Mining Wear Parts, Machine Learning, Predictive Maintenance & Deal Making



The future of mining services M & A / Investment strategy

August 2020

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Background

Demands from mining houses for greater productivity is increasing the urgency for engineering and mining services companies to deliver technology breakthroughs & service based efficiencies.

For Boards & Leadership Teams that are not used to dealing with rapid technological change, a challenge exists in pinpointing investment and acquisition opportunities that will deliver both shareholder value and client "stickiness". Just as has happened in other industry sectors, today's "1.0" METS technology solutions are already becoming redundant in a rapidly changing landscape.

Then enters machine learning and "AI". For CEOs and Boards considering making investments or acquisitions in the machine learning / technology space, the decision matrix is completely different to what would be considered for a traditional industrial acquisition. There are many unique challenges, and a fair deal of "smoke and mirrors" currently around what is truly "predictive" technology.

This paper outlines several factors that need to be considered in the pursuit of the next generation of transaction. It also provides a basic overview of the Machine Learning Algorithm and its potential application in the Mining Services sector in areas such as maintenance.

Machine Learning & Predictive Maintenance

Strategy Of Predictive Maintenance

The concept of predictive maintenance is a simple one, and that is to avoid unplanned breakdowns and other performance issues, which result in loss of ore production. There is a significant difference between a priority on lowering operational cost base vs one of optimising & maximising resource productivity. Each of those objectives has its own "bias" which needs to be separately considered.

The marginal cost of predictive maintenance programs versus reactive maintenance programs is a secondary consideration for the mine owner that is focused on maximising ore output on a 24/7/365 day basis. Each mine site is an ecosystem, and a failure of a piece of machinery in one area can have a domino effect of dislocating operations in other areas.

So What Is Machine Learning?

Machine Learning Algorithms are designed to produce different outputs than simple observation-based technologies, which relay "real time" data typically through some form of sensor tech mounted on hardware.

The Machine Learning Algorithm is *trained* to learn from specific data sets in such a way that when exposed to new data the Machine Learning Algorithm will produce more reliable and consistent outputs. It is a dynamic approach to data interpretation and pattern recognition aimed at producing algorithm based improving outcomes.

This is particularly valuable in the early detection of issues, which are "predicted" far in advance of many current sensor-based technologies that are presenting a picture of "today" but not really "tomorrow".

The medical field is embracing the precision of Machine Learning Algorithms to (*for example*) detect cancer cells much earlier than traditional pathology-based methods. As an example see: pathai.com

Snapshot On Supervised & Unsupervised Machine Learning

Mining services sector startups are designing algorithms based on both Supervised & Unsupervised approaches to data. Supervised Machine Learning is where large volumes of historic data are "labelled" and through a combination of regression analysis and classification analysis the Machine Learning Algorithm leverages these historical observations to predict future outcomes. In essence, this is sophisticated & ever improving pattern recognition in data. As in the field the data collection continues, the ability of the Machine Learning Algorithm to "predict" improvements over time as the model is refined to discard errors.

Unsupervised Machine Learning differs in that the model is not trained in the "right outcome" but rather the Machine Learning Algorithm explores the data to detect patterns or structures within the data that were previously hidden or not observed. The value of Unsupervised Machine Learning could be extremely high where new approaches to predictive maintenance are designed and developed based on, to date unrecognised data patterns.

The process of designing and validating a Machine Learning Algorithm is subject to its own biases and challenges. Particularly around the calculation of optimum outcomes, which can be subject to "overfitting" of historic data which can lead to issues of the reliability of future predictions. This is basically where the algorithm tries to make all the historic data fit too precisely to a pattern at the cost of the accuracy of future data (*which does not fit that historic pattern – and is therefore unreliable).*

Examples Of Machine Learning Application

Simple examples of where a Machine Learning Algorithm will lead to productivity gains for mining services / mine operation include:

1. Estimating the **remaining useful life** (RUL) of various wear parts in the mine ecosystem. Here one is using data to predict windows in which it is highly probable that a specific wear part or parts will fail. Any training data for the Machine Learning Algorithm in such instances needs to be customised for a myriad of specific mine site conditions including ore quality, weather, machinery operating temperature and ore productivity targets.
   One of the beauties of the Machine Learning Algorithm is that once trained the algorithm will be able to adapt to changes in variables in order to produce a new set of "optimal" operating conditions. Therefore operations are automatically adapted to new conditions.
2. **Identifying "events"**. Conveyor belt damage, damaged conveyor rollers (*and bearings*), loosening / detaching wear plate and poorly performing transfer chutes are some of the unforeseen events that cause significant & unplanned loss of productivity. By applying a Machine Learning Algorithm, normal operating patterns of both individual pieces of equipment and equipment circuits can be modelled so that "abnormalities" from normal operating conditions are immediately identified.

What is important to understand is that the Machine Learning Algorithm is designed to train to a level where it will proactively "predict" or "identify" potential events in a superior fashion to traditional methods such as hardware mounted camera systems designed to "observe" things in real time (*that is if the camera is working*).

The entire purpose is to move from "real time" to "crystal ball gazing", and with that a more flexible approach to maintenance planning, which includes the potential for smaller adjustments / repairs to be done ahead of damage.

