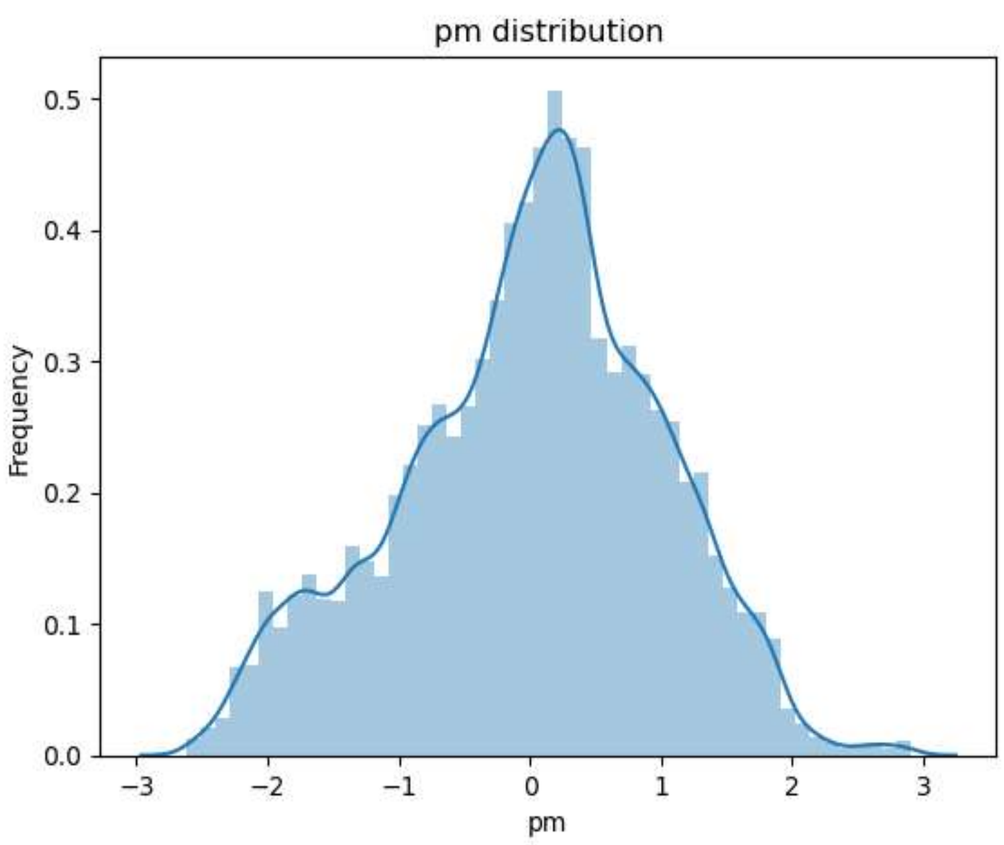
Vehicle Maintenance AI-ML Case Study

Consider, one manufacturer of electric cars hired to propose an estimator for the stator and rotor temperatures and design a predictive machine learning or deep learning model. Such a model could significantly help your new company to utilize new control strategies of the motors and maximize their operational performances. If an accurate Auto-ML model can bu built, the needs of the company for implementing additional temperature sensors in vehicles will be reduced. The potential contribution will directly result in lowering car construction and maintenance costs, and will convince the company to invest further in hiring DS experts.

