Forecasting with digital doppelgängers

Digital twins are dynamic models that keep in touch with reality. Wageningen develops models that know exactly what needs to happen on the farm, what the best humidity level is in the tomato greenhouse, and what fattening foods do to your blood count.

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'When scientists want to predict what is going to happen in a system, they usually do so using a model that approximates to the reality,' says Dick de Ridder, professor of Bio-informatics in Wageningen. 'Digital twins are models too, but these models are continuously fed with the latest data.' The added value of that is that the model's knowledge of reality is always improving. 'The model keeps pace with the reality,' says De Ridder. He is one of the coordinators of the Digital Twins investment theme with which Wageningen University & Research wants to give some impetus to the application of the technology in the Wageningen domains.

Digital twins have been up-and-coming in industry and the construction sector for a number of years, in the form of digital versions of aeroplane engines, cars, wind turbines and buildings. To obtain real-time data to feed into the digital twin, a machine's functioning is monitored in all sorts of ways, for example using sensors. But a digital model of a living organism or an ecosystem is a different ball game altogether. 'Because an amazing number of factors play a role in living systems, it is a lot more complicated to make a digital twin of those than it is for a machine,' says Willem Jan Knibbe, head of research at the Wageningen Data Competence Centre and one of the -coordinators of the investment theme. 'But the rise of sensor technology, the internet of things and the possibility of storing and analysing large amounts of data have brought this kind of digital twin a step closer.'

> 'It shouldn't just be a technical trick'

Wageningen is investing almost four million euros in three digital twin projects over three years: greenhouse tomato cultivation, the digital farm, and the link between nutrition and blood count. 'We have selected projects that could have a big scientific and social impact,' says Knibbe. De Ridder adds: 'It is a marvellous concept with a lot of potential. The challenge is to collect enough data of high quality so we can do something meaningful with it. It shouldn't just be a technical trick.'

SOIL TEMPERATURE

'Imagine you have a field and you want to know what effect the soil temperature has on the harvest,' explains De Ridder. 'You can use a harvest model for the crop, and make use of general data about the average ambient temperature. But you could also put sensors in that particular field, which measure the actual temperature.' Then the model is continuously fed with the latest data, so that it keeps pace with the reality and shows exactly what is happening at a particular moment. What is more, the digital twin does this using specific data from the field in question, rather than a collection of data representing a broadly similar field.

SELF-CORRECTING

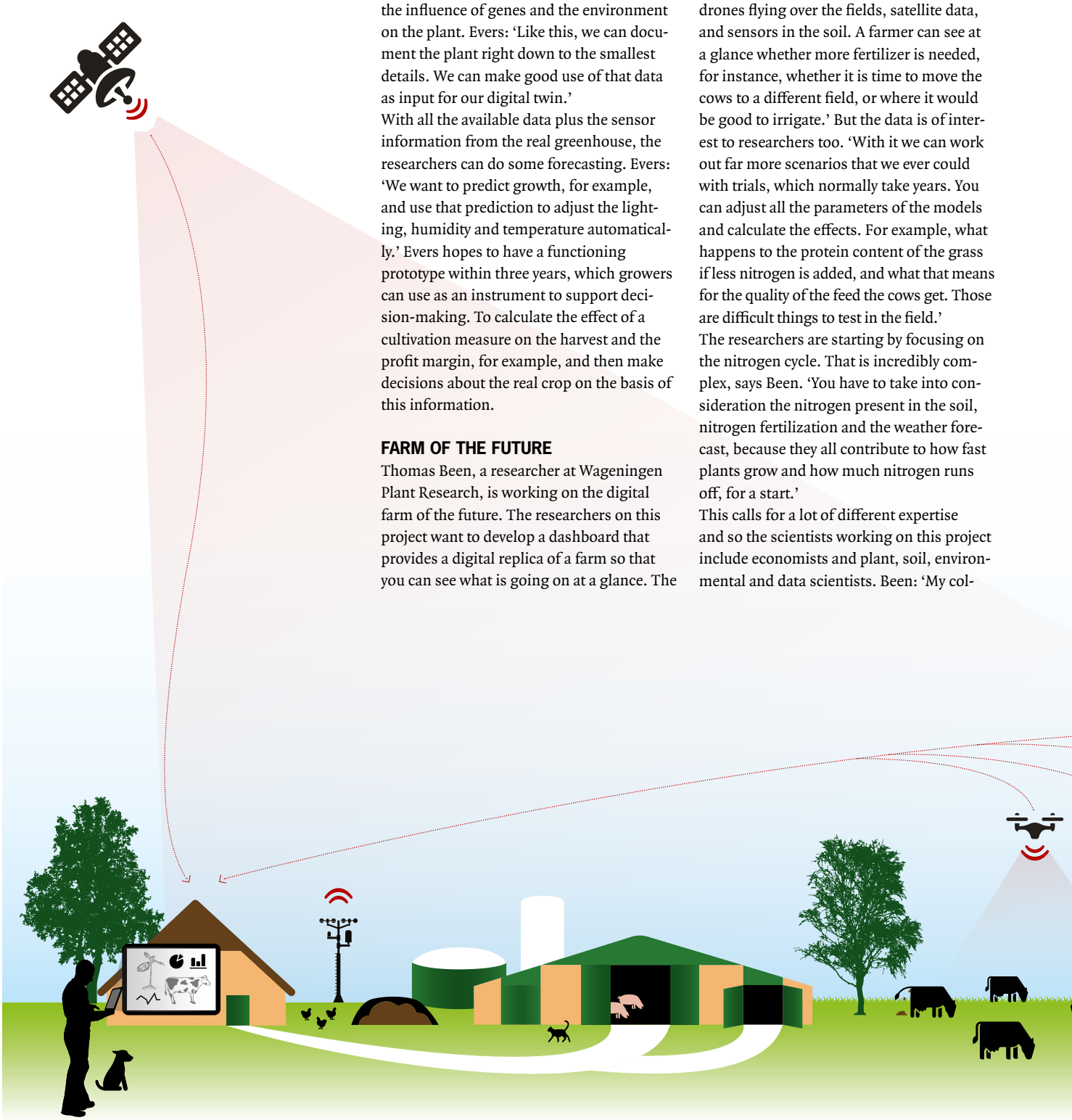
'The best thing would be to make a digital twin that is self-learning,' says Knibbe. 'It can then do things like compare the sensor information with the predictions of the model. If the soil is warmer than the model had predicted on the basis of the ambient temperature, the model can correct itself. Then it is no longer a person but the computer itself that makes the algorithms for the model.'

