Nudges in a simulated real-life road exit

The road in front of you may look real, and it actually is. Only simulated. This makes it possible to evaluate infrastructure nudges on a real location without actually venturing out into real life.

It is totally possible you will get something of a déjà-vu experience when driving around in this simulator. Only a few trees differ from a real-life location, which is the exact location where this nudge is to be tested in real life later on.

IKA in Aachen built a complete model of the surroundings to be able to make a lot of tests on the real location without actually rebuilding anything or potentially bringing anybody into danger.

And indeed, the simulator assured that none of the 54 test persons were in any danger. Except in danger of being tricked. The participants did not know that they were about to be nudged, as this could have affected the results. Instead, they were told that the test was about distraction, and were given a distracting task to do while driving. Naturally, this task was designed to end just before the nudge appeared. Additionaly, they were also told to go speeding at 100 km/h up until they felt it necessary to slow down in order to stay safe. Such an approch may seem rather odd, but it is because this particular nudge is only active when the driver is speeding, and aims to reduce their speed. Stefan Ladwig from IKA describes the situation.

"We don't want to slow down drivers who already are driving safely. This is why we will use lamps to nudge them, as lamps can be turned on when somebody is speeding and turned off when somebody is driving safe".

And in order to get enough data from the simulator study, all drivers were turned into speeders and therefore encountered the nudge. Or actually, they encountered the nudges, in plural. Two different variants of light nudge were used, both based on rows of lights being placed on the roadsides. The first variant simply consisted of every fifth lamp being lit, whereas the second involved the light travelling towards the driver in 50 km/h. This movement is believed to create an illusion of travelling at a higher speed. And it seems to work.

Both nudges reduced the average speeds by a couple of meters per second and made the drivers brake earlier, without having them devote all their attention to the nudge. And just as expected, the moving lights were most effective. The speed reduction is significant, but less than what was expected. Anna-Lena Köhler from IKA explains why this could be.

"The simulator has a wide field of view to all sides, even in the rear mirrors. But it is always fixed to the ground and does not move. Maybe people did not feel that the situation was that dangerous, and did not slow down as much as they would in real life".