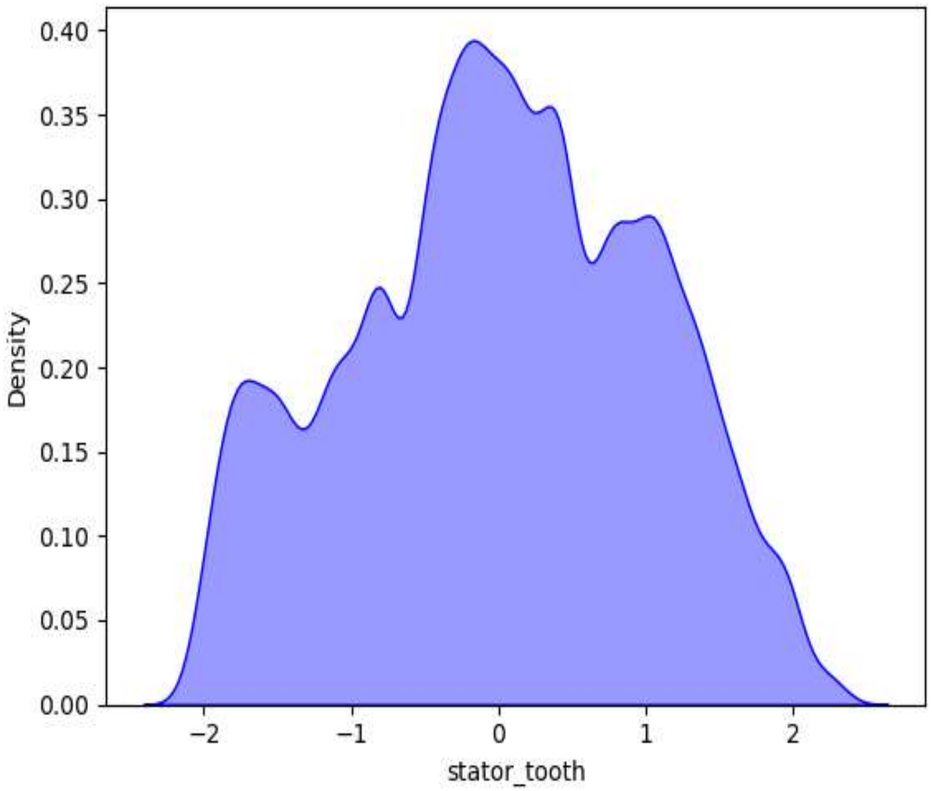
The main goal of the project is to help Improving Efficiency & Production Process of Electric Vehicles using Auto-ML Methods.



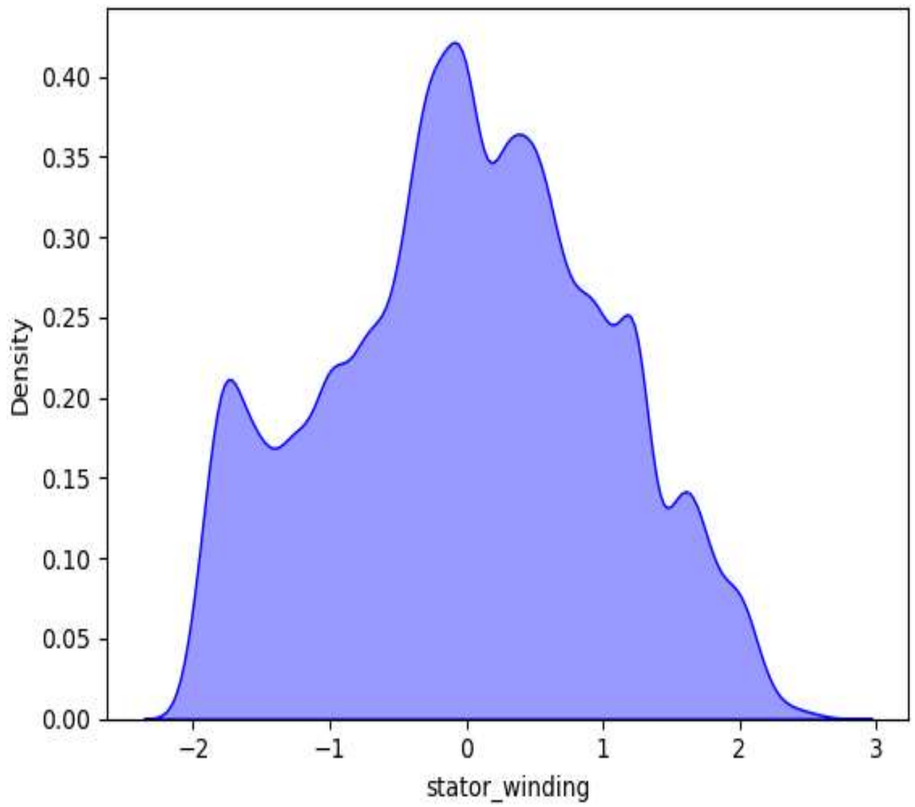
- The business feature we take for Vehicle Maintenace Industry is ‘pm’ [Permanent Magnet surface temperature (the rotor temperature) – measured with an infrared thermography unit]

