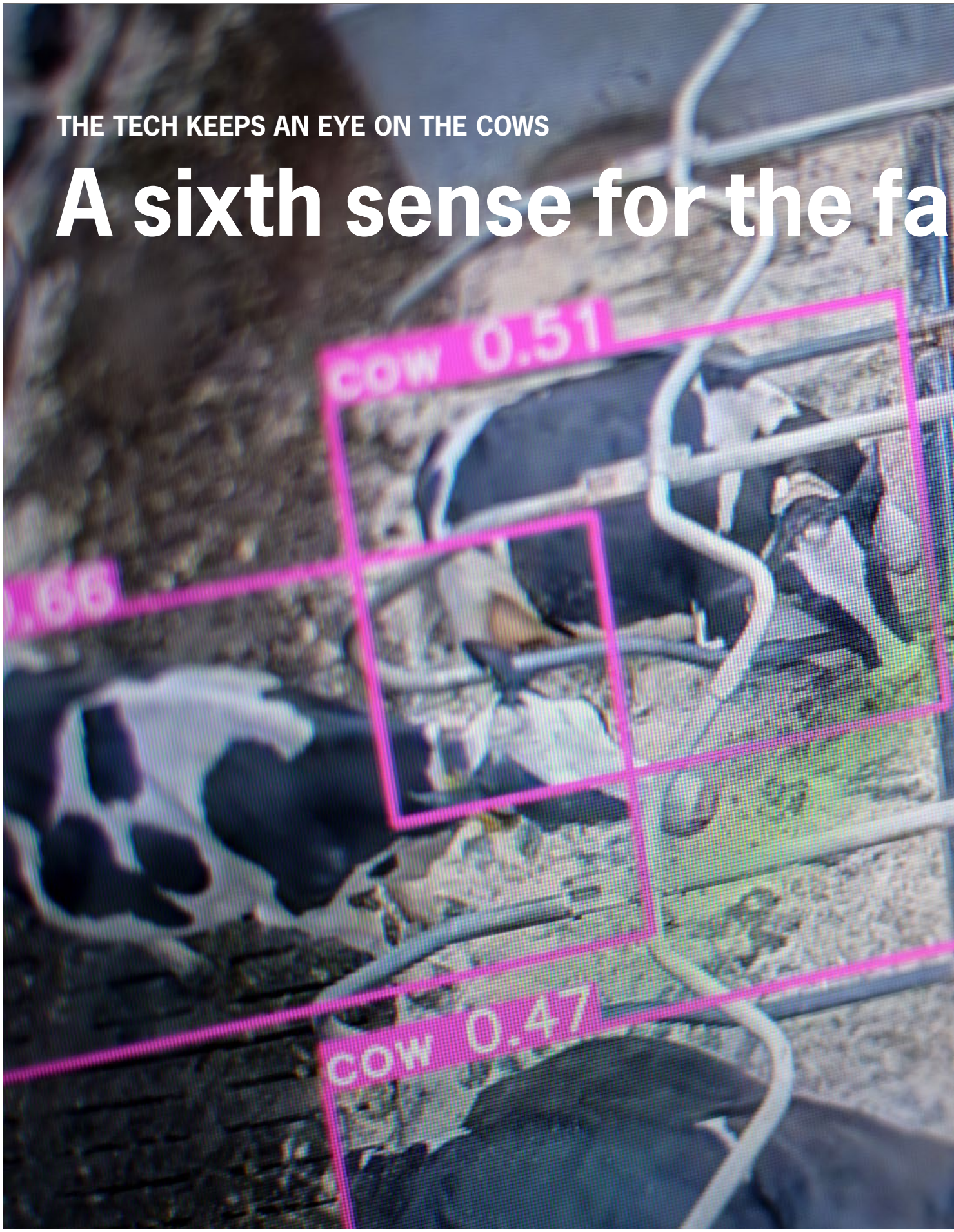
THE TECH KEEPS AN EYE ON THE COWS

A sixth sense for the fa



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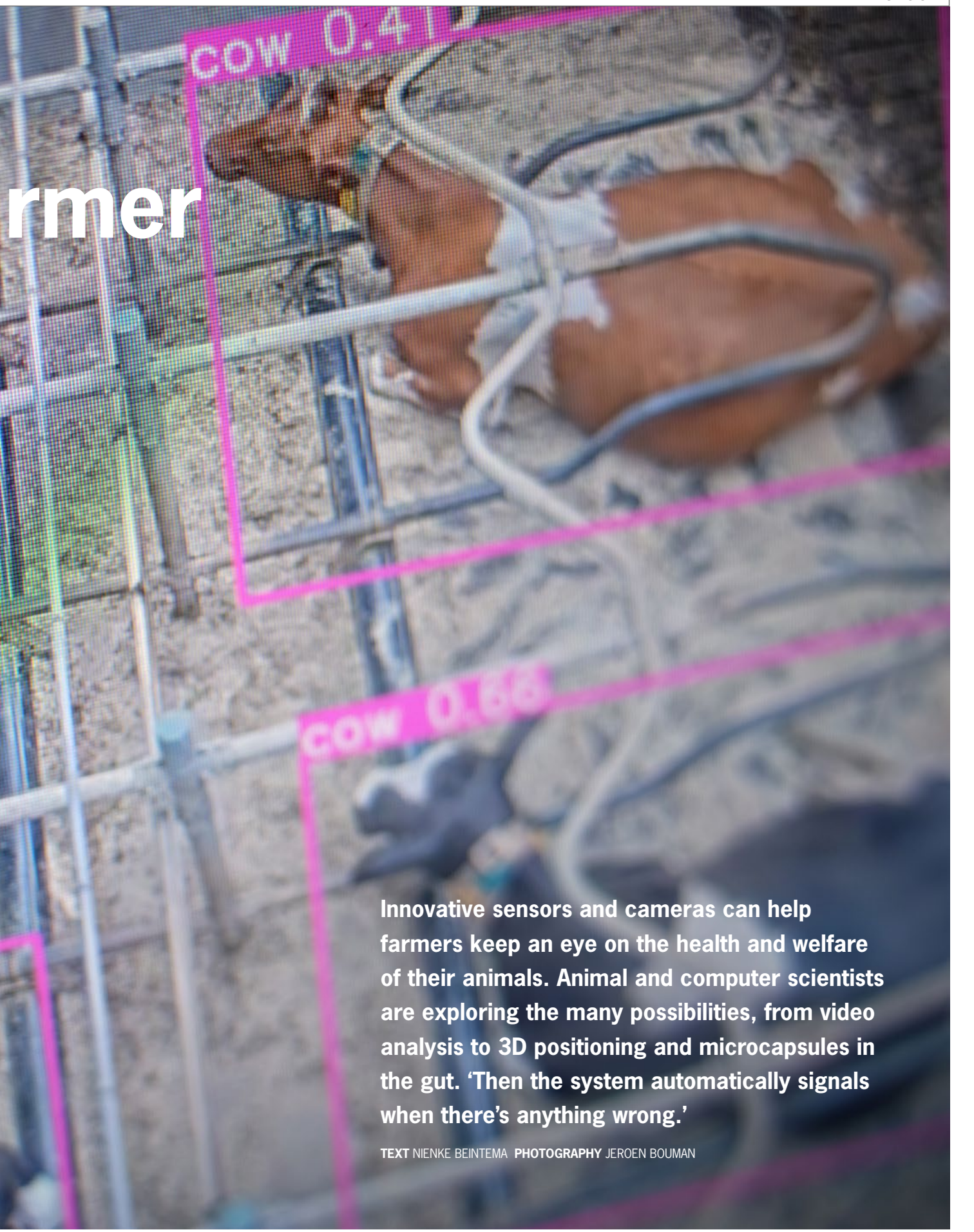
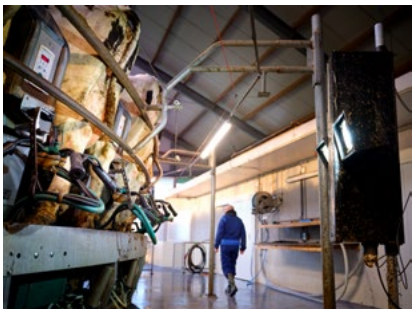


Innovative sensors and cameras can help farmers keep an eye on the health and welfare of their animals. Animal and computer scientists are exploring the many possibilities, from video analysis to 3D positioning and microcapsules in the gut. 'Then the system automatically signals when there's anything wrong.'

TEXT NIENKE BEINTEMA **PHOTOGRAPHY** JEROEN BOUMAN

The health status of the cows is monitored 24/7 using sensor technology and artificial intelligence.

Cameras record the gait of the cows passing them.



In the milking carousel the cow's hooves are automatically photographed.

Early detection of the infectious Mortellaro's disease of the hoof is the aim.

‘You can deduce information about a cow’s health from its movement patterns’

Here they come, walking through the narrow passage in an orderly line. They speed up and then hesitate for a moment, causing a minor traffic jam. But then they’re off again, back to the barn. These are the dairy cows at Dairy Campus in Leeuwarden, freshly milked and checked. There are two cameras suspended in the corridor, pointing at the cows as they pass by. Back in the milking carousel, their hooves have already been automatically photographed. And there is more equipment up ahead in the spacious barn: another eight cameras, plus four anchors positioned high up in the four corners. These anchors pick up signals from tags the cows wear on their collars: small, rectangular boxes that emit high-frequency radio waves and enable a computer to track the exact position of an individual cow over time. Together, these systems locate the cows on the farm 24 hours a day, as well as recording whether they are moving fast or slowly, eating or resting, standing or lying down.

