Fault Detection and Diagnosis for Belt-Starter Generator

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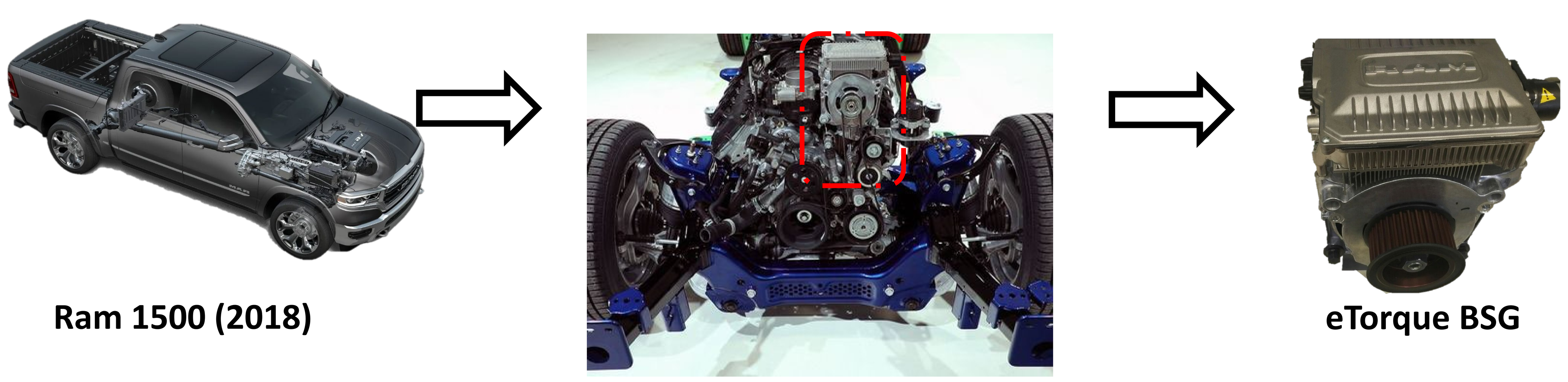
EECOMOBILITY (ORF) & HEVPD&D CREATE

