intellegens

WHITE PAPER

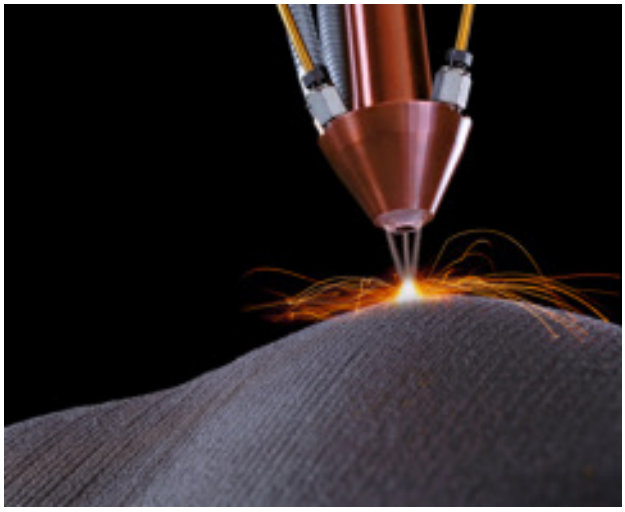
Novel Deep Learning Approach for Predictive Maintenance and Process Optimization in Manufacturing

Executive Summary

In manufacturing, ongoing maintenance of equipment and production line machinery represents a major cost, where unplanned downtime costs an estimated $50 billion a year (according to a 2013 Solomon RAM study) and asset failure is the cause of 42% of this downtime. Predictive maintenance is being readily adopted by forward thinking manufacturers who understand that predicting equipment and process malfunctions can save considerable time and costs. Adopting such methods to existing manufacturing processes is not straightforward. In order to make accurate predictions, there has to be existing data in place to guide the model - however that is rarely the case.Intellegens has developed a machine learning tool, Alchemite™, that trains models on all available data, no matter how sparse or noisy. We bring all the available data together and use underlying correlations to accurately predict missing values and generate the most complete models possible. Applying this novel method to the available historical and simulated data enables organisations to identify opportunities for reducing costs and downtime, time savings, and overall performance improvements, through predictive maintenance and process optimization.

The Challenge

Most organisations apply a “Reactive Maintenance” approach to their processes, in which repairs and replacements are made to the equipment after a failure occurs. It costs around 10x more to repair a machine after it fails, not to mention the direct impact on revenue and customer satisfaction. Through “Preventative Maintenance” equipment is repaired or replaced at pre-set time intervals in order to avoid failure. Whilst this approach reduces unplanned downtime it is expensive as these scheduled repairs take place when there can be nothing wrong with the equipment. However, the benefits of predictive maintenance are significant, so it is becoming the preferred method for manufacturers, enabling organisations to foresee and schedule repairs and replacements when needed, achieving 100% operational uptime of the equipment. One challenge for traditional machine learning in manufacturing is that techniques require clean and complete data. However, manufacturing and process data can be sparse and noisy.



Currently, it is difficult for engineers to access and interpret production process data, they rely on personal experiences and opinions to modify process parameters. This leads to inconsistent and potentially suboptimal decision making, and moreover increases the risk of process failure, increasing associated time and costs. The production line is especially difficult to model using standard techniques due to the inherent time lag and inertia between changing operating parameters and their effect. Costs associated with waste materials and failed production could also be significantly reduced with the application of relevant and innovative deep learning technology to design production processes more efficiently.

Intellegens has developed a machine learning tool, Alchemite™, that trains models on all available data, no matter how sparse or noisy. We bring all the available data together and use underlying correlations to accurately predict missing values and generate the most complete models possible. Applying this novel method to the available historical and simulated data, enables organisations to identify opportunities for reducing costs and downtime, time savings and overall performance improvements, through predictive maintenance and process optimisation.

Solution: A novel approach for predictive maintenance and process optimization

Historical manufacturing data provides a valuable resource for innovative companies to leverage the knowledge contained within it and optimise future processes, leading to reduced material and time wastage. This data, the knowledge that it contains, and all future data, could be exploited to improve manufacturing processes in a self-optimising system reducing the time, cost, and subjectivity of processes while improving both the consistency of approach and outcomes. Predictive maintenance is a technique that collects, analyses, and utilises data from several manufacturing sources such as machines, sensors, and switches. It applies algorithms to the data to predict equipment failure before it occurs. The key to business efficiency is therefore to adopt machine learning approaches and act on real-time insights and current data. Predictive maintenance is the core of manufacturing innovation and involves rethinking and optimising the entire maintenance strategy as a whole. At Intellegens, we use the Alchemite™ machine learning algorithm to train models on limited data, helping companies to move away from time consuming trial and improvement approaches. Our system brings all the available data together, and uses underlying correlations to deliver models that can help identify problems before they happen.Our technology leverages existing process data to reduce the costs of asset maintenance programs and improves the overall understanding of the complete system, optimising production lines and processes involved in manufacturing. Alchemite™, trained on noisy, historical manufacturing data can help guide engineers with suggested process calibrations. The unique Alchemite™ system handles the noisy data typically found in these datasets, delivering models and tools to maximise production performance, reduce failures, and cut costs.

