PREDII

Repair Intelligence™

An Innovative Application of Artificial Intelligence in Automotive Maintenance

INTRODUCTION

The world in which we live is abundant with next generation forms of intelligence; smartphones give us the world at our fingertips; virtual assistants can almost sense our needs before we even know what they are: search engines, like Google, can understand the context of our searches using knowledge graphs; soon there will be an army of drones that will quickly deliver our purchases via Amazon; and some cars are even driving themselves. Our world is rapidly changing. In a way we are experiencing a kind of technological renaissance; we are living in an age of next generation artificial intelligence.

As you drive around Silicon Valley these days you will most likely see a Google self-driving car, and numerous autonomous and electric vehicles such as Teslas, BMWs, and Fiats. On September 20th, 2016, the United States Department of Transportation (DOT) released a 15-point safety standard for the design and development of self-driving cars. This is a major milestone for the evolution of self-driving cars. According to the DOT, "The development of advanced automated vehicle safety technologies, including fully self-driving cars, may prove to be the greatest personal transportation revolution since the popularization of the personal automobile nearly a century ago".

A trip to Silicon Valley now-a-days gives us a glimpse into what is going to come for much of the rest of the world in the near future. In recent years, all major players in the transportation industry, Ford, Toyota, Mercedes, Bosch, GM, and GE all opened up massive innovation centers there and have made acquisitions of technology startups like otto (acquired by Uber) and Cruise Automation (acquired by GM).

Vehicle technologies are getting more and more complex in both hardware and software design. It is not uncommon for vehicle software to contain 100 million or more lines of code located on top of vehicle hardware - various sensors which can number into the hundreds and ten or more engine control units (ECU), depending on vehicle model. With such intricate automotive technology, it is expected that the detection, diagnosis and completion of repairs will become much more complicated, and prognostic vehicle health management will become more critical for consumer and commercial vehicles alike.

In a perfect world our personal vehicles would be completely self-correcting, or at the very least proactive in letting us know when a vehicle failure is imminent. We all get frustrated when we see the check engine light turn on in our vehicle's dashboard. We don't know exactly what is wrong with our vehicle or how long we have to get to a repair shop before we wind up dangerously stranded on the side of the road. For consumer vehicle fleets, having even a small percentage of failures in mission critical vehicles can have a huge impact on the bottom line. For both consumer vehicles and commercial fleets, proper vehicle maintenance, repair, and reliability is imperative for driver safety, and can greatly reduce the costs associated with vehicle ownership.

TRENDS IN REPAIR AND MAINTENANCE

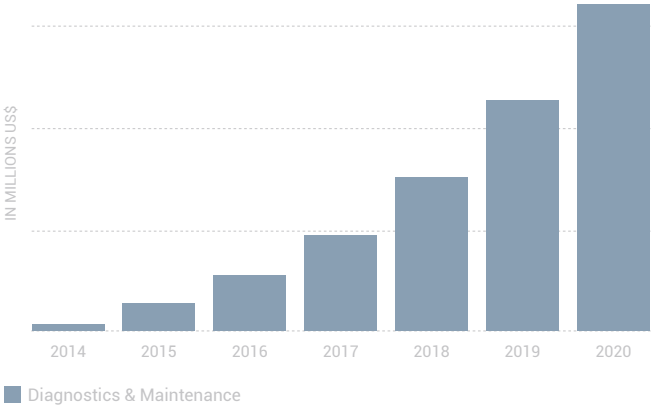
There are three primary trends we are seeing in repair and maintenance (vehicle health management):

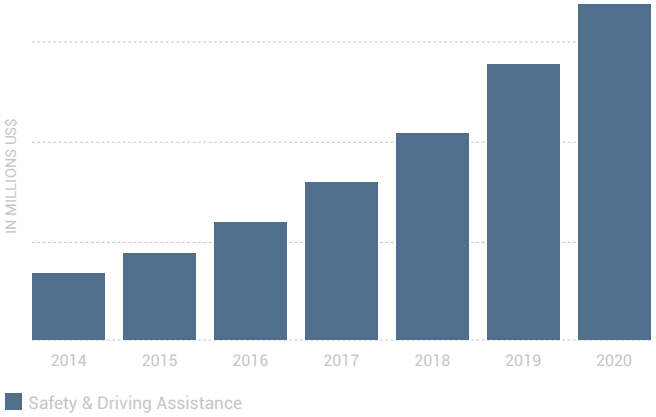
1. Cloud Connected Data Machines through Telematics and Telemetry
2. Predictive and Prognostic Maintenance
3. Guided and "Intelligence" Assisted Repair

Bosch predicts that by 2020, 50% of all cars shipped in Europe will have some form of connectedness. Connected vehicles and highly autonomous vehicles (HAV) of today and tomorrow are generating over 25 GB of data every hour.

