Artificial Intelligence in railway operations and maintenance

When I was just a kid, I was excited by the Deep Blue chess-playing computer developed by IBM which could win against a world champion in 1996. And 20 years later, a robot, Sophia which is backed by Artificial Intelligence (AI) and Machine Learning (ML) could have a "normal" conversation with us, humans. And recently, I bought a small device called Google Home Mini, also an AI product for less than $30. It is fascinating how AI has been evolving remarkably in recent years from a super computer (over $100 million project) to something just for few bucks like Google Home Mini, or even free like Google Photos. AI and ML are undoubtedly booming in all industries, and transport is not an exception.

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Artificial Intelligent is coming to town!

In March 2019, the European Parliament released a briefing mentioning about their plans and actions to support the development of AI and ML in transport. It provides strategical guidelines, rules as well as financial support to enable AI-powered applications. The EU also pointed out that AI is the change agent in transport in the EU and decided to increase the funding for AI to €20 billion by the end of 2020. These generous and strong actions were taken on the basis of positive and foreseeable results from a number of on-going rail transport projects in both operation and maintenance.

One of the biggest strategic momentum in the EU railway transport is the European Rail Traffic Management System (ERTMS) aiming to build EU-wide standards for controlling and signalling systems. When ERTMS would be equipped with Automation of Train Operation (ATO), it could increase the train speed with better capacity, punctuality and safety. ATO has been around since 1968 with its first project, the London Underground system, and it keeps expanding. The introduction of AI and ML will take ATO to the new intelligent level. In 2016, Deutsche Bundesbahn (DB) started its project in ATO and AI aiming at a driverless operation. Currently, they already got initial positive results from the first pilot and DB is aiming to deploy the system to production use in 2021 and 2023.

In addition, a consortium was formed in 2018 by Railenium Institute of Technological Research, Société nationale des chemins de fer (SNCF) together with a group of experts aiming to build driverless train prototypes fuelled by AI. In detail, Internet of Thing (IoT) data coming from on-board sensors and cameras at the platform are processed in real-time and then used to analyse the situation and provide responsive actions when needed. Furthermore, the data captured from the cameras will be used to analyse how passengers behave on the platform to improve door closure with less danger.

Another potential area for AI in railway transport is maintenance work. For a long period, maintenance activities have been carried out by 4 strategies: corrective, preventive, risk-based and condition-based maintenance. Recently, predictive maintenance, empowered by ML and IoT, has disrupted the maintenance work due to its outstanding intelligence. For example, door maintenance has never been easier and more cost effective than now for East Japan Railway Company (EJRC) when applying the PARC's MOXI system which is backed by ML. Sensors are attached to train doors and they keep sending data to the backend systems. Then, an ML model was built to suggest actionable recommendations when needed and be able to learn over the time. As a result, EJRC can save a large amount of money on regular check-ups and at the same time, plan the work ahead more efficiently.

Back to the EU, SNCF also started to use predictive maintenance for pantographs and catenaries. The incident forecasting rate could reach 80% by ML features to learn from past experience over the time. Moreover, the "digital twin" has attracted a lot of interest in the market. As the name depicts, a digital copy, as a twin to the physical object, is built to react to the changes in environment like a real one. The Laing O'Rourke case could be considered as a typical example of a digital twin application where the company could help its customers to shorten the maintenance planning from 3 hours to just 19 seconds, an impressive number.

Figure 1. ML and IoT in Rail Predictive Maintenance.

NO! AI is not magic and it is NOT JUST math!

"AI isn't magic, and it's JUST math" – That's the headline from the speech of Jana Eggers, CEO of Nara Logics. Personally, I partially agree with her. Yes, AI is not the "Magic Lamp" which we just scratch and gets things happen. But No, it is NOT JUST math nor data scientists running the show. This misconception could lead to fatal failures. A $62 million project for IBM Watson for Oncology aiming to cure cancer ended with wrong recommendations that could cause severe and fatal consequences. "This product is a piece of s---", a doctor at Jupiter Hospital in Florida told IBM executive. Microsoft's Tay went from an innocent, faithful chatter bot turned to a crazed racist one just in a day by Twitter trolls. Both of these failures were not caused by math algorithms or data scientists but surrounding factors like wrong business case and bad data.

