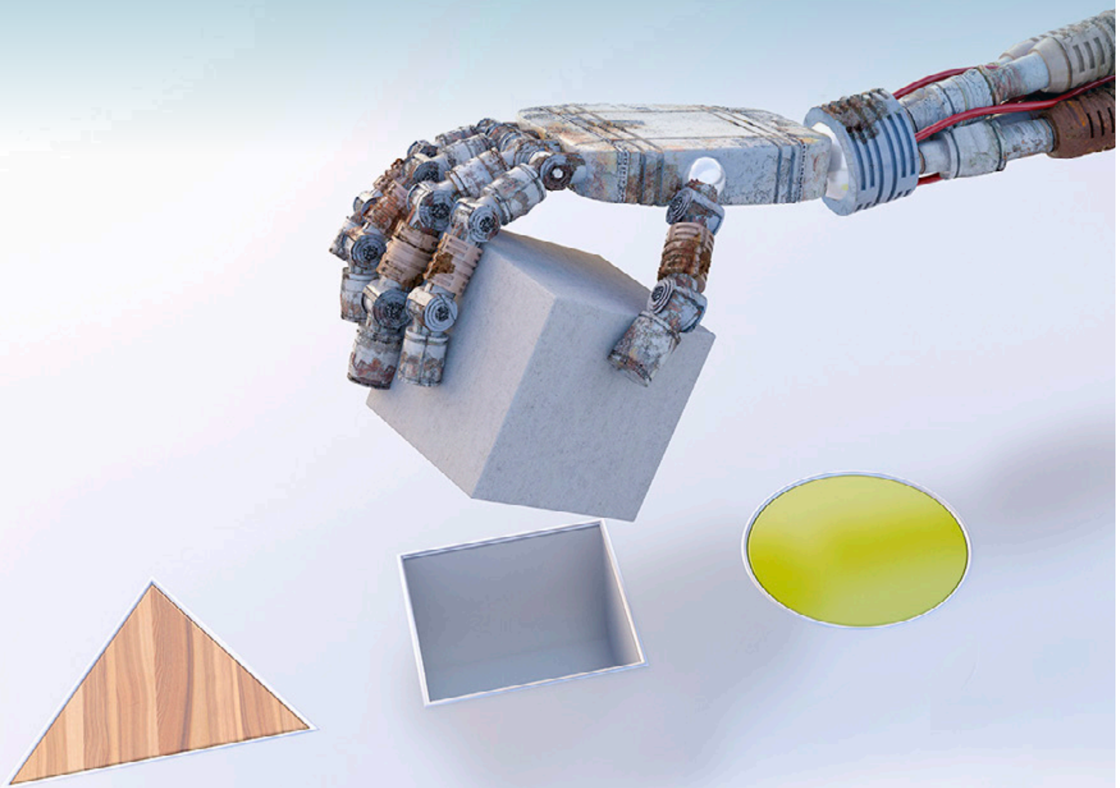
AI must move beyond pattern-matching



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Artificial intelligence and deep learning have revolutionised applications such as computer vision, but more complex problems require a different approach, writes Cliff Saran

One of the most elementary examples of machine learning is the one Google provides to identify iris flowers via its Tensorflow machine learning framework.

Artificial intelligence (AI) practitioners are reaping the rewards of finely tuned image recognition based on the volume of images of data readily available on the internet. Without too much effort, it is possible to train the machine to identify cats or almost any new image using pattern-matching with a high degree of confidence.

Such pattern-matching has many applications, such as in oncology, autonomous driving, chatbots, voice recognition in smart speakers and any requirement to look for patterns in large datasets.

Deep learning models

For instance, in January, Intel published an article describing how medical technologies such as computed tomography, magnetic resonance imaging (MRI) and ultrasound provide deep learning algorithms with a source of learning data. With this data, deep learning models can be used to measure tumour growth over time in cancer patients on medication, said Intel.

But some decisions cannot simply be made by matching against known patterns. This is where physical model mathematical simulations are used.

In a blog post, Vegard Flovik, data scientist at Kongsberg Digital, wrote: "With sufficient information about the current situation, a well-made physics-based model enables us to understand complex processes and predict future events. Such models have already been applied all across our modern society

Home
News
Specialised cyber criminals set their sights on industrial control systems
Google's search for enterprise success
Dentsu Aegis is devoted to digital
Editor's comment
Buyer's guide to software-defined networking in the enterprise
AI must move beyond pattern-matching
Why businesses must report cyber crime
Downtime

for vastly different processes, such as predicting the orbits of massive space rockets or the behaviour of nano-sized objects which are at the heart of modern electronics."

