Machine Learning on Microcontrollers Project Presentation and Selection – Guideline

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Homework Slides

- Project Objectives
- Presentation and selection
- Getting start with your project.

Projects Steps

- Select your platform (ARM Cortex-M / PULP-GAP8) and Framework

- Select the dataset (From IIS or Website)

  Ready before 28th of Nov for approval.

- Design your Machine learning algorithm
  - Evaluate different algorithm to maximize the accuracy
  - Evaluate the impact on the complexity
  - Trade of Complexity (and time) Memory, Accuracy

  Expected latest at the end of 5th of Dec

- Implement it and test on the real platform
  - Optimize the code (and provide new/better library?)
  - Performance evaluation

  Expected at the end of 12th of Dec

- Present your results, showing accuracy, memory and execution time on the target platform
  - Eventually compete with your colleagues

  Final Presentation 19th of Dec – Starting at 1pm for available students

Evaluation:

- Difficulty of the project
- Performance evaluation and comparison of more than one algorithm
- Comparison with state of the art and papers
- Implementation
- Libraries and reusable code
- Challenge your colleagues
- Impressive demo (Not mandatory but welcome…)

Final Presentation example: 5 Slides/topics

Introduction, motivation, dataset, application.
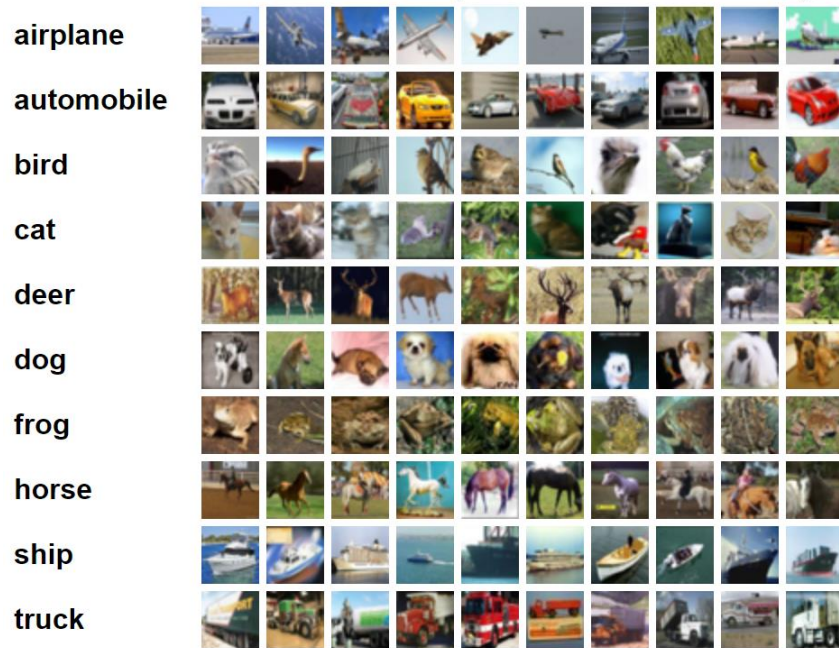Architecture of proposed Algorithms
Preliminary Comparison and decision of the network
Implementation and optimization
Plots/figures with experimental evaluation

DEMO not mandatory but appreciated.

Proposal 1 - Image recognition

Source: CIFRA-10 / CIFRA-100; **MNIST**

PLATFORM
ARM/PULP

Possible topics over the baseline:
- Propose new Architecture
  - Improve Accuracy
- Comparison M4 Vs M7
- Optimization over the paper
- GAP8 Implementation and Comparison
- **Comparison CubeMX-AI vs CMSIS-NN**

Papers: Lai, Liangzhen, Naveen Suda, and Vikas Chandra. "Cmsis-nn: Efficient neural network kernels for arm cortex-m cpus." *arXiv preprint arXiv:1801.06601* (2018).

