New preventive maintenance model can save companies millions

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Philips' Interventional XR scanner on which researcher Collin Drent tested his smart maintenance model. Credit: Philips

72,000 euros. That's what it costs when a chip-making machine breaks down for an hour due to a malfunction. It's logical that companies want

to prevent these kinds of breakdowns at all costs. Their solution is preventive maintenance: detecting potential defects in time, so that they can intervene before it is too late. Predicting the optimal time for maintenance (not too late, but not too early either) however is not easy, particularly as every piece of equipment is different. Ph.D. researcher Collin Drent found the answer to this challenge in smart mathematical models and data—lots of data. He recently received his Ph.D. with honors from the department of Mathematics and Computer Science.

Chip machines are not the only high-tech devices whose failure can costs handfuls of money (and sometimes even lives). Think of trains or planes, CT scanners in hospitals or wind turbines at sea. It is estimated that unplanned machine failures cost businesses worldwide around 50 billion euros every year. About half of this is due to breakdowns. A considerable amount, in other words.

"It is therefore crucial for firms to detect possible failures of critical components in time, so that they can repair or replace them before it is too late," says Collin Drent, a researcher in the Stochastic Operations Research group. "But of course, companies also don't want to intervene too early: parts are expensive, and you'd prefer to use them for as long as possible."