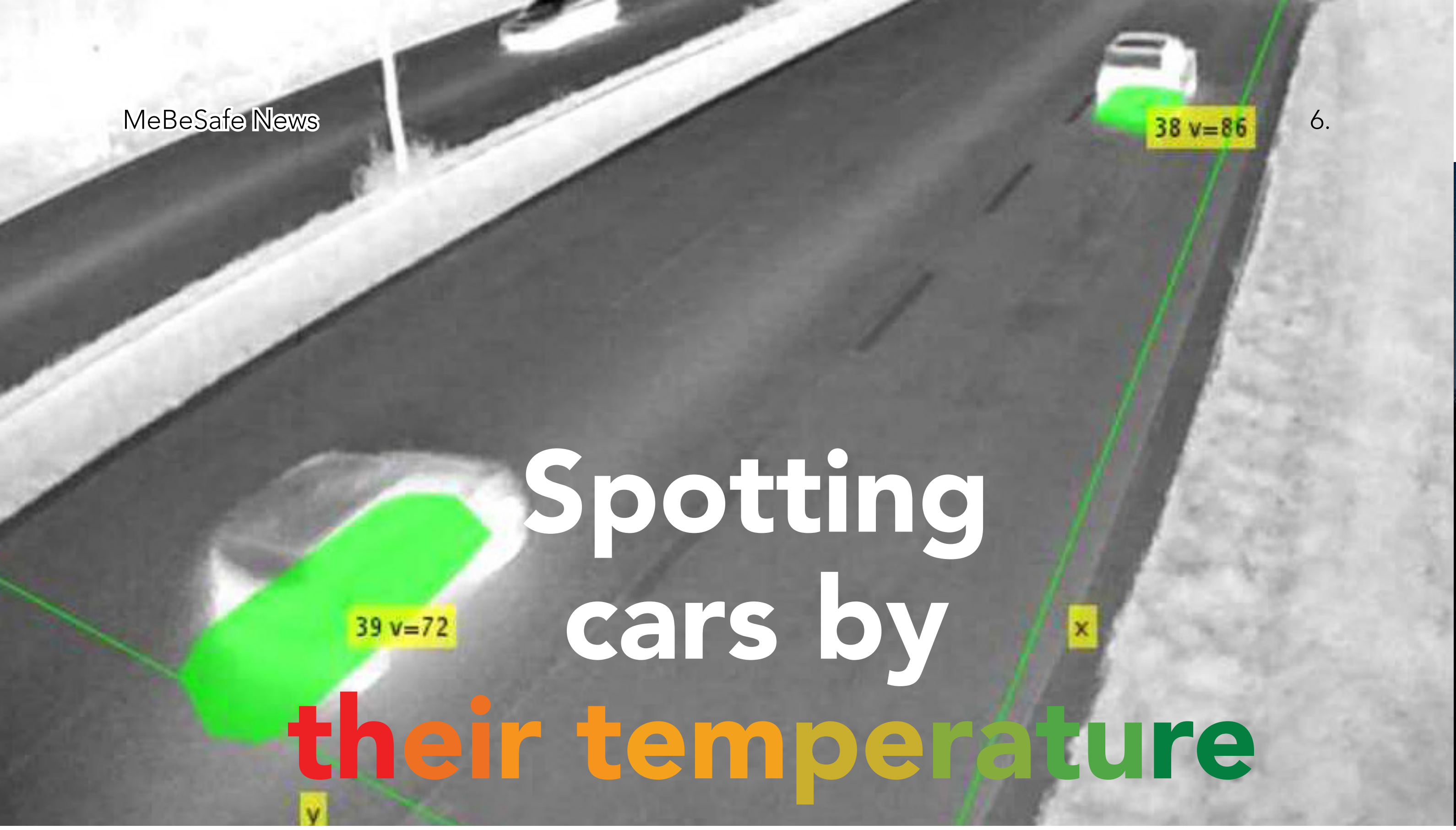
But actually, too large speed decreases may not be good either.

"Of course, we do not want people to just hit the brake and stop on the motorway exit. Now the light seems to guide them more safely through the exit," Anna-Lena Köhler says.

And to make people feel safe and comfortable with the nudge is a top priority. A second part of the simulator study was more focused on driver acceptance. It showcaseed different colours of the lights and made the drivers rate them. Red and orange were found to be the pick. There was initially an idea of having the lights glow red when speeding, and then changing them too a positive green when the drivers reached the desired speed, but this was found to be detrimental. The drivers actually associated the colours with traffic lights, and believed that green lights meant they should speed up again. Quite the contrary to what it actually should mean.

It is not yet known exactly why the nudges work, or if they would work in more complex driving situations, such as having screaming children in a car. Topics like this will be addressed in further studies yet to come. Both that and the studies made provide invaluable input to the development process; input that would have been impossible to get without a simulator. But naturally, it is not only the results from the simulator that count in the end. It is the results from real life. And this light nudge is actually soon to be put up for tria. So soon we will all get to know how it adds up in the real world.

The simulator set-up used in the study.



Spotting cars by their temperature

To implement the light nudge in real life, cars have to be spotted by a computer that could turn the nudge on. It is common to use a regular camera to identify vehicles, but this approach does not work at night time and may lead to privacy issues due to filming the registration plates. MeBeSafe will instead register temperatures and use thermal imaging to spot cars.

Adrian Fazekas at ISAC, Aachen had been working with camera detection for a long time. He used to identify fire or smoke in tunnels when he realised that the cameras also could detect traffic. With this in mind, he developed a system that could monitor the position of a moving vehicle from a film.

