Q&A: Researchers discuss using AI to encourage carpooling and shared transportation

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Imagine hailing a dynamic shuttle whenever you need to go somewhere—and arriving faster than if you had just driven yourself. That's the vision shared by Berkeley researchers: a world where environmentally friendly, energy-efficient high-occupancy vehicles (HOVs) are the preferred and quickest mode of transportation.

Using a simulated environment, the researchers tested a novel traffic signal control algorithm that works to maximize the throughput of people—rather than vehicles—at intersections. Dubbed HumanLight, the technology uses reinforcement learning, a type of artificial intelligence, to prioritize and reward passengers of HOVs with more green lights. Their findings, published in *Transportation Research Part C*, showed that the resultant travel time savings creates a strong incentive for people to choose transit options over single-occupancy cars.

The study's lead author is Dimitris Vlachogiannis, Ph.D. Co-authors are Scott Moura, the Clare and Hsieh Wen Shen Distinguished Professor in Civil and Environmental Engineering; principal investigator Jane Macfarlane, director of the Smart Cities Research Center; and Hua Wei, assistant professor at Arizona State University.

Moura and Macfarlane recently spoke with Berkeley Engineering about this work, explaining how it could someday provide a more democratic and sustainable traffic management solution.

How did your previous work lead you to HumanLight?

Jane: I helped launch OnStar, and we had seat sensors, much like those used with air bags, that would tell us how many people were in the car in the event of an emergency or accident. [I thought] if we have a way of knowing how many people are sitting in those vehicles waiting at a traffic signal, we can develop a traffic signal control system, like HumanLight, that gives priority to those with higher occupancy.

Scott: We had this seven-year project called NEXTCAR, where we looked at ways to optimize the speed of the vehicle to reduce energy consumption based on the traffic light timing. As I got deeper into it, I started to wonder, what if we could control traffic light timing? Transportation engineers, meanwhile, were thinking, but how do you control traffic light timing if the vehicle flow is uncontrollable? But what if we could control both?

Jane and Dimitris then introduced the idea of HumanLight, which looks at how to control traffic light timing so that we can maximize the throughput of people, not cars—which is ultimately what matters.

Why should people care about traffic management?

Scott: The simple answer is: 51 billion tons. That's the amount of greenhouse gases emitted annually around the world. A little less than 1% of that is the state of California. And 40% of California's greenhouse gas emissions are from transportation. Today, California is focused on bringing that toward zero to address the challenges of climate change.

One way to meet that goal is to have everybody buy EVs. But that would require building a whole new supply chain and shifting the world economy. In the meantime, another option is to go after the low-hanging fruit. Ultimately, we're talking about software and using all the hardware and infrastructure that we already have—but being more strategic about how we manage traffic light timing to reduce congestion and energy consumption.

Jane: At an infrastructure level, when you start thinking about who's controlling traffic, you realize that we have a controlled chaotic mess out there. There are city traffic engineers who tune traffic lights and set up the timing. Then you have the Department of Transportation managing freeway on-ramps and off-ramps. In addition, there are numerous navigation apps that are moving people through our city and sometimes directing cars into residential neighborhoods not designed for lots of traffic.

We're getting more people on the roads every year, so we need to put more control into the system to ensure that it is both beneficial to people and to the environment.

How does HumanLight fit into the traffic signal control puzzle? How does this solution work?

Jane: HumanLight is part of the next step in the evolution of transit signal priority and emergency vehicle preemption. Its goal is to optimize traffic signal control for maximum people throughput, not car throughput. Rather than using standard control theory, HumanLight uses an AI technique, reinforcement learning, to manage the dynamic behavior of complex traffic environments.

For example, setting up a corridor of timed traffic lights that are all in a line is fairly easy, but once you get into a grid of traffic lights, it gets much more complex from a control theory perspective. So there's hope that reinforcement learning will help us manage traffic signal timing and phasing a little bit better.