The connected cars will continue be a significant source of high-frequency data that can be monetized for the purposes of predictive, proactive maintenance, marketing, and usage-based insurance products. The big shift to this connected ecosystem is evolving from premium automotive segments to all vehicles. Advances in telematics are also powering fleet management innovations in non-consumer vehicles. The annual cost of vehicle maintenance is expected to increase annually due to the increase in the cost of parts, labor, and increased sophistication of HAVs.

According to Statista, connected cars worldwide revenue is expected to grow from $36B to $118B by 2020. Diagnostics and maintenance revenues are also projected to grow at much higher rate because of increased penetration of connected proactive and predictive vehicle management. Safety and driving assistance will be key drivers to revenue growth.





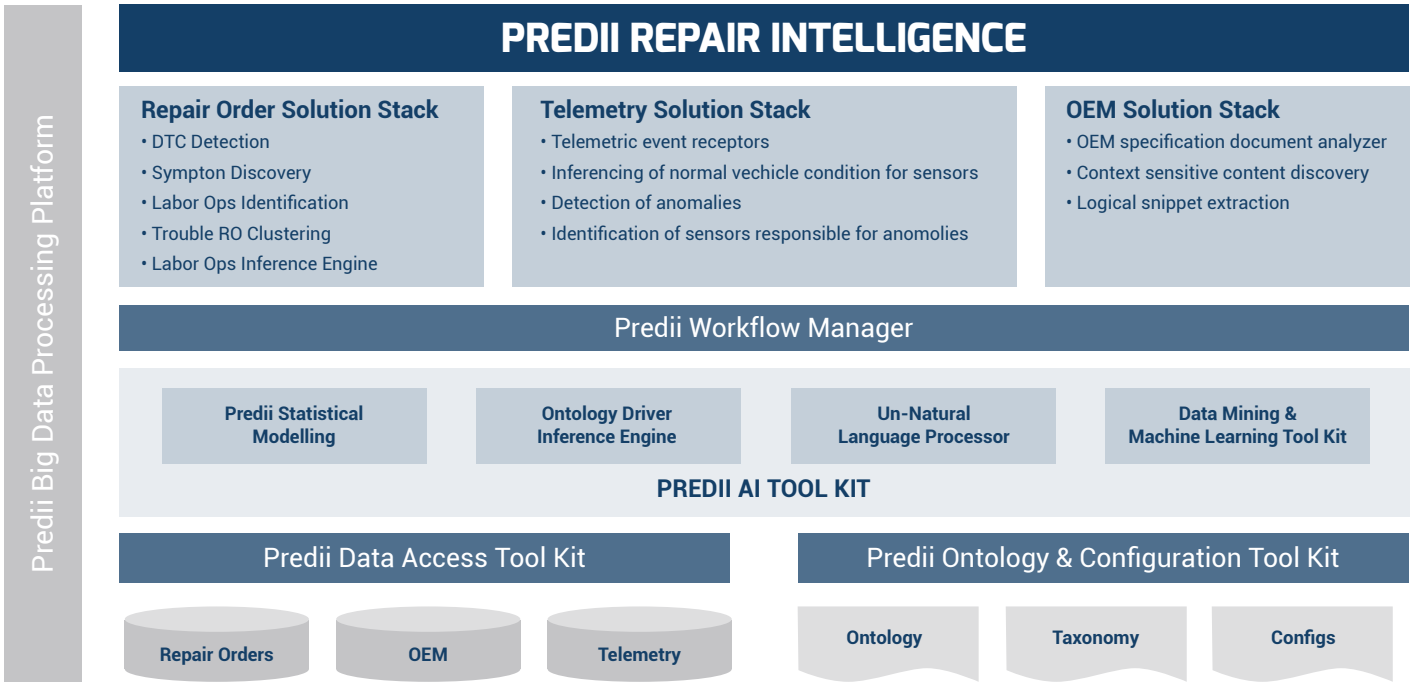
So, what does this all mean to repair and maintenance vehicle management? The field of artificial intelligence (AI) is perfectly positioned to interpret this vehicle big data and apply "cognitive" learning capabilities of AI in repair and maintenance. The availability of continuous streams of data from vehicles will empower vehicle monitoring businesses which are responsible for continuous health checks of your vehicle or fleets of vehicles. Intelligent repair solutions will monitor check engine lights, diagnostic trouble codes, symptoms, and data from advanced driver assistance systems.