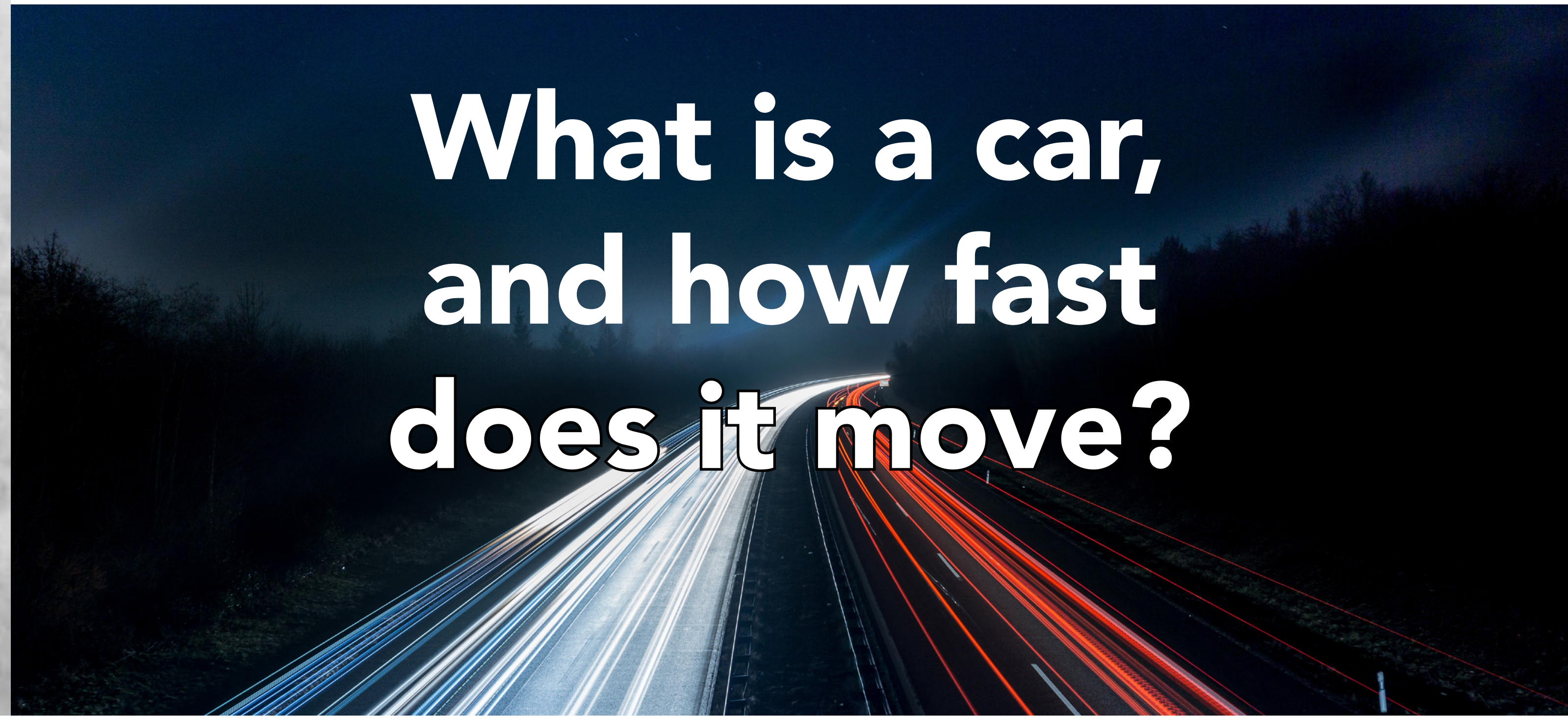
The only issue was that it worked in daylight, and not when it was dark. In dark surroundings, headlights from the car blur the images out and make it virtually impossible to see anything. Was there some way to capture an image without getting the light glare? There was.

Light has no temperature, but other things have. It would be possible to measure the temperatures of everything around with a thermal camera and translate this into a picture. This would mean no glare effects from lights, as well as the ability to see in total darkness without revealing any explicit details. As long as there is a temperature difference between the objects, that is.

