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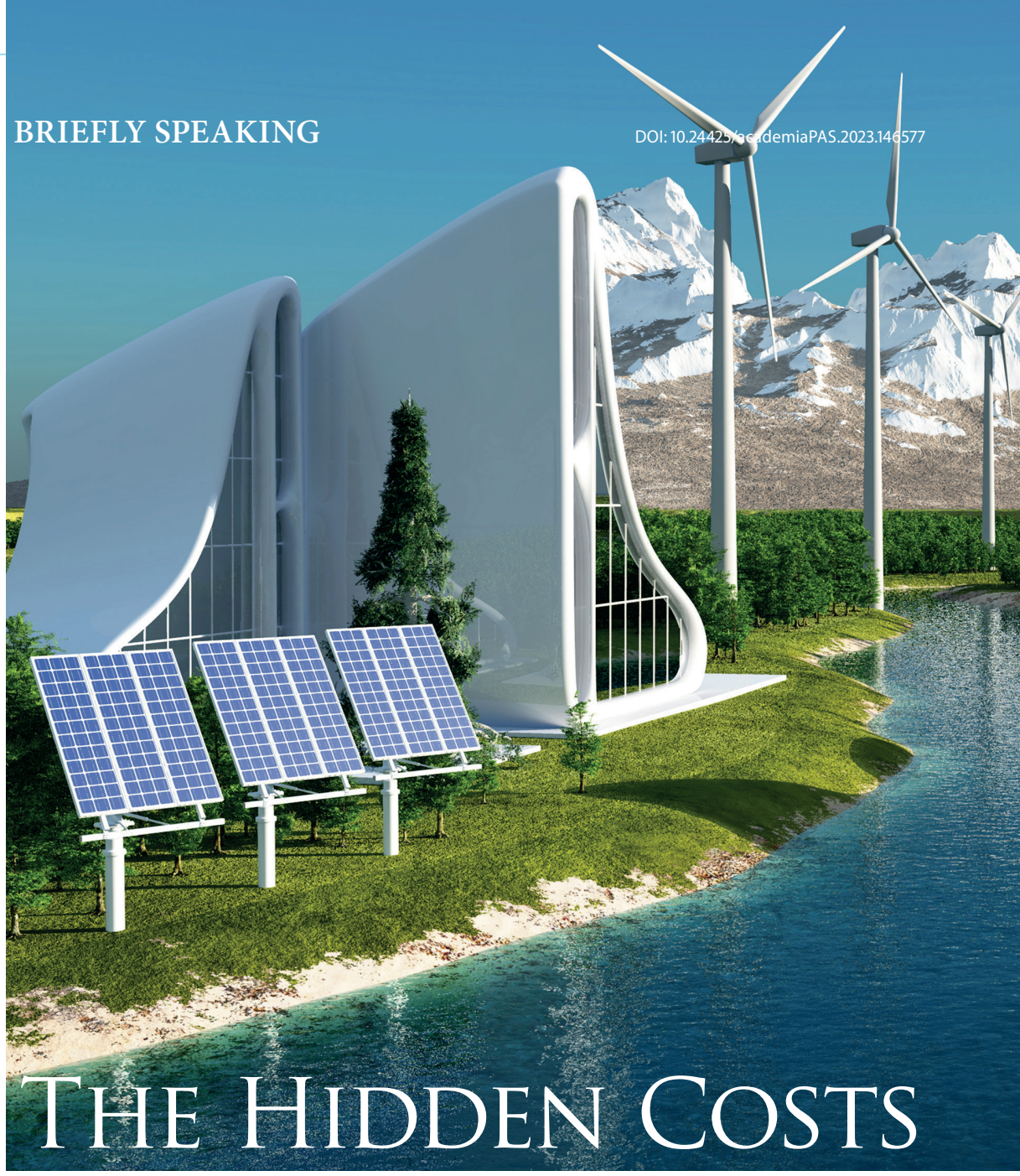


