artificial neural network, ANN, biometrics identification, visual stimulation, Ober2, teaching vectors, recognition, layer, neurone, eye movement

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BIOMETRICAL IDENTIFICATION ON THE GROUND OF THE EYE MOVEMENT, EXECUTED BY MEANS OF THE ARTIFICIAL NEURAL NETWORK

In this article was written attempt to use the eye movement to biometrics identification. There are few words about theory of biometrics identification. After that there is described the way of recording of data. It is made by system 'Ober2'. To process collected data the algorithms of artificial neural network are used. For this need, dedicated application was written. Functionality of the application, in article was described, as well as the examples - results of working of the artificial neural networks, for chosen criterions of researches. The plans for future researches were placed at the end of the article.

1. BIOMETRICAL IDENTIFICATIONS

In traditional methods of biometrical identifications such as fingerprint or iris image, we have lots of defects. There is possibility of counterfeit; identification doesn't take into consideration if person is alive, what the current emotional state of examined person is, and if he isn't under influence of medicine, drugs or alcohol. Because of these reasons, there is one need, to seek the new methods of identification. One of new method is diagnosis of eye movement, as a result of action of external visual signal's force, which make a work of brain. So measurement of eye movement is indirect measurement of functional parameters of brain. Eye movement it is wide gates to brain - there is million direct connections between retina of eye and brain. Considering the brain as object of biometrics we have lots of advantage. As for now the brain is spuriousness and takes into account: person's current emotional state, influences of medicines, drugs, alcohol etc.

Identification on the ground of the eye movement will be executed by artificial neural network (called further the ANN). ANN is a system of mutually connected processing information elements, called neurones. Usually ANN has suitable structure, assembling neurones in layers. To connections between neurones are attributed weights. The whole knowledge of ANN is kept and imitated by value of weights. Weights are calculated and attached in training process - then it is the system that can be taught. The number of neurones in input and output layer is often thrown by specifications of solved task. Their number in hidden layers, most often is chosen experimentally. Too small number causes to

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the inability of ANN, to accumulate sufficient knowledge. Too rich architecture to exactly remember input data and it isn't possible to draw out conclusions for other data. The process of teaching is realised by algorithm of back propagation. The algorithm of backward propagation minimises the error committed by ANN on training data. To estimate the real quality of working model, it is required to test him on test data, different from data from process of teaching.

Force of eye's movement can be realised on many ways – as a visual simulation we can give to examined person:

- all the time the same , or each time different signal,
- static or dynamic view,
- large view or single point.

In each case will be studied the eye movement associated:

- with possibilities of memorisation of given view,
- with speed of noticed changing of the view,
- with precision of concentration of sight on the point,
- from automatic inspection of given painting,
- many other features psycho - physical, which characterise given person.

In this research, as a force to move the eyes, we will use a jumping point on-screen of monitor. This point will appear at random duration in random chosen position, from set of 9 solid points, which form square 3x3. During the research the examined person, will sit before monitor. On his head will be situated the glasses, being the part of the measuring system "Ober2". This system record 4 variables appointed suitably:
'xl' - co-ordinate x of point on monitor, on which looks studied person's left eye,
'yl' - co-ordinate y of point on monitor, on which looks studied person's left eye,
'xr' - suitably the co-ordinate x of right eye,
'yr' - suitably the co-ordinate y of right eye.

When we add the co-ordinates x as well as y of point of force, we will have in total record 6 variables. With regard on need of easy and comparatively quick access to different datasets, the received results become situated in database. Basic differences will become situated in database too:
'x-xl' the difference of value from axis the x, between force and point, on which looks the left eye,
'y-yl' the difference of value from axis the y, between force and point, on which looks the left eye,
'x-xr' suitably axis x for force and right eye,
'y-yr' suitably axis y for force and right eye,
'xl-xr' the difference of value from axis the x between point on which the left and right eye looks,
'yl-yr' suitably left and right eye for value from axis y.

