System Intelligence Laboratory

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The main stream in our lab is related to computational intelligence. So far we have focused our study on three key words: recognition, learning and understanding. The goal of our research is to develop some learning models that are flexible enough to adapt changing environment, and also simple enough to be realized, interpreted and re-used. The ultimate goal is to design a system that can think, and decide what to do and how to grow-up based on its own thinking. For this purpose, many approaches have been studied - e.g., neuro-computation, evolutionary computation, reinforcement learning, awareness computing, and so on. Of course, results proposed in conventional symbol based artificial intelligence are also included.

In 2012, we successfully co-organized the IEEE International Conference on Awareness Science and Technology (iCAST2012) with Korea University. iCAST2012 was technically co-sponsored by IEEE Computational Intelligence Society, and Information Processing Society of Japan. We also prepared the International Conference on Awareness Science and Technology (iCAST2013). We have been trying to promote awareness technology through collaboration with different universities or organizations around the world. Our dream is to propose a new and better approach to realization of artificial intelligence.

So far we have used or proposed the following learning models:

- Neural network trees (NNTrees),

- Nearest neighbor classification trees (NNC-Trees),

- Support vector machines (SVMs),

- Neural network ensembles,

- Modular neural networks,

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- Cellular automata, and

- Recurrent neural networks.

Based on the above learning models, we have proposed many new algorithms. Examples include:

- IEA: individual evolutionary algorithm (also called the $R4$-rule),

- CoopCEA: cooperative co-evolutionary algorithms,

- EPNet: evolutionary programming neural net,

- Evolutionary design of neural network trees,

- Induction of NNC-Trees with the $R4$-rule,

- Fast neural network for face detection,

- Rough null space approach to face recognition,

- User authentication based on image fusion, and

- Decision boundary making for inducing compact and high performance NNs.

To verify and to improve the models and learning algorithms proposed so far, we have being studying on-line growing of neural network trees, evolution of neural network ensemble, evolutionary design of decision trees, and so on. Currently, we are very interested in applying our models and algorithms to solving practical problems related to producing a "safe, secure and healthy" society. Examples include: face detection, face/expression recognition, image morphing, text mining, user authentication, steganography, and so on.

Refereed Journal Papers

[neilyyen-01:2012] Qun Jin Timothy K. Shih Xiaokang Zhou, Neil Y. Yen. Enriching User Search Experience by Mining Social Streams with Heuristic Stones and Associative Ripples. *Multimedia Tools and Applications*, 61(1):129–144, 2012.

    N/A

[neilyyen-02:2012] Stephen Y.F. Kuo Neil Y. Yen. An Integrated Approach for Internet Resources Mining and Searching. *Journal of Convergence*, 3(2):37–44, 2012.

    N/A

Refereed Proceeding Papers

[neilyyen-03:2012] Jason C. Hung Timothy K. Shih Martin M. Weng, Neil Y. Yen. Intelligent Evaluation Rules for Learning Objects. In *Proceeding of IEEE/WIC/ACM International Conference on Web Intelligence*, pages 710–715, 2012.

    N/A

[neilyyen-04:2012] Neil Y. Yen Timothy K. Shih Martin M. Weng, Guangyu Piao. General Pattern Discovery for Social Game on Facebook. In *Proceeding of The 15th International Conference on Network-Based Information Systems*, pages 372–375, 2012.

    N/A

[qf-zhao-01:2012] Q. F. Zhao. An Introduction to Computational Awareness. In IEEE, editor, *Proc. International Conference on Awareness Science and Technology (iCAST2012)*, pages 29–34. Korea University, IEEE, Aug. 2012.

