Final Report: Brain Dataset

Roman Podolski, Philipp Bergmann, Dominik Irimi, Manuel Nickel, Christoph Dehner

Technische Universität München

roman.podolski@tum.de, philipp.bergmann@tum.de, dominik.irimi@tum.de, manuel.nickel@tum.de, dehner@in.tum.de

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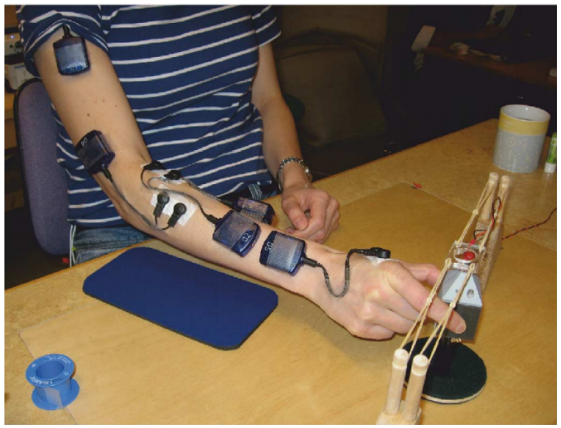
Overview

Dataset

Experiment recording human grasp and lift tasks[1]

- 12 participants, 5 different types of series recorded each
- EEG: 32 electrodes recorded at 5kHz
- EMG: 5 signals at 4kHz
- kinetic: 36 signals at 500Hz
- objects to grasp with different surface friction/weights (165g - 660g)
- preprocessing: trials provided in windowed format (event timing relative to window)



[1] Data source: Luciw, M. D., Jarocka, E. & Edin, B. B. FigShare http://dx.doi.org/10.6084/m9.figshare.988376 (2014).

Experiment

Experimental procedure:

- event/commands signaled visually by LED to participant
- participant starts moving hand to grasp object
- grasp object
- move to target position
- hold position
- move object back to initial position
- hand release object
- move hand back to resting position

Methodology

t-SNE

- expectation
- result

Methodology

Data preparation

- Input normalization to -1/1 range (tanh activation optimization)
- imagine one lifting trial as a single learning sample
  - recordings have different length, therefore equalize it!
  - zero padding $\rightarrow$ learning in danger of being misguided
  - tail cut $\rightarrow$ targets fall of, fails to learn sometimes
- separation into sets of 300 data point records length **improves learning.... Why did Smagt tell us to do that??)**
- Subsampling (10Hz) of EMG data within one trial
- consideration of target vector definition: one dim multi class vector vs one-hot-encoding
- data set split: train/valid/test $\rightarrow$ 0.8/0.1/0.1

Methodology

Recurrent Neural Network

- assuming predictability in human planning $\rightarrow$ history matters
- network shape:
  - 100 neurons (trial and error showed fewer will fail)
  - 1 layer
  - optimizer: adadelta
  - batch size 50 (limit set by available hardware)
- Bernoulli cross entropy loss at output layer
- Data vector shape
  - input [300 x 2428 x 5] $\rightarrow$ [slice, trial length, sensors]
  - target [300 x 1320 x 2] $\rightarrow$ [slice, ???, targets]

Methodology

RNN

- Weight initialization from uniform normal dist
- spectral radius
- Important weights
  - skip 150 samples till transient oscillation

LSTM

- usage of breze library implementation [2]
- finally not used because satisfying results achivable by RNN already

[2] https://github.com/breze-no-salt/breze v0.1 (2016)

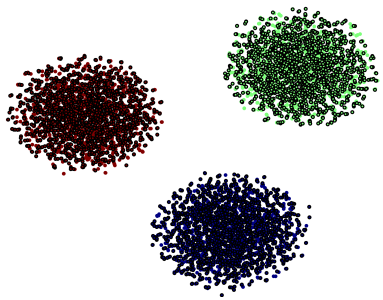
Results (1): t-SNE

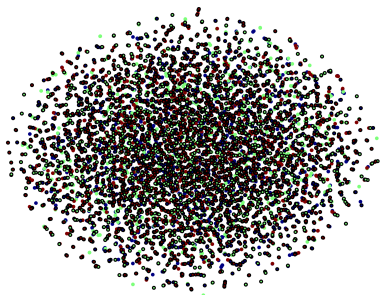
Visualizing high-dimensional EMG and EEG data using t-SNE. Why?

