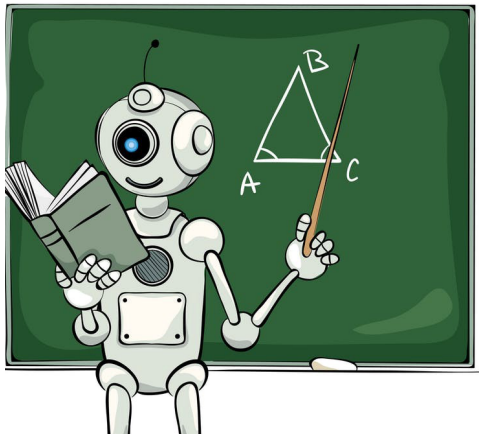

Supervised ML on
ULP Devices
Ingy ElSayed-Aly

# Problem Statement

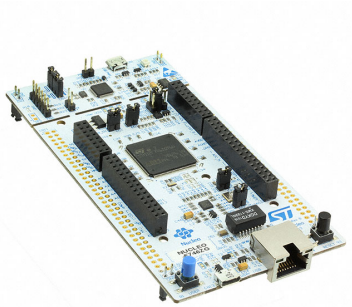
Deploy a Convolutional Neural Network (CNN) inference model for sign language recognition to a Cortex-M processor.

