Towards Prototyping Driverless Behaviors, City Design, and Policies Simultaneously

Hauke Sandhaus, Wendy Ju, Qian Yang

Information Science, Cornell University

Correspondence: hgs52@cornell.edu

Highlights

- **AVs (autonomous vehicles), city design, and policy decisions are complex and difficult to untangle.**
- **Many independent and isolated methods for prototyping exist, but no addressed more than 2 of the complexities.**
- **New integrative AV-city-policy simulation and forecasting tools are needed.**
- **An iterative participatory prototyping process is required for innovating AVs, city design, and policies simultaneously.**
- **Current hand modeling approaches can be replaced with data-driven methods if data sharing of data from AVs gets encouraged.**

Methods

- 1. Conduct a cross-disciplinary literature review covering human-computer/robot interaction (HCI/HRI), transportation science, urban studies, law and policy, operations research, economy, and philosophy.
- 2. Map out the interconnections among AV, city, and policy design decisions to help innovators identify design constraints and opportunities across traditional disciplinary bounds.
- 3. Review the methods in the space and how they target design across boundaries.
- 4. Identify challenges for more integrative prototyping and devise two general approaches.

Abstract

Autonomous Vehicles (AVs) can potentially improve urban living by reducing accidents, increasing transportation accessibility and equity, and decreasing emissions. Realizing these promises requires the innovations of AV driving behaviors, city plans and infrastructure, and traffic and transportation policies to join forces. However, the complex interdependencies among AV, city, and policy design issues can hinder their innovation. We argue the path towards better AV cities is not a process of matching city designs and policies with AVs' technological innovations, but a process of iterative prototyping of all three simultaneously: Innovations can happen step-wise as the knot of AV, city, and policy design loosens and tightens, unwinds and reties. In this paper, we ask: How can innovators innovate AVs, city environments, and policies simultaneously and productively toward better AV cities? The paper has two parts. First, we map out the interconnections among the many AV, city, and policy design decisions, based on a literature review spanning HCI/HRI, transportation science, urban studies, law and policy, operations research, economy, and philosophy. This map can help innovators identify design constraints and opportunities across the traditional AV/city/policy design disciplinary bounds. Second, we review the respective methods for AV, city, and policy design, and identify key barriers in combining them: (1) Organizational barriers to AV-city-policy design collaboration, (2) computational barriers to multi-granularity AV-city-policy simulation, and (3) different assumptions and goals in joint AV-city-policy optimization. We discuss two broad approaches that can potentially address these challenges, namely, “low-fidelity integrative City-AV-Policy Simulation (iCAPS)” and “participatory design optimization”.

