Plenary Tutorial: Modern ICT and Mechatronic Systems in Recent Mining Industry

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Abstract:
This tutorial deals with an overview of modern ICT techniques and systems, and mechatronic systems (with special attention paid to robotized ones) that are developed or even used nowadays in mining industry. The main idea is to present the recent development of different systems and solutions, with particular attention paid to achievements and implementations developed by the authors and their research groups. Regarding IT systems we discuss solutions addressing process and machinery monitoring, fault detection and isolation of processes and machinery, and assessment of risk and hazards caused by exploitation in mining industry. Furthermore, innovative applications of AI (Artificial Intelligence) methods will be also discussed, including pattern recognition and interpretation for process control, classification of seismic events, estimating loads of conveyors, and the other. Special attention will be paid to applications of robotic and mechatronic solutions. To this end, unmanned working machinery and longwalls in coal mines will be presented. Furthermore, specialized robots for basic work (automated drilling, autonomous LHD machines, robotized arms for crushing oversized copper ore lumps, automated loading of blasting holes, and other) will be shown. An important application of mobile robots for inspecting areas of mines affected by catastrophes will be presented as well. Moreover, recent communication solutions for collision avoidance, localisation of mining machinery, and wireless transmission will be addressed. Finally, general conclusions concerning most probably development of ICT and mechatronic systems for mining industry will be given.

Agenda:
1. Introduction
2. IT systems for fault detection of machinery and assessment of risk and hazards
   a. General overview
   b. Diagnostic systems
   c. Prediction of hazards
   d. DISESOR – an example of a diagnostic and monitoring system addressed to mining industry
   e. Diagnostics of belt conveyors systems
   f. Diagnostics of excavators for brown coal mines
   g. SYNAPSA – project focused on monitoring of mobile LHD machines in KGHM
3. AI applications
   a. General overview
   b. Pattern recognition applications
   c. Data mining and knowledge engineering
4. Robotics and mechatronics
   a. General overview
   b. Unmanned working machinery and longwalls
   c. Specialized robots for basic work
   d. Inspection robots
   e. Advanced solutions including Virtual Teleportation
5. Sensing and communication
   a. Collisions avoidance
   b. Wireless comm systems
   c. Localisation of machines in underground environment
6. Conclusions

Speakers' Biographies

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Wojciech Moczulski is Full Professor in the Institute of Fundamentals of Machinery Design at the Silesian University of Technology (SUT). He received his Ph.D. from the Faculty of Power Engineering in 1984, and D.Sc. (habilitation) from the Faculty of Mechanical Engineering, SUT. Since 1973 he has been employed at SUT. His research concerns application of AI methods and expert systems to technical diagnostics, monitoring and control of machinery, fault detection and diagnosis in networked systems, development of foundations and applications of mobile robotics, with special attention paid to real applications in mining industry, and application of innovative ICT technologies to different inspection and working tasks. He has many valuable implementations of Data Mining and Knowledge Discovery in Databases methods. He promoted 14 Ph.D. students. He is author and co-author of more than 250 peer-reviewed research papers in various journals, conferences and books, and editor of several scientific monographs. He is an active member of Polish Association of Computational Mechanics, Polish Association of Theoretical and Applied Mechanics, and Polish Society of Technical Diagnostics. Since 2005 he has been the Editor of Engineering Applications of Artificial Intelligence (Elsevier Journal). He has very broad experience in successful applications for research projects, and then their management and implementation.

Prof. Moczulski is also co-founder and President of SkyTech Research LLC, a spin-out located at the campus of SUT. The company is focused on successful implementations of mechatronic and informatics systems in aviation, UAVs, mining industry, alternative energy sources, and the others. The key-enabling technology of the company is Virtual Teleportation.