    In 2009, we organized the first International Workshop on Aware Computing. During the workshop, Goutam Chakraborty, Runhe Huang, Robert Kozma, Jianhua Ma, Tadahiko Murata, Hideyuki Takagi, Tomohiro Takagi, and I had a meeting and discussed seriously about the future of awareness computing. After that, we decided to establish the technical committee on awareness computing under the umbrella of IEEE SMC society. Since then, we have

evolved our annual event from a workshop to a conference. Time passes quickly; even now many people still do not understand well what we are doing and what we should do. This paper serves as an introduction to computational awareness (CA). Although it is difficult to cover opinions of all people in a short conference paper, something is better than nothing. Hope this paper can help people to understand our activities better.

[qf-zhao-02:2012] K. Watarai, Q. F. Zhao, and Y. Kaneda. Decision Boundary Learning Based on an Improved PSO Algorithm. In IEEE, editor, *Proc. IEEE International Conference on Systems, Man, and Cybernetics (SMC2012)*, pages 2952–2956. IEEE, IEEE, Oct. 2012.

The goal of this research is to design a multimedia analyzer (MA) that can be embedded in portable devices. This MA can recognize different multimedia (e.g. text and image) patterns and help the user to analyze the multimedia contents more efficiently. To realize the MA in an environment with limited computing resource, we propose a new concept called decision boundary learning (DBL). The basic idea is to generate training patterns close to the decision boundary (DB), so that a neural network (NN) with high generalization ability can be obtained. In this paper, the DB is first obtained approximately using a support vector machine (SVM), and the desired training patterns are found using an improved particle swarm optimization (PSO) algorithm. Experimental results show that the NNs so obtained are comparable in performance to the SVMs although the former are much more compact.

[qf-zhao-03:2012] Yuya Kaneda, Qiangfu Zhao, and Kyohei Watarai. A study on the effect of learning parameters in designing compact SVM. In IEEE, editor, *Proc. IEEE International Conference on Systems, Man, and Cybernetics (SMC2012)*, pages 1367–1373. IEEE, IEEE, Oct. 2012.

Support Vector Machine (SVM) is known for offering one of the best performance model in field of Machine Learning. SVM is classified supervised learning model which is available high accuracy because this models learn the learning data. However, the learning data are become higher dimension, the system requires long time and large memory. So it is difficult to use machine learning on mobile device. We use Dimensionality Reduction to solve this problem. In this paper, we use Decision Surface Mapping (DSM) based on Multiple Centroids to design compact SVM, and confirm performance with changing parameters.

[qf-zhao-04:2012] Q. F. Zhao and C. H. Hsieh. Feeling Awareness in Interactive Differential Evolution Based Facial Image Generation. In IEEE, editor, *Proc. IEEE International Conference on Systems, Man, and Cybernetics (SMC2012*, pages 2973–2978. IEEE, IEEE, Oct. 2012.

In our earlier studies, we have proposed an image morphing based steganography. The basic idea is to embed a secrete image into a stego image through morphing. The stego image is a morphed image obtained from the secrete image and some other reference images. To make this method more practically useful, it is essential to make the stego image as natural as possible. For this purpose, we should define a proper feature point set (FPS) for morphing. To find a good FPS efficiently, we use interactive differential evolution (IDE) in this paper. One problem in using IDE is that, in the evolution process the human user may change his/her evaluation criterion subconsciously. This is not desirable for finding an objective evaluation function based on the generated images. To solve this problem, we investigate the effectiveness of k-NN based feeling awareness, and propose a reminder for stabilizing the "user feeling" in the evolution process. Experimental results show that the reminder is useful for reducing the chance of criterion shift. Results also show that increasing k alone may not improve the performance of the reminder for user feeling modeling.

[yliu-01:2012] Y. Liu. New discoveries in balanced ensemble learning. In *Proceedings of the 2012 IEEE World Congress on Computational Intelligence (IEEE WCCI 2012)*, page 8. IEEE, June 2012.

