TU Clausthal

Institut für Software and Systems Engineering

# Teaching Novices Supervised Learning with Autonomous Model Vehicles
# 32nd IEEE International Conference on Software Engineering Education & Training Strategies and Challenges

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**Technische Universität Clausthal**

**Institute for Software and Systems Engineering**

**Dependable and Autonomous Cyber-Physical Systems**

# Agenda

1. Team
2. Motivation
3. Approach of Teaching Artifical Intelligence
4. Setup of Deep Driving Workshop at ESG Technologieforum
5. Overall Software Architecture
6. Workshop Process
7. Feedback and Conclusion

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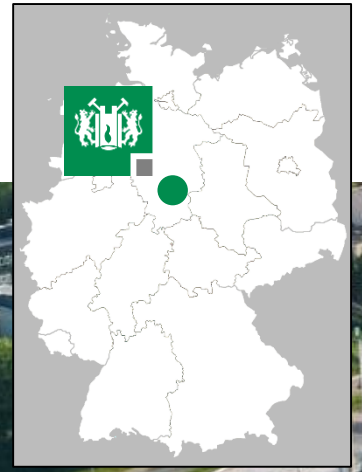
# 1. Team

- Technische Universität Clausthal
- Institute for Software and Systems Engineering
- Research Group: Dependable and Autonomous Cyber-Physical Systems
- Feel free to contact us
  - https://www.tu-clausthal.de/
  - https://www.isse.tu-clausthal.de/
  - https://www.isse.tu-clausthal.de/forschung/forschungsgruppen/dependable-and-autonomous-cyber-physical-systems



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# 2. Motivation

- Artificial Intelligence is hardly understandable for general public
  - Understanding requires in-depth knowledge of higher mathematics
  - Even if the usage Artificial Intelligence is becoming more popular it is still used in special areas
- Media reports are neither positive nor negative [2, 3]
- Nonetheless there is scepticism and concerns about this topic [1, 4]
- **Research Question:** How could the public be educated about the applicability and limitations of AI and which format should be chosen so that people without any previous knowledge can also quickly understand the topic?

1. M. Hengstler, E. Enkel, and S. Duelli, “Applied artificial intelligence and trust - the case of autonomous vehicles and medical assistance devices,” Technological Forecasting and Social Change, vol. 105, pp. 105 – 120, 2016. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0040162515004187
2. E. Fast and E. Horvitz, “Long-term trends in the public perception of artificial intelligence,” in Proceedings of the Thirty-First AAAI Conference on Artificial Intelligence, ser. AAAI’17.
3. C.-H. Chuan, W.-H. S. Tsai, and S. Y. Cho, “Framing artificial intelligence in american newspapers,” in Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society, ser. AIES ’19. New York, NY, USA: Association for Computing Machinery, 2019, p. 339–344. [Online]. Available: https://doi.org/10.1145/3306618.3314285
4. L. Ouchchy, A. Coin, and V. Dubljeví´c, “AI in the headlines: the portrayal of the ethical issues of artificial intelligence in the media,” AI & SOCIETY, 2020.