REPAIR INTELLIGENCE

So, what is repair intelligence and why is it appropriate?

Innovations in powertrain, engine control units (ECU), electronics, autonomous and advanced driver assistance systems have transformed our vehicles into hardware and software systems that understand trouble symptoms, can predict failures, and optimize fixes. This requires sophisticated correlations and data science to augment human intelligence. We call this augmented intelligence, repair intelligence. AI powered software finds meaningful patterns in otherwise meaningless data; interpreting telematics data, telemetry data at the sub-system level, driver logs, and unstructured text. The data inside repair orders and driver logs are mainly in unstructured and unnatural language text. When asked about a symptom their vehicle is experiencing, a consumer vehicle driver might say: “My car is making noises that sound like my grandmother's wheezing”, and a commercial fleet driver might say “engine is doing shimmy at 60 MPH and above on highway". We call this Unnatural Language Processing™ as it doesn't relate directly to a true problem or abide by syntactic and semantic rules of natural language that is relevant to actual vehicle technology.

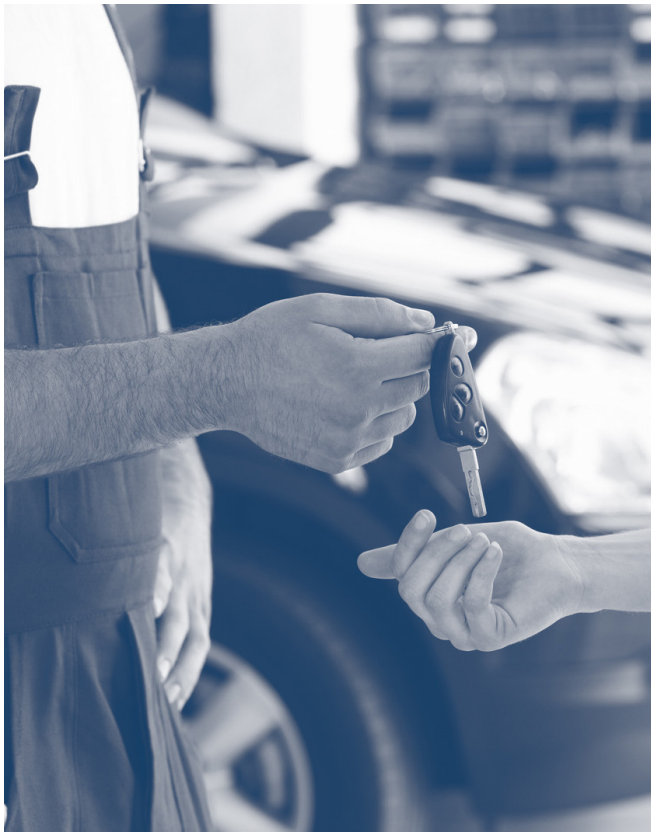
Repair intelligence allows us to learn from these inputs and to assimilate a working knowledge of a new domain rapidly. The repair intelligence system becomes a virtual expert almost overnight, eliminating the need for teams of data scientists and months of development in order to extract value from a data set. As the US DOT is envisioning, by embracing “data oriented” technologies, we can continuously learn from the data and improve.



A CASE-STUDY OF THE APPLICATION OF AI IN AUTOMOTIVE MAINTENANCE

Who?

