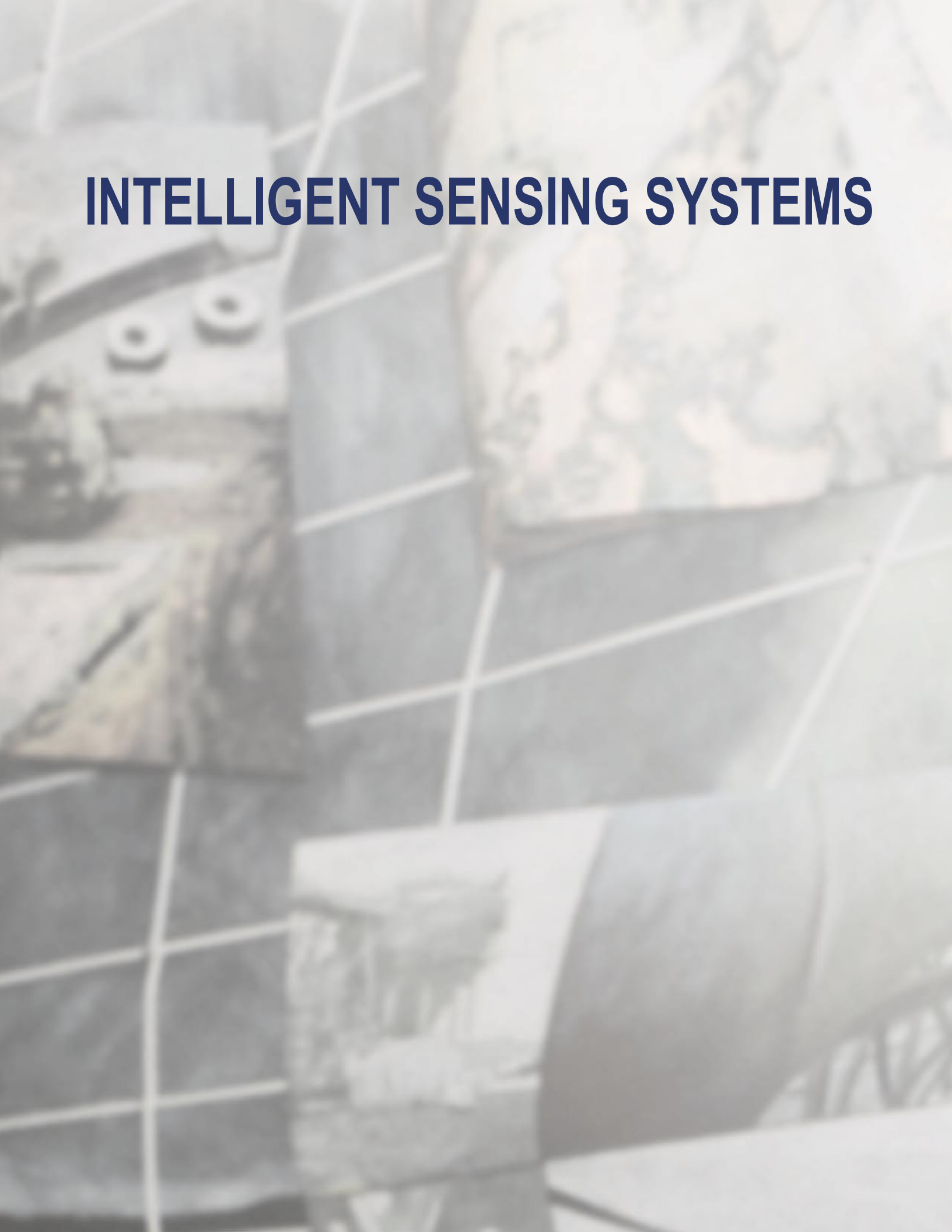


INTELLIGENT SENSING SYSTEMS

HONG ZHANG

NSERC/ICE Syncrude/Matrikon Industrial Research Chair
Centre for Intelligent Mining Systems, University of Alberta

This is an abbreviated report of research activities in the first few months of this iCORE industrial research chair program, the NSERC/iCORE Syncrude/Matrikon Industrial Research Chair in Intelligent Mining Systems, which was started December 1, 2003 and officially launched April 2, 2004.