2. DESCRIPTION OF APPLICATION WRITTEN IN AIM OF PROCESSING THE GATHERED DATA

To have possibility of process and analyse data that we have from our research, the specialised application was written. Using it we can execute the following path of process:

- define the structure of ANN,
- define the parameters of teaching for ANN,
- choice of teaching vectors,
- define the parameters of teaching vectors,
- teaching ANN,
- check the quality of taught ANN.
- we have also the possibility of generating random value of initial weights of the ANN.

First action that we supposed to do using this application is to define structure of ANN. We have to specify the number of layers (from 1 to 4), as well as the quantity of neurones in internal layers. The number of neurones in entrance layer, as well as in last one, will be appointed automatically, on the ground of the settings made in more far part of work with the application. The entrance layer has to distribute the entrance vectors only, therefore it does not be included in calculation in number of layers of ANN, and we can mark it as layer 0. Then we have possibility to change the parameters of teaching of ANN. We can execute these changes also in later stages of work with programme. These settings have influence on speed and quality of teaching the ANN. They are used by algorithm of teaching, because numbers of calculations, as well as lack of guarantee, that the ANN will not stick in local minimum. In this place we can also set the error range up to which the process of teaching will be continued. The next action is choice of measurement – vectors that we use to teach the ANN. After confirmation of our choice we can define the parameters of teaching vectors, and quantity of samples for which the process of teaching will be realised (Fig.1.)

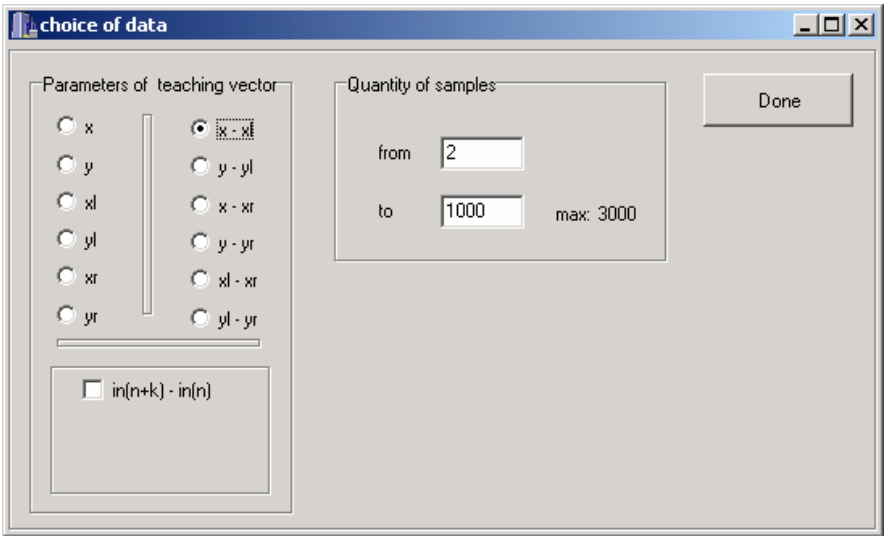

Fig. 1. Selection of data's parameters

The quantity of samples that we set is quantity of neurones in layer 0, so it is numbers of entrance of ANN.

The next stage is to teach ANN. (Fig.2.) We can realise it with stages, checking among them the quality of ANN. We can also teach till the ANN achieves earlier define error range. In a window we have also information about quantity of steps of teachings, that have already been made, as well as the current error of ANN.

