

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, memetic algorithms, reinforcement learning, awareness computing, and so on. Of course, results proposed in conventional symbol based artificial intelligence are also included.

In 2013, we successfully organized the 5-th International Conference on Awareness Science and Technology (iCAST2013), which was technically co-sponsored by IEEE Systems, Man, and Cybernetics Society, IEEE Computational Intelligence Society, and Information Processing Society of Japan. We also edited several special issues related to computational awareness. 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,
- Decision boundary making for inducing high performance neural networks, and
- 3-factor user authentication based on image morphing.

To verify and to improve the models and learning algorithms proposed so far, we have been 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, automatic image morphing, text mining, user authentication, steganography, and so on.

Refereed Journal Papers

- [neilyyen-01:2013] Yong Liu Neil Y. Yen Yuya Kaneda, Qiangfu Zhao. A Study on the Effect of Learning Parameters for Inducing Compact SVM. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 17(4):552–560, 2013.
- [neilyyen-02:2013] Jianhua Ma Qun Jin Timothy K. Shih Neil Y. Yen, Runhe Huang. Intelligent route generation: discovery and search of correlation between shared resources. *International Journal of Communication Systems*, 26(6):732–746, 2013.
- [neilyyen-03:2013] Jason C. Hung Neil Y. Yen Szu Ju Chen Kuan Cheng Lin, Tien-Chi Huang. Facial Emotion Recognition towards Affective Computing-based Learning. *Library Hi Tech*, 31(2):294–307, 2013.
- [neilyyen-04:2013] Qun Jin Neil Y. Yen, Timothy K. Shih. LONET: An Interactive Search Network for Intelligent Lecture Path Generation. *ACM Transactions on Intelligent Systems and Technology*, 4(2):Article 30, 2013.
- [neilyyen-05:2013] James J. Park Jason C. Hung Neil Y. Yen Yu-Wei Chan, Feng-Tsun Chien. Coalitional Game Theoretic Approach for Efficient Resource Allocation in Cooperative Cognitive Radio Networks. *Sensor Letters*, 11(9):1741–1749, 2013.
- [neilyyen-06:2013] Zixue Cheng Lei Jing, Yinghui Zhou and Neil Y. Yen. Context-Aware Service Roaming for Heterogeneous Embedded Devices over Cloud. *Journal of Systems Architecture*, 59(9):776–784, 2013.
- [neilyyen-07:2013] Qun Jin Timothy K. Shih Neil Y. Yen, Jong Hyuk Park. Modeling user-generated contents: an intelligent state machine for user-centric search support. *Personal and Ubiquitous Computing*, 17(8):1731–1739, 2013.
- [qf-zhao-01:2013] Qiangfu ZHAO Jie Ji. A HYBRID SVM BASED ON NEAREST NEIGHBOR RULE. *International Journal of Wavelets, Multiresolution and Information Processing*, World Scientific Publishing Company, 11(6):21 pages, 2013.

This paper proposes a hybrid learning method to speed up the classification procedure of Support Vector Machines (SVM). Comparing most algorithms

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trying to decrease the support vectors in an SVM classifier, we focus on reducing the data points that need SVM for classification, and reduce the number of support vectors for each SVM classification. The system uses a nearest neighbor classifier (NNC) to treat data points attentively. In the training phase, the NNC selects data near partial decision boundary, and then train sub SVMs for each Voronoi pair. For classification, most non-boundary data points are classified by NNC directly, while remaining boundary data points are passed to corresponding local expert SVM, which is much simpler than a conventional SVM. We also proposed a data selection method for training reliable expert SVMs. Experimental results show that the proposed method significantly accelerates the testing speed on several generated and public machine learning data sets.

[qf-zhao-02:2013] Y. Liu Y. Kaneda, Q. F. Zhao and N. Y. Yen. A Study on the Effect of Learning Parameters for Inducing Compact SVM. *Journal of Advance Computational Intelligence and Intelligent Informatics*, 17(4):552–560, 2013.