EXECUTIVE SUMMARY

The report includes only those sections that are the most relevant for iCORE to compile its Annual Research Report and Performance Measures Report. As the chair ramps up and attains its steady state within the next several months, the quarterly and annual iCORE reports will provide more coverage on the research projects.

RESEARCH PROGRAM OVERVIEW

The chair's research proposal is in the area of intelligent sensing applied to oil sands mining. The long-term direction of the research program is to push the scientific envelope of information and communications technologies and apply these technologies to the optimization of the performance of oil sands mining. We will study sensor processing algorithms for monitoring the various stages of oil sands mining, and the research will lead to objective performance models of the mining components as well as the entire mining process. These performance models will enable the industry to improve the performance of its mining process by maximizing the throughput, while minimizing the rejects and its environmental impact.

A key performance indicator of the mining process is the size of the oil sand ore as it progresses through the ore sizing and delivery pipeline. On that basis, our research will address two research areas that are fundamental for objectively evaluating mining process, focusing on ore size: (a) reliable sensor processing algorithms for ore size measurement under variable environmental conditions, and (b) statistical modeling of a system and its components with respect to their performance metrics. The specific scientific objectives consist of the following:

- To investigate adaptive algorithms for image analysis which are robust with respect to lighting, weather, and ore geology and size characteristic changes;

- To develop multi-spectral sensor fusion algorithms that combine range and intensity data for measuring 3D volumetric ore size;
- To study statistical image characterization algorithms to extract ore size information from image statistics in the transformation spaces without image segmentation; and
- To derive the oil sand ore sizing model (OSSM) as a mathematical vehicle to understand the relationship between the mining process variables and the mining performance.

RESEARCH PROJECTS

Contrast Enhancement (Andrzej Zadorozny, MSc candidate)

This project is intended to understand the basic issues in improving image quality through the manipulation of image contrast. This understanding will allow us to optimally perform the critical step of image pre-processing before the actual image segmentation and ore size analysis algorithms.

Adaptive Threshold (Dr Fexiang Yan, Post-Doctoral Fellow)

Thresholding represents the important step of separating large oil sand ore particles from the background, that is, fines. This project has led to the design of a novel thresholding algorithm that calculates the threshold adaptively first with two global thresholds and then a local threshold computed from local image statistics.

Hong Zhang

Oil Sand Fines Model (Dr Minghong Pei, Research Assistant; Xiaoli Wang, MSc Candidate)

This research projects uses the idea of inferring ore size distribution of fine oil sand particles (fines) from the image statistic of first order derivatives. It performs size analysis without going through the difficult step of segmentation.

Efficient Implementation of Image Processing Algorithms (Haobin Li, undergraduate student)

This summer project allows the student to become familiar with the OpenCV/IPP, an open-source image processing system created by Intel. The experience will allow CIMS to implement present and future image processing software in an efficient manner for its real-time performance.

Adaptive Color Classification (Xiaohu Lu, MSc Candidate)

This project is aimed at achieving a system that can reliably recognize colors under variable color conditions so that we can take advantage of the rich information present in color cues. A novel representation of color classes in color subspaces provides a practical solution to the high memory requirement experienced by look-up table (LUT) based methods.

Scale-Invariant Feature Transform (SIFT), Its Extension and Applications (Xiang Wang, PhD candidate)

This project looks at the use of SIFT, developed by David Lowe of UBC, as a way of modeling objects for recognition tasks. We are interested in extending the basic ideas behind SIFT and applying SIFT to the modeling an environment by focusing on its salient features.

