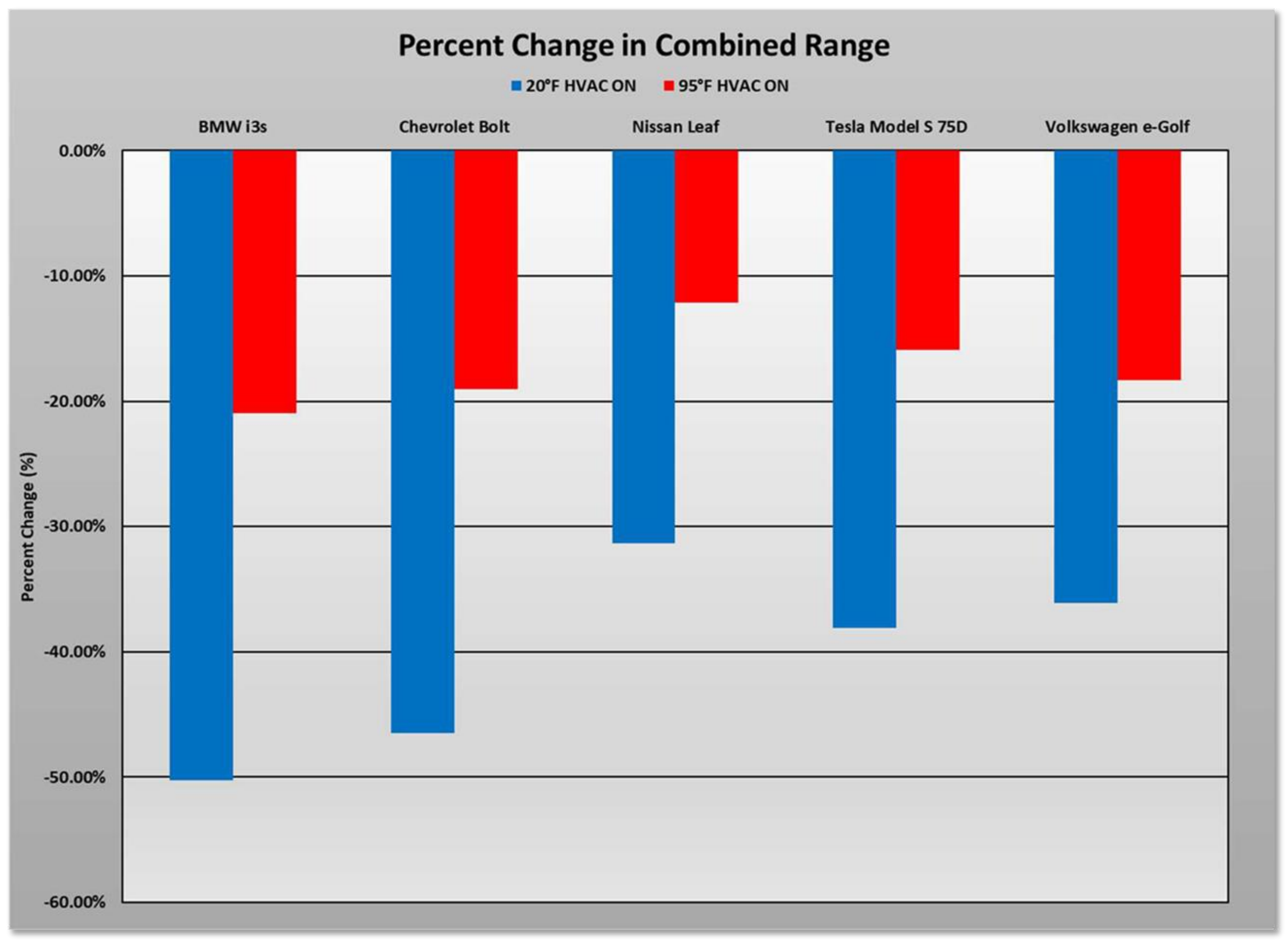
Electric Vehicle Range Improvement by Utilizing Deep Learning to Optimize Occupant Thermal Comfort