‘This system is part of our innovation programme called Next-Level Animal Sciences,’ says Claudia Kamphuis, a researcher at Wageningen Livestock Research. ‘We are

The cows wear tags that emit high-frequency radio waves.

Anchors receive signals from the tags and track the position of individual cows.

All the information from the barn comes together in the computer.

studying the use of sensor technology in combination with artificial intelligence to monitor particular health traits and the welfare of farm animals.' NLAS is a four-year innovation programme (2020–2024) with a budget of 12 million euros, partly facilitated by the Dairy Campus Innovation Fund. The programme, Kamphuis explains, pursues three lines of research: sensor technology, complex cell systems, and data and models. The project in Leeuwarden comes under that last category and is being implemented in collaboration with Noldus Information Technology.

PAINFUL SWELLING

At the Dairy Campus the researchers are focusing on Mortellaro's disease, a common bacterial infection that occurs where the cow's skin and hoof meet. The disease can cause a painful, inflamed swelling between the two claws. Mortellaro's disease not only makes it harder for animals to walk, but also makes their stools looser and affects their general health, their fertility and their milk yield. It is a contagious disease, which, according to some estimates, affects 40 per cent of Dutch dairy cattle. Ideally, farmers aim to detect the infection before the cow has visible inflammation, explains Kamphuis. Then they can treat it with a spray or antibiotics, and prevent other cows in the barn from becoming infected too. 'We are investigating the extent to which sensor technology can help with that early detection,' she says. 'We also want a deeper understanding of how the infection spreads in a herd of cows. That might help us to develop measures to stop it from spreading.' This research is taking place at Dairy Campus, a high-tech experimental farm run by Wageningen Livestock Research that works closely with universities, colleges, the Netherlands Agricultural and Horticultural Association LTO, and a major milk producer. Here, all cows wear the kind of collar with an identification chip that many dairy farmers have adopted to make their operations more efficient. This chip is recognized by sensors at various places on the farm, such as the feed dispenser and the milking shed, and it communicates with the farmer's computer system. The computer then reports that one cow has already been milked, or that another has had enough concentrate feed. 'Those aspects of farm management are already quite highly automated in the Netherlands,' says researcher Kamphuis. 'What our sensor technology adds is behavioural monitoring. That fits in with the development we are seeing: society and farmers alike are going to give increasing importance to animal health and welfare. A farmer with a large farm cannot monitor all the cows closely 24/7. That's why we are keen to automate it.'

LAME

The cameras at Dairy Campus play an important role in the early detection of Mortellaro's disease and in monitoring the way the cows move. Those images are automatically analysed with image processing techniques, explains Kamphuis. 'Together with our colleagues in the Agricultural Business Technology chair group, we created a model that identifies 17 key points on the cow,' she says. 'Taken together, these tell us something about the cow's gait. Things like the curvature of the spine, or the stride length, or the extent to which the head moves up and down. If this system tracks an individual cow daily, it "learns" what that cow's normal gait is like, and can sound >

CLAUDIA KAMPHUIS
Researcher at Wageningen Livestock Research

the alarm if there is any change, because the cow is lame due to Mortellaro's disease or another cause, for instance.'
The researchers are now 'training' this system by manually validating the data. They do this by viewing and analysing images, and by looking at automatic photos of the hooves taken during milking. The researchers also get information from the worker responsible for hoof care, who regularly inspects the cows' hooves and treats them if necessary. 'That is the advantage of Dairy Campus,' notes Kamphuis. 'These cows are already very thoroughly monitored.'
The four sensors in the barn record the cow's position in two dimensions to the nearest centimetre. The researchers use camera images to validate the data from this system, but also to record other details about the cow, such as whether she is standing or lying down. 'You can derive a lot of information about a cow's health from those patterns,' says Kamphuis. 'How long does it take the cow to get up, for example, or to lie down? If a cow is in pain, we expect it to take longer than usual. So far, we've only collected that information on a small scale and incidentally.' Here again, the earlier you detect health problems, the better you can treat them, Kamphuis emphasizes. 'First and foremost, that is better for the cow, but it's nicer for the farmer to work with healthy animals, too.'
In time, the researchers believe they will be able to collect all the information farmers need with the cameras. 'Thanks to the combination with position measurements, we can now develop very efficient image-processing software for this purpose,' says Kamphuis. 'We expect that cows with something wrong with their hooves or legs will also display subtle behavioural changes in the barn, besides an abnormal gait. The other changes might be more obvious or be visible earlier. By comparing the information from the sensors with what employees observe themselves, we will gain insight into the added value of this sensor data.'