Proposal 2 - Speech Recognition
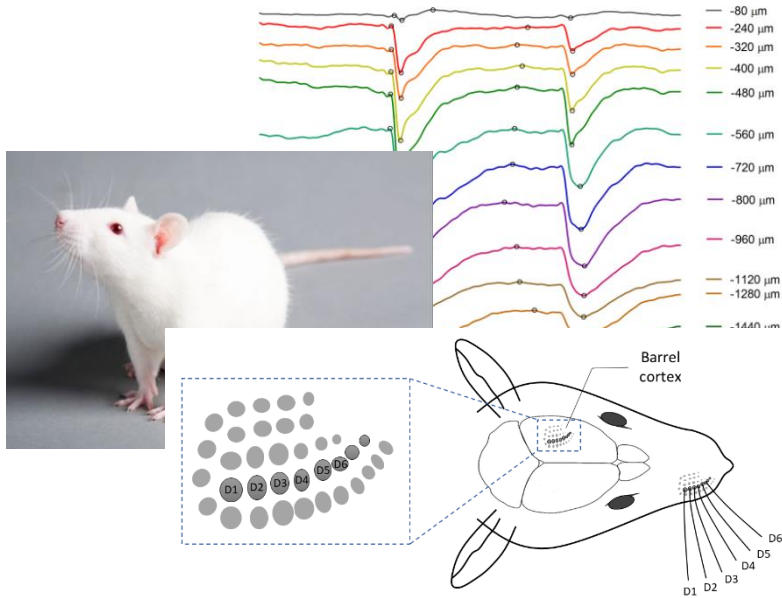

PLATFORM
ARM/PULP

Possible topics over the baseline:

- Propose new Architecture
  - Improve Accuracy
- Optimization over the reference
- GAP8 Implementation and Comparison
- Comparison CubeMX.AI Vs CMSIS-NN

Source: Keywork Spotting https://github.com/snipsco/keyword-spotting-research-datasets

Reference: How to Achieve High-Accuracy Keyword Spotting on Cortex-M Processors
And the associated white paper.

Proposal 3 - Neural Decoding

PLATFORM
ARM/PULP

Possible topics over the baseline:
- Propose new Architecture
  - Improve Accuracy
  - FANN
- Comparison with reference
- Optimization over the reference
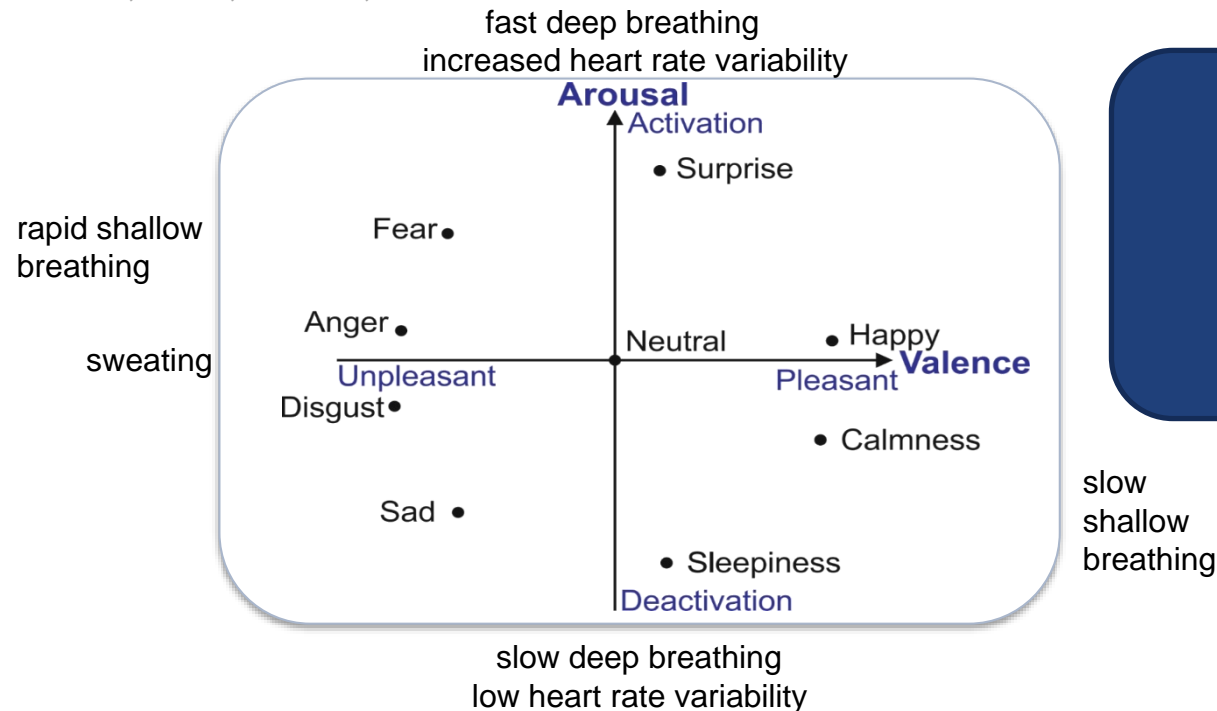- PULP Implementation and Comparison

