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The automotive domain – From Multi-disciplinarity to Trans-disciplinarity

Salome Maro

Chalmers | University of Gothenburg; Salome.maro@cse.gu.se

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Abstract: The automotive domain has witnessed a tremendous growth in the amount of software deployed in cars. The car no longer contains mechanical components only, but more and more functionality is controlled by embedded systems. Due to this, the domain is multi-disciplinary, involving engineers from mechanical, electrical, electronics and software disciplines. However, this is now changing as the problems being addressed in the domain are becoming more complex. Problems are now societal such as smart cities or green mobility. Solving such complex problems requires going beyond multi-disciplinarity and towards transdisciplinarity. This involves including stakeholders that represent the users and also the societal interests. This paper discusses opportunities and challenges for trans-disciplinarity in the automotive domain.

Keywords: Automotive; Trans-discipline; Multi-discipline

1. Introduction

Multi-disciplinarity is research involving complex problems that require researchers from several disciplines to coordinate [8]. In multi-disciplinary research, theories and models from the different fields are brought together and each field only solves a piece of the bigger problem. The different disciplines merely complement each other usually in a sequential manner, but no new knowledge is formed between them [8,10]. Trans-disciplinarity on the other hand, goes beyond several disciplines collaborating to solve a problem. The focus is to synthesize and unify knowledge from the different disciplines in order to solve complex problems [11]. Models and theories from the different disciplines can be altered and improved since the major aim is to solve a practical problem.

Over the past 20 years in the automotive domain, there has been a rise in the amount of embedded systems that are deployed in cars [2]. A modern car contains approximately 100 million lines of code in total distributed over about 100 Electronic Control Units (ECUs) [3]. Examples of embedded systems in a car are adaptive cruise control, brake assist system, airbag control systems and navigation systems. The development of such embedded systems has made the automotive domain multi-disciplinary in nature due to the different disciplines that are involved in making these systems. For example, a typical embedded system needs to be worked on by mechanical engineers, electronic engineers, electrical and software engineers. These engineers bring their expertise to create the final system. This kind of development is known as Systems Engineering [12].

Recently, embedded systems in the automotive domain are shifting towards more complex problems e.g., autonomous driving. This means using only engineering knowledge from the different disciplines is no longer enough, and this field needs more appropriate research methods. Since trans-disciplinary research focuses more on problem solving rather than specific field enhancements, it is

better suited for the current complex problems in the automotive industry [5]. In this paper, we will discuss the opportunities and challenges for trans-disciplinary research in this domain.

2. From Multi-disciplinarity to Trans-disciplinarity: Bigger and More Complex Problems

In [1], the authors reviewed 30 years of autonomous driving and synthesized a timeline of how the automotive industry has evolved in terms of the systems developed, and how the goals for these systems have evolved. As seen in Figure 1, the focus is moving from purely technical goals such as vehicle dynamic stabilization, which is more on how to improve the car itself technically, to broader goals that involve the society such as automated and cooperative driving. A similar trend us reported in [12]. This shows that the problems that are now being tackled with both industry and academia in the field of autonomous driving, are leaving the bound of multi-disciplinary and becoming more trans-disciplinary. E.g., to be able to have an autonomous vehicle on the street, several things such as safety, ethics, legal issues and even urban planning need to be taken into account. This can only be achieved if researchers and practitioners from these different disciplines work together.

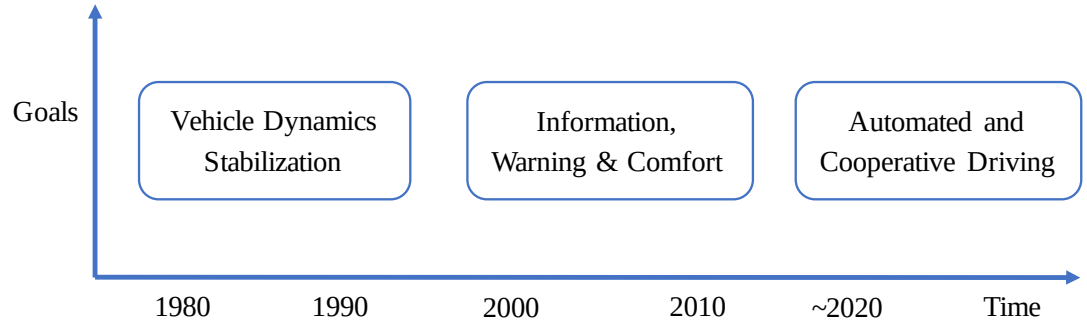

Figure 1:Timeline of the past and potential future of autonomous driving [1].

3. Opportunities for Trans-disciplinary research

This section outlines opportunities for trans-disciplinarity in the automotive domain.

3.1. Research Funding Opportunities

The rise of autonomous driving brings along some opportunities for researchers. E.g., opportunities to apply for grants that support trans-disciplinary research [9]. Such grants are focused on solving societal problems more than scientific advancements of particular disciplines. For instance, one societal problem is environmental pollution. Autonomous vehicles can be seen as a solution to minimize waste caused by having so many cars produced and used. A more realistic example is seen in the European Union Framework Program for Research and Innovation from 2014 to 2020, which has set aside funding to investigate societal problems such as smart, green & integrated transport [6].