- The most ‘pm’ distribution is from -1 to 1

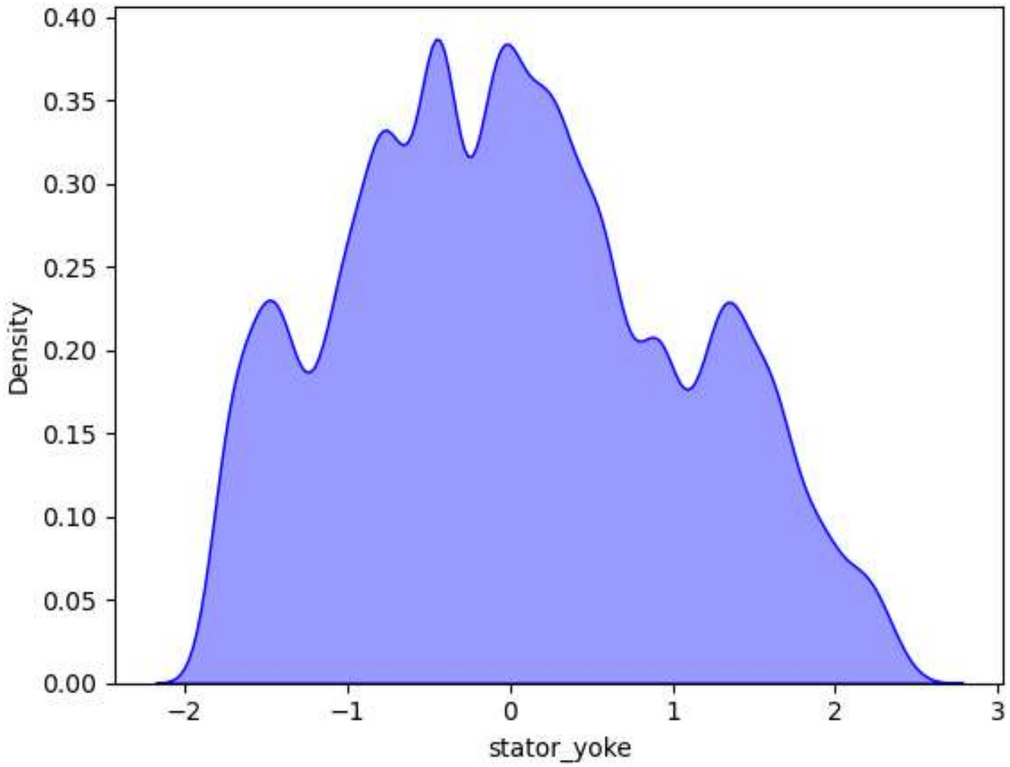
Features Responsible

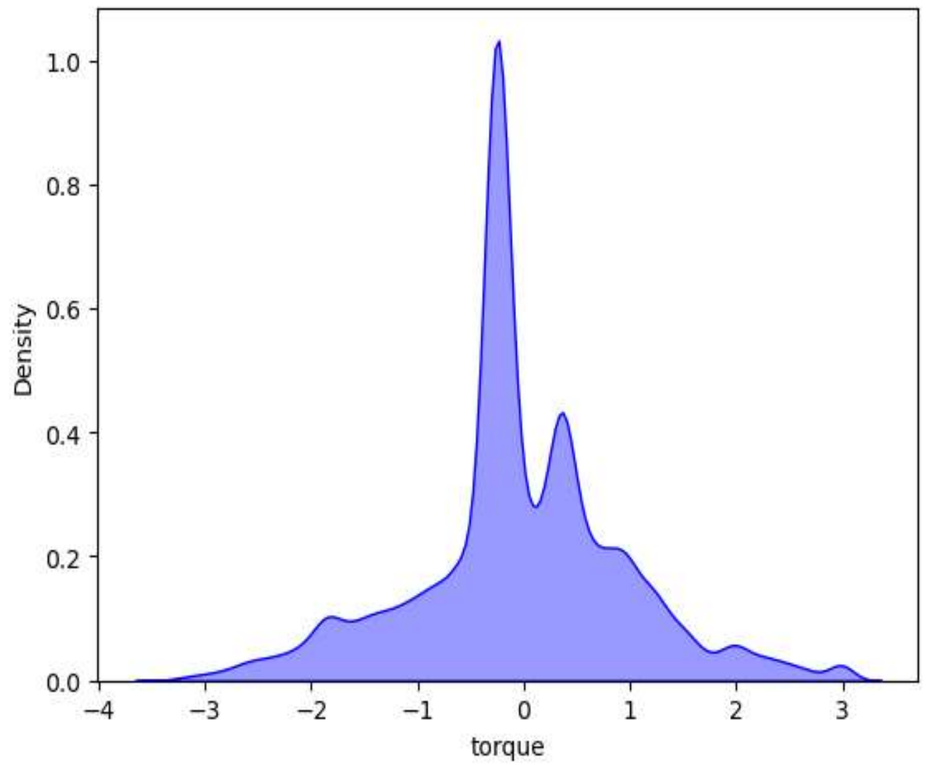


- **stator_tooth** = Stator tooth temperature – measured by a thermal sensor



- **stator_winding** = Stator winding temperature – measured by a thermal sensor
- In electrical motors or generators, the stator is the non-moving, fixed counterpart in a machine.





- **stator_yoke** = Stator yoke temperature – measured by a thermal sensor
- The magnetic frame or the yoke of DC motor made up of cast iron or steel and forms an integral part of the stator or the static part of the motor. Its main function is to form a protective covering over the sophisticated inner parts of the motor and provide support to the armature.

- **torque** = Torque induced by current
- One of the major benefits of driving an electric vehicle (EV) is the instant torque that they can produce. Measured in Newton Metres (Nm), torque is the turning or rotational power of the engine.

Auto-ML Methodology Results

Algorithms	Test Accuracy (25 percentile)	Test Accuracy (50 percentile)	Test Accuracy (75 percentile)	Test Accuracy (90 percentile)
Lasso	58.7	57.9	66.6	66.6
Random Forest	85.7	98	99.9	99.9
XGBoost	81	96.6	97.8	97.7
RNN	76.84	85.93	90.14	90.82
ANN	73.37	79.03	81.77	81.56
Total Features	3	6	9	10
Avg. Accuracy	75.122	83.492	87.242	87.316

- **Based on our observation from the standard ML algorithms, 90th percentile has the best average accuracy.**
- **Random Forest was the best performing algorithm with 99.9% accuracy in 75 and 90 percentile.**

Conclusion

- Data science and Auto-ML models can be trained to analyze equipment performance data, usage patterns, and other relevant information to predict when a vehicle or piece of equipment is likely to fail. This allows maintenance crews to proactively schedule repairs and maintenance, reducing downtime and improving overall efficiency. The dataset has 50,000 records with all 13 features as numerical.

- For regression, models were created with algorithms using Auto-ML techniques like Lasso, Random forest, XGBoost, Multilayer Perceptron, Recurrent Neural Network and Artificial Neural Network. With these models, performance measurement values were obtained for feature sets of 3, 6, 9 and 10. The Auto-ML algorithms were able to predict ‘pm (Permanent Magnet surface temperature)’ with an average accuracy between 75% – 88% and helped to determine factors that improve the efficiency of EV Vehicles. The major factors include stator_tooth, stator_windings, stator_yoke and torque. The Random forest with 99.9 % accuracy in 90th percentile where tree showed a threshold of stator_tooth >= 1.02 units and ambient <= -2.75 units which leads to lowest permanent magnet surface temperature.