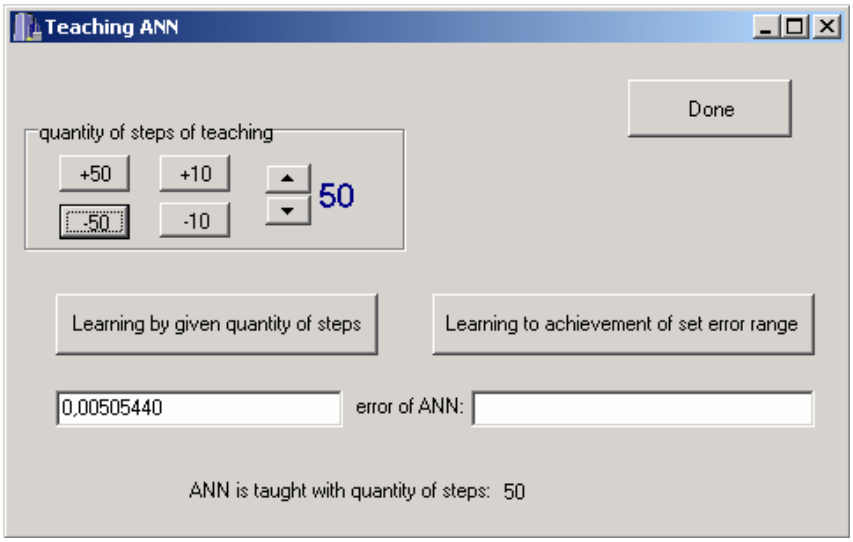

Fig. 2. Process of teaching an ANN

The last stage is checking the quality of taught ANN. (Fig.3.) We can read in checking vector, then by checking it we receive on-screen value from exits of ANN, as well as corresponding persons to these exits.

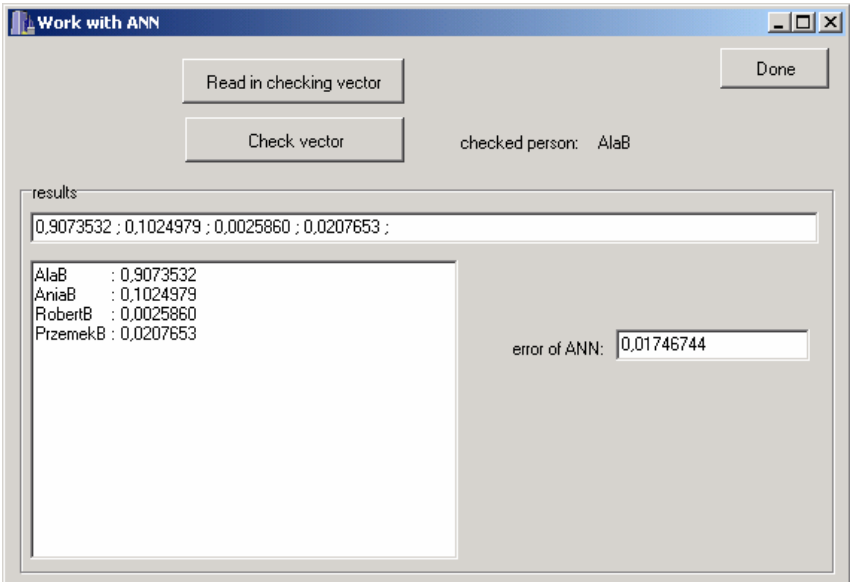

Fig. 3. Result of working with ANN

3. RESULTS AND ANALYSIS OF MEASUREMENTS

The aim of data processing by written application is:

- the choice of optimum signals of force, the movement of eye,
- the qualification of sufficiency of input data,
- the qualification of optimum frequency and length of duration of individual measurement,
- the choice of proper parameters of data,
- the qualification of quantity of internal layers,
- the qualification of quantity of neurones in internal layer,
- the qualification of quantity of teachings steps,
- the qualification of suitable parameters of teaching.