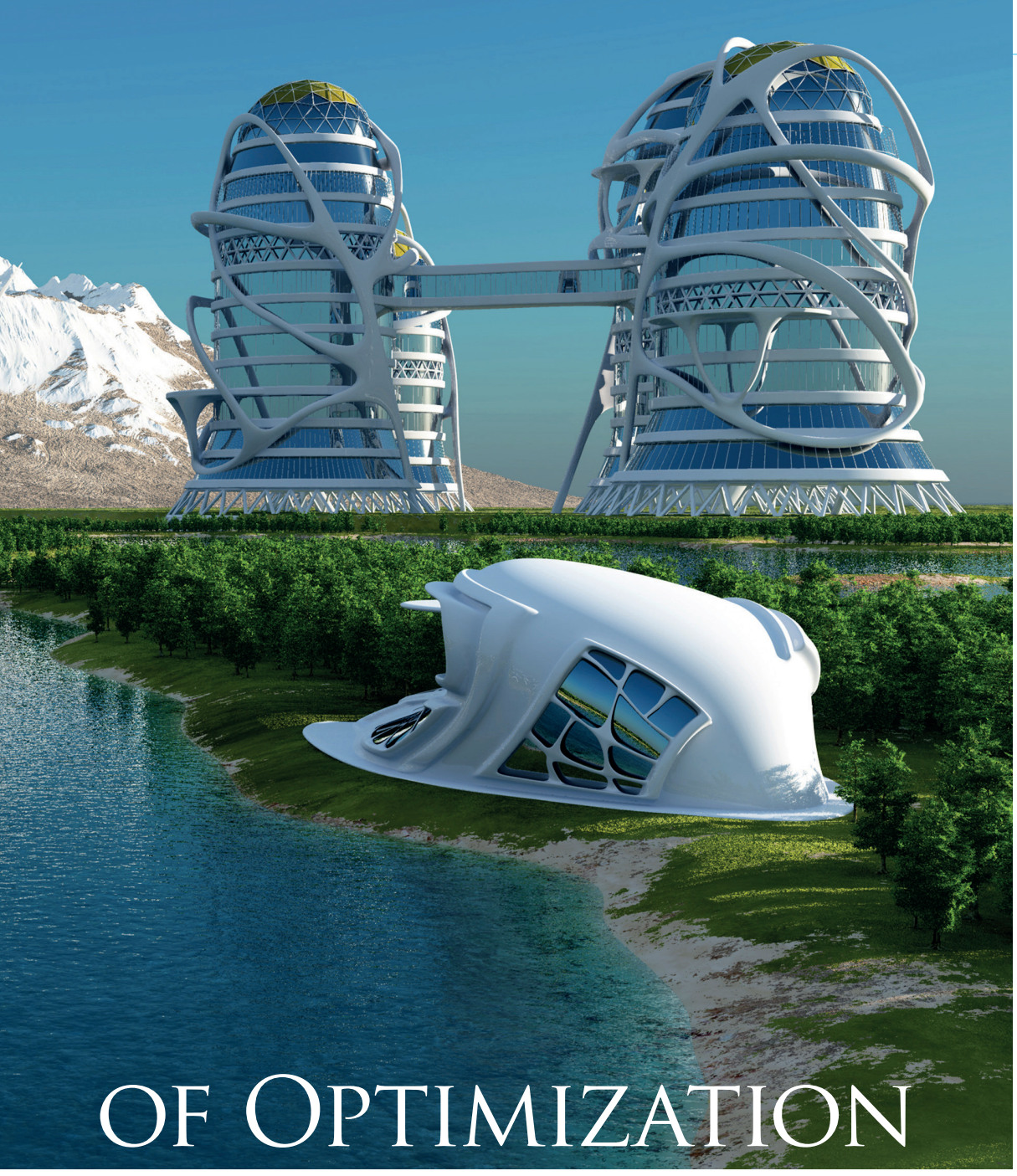
The Hidden Costs

Someday soon, autonomous vehicles could greatly improve our safety. But once we turn decision-making over to machines, will our cities still be ours? – wonders **Dr. Rafal Kucharski** from the Group of Machine Learning, Jagiellonian University in Kraków.

What does it mean to study the future of transportation?

RAFAŁ KUCHARSKI: A project funded by the European Research Council has to stretch beyond day-to-day research work; it requires the researcher to step into a new role. My work to date has looked at transportation systems in cities from the social, human perspective. That means I have not treated them as purely engineering systems, but as systems in which people make various decisions about how to get from place to place. Which routes they decide to take, at what times and by what means, determines whether there will be congestion or traffic jams. All of this contributes to the image of the particular city we live in, how efficient it is, whether it allows people to commute easily, whether it gives them a sense of safety, aesthetics, comfort.

In scientific terms, this subject has to be approached very interdisciplinarily. On the one hand, a city is a large engineering system with means of transport, infrastructure, and signal control systems, while on the other it consists of people who have their own