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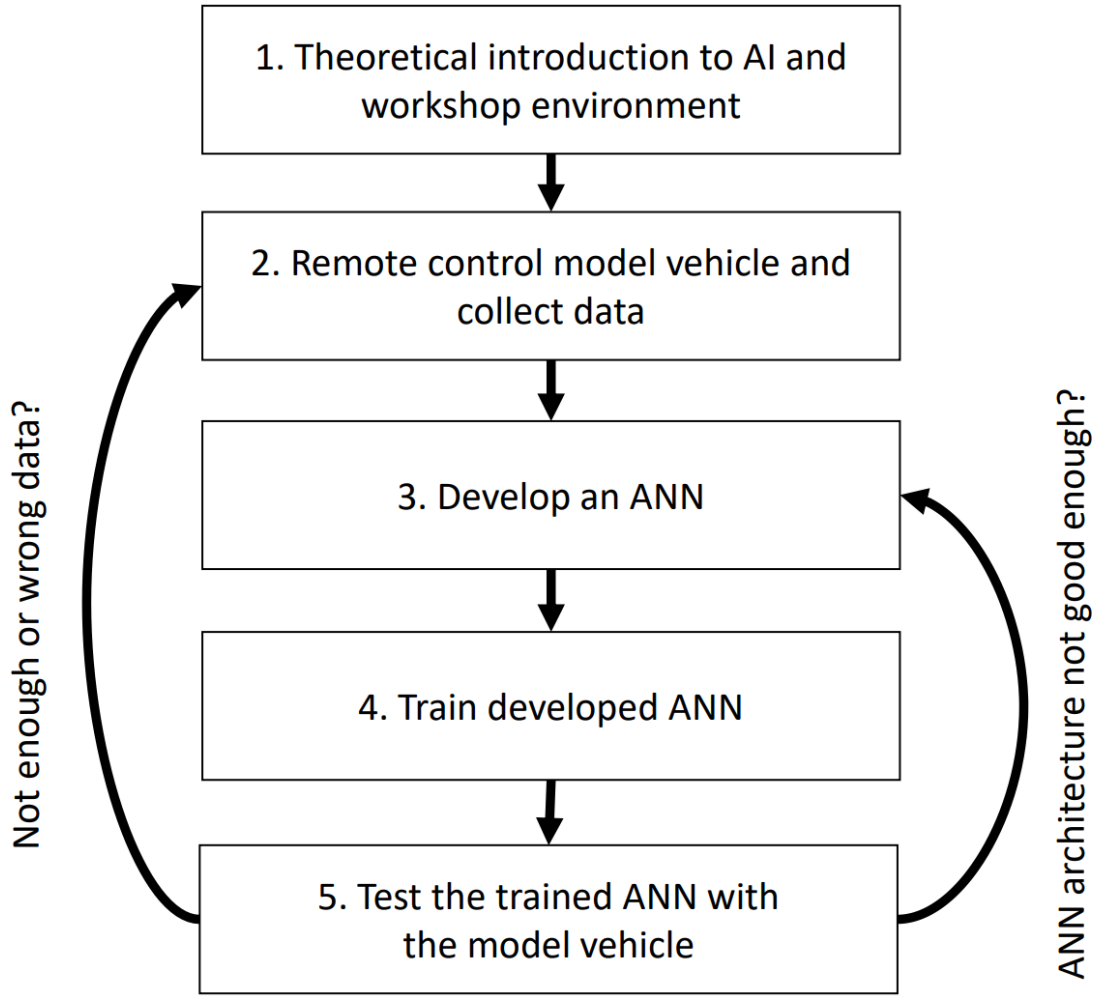
# 3. Approach of Teaching Artifical Intelligence



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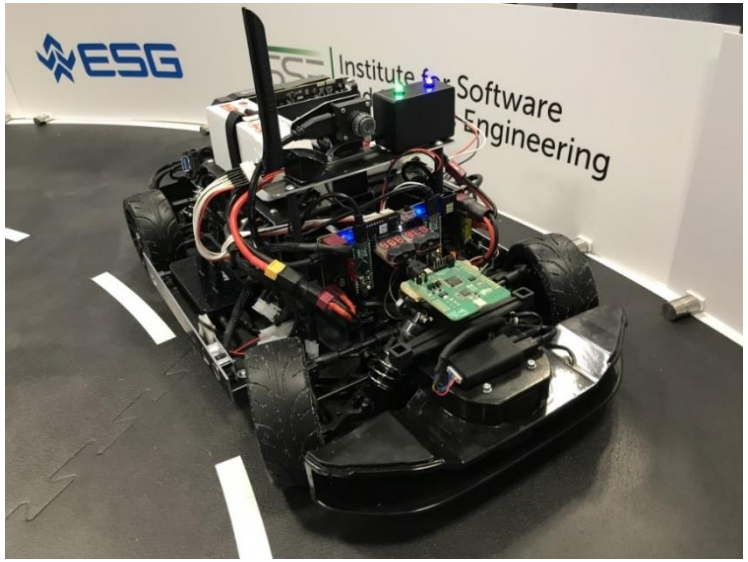
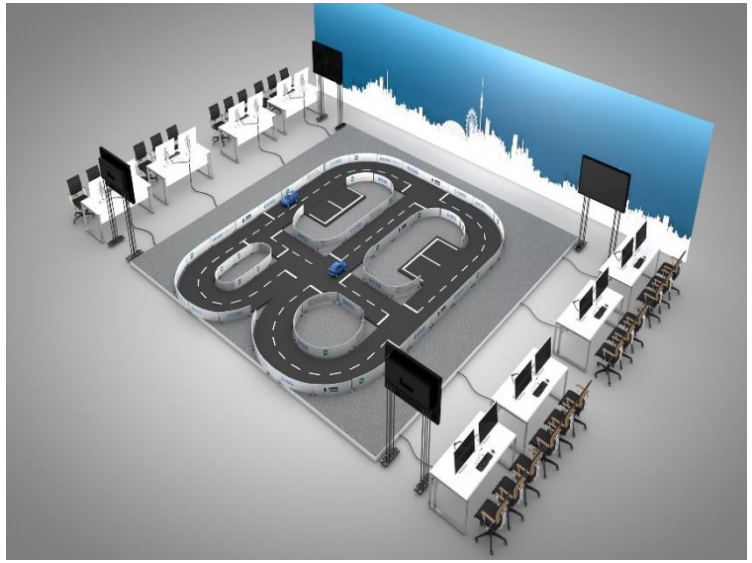
# 4. Setup for Deep Driving Workshop at ESG Technologieforum