- Get a *feeling* for the data
- See if notion of *grasping* could possibly be captured by a Feedforward NN

Idea

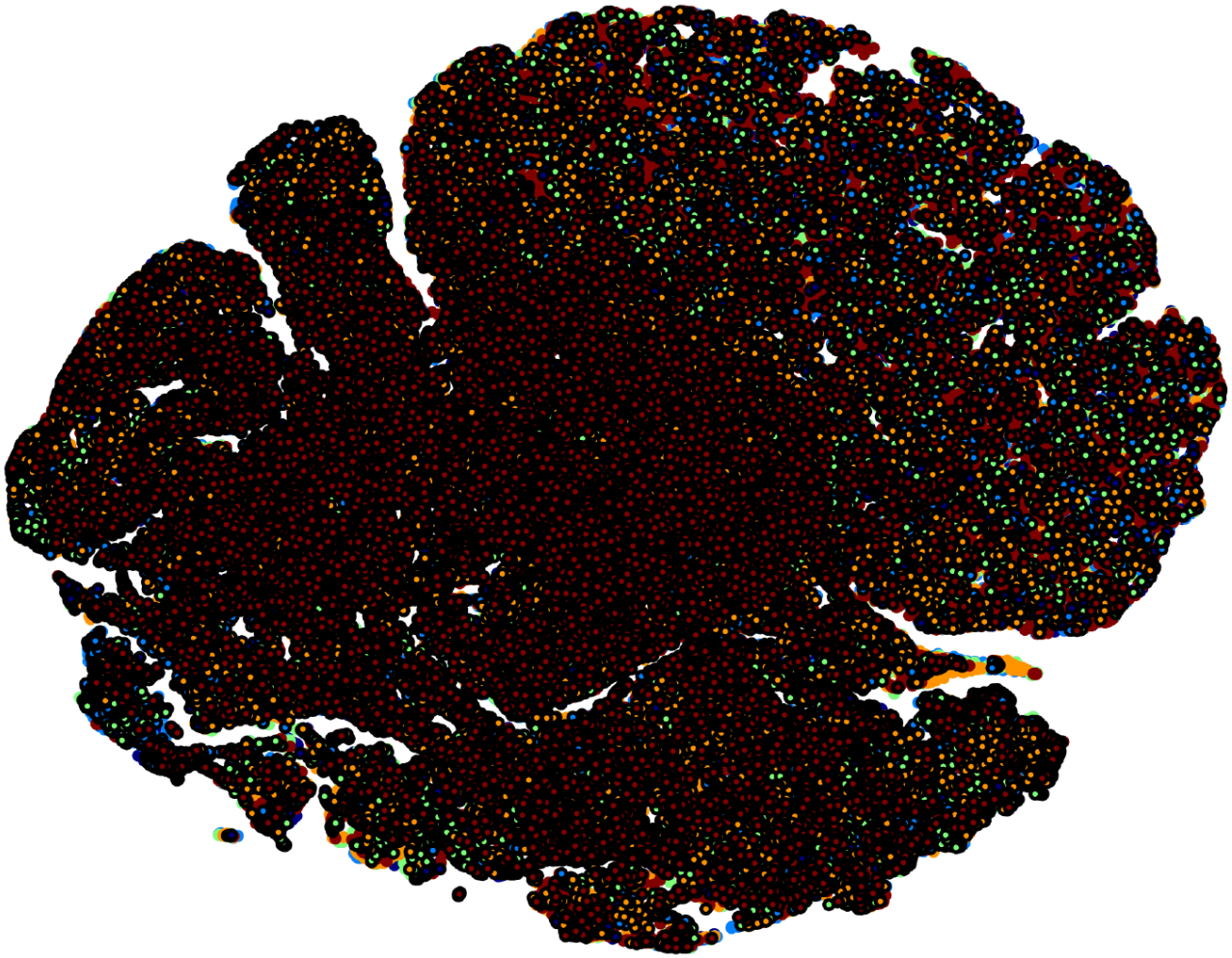
- *Grasping*-states and *Not Grasping*-states clustered respectively $\rightarrow$ Use Feedforward NN to classify *Grasping*.
- No apparent structure in the plot $\rightarrow$ Use Recurrent NN.