Below will be shown the few combinations of the experiments:

4. THE ERROR OF THE ANN FOR DIFFERENT STRUCTURES OF THE ANN AND DIFFERENT QUANTITY OF STEPS OF TEACHING

Table 1. Results of measurements – error of ANN for parameters 'x-xp'

Quantity of steps of teaching Time of measurement [s] and structure of ANN	**10**	**20**	**50**	**100**	**250**	average
12s (3000)-160-25-4	0,03047250	0,00634991	0,00633930	0,00277579	0,00230793	0,009649
8s (2000)-160-25-4	0,01316317	0,01646384	0,00605030	0,00312988	0,00287859	0,008337
6 s (1500)-160-25-4	0,02406827	0,00668091	0,00362830	0,00235398	0,00263532	0,007873
4s (1000)-160-25-4	0,02455344	0,01230661	0,00505440	0,00224299	0,00336938	0,009505
2s (500)-160-25-4	0,03806822	0,01057158	0,00821636	0,00702826	0,00270011	0,013317
average	0,0260651	0,0104745	0,0058577	0,0035061	0,00277826	

In research ware used 5 different structures of ANN. For 5 different length of measurement (2 seconds, 4s, 6s, 8s, 12s), quantity of neurones in layer 0 was altered. For all structures, the error of teaching was studied, for 5 different quantities of steps of teachings. In this research parameter 'x-xp' was used.

From the results we can see, that for that ANN with 4 exits, the error of ANN is going down, and we have acceptable error after about 50 steps of teachings. We can also notice that the smallest structure has the worse results of teaching.

Therefore in future research, we will use for ANN, 50 steps of teachings.

5. THE ERROR OF THE ANN FOR DIFFERENT LENGTH OF DURATION OF MEASUREMENTS AND THEREBY DIFFERENT STRUCTURES OF THE ANN AND DIFFERENT PARAMETERS OF VECTORS OF TEACHING

Table 2. Results of measurements – error of ANN for parameters ‘x-xp’

Parameters of teaching’s vektors Time of measurement [s] and structure of ANN	**x-xl**	**y-yl**	**x-xr**	**y-yr**	**xl-xr**	**yl-yr**	**average**
12s (3000)-310-40-4	0,003694	0,005966	0,004243	0,006191	0,005509	0,003659	0,004877
8s (2000)-260-35-4	0,004846	0,005575	0,006513	0,007744	0,006182	0,005184	0,006008
6s (1500)-210-30-4	0,006957	0,005871	0,004831	0,004889	0,005989	0,004290	0,005472
4s (1000)-160-25-4	0,003913	0,007557	0,007502	0,004899	0,003520	0,007127	0,005753
2s (500)-100-20-4	0,006078	0,008157	0,012696	0,014566	0,011123	0,006275	0,009816
average	0,005098	0,006626	0,007157	0,007658	0,006465	0,005307	

In this research ware used 5 different structures of ANN. For 5 different length of measurement (2 seconds, 4s, 6s, 8s, 12s), quantity of neurones in every layers ware altered. For all structures, the error of teaching was studied, for 6 different parameters of vectors of teachings. In this research results ware taken after 50 steps of teaching.

From the results we can see, that for that ANN with 4 exits, we have similar error for every parameters. We can also notice that the smallest structure has the worse results of teaching.

Therefore in future research, we will use the structure (1000)-160-25-4.

6. RESULTS OF RECOGNITIONS FOR DIFFERENT PERSONS AND PARAMETERS OF VECTORS OF TEACHING

Research was conducted for 4 persons: AlaB, AniaB, RobertB and PrzemekB. Every of these persons have corresponding exit of ANN. After process of teaching, we made series checking of quality of diagnostics for every of persons. During the checks process, to the ANN were passed 2 kinds of vectors: the same as in teaching process, marking as "teach", and the other one - those weren’t use in teaching process, marking as "test". The values on exits of ANN can appear from range (0 ÷ 1). The higher value on the exit, the larger degree of recognition. Thus value above 0,8 or more, shows on person's recognition, described to given exit, however value below 0,2 indicate rejection of person, described to this exit, as presently studied. Values from range 0,2 to 0,8 shows on uncertainty of ANN, what to studied person's recognition.