Scott: Imagine a four-way intersection where, in one direction, you have a lot of buses and shuttles going through. Meanwhile, in the opposite direction, there are more private cars, single-occupancy vehicles going through. The traffic light timing might be, for example, that each direction is green for 30 seconds. Seems fair; you've got two different directions.

But if you want to move people from point A to point B quickest, it might make sense to actually prioritize the direction that has more people going through. That's the core idea: to somehow make the traffic light timing intelligent, where it understands the occupancy of the incoming vehicles. And then it basically prioritizes the flow of vehicles where there are more people.

You're taking a human-centric approach to traffic management. Is this different from earlier work or other approaches being used now?

Jane: Yes. I would say that HumanLight is unique in this respect. For example, current transit signal priority systems will prioritize an empty bus because they don't know how many people are on the bus. They just know the bus is coming. Still, that bus might pick up 50 people on the other side of the light. But HumanLight could potentially provide a clearer picture of vehicle occupancy for multiple modes of transportation, from cars to shuttles and buses, and get more people where they want to go faster.

Scott: In the past, there was a technology called adaptive traffic light signal timing. It consists of a network of cameras or magnetic detectors placed along a corridor to detect traffic. But these devices just detect metal boxes, not people. So, a bus or a shuttle containing twelve people is viewed the same as a Suburban SUV with one person. And so that approach doesn't make sense when we're trying to move people.

HumanLight not only puts the focus on moving people, but it also provides a framework for bringing together two enabling technologies.

One is connected vehicles, which are connected to the internet infrastructure. Like Jane said, with OnStar, you can know how many people are in a vehicle and potentially communicate this information to the traffic control network. The other technology is AI. Given all the advances of reinforcement learning and AI, you can now tackle this complex infrastructure problem in ways that we couldn't have five, ten years ago.

Could you tell me about the findings of this study? Were there any surprises?

Jane: I didn't expect to see such good results for people who aren't in high-occupancy vehicles. After all, you don't want to design a solution in which people who can't take a shuttle, for whatever reason, are penalized or must wait an extra half hour to get where they need to go. With HumanLight, we were able to design a democratic solution.

Scott: Dimitris helped us realize another important outcome: incentivizing people to carpool. Initially, I thought of HumanLight as just an infrastructure control solution. But because we're prioritizing humans, it's also incentivizing human behavior to carpool, use shuttles and buses.

What still needs to happen before we implement a system like HumanLight?

Scott: First, I think we need to align stakeholders. But finding the right infrastructure owner/operator, the right city that is willing to try this out, will be challenging because these are generally risk-averse organizations. They are just trying to keep traffic flowing, so experimenting with things is very nerve-wracking.

Second, we need connected infrastructure. We need to outfit the traffic cabinets, which you see at every intersection, to have a radio that communicates with the vehicles and the cloud. They can then receive information about the vehicle's occupancy and modify the little computer in the cabinet that's changing the traffic lights.

The U.S. Department of Transportation has what they call the Vehicle-to-Everything [V2X] deployment plan. By the year 2035, they want every intersection in the United States to have this connected technology, basically a radio on the traffic cabinet that talks to cars, and the cars talk to the traffic cabinet.

If that occurs, then potentially we can do this. But in the meantime, there are already places that are trying to do this. I was just working with Caltrans District 12 in Orange County. They've got 180 locations throughout their traffic network that already have these radios that can control traffic signals.

Jane: And I'd like to add automotive OEMs [Original Equipment Manufacturers] to that list of key stakeholders. Those seat sensors are part of today's vehicles. Certainly, they were in GM vehicles and available to OnStar. We'll need the OEMs to give us information about the number of people in the vehicle.

Finally, I would emphasize that the success of a system like HumanLight depends on the connected car world that Scott is building. That data about where you're trying to go must get pushed into the cloud control system so that we can do a better job of getting you there faster.

More information: Dimitris M. Vlachogiannis et al, HumanLight: Incentivizing ridesharing via human-centric deep reinforcement learning in traffic signal control, *Transportation Research Part C: Emerging Technologies* (2024). DOI: 10.1016/j.trc.2024.104593

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