On Electron/Pion Identification Using a Multilayer Perceptron in the CBM TRD

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The measurements of charmonium is one of the key goals of the CBM exeriment. To detect J/ψ meson in its dielectron decay channel, the main task is the separation of electrons and pions. We compare two neural networks (a multi-layered perceptron – MLP) from JETNET3 and ROOT packages for the e/π identidication using the Transition Radiation Detector (TRD). The method is based on a set of energy losses $\{\Delta E_{i=1,\dots,n}\}$ measurements in n TRD layers for π and e with momenta 1 GeV/c $\leq p \leq$ 11 GeV/c.

To obtain reliable and comparable results, it is important to select correctly the architecture of the network [1]. The choice of the MLP architecture includes the determination of: a) number of the MLP layers, b) number of neurons in each layer.

In our case, the network included $n = 12$ input neurons, 12 neurons in the hidden layer, and 1 output neuron. To choose the number of neurons in the hidden layer, we analyzed the error distribution – difference between the target value and the MLP output signal (Fig. 1). It has to satisfy the following criteria: 1) to be symmetrical relative to zero average, 2) the dispersion must be minimal.

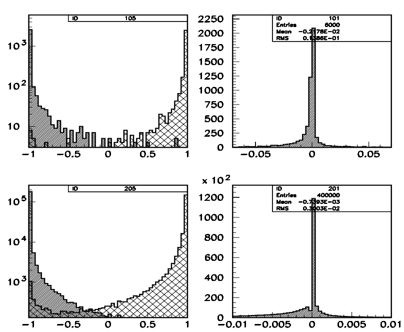

Figure 1: Distributions of the MLP output signals obtained at the training and testing stages (left plots); the right plots show the distributions of errors at the training and testing stages

To obtain an acceptable level of pions suppression, the energy losses in the TRD layers should be transformed to more "effective" variables:

$$\lambda_i = \frac{\Delta E_i - \Delta E_{mp}}{\xi_i} - 0.225, \qquad \text{i = 1,2,...,n},$$

where ΔE_i is the energy loss in the i-th absorber, ΔE_{mp} is the most probable energy loss, $\xi_i = \frac{1}{4.02}$ FWHM of the distribution of pion's energy losses [2]. This transformation permits one to obtain a reliable level of the e/π identification by the network after a minimal number (around 50) of training epochs in conditions of practical absence of fluctuations against the trend (the top curve in Fig. 2). In case of original data, in spite of a large number of training epochs, one can not reach the needed level of particle identification (the bottom curve in Fig. 2).

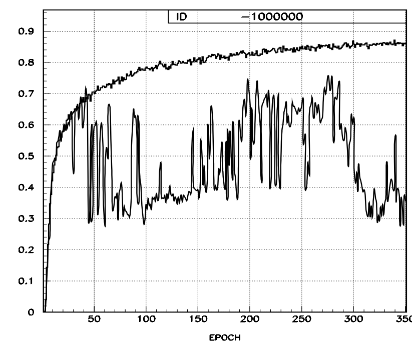

Figure 2: The efficiency of e/π identification by the MLP for original (bottom curve) and transformed (top curve) samples

The formulas for enumerating the transformation parameters depending on the momentum are as follows:

$$\Delta E_{mp}(p) = 0.0005451p^3 - 0.01572p^2 + 0.1657p + 0.8866,$$
$$\xi(p) = 0.0001789p^3 - 0.005178p^2 + 0.05472p + 0.4983.$$

At the stage of the MLP testing the event type is determined by the value of the output signal: when it does not exceed the preassigned threshold, the event is assumed to be π, in the opposite case – e.

To estimate the efficiency of e/π identification and pion suppression by MLP, the networks were trained for each momentum separately and with corresponding transformation parameters (Table 1).

Table 1: The pion suppression factors for the 90 % efficiency of electrons registration applying MLP

p, GeV/c	1	2	5	7	9	11
JETNET	273	647	477	541	506	364
ROOT	294	447	456	524	448	323

Table 1 demonstrates that for the correctly chosen MLP architecture both networks give comparable results. In the opposite case, the pion suppression factor for networks may be essentially different.

References

[1] N.A. Ignat'ev. Comp. techn., t.6, No.1,2001,p.23-28.

[2] E.P. Akishina et. all, JINR Communication, P10-2009-61, JINR, Dubna, 2009.