Shaping the Future

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Shaping the Future

Developing Air Traffic Controls for Drones

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Imagine if all the roads and streets of a city were empty. With no other cars and no variables like pedestrians, it would be relatively easy to direct an autonomous car from one place to another. But what about 20,000 autonomous cars all trying to get to and from different places? Each car has a different goal. One car might be delivering a package, another might be driving someone to work and still another could be an emergency vehicle taking a patient to a hospital. How does each individual autonomous car account for their own particular goal and for these many variables?

According to Dr. P.R. Kumar, Texas A&M University Distinguished Professor in electrical and computer engineering, they can't yet.

"Autonomous cars presently are mostly like lone wolves," Kumar said. "They have all these sensors and capabilities to create a highly precise map of the environment and they can thread their way through the traffic, but they don't collaborate with other vehicles, they're not a system."

That inability to collaborate is part of why, even though we already have the technology for autonomous cars, experts like Kumar believe we're still years away from truly autonomous transportation systems on the roads.

The sky is a different story.

"I thought, 'why don't we try to develop a completely autonomous system of drones?'" Kumar said. "Autonomy will be sooner realized in the sky than on the ground. You can't automate pedestrians and cyclists and other interferences, but in the air there are fewer of those."

Using drones for agriculture and infrastructure surveillance is expected to have a significant economic impact. The idea of short-range drone deliveries seems like more a question of when than if. Over the last year, there have been news stories about companies ranging from Amazon to Dominoes testing the idea. In a basic sense, drone delivery is something we're already technologically capable of.

But right now there's a huge catch: it only works because there's relatively no traffic in the air. If the Amazon and Dominoes drones' flight paths crossed, there is no agreed upon framework for how they should interact with each other to prevent them from crashing into one another. It gets even more complex if there are many drones in the sky.

"What we need is a set of traffic rules for drones in the sky, or what we researchers call "a traffic protocol," Kumar said,

Kumar and his team of student researchers have been working to solve this problem, which doesn't even exist yet, by designing the framework in which all these autonomous systems could safely operate.

"Think of all the things the highway system has. Roads, signs, signals, driving laws and all of that. We're designing those things, the rules of the road, for the sky," he said. "We wanted to build a system that was provably safe from the bottom up. Instead of trial and error, we just wanted to design it so it would have the right architecture and the right algorithms from the get-go."

There is obviously some inherent risk in the very idea of drones flying overhead, but it's minimizing the risk to create a great benefit that's key. If there are accidents as the technology becomes more widespread, it could slow or even stop something that has the potential to be a tremendously beneficial to society.

So safety is exactly where Kumar decided to begin. Rather than worry about efficiency first and then safety, Kumar and his team went the other direction. But to create rules for a safe system requires overcoming a myriad of challenges.

"What we decided was for a drone to never move forward unless it is guaranteed that that piece of airspace is ceded actively by everybody else," he said. "So unless it proactively gets permission from everyone within a certain region, it will not move into the region. Furthermore, if there is nowhere to go then it has to land, safely."

Unlike cars, a drone in the air can't just pull over and stop if things go wrong. And the actual implementation of a safety-first system increases the risk of complications.

"A lot of issues have to be solved. You need to proactively communicate with everybody and get acknowledgements so there's a whole network broadcast with active replies," said Kumar. "And somehow we have to know that we heard from everybody, so there has to be a database saying who are the vehicles in this neighborhood. We have to know whenever anybody enters and leaves the system. That's a lot of management to be done right there."

Operation of that database could be done by a Federal Aviation Administration or another ground server that monitors drones entering and leaving.

"The system is designed so that at any time, any drone can decide to change its path and its destination. It's completely up to the drone," Kumar said. "It can suddenly get a message to go somewhere else, and our architecture is provably safe under those circumstances. That permits drones from different enterprises to talk to each other and adjust. Let's say a drone delivering medical devices suddenly has a high priority because of an emergency or something, the rest of the drones in the system will adjust to that priority drone."

The question that Kumar's group must ultimately answer is what exactly will happen when the system is turned on. The answer might not be as straightforward as you think. It's one thing to create a set of rules, it's quite another to see how they're actually followed.

"We designed this from a safety first perspective, but how much inefficiency does that result in?" Kumar said. "Will this system result in several drones aborting their missions, or will it actually be pretty efficient? If it is, then by creating a

provably safe system you open the doors for creative applications.

"We cannot anticipate the uses," he said. "We can develop technology, but some kid somewhere could come up with an amazing use that we've never thought of. In Sweden they're using drones to deliver emergency medical equipment. We aren't trying to develop the uses, we're just developing the system's protocols."

By designing its operational protocols, Kumar is bringing to the air something we already have on the roads. Competing companies can then share the airspace with others in the system by conforming to by the same rules.

Kumar also anticipates that this system will create other less obvious business opportunities. For example, as part of a safe infrastructure, there will need to be places for drones to safely exit the system in case of problems. That creates a market for rooftops of high rises to be available as potential landing pads.

"Drones are complicated because they can't just stop, they have to land," Kumar said. "For a completely safe architecture, for example, companies flying drones will have to contract rooftops in Manhattan. There will be an economy for this kind of rooftop or landing patch real estate."

Kumar's group's next step is a simulation of the system, which will recreate the real world and its variables, like wind, faulty communications channels and malfunctioning drones to test the framework. After that, Kumar hopes to test the system with drones at the Texas A&M RELLIS Campus, possibly in collaboration with other researchers working with drones at A&M.

18_2396 • Printed 04/24/18