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Piotr Przystałka is an Assistant Professor in the Institute of Fundamentals of Machinery Design at the Silesian University of Technology. He received his Ph.D. from the Faculty of Mechanical Engineering in 2009 with his dissertation on the methodology of neural modelling in fault diagnosis with the use of the chaos theory. His current research focus is on hard and soft computing optimization methods and techniques in the context of fault diagnosis and fault tolerant-control, as well as the rapid prototyping of control systems of mobile robots. One of his main areas of research is the application of soft computing methods and techniques to increase the functionality of diagnostic expert systems for mining machinery and equipment (i.e. scraper and belt conveyor systems, longwall shearers), and also to develop algorithms for fault diagnosis of composite structures, leakage detection and localisation in water distribution systems, control of wheeled and legged mobile robots, velocity planning of electric racing cars. As author and co-author, he has published more than 90 peer-reviewed research papers in various journals, conferences and books. He is an active member of Polish Neural Network Society and Polish Society of Technical Diagnostics.

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Marek Sikora was born in Poland in 1969. He received the M.Sc. degree in applied mathematics from the University of Silesia in 1993 and the Ph.D. and D.Sc. degrees in informatics from the Silesian University of Technology in 2002 and 2012, respectively. He is an associate professor at Faculty of Automation, Electronics and Informatics, Silesian University of Technology (Gliwice, Poland) and at Institute of Innovative Technologies (Katowice, Poland).

His scientific interests focus on rule induction and evaluation, machine learning, and application of intelligent systems in industry, biology and medicine. He is an author or co-author of more than 80 scientific papers. In recent years he was involved in several research and commercial projects related to data mining, risk assessment and decision support systems (e.g. DISESOR – the decision support system for systems that monitor equipment, processes and natural hazards (National Centre for Research and Development); Methods and tools using functional annotations in gene groups analysis in order to improve quality of clustering and description (National Science Centre); SIR Leak Detection for Underground Storage Tanks (AIUT Ltd.).

He is a reviewer for many scientific journals (e.g. Applied Soft Computing, IEEE Transactions on Industrial Informatics, Information Sciences) and Program Committee member of several scientific conferences. In EMAG Institute he is a member of the Scientific Council and Editor-in-Chief of Mining – Informatics, Automation and Electrical Engineering journal.

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Radosław Zimroz received M.Sc. in Acoustics, Faculty of Electronics, Wroclaw University of Technology, Poland in 1998 and PhD and DSc (habilitation) degrees from Faculty of Mining, the same university, in 2002 and 2011, respectively. He is Professor (since 2012) at Faculty of Geoengineering, Mining and Geology, WUT, Poland and chair of *Diagnostic and Vibroacoustic Science Laboratory, Machinery Systems Division*. In the same time he is leading *Monitoring, Diagnostics and Automation of Industrial Processes Group* and *Department System Analysis* at *KGHM Cuprum Research and Development Centre*. In 2004-2005 he was working at *Applied Mathematics and Computing Group in Cranfield University*. He has visited (short visit) several European universities (*Cranfield, Compiegne, Grenoble, Roanne, Lyon, Athens, Reggio-Emilia, Ferrara, Bologne*).

His research is primarily focused on condition monitoring of mining machines but recently becomes more interdisciplinary including such areas as applied signal processing, data mining, monitoring systems, process diagnosis, robotics, autonomous machines etc. He is supervising 8 PhD thesis on mentioned subjects. He is author/co-author more than 270 works, including leading journals and indexed conferences. He was co-editor of special issues (Applied Acoustics, Shock and Vibrations) and book series published by Springer (4).

He is member of Society of Mining Technicians and Engineers, IEEE, vice-president of Polish Society of Technical Diagnostics, expert in European Innovation Partnership on Raw Materials and National Intelligent Specialization Committee (Automation and Robotics for Industrial Processes). He is an initiator of Condition Monitoring of Machines in Non-stationary Operations (CMMNO) and book series Applied Condition Monitoring (Springer, co-Editor). He serves as reviewer in several leading journals (Elsevier, IEEE, Hindawi, etc). He was also invited to evaluate PhD thesis in France (2x), Spain, Colombia, Finland.