This has proved to work well, according to Adrian's fellow scientist Moritz Berghaus. All cars in the early tests have been possible to spot, as there is likely always a temperature difference between car and road. In winter, the car is much warmer than the road and in summer the road is potentially much hotter.

There is of course a risk that somewhere in-between comes is a time when both cars and road share the same temperature. This is nothing yet encountered, and in case the car and road blur together it would be possible to calibrate the camera to more clearly emphasise minute temperature differences.

That said, there may still be problems with this type of camera. Heavy rain or fog could potentially make it difficult for to reach out and measure the correct things. However, even an ordinary camera will have problems coping with these situations. The future will tell if thermal cameras will be used everywhere, but it certainly looks warm to the MeBeSafe project.



What is a car, and how fast does it move?

It is easy for a human to see what is a car and what is not. For a computer, this has traditionally been very difficult. But emerging smart technologies make new ways of identification possible.

To select which car drivers to nudge for the light nudge, the cars must first be seen. A thermal camera can be used to get images of the actual site, but somehow the cars must be identified from the rest of the image. One cannot detect everything moving between two image stills, as it could be anything from grain flicker to a leaf blowing past. But computers have gotten a lot smarter in the last few years.

Moritz Berghaus from ISAC, Aachen, describes that the software has been taught to 'think', similar to the way an automated vehicle has. It all comes from intricate machine learning, in which the software is fed huge amounts of data and then learn by mass exposure and trial-and-error; as a human would.

After this, the complex algorithms will make it possible to find the contours of vehicles and not only detect what they are but also predict where they will be in a few seconds time. The approach works very well and only a few flaws exist. It is for example still difficult for the computer to differentiate between one large vehicle or two small ones close to each other at long distances.

The software does however not only need to identify which pixels are cars, but also measure their speed. To do this, the position and angle of the camera has to be known. A 3d-model of the actual road is then superimposed over the image from the camera and tilted so that it matches reality.

As the distances between various objects along the road are known in the 3d-model, they will also be for the real world images placed below. It is therefore possible to know exactly how far a vehicle has moved between two image stills, and thereby calculate the speed.

As several images are taken every second, it is possible to get a more or less continuous speed plot. So it is not only possible to see the cars and identify them digitally but also to note their speed. But then their speed has to be assessed to see whether the light nudge should be activated or not. And that is a totally different story.

When is a nudge satisfactory?

When an infrastructure nudge is set up and running, a completely new field opens up. Are the drivers nudged into safer behaviour? And what is actually safer behaviour?

When a nudge is active and measurements are being made, then comes the time to compare driver behaviour with and without the nudge. It may seem rather straightforward, but it is in fact not. Measuring difference in speed is one thing, measuring whether the speed was appropriate for the situation is a completely different story.

Moritz Berghaus at ISAC, RWTH Aachen will be doing a lot of the data analysis to see if the light nudge in has worked out or not. He will work out a number of parameters, including average velocities, speed distributions and lateral acceleration. But to make some kind sense of the data, it has to be translated into a single safety parameter. A parameter measuring the likelihood of a crash.

At this moment, Moritz and his colleagues are investigating which factors could be included in such a parameter. Except accelerations and configurations of the curve, many other external factors have to be taken into account as well.

Different weather conditions provide very different driving environments and can change numerous factors such as line-of-sight and modified friction for the wheels. Night and day time are not equal, neither are wet and dry roads. But even if the most important parameters are identified, the problem is to connect them to values of how dangerous they are, and which type of behaviour they require.

"It would be great to have lots of data on what happens before a crash," Moritz Berghaus proclaims. The problem is that accidents are rare, and MeBeSafe is striving to remove them. It would be a bittersweet paradox if we had to rely on crashes actually happening. *"So"*, Berghaus says, *"it will be very interesting to see where we will end up with this in the end."*