Shashidhar, Shrusti(MS Electrical Engineering)

Introduction

- As the design complexities of CNN has increased, the implementation of such models on embedded devices have become harder.
- The right choice of numeric representation format can either increase the performance of the overall system or degrade it.
- Here the use of fixed point which is hardware friendly is compared with IEEE754 floating point format on several CNNs.
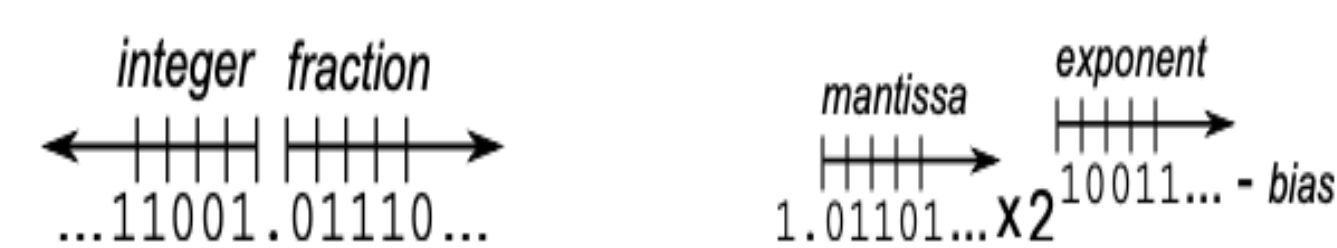

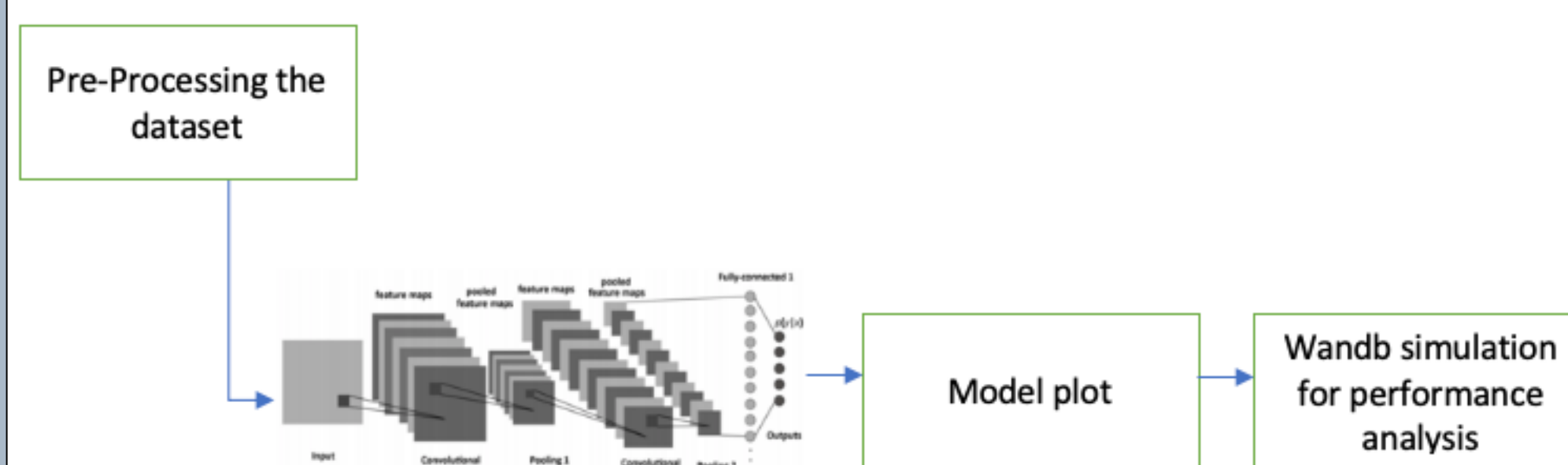Figure 1: Fixed point and Floating-point format

