Artificial intelligence

for surface condition evaluation

The Danish Road Directory partnered with Albertslund Municipality and Ishøj Municipality to test how artificial intelligence can be used to monitor the road network condition and help to get a better overview for road maintenance. In the test, artificial intelligence was used to analyze road images, which were captured with a smartphone placed in the vehicle windshield. The aim is to deliver an objective and transparent road damage report.

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The roman empire was built on a well-maintained infrastructure. To achieve this the roman road engineers conducted a systematic visual inspection of the road condition in which damages were measured and assessed. The method of visual inspections are still in use today, but has limitations as it's a basically a task of counting the uncountable.

Nowadays, the supervision of municipality road and trails happen primarily through a manual damage assessment completed by a road inspector, which sits in a vehicle moving at a pace of 10-20 km/h. This measurement method is not always consistent due to its subjective nature and it's not transparent to evaluate.

New possibilities with artificial intelligence

Image recognition is today a mature technology and can be used to detect the many different types of road damages that is used to classify the condition. This makes it possible to conduct an objective and transparent visual inspection – although done digitally instead of manually - from images captured by a smartphone. Pluto Technologies is a Danish company with a solution that uses the latest technology within artificial intelligence. While recording from a smartphone app, images are saved every 5 meter with timestamp and geocoordinates in a cloud database. All of this happens in the background automatically, so the user just needs to click start.

For every image, the algorithms runs millions of computations to classify the different objects (damges, road inventory, etc.) and their respective sizes. After the analysis, all the data can be be accessed directly from a web map – similar to Google Maps.

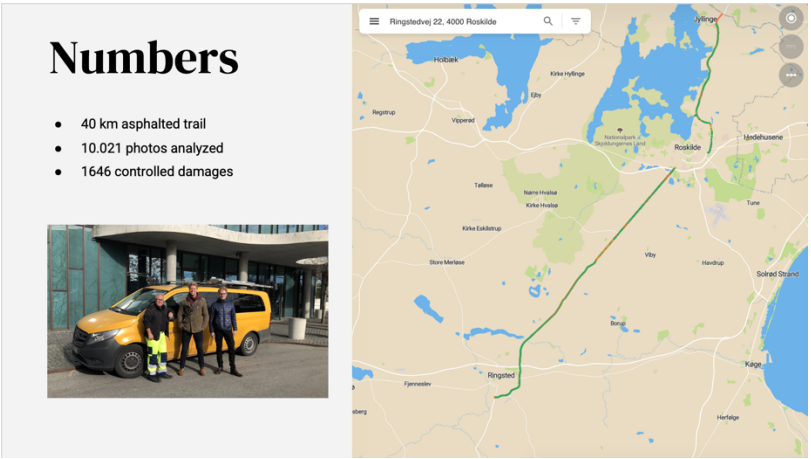
Municipality decision-makers gets a full overview of the condition of the road network - so they know where to focus – and can zoom in an review high resolution images every 5 meters. This helps coordinate tasks for smaller repairs and larger maintenance work directly from the office. Additionally, as the technology makes more frequent analysis possible, it will be possible to conduct more timely repair and better prioritization of the finite available resources.

Testing surface condition evaluation on the Danish Road Directory trails

The Danish Road Directory has worked towards an objective of damage detection on the national road network for some years. This has been conducted with the help of lasers mounted on specialized measuring vehicles, which can't be used outside of larger highways.

Access to municipality roads and trails is possible with Pluto's solution, and therefore the Danish Road Directory decided to test Pluto's system on 40 kilometers of asphalt trail in Q2 2020. The system also uses the guidelines by the Danish Road Directory for damage detection defined in booklet 4 of construction and maintenance of roads and trails, making it compatible with previous visual measurements.

More than 10.000 individual damages were registered from which the Danish Road Directory reviewed 1600 manually to assess the accuracy of the system. The evaluation instructions were that evaluator had to be sure that a detection was wrong in order to classify it as an error. This instruction was made to ensure a fair evaluation relative to a regular uncertainty.



As an example when multiple smaller cracks are next to each other than can be categorized as crocodile crack even if they are not fully connected. The study found the system to be correct in the majority of the cases of detected damages and their corresponding categories. Similar results were found in the estimation of the damage sizes, however, the evaluation was based on the images as the damages were not individually measured in the field.

