CMOS Pixel Sensors with on-chip Neural Network

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Résumé :

CMOS pixel sensors are being used in subatomic physics experiments. Neural network also has so many applications, such as the Lenet-5, which is used in the area of written number recognition [1]. However extensively neural network algorithms are used in embedded systems and based on the CPU. There are much limitation for these systems, robustness of the embedded system, power consumption, real time processing and so on. We propose to integrate neural network in CMOS pixel sensor, combine these two different fields.

We use a CMOS pixel sensor (MIMOSA 18) and an artificial neural network implemented in a FPGA board. The purpose is to verify the feasibility of reconstructing the incident angle of a particle, then the feasibility of tagging and removing clusters generated by particles coming from background. As a consequence, we use a Neural Network algorithm to classify these two kinds of hits through their charges distribution and shapes [2].

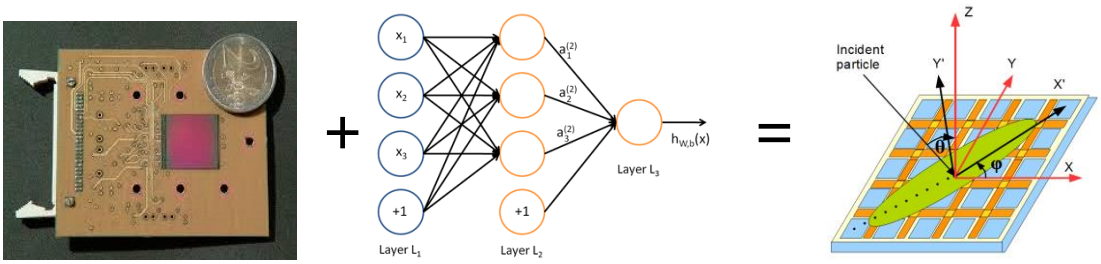

Figure 1 : CMOS sensor pixel chip and the neural network implemented in FPGA

The feasibility study contains two procedures:

- Training procedure: calculating the weights of the neural network by the software of TMVA;
- Regression procedure: using raw data and the neural network to reconstruct the incident angle θ.

Figure.2 shows the difference between the obtained mean values of θ and the real incident angles θ. The blue one is obtained from TMVA and the red one from the FPGA board. The results of the FPGA regression are basically the same as the software (TMVA) regression results.

In future, we need to gather more data to train the neural network, get accurate of the weights, and try to develop a structure to integrate the neural network in CMOS pixel sensors.

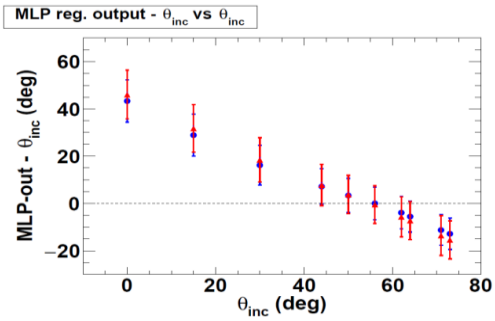

Figure 2: distribution of the regression result θ

Références :

[1] LeCun Y, Bottou L, Bengio Y, et al. Gradient-based learning applied to document recognition [J]. Proceedings of the IEEE, 1998, 86(11): 2278-2324.

[2] A. Besson ; CMOS pixel sensors with on-chip Neural Network : A new horizon for embedded systems, ATTRACT TWD Symposium : Trends, Wishes and Dreams in Detection and Imaging Technologies; Strasbourg, 4-5 November 2016.