AIR FORCE

GERMAN AIR FORCE CENTER OF AEROSPACE MEDICINE

Department I 3 a – Ergonomics, Experimentation und Research

Pilot assistence based on user state inference using an artificial neural network

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BUNDESWEHR

OUTLINE

1. **Do we need a pilot assistance system?**
2. **Artifical neural network (ANN)**
3. **Measuring Workload**
4. **Assistance system**
5. **Outlook**

https://wall.alphacoders.com/big.php?i=875572&lang=German

- Modern Cockpits have high information density

- Trend towards operating drone swarm from mobile base station (carrier)
  ➡ MUM-T

- Higher speeds and agility
  ➡Increased mental workload for pilot / operator

- Long-haul flights

- Monotonous task
  ➡Low mental workload leads to fatigue

<u>Both states increase the risk of mistakes and have to be addressed</u>

A400M Simulator Bundeswehr/Volker Muth

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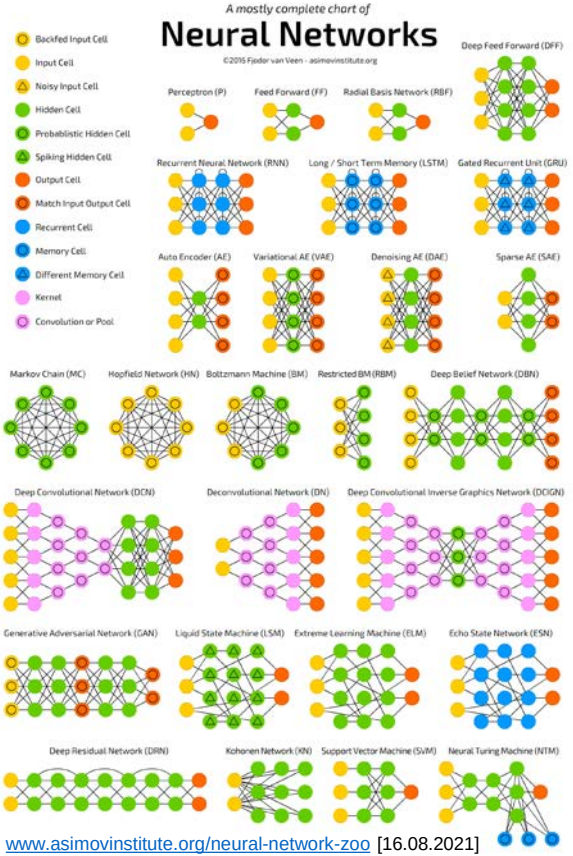
- Imitation of Neurons in the Human brain
- Base: Perceptron
- Feed-Forward networks with Back-Probagation
- Known use-cases:
  - RN Networks: machine translation (short texts)
  - GA Networks: Upscaling
  - DC Networks: face recognition
  - VAE: Deepfakes
- Discussion regarding cognitive neural networks
  - Prediction of Human behaviour