Balanced ensemble learning was developed from negative correlation learning by shifting the learning targets. From the different learning behaviors in balance ensemble learning for the two structures of neural network ensembles on both low noisy data and high noisy data, a number of new discoveries are revealed in this paper. The first discovery is that the ensembles with small neural networks by balanced ensemble learning could perform as well as the ensembles with large neural networks by negative correlation learning. The second discovery is that there is seldom overfitting in balanced ensemble learning for the ensembles with small neural networks. In contrast, overfitting had been observed in balanced ensemble learning for the ensembles with large neural networks on both low noisy data and high noisy data. The third discovery is that both the large and the small mean squared errors could lead to overfitting. Overfitting rather than underfitting arising from the larger

mean squared error might come out at a surprise. The explanations of such a rare phenomenon are presented in this paper.

[yliu-02:2012] Y. Liu. Constraint awareness in balanced ensemble learning. In *Proceedings of the 4th International Conference on Awareness Science and Technology (iCAST 2012)*, page 4. IEEE, August 2012.

By weakening the error signals on the learned data points and enforcing the error signals on those not-yetlearned data points, balanced ensemble learning was developed from negative correlation learning. Although balanced ensemble learning could learn faster and better than negative correlation learning, it also carried higher risk of overfitting in case of having limited number of training data points. If there could be enough data points, such risk could be removed away. In this paper, balanced ensemble learning with constraint was developed through bringing random data points in training. Experimental results were carried out to analyze how such constraint awareness could guide the learning trace, and limit the variances in balanced ensemble learning.

[yliu-03:2012] Y. Liu, Q. Zhao, and N. Yen. Variation aware control for reliability. In *Proceedings of the 2012 IEEE International Conference on Systems, Man, and Cybernetics (IEEE SMC 2012)*, page 4. IEEE, Oct. 2012.

It has been proved that there is a bias-variancecovariance trade-off among the trained neural network ensembles. In this paper, extra learning on random data points was proposed to control the variations of the correlations in the negative correlation learning (NCL). Without the control of the correlations, NCL might have arbitrary values on the unknown data points after learning too much on the training data points. With learning on random data points, the individual neural networks in an ensemble trained by NCL could become even more different by having the lower overlapping rates. Such lower overlapping rates imply that learning on random data could control the variation of the correlations among the individual neural networks. It is necessary to have such variation awareness in learning when the correlations have a great impact on the performance of the learned ensemble.

[yliu-04:2012] Y. Liu. Balanced ensemble learning between known and unknown data. In *Proceedings of the 6th International Symposium on Intelligence Computation and Applications (ISICA 2012)*, pages 381–388. Springer, Oct. 2012.

Without guidance on the unseen data, learning models could possibly approximate the known data by having different output on those unseen data.

The results of such differences are the large variances in learning. Such large variances could lead to overfitting on many noisy data. This paper proposed one way of guidance by setting a middle value on the unknown data in balanced ensemble learning. Although balanced ensemble learning could learn faster and better than negative correlation learning, it also carried higher risk of overfitting in case of having limited number of training data points. Experimental results were conducted to show how such random learning could regulate the variances in balanced ensemble learning.

Books

[neilyyen-05:2012] Gabriella Pasi Takahira Yamaguchi Neil Y. Yen Beihong Jin Runhe Huang, Ali A. Ghorbani. *Active Media Technology (AMT' 12 Conference Proceeding)*. Springer, 2012.

[yliu-05:2012] Z. Li, X. Li, Y. Liu, and Z. Cai. *Computational Intelligence and Intelligent Systems*. Number 316 in Communications in Computer and Information Science. Springer, 2012.

Grants

[yliu-06:2012] Y. Liu. The Grant-In-Aid for Scientific Research Fund (Kakenhi), 2011-2013.

Academic Activities

[neilyyen-06:2012] Neil Y. Yen, 2012.

Organizer (Coordinator), Special Session on Human Factors Awareness, International Conference on Awareness Science and Technology (iCAST' 12), Seoul, Korea

[neilyyen-07:2012] Neil Y. Yen, 2012.

Publicity Co-Chair, IEEE International Conference on Cyber, Physical and Social Computing (CPSCom ' 12), Besancon, France

[neilyyen-08:2012] Neil Y. Yen, 2012.