Alok Warey, Shailendra Kaushik, Bahram Khalighi, Michael Cruse, Ganesh Venkatesan

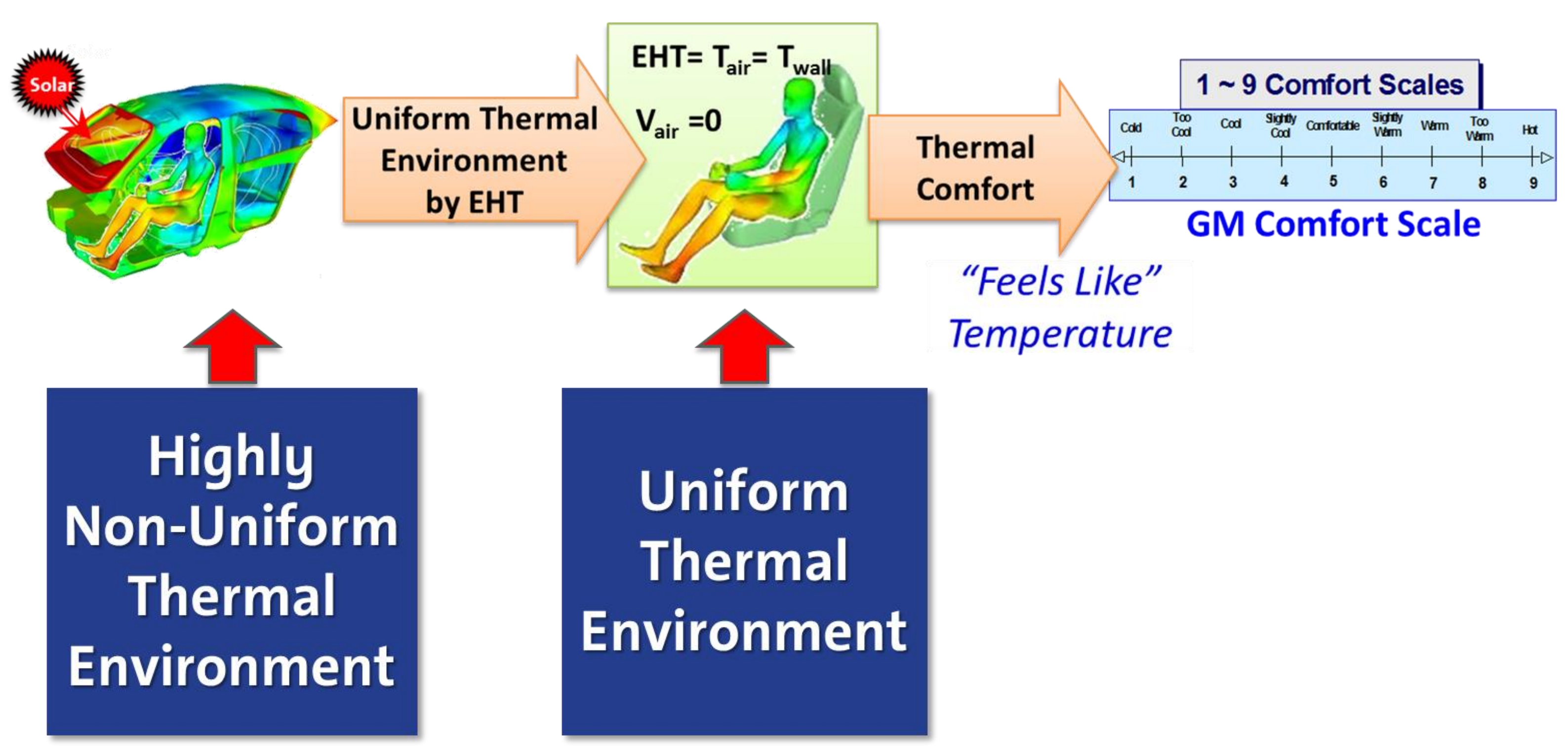
NEURAL INFORMATION PROCESSING SYSTEMS

Energy-efficient HVAC systems are critical for increasing EV range