Figure 2: Block Diagram Overview of the CNN model

Methodology

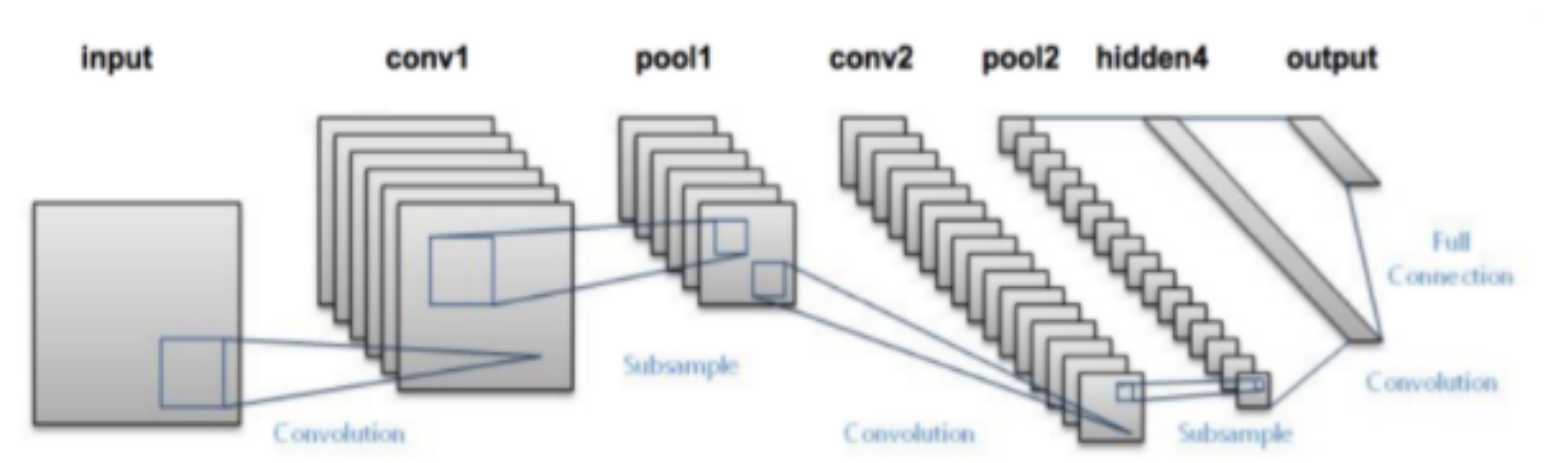### Convolutional Neural Network Architectures

1. LeNet

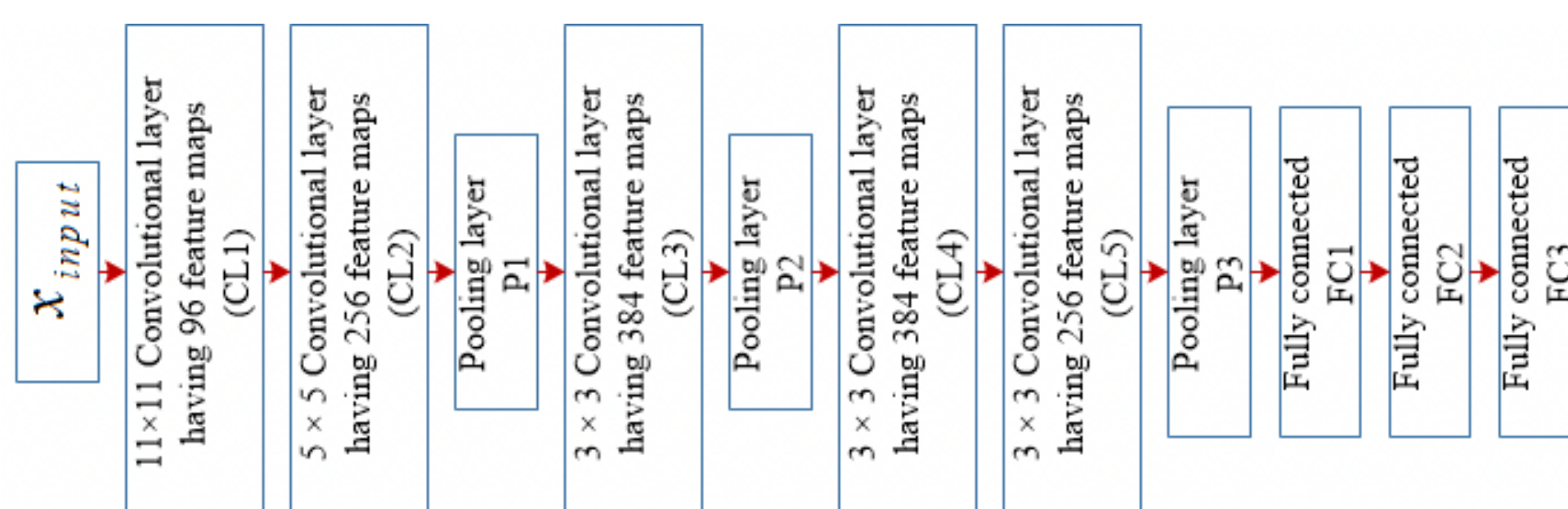Figure 3 : LeNet Model (the first CNN for digit recognition)