However, if there is no direct knowledge available about the behaviour of a system, says Flovik, it is not possible to formulate any mathematical model to describe it in order to make accurate predictions.

› Among the technological drivers in industrial firms are IoT platforms that implement the concept of a digital twin. We explore the benefits.

Machine learning can help

This is where machine learning can help by effectively matching an unknown problem with a pattern that has already been learnt, drawing on massive datasets.

Flovik says machine learning can be used to learn any underlying pattern between the information about a system (the input variables) and the outcome that the AI needs to predict (the output variables). But machine learning has yet to evolve to a stage where it can confidently predict complex physics.

In a paper entitled Deep learning for physical processes: incorporating prior scientific knowledge, submitted to Cornell University Library in November 2017, researchers Emmanuel de Bézenac, Arthur Pajot and Patrick Gallinari described how machine learning based on deep learning methods cannot easily be applied to a problem such as predicting sea surface temperature.

In the introduction to the paper, the authors write: "We considered the use of deep learning methods for modelling complex phenomena like those occurring in natural physical processes. With the large amount of data gathered on these phenomena, the data-intensive paradigm could begin to challenge more traditional approaches elaborated over the years in fields like maths or physics.

"However, despite considerable successes in a variety of application domains, the machine learning field is not yet ready to handle the level of complexity required by such problems."

Commoditised AI

AI platforms are being commoditised, so businesses should use the technology provided by the major AI providers, says Bill Ruh, CEO at GE Digital and chief digital officer at GE. However, he says the challenge is how to use these commoditised AI platforms in atypical application areas where an AI cannot simply rely on the ability to pattern-match.

"With sufficient information, a well-made physics-based model enables us to understand complex processes and predict future events"

Vegard Flovik, Kongsberg Digital

Instead, domain knowledge is required. According to Ruh, matching the inputs of a physical system with the desired outcome

Home

News

Specialised cyber criminals set their sights on industrial control systems

Google's search for enterprise success

Dentsu Aegis is devoted to digital

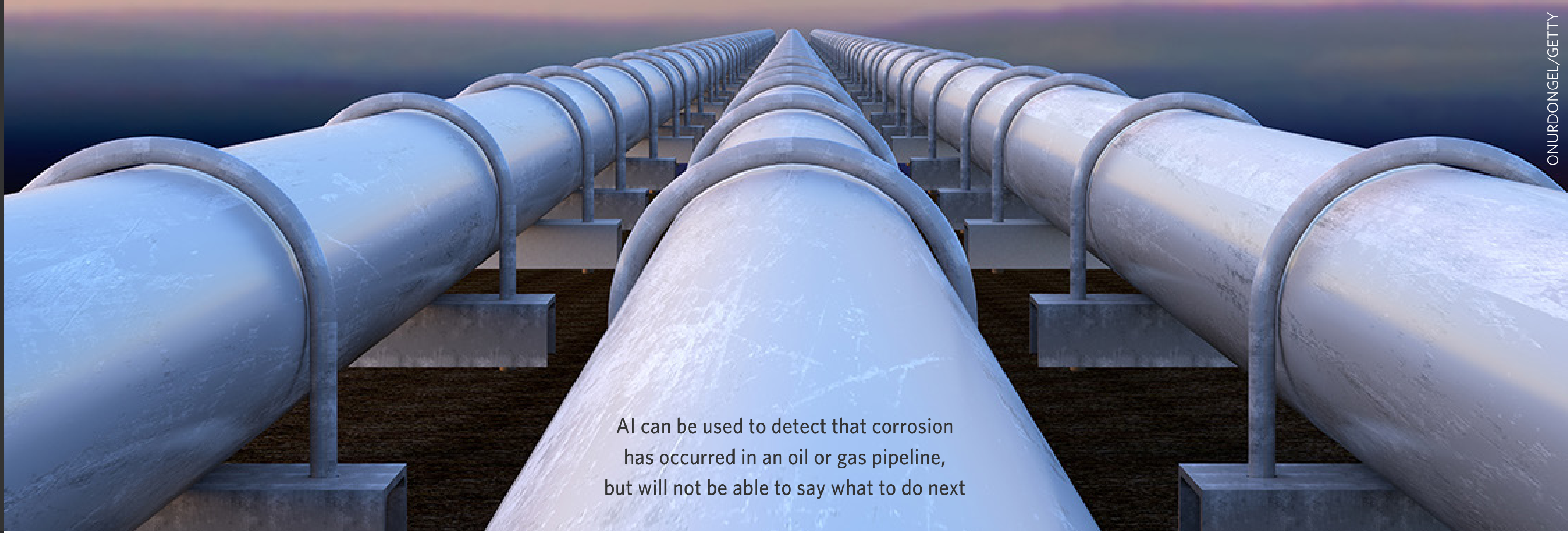
Editor's comment

Buyer's guide to software-defined networking in the enterprise

AI must move beyond pattern-matching

Why businesses must report cyber crime

Downtime



AI can be used to detect that corrosion has occurred in an oil or gas pipeline, but will not be able to say what to do next

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– the output variables – is something few people are actually doing in live production scenarios.