- 2 workshop groups of 8 participants each
- 2 ADAS model cars [1]
- 2 tracks
- Modular track parts
  - Mats with lanes
  - Bands
- 8 learning stations
  - 1 High-End PC
  - 2 monitors
  - 2 workshop participants
- 4 visualisation monitors
- 1 High-End PC for infrastructoral software components




1. https://www.digitalwerk.net/adas-modellauto/

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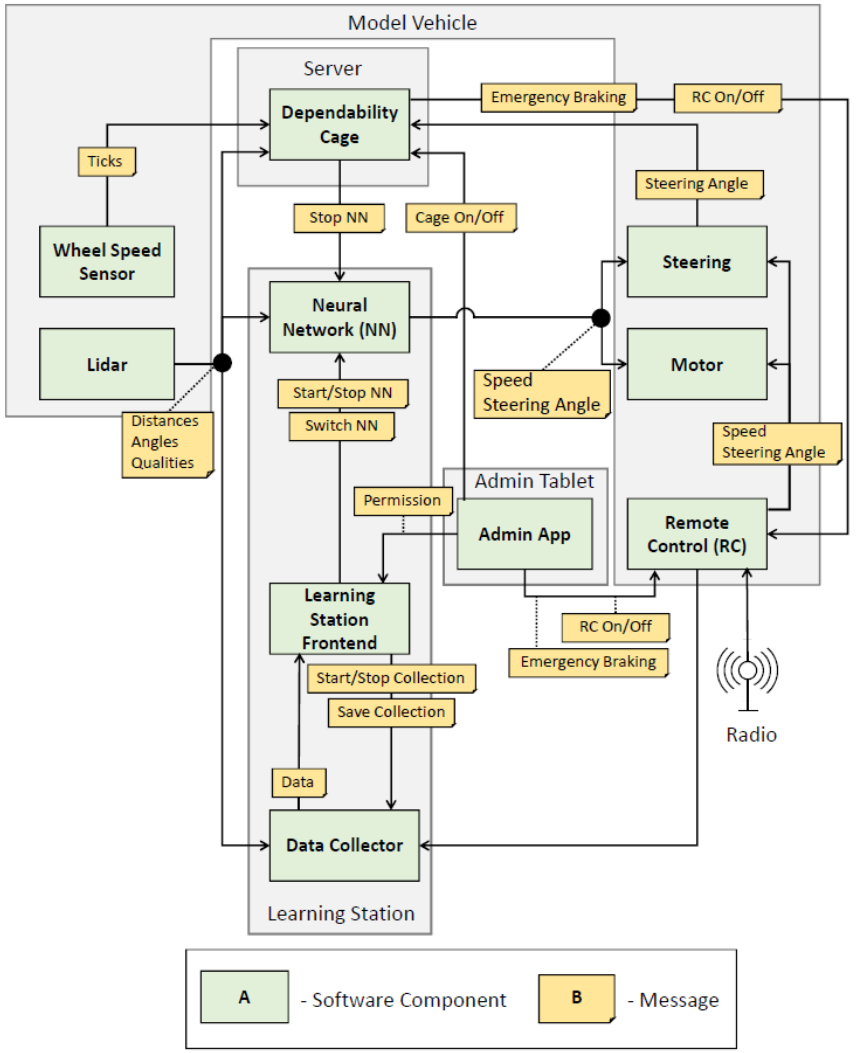
# 5. Overall Software Architecture