Predii was founded in 2013 to solve a business problem. Snap-on, a leading global innovator, manufacturer and marketer of tools, equipment, diagnostics, repair information, and systems solutions for professional users was capturing huge amounts of service data that it wanted to monetize. Predii responded by creating an enterprise scale machine learning platform that could use this unstructured data to solve repair issues. This platform became known as Predii Repair Intelligence ™ and was embedded in a range of diagnostics products, transforming the industry, and holding our customer up as the leader in automotive innovation.



Turning Challenges into Solutions

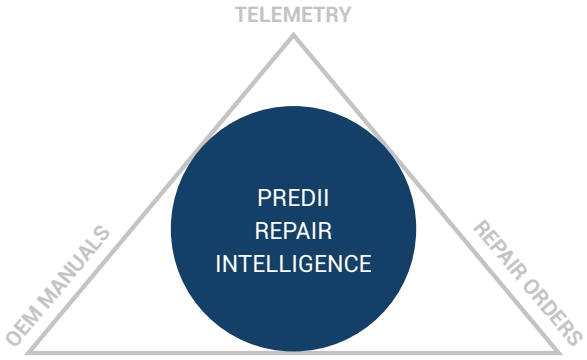
The main challenges Snap-on wanted our help with were threefold:

1. Gain real-time analysis and forecasting using huge amounts of vehicle telemetry data.
2. Search, translate, and configure an overwhelming amount of specific data from original equipment manufacturer (OEM) manuals and reference documents to be used for building applications for targeted contextual searching and content snippet extraction.
3. Quickly make sense out of unstructured repair order and warranty data.

Professional automotive technicians rely on Snap-on's expertise and information and Snap-on wanted to transform the automotive industry in the form of reduced component failures, accelerated repair times, prediction of maintenance needs and enhanced inventory management, to name but a few. They wanted this innovation to enhance some of their most powerful diagnostic tools, including their production of Real Fixes (tips produced by Snap-on's automotive experts used to help professional automotive technicians diagnose and fix vehicle issues quickly and efficiently), as well as their sophisticated diagnostic equipment.

Telemetry Data: Framework for Connection

Data is multi-faceted; it varies in its granularity, scale, and rate of availability. Irrespective of the complexity of each of these facets, modern machine learning solutions are expected to deliver accurate inferences in real-time. Predii's framework addresses these challenges as the data produced by the repair and maintenance life cycle is no different.



The Challenge

Automotive vehicles are embedded with thousands of sensors which monitor the vehicle condition, respond to changes, and use feedback to adapt. Under the circumstances of failure and malfunction, these same sensors provide insights for efficient diagnostic processes. Telemetry data is produced at a rate of millions of events per second and demand real-time analysis and forecasting.

Our Solution

Predii provides the framework for connecting with multiple data sources, the ability to choose and apply repair intelligence algorithms, and most importantly, provision critical domain knowledge to be seamlessly integrated into the solution. Repair applications are agnostic to the complexity of the algorithm and Predii's ability to distribute these algorithms over hundreds of processing nodes in parallel provides efficiency for quick turnaround time.

OEM Manuals and Reference Documents: The Data You Need, Quickly

The Challenge

Original equipment manufacturers produce manuals for every vehicle detailing system specification, diagnostic procedures and troubleshooting. These documents are highly detailed to the extent of providing information about the exact pressure needed to tighten each bolt. These manuals can run into thousands of pages, making the information overwhelming and challenging to use for practical purposes.

Our Solution

Predii uses a natural language processor powered engine which processes large, well-structured documents such as manuals and specification documents to mine key concepts. In other words, it can search, translate and configure specific data quickly from a large pool of information. These concepts enrich the document with meta-information used for building applications for targeted contextual searching and content snippet extraction.

Repair Order and Warranty Data: Creating Order Out of Chaos?

