



Thermal Management Systems Symposium

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October 14-15, 2025 | Ypsilanti, Michigan

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Thermal Management Systems Symposium

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AI-Driven Climate Control



Simply Cozy – The Modules



Ease of Use

- user-centered
- intuitive climate operating philosophy
- new look & feel

Simply Cozy – The Modules



Ideal Individual Comfort

- machine learning for completely individualized thermal comfort
- personalized climate calibration

Simply Cozy – The Modules



Al-Driven Climate Control

 Artificial intelligence for the development of climate functions and their calibration





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AI-Driven Climate Control

Al-Driven Climate Control – The Challenges



- Increasing system complexity
 - Extended range of sensors Additional climate components
 - · Seat-related air conditioning
 - Highly networked heat sources and sinks heat pump systems
- Increasing demands on occupant comfort and efficiency
- Decreasing development times
- Increasing pressure to be innovative
- Increasing risk of errors

Al-Driven Climate Control – The Challenges



Mastering complex functions with AI

- Al must fulfill some requirements to be usable as functional software for an automatic climate controller
 - Partially varying time dependencies of input and output data both on the system side and in terms of perception by occupants
 - Different relevance of sensor data depending on the specific sensor values
 - Beneficially puts history of conditions in context of current condition

Al-Driven Climate Control – Our Solution



IAV Solution

- Artificial neural networks inspired by the highly selective perception of the human brain
- Features:
 - Highly precise
 - Low resource requirements
 - Fast training success
 - Only sensor data and target values are required
 - There are no parameters and their chains of action that need to be known

Al-Driven Climate Control – Our Solution



- Further features
 - Reduced complexity
 One step function development and
 calibration
 - Parallel calibration possible
 worldwide in different climate zones by
 several developers
 - Classic functions in addition to Al possible e.g. defog / defrost, consistency checker
 - In accordance with homologation the final trained model is transferred unalterably to the control unit

Al-Driven Climate Control – Tech Insides



Underlying technology

- IAV-AI is based on the DA-RNN architecture, inspired by the selective attention of the human brain and has been further improved
 - Precise conditional and temporal selection of relevant values
 - In comparison to other architectures significantly improved precision of prediction
 - Processes variable number and type of input and output data via sophisticated encoder and decoder [3]
 - Compressed data reduce resource consumption

Al-Driven Climate Control – Tech Insides



- High proportion of virtual development possible
- No "classic" function development necessary
- Calibration independent of model and parameter operating chain knowledge
- Detailed tuning in the vehicle

Training Process

- Feed inputs (sensors, system states, environmental and other data) and outputs (controller targets) to the Al
 - e.g. available **recorded data** of the previous model version
 - **simulated data** for interior comfort / thermal management system.
- Whenever sufficient accuracy is reached, integrate it in your target vehicle
- Fine tune AI while using the vehicle and performing specific tests
- Need for changes in target values are inputted "in realtime" from occupants
- Feedback from target functions (including measurement data and comfort models etc.) possible as well

Al-Driven Climate Control – Results



Accuracy of setpoint formation

- Training on a subset of measurement data from a test vehicle, testing on the remaining data
- Comparison of target interior temperature and proportion of air recirculation prediction with high-performance AI architectures optimized for the use case
- Result: none of the comparative architectures can predict the control variables with sufficient accuracy.
- IAV-AI predicts almost completely in line with the real value
 - Almost no deviations
 - Steps, variations and static conditions are excellently reproduced or predicted, respectively

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Al-Driven Climate Control – Results



Training error

- Compared to other architectures
 - Better results in the first training run MSE ~ 0.1 vs. approx. 4
 - Only 5% of the training epochs are sufficient for a comparably relative rate of change of further MSE reduction
 - 3 orders of magnitude lower errors MSE ~ 0.001 vs. approx. 2

Al-Driven Climate Control – Results



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Test error

- Dramatically reduced test error compared to comparison architectures
- Only rare events stand out as singular peakse.g. by sensor init values
- Almost no deviation from zero-error line

Al-Driven Climate Control – Conclusion



Advantages of AI-Driven Climate Control

- Potentially faster and less complex calibration process
- No model development
- Challenging conditions are easily mastered
- Reduced complexity creates space for innovations
- Reduced probability of errors
 new function implementation, tuning of correct
 parameters for specific conditions

Timely parallel work possible worldwide

• High number of developers provide average of individual preferences (thermal perception) and thus potentially matching a larger quantity of customers

Contact Info

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