Operationalizing the Ethics of Connected and Automated Vehicles:
An Engineering Perspective

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ABSTRACT

In response to the many social impacts of automated mobility, in September 2020 the European Commission published "Ethics of Connected and Automated Vehicles," a report in which recommendations on road safety, privacy, fairness, explainability, and responsibility are drawn from a set of eight overarching principles. This paper presents the results of an interdisciplinary research where philosophers and engineers joined efforts to operationalize the guidelines advanced in the report. To this aim, the authors endorse a function-based working approach to support the implementation of values and recommendations into the design of automated vehicle technologies. Based on this, they develop methodological tools to tackle issues related to personal autonomy, explainability, and privacy as domains that most urgently require fine-grained guidance due to the associated ethical risks. Even though each tool still requires further inquiry, they believe that the work might already prove the productivity of the function-based approach and foster its adoption in the CAV scientific community.

KEYWORDS

INTRODUCTION

Connected and Automated Vehicles [CAVs] are arguably one of the most researched and discussed applications of Artificial Intelligence [AI] technologies. Advances in design and development fuel the anticipation of a future where our roads will be populated by both regular and automated vehicles. Concurrently, social, ethical, and legal issues surrounding the impacts of CAV technologies have been raised (Nyholm, 2018a, 2018b; Taeihagh & Lim, 2018). This kindled a lively interdisciplinary debate and highlighted the necessity of shared normative frameworks to steer innovation towards

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ethically desirable and socially sustainable directions. In line with this trend, the European Union [EU] has recently presented its ethical framework to promote responsible innovation in CAV technology (Horizon, 2020) and asked stakeholders to contribute to its operationalization.

This paper responds to the call by presenting some methodological suggestions on how to ease the translation of the EU recommendations into practice from the viewpoint of engineering.[1] In what follows, we elaborate on a bottom-up, *function-based working approach* for the development of flowcharts, checklists, and similar methodological tools supporting the exercise of moral judgment aimed at aligning CAV design to the EU normative framework[2]. By focusing on given functions, determining which ethical challenges they pose vis-à-vis the EU framework, and devising *ad hoc* methodological tools to discuss them, the gap between principles and design practices can be narrowed down and the need for further conceptual refinements of the normative framework can be better specified.

The paper is structured as follows. In Section I we present the EU ethical framework, while in Section II we further clarify our aims and sketch the main features of the function-based working approach. In the remaining sections we show how this approach can be applied to outline tools for bridging gaps between recommendations and practice. In particular, Section III focuses on problems revolving around the principle of personal autonomy; Section IV considers challenges posed by explainability; finally, Section V takes a closer look to privacy issues. In each case we map a methodological tool aimed at further operationalizing the EU guidelines. However, due to the preliminary stage of our research, the suggestions we advance are to be read more as evidence in support of the function-based approach than as refined tools for inquiry. Therefore, for each tool we underline what aspects are still in need of further clarification, thus setting the agenda for future research. Notwithstanding this limitation, we believe that our work might already demonstrate the productivity of the function-based approach and foster its adoption in the CAV scientific community.

Ethics of Connected and Automated Driving

In September 2020, the European Commission released its first systematic document on the ethics of autonomous driving. The report, entitled *Ethics of Connected and Automated Vehicles. Recommendations on Road Safety, Privacy, Fairness, Explainability and Responsibility* (ECAV from now on) is authored by the 'Horizon 2020 Commission Expert Group to advise on specific ethical issues raised by driverless mobility', an independent task force of 14 experts – mostly academics: philosophers, law scholars, engineers – led by Jean François Bonnefon and Filippo Santoni de Sio (Horizon, 2020).

Following closely the European approach to ethical AI put forward in *Ethics Guidelines for Trustworthy AI* (AIHLEG 2019) and analogous documents, the report aims at developing a coherent framework to analyse, assess, and manage ethical issues proper to CAVs, thus ensuring a "safe and responsible transition" (Horizon, 2020, p. 15) to driverless mobility in the EU. By applying a Responsible Research and Innovation approach (Owen *et al.*, 2012), the authors consider both risks and benefits related to CAVs, stressing the need for legal and ethical guidelines to steer technological advancements towards socially desirable outcomes. Based on this, the report presents 20 recommendations to promote alignment of CAV technologies to the EU fundamental values and, thus, justified social trust in innovation.

As such, the report is directed to all stakeholders and is intended to serve as a basis for a widely participated debate on how to face the ethical challenges posed by CAVs. Particular attention is indeed dedicated to the main stakeholders – manufacturers and deployers, policymakers, and researchers – whose roles in the accomplishment of each recommendation is carefully outlined (Horizon 2020, pp. 65-69). As we will see, this is supposed to help go over a common hurdle of similar enterprises, i.e., the necessity of filling the gap between statements and practice.

As in the case of AIHLEG (2019), the report opens with a section where the "fundamental ethical and legal principles" (Horizon, 2020, p. 21) are listed and briefly commented. The principles, which

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