Classification of Abnormal Cervical Cells Using Hierarchical Multilayered Perceptron Network.

Nor Ashidi Mat Isa[1], Mohd Yusoff Mashor[1], Nor Hayati Othman[2]
[1]Control and Electronic Intelligent System (CELIS) Research Group, School of Electrical & Electronic Engineering, Universiti Sains Malaysia, Engineering Campus, Penang, Malaysia.
[2]Pathology Department, School of Medical Science, Universiti Sains Malaysia, Kelantan, Malaysia.

Abstract
The paper discusses the use of neural network to classify the types of cervical cells based on Bethesda system; which are normal, *low-grade squamous intraepithelial lesion* (LSIL) and *high-grade squamous intraepithelial lesion* (HSIL). The current study proposed new neural network architecture, namely hierarchical multilayered perceptron (HiMLP) network. The proposed neural network was trained using modified recursive prediction error (MRPE) algorithm. Four cervical cells features, which are size of nucleus, size of cytoplasm, grey level of nucleus and grey level of cytoplasm, were used as input data. The HiMLP network was trained using 128 samples and tested using 72 samples. The results show that the HiMLP network gave promising diagnostic performance by producing high accuracy, sensitivity and specificity as well as reducing false negative and false positive rate. Furthermore, the proposed neural network also produced better diagnostic performance compared to two common neural networks; the RBF and MLP networks.

Introduction
In general, cancer of the cervix is the second most common cancer among females in developing countries after breast cancer (Othman, 2003, HTAC, 2003). Cancer of the cervix is preventable. The precursor cells can be easily detected provided the women do regular screening tests called Papanicolaou test or better known as Pap test (Othman, 2003, Kuie, 1996, Adami *et al.*, 1994). A computer model analysis has found that the proportion of cervical cancer reduction are approximately 30% for a smear taken once every 10 years, 80% for every five years, 90% for every three years, 91% for every two years and 92% for an annual smear (Kuie, 1996).

However, Pap test does not always produce good diagnostic performance due to bad Pap smear samples, technical errors and human errors (Othman *et al.*, 1997, Kuie, 1996, Hislop *et al.*, 1994). Besides that, the task of examining Pap smear slides for abnormal cervical cells requires an experienced cytopathologist and thus expensive and time-consuming, especially in developing countries. These problems have encouraged several previous studies to develop diagnosis technique or system based on neural networks to increase the diagnostic performance. In the literature, neural networks offer good diagnosis performance as a cervical cancer diagnosis technique. For example, Frable (2001) and Kok *et al.* (2001), proved that neural networks have good ability to detect rare and significantly abnormal cell as well as the small undifferentiated reserve parabasal type cell that, when present in small numbers, is very difficult to find by conventional screening.

In the current study, we proposed a new specially designed neural network as an intelligent cervical cancer diagnostic system. As compared to previous studies (eg. Li

& Najarian, 2001, Balasubramaniam *et al.*, 1998), the current study took one step further by classifying cervical cells into three classes based on Bethesda system; which are normal, *low-grade squamous intraepithelial lesion* (LSIL) and *high-grade squamous intraepithelial lesion* (HSIL). For that purpose, the current study proposed a new neural network called hierarchical multilayered perceptron (HiMLP) network.

Hierarchical Multilayered Perceptron Network

In many previous studies, multilayered perceptron (MLP) network has commonly used to classify cervical cells into normal and abnormal cells (Li & Najarian, 2001, Mitra *et al.*, 2000, Balasubramaniam *et al.*, 1998). In those studies, the MLP network gave acceptable and very promising results. In the current study, a modified version of the MLP network called hierarchical multilayered perceptron (HiMLP) network is introduced to increases the MLP network's performance in classifying cervical cells' types. The HiMLP network consists of two MLP networks, which are cascaded together as shown in Figure 1.

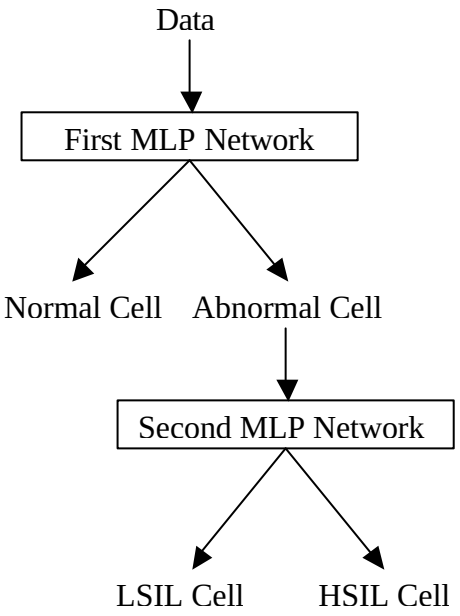

Figure 1: Block diagram of the HiMLP network.

The classification of cervical cells' type is divided into two stages. In the early stage, all data will be fed to the first MLP network. The first MLP network will classify the data into normal and abnormal cervical cells. The first MLP network also has a purpose to filter the normal cells and ensure only the abnormal cells consists of LSIL and HSIL cells to be fed to the second MLP network. The classification of the abnormal cervical cells into LSIL and HSIL cells will be done by the second MLP network. The HiMLP network is trained using modified recursive prediction error (MRPE) algorithm. Refer to reference Mashor (2000a) for implementation of MRPE algorithm.

Methodology

In order for HiMLP network to be used as cervical cancer diagnostic technique, the features of cervical cells that are extracted by human expert could be used as HiMLP network inputs. The images of cervical cells have been captured from Pap smear slides

using a computerised microscope. Four features have been manually extracted from the computer images of cervical cells. The features are size of nucleus, size of cytoplasm, grey level of nucleus and grey level of cytoplasm.

