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Digital copy of your body allows treatments to be tried out

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What if doctors could predict the treatment success for each individual? Patients would not be burdened unnecessarily and healthcare costs would drop. Researcher Natal van Riel of Eindhoven University of Technology is working on mathematical models that show the human metabolism for each person. With his DigiTwin research project, he wants to build a digital copy of individual patients to predict the success and to determine the necessary aftercare of a treatment such as gastric bypass surgery in the case of obesity.

Every human being is unique. With a unique life in a unique environment, unique behavior, a unique genome and a unique history of diseases. That is why each person reacts differently to treatment, and medication does not always work. Doctors have difficulty estimating this difference. From this fact, a new field of research has emerged in science: personalized medicine. Van Riel: "Based on the idea that the average patient does not exist, we use computer models to try to predict an individual's response to a therapy or medication."

With the increase of metering citizens, who use fitbits and other health apps to monitor their own health, more and more data is becoming available per individual. This goldmine of data is currently unused by doctors, while this data can be very interesting in determining what makes you different from others. When people use these apps for a longer period of time, the resulting database runs parallel with your life, so to speak.

That is exactly the information that the DigiTwin research program wants to use. Of course, with due regard for matters such as privacy, ethics and data security. Van Riel: "We are creating a computer model based on the mountain of data. And because the model always uses new data, which the individual collects over a longer period of time, the model grows with the individual. This creates a digital twin of the individual. In our case, a simplified digital twin of your metabolic system."

From general to personal model

However, human metabolism is an incredibly complex system to replicate. Not only does food intake play a role but also bacteria in the intestine and hormones whose job is to turn digestive processes on and off. In order to develop digital twins, you first need to know how these processes work. Van Riel: "Only then can you determine what makes a healthy system different from an unhealthy system."

Once you have developed such a standard model, you can start working with the individual. Instead of using standard values, Van Riel and the researchers in his group fill the models with personal data of an individual patient, for example the hormone values and the eating pattern of that person. You can then carry out simulations; adjust the diet or simulate surgery. The chain reaction that this intervention brings about is visible as an output of the system. And that shows whether the intervention is successful for the patient's metabolism or not.

Obesity and type 2 diabetes

A person's lifestyle plays an enormous role in his or her metabolism. For example, an unhealthy lifestyle can contribute to the development of all kinds of diseases, such as obesity and type 2 diabetes. But not necessarily. Van Riel wants to know where these differences come from.

For example, a lot is still unclear around gastric bypass surgery in obese people. A gastric bypass, which reduces the stomach to the size of a kiwi, leads to a significant weight reduction in 75% of people. Van Riel: "The strange thing is that people's metabolism becomes healthier even before they lose weight. For example, people with type 2 diabetes can stop injecting insulin as early as two weeks after the operation, while the weight loss after the operation typically lasts a year." By making digital twins of the metabolism of these patients, Van Riel wants to discover why this is the case and whether major surgery was the right treatment for that specific patient.

Domain knowledge generates better models

Van Riel and his research group are particularly interested in changes over time, described by means of differential equations in his models. His mathematical models are based on physical laws; the biochemical reactions that occur during digestion, uptake and metabolism. This prevents the creation of a black box, whereby a doctor can always deduce why the model gives a certain result.

Van Riel: "In order to be able to convert existing computer models of blood sugar levels in healthy people for application to people with diabetes, you need to include medical domain knowledge in your models, such as in this case how glucose is absorbed and processed in a body with diabetes. Only then can you really make your model fit the patient." And while that may sound obvious, it is not. Many models that are made on the basis of artificial intelligence only look for patterns in the data repository, without considering any physical laws.

Van Riel continues: "A disturbance occurs in people with type 2 diabetes, with a strong effect on either the liver or the muscle. In our model you can investigate these two problems separately. For example, by simulating that no glucose goes to the liver. It is not possible to carry out this type of examination in the patient himself. While we can tell the doctor which part of the glucose uptake is disturbed in a particular patient." In this way, the doctor can already estimate the effect of the intervention before the treatment.

Diabetes game for patients

Van Riel's research is not only applicable to doctors. With the diabetes results, Van Riel is currently developing a personalized diabetes game for patients. A person who has just been diagnosed with 'type II diabetes' has yet to learn how to deal with his illness. For example, he has to learn how his body reacts to, for example, sports or food, and which choices are therefore good and less good.

The game that Van Riel is now developing together with internist Harm Haak of the MMC is aimed at people with a device that automatically measures the glucose level every five minutes. This data goes directly to the game, and thus also grows with the patient over time. In this way the patient can safely practice making choices, such as gardening or eating a birthday cake, on a digital copy of themselves.

Provided by Eindhoven University of Technology

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