

Intelligent Systems in Nanjing University

Intelligent systems is a major research theme in Nanjing University, with the support from the State Key Laboratory for Novel Software Technology of China, one of the top laboratories in the information technology field in the whole country. Currently, the research carried out by the intelligent systems group at Nanjing University mainly focuses on the following topics:

- Fundamental methods of intelligent computing, particularly reinforcement learning, incremental learning, granular computing and rough sets.
- Intelligent agents and multi-agent systems.
- Content-based multimedia (images and 3D models) retrieval.

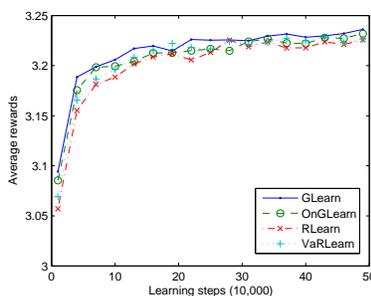
The intelligent systems group aims to design intelligent algorithms and systems to deal with real problems efficiently. The group has developed software tools and applications covering wide areas, including medical treatment, public security, and virtual games.

I. RESEARCH

- Reinforcement learning

Reinforcement learning is an on-line, incremental learning technology, by which intelligent agents interact with the surrounding world by trial-and-error, and learn the optimal policy of decision sequences according to reinforcement signals. Our group has studied various algorithms for reinforcement learning problems, including average reward reinforcement learning, multi-agent reinforcement learning, relational reinforcement learning, function approximation in reinforcement learning and option discovery, etc. For example, our G-learning algorithm addresses the average reward domain, and is more stable than the classical R-learning and Q-learning. The following figure shows four curves of

the average rewards computed in every 10,000 steps in the access-control queuing task. As shown in this figure, G-learning outperforms R-learning and its variation in the learning speed.

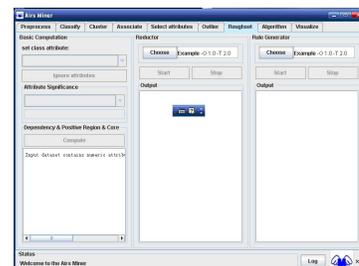


Besides the theoretical algorithm research, the group also studies the application of reinforcement learning. The proposed algorithms have been applied to video game tasks such as Tetris. The group attended the RL 2008 competition and won the 6th place in the game of Tetris. Research in learning classifier systems is related to reinforcement learning as well. Our group has successfully applied the learning classifier systems technology to different problem domains including data mining, medical data analysis and image steganography detection.

- Rough set

Rough set theory is a sound mathematical tool to deal with imprecise, uncertain, and vague information. Most of the group's work in this area can be characterized by rough-set-based hybrid approaches in classification and features selection. For incomplete information systems, rule generation by the GDT(General Distribution Table) approach and a default rule extracting method were proposed. Incremental algorithms are important, as data sources are increasingly in quantity. The group has investigated the incremental updating algorithms for core computing in the dominance-based rough set model. For face recognition, our group applies multiple applications of a reduction process based on approximation quality, and achieves fewer attributes. For natural language processing, we explore a RoughTree classifier with rough set and semi-naive Bayesian hybrid in decision tree representation, and conduct a dependency parsing task on Chinese corpus embedded with Nivre's deterministic

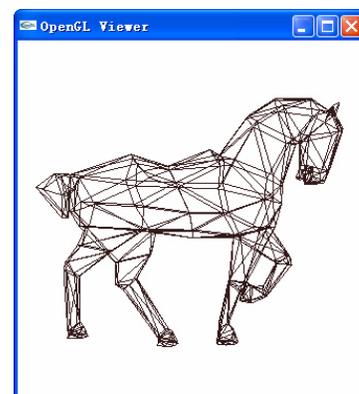
parsing algorithm. The results show that RoughTree has better performance on a dependency parsing task. Combining rough set with other data mining algorithms, the group has developed a software tool, AirsMiner1.1, for data analysis.