RAPID GROWTH

Ingrid de Jong of Wageningen Livestock Research is also focusing on an advanced camera detection system, but in this case for poultry, in a project financed by a fund and several companies. 'We want to automatically analyse the behaviour of broilers, especially how they walk,' says De Jong. Difficulty walking is among the main welfare problems in broilers, she explains. 'They are often bred to grow as fast as possible, but their bones and joints can't always keep up with that rapid growth and become prone to strain or infections.
'It would be ideal if the poultry farmer could spot that something is wrong at an early stage,' says De Jong. 'We want to achieve that with a camera system that automatically analyses the images.' But unlike Claudia Kamphuis' approach, this system does not target the chickens individually, but looks at the flock as a whole – all the poultry in the shed.
'The camera records pixel changes,' says De Jong. 'The chicks are white, and you film them against a dark background. The system can extract an amazing amount of information from that: whether the chicks are moving, and how fast, and also the variation between chicks.' These are all established measures of animal welfare, which are currently scored manually in the course of a welfare assessment of a small sample – a time-consuming and imprecise method. 'This camera system can be a big improvement on that.'
The poultry farmer can then proceed to improve the conditions in the shed, says De Jong. 'For example, by slowing down the growth rate of the chicks a bit, which can be done via the feed. The farmer can also adjust the lighting schedule to control the activity of the chicks. Or improve the barn design, by enriching it with raised platforms, for example, to get the chicks moving around more.'
The team has now delivered a prototype: a camera system plus automatic image processing. 'Now we are waiting for an investor to take this a stage further,' says De Jong. 'For us, from a scientist's point of view, this project is already highly successful. We have developed interesting new knowledge that will be very useful to us in other projects.'

A BIG PILL

Guillermo Amador of Wageningen's Experimental Zoology chair group is working within the Next-Level Animal Sciences innovation programme on a completely different sensor system: microcapsules that measure intestinal health. 'We are doing this together with a company that wants to develop this kind of measuring capsule for humans,' he says. 'We are testing them in pigs first. A nice added advantage is that

this technology can help farmers monitor the health of their animals.'
The capsule Amador is developing is ovoid and made of plastic. It is two centimetres long and three quarters of an inch in diameter. 'A big pill to swallow, but pigs can do so easily. Eventually, we do want to scale down this design, but the technology is not up to that yet.'
Inside the capsule is a chip that is connected with the outside world via little metal strips. 'That is the trickiest bit, technically' says Amador. 'The pill has to pass through the stomach, a hostile environment, and you want to protect the sensor from that. At the same time, it does need to be in contact with the contents of the stomach and intestines, to pick up chemical signals.' These include acidity, certain substances released by the metabolic process, and temperature. Together, this information provides a picture of the pig's intestinal health. The thermometer detects a fever, for example. Some proteins reveal a digestive problem, or the presence of a particular disease.

HOLLOW NEEDLE

That information goes wirelessly to a receiver in the barn, which transmits the data to the farmer's computer ¬ or, in this case, the researcher's. 'The farmer can then intervene at an early stage, for example with medication or by adjusting the diet before the animal gets really sick.'
The system already seems to be working quite well, Amador says, although the pill gets stuck in the gut now and then. 'So there is still some work to be done on the design. A next step is that we want to validate the sensor data by having the capsule take little samples from the gut along the way, as well. One way of doing that is with a hollow needle that briefly comes out and retracts again, driven by a tiny motor.'
The researchers also want to start teaching computers to recognize certain health traits among pigs. 'Then farmers won't have to monitor all the data themselves, and the system will automatically signal when there's anything wrong.'
Meanwhile, the cows at Dairy Campus in Leeuwarden are quietly ruminating in the half-open barn, while noisy starlings fly in and out to get a share of the pickings. It looks like any other modern barn ¬ apart from the high-tech gadgets on the wall. 'You see, that's a nice way of watching the ladies,' says Claudia Kamphuis. 'Those technologies are constantly keeping an eye on things, in a non-invasive way. If a cow needs special attention, the farmer gets there quickly. It's beneficial to both animals and humans.'
The innovation programme on Dairy Campus will run until mid-2023, by which time Kamphuis hopes to have a prototype ready. How realistic is it that these technologies will then be adopted in barns around the Netherlands? 'Some of these technologies can already be found in barns,' answers Kamphuis. 'But the use of cameras is definitely going to take off; I have no doubt about that. It's relatively cheap, whereas tech like the individual sensors with which you can track each cow's movements is still expensive. But eventually we hope to have a system that can monitor behaviour using cameras alone.' ■

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> **'Society is going to value animal health and welfare more and more'**

INGRID DE JONG
Senior Poultry Welfare researcher at Wageningen Livestock Research

GUILLERMO AMADOR
PhD student in the Experimental Zoology chair group