In recent years, portable computing devices (PCDs) such as smart phones and tablet terminals have been popularized at a tremendous speed. People around the world are now using PCDs for different purposes. To resolve “digital divide” problem, it is desired to embed awareness agents (A-agents) that can recognize different situations, detect important information, and help human users make decisions efficiently and effectively. To use A-agents in one PCD, it is necessary to implement each agent with a reasonable cost. For this purpose, we can use dimensionality reduction (DR). To reduce the total cost, sophisticated DR methods cannot be used. In this paper, we investigate the performance changes of SVM-based A-agents, before and after centroid based DR. Experimental results show that in most cases the performance can be preserved with the properly chosen learning parameters.

[qf-zhao-03:2013] Yuya Kaneda and Qiangfu Zhao. Inducing High Performance and Compact Neural Networks Based on Decision Boundary Making. *IEEJ Trans.-C*, 134(9):TBD, 2014.

In recent years, portable computing devices (PCDs) are becoming very popular. To improve the quality of service(QoS) for each individual user, it is necessary to develop application programs that can be aware of the user intention, preference, situation, etc., so that proper services can be recommended at proper timing. We call these kinds of programs awareness agents (A-agents). To satisfy various needs of a user, many A-agents should work together in one PCD.

Since the computing resource in a PCD is limited, it is necessary to reduce the implementation costs of the A-agents while preserving their performance. For this purpose, we propose two decision boundary making (DBM) algorithms in this paper. The basic idea of DBM is to generate new training data using given ones to fit the decision boundary (DB) of the given problem, and induce small neural networks (NNs) using the new data. Both algorithms proposed here are simplified versions of the decision boundary learning (DBL) algorithm proposed by us earlier. Using the new algorithms, the cost for data generation can be greatly reduced. Experimental results show that if the new data are generated properly in positions close to the DB, the induced small NNs can perform even better than support vector machines, which are known as the state-of-the-art learning models.

Refereed Proceeding Papers

- [neilyyen-08:2013] Yong Liu Neil Y. Yen, Qiangfu Zhao and Joseph C. Tsai. An Intelligent State Machine towards Task-Oriented Search Support. In *Proceeding of The 2013 IEEE International Conference on Cybernetics (CYBCONF-13)*, pages 46–50, Lausanne, Switzerland, June 13-15 2013. IEEE.
- [neilyyen-09:2013] Runhe Huang Jianhua Ma Neil Y. Yen Atsushi Sato, Toshihiro Tamura. Smart Business Services via Consumer Purchasing Behaviour Modeling. In *Proceeding of The 2013 IEEE International Conference on and IEEE Cyber, Physical and Social Computing (CPSCom-13)*, pages 812–817, Beijing, China, August 20-23 2013. IEEE.
- [neilyyen-10:2013] Yong Liu Neil Y. Yen Yuya Kaneda, Qiangfu Zhao. Induction of High Performance Neural Networks Based on Decision Boundary Making. In *Proceeding of The 2013 IEEE International Conference on Systems, Man, and Cybernetics (SMC-13)*, pages 2831 – 2836, Manchester, U.K., October 13-16 2013. IEEE.
- [neilyyen-11:2013] Qun Jin Neil Y. Yen, Jason C. Hung. Instant Decision-making Support via Social Context Extraction. In *Proceeding of The FTRA 9th International Symposium on Wireless sensor network Technologies and Applications for Smart Space (WTA-13)*, pages 46–51, Gwangju, Korea, September 4-6 2013. FTRA.

Best Paper Award

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[neilyyen-12:2013] Yong Liu Neil Y. Yen Qiangfu Zhao, Yutaro Minakawa. Feature point detection in image morphing based steganography. In *Proceeding of The 2013 IEEE International Conference on Systems, Man, and Cybernetics (SMC-13)*, pages 2837 – 2842, Manchester, U.K., October 13-16 2013. IEEE.

[neilyyen-13:2013] Bin Guo Runhe Huang Jianhua Ma Tao Ban Hong Zhao Jingwei Wang, Neil Y. Yen. User Travelling Pattern Prediction via Indistinct Cellular Data Mining. In *Proceeding of The 10th IEEE International Conference on Ubiquitous Intelligence and Computing (UIC-13)*, pages 17–24, Vietri sul Mare, Italy, December 18-21 2013. IEEE.

