This white paper provides an overview of machine learning, and how machine learning is impacting and improving the trucking industry now and in the future.
What is machine learning?

While it may sound like something out of a sci-fi movie, machine learning is already part of our daily lives. If you’ve used Google Maps or Google Search, binge watched a “recommended for you” show on Netflix, asked Alexa to recommend a restaurant or song, shared a photo that auto-tagged your friends on Facebook or received a call from your credit card company about fraudulent activity, you’ve benefited from machine learning.

Machine learning is the common denominator in making all of these activities work. It’s estimated that machine learning is used in more than half of today’s mobile apps.

Machine learning uses computer algorithms to detect patterns in large data sets and predict outcomes. In some machine learning applications, computers are initially programmed to learn how to solve problems, but can change and improve algorithms on their own – making faster, more accurate predictions.

Machine learning essentially helps to find the needle in a haystack of data, taking in large quantities of complex data and identifying patterns to provide reliable, effective and repeatable results. For example, according to the Google Research Blog, the company introduced machine learning to Google Maps, improving the usability of the service. The algorithms help the app extract street names and house numbers from photos taken by Street View cars and increase the accuracy of search results. With over 80 billion high-resolution photos collected by Street View cars, analyzing these images manually would have been impossible; instead, Google’s finely-tuned machine learning algorithms automatically extract information from geo-located images.

While machine learning and artificial intelligence (AI) are sometimes used interchangeably, they are different. Machine learning is the technique that has most successfully made its way out of labs into the real world, while AI is a broad field covering areas such as robotics and natural language processing. Machine learning is also commonly mistaken as simply using averages or statistics. Instead, it entails a complex process of understanding and preparing the data that is analyzed, developing algorithms that produce valuable predictions and outcomes, and testing and refining the algorithms to ensure accuracy.

The term “machine learning” was coined in 1959 by Arthur Samuel, a pioneer in computer gaming and AI, and it evolved from the study of pattern recognition and computation learning.

Samuel created a checkers-playing computer program that was among the world’s first successful self-learning programs, an early demonstration of AI. In 1967, the “nearest neighbor” algorithm was developed, allowing computers to begin using very basic pattern recognition. This was used as a solution to the famous “Traveling Salesman” problem, starting at a random city but ensuring they visit all cities in their territory in the most efficient way.

Fast-forward to the 1990s, when development of machine learning shifted from a knowledge-driven approach to a data-driven approach. Experts began creating computer programs to analyze large amounts of data and draw conclusions from the results. From 2012 to 2015, Google, Facebook, Amazon and Microsoft all developed machine learning algorithms and platforms that are commonly used today. While machine learning has been around for roughly 60 years, it’s truly coming of age right now thanks to advances in better and faster computational processing power, adoption of cloud computing which allows for scalability, and the need for vast amounts of data to be analyzed in real time.
IMPROVING THE TRUCKING INDUSTRY

In support of ELD regulations, and to generally improve our understanding of what is happening with a truck, more and more sensors are being added to equipment. As a result, the amount of data being generated is growing exponentially. For example, the engine data elements collected from the Trimble customer base generate more than 10 billion data points a day. And that’s just scratching the surface: Intel Corporation estimates that one self-driving car will produce four terabytes of data per day.

In case you’re curious, just one terabyte can hold roughly 500 hours worth of movies or 17,000 hours of music.

Needless to say, the sheer volume of data being generated in the trucking industry is on a steep incline. As the volume of data increases, machine learning is gaining traction in trucking – providing tools to analyze the data, make decisions and make predictions that can reduce occurrences of truck breakdowns, improve safety and retain drivers.

Machine learning is already improving trucking by allowing fleets to be proactive, from predicting the most efficient routes, to improving safe driving, to predicting truck breakdowns before they occur.
DRIVER RETENTION

A structural issue in the trucking industry is an aging population of drivers and not enough young drivers entering the workforce. It costs thousands of dollars to find and recruit a new truck driver. This problem will continue to worsen as the Bureau of Labor Statistics estimates the average age of a commercial truck driver is 55 years old. This means approximately a quarter of the driver population will be retiring soon.

Trimble built a driver retention model that uses mobility and enterprise data to predict the specific factors and identify in each fleet the drivers who are at risk for departure. This application includes two uses of machine learning: predictive and prescriptive analytics.

PREDICTIVE DRIVER RETENTION

The process starts with data integration. Trimble draws upon its extensive reach into the data ecosystem to pull essential information to drive the process.

We also know that drivers typically don’t leave an employer based on a single event. Data is normalized, transformed, combined and put through a process which distills and captures inter-relationships. When processed with machine learning it generates accurate predictive models and scored risk factors. These risk factors are fed into the prescriptive engine where they generate suggested actions.

For example, a driver hasn’t been home, or who may have frustration with payroll has that issue addressed by the next action, whether that’s a dispatch event or a call from payroll or their driver manager. These model demonstrate 90 to 95% accuracy in identifying drivers who at-risk for departure over a seven-day horizon.