Theoretically speaking, ML, or data mining to be exact, is a complex process which is composed of 6 different steps and involves a number of different actors. Like 6 infinity stones from Marvel's world, each of them is powerful, but they would be able to create ultimate power only when they are put together in a correct order. Each step plays an important role for the whole chain which demands premium care from high level managers, software teams and data scientists as well as external parties. For example, problem identification involves finding the real business cases which require market and industry senses from strategy development team together with inputs from data scientists.

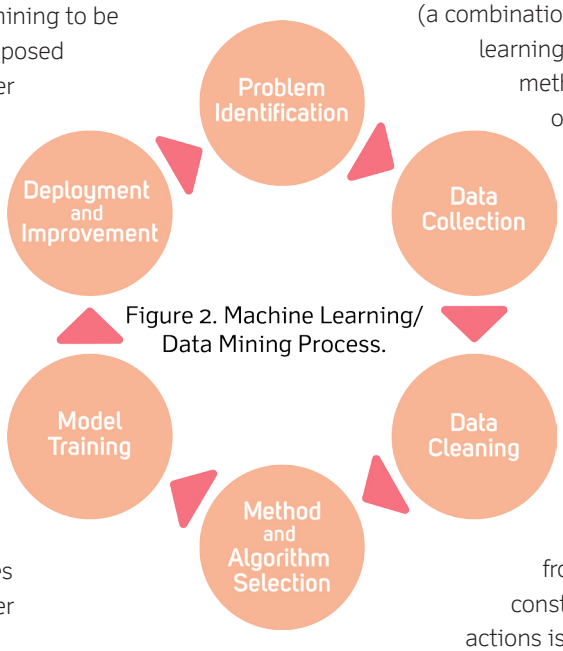

Figure 2. Machine Learning/ Data Mining Process.

Then, it comes to data collection where the involvement of Application Programming Interfaces (APIs) experts and data engineers are needed. In railway industry, even when the people are ready, the actual work is a nightmare. One of the product I am managing receives data from 9 different external systems in different formats. As a result, building interfaces, unifying those data took months even though, no insight from ML has been generated. However, thanks to the effort of the EU, as a regulator, standard data exchange formats like Technical Specifications for Interoperability (TSI) or RailML are defined to ease the pain.

Now, thanks to the hard work of those actors, data is in place, safe and sound. However, the next obstacle will arise which is data cleaning – where I have seen many AI projects failed. In the railway business, the amount of data is massive, a train traffic management system in a city could generate more than 10 Gigabytes data a day. These data are, in many systems, collected in the form of log files or stored just in cache (which is temporary and will be deleted). One of the major issues in software development is the bad structure logs and undocumented specification which then make those received data become meaningless or impossible to clean. Therefore, it is critical for application development decision makers to keep in mind "built for machine learning" also, not just built for business features.

Once the above steps are completed, it is the data scientist's turn to play the key role. Then, it comes to the selection of learning methods and algorithms to build the model. Based on the business cases and actual situations, data scientists will decide to select either supervised learning (where both input and expected output are provided); or unsupervised learning (where only input is provided, meaning machine will try to find possible outputs and making sense to it); or reinforcement learning (where machine learns by itself by performing actions and receiving consequent rewards); or semi-supervised learning (a combination between supervised and unsupervised learning). Then, depending on the learning method, algorithm (like regression, classifier or deep learning…) will be selected. The result will be models which then will be trained and tested and finally deployed.

At this point, everyone could already celebrate as the machine is now learning and running in the production after a long journey. However, it is not the end, and again, it requires the effort from the whole organization as well as external parties. One of the superior features of ML is the ability to learn from the past experience, as the result, constantly retrieving feedbacks for its actions is a must-have. One of the failed cases I experienced is that although the model was ready, but it was impossible to get the feedbacks, so the machine couldn't learn and improve its intelligence. And the railway industry makes it trickier when there are many different bodies like railway undertakings, infrastructure managers or even worst when in some situations, purchasers and actual users are two different entities.

The take-away – It is BIG!

Yes, AI and ML is a big thing. It is big by its definition due to the huge amount of data it handles. From business perspective, AI and ML is a big thing with huge potential and unforeseen risks, as it is still in growing phase where preliminary results are visible and possibilities are being explored. It is also big because it demands high level of commitment and effort from all levels in organizations and involved partners. Last but not least, there is still big question for firms to decide: "Will you want to be a pioneer for a high risk but high return or a follower in a safe side?".