[neilyyen-14:2013] Tonjun Huang Peng Li Neil Y. Yen Joseph C. Tsai Yingjui Zhou Lei Jing Zixue Cheng, Junbo Wang. A Situation-Oriented IoT Middleware for Resolution of Conflict Contexts Based on Combination of Priorities. In *Proceeding of The 8th International Conference on Embedded and Multimedia Computing (EMC-13)*, pages 441–454, Taipei, Taiwan, August 23-25 2013. Springer.

[qf-zhao-04:2013] J. Brine Q. F. Zhao and D. Filev. Cybernetics: Where Shall We Go? In IEEE, editor, *Proc. IEEE International Conference on Cybernetics*, pages 25–31. IEEE, IEEE, 2013.

Cybernetics, as defined by Plato and later by Ampère, is the science of governance. In the 1940s, Wiener used cybernetics as an umbrella term to refer to control and communication in both the animal and the machine. In the following decades, the term has been defined in various ways by different researchers, and because of this, cybernetics has been perceived rather negatively as a “nomad science”. Consequently, few people understand the true meaning of cybernetics. For the appropriate development of our field of research, we think it is necessary to re-consider the meaning and the scope of cybernetics, so that we can have a relatively clear mission in our research. In this paper, we try to provide a kind of governance message that might also be very weak, but nevertheless may be helpful for the cybernetics community to become cybernetic itself.

[yliu-01:2013] Y. Liu, Q. Zhao, and N. Yen. Transition learning between balanced ensemble learning and negative correlation learning. In *Proceedings of the 2013 IEEE International Conference on Systems, Man, and Cybernetics (IEEE SMC 2013)*, page 4. IEEE, Oct. 2013.

In this paper, transition learning was introduced between balanced ensemble learning and negative correlation learning. The idea of transition learning is to apply balanced ensemble learning for a certain time, and then to switch to negative correlation learning. The short learning period with the sudden changes of learning behaviors is called transition learning. Experimental studies had been conducted to examine the learning behaviors in the transition process. It was found that the training error rates had big sudden changes in the beginning of transition process. The changes in the training error rates became smaller and smaller at the end of transition process. The more interesting results are how such sudden change on the training set would lead to the testing set. By observing the performance on the testing error rates, it was found that transition learning were able to prevent the learning from overfitting.

- [yliu-02:2013] Y. Kaneda, Q. Zhao, Y.Liu, and N. Yen. Induction of high performance neural network based on decision boundray making. In *Proceedings of the 2013 IEEE International Conference on Systems, Man, and Cybernetics (IEEE SMC 2013)*, page 6. IEEE, Oct. 2013.

Smartphone, in recent year, becomes popular and has been widely applied by users. In order to meet different needs from users, embedding “awareness” providing supports by understanding onto smartphone devices is necessary. Due to the limitations (e.g. computing resources, etc.) on smartphone, methods that is light but with high performance are strongly expected. In this study, the concept of awareness agent (A- agent) is proposed for the purpose. For this purpose, we have proposed decision boundary learning (DBL) based on particle swarm optimization (PSO). Results show that this method can yield compact neural network (NNs) agents that are comparable in performance to support vector machines (SVMs). However, the computational cost of PSO is high, and the method cannot be used in smartphone environments. To reduce the computational cost, we propose a simple method called decision boundary making (DBM). The basic idea of DBM is to generate new training data around the support vectors of an SVM, add them to the training set, and then induce an NN agent. We conducted experiments using several public databases, and experimental results show that the proposed DBM is comparable to DBL in performance, and the computational cost can be greatly reduced.

- [yliu-03:2013] Y. Liu, Q. Zhao, and N. Yen. Make decision boundary smoother by transition learning. In *Proceedings of the 5th International Conference*

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on Awareness Science and Technology (iCAST 2013), page 5. IEEE, Nov. 2013.

Transition learning means the short learning period after switching from one learning method to another in this paper. learning is to apply balanced ensemble learning for a certain time, and then to switch to negative correlation learning. Because of the different learning functions between the two methods, the learning behaviors are expected to have a sudden changes in transition learning. Experimental studies had been conducted to examine such learning behaviors in the transition process. It was found that the training error rates jumped immediately in the transition while the testing error rates often appeared to fall slightly. Such large changes in error rates suggested that the decision boundary formed by balanced ensemble learning had been greatly altered in transition learning. This paper presents the explanations of the transition learning from both the ensemble and individual neural network levels.