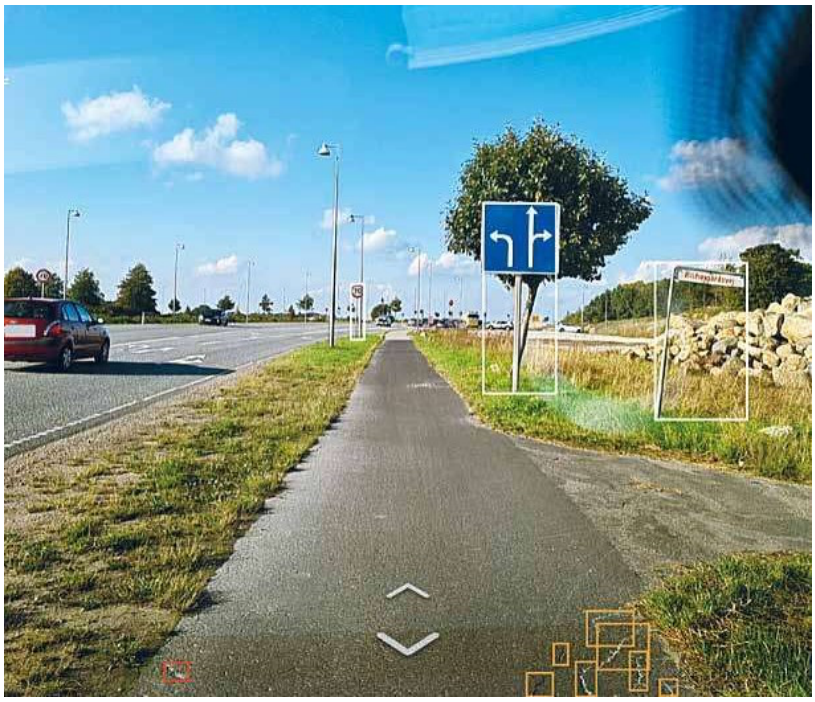
Transition to digital damage assessments

Where the objective digital measurements has a high resolution and high reproducibility, an experienced measurement technician can evaluate damages beyond just the detections. This can include predictions of the future damage development and importance.
That said, you can't expect the same reproducibility when the assessment is conducted manually. Since manual registrations of road damages requires high concentration it is a challenge for a human to do consistently for multiple hours. Whereas human concentration is not consistent across multiple hours at the time, a computer system isn't restricted by the same limitation.

The subtle differences manual vs. digital registration requires a deeper investigation before it is possible to conclude if whether they can be used interchangeably such that the weights of existing degradation models for asphalt roads wouldn't have to updated.

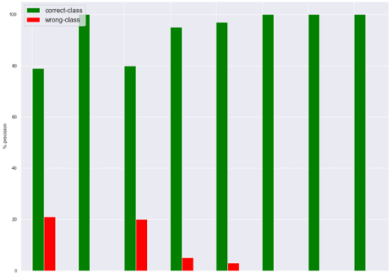
Here it's important to recognize that the manual approach does not achieve the same results each time. That said, the results are still within a certain tolerance level. One of the factors leading to variance of visual inspections in the results is that damages may sometime appear more clearly due to the weather from one day to the other.

Solutions such as lasers offer an alternative to regular visual inspections and doesn't depend on visibility the same way. Lasers can measure with my millimeter accuracy, but they are also prone to miss calculations as soon as there is any dirt or road objects such as drains. These will be classified as damages as lasers pick up on an uneven road surface. Further, lasers are expensive to maintain and results are not as straight-forward to evaluate as visual images. So visual inspections and lasers have different advantages when it comes to assessing the road environment.



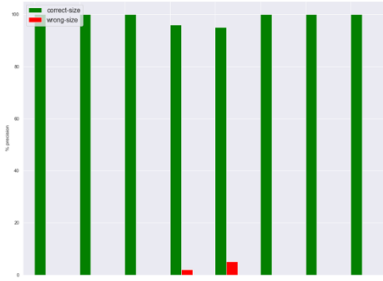
Classification

	Correct	Wrong
Hole	22	6
Curb Damage	4	0
Crocodile Crack	4	1
Area Patch	53	3
Crack	1299	34
Crack Seal	79	0
Pothole	1	0
Missing Road Paint	39	0



Size estimation

	Correct (%)	Wrong (%)
Hole	100.0	0.0
Curb Damage	100.0	0.0
Crocodile Crack	100.0	0.0
Area Patch	96.0	2.0
Crack	95.0	5.0
Crack Seal	100.0	0.0
Pothole	100.0	0.0
Missing Road Paint	100.0	0.0



TECHNOLOGY

- Artificial intelligence and image detection have in the past years been through a renaissance period. Before 2012 it was a hindrance to identifying even simple objects such as cars in images.
- Nowadays, can the technology identify cancer in an X-ray image with the same accuracy as the best doctors.
- Most have also experienced the technology when opening our smartphones with face recognition or going through passport control in international airports.

"Pluto's solution is fast and effective, gives a consistent assessment, and all the damages are documented with images, thus giving the possibility to make the inspection from the office. If Pluto's algorithms deliver results of a very high quality, the technology will not only provide a great immediate overview of the road the condition, but also in the long term, track the decay, thus providing better tools for long-term prevention of damage development."

-Niels Skov Dujardin Engineer at The Danish Road Directory.

The system keeps improving

One of the characteristics of artificial intelligence is that it improves as the amount of data increases. The study was conducted with the help of the Danish Road Directory in the middle of 2020. Since then it has been adjusted and improved – in particular when it comes to the classifications of crocodile cracks and holes. Moreover, the system's capacity within road inventory has been extended and it can now classify over 300 types of road signs. Contact information and further information can be found on Pluto's webpage: www.pluto.page/en.