> Workshop and Special Issue Chair, IEEE International Conference on Active Media Technology (AMT ' 12), Macau, China

[neilyyen-09:2012] Neil Y. Yen, 2012.

> Organizer (Coordinator), Special Session on Computational Awareness, IEEE International Conference Systems, Man, and Cybernetics (SMC ' 12), Seoul, Korea

[yliu-07:2012] Y. Liu, October 2012.

> Program Chair, ISICA 2012.

Ph.D and Others Theses

[qf-zhao-05:2012] Yoshiharu Nanaumi. Graduation thesis, Undergraduate School, The University of Aizu, 3 2012.

> Recently, the opportunities of using cards that include those for entering or leaving offices and credit cards used for shopping have been increasing. On the other hand, forgery and illegal use of credit cards have caused serious damage to the users. To prevent such cards from being illegally used, card user authentication has gained importance for correct distinction between authorized and unauthorized users. In our laboratory, we have studied a method for face image authentication using image morphing. We use a morphed image to hide the true image of the card owner. If the images of different sizes and images with different features are used, the morphed image may become an unnatural image. In this thesis, we propose to reduce the unnaturalness of the morphed image by normalization based on the feature points and by using facial recognition.

[qf-zhao-06:2012] Kazuho Kanno. Graduation thesis, Undergraduate School, The University of Aizu, 3 2012.

> Automatic morphing is one research topic in my lab. The first step is to detect the face in the given image. The platform used is the Android smartphone. There is a tool FaceDetector for detecting human faces. It is a class written in Java and is included in Android SDK(Software Development Kit). The purpose of my study is to understand the method used in this tool, and try to re-build the system for our own use. I succeeded in detecting and segmenting the face part from any captured photo. However, due to limited time, I could not understand the core well.

[qf-zhao-07:2012] Fumiya Nagashima. Graduation thesis, Undergraduate School, The University of Aizu, 3 2012.

In this study, we apply image morphing to improve security of credit card. For this purpose, it is necessary to generate natural facial images more efficiently. We propose to use interactive evolution algorithm (IEA). We used two types of IEAs. One is the interactive differential evolutionary algorithm (IDE), and the other is the interactive genetic algorithm (IGA). We compared the results of these two IEAs, but did not find significant differences between them.

[qf-zhao-08:2012] Shigeki Okabe. Graduation thesis, Undergraduate School, The University of Aizu, 3 2012.

Currently, Social Networking Service (SNSs) are used all over the world. Therefore, it is much easier to send information by individuals. However, it is more and more difficult to find necessary data or detect users from long stream of data. To solve this problem, we study User Modeling in this research. User modeling is to make a system that can understand the user preference (e.g. like and dislike), user intention (e.g. want to find certain information), and so on. In this research, we focus on Twitter service.

[qf-zhao-09:2012] Kyohei Watarai. Master thesis, Graduate School, University of Aizu, 3 2012.

In recent years, portable computing devices (PCDs) such as smart phones and tablet terminals have been popularized at a tremendous speed. Many people around the world are now using PCDs for different purposes. To increase the usability of PCDs and to resolve the so called "digital divide" problem, it is desired to embed some awareness agents (A-agents) that can recognize different situations, detect important information, and help human users to make decisions more efficiently and effectively. Ideally, the A-agents should be simple and easy to implement, because many of them must work together in a small PCD to cover different applications. For this purpose, we propose in this paper a new algorithm called decision boundary learning (DBL). The basic idea of DBL is to generate training patterns close to the true decision boundary (DB), so that a compact multilayer feedforward neural network (MFNN) with high generalization ability can be obtained. In this paper, the true DB is first approximated using support vector machine (SVM), training patterns closed to the DB are then found using particle swarm optimization algorithm, and an MFNN is induced based on the newly produced training patterns. Experimental results with

Summary of Achievement

5 public databases show that in 4 out of 5 cases the MFNNs obtained by DBL are more compact, and perform better than those obtained by SVM.