Self-driving cars: a city's perspective

Hardly a week passes without new research being published exploring self-driving cars. In the past ten years, the Institute of Electrical and Electronics Engineers alone has published more than two thousand conference papers and three hundred journal papers on the topic [1]. Besides focusing on vehicular technology, research has been conducted concerning the building of driving models for self-driving cars, the legal liabilities and ethical aspects of such systems [2], and the broader moral and social dilemmas society needs to engage with when this technology will be fully implemented [3] [4].

However, most of these papers consider the city a passive "context" or an experimental test site, and not an active technological artifact itself. They seem to miss an important point about technological changes: the device itself (in this case, the self-driving car) is only one element of the transformations that happen within a broader technological ecosystem. Indeed, a major challenge in advancing robotics is "to richly mix elements from multiple input modalities (...) to more fully capture the rich, dynamic nature of social interactions" [5].

Here we address three aspects of the urban interactions triggered by self-driving cars: first, the moral and regulatory context within which self-driving cars will be operating in cities; second, the symbolic layers that embody some of these regulations, such as road signage, which communicate the specific road regulations and mediate the often conflicting relations between people and vehicles; and third, the urban environment itself, that is being increasingly digitized, embedded with sensors, and becoming an active and responsive environment.

It has been noted that self-driving cars are "less able to anticipate how the underlying systems work" [6], they "fail to recognize the social nature of the road", missing discrete cues between human drivers, and that users of self-driving cars don't have information about how the engine is calibrated or how the car make decisions. Some authors [7] advocate that more detailed information should be available to users of self-driving cars, and human intervention should always be required. Supporting these arguments is the notion that human drivers are more predictable or reliable than the algorithms driving autonomous cars.

However, if we consider data about driving behavior in the United States, we might re-evaluate such assumptions. In most states, only drivers under 18 years of age are required to accumulate hours behind the wheel before taking the driver's license exam—and the required practice time rarely goes beyond 30 hours in total, with teenagers obtaining their license during the summer, when road conditions are likely less dangerous than during rainy or snowy seasons. Not surprisingly, novice drivers are over-represented in fatal crashes involving automobiles [8]. On the other end of the driving population, crashes increase among older drivers, who show a lower ability to scan the surrounding environment for unexpected threats [9]. Indeed, [10] estimates that approximately 93% of car accidents are caused by driver error.

Self-driving cars, on the other hand, learn by brute force, trained for the equivalent of hundreds of thousands of driving hours in machine learning datasets composed of a vast range of driving conditions and driver behaviors. When self-driving cars hit the roads, they have driven in windy and snowy conditions, in heavy traffic and highways. The argument that we should think self-driving cars as we think of aircrafts [6], in terms of having humans in control, ignores an important fact: in aircrafts, professionally trained pilots, seconded by co-pilots, can take control of the plane any time, in particular in critical situations—and, still, human error is among the top causes of plane crashes [11]—whereas in cars, we have drivers, not professional pilots, and at least in the United States those drivers might be someone with less than a week of active driving.

The second point refers to specific regulations and policies involving self-driving cars. Public social arrangements are often translated into enforceable regulations. Self-driving cars operate through algorithms that extract actionable information from data—both offline data, accumulated in the vehicle's operating systems, and online data, gathered while the vehicles are driving. Thus, the point is not to prepare new regulations to be followed by manufacturers and operators, but rather to encode existing and new regulations into the self-driving cars' operating systems. For example, when an autonomous vehicle enters a residential area, it immediately adjusts its behavior according to the speed-limit of different areas encoded into its operating system. Any regulatory framework relies on a chain of trust links. By encoding such regulations in the self-driving car operating system, and establishing standardized, mandatory data reporting [12], neither additional implicit trust in drivers nor the deployment of law-enforcement agents are required anymore.

The same goes for artifacts whose only function is the display of regulations, such as pedestrian crossings, traffic signals, or traffic lights. They are communication devices devised to negotiate conflicting interests: do not turn right, for this is a one-way road; stop at the red light, for another vehicle might be coming in a conflicting (usually perpendicular) direction. Most of these signs will probably be kept when self-driving cars become the predominant technology. But they will be mostly used to instruct pedestrians, not drivers or cars: after all, these are merely representations of regulations that will be embedded in the self-driving car operating system.

Finally, self-driving cars must consider the city as an active technological artifact, for a multiplicity of sensors, telecommunications, data processing, and artificial intelligence will be playing an increasingly critical role in cities. In fact, the argument that people are more adaptable and creative than machines is debatable—at least, it is contextually dependent. We are not only collecting more data about the city's natural and built environment, infrastructure and services than ever before; we are also increasingly collecting data about human behaviors and social interactions that happen in the city, from self-tracking devices to cell phone communications. Thinking of self-driving cars as independent technological units only exchanging data with each other or reading a mostly passive urban environment is an extremely narrow way of addressing such transformational technology, and seeing the problem within a very limited time span. Such a urban system is also fed by data such as pollution levels or school releases in particular areas. By responding to these factors, self-driving cars also change them—encoded to avoid certain areas in certain period would help to reduce emissions in these areas, or make streets safer for school children.

Thus, the road to autonomy will not be achieved by setting humans, regulations, the physical city, and self-driving cars as independent units. The transformation will come from the integration of the multiple systems and entities (including humans) that are generating data and making data-driven decisions—which, if thought organically and integrated, will make our cities more responsive and adaptive.

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