologies are also ongoing growing support.

The ongoing transport research generally focuses on the implementation of intelligent transport systems (ITS). In the ITS concept intelligent infrastructures must be also emphasized which build up a complex traffic network together with the partly or fully autonomous vehicles.

Lane Marking

Poor road markings are challenging even for the already existing connected vehicles. It's something that has to be worked on for the effective adoption of AVs. The road markings should not only be reflective but machine-readable.

Roadside Sensors

To be prepared for the driverless future, roadside sensors should be included on sidewalks, curbs and lanes. They will allow vehicles to keep track of their surroundings and foresee potentially dangerous situations.

Smart Signage

Current autonomous vehicles use image recognition for reading road signs. However, a much more reliable approach would be machine-readable signs. They will include an embedded code that could be transmitted. They'll send messages detectable by computers.

These are just three of the many methods smart cities can update their infrastructure to accommodate autonomous vehicles. Street lighting and smart buildings are two other areas that could yield savings, with smart street lights expected to cut repair and maintenance costs by 30 percent. It is important to note that this is a very time consuming and expensive fixed cost to allocate, and as a result may see an increase in municipal tax rates to cover the costs.

The ADS-first approach

Highly automated and autonomous control of a road vehicle requires a well-defined and separated structure of environment perception, potential trajectory analysis, decision making and decision execution. All these need to happen in real-time and in a fault-tolerant but at least fail-safe way. The technology related challenges are partially solved already today (e.g. series production of Adaptive Cruise Control or Lane Keeping Assistance functions), and although autonomous driving requires the next level in technology, the major challenges are not technology related.

Researchers and vehicle manufacturers may have different control structure implementations (see the HAVEit structure as an example in Fig. 2), but all of them have to ensure the following four layers for integrated vehicle control as a minimum:

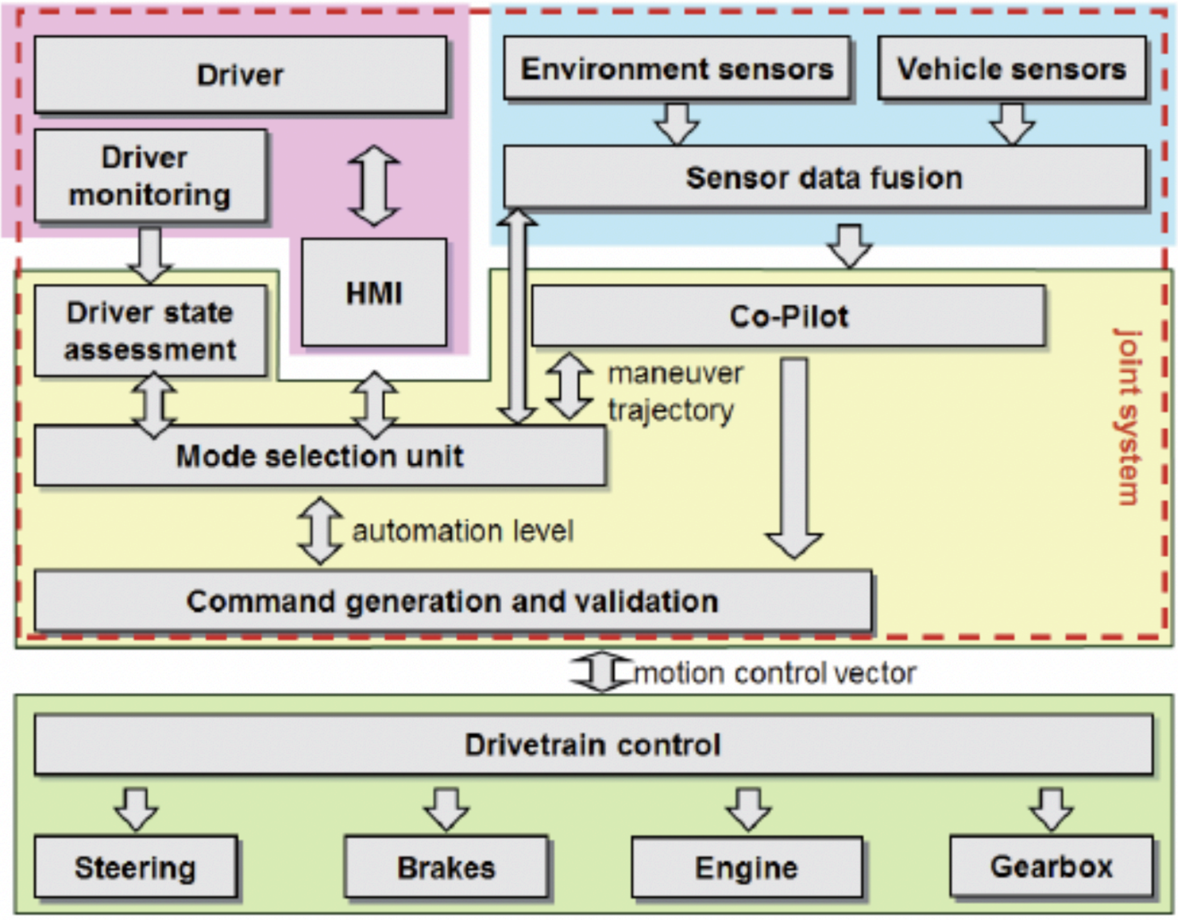

Fig. 2 Example of an integrated vehicle control structure (source: HAVEit, Hoeger et al., 2011)