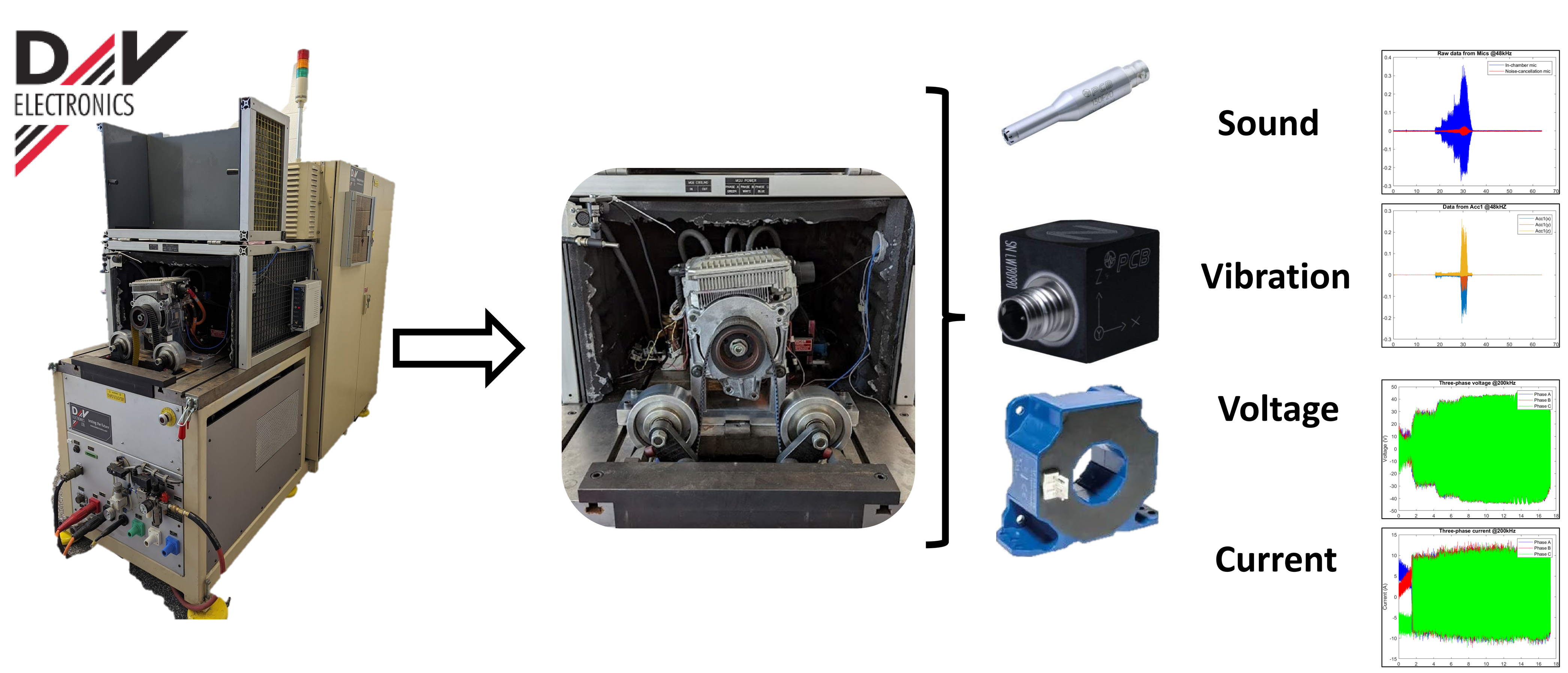
BELT-STARTER GENERATOR

As we become more environmentally conscious, it's no surprise that Hybrid Electric Vehicles (HEVs) and Electric Vehicles (EVs) are increasing in popularity among users in the automotive industry. With their fuel efficiency and lower operating costs, these cars are becoming a more practical choice for many. One crucial component is the Belt-Starter Generator (BSG), which connects the Internal Combustion Engine (ICE) crankshaft and the electric motor. This connection allows the ICE and the electric motor to work seamlessly together. The BSG can also assist with starting the engine, provide extra power during acceleration, and capture energy through regenerative braking, storing it in the battery.



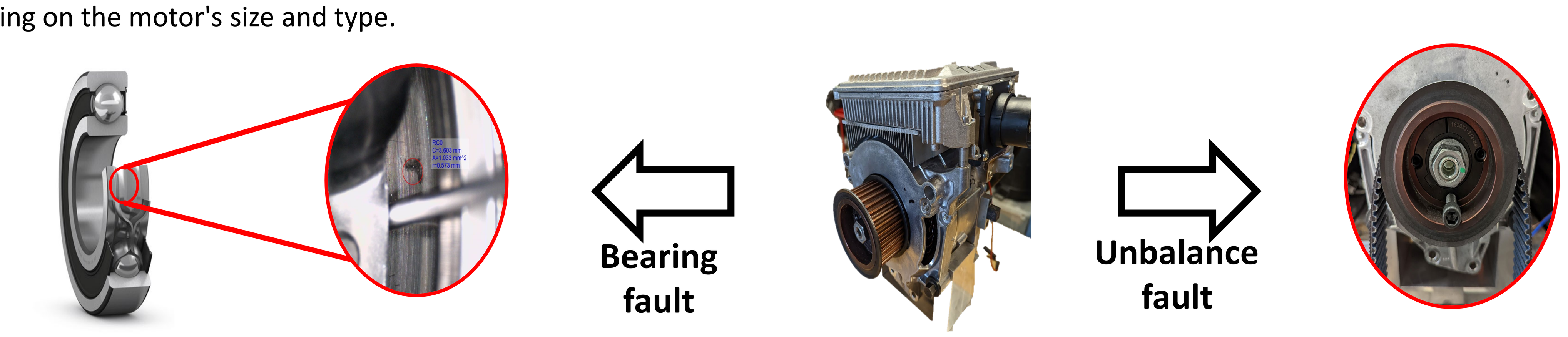
EXPERIMENTAL SETUP D&V ELECTRONICS

The testing equipment used for this project is a combination of the HT-250 Specialty Motor Testing tool from D&V Electronics, an industry partner, and the BSG eTorque from Stellantis, a partner in the automotive industry. To gather data, the HT-250 utilizes a dynamometer that facilitates variable torque and speed, while the Battery Simulator (BSIM) provides the voltage and current necessary for the BSG's controller. The BSG is a 3-phase induction motor that works on a 48-volt topology, and the test bench was used to collect signals, including acoustic noise, vibration, and 3-phase current and voltage.



MECHANICAL FAULTS

Electric motors are subject to mechanical faults due to various factors, such as poor maintenance, contamination, manufacturing defects, excessive loads, poor lubrication, or wear and tear. These faults can present themselves in various ways, such as decreased performance, noise, and vibrations. Common mechanical faults in electric motors include unbalanced and bearing faults, accounting for 40-50% of all failures, depending on the motor's size and type.