- **Learning Station Frontend** to guide workshop participants without complex implementation details
- **Remote Control (RC)** to let the ADAS model cars be manual driven by workshop participants (Motor and Steering)
- **Motor** and **Steering** to control the actuators
- **Lidar** to deliver point clouds as input for the Neural Network (NN) and Data Collector
- **Data Collector** to collect lidar point clouds for NN training
- **Neural Network (NN)** for autonomous ADAS model car control based on End-to-End Learning
- **Dependability Cage** (Qualitative Runtime Monitor) to ensure that „nothing bad“ will happen [2]
- **Wheel Speed Sensor** to determine Speed for the Dependability Cage
- **Admin App** to help workshop supervisors to control resources
- *Integration was realized using the middleware MQTT* [1]




1. http://mqtt.org/
2. A. Aniculaesei, J. Grieser, A. Rausch, K. Rehfeldt, and T. Warnecke, “Towards a holistic software systems engineering approach for dependable autonomous systems,” in 2018 ACM/IEEE 1st International Workshop on Software Engineering for AI in Autonomous Systems, R. Stolle, S. Scholz, and M. Broy, Eds. Piscataway, NJ: IEEE, 2018, pp. 23–30.

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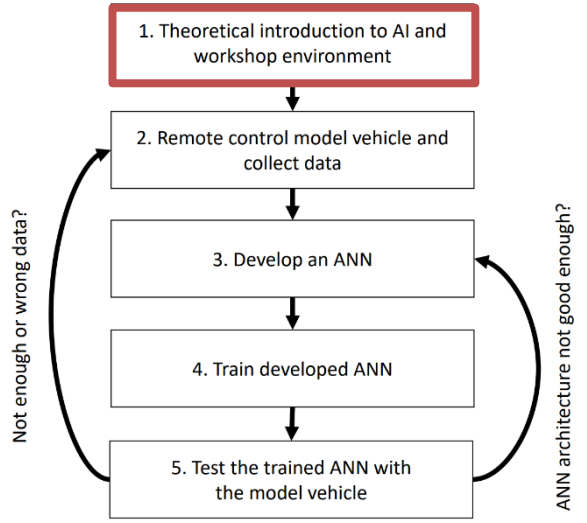
# 6. Workshop Process: Introduction

- Classic- vs. End-to-End Learning based autonomous driving
- Basics of Deep Learning
  - General idea
  - Layers
  - Neurons
  - Activation functions
  - Network- and hyperparameters
- Workshop environment
  - Learning Station Frontend
  - ADAS model car
  - Track
- Handout



