香港城市大學
City University of Hong Kong

City University of Hong Kong
College of Science and Engineering

Seminar jointly organized with
IEEE Technology Management Council HK Chapter
Hong Kong Association of Risk Management & Safety

Introduction to DUCG: The Dynamic Uncertain Causality Graph for Knowledge Representation and Probabilistic Reasoning Applied in Fault Diagnoses of Complex Systems

Professor Qin Zhang

Nuclear and New Energy Technology, Tsinghua University, Beijing
School of Computer Science and Technology, Beihang University, Beijing

Date 16 March 2013 (Saturday)
Time 10:00 am - 12:00 noon (light refreshment will be served from 9:30am)
Venue LT7 - Lily Chiang Lecture Theatre, 4/F, Academic 1, CityU

Abstract

Forecast, diagnoses and predictions are three of the core issues in artificial intelligence. In many expensive, large and complex engineering systems such as nuclear power plants, chemical plants and space systems, the accurate and rapid (usually within a few or even less than one second) fault diagnoses and fault development predictions are very important, because they can help people avoid big loss of money and danger of safety. The failure forecast before fault is of course another important issue to these systems, because accurate failure forecast can help people plan focused maintenance to prevent faults. However, as high reliable systems, the data of system faults are rare. Moreover, usually the data of a system cannot be simply applied to another system, because systems are usually different even in a same type. Another realistic requirement to expert systems is to diagnose system failures never happened before, where no statistic data are available. Therefore, data mining is not a realistic approach in these cases. The only available knowledge for solving the diagnostic problems is the domain engineer's experience/knowledge based on their understanding to each specific system. The understanding is because engineers design, construct, operate and maintain these industrial systems. Meanwhile, the large scale and complexity such as involving a few hundreds or thousands of variables, the uncertain and complex causalities between variables, the uncertain delay of influence propagation, the dynamic system behavior during the occurrence of faults, the negative feedback mechanism, the logic cycles of causalities, the spurious sensor signals or some pieces of incorrect knowledge, the incomplete knowledge, the uncertain/fuzzy evidence, etc, are difficult to be modeled and processed in the existing intelligent systems. The newly developed DUCG (Dynamic Uncertain Causality Graph) methodology provides a solution to all these problems.

DUCG graphically represents the uncertain causal relationship among variables in an intuitive way, so that it is easy for domain engineers to use. It can represent the knowledge only in concern, which means that DUCG can be incomplete, while the exact inference in concern can be made. Also, causality cycles are allowed, which leads to the ability of DUCG to divide a large and complex DUCG into small and simple modules, where overlaps are allowed. The final DUCG is automatically composed by simply connecting individual modules together. Thus, the maintenance and modifications of the knowledge base become easy, because people need only to check and update individual modules. When dynamic evidences are received sequentially, the DUCG is dynamically simplified to exponentially reduce the scale and complexity of the problem (only the current problem related part remains). After this, the logic outspread is performed to obtain the event expressions composed of only the independent events as defined in DUCG. During the outspread, the logic cycles are broken. At the end of this operation, the candidate hypotheses (the possible root causes) involved in the current problem are found. Finally, the conditional probabilities of these hypotheses are calculated and ranked. As a result of the inference, the simplified DUCG graph is displayed on screen so that users know not only the inference results but also why the results. All the sequential evidences are included in the condition of the dynamic probabilistic reasoning. The spurious signals can be found when the observed signals/evidences are inconsistent with each other. Predictions can be made based on the inference results and shown graphically on screen to the users, so as they to know what will probably happen next. An industrial software of DUCG has been developed and is being applied to Lingdong Nuclear Power Plant in China.

About the Speaker

Qin Zhang, executive secretary of China Association for Science and Technology; professor of Institute of Nuclear and New Energy Technology, Tsinghua University, Beijing, and School of Computer Science and Technology, Beihang University, Beijing. He is the chairman of Society of Artificial Intelligence with Uncertainty under the society of Artificial Intelligence of China. He was a visiting scholar of UCLA and University of Tennessee, USA, during Oct. 1987 - Oct. 1989. He graduated from Tsinghua University with bachelor degree, master degree and Ph.D. degree in nuclear engineering. He was a post-doctor of School of Economics and Management, Tsinghua University. His recent research interests include reliability analysis, expert system and intellectual property right, etc. He has published about 60 papers in IEEE Trans. Reliability, Reliability Engineering and System Safety, Journal of Computer Science and Technology and other scientific journals.

All are welcome | Enquiry: 3442 8408