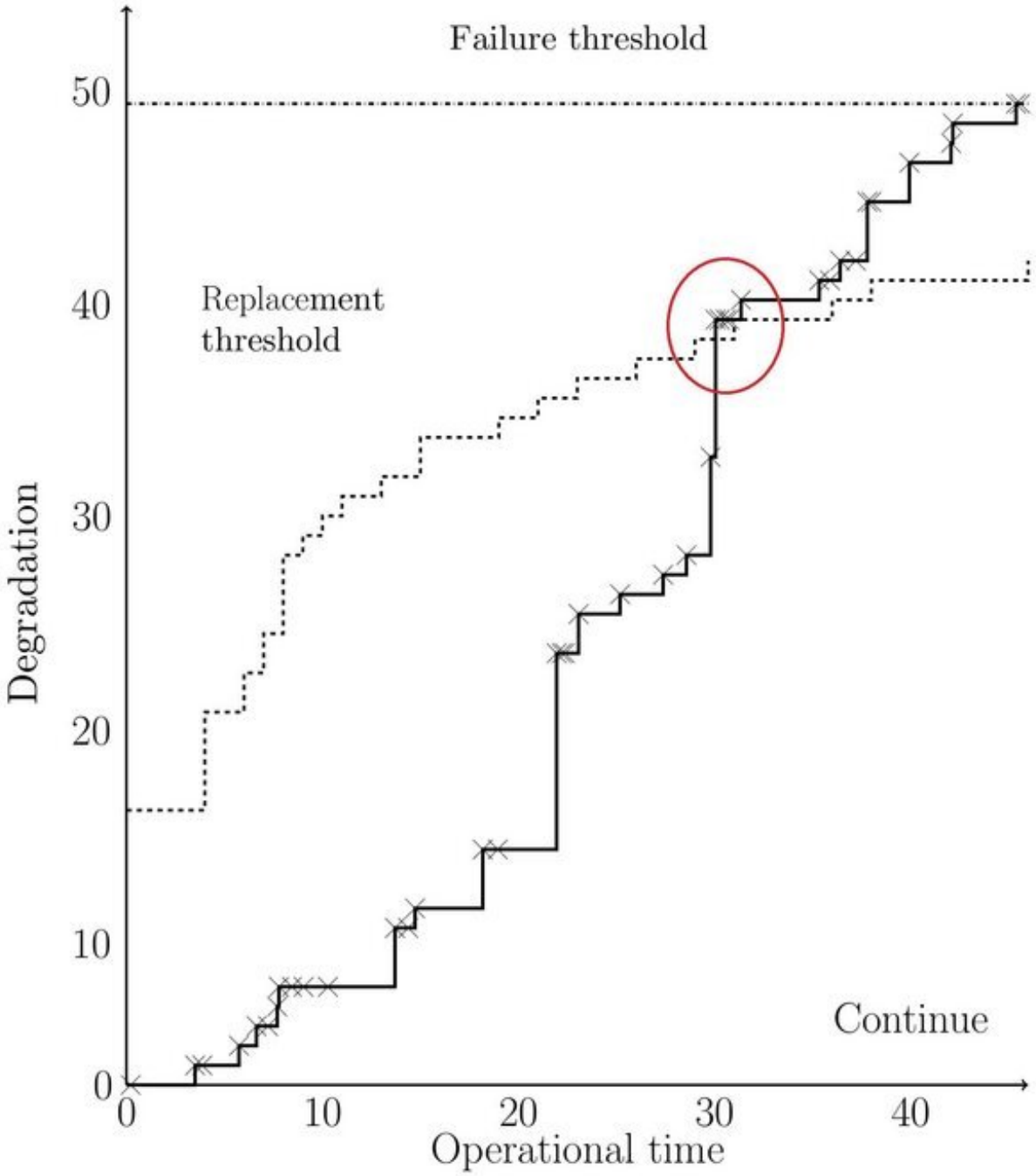
An expensive scanner

To determine the best time to intervene, Drent researched Philips' so-called IXR scanner. These expensive CT scanners allow doctors to perform image-guided surgery that is minimally invasive to the patient.

Drent quickly found out during his research that the standard models for preventive maintenance do not work well in this case. "They assume that devices are all the same, and that you can therefore predict with great certainty when certain parts need to be replaced. But that's often not

true. Every CT scanner is different, and so is the way and place where it is used. Think about the temperature or humidity."

Fortunately, these modern devices, because of the many sensors they are equipped with, produce an awful lot of data. "We can use this data to make our models smarter and smarter. In this way we are able to make specific predictions for each device and component, even though we don't know in advance exactly which factors will influence the aging process."



This diagram shows the aging process in time of an X-ray tube, a critical component of Philips' IXR device. Drent's combined Bayes and Markov methods predict from sensor data the optimal moment (t = 31) for replacement of the tube (the point where the dotted line of the replacement threshold crosses the degradation line). The moment is clearly below the failure threshold. Credit:

Drent used two different methods for his analysis: Bayesian Learning and the Markov decision model. "This has two advantages: by combining the learning capability of Bayesian Learning with the Markov decision model, I was able to make my predictions even more accurate. Moreover, these algorithms are very transparent. So we know exactly what is happening and for what reason. In that respect, these algorithms complement traditional AI methods such as deep learning, where the exact workings remain hidden in a black box."

In the end, the researcher managed to reduce the maintenance costs of the IXR devices by about 10 to 20 percent on average, compared to standard models. "And that's really a lot, if you look at how much money goes into maintaining this kind of high-tech equipment: the maintenance costs of such machines are generally at least as high as the purchase costs."

Twins

Drent (28) was told during the promotion ceremony that he had been awarded his Ph.D. cum laude. "That came as a total surprise to me, but my supervisors later told me that it was mainly due to my contribution to the field and the broad applicability of my method."

In addition to CT scanners, he looked at five other scenarios. This showed that his models also work in principle for wind turbines and chip machines, for example. Drent therefore calls his model a "unified framework."

Although much of his research is mathematical, the researcher is

originally an industrial engineer. And that is the field where he will return after his doctorate. At the end of August Drent will start working as an assistant professor at the Operations Planning Accounting & Control research group in the department of Industrial Engineering & Innovation Sciences.

There he will join his (identical) twin brother Melvin, who has also recently started working as an assistant professor in the OPAC group. Is that a coincidence? "Not quite. My brother and I have always had the same interests. And we can also work very well together. So I'm really looking forward to my new job."

More information: Structured Learning and Decision Making for Maintenance. pure.tue.nl/ws/portalfiles/por … 0220701_Drent_hf.pdf

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