Source: Provided by IIS – Contact Xia

Reference:
https://www.researchgate.net/publication/329568995_Embedded_Classification_of_Local_Field_Potentials_Recorded_from_Rat_Barrel_Cortex_with_Implanted_Multi-Electrode_Array

Proposal 4 - Emotion Detection (or other bio-signals)

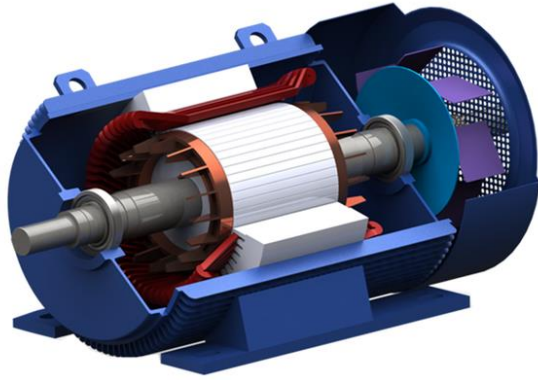K. Kim, et al., IFMBE, 2004

PLATFORM
ARM/PULP

Possible topics over the baseline:

- Propose new Architecture
  - Improve Accuracy
  - FANN
- Comparison with reference
- Optimization over the reference
- PULP Implementation and Comparison

Source: **Augsburg Biosignal -** https://www.informatik.uni-augsburg.de/lehrstuehle/hcm/projects/tools/aubt/

Reference: Magno, M., Pritz, M., Mayer, P. and Benini, L., 2017, June. DeepEmote: Towards multi-layer neural networks in a low power wearable multi-sensors bracelet. In *2017 7th IEEE International Workshop on Advances in Sensors and Interfaces (IWASI)* (pp. 32-37). IEEE.
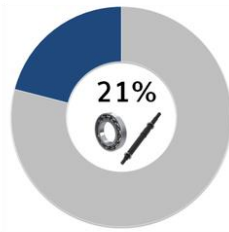
Proposal 5 - Condition monitoring
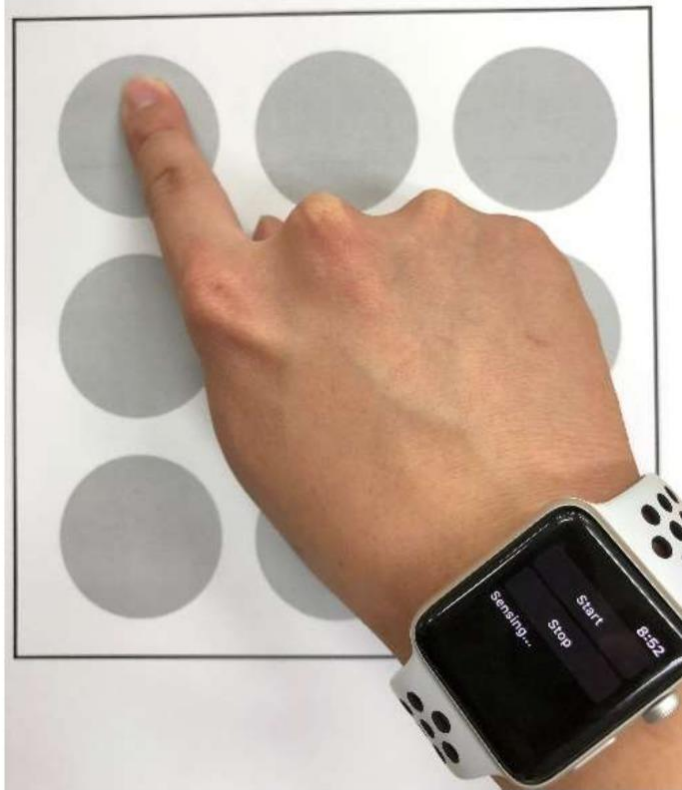
PLATFORM
ARM