Paper

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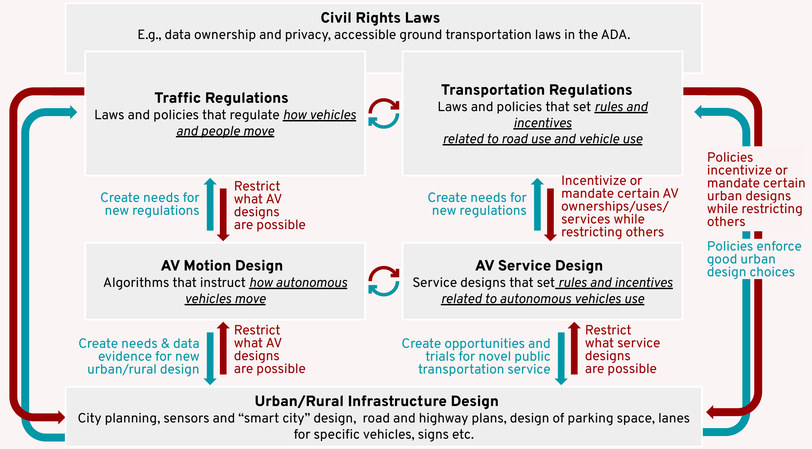
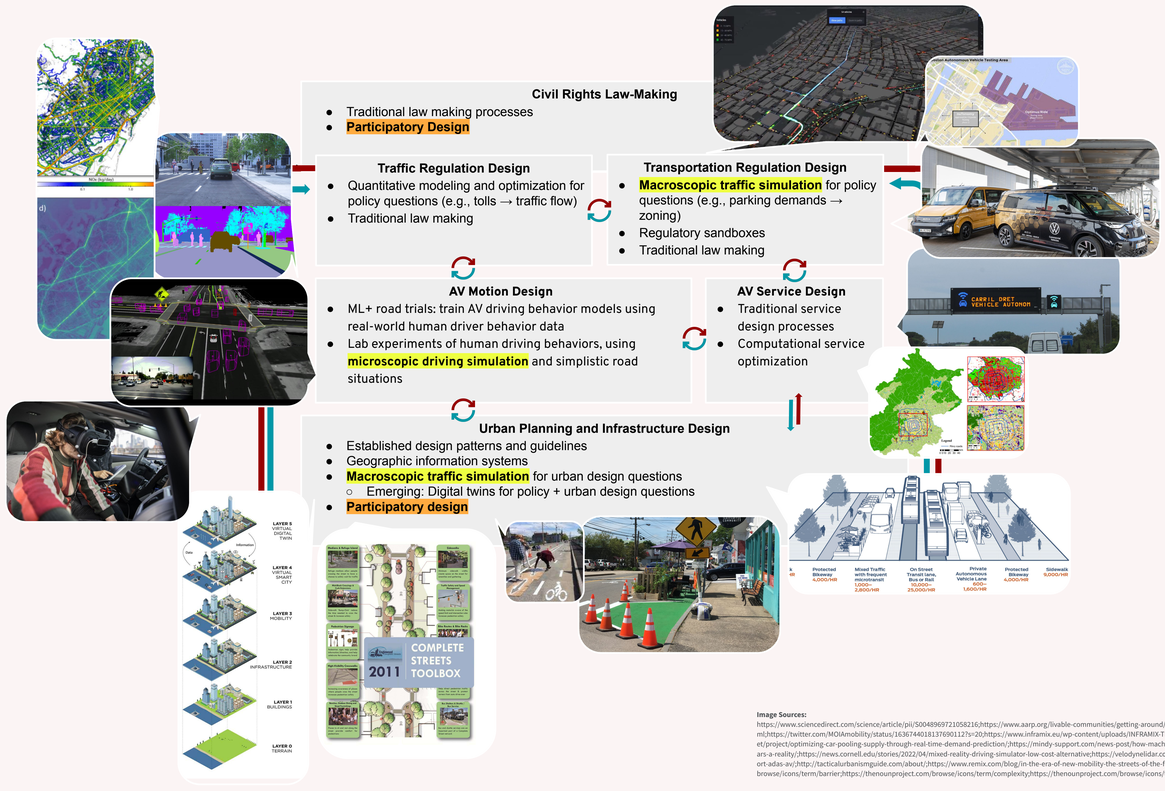
The AV-city-policy design “knot”



There are only methods that design two at a time, no method designing all three; leading to siloed design of solutions



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Challenges

Organizational barriers

- Coordinating stakeholders (AV designers, urban planners, policymakers)
- Fostering interdisciplinary collaboration and communication

Individual and societal levels computational complexity

- Intricate simulations to prototype interactions between individual vehicles and pedestrians, often focusing on simplified, abstracted, and isolated road situations
- Urban planning and policy-making require large-scale simulations to prototype traffic flows, longitudinal patterns, and the holistic impact on the city,

Differing assumptions and goals

- Aligning objectives and priorities
- Engaging stakeholders with participatory design methods

Proposed approaches

Collaboration Tools and Communities for AV Designers, Urban Planners, and Policymakers

- Need for productive collaborations and communities
- Existing collaborations: car safety, smart cities, ride-sharing policies
- Opportunities: strengthen collaborations for sustainability, social equality, and accessible mobility

Participatory AV-City-Policy Design Optimization

- Integrative simulation and Participatory Design (PD) methods
- Workflow: PD activities, integrative simulation and Bayesian optimization, stakeholder evaluation
- Benefits: align assumptions and goals, leverage computational methods for optimal solutions

Low-fidelity, integrative City-AV-Policy Simulation (iCAPS)

- Goal: synchronous prototyping and easy collaboration among AV, city, and policy designers
- Building blocks: digital twins, modifiable point clouds, machine learning models
- Challenges: low-fidelity prototyping, visualization and ML needs, data-sharing across stakeholders