1. The driver interface layer is not only responsible for interacting with the driver about the actual status of the autonomously running vehicle, but it also has to continuously evaluate the driver status and his/her capability to take over control in case a fallback performance is required.

2. The environment perception layer is responsible for providing comprehensive information about the traffic situation including the surrounding objects around the vehicle. There are different types of sensors installed all around the vehicle like sonars, radars, lidars, video cameras and laser scanners. They are combined with e-Horizon based location data (GPS/Glonass/Beidou, etc.) and high-definition mapping information. Since different sensors are working based on different phenomena, the condense level of the output data strongly depends on the environmental (e.g. weather) conditions they operate under. That is why sensor fusion algorithms have key importance in resulting reliable situation awareness and environmental information.

3. Depending on the automation level, the trajectory planning layer calculates possible vehicle trajectories with priorities, ranks of performance and safety. It involves the calculation of longitudinal and lateral trajectory options, different route possibilities with respect to the

surrounding environment, the ranking, prioritization of the different route options based on minimizing the risk of a collision and ends up in the selection of the optimum trajectory.

4. The trajectory execution layer gets the selected trajectory as an input from the planning layer. Starting with the trajectory segmentation and the generation of the motion vector containing longitudinal and lateral control commands that will be carried out by the intelligent actuators of the execution layer. The execution of the motion vector is distributed among the intelligent actuators of the vehicle drivetrain.

Autonomous Parking

The biggest impact from ADS could be parking. Since people will be dropped off and not parking the cars themselves, the ADS could park in more remote locations, freeing up precious city land for other uses. These locations, as shown in the regulation (in the US) are called Autonomous Parking Facilities, which much be filled 2 years in advance.

Hitachi is now rolling out another piece of technology that will make commuting easier for citizens. With the use of connected mobility, autonomous parking will allow cars to automatically park in targeted positions with 360-degree sensing and automatic braking. A few of the other key advantages include automatic exits from tight parking spaces and easy app control, meaning parallel parking is as easy clicking a button.

When Intel helped develop intelligent parking solutions in Berlin, the company was able to provide quantifiable returns. Residents spent 43 percent less time looking for parking and reduced traffic volume by 8 percent.

Cyber vulnerabilities

Recent attacks showed taking over the control of the multimedia system of the car, unintentional reconfiguration of the airbag system and partial control of the vehicle dynamics (Szíjj et al., 2015; Greenberg, 2015). The risk is that conventional road vehicles do not have dedicated electronic interfaces for electronic vehicle control, but autonomous vehicles will definitely have. Highly automated and autonomous vehicles have dedicated control functions for longitudinal and lateral vehicle control (e.g. turn right or left, change lane, brake or accelerate). Comparing the hacking threat of externally changing the radio station or activating the windshield wiper to an intentionally wrong driven vehicle, there is a magnitude difference. The most threatening scenario is that if someone would like use the intelligent vehicle functions for malicious purposes, e.g. to make accident intentionally.

Beyond the cyber security of the Smart City, one should not forget that each connected car has access to other vehicles with relevant data (location, speed, etc.). Therefore, one has to make sure that sensitive data are used transparently and obey the requirements of privacy.

Conclusion:

ADS systems would have a strong impact on the decision making of infrastructure in future urban planning. This includes road transport automation, V2V communication, smart sensors, and much more. We will see how this unfolds, but there are likely many obstacles along the way that will delay the implementation of Smart Cities until regulation, technology and society is prepared to democratize the living space of such a city.

As of 2020, companies around the world are investing in more and more smart cities to achieve this, with around 443 smart city projects in 286 cities currently worldwide. For example, Japanese car manufacturer Toyota built, at the base of Mt. Fuji, Woven City – a fully connected smart city with ADS systems. It hosts 2000 people and features three types of streets: one for automated driving, another for pedestrians, and a third for users of personal mobility devices.

Spending on smart technology has grown (on average) from 0.7 percent of city IT budgets in 2005 to 4.1 percent in 2015. That percentage is expected to grow to 7.5 by 2025, according to Deltek, a global provider of enterprise software and information solutions for government contractors and professional services firms.

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