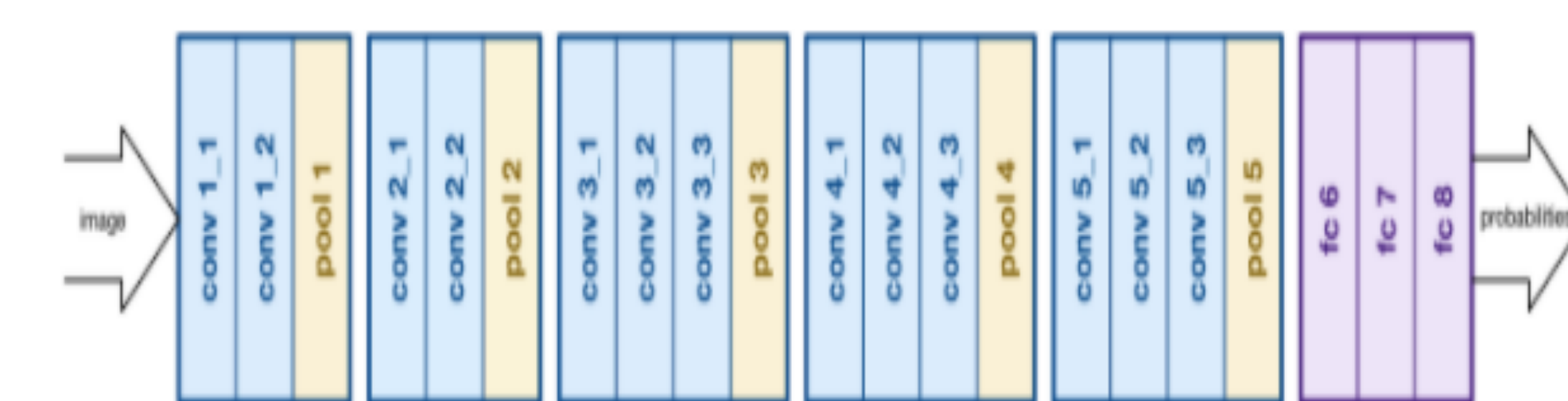#### 2. AlexNet

Figure 4 : AlexNet Model

3. VGGNet

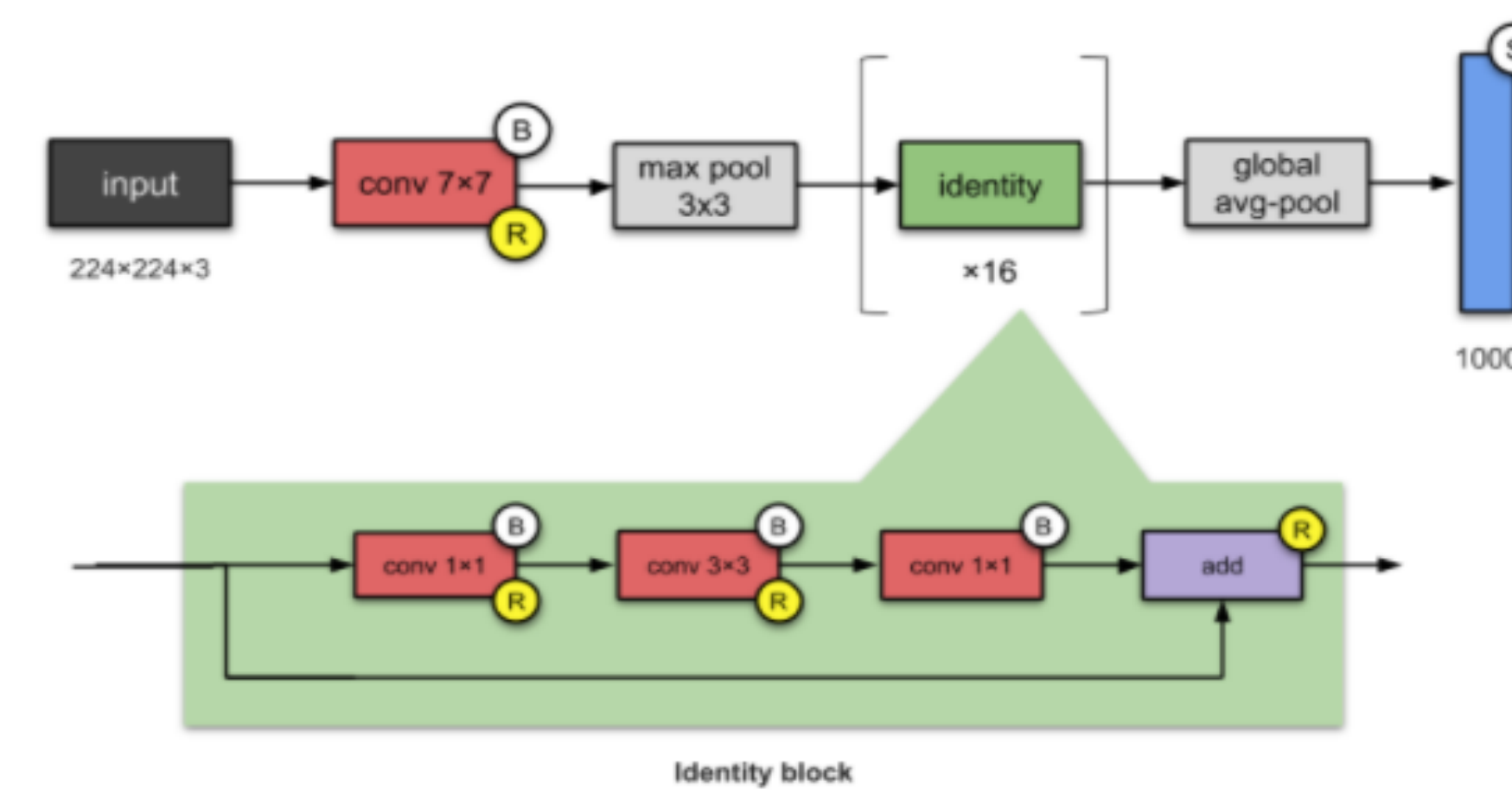Figure 5: VGGNet

Methodology