In the current study, the HiMLP network was trained with 128 samples, which consisted of 32 normal cells, 32 LSIL cells and 64 HSIL cells, while 72 samples, which consisted of 18 normal cells, 18 LSIL cells and 36 HSIL cells, were used as testing data. Accuracy, sensitivity, specificity, false negative and false positive were used to determine the suitability and capability of HiMLP networks to classify the cervical cells.

Results

In the current study, the diagnostic performance of the proposed HiMLP network was compared to the performance of conventional RBF and MLP networks. The RBF network was trained using Given least squares (Chen *et al.*, 1992) and moving *k*-means clustering (Mashor, 2000b) algorithms. The MLP network was trained using MRPE algorithm. Table 1 shows the cervical cancer diagnostic performance of those neural networks. From the results, the proposed HiMLP network has successfully screened the cervical cells with much higher accuracy and sensitivity than the conventional RBF and MLP networks. The HiMLP network improved the accuracy with 19.50% and 19.00% compared to the RBF and MLP networks respectively. The HiMLP network also achieved better sensitivity than the RBF and MLP network with 26.00% and 25.33% improvement respectively.

The HiMLP network also kept the false positive rate to some considerably low value, which was only 7.00%. The reduction of rate is 42.00% and 41.00% compared to the RBF and MLP networks respectively. False negative rate was also very low, which was 2.00%.

Table 1: Cervical cancer diagnostic performance of RBF, MLP and HiMLP networks.

	RBF	MLP	HiMLP
Accuracy	75.50	76.00	95.00
Sensitivity	67.33	68.00	93.33
Specificity	100.00	100.00	100.00
False Negative	0.00	0.00	2.00
False Positive	49.00	48.00	7.00

Conclusion

In this study, a new neural network called HiMLP network was proposed to perform cervical cells classification. The HiMLP network was trained using MRPE algorithm. The results show that the HiMLP network produced high accuracy, sensitivity and specificity, and reduced false positive and false negative rate. The results also show that the HiMLP network gave better diagnostic performance compared to two conventional neural networks; the RBF and MLP networks. These indicate that the HiMLP network is suitable to be used for classification of cervical cells into normal, LSIL and HSIL cells.

This finding is very useful in developing an intelligent screening system for cervical cancer. The proposed neural network produces high diagnostic performance that could

increase the conventional diagnostic performance. Furthermore, it can reduce the workload of pathologists, thus it is more time-effective and cost-effective.

References.

[1] Adami, H. O., Ponten, J., Sparen, P., Bergstrom, R., Gustafsson, L. & Friberg, L. G. 1994. Survival Trend After Invasive Cervical Cancer Diagnosis in Sweden Before and After Cytologic Screening. *Cancer*. 73(1). 140-147.

[2] Balasubramaniam, R., Rajan, S., Doraiswami, R. and Stevenson, M. 1998. A Reliable Composite Classification Strategy. *Proceedings of IEEE Canadian Conference on Electrical and Computer Engineering*. 2. 914-917.

[3] Chen, S., Billings, S. A. & Grant, P. M. 1992. Recursive Hybrid Algorithm for Non-Linear System Identification Using Radial Basis Function Networks. *Int. J. of Control*. Vol. 55. pp. 1051-1070.

[4] Frable, W. J. 2001. Cervical Screening by Neural Networks. *Cancer Cytopathology*. 93(3). 171-172.

[5] Hislop, T. G., Band, P. R., Deschamps, M., Clarke, H. F., Smith, J. M. and Ng, V. T. Y. 1994. Cervical Cancer Screening in Canadian Native Women: Adequacy of The Papanicolaou Smear. *The Journal of Clinical Cytology and Cytopathology*. 38(1). 29-32.

[6] HTAC. 2003. Pap Smears and Prevention of Cervical Cancer. *http://www.health.state.mn.us/htac/papq&a.html*

[7] Kok, M. R., Boon, M. E., Kok, P. G. S., Hermans, J., Grobbee, D. E. and Kok, L. P. 2001. Less Medical Intervention after Sharp Demarcation of Grade 1-2 Cervical Intraepithelial Neoplasia Smears by Neural Network Screening. *Cancer Cytopathology*. 93(3). 173-178.

[8] Kuie, T. S. 1996. *Cervical Cancer: Its Causes and Prevention*. Singapore: Times Book Int.

[9] Li, Z. and Najarian, K. 2001. Automated Classification of Pap Smear Tests Using Neural Networks. *Proceedings of International Joint Conference on Neural Networks*. 4. 2899-2901.

[10] Mashor, M. Y. 2000a. Hybrid Multilayered Perceptron Networks. *International Journal of System Science*. Vol. 31. No. 6. pp. 771-785.

[11] Mashor, M. Y. 2000b. Nonlinear System Identification Using HMLP Network. *Journal – Institution of Engineers, Malaysia*. Vol. 60. No. 2. pp. 33-40.

[12] Mitra, P., Mitra, S. and Pal, S. K. 2000. Staging of Cervical Cancer with Soft Computing. *IEEE Transaction on Biomedical Engineering*. 47(7). 934-940.

[13] Othman, N. H., Ayub, M. C., Aziz, W. A. A., Muda, M., Wahid, R. and Selvarajan, S. 1997. Pap Smears – Is It An Effective Screening Methods for Cervical Cancer Neoplasia? – An Experience with 2289 Cases. *The Malaysian Journal of Medical Sciences*. 4(1). 45-50.

[14] Othman, N. H. 2003. *Cancer of The Cervix: From Bleak Past to Bright Future*. Kelantan, Malaysia: Pustaka Reka.