Results (1): t-SNE

Visualizing EMG data using t-SNE



Attributes

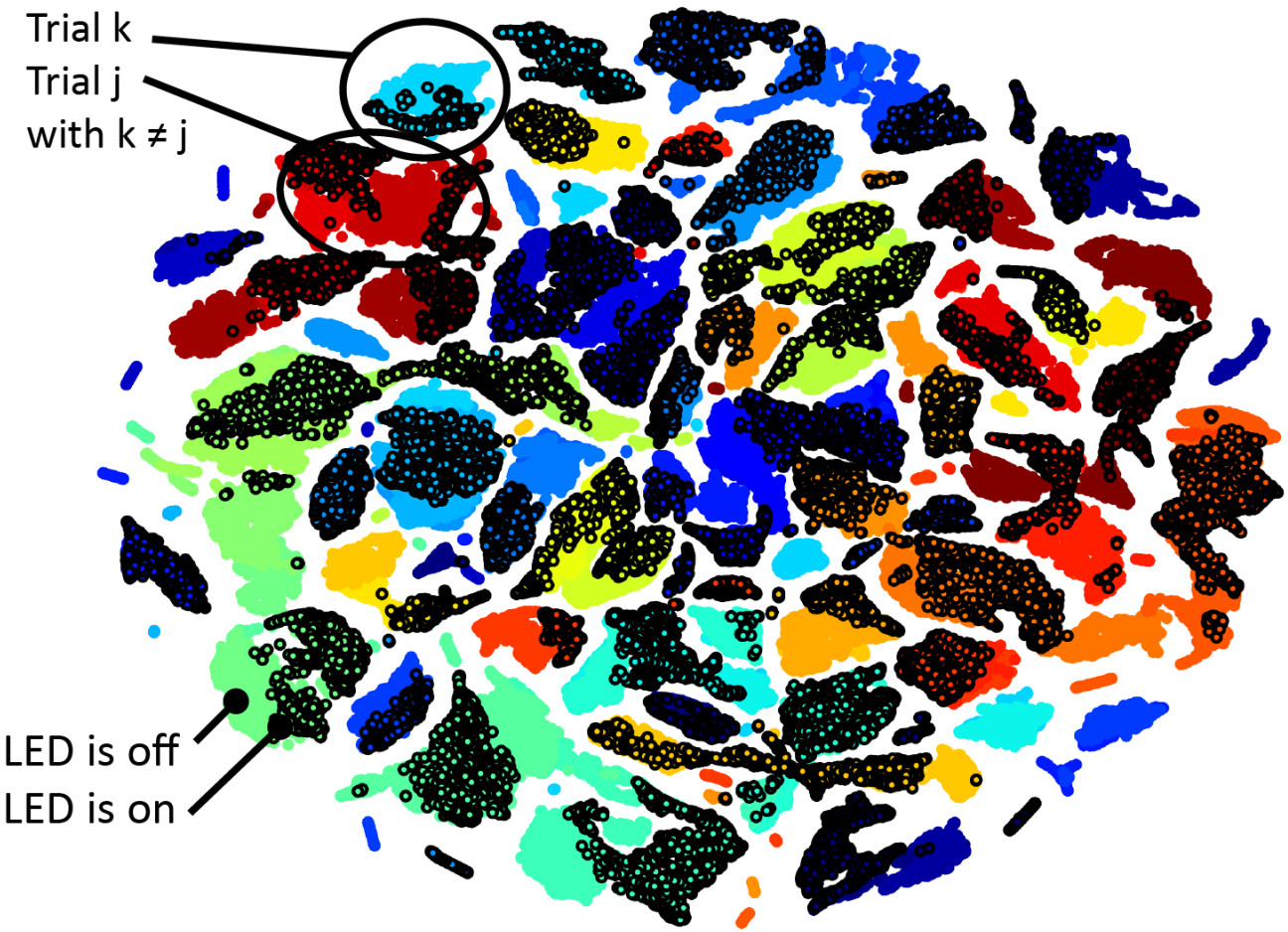
- Data of 34 trials
- Each color stands for one trial
- Black spots mark *Grasping*-states

Conclusion

No apparent structure
$\rightarrow$ Feedforward NN not sufficient, use Recurrent NN instead.