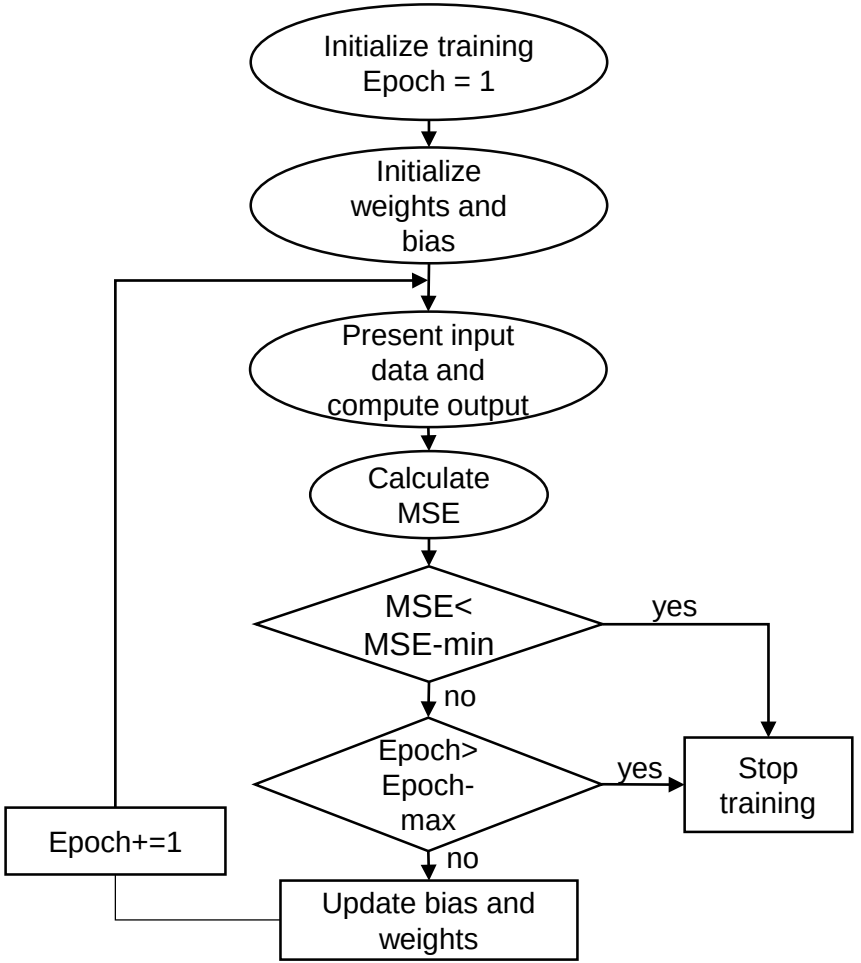


www.asimovinstitute.org/neural-network-zoo [16.08.2021]

- Networks need to be trained
  - Specialized towards specific tasks

- Different ways to train the network:
  - Supervised Learning
  - Unsupervised Learning
  - Semi-Supervised Learning
  - Reinforcement Learning
  - Federated Learning
  - Deep Learning

- All need a large dataset
  - Difficult to obtain
  - Need data for all possible user states



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Main requirements:

- The measurements may not impede the main objective of the pilot / operator

- The measurement has to be usable to infer the user state:
  - Small time-difference for changes
  - Direct Evaluation has to be possible

Tabelle 3.1: Klassifizierung für die verschiedenen passiven Methoden der Messung/Abschätzung der Workload.

Klassifizierung	Methode	Interaktion
Intrusiv	EEG	Elektroden am Kopf des Benutzers
Non-intrusiv	EEG	Elektroden in Helm integriert
Intrusiv	EKG	Elektroden am Oberkörper des Benutzers
Non-Intrusiv	EKG	„*Smart Textiles*“
Intrusiv	Augenbewegung	
Non-Intrusiv	Augenbewegung	
Non-Intrusiv	Atmung	Messung über „*Smart Textiles*“
Intrusiv	Hormone	Messung durch direkte Abgabe von Proben
Non-Intrusiv	Hormone	Messung über normale Speichelausscheidung (z.B. beim sprechen)
Intrusiv	Temperature	Messung mittels Thermometer direkt am Körper (übliche Stellen)
Non-Intrusiv	Temperature	Messung mittels Infrarot, oder „*Smart Textiles*“
Intrusiv	Hautleitfähigket	Messung über speziell geklebte Elektroden am Arm/Bein
Non-Intrusiv	Hautleitfähigkeit	Messung mittels „*Smart Textiles*“

