EE6222 Machine Vision

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Due to my laptop's limited capability of computing, I choose 10 datasets from all 121 UCI datasets to investigate following issues. These 10 datasets are shown in Table 1.

Table 1 Datasets used in this work

Datasets	Patterns	Features	Classes
abalone	4177	8	3
chess-krvkp	3196	36	2
letter	20000	16	26
magic	19020	10	2
molec_biol_splice	3190	60	3
nursery	12960	8	5
page-blocks	5473	10	5
spambase	4601	57	2
twonorm	7400	20	2
w-qua-white	4898	11	7

1. Effect of direct links from the input layer to the output layer (i.e., with and without).

To find the effect of direct links from the input layer to the output layer, I choose $radbas$ as the activation function and regularized least square for the solution to the output. I also choose two different conditions to have more pairs for comparison. One is without bias in the output neuron,

another is with bias. The results are shown in Table 2.

Table 2 Means of classification accuracies of RVFL with and without direct links

Datasets	-bias, -link	-bias, +link	+bias, -link	+bias, +link
abalone	0.6561	0.6576	0.6576	0.6573
chess-krvkp	0.9543	0.9524	0.9534	0.9587
letter	0.7958	0.7959	0.7959	0.7959
magic	0.8494	0.8497	0.8497	0.8496
molec_biol_splice	0.8184	0.8152	0.8187	0.8168
nursery	0.9285	0.9287	0.9284	0.9285
page-blocks	0.9556	0.9556	0.9558	0.9556
spambase	0.9037	0.9054	0.9039	0.9057
twonorm	0.9788	0.9789	0.9788	0.9789
w-qua-white	0.5472	0.5523	0.5529	0.5525
mean accuracy	0.8388	0.8392	0.8395	0.8400

In Table 2, each column presents the mean accuracy of RVFL with or without direct links from the input layer to the output layer. Comparing 3rd and 5th columns with 2nd and 4th columns, it's obvious that the RVFL with direct links has much higher accuracy than the one without them in most cases. Therefore, the direct links from the input layer to output layer working as a regularization for the randomization of initial parameters can help RVFL to achieve better performance than the RVFL without direct links. The conclusion is the same as that in [1].

2. Performance comparisons of 2 activation functions: one from "relu,

sigmoid, radbas, sine" and one from "hardlim, tribas"

From Table 2, we can observe that the RVFL with direct links and bias has the highest accuracy. So, I implement direct links and bias in the network structure and choose the default regularized least square for the solution. The results are shown in Table 3.

Table 3 Means of classification accuracies of RVFL with different activation functions

Datasets	relu	sigmoid	radbas	sine	hardlim	tribas
abalone	0.6329	0.6607	0.6573	0.6648	0.6456	0.6511
chess-krvkp	0.9446	0.9534	0.9587	0.9543	0.9437	0.9512
letter	0.5563	0.7730	0.7959	0.8301	0.5807	0.6549
magic	0.7805	0.8490	0.8496	0.8574	0.7946	0.8190
molec_biol_splice	0.8058	0.8096	0.8168	0.8049	0.8011	0.80870
nursery	0.8917	0.9262	0.9285	0.9523	0.8917	0.8937
page-blocks	0.9264	0.9578	0.9556	0.9585	0.9466	0.9560
spambase	0.8800	0.9037	0.9057	0.9104	0.9041	0.9120
twonorm	0.9796	0.9796	0.9789	0.9789	0.9791	0.9793
w-qua-white	0.5331	0.5484	0.5525	0.5568	0.5445	0.5455
mean accuracy	0.7931	0.8361	0.8400	0.8468	0.8032	0.8174

In the last row of Table 3, the mean accuracy is calculated to compare the performance of RVFL with different activation functions. It's obvious that $sine$ has the highest mean accuracy and $relu$ has the lowest mean accuracy. So, from Table 3, we can conclude that

$$sine > radbas > sigmoid > tribas > hardlim > relu,$$

where $>$ means the left side performs better than the right side. The result

I obtain in this experiment is different from that in [1] because I only choose 10 out of 121 datasets. Thus, the conclusion is not convincing, and experiment based on large number of datasets should be done further.

3. Performance of Moore-Penrose pseudoinverse and ridge regression (or regularized least square solutions) for the computation of the output weights.

To estimate the performance of Moore-Penrose pseudoinverse and regularized least square solutions for the computation of the output weights, I choose the RVFL with direct links and bias and the activation function is $radbas$. The results are shown in Table 4.

Table 4 Means of classification accuracies of RVFL with different solutions

Datasets	Moore-Penrose pseudoinverse	regularized least square
abalone	0.6533	**0.6573**
chess-krvkp	**0.9599**	0.9587
letter	**0.8366**	0.7959
magic	**0.8578**	0.8496
molec_biol_splice	0.8118	**0.8168**
nursery	**0.9584**	0.9285
page-blocks	**0.9563**	0.9556
spambase	**0.9102**	0.9057
twonorm	0.9785	**0.9789**
w-qua-white	**0.5537**	0.5525

According to Table 4, it's obvious that the Moore-Penrose pseudoinverse

performs better than regularized least square in 7 datasets (i.e., chess-krvkp, letter, magic, nursery, page-blocks, spambase and w-qua-white). Therefore, based on the chosen 10 datasets, the RVFL using the Moore-Penrose pseudoinverse will have a better performance than that using regularized least square solution. However, the conclusion is not persuasive. More precise result can be obtained by using more datasets for experiments.

References:

[1] L. Zhang, P. N. Suganthan, "A Comprehensive Evaluation of Random Vector Functional Link Networks", Information Sciences, DOI: 10.1016/j.ins.2015.09.025, Volumes 367–368, pp. 1094–1105, Nov 2016.