Possible topics over the baseline:

- Propose NN Architecture
- Comparison with reference
- Optimization over the reference
- CMSIS-NN optimization and comparison with CUBE-MX-AI
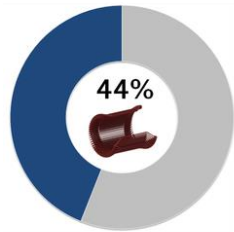
44% — Damage of the stator windings (inter-coil, phase short circuit, ground connection)
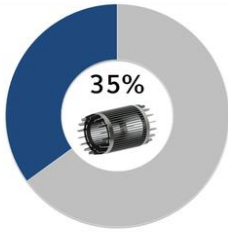
35% — Damage of the rotor windings (rotor cage bar rupture, cage ring, inter-coil short circuit)

21% — Other reasons (shaft with bearings)

Source: http://csegroups.case.edu/bearingdatacenter/home

Reference: **Wavelet filter-based weak signature detection method and its application on rolling element bearing prognostics**
https://www.sciencedirect.com/science/article/pii/S0022460X0500221X

Proposal 6 – Gestures/Activities Recognition

PLATFORM
ARM

Possible topics over the baseline:

- Propose your MCU (C)NN Architecture
- Comparison with reference or other state of the art.
- Optimization over the reference
- CMSIS-NN optimization and comparison with CUBE-MX-AI

Source: Many option possible with several sensors, we leave you to find them

Reference: Kwon, Min-Cheol, Geonuk Park, and Sunwoong Choi. "Smartwatch User Interface Implementation Using CNN-Based Gesture Pattern Recognition." *Sensors* 18.9 (2018): 2997.

Proposal 7: Face Detection on Wearable MCU

Figure 6. Qualitative performance of the proposed IFQ-Tiner-YOLO ($k = 2$) face detector on Wider Face dataset [18].

PLATFORM ARM /GAP 8

Possible topics over the baseline:

- Propose your MCU (C)NN Architecture
- Binary NN[2]
- Comparison with reference or other state of the art.
- Optimization over the reference
- CMSIS-NN optimization and comparison with CUBE-MX-AI
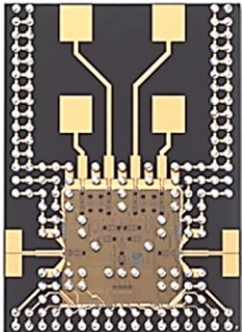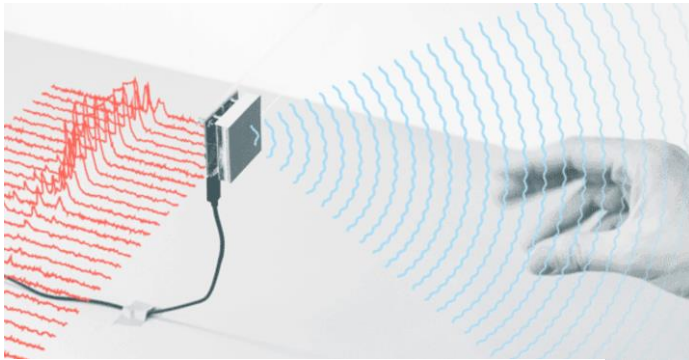- Comparison different tools NNoN Vs Cube -AI

DATASET:
S. Yang, P. Luo, C. C. Loy, and X. Tang.
WIDER FACE: A face detection benchmark. In
IEEE Conference on Computer Vision and
Pattern Recognition, CVPR 2016, 2016.