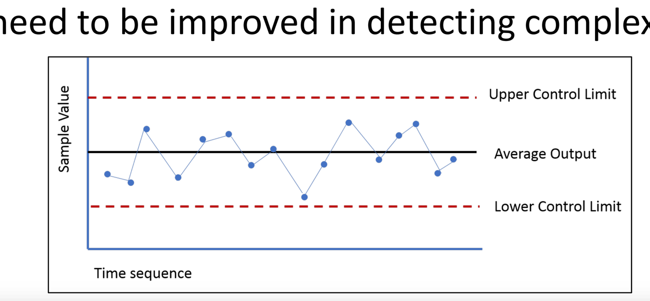


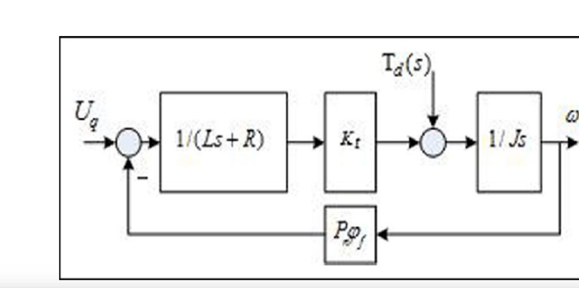
FAULT DETECTION AND DIAGNOSIS

•The goal of Fault Detection and Diagnosis (FDD) is to provide tools for health monitoring by detecting any abnormal behaviour from an unexpected range or detecting early symptoms and then diagnosing the characteristics and causes of faults that would prevent future damage, degradation or complete failure of the device.

•Identifying and repairing faults is critical in the industry to maintaining electric motors' health and longevity, improving their availability, quality, efficiency, and safety while reducing costs and downtime operation.

Traditional FDD techniques in industry involve limit checking with predefined boundaries for fault identification, providing no information about the location or reason for the fault in the electric motor. Model-based FDD techniques use mathematical models based on a detailed understanding of the motor's physical properties, behaviour, and operating conditions. However, traditional limit checking and model-based FDD techniques may need to be improved in detecting complex or intermittent faults.





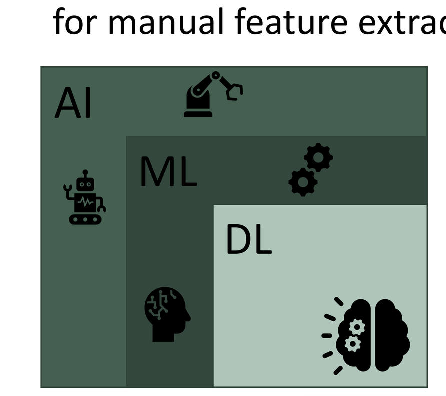
AI FDD TECHNIQUES

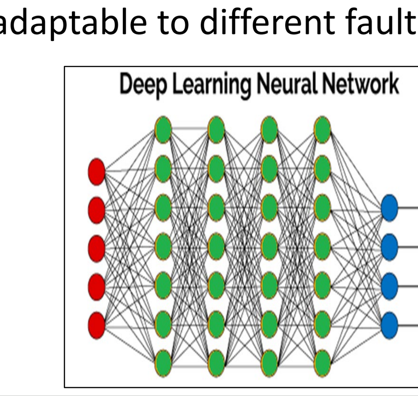
•In the past decade, industry and academia have worked on more data-driven approaches using Artificial Intelligence (AI), offering results in accuracy and adaptability.

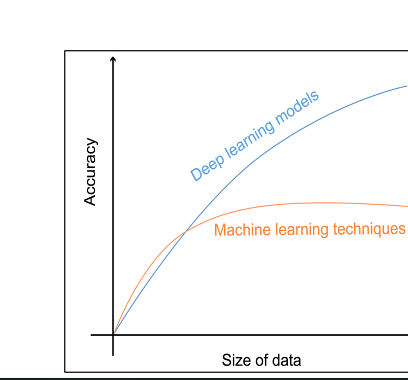
•AI techniques can be broadly classified into traditional ML and Deep Learning (DL) techniques.

•The performance of traditional ML techniques depends on the extracted features' quality and the classifier's choice. Traditional ML algorithms include Artificial Neural Networks (ANN), Principal Component Analysis (PCA), and Support Vector Machines (SVM), among others. Most of these methods report good results, with over 90% for classification accuracy.

•DL is a subset of ML that goes beyond in power by using higher amounts of data, resulting in an increase in performance and removing the need for manual feature extraction making it more robust and adaptable to different fault conditions.







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