[yliu-04:2013] Y. Liu. Transition learning by negative correlation learning. In *Proceedings of the Second International Conference on Innovative Computing and Cloud Computing (ICCC 2013)*, page 5. ACM, Nov. 2013.

The idea of transition learning is to apply negative correlation learning with one error learning function for a certain time, and then to switch to another learning error function. Because of the different learning functions between the two periods, the learning behaviors are expected to have a sudden changes in transition learning. On one hand, negative correlation learning with the lower correlation penalty term might learn too well the training data while generating less negatively correlated neural networks. On the other hand, negative correlation learning with the higher correlation penalty might not be able to learn well the training data, but be capable of generating highly negatively correlated neural networks. With transition learning, the ensembles could have both the good performance and the diverse individual neural networks.

[yliu-05:2013] Y. Liu. Transition learning for creating diverse neural networks. In *Proceedings of the 6th International Conference on BioMedical Engineering and Informatics*, page 4. IEEE, Dec. 2013.

Besides the studied transition learning between the two different ensemble learning algorithms such as negative correlation learning and balanced ensemble learning, transition learning could also implemented in negative cor-

relation learning with different correlation penalties. On one hand, negative correlation learning with the lower correlation penalty named as low negative correlation learning might learn too much the training data while generating less negatively correlated neural networks. On the other hand, negative correlation learning with the higher correlation penalty called as high negative correlation learning might not be able to learn the training data, but be capable of generating highly negatively correlated neural networks. By conducting transition learning from low negative correlation learning to high negative correlation learning, this paper shows that the ensembles could have both the good performance and the diverse individual neural networks.

Books

[neilyyen-15:2013] Neil Y. Yen James J. Park Hwa-Young Jeong, Mohammad S. Obaidat. *Advances in Computer Science and its Applications (CSA '13 Conference Proceeding)*. Lecture Notes in Electrical Engineering, No. 279. Springer, 2013.

Chapters in Book

[neilyyen-16:2013] Neil Y. Yen Martin M. Weng, Yonghui Chen. *Cloud-Based Intelligent Tutoring Mechanism for Pervasive Learning*, page Chapter 6. Cloud Computing and Digital Media: Fundamentals, Techniques, and Applications. Chapman and Hall/CRC, March 7 2014.
Kuan-Ching Li, Qing Li, Timothy K. Shih (eds.)

Grants

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

Academic Activities

[neilyyen-17:2013] Neil Y. Yen, September 4-6 2013.

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Workshop Chair, The 3rd IET International Conference on Frontier Computing (FC-13), Gwangju, Korea

[neilyyen-18:2013] Neil Y. Yen, August 22-24 2013.

Publicity Co-chair, The 6th FTRA International Conference on Human-centric Computing (HumanCom-13), Taipei, Taiwan

[neilyyen-19:2013] Neil Y. Yen, 2013.

Serve as Managing Editor of the journal

[neilyyen-20:2013] Neil Y. Yen James J. Park, 2013.

Guest Co-Editor, Special issue on Context-Awareness Services and Sensor Network Applications for Smart Space

[neilyyen-21:2013] Neil Y. Yen James J. Park, Uyen Trang Nguyen, 2013.

Guest Co-Editor, Special Issue on Mining Social Media for Knowledge Discovery

[neilyyen-22:2013] Neil Y. Yen, May 9-11 2013.

Workshop Chair, The 7th FTRA International Conference on Multimedia and Ubiquitous Engineering (MUE-13), Seoul, Korea – Outstanding Service Award

[neilyyen-23:2013] Chien-Hsien Hsu Qiangfu Zhao Neil Y. Yen, Qun Jin, 2013.

Leading Guest Co-Editor, Special Issue on Hybrid Intelligence for Growing Internet and its Applications

[neilyyen-24:2013] Neil Y. Yen, October 13-16 2013.