# of Optimization

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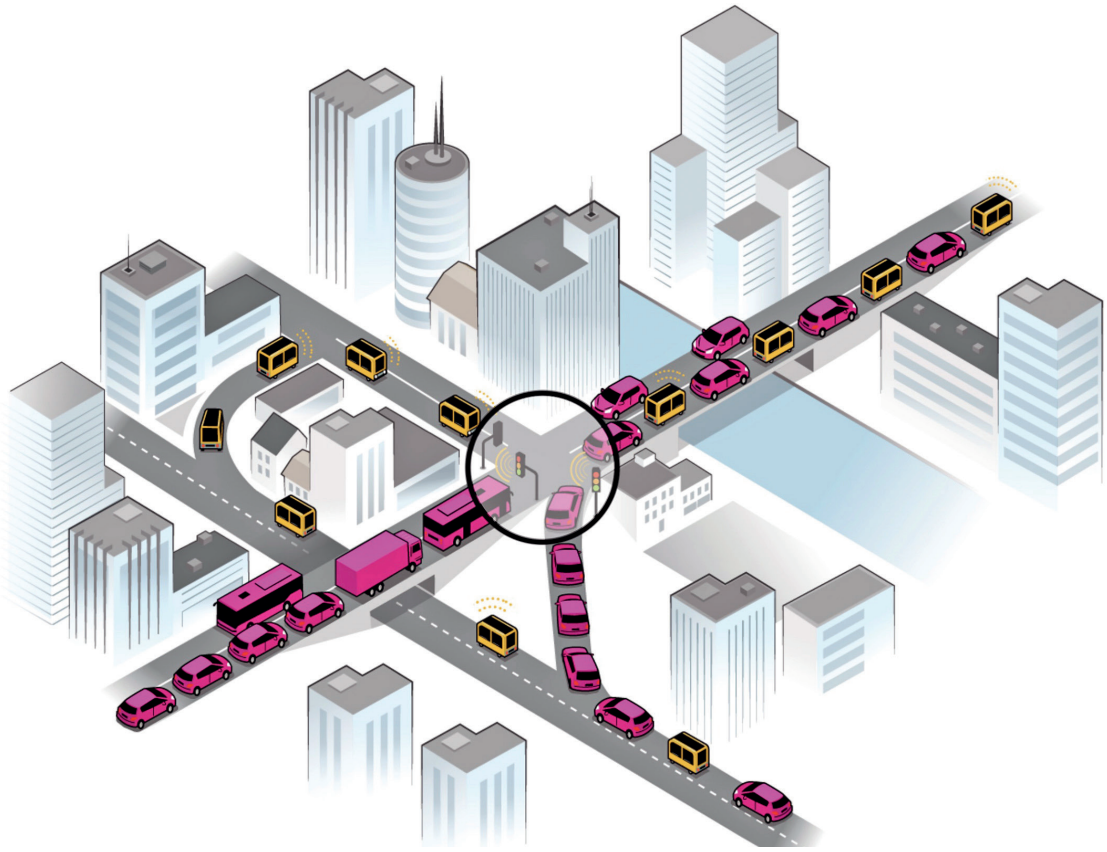
traits, preferences, are in various situations, and quite often make suboptimal decisions. Simulating how all of this might change over months and years is very difficult and interesting. I have built such models for the cities of Kraków and Warsaw, which can be used to anticipate what we can expect. Transportation systems need to be planned out well in advance – the projects we are working on today must also serve our children. In the paradigm I work in, the ideal city will function well without cars. More and more of us are dreaming of such cities, but few people today are ready to stop using this mode of transportation altogether.

What will your work under the ERC grant focus on?
I'll be looking at what will change in the next few years if artificial intelligence and, to some extent, automation starts making decisions affecting the transportation system for us. This means that the space of our cities will have to be shared between humans and machines, probably equipped with AI. The way things stand today, each and every decision related to car travel, for instance, is made by a human being: which way to go, at what time, by what route, at what speed, etc. What if these decisions are instead delegated to AI-based systems? Such a question opens up a Pandora's box of issues that I would like to unpack. We know for certain that the current systems are not optimal. We all say that we would like to streamline them, improve them from the perspective of sustainable transportation. If all our decisions were to be made by autonomous vehicles, transportation efficiency could be increased by 20–30 percent, which means less fuel burned, less harmful emissions, less noise and other side effects of transportation. This all sounds very tempting, but the question is whether such a city will continue to be a city, in the sense of a place created by people. I compare such an automated city to a warehouse, such as an Amazon or DHL hub – a large logistics



facility where optimization criteria trump everything else, in the quest to attain the most efficient operation of the system. This can be done with a city, too, but we have to bear in mind that such optimization will change it. A city is a mix of people who leave their homes, meet in public spaces, and interact with each other, there is a kind of creative hustle-and-bustle. Won't optimization destroy that?

Does your work require more mathematical or psychological expertise?

I work in the Department of Mathematics and I apply mathematical methods, but the decisions about whether to implement the solutions so developed will be philosophical or ethical, and in practice probably political. It is important that such decisions should be made on the basis of rigorous research results. In the ERC project I will use mathematical simulations comparing two variants, so it will be based on a transparent methodology. We can then compare two hypothetical scenarios: one for a city with autonomous vehicles only, in which decision-making is delegated to artificial intelligence, and another in which it is humans who choose how they use the vehicles. For the first scenario, the positive effects are fewer emissions and fewer accidents, but we also have to reckon with negative social impacts. The second version assumes that we do not harness artificial intelligence to improve our cities, but on the other hand, the cities still stay ours. And between these two extremes there lie a whole host of intermediate scenarios, where humans and machines share a common space.