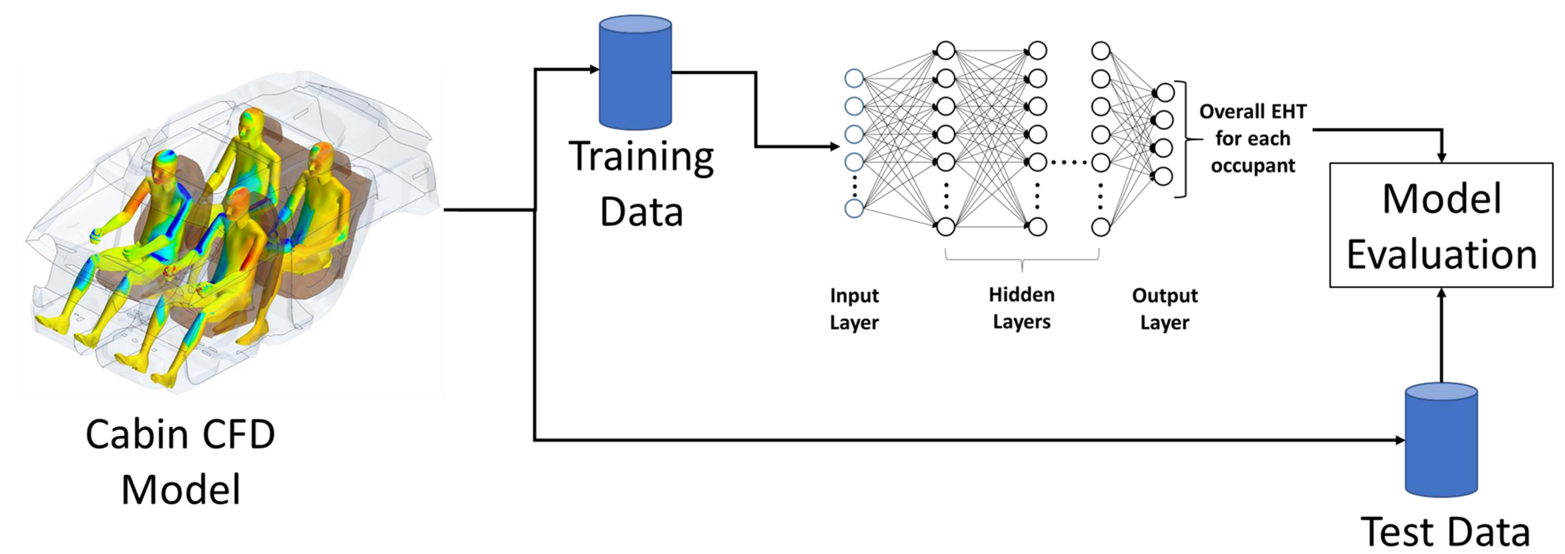


Source: AAA Newsroom, Icy Temperatures Cut Electric Vehicle Range Nearly in Half, https://www.aaa.com/AAA/common/AAR/files/AAA-Electric-Vehicle-Range-Testing-Report.pdf, 2019

Equivalent Homogeneous Temperature (EHT)