Researcher Jochem Evers of the Crop and Weed Ecology chair group is working with a diverse team of 12 scientists on virtual tomato cultivation with a 3D simulation model that is continuously fed with sensor information from a real greenhouse. That makes this digital twin more advanced that the existing simulation models. 'The model is becoming more and more accurate as well,' says Evers. He hopes to use the digital twin in future in the quest for optimal permutations of plant characteristics and environmental factors. To look, for instance, at what happens if you use a different kind of glass in the greenhouse, or if you use a new tomato variety, maybe even one that has still to be created. The researchers want to make use of data from the Netherlands Plant >

Eco-Phenotyping Centre, which is to be built on the campus, in order to do research on the influence of genes and the environment on the plant. Evers: 'Like this, we can document the plant right down to the smallest details. We can make good use of that data as input for our digital twin.'
With all the available data plus the sensor information from the real greenhouse, the researchers can do some forecasting. Evers: 'We want to predict growth, for example, and use that prediction to adjust the lighting, humidity and temperature automatically.' Evers hopes to have a functioning prototype within three years, which growers can use as an instrument to support decision-making. To calculate the effect of a cultivation measure on the harvest and the profit margin, for example, and then make decisions about the real crop on the basis of this information.

FARM OF THE FUTURE

Thomas Been, a researcher at Wageningen Plant Research, is working on the digital farm of the future. The researchers on this project want to develop a dashboard that provides a digital replica of a farm so that you can see what is going on at a glance. The researchers will be making use of real-time information from a real farm. Been: 'Think: drones flying over the fields, satellite data, and sensors in the soil. A farmer can see at a glance whether more fertilizer is needed, for instance, whether it is time to move the cows to a different field, or where it would be good to irrigate.' But the data is of interest to researchers too. 'With it we can work out far more scenarios that we ever could with trials, which normally take years. You can adjust all the parameters of the models and calculate the effects. For example, what happens to the protein content of the grass if less nitrogen is added, and what that means for the quality of the feed the cows get. Those are difficult things to test in the field.'
The researchers are starting by focusing on the nitrogen cycle. That is incredibly complex, says Been. 'You have to take into consideration the nitrogen present in the soil, nitrogen fertilization and the weather forecast, because they all contribute to how fast plants grow and how much nitrogen runs off, for a start.'
This calls for a lot of different expertise and so the scientists working on this project include economists and plant, soil, environmental and data scientists. Been: 'My col-



> ‘The challenge is to collect high quality data so that we can do something useful with it’

leagues have already made models for a lot of situations. The challenge now is to bring them together and get them to communicate with one another, so we obtain an integrated overview.’

PERSONAL DIETARY ADVICE

Lydia Afman, a researcher at Human Nutrition, is working with her team of biologists, computational biologists, bio-information technologists, economists and consumer science researchers on a very different kind of digital twin: a virtual replica of the blood count values in the body. She wants to use it to create an app that can give people personal dietary advice. This app takes into account things like blood sugar, blood fat levels after a meal, and factors such as behaviour and personal preferences, including vegetarianism and religious convictions.

The researchers will start by working out which factors influence how the human body processes fats after a meal. ‘Whether you are a man or a woman, your age, or whether you have just taken some exercise: all of this has an influence,’ says Afman. The researchers already have data on lipids from nearly 500 overweight people. In the next phase, they will research whether they can make predictions based on the data in reality. This involved measuring the actual fat and sugar levels. If that works, that data can be used as a starting point for the app. ‘We eventually want to work towards an app that gives advice based on a digital twin of the app user. On the basis of unique individual data, the app can predict how high the person’s blood fat levels will go after a meal, and can adjust its dietary advice accordingly.’

Because the app collects more and more data and gets feedback, comparing the predictions with the real blood counts for fats and sugars makes the predictions increasingly accurate.

The app will also have to take into account factors such as a person’s behaviour or personal preferences. Whether they are morning people or evening people, for instance, or whether they eat meat. Afman: ‘Because personal preferences are taken into account, there is a better chance that people will actually follow the advice.’ ■

www.wur.eu/digitaltwins