Table 3. Results of measurements for parameter ‘xl-xr’

Exit of ANN / Recognised persons	AlaB	AniaB	RobertB	PrzemekB	error of ANN
AlaB wek1 teach	**0,9698014**	0,0150189	0,0327180	0,0120530	0,00542364
AlaB wek2 test	**0,7587758**	0,2553870	0,0427894	0,00018655	0,03956681
AlaB wek3 test	**0,8353974**	0,3815837	0,0235804	0,00062719	0,04653716
AniaB wek1 teach	0,0114553	**0,9830030**	0,0205171	0,0072731	0,00334285
AniaB wek3 test	0,5539883	**0,6660846**	0,0014463	0,0984609	0,07315217
AniaB wek3 test	0,1158362	**0,9105234**	0,0274321	0,0044275	0,01665690
RobertB wek1 teach	0,0093061	0,0306240	**0,9601534**	0,0371653	0,00706527
RobertB wek3 test	0,1393218	0,1165063	**0,0132743**	0,4178888	0,12151352
RobertB wek3 test	0,2050641	0,8285734	**0,1536671**	0,0022338	0,13439074
PrzemekB wek1 teach	0,0242345	0,0165031	0,0140741	**0,9733834**	0,00469866
PrzemekB wek2 test	0,3369280	0,4431770	0,0039719	**0,0515053**	0,12296260
PrzemekB wek3 test	0,1956381	0,4603524	0,0722143	**0,0150400**	0,12377195

Table 4. Results of measurements for parameter ‘x-xl’

Exit of ANN / Recognised persons	AlaB	AniaB	RobertB	PrzemekB	error of ANN
AlaB wek1 teach	**0,9420346**	0,0330035	0,0254159	0,0405988	0,00918113
AlaB wek2 test	**0,0785264**	0,5435266	0,0371421	0,0357317	0,11974927
AlaB wek3 test	**0,0687287**	0,0717112	0,0293881	0,1636272	0,10606873
AniaB wek2 teach	0,0121099	**0,9479331**	0,0191125	0,0266943	0,00701381
AniaB wek3 test	0,0430749	**0,7147145**	0,0053673	0,2446289	0,04229589
AniaB wek3 test	0,0127232	**0,3932523**	0,0270572	0,3301412	0,07730054
RobertB wek1 teach	0,0094276	0,0181678	**0,9789115**	0,0188220	0,00390183
RobertB wek3 test	0,0675386	0,0190660	**0,7681135**	0,0761985	0,02839509
RobertB wek3 test	0,1539397	0,0949281	**0,4696967**	0,0762030	0,06321957
PrzemekB wek1 teach	0,0201446	0,0143255	0,0397441	**0,9747948**	0,00594340
PrzemekB wek2 test	0,0156426	0,6133435	0,0419278	**0,1204115**	0,11999317
PrzemekB wek3 test	0,5544548	0,0890635	0,2433468	**0,0122457**	0,12991482

On the ground of results that we have, it is possible to draw out following conclusions: At present, system too seldom, and with too small probability, recognise studied persons. However important is that it does not generate incorrect recognition for given person. It is visible also that for different parameters, the ANN gives the similar quantity of recognition, work with the same effectiveness. Also, it is proper to notice that for different parameters, recognition steps out for different persons. From here the conclusion is, that processing simultaneously few or all of the parameters of vector, will give better results of recognition.

7. FINAL CONCLUSIONS AND PLANS FOR FUTURE WORKS

The System at present - the phase of preliminary researches – gives us enough positive results that it is worth to undertake more far work. There is a need to improve application from algorithmic side, especially to give possibilities to process several parameters of teaching vectors parallel. Also there is a need to make more experiments for larger quantity of persons with larger quantity of measurements.

There is also the plan to check:

- whether 3 layer ANN is optimum structure,
- how the quantity of steps of teaching is dependent on studied persons' quantity,
- whether are differences in quality of ANN for different visual force signals for movement of eye,
- how the changes of teaching parameters influence on results.

All of these are being made to improve methodology, which will give us the best results of identification.

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