# 6. Workshop Process: Data Collection

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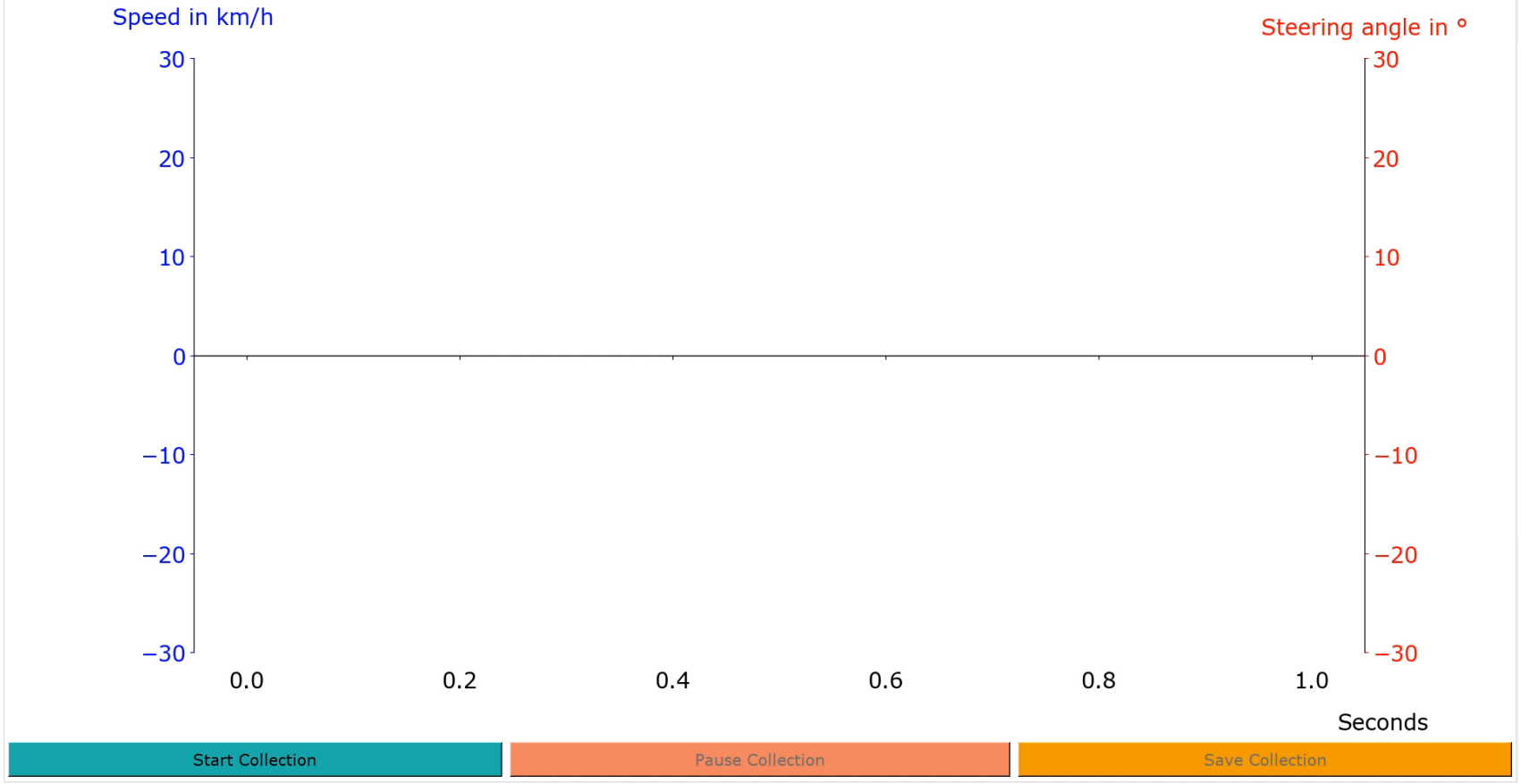
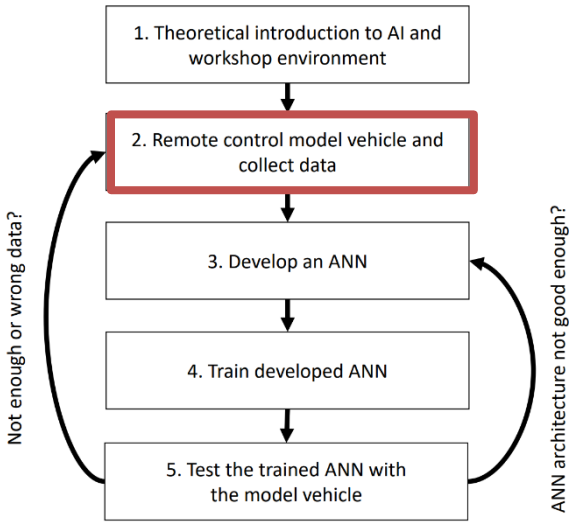
**1. Collect training data** | **2. Configure network and training** | **3. Train network** | **4. Test network**