4. ResNet

Figure 6: Identity block and skip Connection of ResNet

MNIST dataset

For performance analysis of each CNN architecture the MNIST digit recognition is implemented consisting 60,000 training images and 10,000 testing images.
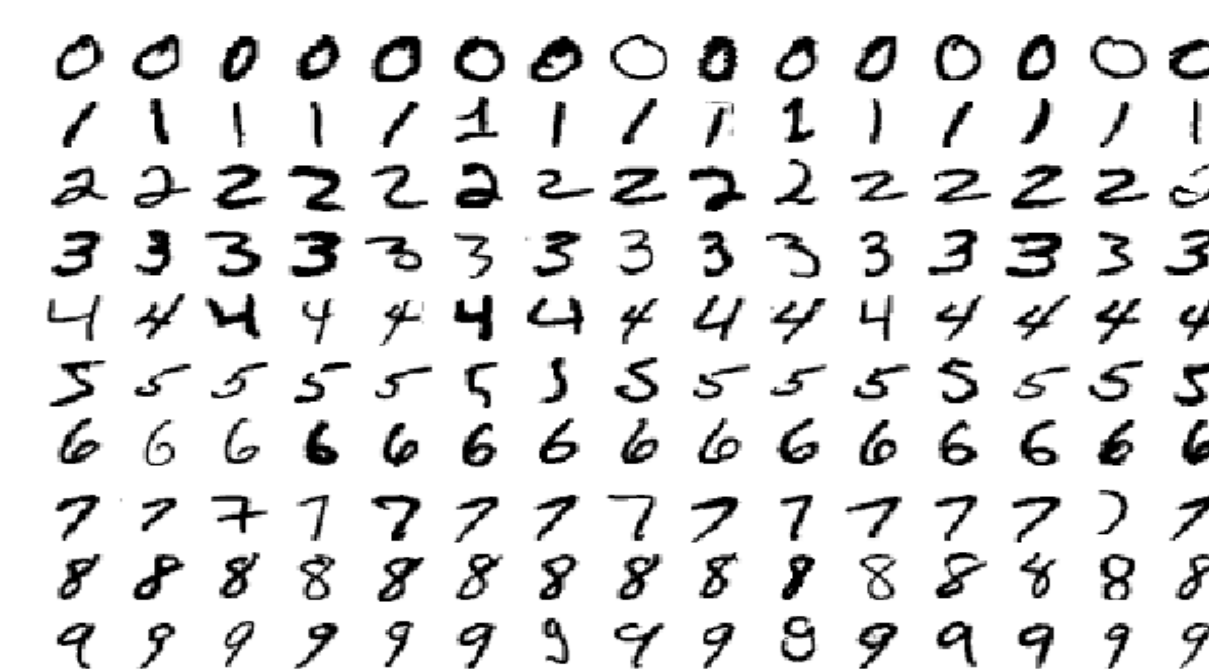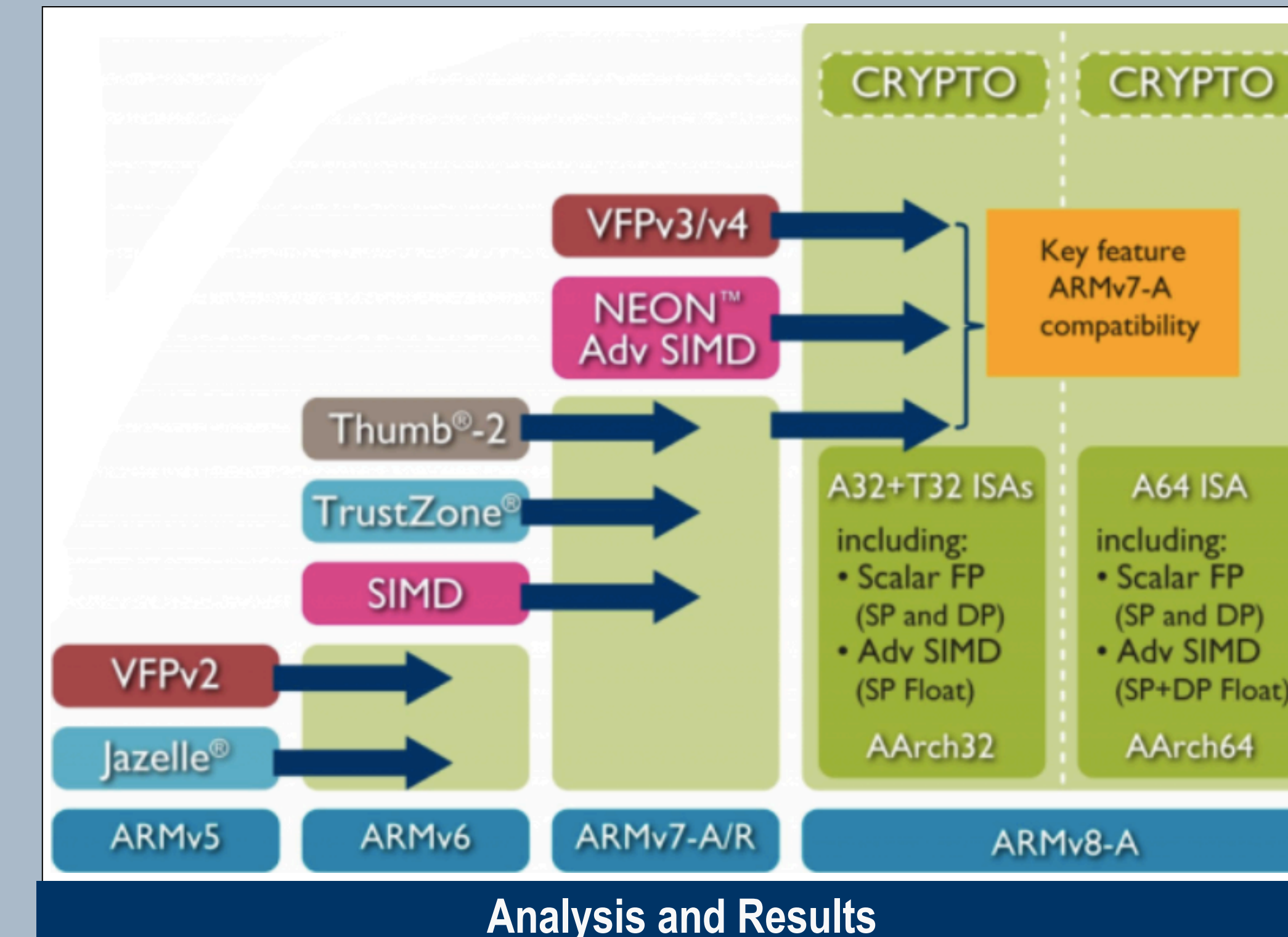