Are machines actually less likely to make mistakes, will they make us safer on the roads?

My study deals with macro-level decisions, such as which route to take. The frequency of accidents, on the other hand, will be affected by how autonomous vehicles behave on a micro-scale – in interactions between two vehicles, or between a vehicle and a pedestrian or a bicycle. But I'm certain they are safer, they essentially do not make mistakes, and they also can't abuse alcohol. So while there remain ethical issues about how to choose the lesser of two evils, when, for example, a vehicle might collide with either a child or an elderly person, these are extreme cases. Such situations will actually occur very rarely.

Autonomous vehicles might fare very badly in spaces where the normal traffic rules do not apply – such as pedestrian zones, where cars, cyclists, and numerous pedestrians might all be moving. If people realize that vehicles are driven by an automated system that will always yield to them, they will take advantage of it. A car with a human driver will also let pedestrians pass, but after a while they will exert pressure and manage to get through. But if an automated driving system cannot

accept any risk, pedestrians may abuse that fact. Think of the situation with elevator doors: we simply know the door won't close and hurt us. If we were not sure there was a sensor in there, we would behave differently, and not go sticking our limb into a closing door.

How can you go from the level of individual people making decisions, up to simulating whole transport systems of the future?

Fortunately we have many models and empirically verified theories in this regard. For instance, discrete-choice models. A "discrete choice" is a situation in which someone decides between a number of distinct alternatives: for instance, I might decide to go somewhere either by car or by bike. If we look at this from the perspective of the individual making the choice, it seems simple enough. But from the perspective of an outside observer, without direct knowledge of the individual's personal preferences, trying to evaluate what decision he or she will make and why is quite complicated. Moreover, preferences can be classified as latent or revealed – in the theory of economist Paul Samuelson, people's personal convictions are not always in synch with their actual behavior, for instance on the part of a consumer. The data we have, gathered from measuring devices, navigation apps, etc., reflects revealed preferences – the outcomes of real individual decisions, in other words how someone *actually* chose to behave. Such data can be analyzed in terms of various variables. For instance, we can verify whether it is true that fewer people take public transport after ticket prices go up, or that fewer people use cars when fuel prices rise. When a tramway line becomes faster or more convenient, does it end up having more passengers? Such kinds of data are widely used in online and political marketing. In our research, we make use of extensive existing databases reflecting how people behave in various situations, and on this basis we try to forecast how they will behave the future. Of course, we do not know what the future will bring, and sometimes changing just a single parameter in these models can completely alter the outcome – for instance, from a scenario in which a city becomes even more traffic-congested to one in which there are no cars at all.

Caroline Criado-Perez's book *Invisible Women: Data Bias in a World Designed for Men* points out (among other things) how differently men and women tend to travel. Can your models be differentiated in terms of gender?

Yes, we always take gender into account, and doing so shows some differences between men and women. But it's not just women that we make sure are adequately represented in our samples. There are many transportation-excluded groups. We shouldn't kid ourselves: cars are primarily used by young, physically fit men who need to get somewhere quickly, whereas their children often have no good way to get to school by themselves, or their parents to get to the doctor. There are quite a few activists who would like to see cities without any cars at all, or at least with far fewer of them. But since they often lack solid arguments, their efforts have the opposite effect and provoke strong resentment among motorists. Studies like ours can help supply such arguments.

You compared Warsaw and Kraków. How do their transportation systems differ?

Although the layout of these cities is quite different, and Kraków has historically had a much higher share of pedestrian travel, their transportation systems actually look quite similar. In Kraków, as much as one-third of movement is on foot. This is a great starting point for putting the "15-minute city" concept into practice – the idea that if all the most important points for us, such as school, work, home, the doctor, are within 15 minutes on foot, cars will cease to be necessary. The layouts of Warsaw and Kraków are quite different, but the behavior is generally similar. In both of these cities, there has been a trend toward building large suburban roadways, and the new neighborhoods being developed near them are populated by young people very attached to their cars, because they represent one way to accrue social status. However, activist groups that promote a completely different approach are growing in strength. It seems to me that this trend may repeat itself in all large cities in Poland. The solutions that are ultimately implemented often depend on young active policymakers who are determined to make changes.

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So will we end up living in carless cities?

We'll have to be patient, but I do think our cities will become more sustainable. The shift away from cars will gain steam as more and more young people take a different approach. This is a trend that is not going to stop. Ultimately, in my opinion, it doesn't matter much whether the cars we drive are electric or autonomous. A significant improvement in the quality of life will happen only once we give up our dependence on the car, in favor of walking, biking, and public transportation.

Interviewed by **Justyna Orłowska, PhD**