Neural Network Applications for the OPERA Experiment

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The method based on the neural networks was developed for determining the emulsion brick containing the vertex of tau neutrino events for the target tracker (TT) of the OPERA experiment. The TT consists on 31 walls each containing 3328 bricks from emulsion and led layers. Walls are separated by scintillator strips designed for rough determining XY-coordinates of bricks (see fig.1)

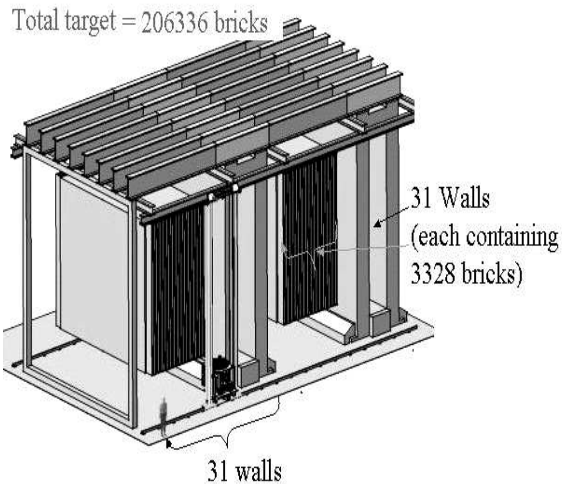

Fig.1. Scheme of Target Tracker part of the OPERA setup

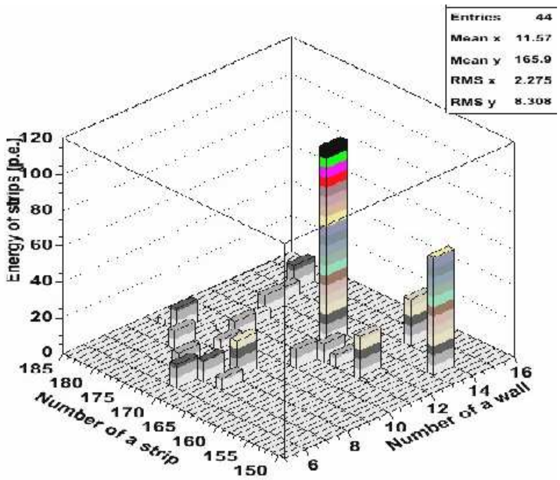

Fig.2. Hit amplitudes of one scintillator plane

Therefore the first important step was to find the right wall with vertex avoiding a backscattering effect. Neural networks of multilayer feed forward (MFF) type were used for a preliminary selection of some scintillator walls which are likely to be candidates for being the first downstream wall after the vertex. The choice of the first of these walls is of the utmost importance since in the absence of back-scattered particles the first touched scintillator wall is the one of interest while in the presence of back-scattered particles the first touched wall and even one or two successive walls are to be eliminated. To facilitate the vertex location preliminary data filtering is fulfilled. It should eliminate or, at least, reduce the number of disconnected strips corresponding to electronic noise. The method is based on cellular automaton principle that rejects strips that have no nearest neighbours.

After cellular automation filtering we use the variable slope histogramming method for a muon track finding. The criterion of the muon track definition is that a bin of histogram with the maximum value must contain at least 10 points. When the maximal bin is found the directions corresponding to 95% of maximum are fixed. If the number of such directions is less than 3 their parameters are used to determine then a vertex brick. Otherwise only a shower axis is reconstructed. Then to determine so called 'shower axis'

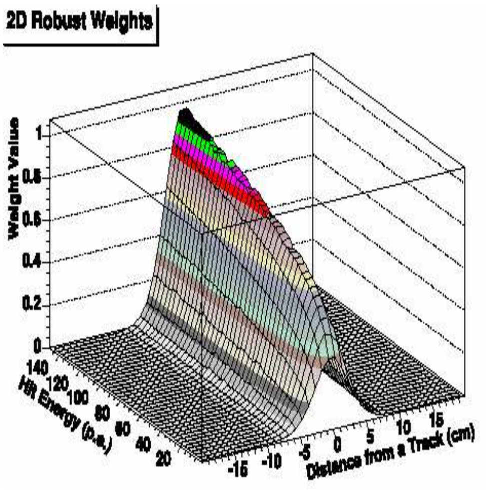

Fig.3. 2D robust weight function

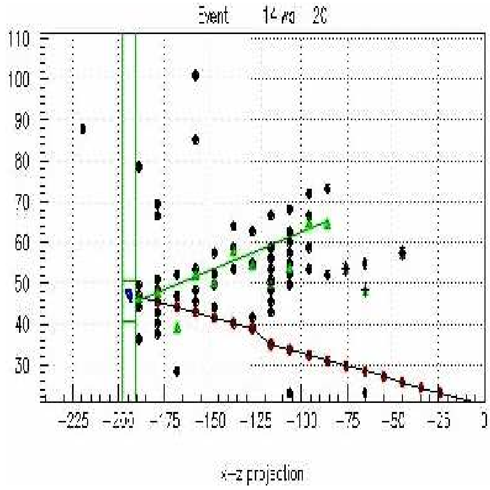

Fig.4. Event with muon track and hadron shower

we use the robust fit of a straight line to all points excluding the points of the found muon track, but including points belonging to the first three walls having the energy exceeding the average track energy, in order (see fig.2 and 4). The robust fit starts from the initial approach, which is a line passing through the center of gravity of all points and parallel to Z axis. Robust weights of each point are calculated with taking into account their amplitudes, i.e. energies of corresponding strips and distances from fitted line (see fig. 3.)

Since three types of events were simulated, namely ν_τ - hadronic, ν_μ - charge current, and ν_μ - neutral current, three corresponding neural networks (NN) were constructed, one for each type, and then trained by those simulated data. To decrease the number of neural net input parameters it was proposed to use only 6 walls of 31 in the TT in which the maximum of energy was collected. Only four parameters were used for each wall which gives 24 input parameters for training each neural net by standard back propagation algorithm. The NN outputs give the probability of each of the considered walls to be the first plane after the vertex.

Testing our set of NN on a mixture of events of different types we choose the results with the highest probability. The NN has been trained on about 2700 events. The wall finding efficiency by NN is about 85%. Once the right wall is found, the muon track and event shower axis are used to determine x-y position of the vertex, as a projection of the point nearest to these two skew lines. The efficiency of brick finding is about 75%. The vertex localization accuracy is on the level 2-2.5 cm. An OPERA note with the recent results is prepared.

References

[1] Г.А.Ососков, А.В.Стадник, Эффективные нейросетевые алгоритмы для обработки экспериментальных данных, "Информационные технологии и вычислительные системы", изд-во УРСС, М., 2004, стр. 103-125.

[2] Ососков Г.А., Дмитриевский С.Г., Стадник А.В, Нейронные сети с самоорганизацией в задачах классификации и обработки изображений, Искусственный Интеллект, в.3, (Украина), 2004, 574-586.