DRIVER DATA

<table>
<thead>
<tr>
<th>Driver Data</th>
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<tbody>
<tr>
<td>Hours of Service (HOS)</td>
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<td>Driver profile</td>
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<tr>
<td>Safety</td>
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<td>OTR/Driving</td>
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<td>Equipment</td>
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DATA SCIENCE

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<th>Data Science</th>
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<tr>
<td>Predictors</td>
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<td>Predictive Engine</td>
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<td>Prescriptive Engine</td>
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DOMAIN

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<tr>
<td>Dispatch</td>
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<td>Safety</td>
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<tr>
<td>Driver Mgr</td>
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<td>Payroll</td>
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Driver retention predictor variables include:

- Tenure
- Loaded/empty miles
- Type of load
- Equipment
- Region
- Pay

Most Impacted: Large Truckload Fleets

![Annualized Driver Turnover Chart]

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<thead>
<tr>
<th>Quarter</th>
<th>Large Fleets</th>
<th>Small Fleets</th>
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<tbody>
<tr>
<td>Q1 - 2019</td>
<td>25%</td>
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<td>Q2 - 2019</td>
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<td>Q4 - 2019</td>
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Trimble builds a driver retention model using mobility and enterprise data to predict specific factors and identify drivers at risk for departure. This application includes two uses of machine learning: predictive and prescriptive analytics.
PREDICTIVE MAINTENANCE

One of the ways the trucking industry is currently utilizing machine learning is the field of predictive maintenance. Noted previously, the 10 billion data points generated every day by Trimble customers are used in various machine learning algorithms to understand the health of a vehicle and detect anomalies. Based on those anomalies, Trimble Transportation has built an algorithm that can detect when a semi-truck will derate in the next one to three days. Instead of being stranded in the countryside, waiting for an expensive repair, the truck can be routed to maintenance before it fails, and the load transferred to a different truck.

The data utilized to make these modeling decisions are captured from the telematics device which is connected to the engine’s electronic control module (ECM). This integration provides a wealth of data, including more than 50 signal variables, such as engine temperature, turbo speed, oil pressure, velocity and coolant levels. Using machine learning on this data, Trimble is able to identify trucks not hitting the “performance” mark compared to the normal operating conditions for its peers. Trimble specifically built a model to identify vehicles that are likely to breakdown due to a fault. Prior to feeding this data into the machine learning algorithms, data scientists “clean” and prepare it to ensure the predictions and outcomes are accurate.

Machine learning analyzes the massive amount of data collected from the truck’s ECM, and feeds it into TMT’s Predict Fault Code application to show the truck’s health score along with the indicators identifying a potential fault. Fleets can act on this information to bring a truck in for maintenance, prior to an unexpected, costly and inefficient roadside breakdown.

Preventing 35 percent of unplanned repairs can save a fleet an estimated $490 per vehicle every year in towing, labor, parts and lost margin.

Forecasting when a breakdown is looming also provides dispatchers with an important new tool to help them avoid assigning an at-risk vehicle to a time-sensitive load.

Benefits of proactive predictive maintenance:

- Reduce equipment downtime, increasing the profitability of the vehicle
- Identify and prioritize the trucks that require service
- Reduce road breakdown events, getting employees home safe and in a timely manner
- Lower service costs
- Reduce towing expense
- Improve customer service/on-time performance
- Reduce cascading damage
The Future of Machine Learning in Trucking

As technology evolves, machine learning will continue to advance, delivering faster, more accurate predictions in trucking and beyond. Watch for machine learning to be applied to solving the industry’s most complex and costly issues, including driver retention and driver safety. For instance, patterns discovered by machine learning algorithms may be useful in the future for predicting risky driver behavior.

Additionally, as the industry moves toward autonomous vehicles, the need for machine learning will dramatically increase. In vehicle autonomy, one of the most critical tasks of machine learning algorithms is continuously rendering the surrounding environment and predicting changes. Through machine learning algorithms, autonomous vehicles learn to detect, identify, recognize, and predict the movement of objects around them.

Trimble is continuing to innovate through machine learning, employing a team of data and computer scientists and engineers to develop and share best practices, solutions and technologies in machine learning across business groups. The Trimble team brings together fleet mobility data, maintenance and operational data and navigation and routing data, providing a robust data pool to provide more accurate predictions and insights to all customers. This shared expertise in the trucking industry also brings a holistic view and business knowledge to utilizing machine learning in real-world applications, delivering solutions that help fleets become better, safer and greener.

**Top Takeaways**

- Machine learning analyzes large quantities of complex data and identifies patterns to provide reliable, effective and repeatable predictions.
- Machine learning is a common part of our everyday lives, including recommendations for what to buy or watch through online retailers, directions for the fastest route through Google Maps, and more.
- Applications of machine learning are also improving trucking, from routing to predictive maintenance. The use of machine learning in trucking will continue to grow and improve trucking as technology advances.

**ABOUT TRIMBLE TRANSPORTATION**

Trimble Transportation is multi-modal and provides solutions for the long-haul trucking, field service management, rail and construction logistics industries to create a fully integrated supply chain. In trucking, Trimble provides enterprise and mobility solutions focused on business intelligence and data analytics; safety and regulatory compliance; navigation and routing; freight and supply chain visibility; transportation management and fleet maintenance. With an intelligent ecosystem of products and services, Trimble Transportation enables customers to embrace the rapid technological evolution of the industry and connect all aspects of transportation and logistics — trucks, drivers, back office, freight and assets. Through the combined legacy of PeopleNet and TMW Systems, Trimble Transportation delivers an open, scalable platform to help customers make more informed decisions and maximize performance, visibility and safety.

**ABOUT TRIMBLE**

Trimble is transforming the way the world works by delivering products and services that connect the physical and digital worlds. Core technologies in positioning, modeling, connectivity and data analytics enable customers to improve productivity, quality, safety and sustainability. From purpose built products to enterprise lifecycle solutions, Trimble software, hardware and services are transforming industries such as agriculture, construction, geospatial and transportation and logistics. For more information about Trimble (NASDAQ:TRMB), visit www.trimble.com.