3.2. Opportunity to Show Applicability of Research Results

Trans-disciplinary research is an arena for researchers to show case the application of their research in different contexts. This is because for research focused on advancement of a particular discipline, the research usually ends at a proof of concept phase. Theoretically, or in very restricted environments, the advancements such as models and concepts are proved to work. Trans-disciplinary research projects however, give room to apply this knowledge to complex practical problems in practical environments. This facilitates knowledge synthesis from various contexts.

4. Challenges of Trans-disciplinary research

This section describes the challenges of trans-disciplinary research in the automotive domain.

4.1. Coordinating large projects

Trans-disciplinary research involves very large projects [4] and such projects involve people from separate disciplines. Coordinating these projects is complex, it requires the skills to be able to manage people from the different disciplines. It is also crucial to make sure that everyone in the project feel important, needed and feel that they are contributing to the final goal of the project. Depending on the project, there might also be several goals and it is difficult for all the stakeholders to keep in mind the final goal. Furthermore, objectives of the different stakeholders might be conflicting. For instance, for autonomous driving from the context of software engineers', low memory consumption of the program might be an important objective but for safety engineers this may not be the case. Also, different disciplines have different research traditions that may be conflicting.

4.2. Communication problems

When different disciplines need to coordinate, communication problems arise. This is because the different disciplines have different vocabularies. For trans-disciplinary research projects this is a challenge. Research suggest that before the beginning of the project, the different stakeholders involved need to discuss the objectives of the project. Also during the course of the project regular contact in form of meetings or workshops are advised to ensure that everyone is on the same page. It is important to communicate the expected outcomes as early as possible. Expectations of all the different disciplines should also be communicated early on.

4.3. Applied research vs. Fundamental research

Fundamental research is research where scientists act out of curiosity and gather knowledge for the sake of knowledge without a specific problem in mind that this knowledge will solve [7]. Applied research is more practical where scientists seek knowledge that will solve a particular problem. As discussed, what differentiates trans-disciplinary research from other types of research is that it is aimed at solving a practical problem. For research this translates to mostly applied research rather than fundamental. This means that the contribution is not a new advancement in any particular field, but rather unified knowledge to solving a practical problem. While publishing such results is not a problem as many publication venues accept such papers, for researchers, it can be hard to have an identity of belonging and contributing to a particular discipline (which is expected in academia). This is also reflected in how universities hire researchers based on needs of a certain discipline.

5. Conclusion

Based on our discussion, there are two ways in which trans-disciplinarity can advance in the automotive domain: One is that using trans-disciplinary research, the automotive domain advance to solving more complex problems. This is an opportunity for advancement that would not have been possible using mono-disciplined research approaches. On the other hand, applying the different research methods suggested to be suitable for transdisciplinary research gives an opportunity for such methods to be used and evaluated in the automotive industry. This does not only benefit researchers, but also practitioners and the society in the end.

References

1. Bengler, Klaus, et al. "Three decades of driver assistance systems: Review and future perspectives." IEEE Intelligent Transportation Systems Magazine6.4 (2014): 6-22.
2. Broy, Manfred. "Challenges in automotive software engineering." Proceedings of the 28th international conference on Software engineering. ACM, 2006.
3. Busnelli, Andrea. Car Software: 100M Lines of Code and Counting. https://www/linkedin.com/pulse/201406152045-3625632-car-software-100m-lines-of-code-and-counting, 2014. [Online: accessed 07-10-2016]
4. Cundill, Georgina NR, Christo Fabricius, and Neus Marti. "Foghorns to the future: using knowledge and transdisciplinarity to navigate complex systems." Ecology and Society 10.2 (2005).
5. Dodig-Crnkovic, Gordana, et al. "Transdisciplinarity seen through Information, Communication, Computation, (Inter-) Action and Cognition." arXiv preprint arXiv:1604.04711 (2016).
6. E. C. for Automotive R&D. Horizon 2020. http://www.eucar.be/horizon2020/, 2014. [Online; accessed 12-02-2017].
7. Kothari, Chakravanti Rajagopalachari. Research methodology: Methods and techniques. New Age International, 2004.
8. Madni, Azad M. "Transdisciplinarity: Reaching beyond disciplines to find connections." Journal of Integrated Design and Process Science 11.1 (2007): 1-11.
9. Pohl, Christian. "From science to policy through transdisciplinary research." environmental science & policy 11.1 (2008): 46-53.
10. Ramadier, Thierry. "Transdisciplinarity and its challenges: the case of urban studies." Futures 36.4 (2004): 423-439.
11. Simon, David, and Friedrich Schiemer. "Crossing boundaries: complex systems, transdisciplinarity and applied impact agendas." Current Opinion in Environmental Sustainability 12 (2015): 6-11.
12. Winner, Hermann. "Challenges of automotive systems engineering for industry and academia." Automotive Systems Engineering. Springer Berlin Heidelberg, 2013. 3-15.