Figure 7 : MNIST dataset

Processor Specifications

- CPU : ARM64/AArch64
- Instruction set: 64 bit
- Architecture: ARMv8-A
- Core: 8
- OS: Android
- Platform: Python3
- code editor: Jupyter
- Notebook

Figure 8: Processor specification obtained from Android

Analysis and Results

1. Embedded devices performance also depends on the use of number representation used to run the computation. Fixed point is hardware and power efficient but only at register transfer level.
2. Floating point provides better accuracy but requires more power.
3. The comparison of these two formats are tested against multiple CNNs for comparison.

Various CNN architectures are inferenced on CPU/GPU for 20 epochs each and the the performance metrics considered : Loss, Accuracy, Power usage, GPU/CPU usage
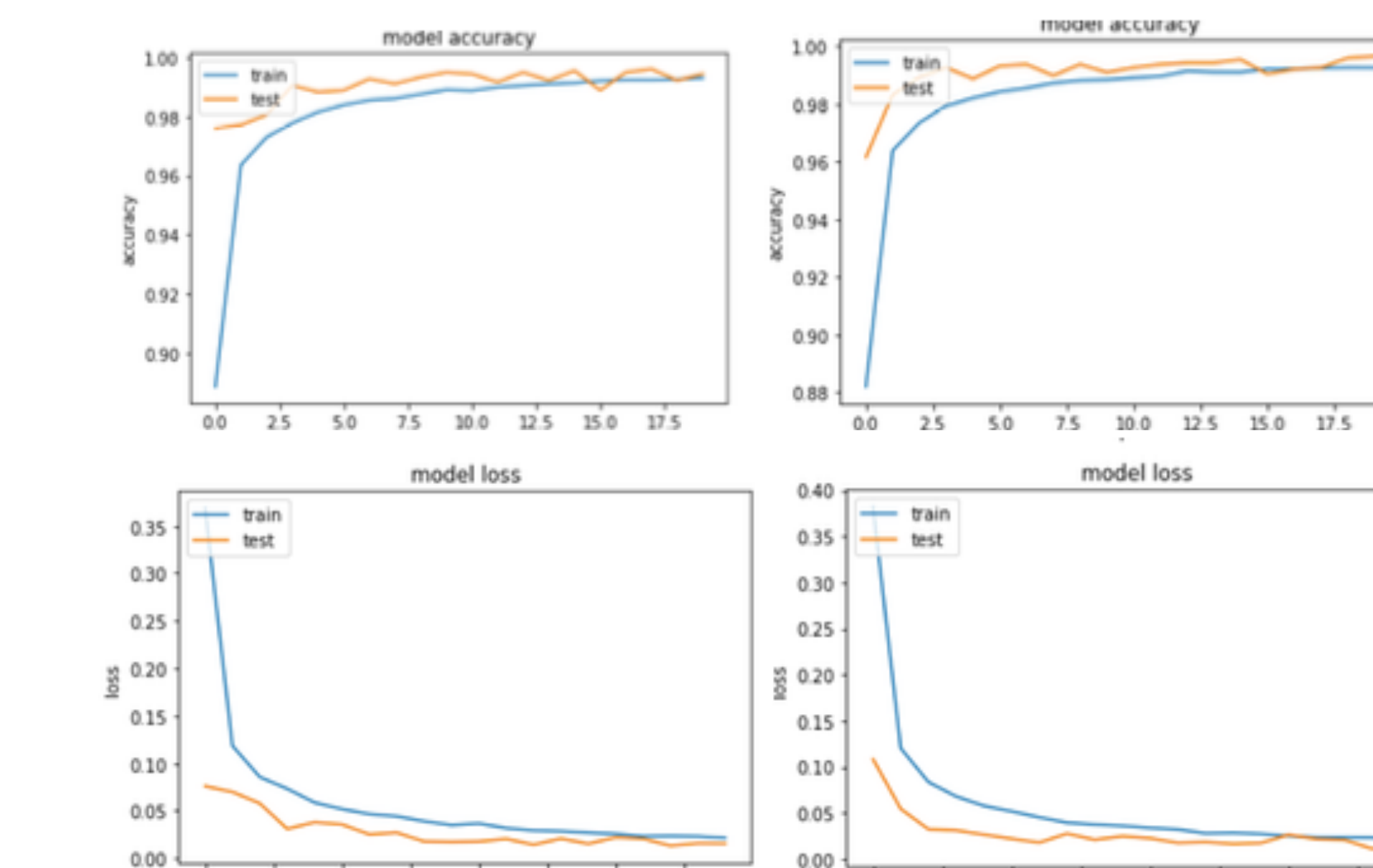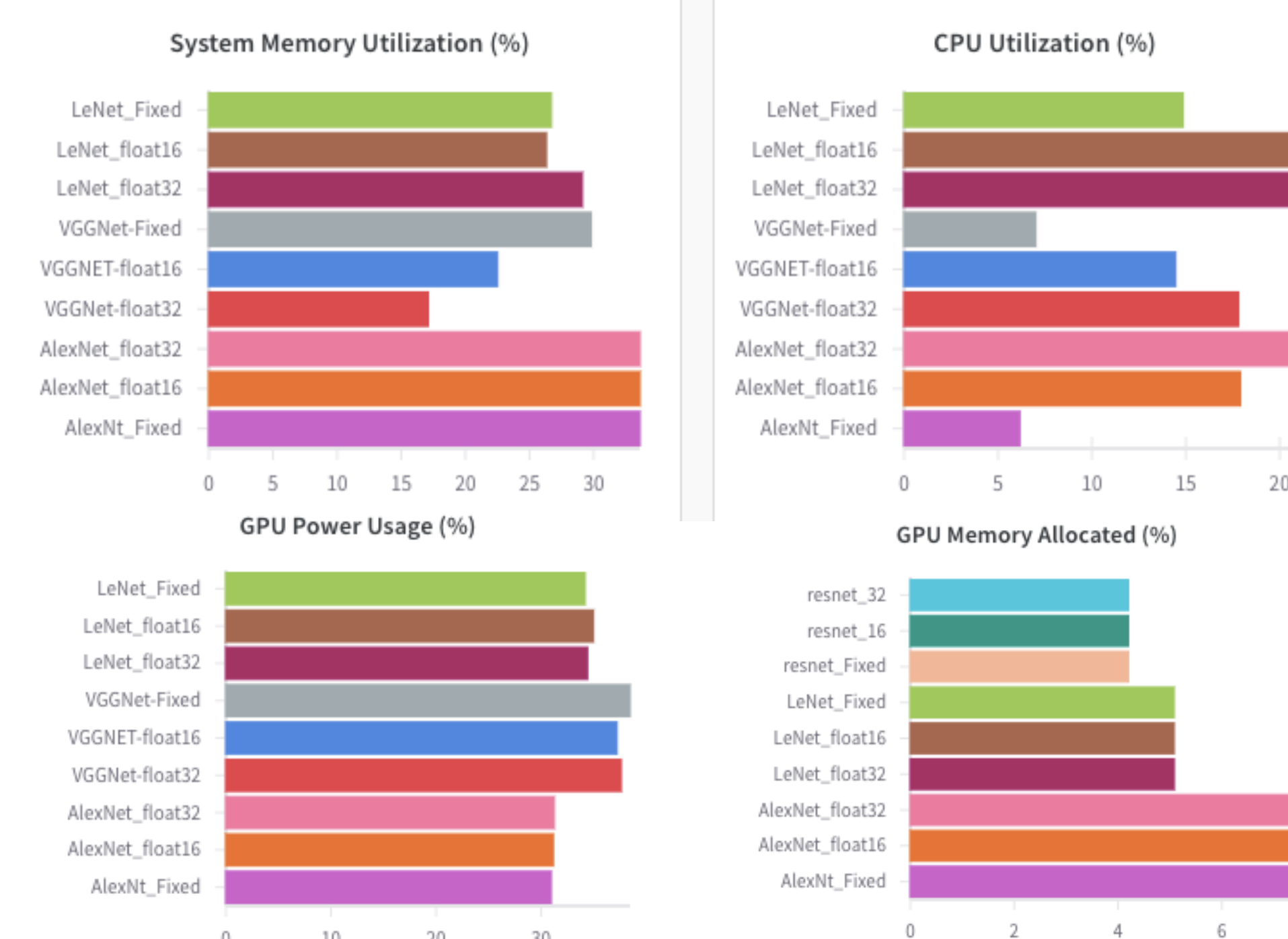