The Challenge

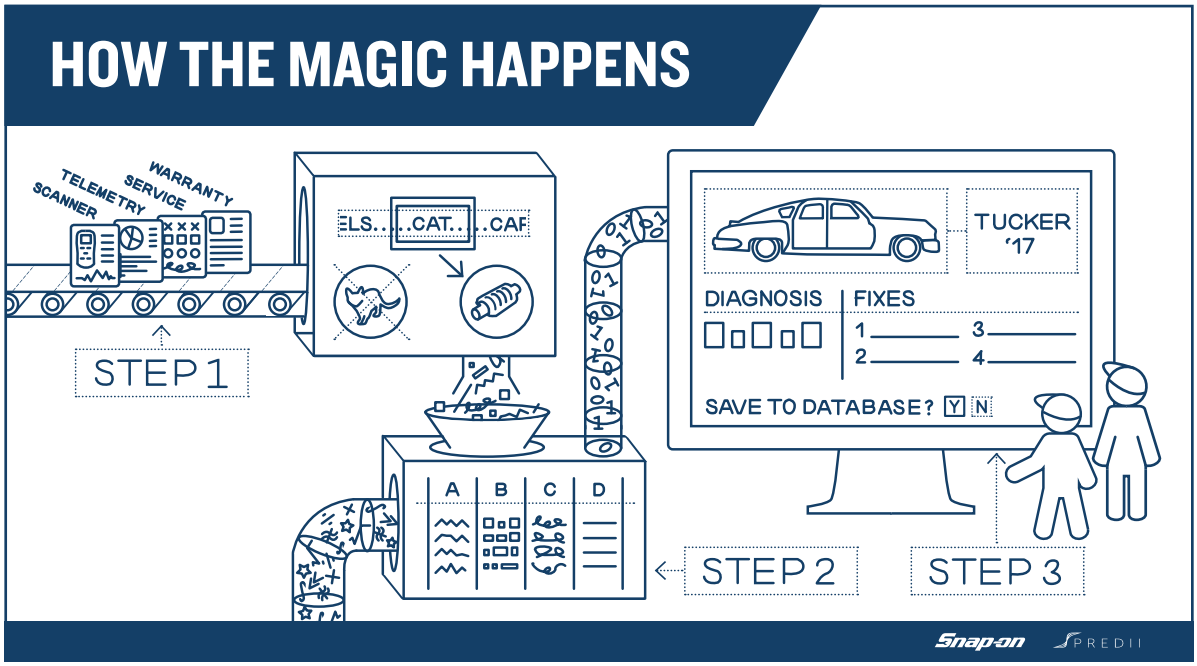
Repair orders are distributed bits of information created by a large group of technicians working independently. These repair orders lack language structure and semantics, often containing grammatical errors and are created in domain specific contexts. Each repair order may not make sense in isolation but billions of orders, when collectively analyzed, can bring about a pattern. It is extremely hard for human experts to mine the data with traditional databases and business intelligence technologies, as the underlying data is completely out of context and written as gibberish. It takes an expert to form correlations between these forms of data because of their automotive experience.

Our Solution

Predii created a custom-built unnatural language processing technology to consume data generated from crowdsourcing similar repair orders. This data does not abide by syntactic and semantic rules of natural language. Repair order data often suffers from human writing errors and has a heavy influence of domain specific slang. Predii analyzes this data and discovers various bits of latent information and the inference relationship between the data.

PREDII SOLUTION: REPAIR INTELLIGENCE

The Predii Repair Intelligence™ engine interprets large volumes of data coming from both connected and disconnected vehicles, unstructured textual content, as well as, sub-system/component level IoT type of data (sensor and on-board diagnostic data coming from ECUs). The Predii Repair Intelligence™ engine has built-in, unsupervised learning algorithms to form correlations between symptoms, components, labor operations, and diagnostic trouble codes.



Results

Predii Repair Intelligence™ is already embedded in more than 100,000 hardware tools, performing automotive fault diagnosis. Our customers have processed more than 1 billion repair transactions while building a true data asset. The initial deployments of the Predii platform have powered more than 16 million Real Fixes to vehicles that are now back on the road. We continue to aim for exponential returns and growth for our customers.

Predii's innovation turned challenges into solutions for Snap-on. Predii provides a single cohesive solution to all stages of the automotive maintenance life cycle. Predii's software provides an effortless approach to problem detection, investigation, solution discovery and recommendation of corrective actions.

Data analytics at each stage provides feedback which enables Predii Repair Intelligence™ to learn and adapt to the changes in the operating environment. Predii Repair Intelligence™ has an extremely high rate of precision when recommending a repair solution.

Our customers have reported that using Predii Repair Intelligence™ has given them an ROI 20 times their initial investment and the accuracy of discovering a symptom, component, and a diagnostic trouble code has increased up to 94% (compared to a human interpreting the content).

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