- Accurate temperature measurement is crucial for safe operation of PMSMs in electric vehicles.
- One effective method is using LSTM and convolutional layer to learn temporal and local features of PMSMs

Estimating Electric Motor Temperature with LSTM+Conv1d

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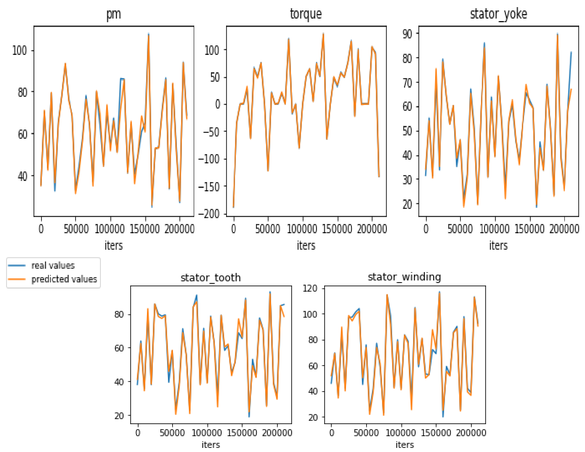
Results

- Estimating MSE for LSTM and LSTM+Conv1d in various experiments, including separate estimation of PM, torque, and three stator parameters, estimation of stator parameters and PM as one target vector, and estimation of all target parameters together.
- The five experiments revealed that the proposed method outperformed the one-layer LSTM model in terms of MSE, indicating its effectiveness in accurately predicting PMSM component temperatures.

MSE loss for each experiment

Experiments Targets	MSE (LSTM+Conv1d)	MSE (LSTM)
PM	0.019	0.0189
Torque	4.44e-05	6.71e-05
Stator_winding, Stator_yoke, Stator_tooth	0.022	0.026
PM, Stator_winding, Stator_yoke, Stator_tooth	0.020	0.025
PM, Torque, Stator_winding, Stator_yoke, Stator_tooth	0.0194	0.0198

- To compare precisely between predicted and actual values, the matching between them was demonstrated for all five parameters at every time step.



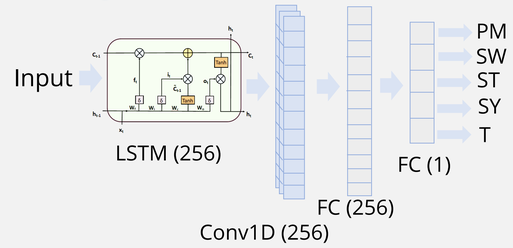
Comparison of real and predicted values per second

Introduction

- The emergence of a new generation of electric vehicles has led to significant developments in electric motor technology.
- PMSMs are a popular choice for electric vehicles due to their high efficiency in a wide range of speeds, but require accurate temperature measurement for safe operation.
- As PMSM temperatures are time-dependent, the proposed method employs LSTM followed by a convolutional layer to accurately predict them by capturing both temporal and local features.

Methods

- The network consists of an LSTM layer following a convolution layer with 256 units, and a fully connected layer with 256 units in the output layer.
- Predicting permanent magnet (PM), stator winding (SW), teeth (ST) and yoke (SY), and also torque (T), both separately and together.



Conclusion

- The objective of the study was to explore the effectiveness of RNN and CNN models in predicting component temperatures in PMSMs.
- The proposed model incorporated an LSTM network and a convolution layer to capture both temporal and local features, enabling separate and combined prediction of rotor and stator temperature parameters.
- As demonstrated by its accurate MSE predictions, the proposed method achieved a high level of performance.