Figure 9 : CNN model accuracy and loss for 16 bit(left) 32

The change of numeric format can change the accuracy of the CNN model as shown below.

CNN Architecture	Fixed point	32 bit floating point	16 bit floating point
Pure CNN	43.32	43.32	43.39
AlexNet	98	98.4	98.6
LeNet	99.2	99.6	99.4
VGGNet	99.38	99.2	99.2
ResNet	98.8	98.58	98.76

Summary/Conclusions

1. Fixed point number representation format is compared with floating point representation to attain higher accuracy over the CNN architectures.

2. IEEE754 floating point various precisions are also compared for the same CNN architectures for change in accuracy, power usage and memory utilization.

3. The performance of the CNN increased by 0.7X when shifted to 32 bit floating point from fixed and 0.25X when switched with 16bit over 32 bit floating point.

Key References

[1] Deep Convolutional Neural Network Inference with Floating-point Weights and Fixed-point Activations: https://arxiv.org/abs/1703.03073

[2]] Exploration of Low Numeric Precision Deep Learning Inference Using Intel® FPGAs

[3] Ristretto: A Framework for Empirical Study of Resource-Efficient Inference in Convolutional Neural Networks Philipp Gysel, Jon Pimentel, Mohammad Motamedi, and Soheil Ghiasi

[4]] A Survey of the Recent Architectures of Deep Convolutional Neural Networks

[5] Fine-Grained Exploitation of Mixed Precision for Faster CNN Training

Acknowledgements