Leading Organizer, Special Session on Computational Awareness, IEEE International Conference Systems, Man, and Cybernetics (SMC-13), Manchester, U.K.

[neilyyen-25:2013] Neil Y. Yen, November 2-4 2013.

Local Organizing Chair, Joint Conference on iCAST (The 5th IEEE International International Conference on Awareness Science and Technology) & UMEDIA (The 6th IEEE International Ubi-Media Computing), Aizu-Wakamatsu, Fukushima, Japan

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[neilyyen-26:2013] Sajid Hussain Neil Y. Yen James J. Park, Han-Chieh Chao, 2013-2014.

Guest Co-Editor, Special Issue on Pervasive Sensing Technologies and Emerging Trends

[neilyyen-27:2013] Runhe Huang Beihong Jin, Neil Y. Yen, 2013.

Guest Co-Editor, Special Issue on Advances in Big Data Processing via Convergence of Emerging Techniques

[neilyyen-28:2013] Neil Y. Yen, December 18-21 2013.

Program Co-Chair, The 5th FTRA International Conference on Computer Science and its Applications (CSA-13), Danang, Vietnam

[neilyyen-29:2013] Beihong Jin Neil Y. Yen, Runhe Huang, 2013.

Leading Guest Co-Editor, Special Issue on Hybrid Intelligence Towards Next Generation Human-Centered Support

[neilyyen-30:2013] Neil Y. Yen, January 12-14 2014.

General Vice-Chair, FTRA International Symposium on Frontier and Innovation in Future Computing and Communications (FCC-14), Auckland, New Zealand

[qf-zhao-05:2013] Qiangfu ZHAO, 2012-2013.

Served as the Chairperson of the IEEE SMCS Japan Chapter.

[qf-zhao-06:2013] Qiangfu Zhao, 2010-2013.

Served as the Steering Committee chair of the iCAST (International Conference on Awareness Science and Technology) conferences, which has been technically co-sponsored by IEEE SMCS and IEEE CIS.

[qf-zhao-07:2013] Qiangfu Zhao, 2010-present.

Served as the co-chair of the IEEE SMCS Technical Committee on Awareness Computing.

[qf-zhao-08:2013] Qiangfu ZHAO, 2013.

Served as the Associate Editor of the IEEE Trans. on Cybernetics (Since 2005).

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[qf-zhao-09:2013] Qiangfu Zhao, 2013.

Co-author (as supervisor) of Best Student Paper Award. Paper title: Awareness of manipulation in on-line review. Conference: iCAST2013.

[qf-zhao-10:2013] Qiangfu Zhao Jie Ji, 2013.

Lotfi Zadeh Best Paper Award, “NNC+SVM: An empirical study for fast classification,” IEEE International Conference on Machine Learning and Cybernetics.

[qf-zhao-11:2013] Qiangfu Zhao, 2013.

The Most Active SMC Technical Committee Award (as co-chair of the TC).

Ph.D and Others Theses

[qf-zhao-12:2013] Yutaro Minakawa. Master thesis, Graduate School of the University of Aizu, 3 2014.

In recent years, information security becomes more necessary than it used to be. Information hiding technology is one of the effective mechanisms to protect one's privacy (e.g. secret). Then, we study the information hiding by using image morphing. The morphing (synthesized) image is used to cover the secret. If synthesized image has any unnatural qualities, it may attract attention from a malicious third party. Therefore, the naturalness of synthesized images becomes important. The naturalness of a synthesized image highly depends on feature points. Thus, to synthesize natural cover images, we need to study methods that can detect the feature points automatically and effectively. In this thesis, I propose a neural network (NN)-based method for feature point detection. In this method, the difference in luminance values between a sub-image A and a basis sub-image B is used as the input of the NN, and the output is the estimated difference between the coordinates of the centers of A and B. If B is a sub-image center by a feature point, and the NN is properly designed, we can move A to B directly based on the output of the NN, given any A with a center around the feature point. In this thesis, I propose a novel method for inducing the NN, and show that in most cases the feature points can be detected effectively and efficiently.

[qf-zhao-13:2013] Yuya Kaneda. Master thesis, Graduate School of the University of Aizu, 3 2014.