# Motivation

- Machine Learning applications
- Robustness
- Privacy Concerns



# Related Work



**Research**

- Quantization
- Model compression
- Jetson TX1

**CMSIS NN**

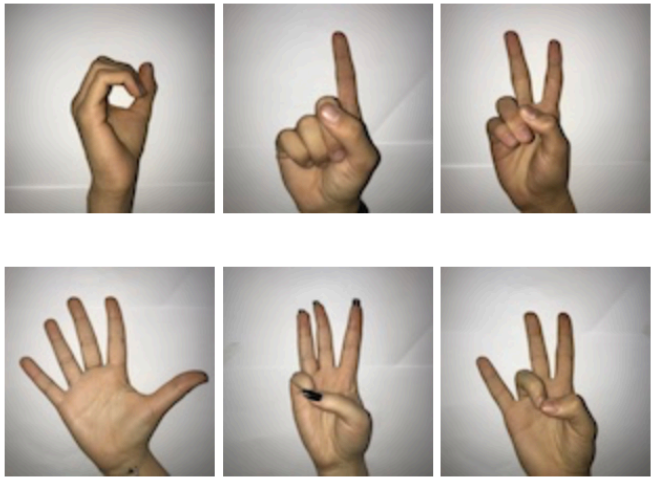
- CIFAR 10 problem
- Cortex-M7




# Workflow for deployment

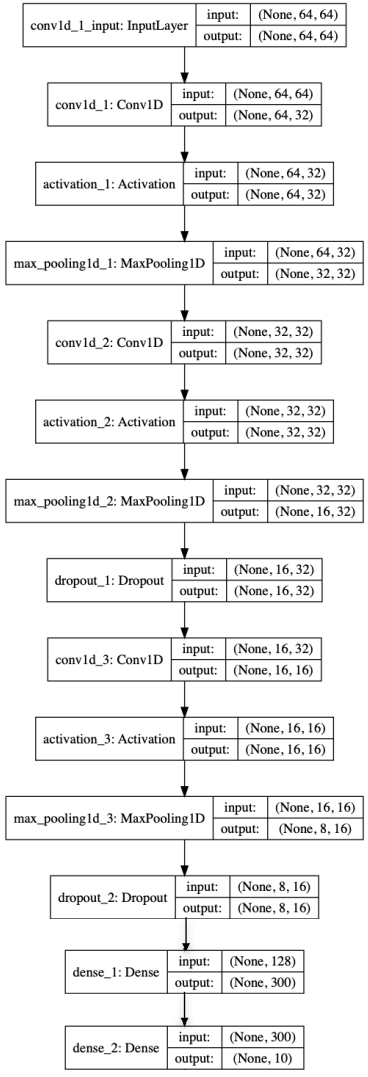
# Dataset

Original Dataset: 64 x 64 x 3

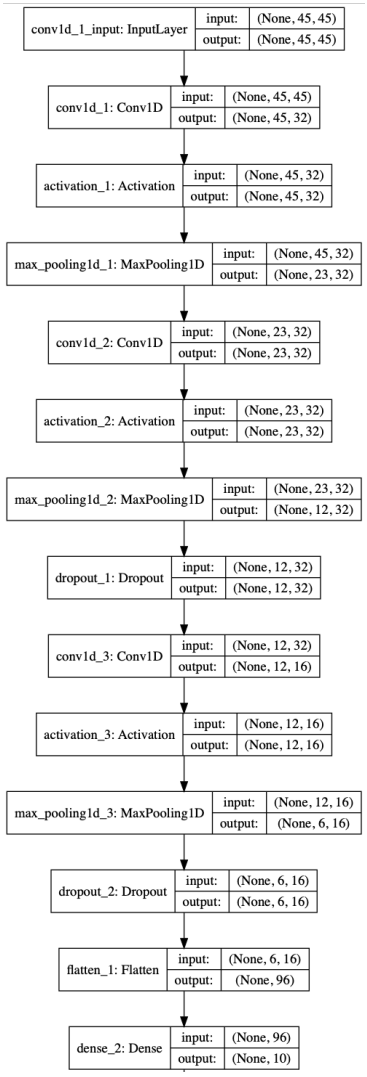


Transformed Dataset: 45 x 45 x 1

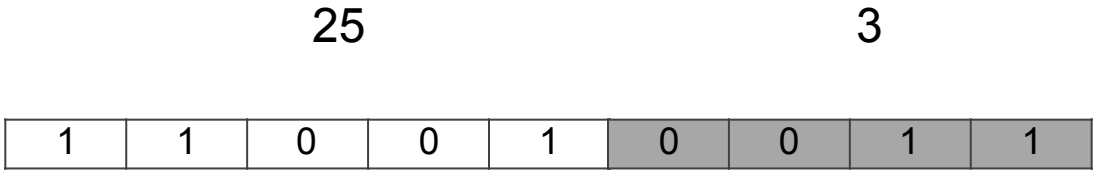
# Model Architecture




| Layer | Type | Kernel Shape | Output Shape |
|---|---|---|---|
| Input | - | - | $45 \times 45 \times 1$ |
| Layer 1 | Convolution | $5 \times 5 \times 32$ | $45 \times 45 \times 32$ |
| Layer 2 | Max Pooling | $2 \times 2$ | $23 \times 23 \times 32$ |
| Layer 3 | Convolution | $5 \times 5 \times 32$ | $23 \times 23 \times 32$ |
| Layer 4 | Max Pooling | $2 \times 2$ | $12 \times 12 \times 32$ |
| Layer 5 | Convolution | $5 \times 5 \times 16$ | $12 \times 12 \times 16$ |
| Layer 6 | Max Pooling | $2 \times 2$ | $6 \times 6 \times 16$ |
| Layer 7 | Dense | $6 \times 6 \times 16 \times 10$ | 10 |



# Fixed Point Quantization




200.305 ~ 25 x 2 ^ 3

# Conversion to C/C++

arm_sign_nb_inputs.h

arm_sign_nb_parameter.h

arm_sign_nb_weights.h

arm_sign_nb.cpp

```
#define CONV1_IM_DIM 45
#define CONV1_IM_CH 1
#define CONV1_KER_DIM 5
#define CONV1_PADDING 2
#define CONV1_STRIDE 1
#define CONV1_OUT_CH 32
#define CONV1_OUT_DIM 45
```

## Demo

```
0: 0
1: 0
2: 0
3: 0
4: 42
5: 0
6: 0
7: 42
8: 42
9: 0
```

# Limitations

- Unclear quantization method
- Unclear weight ordering
- Runs but classification is wrong

# Thank you

# References

**Images:**


- http://parneetk.github.io/images/2017-01-23-cnn-cifar10_files/2017-01-23-cnn-cifar10_8_0.png
- https://media.digikey.com/photos/STMicro%20Photos/NUCLEO-F746ZG_Top.jpg
- https://images.anandtech.com/doci/9779/Jetson_TX1_Press_Deck_Final-page-006.jpg
- https://towardsdatascience.com/the-4-machine-learning-skills-you-wont-learn-in-school-or-moocs-c641cae24f1f
- https://start.lesechos.fr/actu-entreprises/technologie-digital/comprendre-l-internet-des-objets-iot-en-5-questions-12253.php
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# References


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- [10] L. Lai, N. Suda, and V. Chandra, “Deep convolutional neural network inference with floating-point weights and fixed-point activations,” CoRR, vol. abs/1703.03073, 2017. [Online]. Available: http://arxiv.org/abs/1703.03073