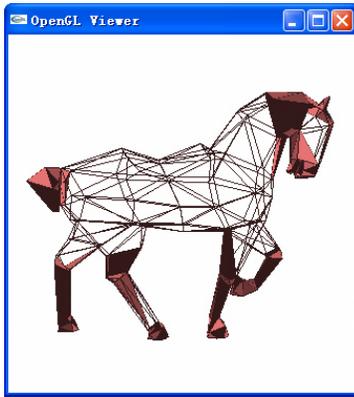


- Content-based 3D models retrieval

With the development of computer graphics and the progress in multimedia hardware technologies, 3D models are increasingly demanded in many application fields. The content-based 3D model retrieval researchers in this group has been exploring this challenging research field since 2004. The group proposes a novel retrieval performance metric, GSSS(Get Score from Similarity Sequence), which has been proved better than the widely used Precision-Recall(PR) curve benchmark on most shape-based 3D model retrieval cases.

One of the key issues in Content-Based 3D Model Retrieval is to define appropriate feature descriptors. To address this issue, we have developed a novel 3D feature extraction algorithm combining global and local characteristics, by which a 3D model is first segmented into several meaningful parts, and then representative 3D feature descriptors are extracted from those parts.

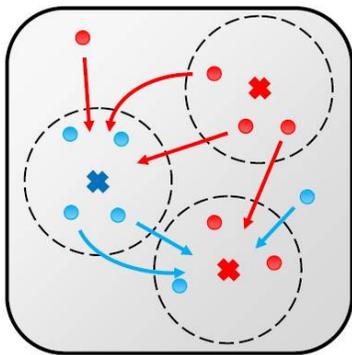




The group has also carried out research in semantic-based retrieval and made significant progress. A small-scale semantic network has been constructed and used to retrieve text-based annotations of 3-D models. The experimental results prove that these annotations are more understandable for human beings than those generated solely based on visual features.

- Intelligent agent and multi-agent systems

Agent technology is key for designing and developing distributed systems and adaptive software. The research conducted by the group includes developing multi-agent belief revision modeling, agent negotiation and multi-agent learning. We propose a multi-sentence batch belief revision model, a computational method, and a persuasive multi-agent multi-issue negotiation model. In multi-agent reinforcement learning, our group designed a meta-Q learning algorithm which overcomes the shortcomings of Nash Q-learning algorithm, and discovers the Pareto efficiency solutions as well.



The group applies agent technology to first-person shooting games. For example, we developed a RL-DOT (Reinforcement Learning-based DOMination

Team) algorithm to learn the winning policy in UT's domination mode.



II. EDUCATION AND ACTIVITIES

The intelligent systems group has three tenured faculty members, Dr. Yang Gao (the leader of the group), Dr. Lin Shang and Dr. Yubin Yang. In the Department of Computer Science and Technology of Nanjing University, the group offers courses in Artificial Intelligence, Image Processing, Multimedia and Intelligent Agents. Currently, more than twenty graduate research students join the group and actively participate in our research projects. Within the past five years, eighteen MSc degrees and two PhD students have graduated from the group. The research of the intelligent systems group has led to a number of publications, most of which are published at top conferences and journals. Moreover, the group has won two Science and Technology Advancement Awards of Jiangsu Province, China in the past five years.



The group have also organized and hosted many research conferences held in Nanjing, China, such as:

- The 11th Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD 2007), May, 2007.
- The 2nd Chinese Conference on Agent Theory and Applications (Agent'08), Apr. 2008.

- The 3rd, 4th, 5th and 6th Chinese Workshop on Machine Learning and Applications (MLA'05, MLA'06, MLA'07 and MLA'08).

In the department of computer science of Nanjing University, the group offers courses in artificial intelligence, image processing, multimedia and intelligent agents. Currently, more than twenty graduate students in the group actively participate in our research projects. Within the past five years, eighteen M.S. degrees and two Ph.D. degrees have been granted in the group.



III. CONCLUDING REMARKS

The research work of Intelligent Systems group has been funded by National Grand Fundamental Research 973 Program of China (No.2002CB312002, 2009CB32702), National Science Fund for Distinguished Young Scholars (No.60325207), National Natural Science Foundation of China (No.60775046, 60721002, 60503012, 60505008 and 60875011), Natural Science Foundation of Jiangsu Province, China (No.BK2007520) and Jiangsu Province Science and Technology Project (No. BE2006011). We have explored various interests in intelligent systems such as machine learning, multi-agent systems, content-based multimedia (images and 3D models) retrieval. To contact us, please use the following information.

Contact Information:
 Department of Computer Science
 and Technology, Nanjing University,
 No.22 Hankou Road, Nanjing
 210093, China
gaoy@nju.edu.cn
shanglin@nju.edu.cn
yangyubin@nju.edu.cn
 Website: ai.nju.edu.cn