Lidar: 0 X 180 Points



# 6. Workshop Process: Development of Neural Networks

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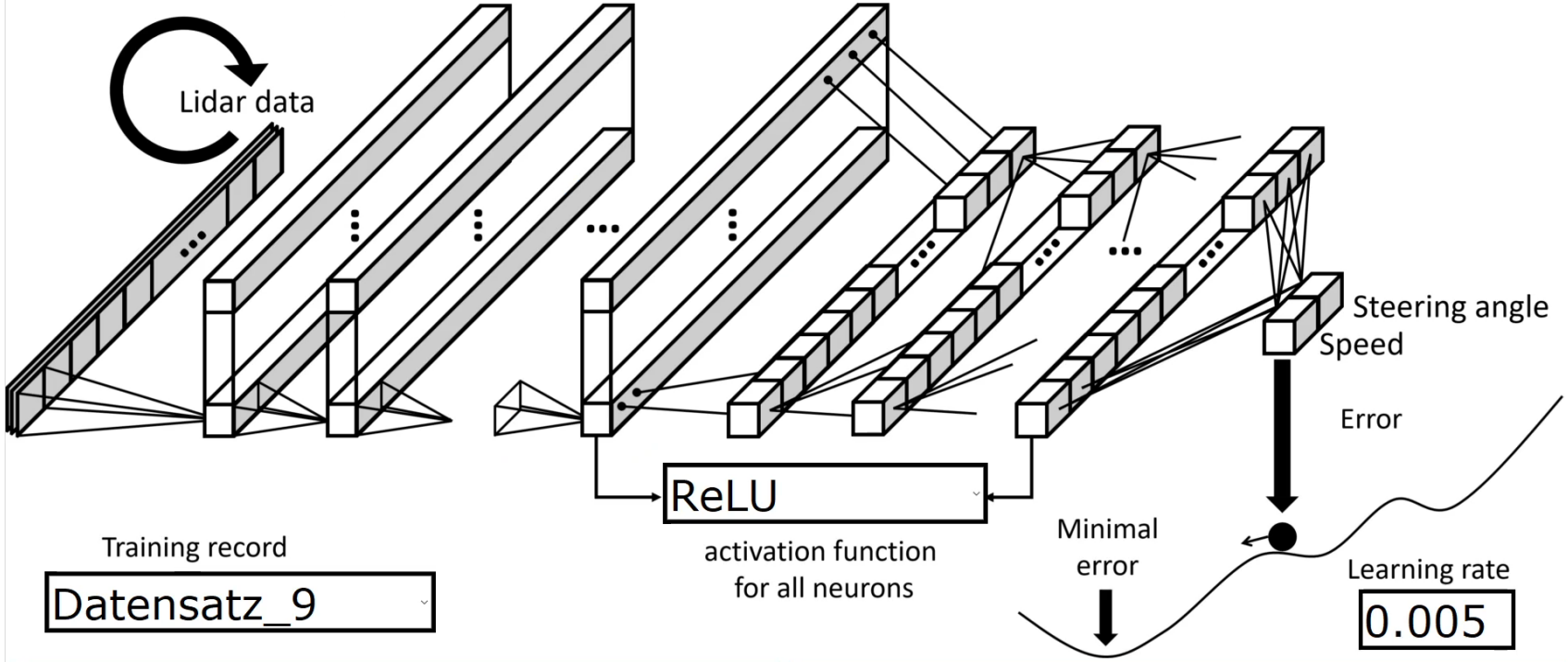
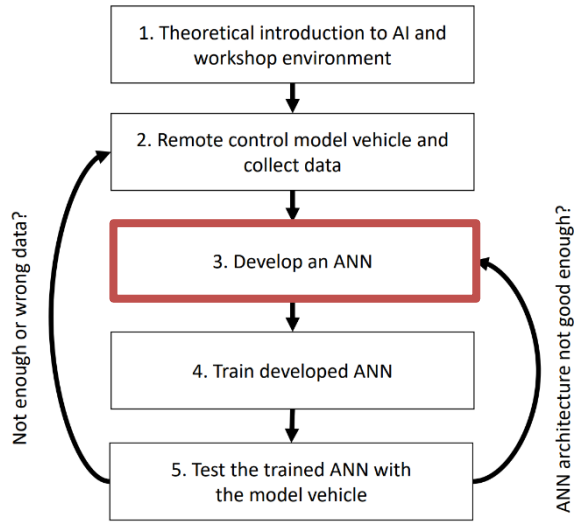
**1. Collect training data** | **2. Configure network and training** | **3. Train network** | **4. Test network**

Number of epochs: 80

Subnet for lidar data analysis: Number of layers and neurons per layer: 16, 64

Subnet for driving manoeuvres: Number of layers and neurons per layer: 500, 250, 50