Steady-State Vehicle Cabin Computational Fluid Dynamics (CFD) Model

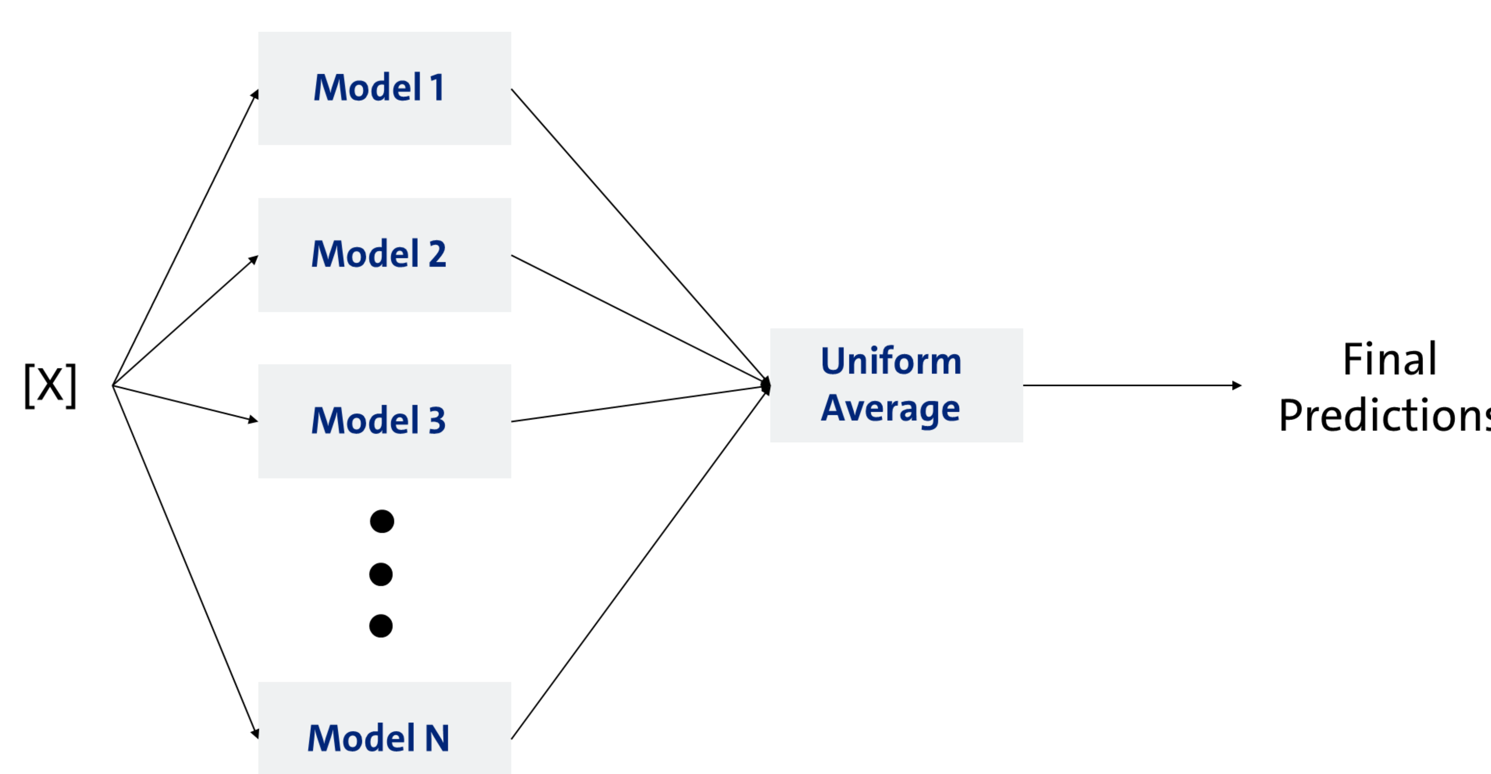


Total number of input variables/features: 104

Feature Category	# of Features
Environmental Variables	6
Convection HVAC Settings	14
Glass Glazing Properties (Visible and IR)	28
Heated Glass	6
Radiant Heating Pads	40
Climate Seats	8
Heated Steering Wheel	1
Passenger Profile	1
	Total: 104