Proposal 8: Gesture recognition with short-range radar

(Challenging and advacned project with risks to talk with Michele net week before the lecture)
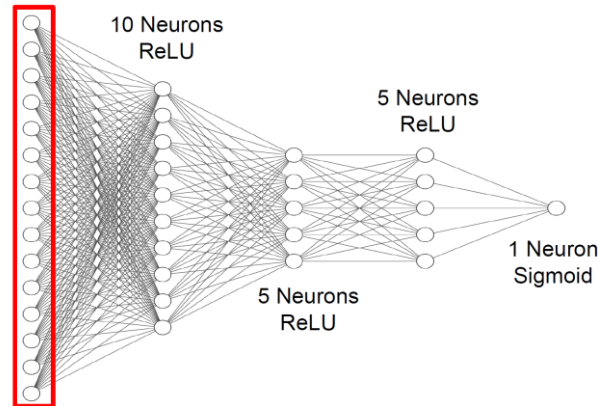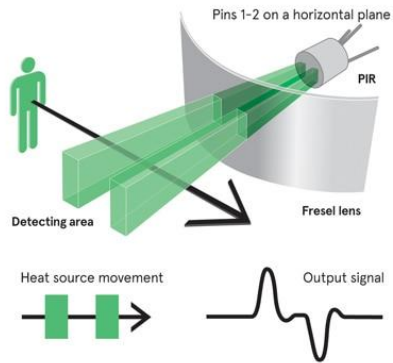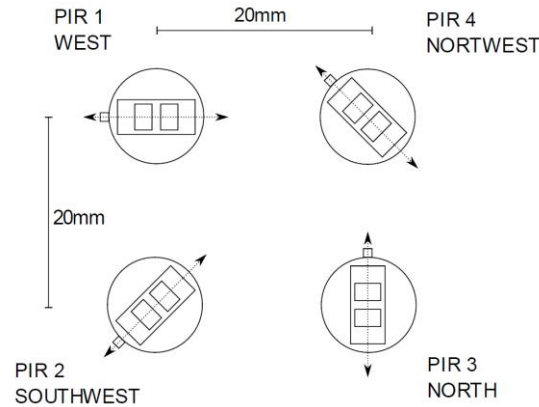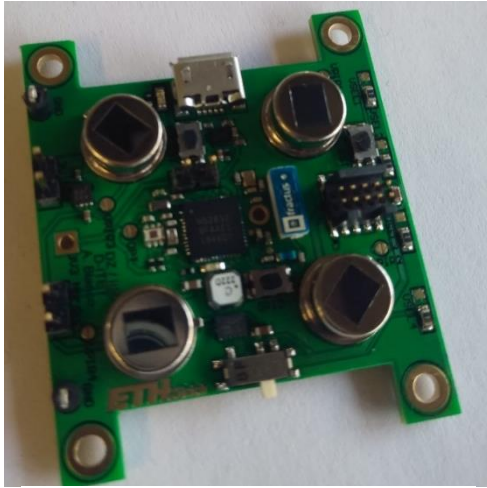

PLATFORM
ARM

Arm Cortex-M7
Platform

Possible topics over the baseline:
- Implement a Model IIS already started and validated on Keras
- Real-time demo possible.
- Optimization and comparison
- CMSIS-NN optimization
- Use and comparison NNoN

Dataset Acquired in IIS with 11 gestures.