The Challenges

It is not all good news. The Machine Learning Algorithm is heavily dependent on dynamic data which can bring new challenges to mine sites – many of which operate in both extreme conditions and remote areas.

Data Is King

Deal teams should not be distracted by claims of "big data" but rather seek to understand the deep data that allows the Machine Learning Algorithm to be trained for the specific purpose. With predictive maintenance, ML this is not straightforward as one is looking for failure "events" that only take place rarely. As such it is important to understand how deep the data is upon which the computations are being made – including the frequency and range of potential events that are being modelled for.

As such, in order to build a prediction technology, large quantities of data are required both to train the Machine Learning Algorithm and also to test the model for accuracy & observation. As a part of the algorithm's development it is important that best practice is maintained and both sets of data are kept separate so as not to apply *both* to the model training process. In any transaction diligence exercise, therefore, one should be seeking to understand the process by which the data has been developed and then the approach taken to construct, train and validate the Machine Learning Algorithm.

Any machine learning application is meant to improve this predictive efficiency as increasing levels of data are processed over time. From a practical perspective, however, this means long periods of data collection which need to be undertaken with rigour in order to have statistically relevant samples available. It also raises practical questions on in the field data collection.

The Importance of Digital Twins

We also look for the use of technologies such as Digital Twin approaches to model predictive maintenance for specific operational aspects.

Digital Twin technology creates a digital twin of an operating asset or a component in order to observe the performance of that asset under various scenarios. In order to be successful the virtual operating environment needs to be able to share data seamlessly and continuously with the physical operating asset (*and this can be difficult to accomplish as discussed below*).

Understanding from a diligence perspective the approach that has been taken to the development of the Machine Learning Algorithm is separate to the purity of the IP itself. It goes to the robustness of the technology and its ability to integrate with the physical assets in the real world environment.

Early technology companies often fall short on the ML model's in field experience – often a result of the lack of "events" across the data collection period creating a sufficient sample size.

Storage, Sensors, Networks & Security

Not only does the volume of data required to commence analysis need to be significant, it raises additional practical day-to-day issues which any diligence activity should be careful in analysing. These include:

- **On Site Networks.** Not all networks are efficient and capable of conveying vast amounts of data in real time. Machine learning requires data to be pushed to the cloud continually – placing uptime requirements on network efficiency (*one does not want to lose data at an important "event" point).* Networks also need to support connectivity (*including for autonomous functions*), real time data transfers for other day to day functions, machine to machine communications as well as basic communication functions. As more technology is loaded onto a network the congestion / potential for failure increases. Investing and upgrading networks in advance of technology advances, is a fundamental requirement even within a CAPEX constrained environment.
- **Data ownership.** There can be questions on both data ownership and cost of leveraging an on-site network for a third-party application. Consuming bandwidth comes at a price – and the more remote the location the higher the cost associated with that bandwidth.

- **Sensors.** The physical placement of a sensor on a piece of infrastructure may require the consent of multiple parties including OEMs, engineering companies holding O & M contracts and the mine operator itself. Issues of insurance need to be considered where sensors fail and thanks to Murphy's law, end up in the wrong part of the mine circuit/processing plant.
- **Data Storage.** The ability for complex algorithms to perform requires continual 2-way access to vast amounts of data storage. Whilst storage costs have declined with time it is the efficiency of accessing the storage that becomes critical – hence the critical importance in networks.
- **Digital Security.** As ML solutions extend across the mine site the requirement the importance of digital security only increases. Hackers target the "weakest link" in networks, including any customised router or industrial sensor that is deployed in field.

These practical matters will present challenges on a case-by-case basis depending on the communication infrastructure associated with the specific mine.

Tying Mining Technology To Valuation

The valuation approach to technology-based companies has always been based on different metrics and principals to those applied to industrial companies. This in turn feeds into diligence approaches required to verify the robustness of the technology model.

Additionally, the failure rates of technology companies are high – often due to either a competitor overtaking them on the road to commercialisation, or alternatively the technology underlying the company failing to transition from concept to hardened in the field operational tool.

Finally, with the abundance of Venture Capital available today, the timetable for successful startups to move from concept to commercial product can be very short. This also means that technology can have a limited lifespan of potency – as new startups pickup the baton and run. These short life companies are often referred to as “shooting stars” for a reason. They burn bright and fast.

All this makes the task of developing a valuation range and deal structure all the more challenging with mining technology companies – and that complexity will only increase where Machine Learning Algorithms are involved.

Conclusions & LCC Asia Pacific Provides Clients With Specialist Counsel To Identify & Pursue Strategic Priorities

The introduction of machine learning and artificial intelligence driven technology into the mining services sector promises to bring greatly improved productivity, enhanced safety and boosted profits (*for mine owners*).

In the chase for the technology high ground, however, mistakes will be costly given that setbacks / poor decisions on transactions will take time to be understood – during which period other more attractive opportunities will be missed and competitors will continue to move forward.

LCC brings experience significant experience in both the mining services and communications sectors to client engagements that allows objective analysis of the opportunity to be conducted. In addition to our M & A capabilities LCC works closely with CEOs and Boards of Directors to provide independent advice on the robustness of the technology that underpins METS companies.

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