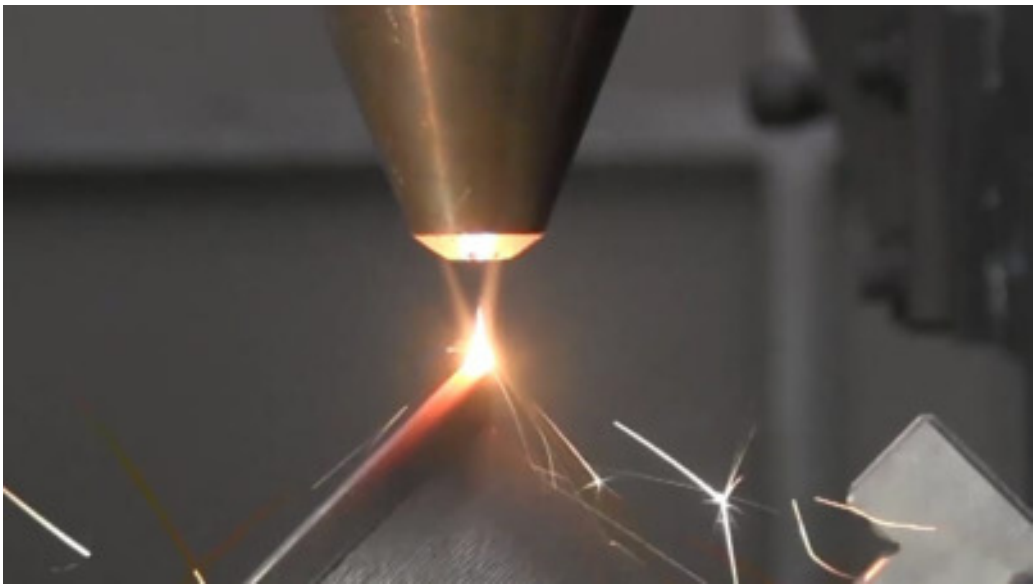
Adopting Alchemite™ alongside manufacturing processes yields the following benefits:

- **Reduction of material cost by minimising waste**. The application of Alchemite™ and the ability to run virtual experiments can reduce the amount of waste produced at all stages of production.
- **Transparent understanding of processes.** Achieve the best possible understanding of how production techniques correlate to the final properties and a platform to do virtual experiments of changing parameters that cannot be tried on a live production line. This is especially important due to the time-varying character and inherent time lag present on the production line.
- **Optimized process design.** Deliver new insights from all the underlying correlations in the manufacturing data and allow the development of new processes based purely on the data.
- **Lead the market with as technology innovators with an improved brand image**, providing additional evidence for pioneering in industrial design that is able to leverage cutting-edge science, across all disciplines, in order to improve both manufacturing design and operating margins.

Case Study: Modelling new processes for additive manufacturing

Additive Manufacturing (AM) is a new processing technology used in a wide range of industries to produce and repair bespoke and high-value parts including, for example, aerospace engine components, turbine blades, and oil drilling tools. Quicker than conventional production techniques, AM has the potential to save manufacturers vast amounts of time and money. However, for this method to reach its full potential manufacturers need to understand the behaviour and properties of different processing variables. To date, very few materials have been fully experimentally verified going through these processes, severely restricting the application of the technology to wider fields of use. We outline a case study of how we optimised the direct laser deposition process for AM using historical welding data and the available sparse direct laser deposition dataset. A particular challenge is that the ability to print materials is poorly understood - direct laser deposition (one AM method) has only been applied to just ten sets of processing variables. This provides a mere ten data points which are not enough for traditional machine learning techniques to predict the properties of a wider family of processing variables.

Alchemite™ was able to leverage abundant weldability data to automatically identify and exploit property-property relationships enabling the capture of new insights into the changing processing variables. By using historical welding data combined with the sparse data from direct laser deposition, we were able to optimise this AM process and broaden its application to new processing variables, saving 15 years of research and reduce development costs by $10 million. This approach is not limited to AM and can be applied to the introduction to any manufacturing process.



About Intellegens

Intellegens has developed a unique artificial intelligence engine, Alchemite™ for training neural networks from incomplete, sparse, and noisy data, typical of real-world data. The technique was first developed at the University of Cambridge where it has been used to develop several superalloys, guide the design of new drugs and help optimise battery pack design. The tool is now being used to solve a wide range of real world industrial process problems where rare but valuable data can be used to improve real world industrial processes leading to reduced costs and environmental impact. For more information on how we can help with predictive maintenance and process optimization, please visit https://intellegens.ai/manufacturing/

For more general information, please visit intellegens.ai.

Want to learn more about how our AI technology can be applied to your specific needs? Contact us to learn more at info@intellegens.ai

Reference

Probabilistic neural network identification of an alloy for direct laser deposition. B.D. Conduit, T. Illston, S. Baker, D. Vadegadde Duggappa, S. Harding, H.J. Stone & G.J. Conduit Materials & Design 168, 107644 (2019)

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