# 6. Workshop Process: Training of Neural Networks

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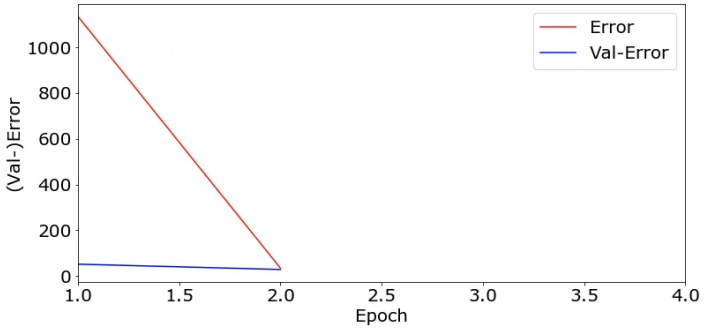
**1. Collect training data** | **2. Configure network and training** | **3. Train network** | **4. Test network**

**Error history of the training**



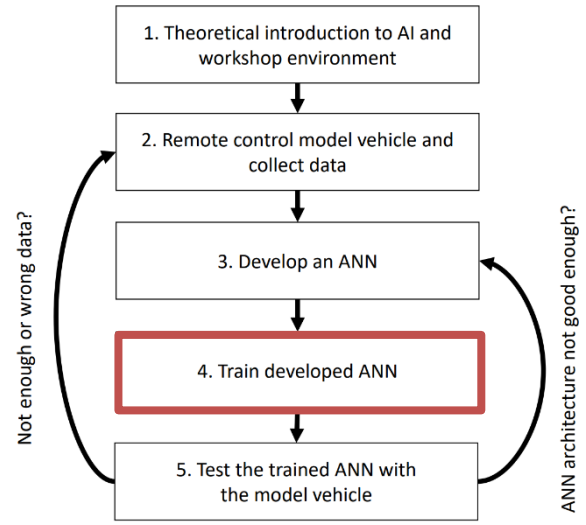

**Training Progress**

| Epoch | Error | Val-Error | Duration |
|---|---|---|---|
| 1 | 1134.95 | 51.47 | 10.37 |
| 2 | 34.23 | 28.19 | 5.87 |

**Network and Training Configuration**

| Parameter | Value |
|---|---|
| Number of epochs | 100 |
| Learning rate | 0.01 |
| Training record | Datensatz_10 |
| Activation function | TanH |
| Subnet for lidar data analysis | 16, 32 |
| Subnet for driving manoeuvres | 500, 250, 50 |

Start Training | End training manually



# 6. Workshop Process: Testing of Neural Networks

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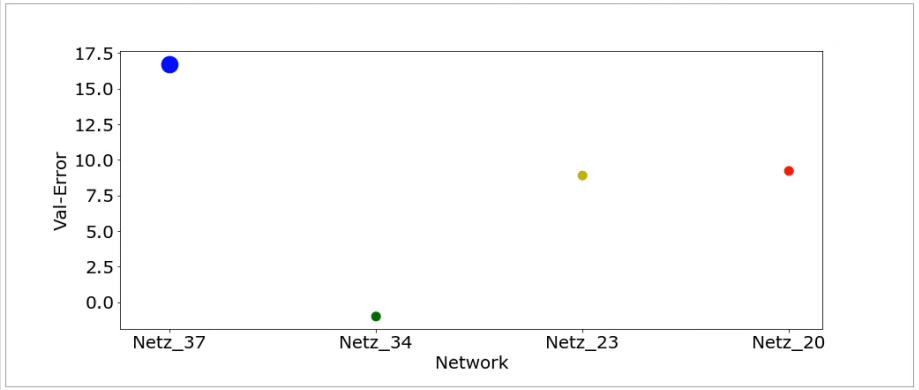
1. Collect training data | 2. Configure network and training | 3. Train network | 4. Test network