Results (1): t-SNE

Visualizing EEG data using t-SNE



Attributes

- Data of 34 trials
- Each color stands for one trial
- Black spots mark *Grasping*-states

Conclusion

Trials cluster → Weird? Use Feedforward NN to classify trials?

Results (1): t-SNE

Further analysis of EEG data

Verifying correct function of implementation

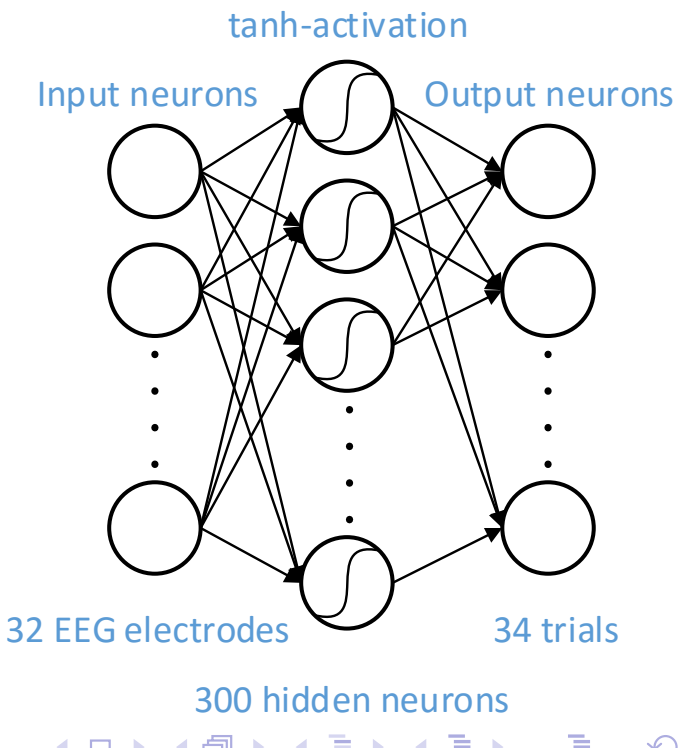
Check code over and over, use reference data sets to make sure the plot is indeed correct $\rightarrow$ Everything seems fine

If there is some truth to the t-SNE plot, classification of trials should be possible

Classify trials using a Feedforward NN

Feedforward NN with:

- 32 EEG electrodes as input
- 300 tanh-activated hidden neurons
- 34 trials as output classes



Results (1): t-SNE

Results of trial classification

Depending on participant and series nearly perfect classification with up to just about 0.01% error on test set.
Even when classifying all participant 1's 296 trials still a good test error of about 15% was achieved.

Conclusion

We conclude that there indeed has to be some kind structure encoding the time of measurement within the EEG data

Results (1): t-SNE

- Figure of t-SNE of EEG data $\rightarrow$ Seperability of trials
- Possible to separate with standard NN
- Figure of t-SNE of EMG data $\rightarrow$ As expected

Results (2): RNN

- Overview of the targets
- Hand move to target works good.
- Touch phase target also quite ok.
- hand move back target also (partially) sucessful
- Comparison: Training with data of one person vs. data of more participants
- etc.

Pitfalls

- Prediction do not fit to the target borders exactly
- No working early stopping criterion (so far)
- Targets within the lift phase cannot be predicted properly
- etc.

Blocks of Highlighted Text

Block 1

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Multiple Columns

Heading

1. Statement
2. Explanation
3. Example

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Table

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table: Table caption

Theorem

Theorem (Mass–energy equivalence)

$E = mc^2$

Verbatim

Example (Theorem Slide Code)

```
\begin{frame}
\frametitle{Theorem}
\begin{theorem}[Mass--energy equivalence]
$E = mc^2$
\end{theorem}
\end{frame}
```

Figure

Uncomment the code on this slide to include your own image from the same directory as the template .TeX file.

Citation

An example of the `\cite` command to cite within the presentation:

This statement requires citation [Smith, 2012].

References

John Smith (2012)

Title of the publication

Journal Name 12(3), 45 – 678.

The End