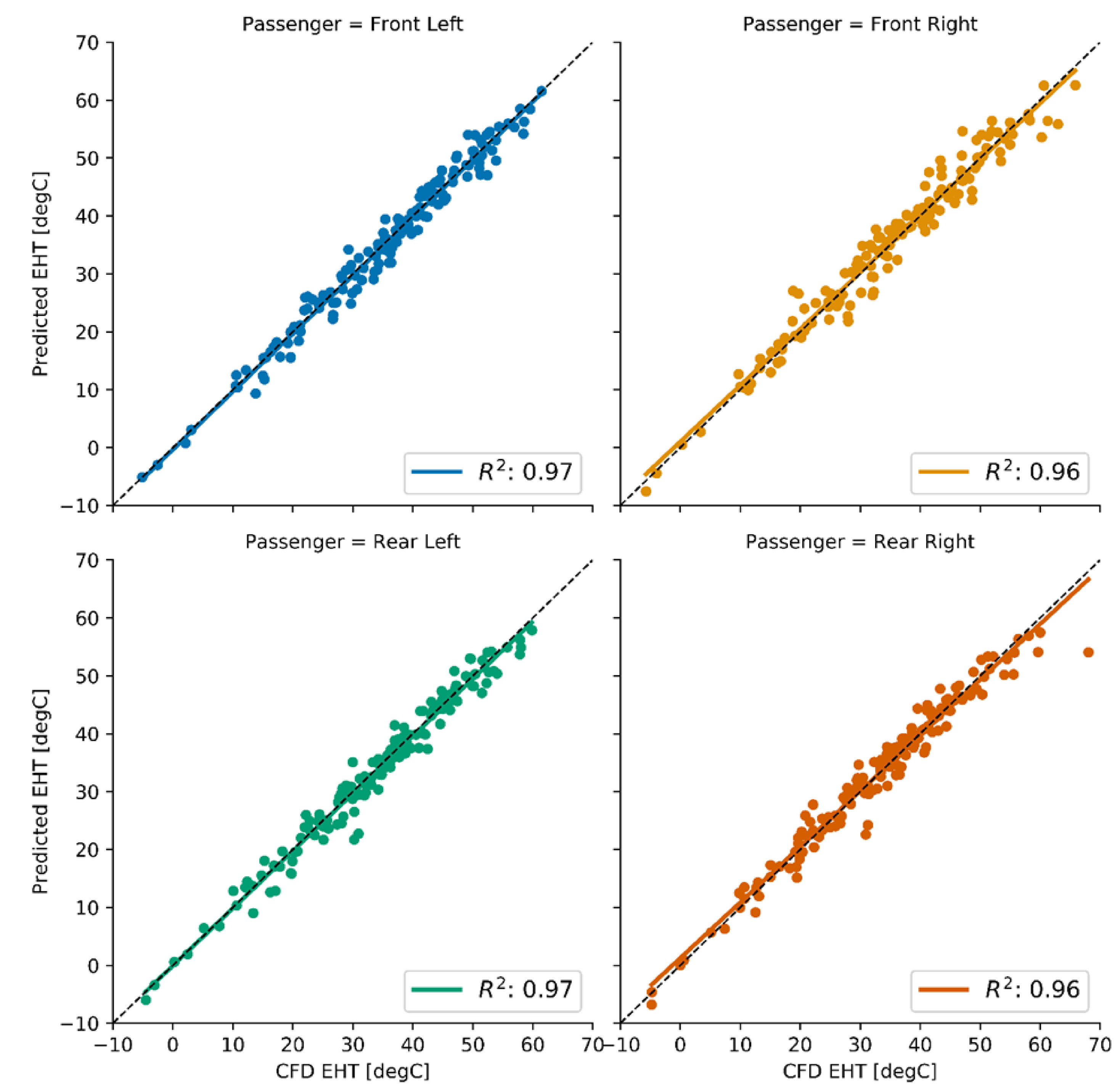
Total predicted variables: 4 (Overall EHT values for each occupant)

Uniform Average Ensemble of Artificial Neural Network (ANN) Models



Results of the ANN Ensemble Model on Test Set

Metric	EHT: Front Left (Driver)	EHT: Front Right	EHT: Rear Left	EHT: Rear Right
MAE [°C]	1.7	2.0	1.7	1.8
RMSE [°C]	2.2	2.7	2.2	2.5
MAPE [%]	5.6	6.8	6.3	6.8



Predicted EHT values (°C) by the ANN ensemble vs. EHT values from experimentally validated CFD simulations for all four passengers over the test set

Summary

- A deep learning model developed in this work enables predictions of thermal comfort for any combination of steady-state boundary conditions in real-time without being limited by time-consuming and expensive CFD simulations or climatic wind tunnel tests.
- This model has been deployed as an easy-to-use web application for HVAC engineers and its performance is being actively monitored.