**Comparison of TOP-3 networks with current network**



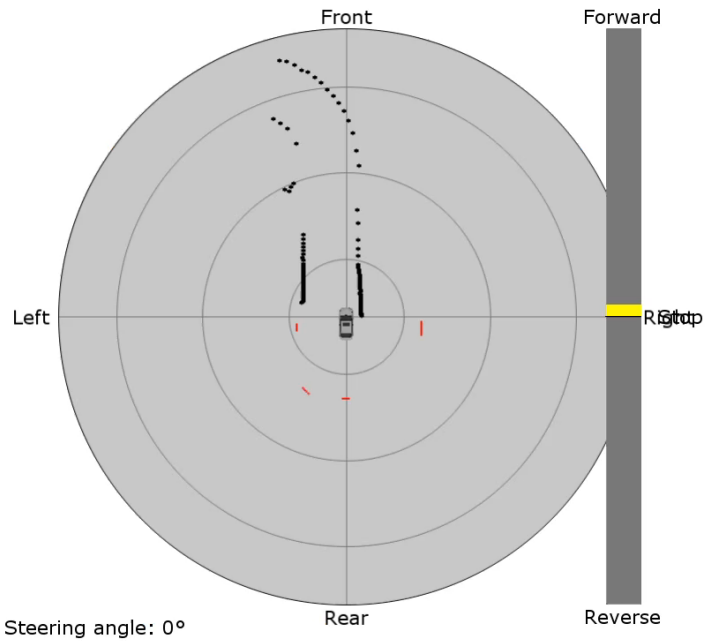

**Ranking of all networks**

| Network | Val-Error |
|---|---|
| Netz_23 | 8.9 |
| Netz_20 | 9.22 |
| Netz_21 | 9.95 |
| Netz_14 | 10.88 |
| Netz_35 | 11.02 |
| Netz_19 | 11.04 |
| Netz_15 | 11.43 |
| Netz_12 | 11.54 |
| Netz_26 | 12.07 |
| Netz_16 | 13.48 |
| Netz_13 | 14.26 |

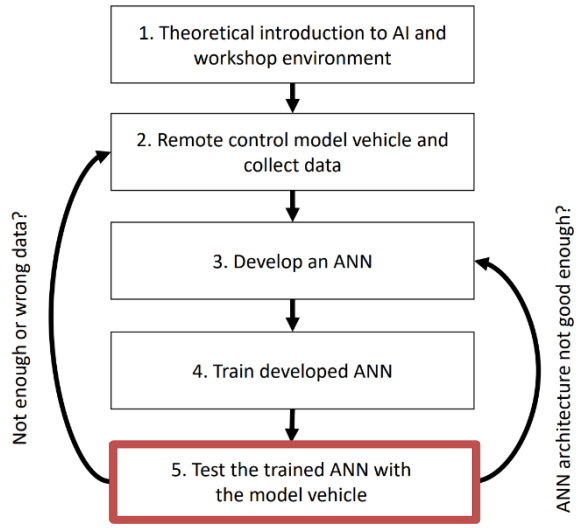
**Installation**

Network: Netz_22 | Status: Off | Install

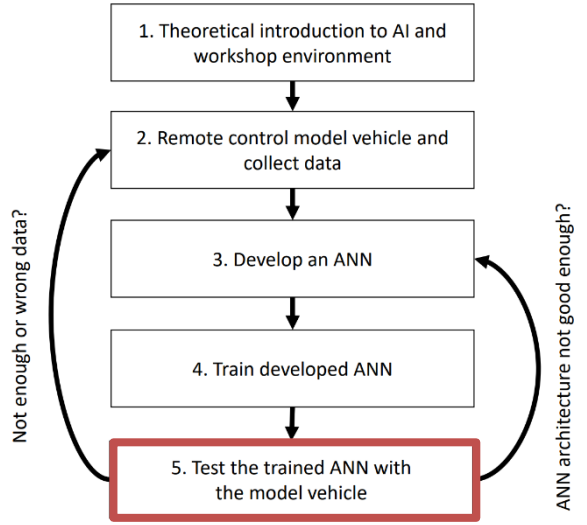
**Current vehicle data**




Start Test | Stop Test



# 6. Workshop Process: Testing of Neural Networks

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# 7. Feedback and Conclusion

- 4 groups of 12 people each = 48 workshop participants
- 24 workshop participants were asked for feedback
- Some participants had already a basic understanding of this topic
- This approach exceeded our expectations our expectations
  - Even in limited time period
  - Satisfied workshop participants
  - Lively discussions with workshop participants from different working areas

# Acknowledgement

Special thanks goes to **ESG GmbH** in Germany and the 48 workshop participants

**Thank you very much!**

# Thanks for your attention!