Either integrated into the helmet or separate

Standard electrodes

Eye Tracking difficult in jets

Breathing

Hormons

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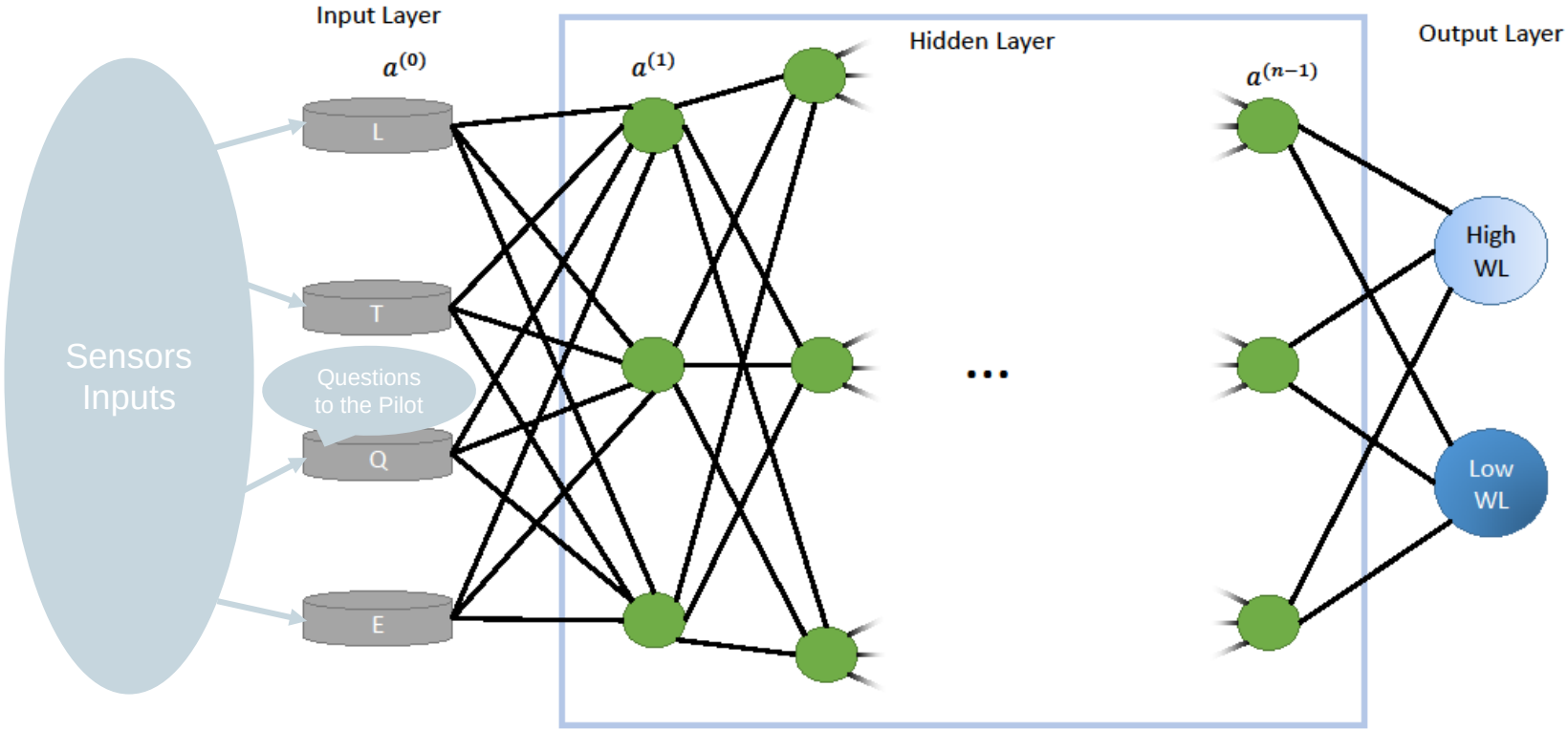
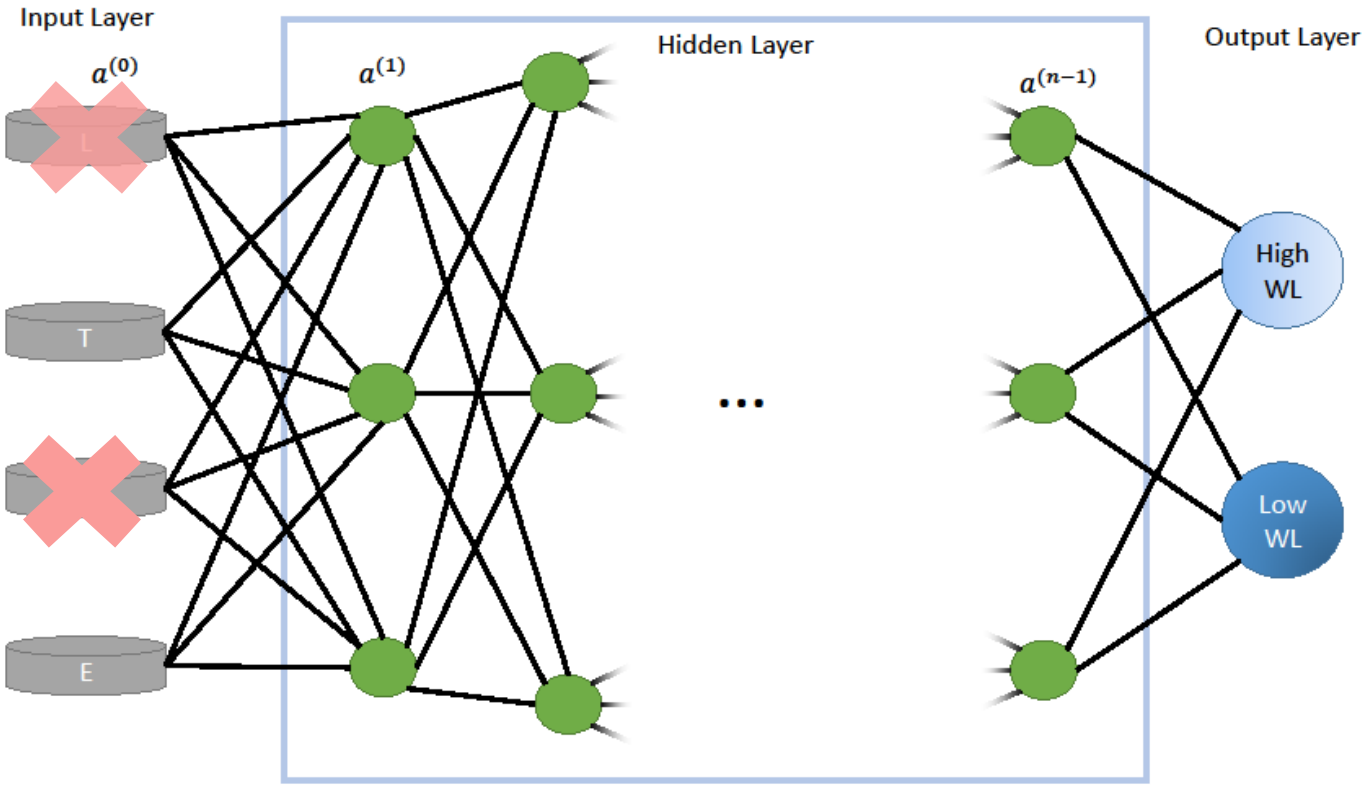