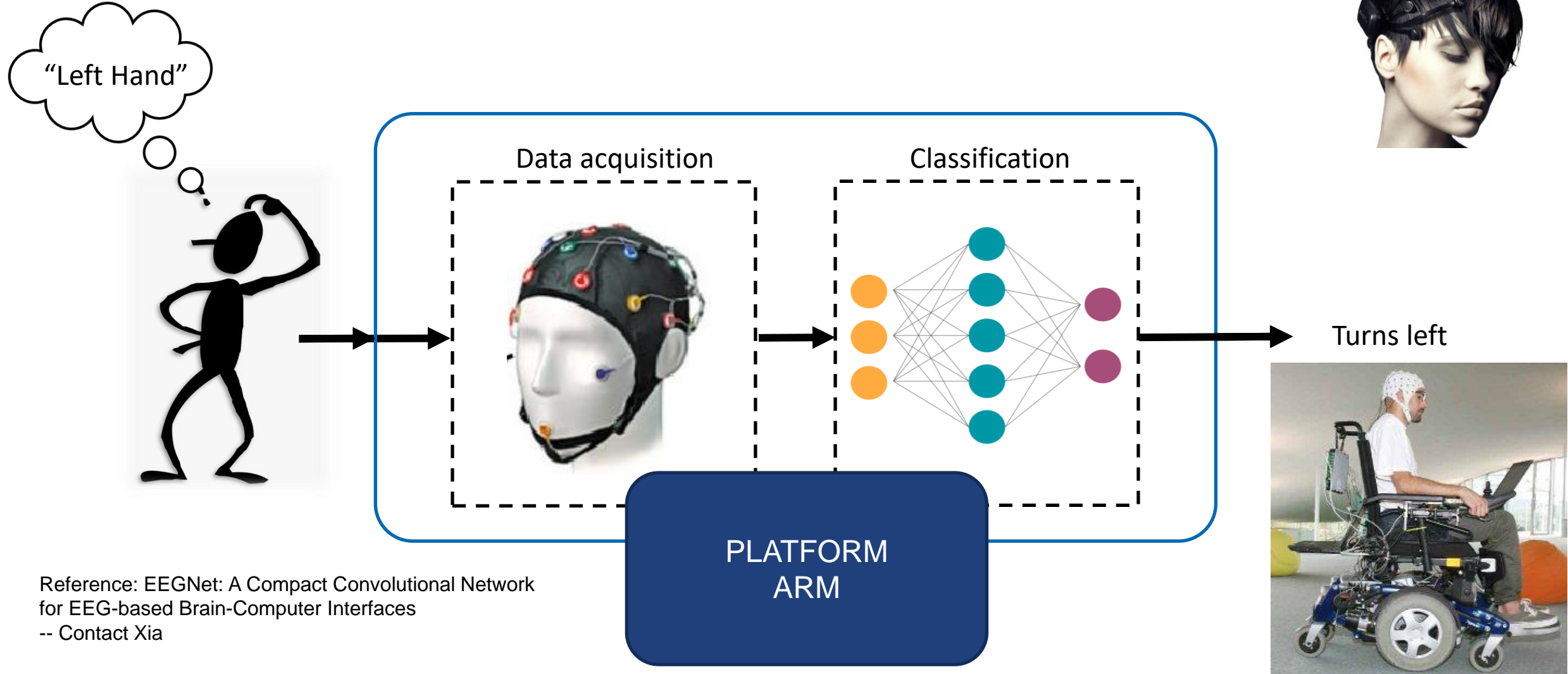# Proposal 9: Low Power Context Intelligence with PIR sensors

PLATFORM
ARM

BTLE Nrodic Nordic
with ARM Cortex-M4
Good to see also
Bluethoot

Dataset Acquired in IIS ready to be used- Example
of NN on Keras/FANN ready… Margin of
Optimization

Proposal 10: Brain Computer Interface

"Left Hand"

Data acquisition

Classification

PLATFORM
ARM

Turns left

Reference: EEGNet: A Compact Convolutional Network
for EEG-based Brain-Computer Interfaces
-- Contact Xia

You can propose your own project

To propose a project:

- Prepare a slide with similar information as in the previous example projects:
- Application
- Data Source
- Possible reference to beat
- Option to go beyond the baseline (To be discussed with the supervisors)

(Discuss with Michele BEFORE next week (latest 28.11 in the morning) for definition)

Register your project on google doc

https://docs.google.com/spreadsheets/d/1nLqCKntwgRaC8KudRdZeLXAPrvpvOS-1sSmuaeo7tMo/edit