In recent years, portable computing devices (PCDs) are becoming very popular. To improve the quality of service (QoS) for each individual user, it is necessary to develop application programs that can be aware of the user intention, preference, situation, etc., so that proper services can be recommended at proper timing. We call these kinds of programs awareness agents (A-agents). To satisfy various needs of a user, many A-agents should work together in one PCD. Since the computing resource in a PCD is limited, it is necessary to reduce the implementation costs of the A-agents while preserving their performance. For this purpose, we propose two decision boundary making (DBM) algorithms in this thesis. The basic idea of DBM is to generate new training data using given ones to fit the decision boundary (DB) of the given problem, and induce small neural networks (NNs) using the new data. Both algorithms proposed here are simplified versions of the decision boundary learning (DBL) algorithm proposed by us earlier. Using the new algorithms, the cost for data generation can be greatly reduced. Experimental results show that if the new data are generated properly in positions close to the DB, the induced small NNs can perform even better than support vector machines, which are known as the state-of-the-art learning models.

[qf-zhao-14:2013] Mitsuru Abe. Graduation thesis, The University of Aizu, 3 2014.

Recently, our laboratory has proposed an image morphing based method for information hiding. Image morphing is a technology for generating natural images from a source image and a reference image. In this thesis, we propose a neural network based method for automatic extraction of feature points for image morphing. Facial images are used in this study. Training patterns and teacher signals are made based on the coordinates of the feature points, and the sub-images around the feature points. A neural network is designed for each feature point using the training patterns and the teacher signals. Experimental results show that the proposed method can extract feature points. However, the accuracy of the feature points positions are not good enough for image morphing.

[qf-zhao-15:2013] Kazuki Murakami. Graduation thesis, The University of Aizu, 3 2014.

In recent years, many cloud computing systems have been introduced in the world. What have also increased are cyber attacks accessing private and personal information stored in cloud servers, and information security has become one of the most studied areas. To protect the personal information, this paper proposes and develops a system that can encrypt a secret message and embed it into an

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image file by using a new morphing based steganography technique. The idea is that even if hackers steal the image containing private information, they cannot read the stolen information because it is almost impossible to read them without a stego key. What is expected is the improvement in the security of cloud systems using our method.

[qf-zhao-16:2013] Kagekatsu Okubo. Graduation thesis, The University of Aizu, 3 2014.

Our research is to predict the destination a user wants to go. Research on smart phone based destination prediction has been conducted by many researchers. In this study, we investigate a simple method. We apply machine learning to the prediction of a destination. Prediction user location information because it is easy to get. Learning for predicting the destination takes place from the location data. Namely, it predicts the destinations of users by learning from the location data. Prediction accuracy should be high if we collect more and more data. We tested the proposed method. Accuracy of predicting a destination was not high because we used location data only. We need to add other information to improve the performance.

[qf-zhao-17:2013] Kazuki Omomo. Graduation thesis, The University of Aizu, 3 2014.

In our laboratory, we have studied neural network trees (NNTrees). NNTrees are decision trees (DTs), in which each internal node has a neural network (NN), and each leaf node has a label. Generally speaking, NNTrees have good performance compared with conventional NNs and DTs. In addition, the scale of an NNTree can be determined automatically through learning, based on the complexity of the given problem. To improve NNTrees, we consider to apply decision boundary making (DBM) algorithm and K-means algorithm.

[qf-zhao-18:2013] Kentaro Sekine. Graduation thesis, The University of Aizu, 3 2014.

In our laboratory, we have studied a method to generate natural facial images using image morphing. However, we may not generate natural images because of noises introduced in the warping process. In this thesis, we tested the possibility of improving the naturalness of the generated images through image classification. We classified images into several clusters using K-means, and then conducted morphing using images taken from the same or different clusters. We found that the images from the same cluster can generate much natural images.

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[yliu-07:2013] Takuma Kimura. Developing Smart Educational Software for Improving Calculation Skills, University of Aizu, 2013.

Thesis Advisor: Y. Liu

[yliu-08:2013] Satoshi Kaji. Optimization of GUI Layout for User Interface, University of Aizu, 2013.

Thesis Advisor: Y. Liu