Ruh says the most prevalent use of AI is in targeted selling: "The price of being wrong is almost zero, while the value of being right is high, so the AI can be wrong a lot of the time and still do well."

But when used to assess the need for repairs on an gas or oil pipeline, the AI cannot afford to be wrong often, says Ruh.

Limitations of AI

Ruh says it is harder to find practitioners of AI than the people who build AI tools. "Commoditised toolsets can actually solve large problems, but AI people tend to be more interested in building the tools than solving application problems," he says.

In Ruh's experience, a general-purpose AI specialist tends to lack the domain expertise to solve an application-specific problem. "When I go to conferences and the presenter asks, 'How many people have AI projects?', all the hands go up," he says.

"When the presenter asks, 'How many people are doing pilots?', maybe a little more than half the audience put their hands up. But almost zero are actually in production."

The reason businesses are not yet seeing value in AI, says Ruh, is because the people building the AI systems are not sophisticated enough to engineer in domain expertise. "It is not true that with machine learning you just pump in some data and it works," he says. "A lot more work is required. The more domain knowledge built into the AI, the more valuable it becomes."

Ruh argues that although machine learning and AI basically use a pattern to achieve a goal, there are some situations where a wrong outcome is dangerous or costly. "If you put in enough data of the right level of quality, the AI will eventually become very good at spotting a pattern and can tell you about it," he says. "That may be good at picking salespeople, but in an oil or gas pipeline, while the AI is used to identify that corrosion has occurred, the question of what to do next is complex. If an expert

Home

News

Specialised cyber criminals set their sights on industrial control systems

Google's search for enterprise success

Dentsu Aegis is devoted to digital

Editor's comment

Buyer's guide to software-defined networking in the enterprise

AI must move beyond pattern-matching

Why businesses must report cyber crime

Downtime

sees corrosion, they can start to do analysis, understand the physics of the corrosion to decide whether it needs to be repaired now or can wait another year. A wrong decision is very costly, but a correct decision is highly valuable."

AI will never be able to give the user the correct answer to the question of what to do next, says Ruh. "The only way to do it is through modelling and simulation, looking at every instance of corrosion to understand the physics of what is happening to the pipeline. AI doesn't understand this physics; it understands patterns."

Given that not every instance of corrosion can be repaired immediately, Ruh says modelling and simulation enables the analyst to assess millions of possible scenarios to decide whether the repair can be scheduled in efficiently and cost-effectively.

"With machine learning, the action is not learned; it is predetermined," he says. "If you see this pattern, perform this action."

Ruh says this action is only as good as the algorithm coded by the programmers. The only way to look at all possible outcomes in real time is through modelling and simulation, he adds.

Over time, Ruh expects hardware will evolve to build in physical modelling. "I believe that chip technology will continue to evolve to where physical modelling will be part of the decision-making process and it will be possible to look at all possible choices to optimise the action to take in a way that presents the least risk or costs the least," he says.

> **"I believe that chip technology will continue to evolve to where physical modelling will be part of the decision-making process"**
>
> Bill Ruh, GE Digital

At GE's pipeline inspection business, Ruh says the company produces massive datasets from miles of pipeline "It takes several years before someone can correctly identify from the data where in the pipeline corrosion is actually a problem, even when there is no leak," he says.

GE is using AI to preprocess the data, to help its analysts identify the areas of the pipeline that are most likely to have corrosion. "This is a perfect case for machine learning because domain knowledge and domain data can be coupled together to feed a machine learning tool," says Ruh. "The more data is pulled in, the more the AI can learn from the analyst identifying problems in the pipeline."

This is effectively using AI to augment a human, where the expert trains the machine so it can identify more complex patterns.

The authors of the *Deep learning for physical processes: incorporating prior scientific knowledge* paper also believe deep learning can be combined with physical modelling data. "We believe that knowledge and techniques accumulated for modelling physical processes in well-developed fields such as maths or physics could be useful as a guideline to design efficient learning systems," wrote Bézenac, Pajot and Gallinari. ■