Input Layer
$a^{(0)}$
$a^{(1)}$
Hidden Layer
$a^{(n-1)}$
Output Layer
Sensors Inputs
L
T
Questions to the Pilot
Q
E
High WL
Low WL

physiological Data (MobPhysioLab, Smart Textiles)

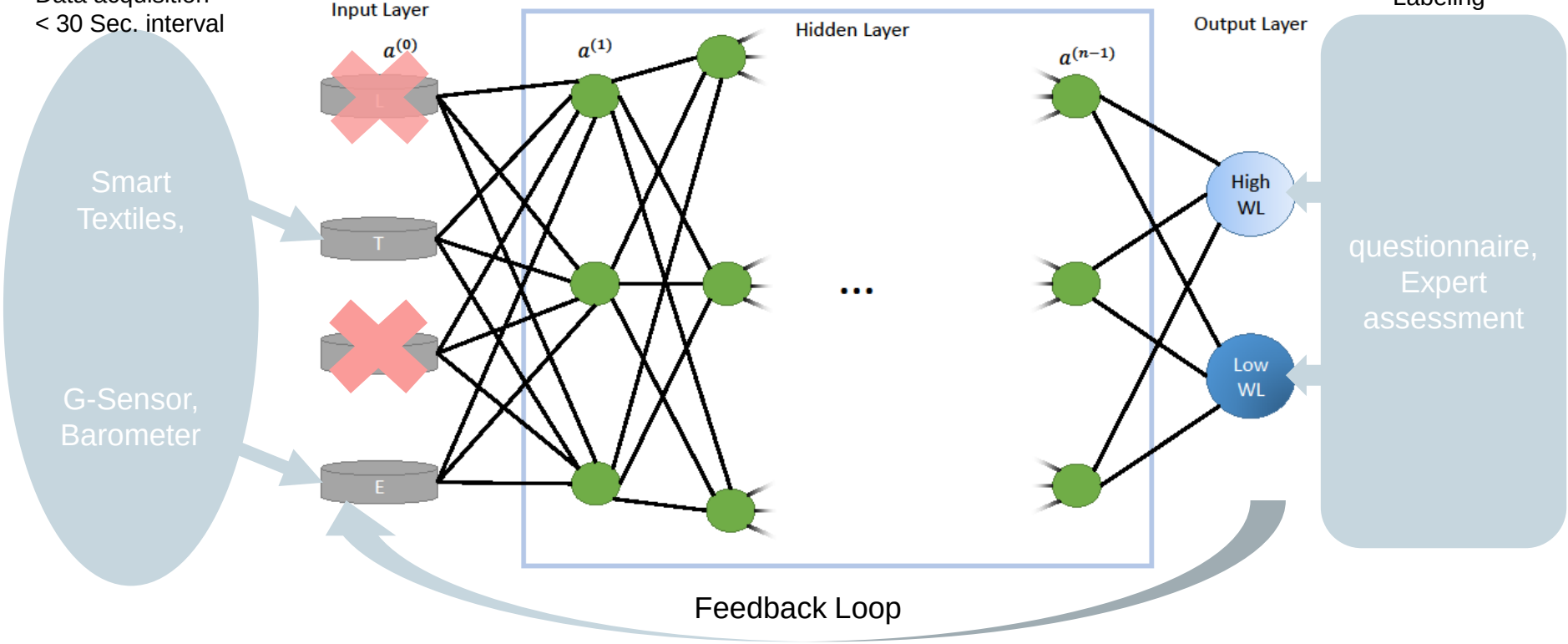
Environment (Acceleration, State of flight, Pressure, etc.)



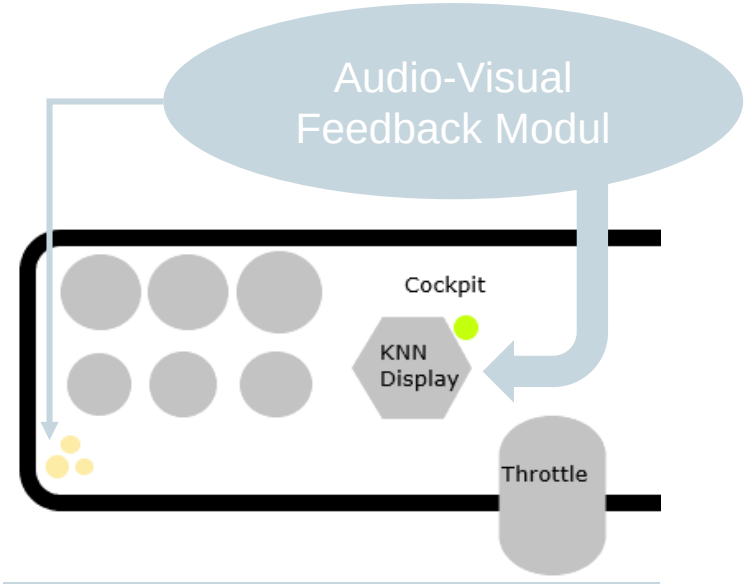
Data acquisition
< 30 Sec. interval

Network DCN + LSTM

Labeling



A simple possibility:



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Open Questions

- Difference between Simulator vs. real flight
- Exact setup of network
- System architecture
- Full integration in existing aircraft
- Miniaturization of sensors
- Possibility for EEG in flight

- Ethical and legal questions
- Information security issues

- Behaviour of network during loss of sensors

Outlook

- Contact with NATO Research Task Group HFM 319
- **Exchange with BAAINBw**
- **Research study for an encapsulated system to detect fatique as a first step towards a more complete system**

Thank you for the attention!

Questions?

For further questions and remarks please contact me here:

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