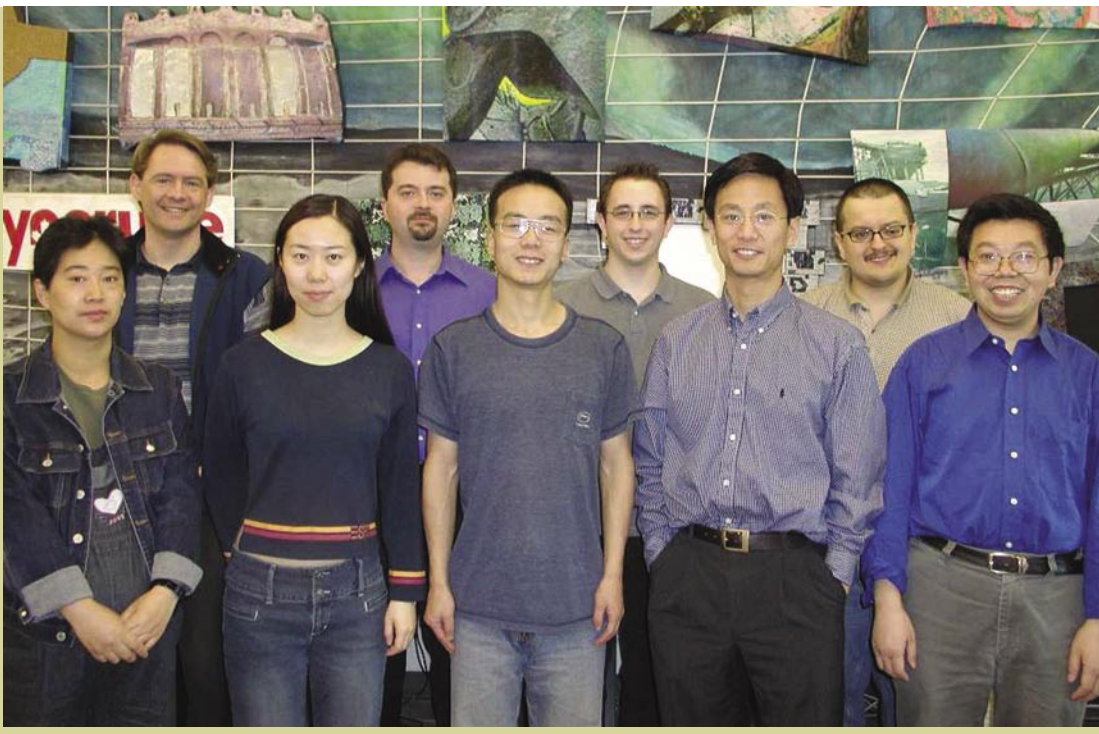
Ore Size Analyst Parameter Optimization (Chao Hu)

This research is intended to apply machine learning techniques to tune image processing parameters for the optimal performance of ore size calculation. It is based on the classical approach of multifunctional minimization, and serves as a potential solution for automatically selecting parameters for any image processing algorithms.

Image-Based Model for Sensor Fusion (Dana Cobzas)
This research applied the techniques in image based modeling and computer graphics for texture mapping depth data, and paves the way for future study of fusing intensity and range information for ore size analysis. The research focuses on the problem of registering the sensory data acquired in two coordinate systems so a texture 3D model of the environment can be rendered from an arbitrary viewing direction.

RESEARCH TEAM MEMBERS AND CONTRIBUTIONS

	ROLE/TOPIC
Dr Hong Zhang	Team Leader/Chair Holder
Dr Ron Kube	CIMS co-director/industrial partner from Syncrude
Dr Mark Polak	Lab Manager/industrial partner from Matrikon
Dr Martin Jagersand	Faculty member
Dr Feixiang Yan	Postdoctoral fellow
Dr Minghong Pi	Research assistant



Hong Zhang and some research team members in the Centre for Intelligent Mining Systems, Edmonton, 2004

STUDENTS

	ROLE/TOPIC
Xiang Wang	PhD candidate
Chao Hu	PhD candidate
Xiaoli Wang	MSc candidate
Andrzej Zadorozny	MSc candidate
Xiaohu Lu	MSc candidate
David Laing	Undergraduate student
Yury Potapovich	Undergraduate student/IIP student with Syncrude
Haobin Li	Summer student

FUNDING

Hong Zhang started this year with an iCORE Industry Chair with partners iCORE ($150K/year), NSERC ($161K/year), Syncrude ($100K/year), Matrikon ($50K/year), and the University of Alberta ($20k/year).

PUBLICATIONS

REFEREED JOURNAL PUBLICATIONS

Max Q. H. Meng and Hong Zhang, "Perspectives of Computational Intelligence in Robotics and Automation," *Journal of Advanced Computational Intelligence & Intelligent Informatics*, Vol. 8 No. 3, May 2004

Dana Cozbas, Martin Jagersand, and Hong Zhang, "A Panoramic model for remote robot environment mapping and predictive display", to appear in *International Journal of Robotics and Automation*, 2004.

Hong Zhang and Dmitry Gorodnichy, "Latest research in computer vision - a special issue on VI 2002", to appear in *Image and Vision Computing*, 2004.

REFEREED CONFERENCE PROCEEDINGS

Yisheng Guan and Hong Zhang, "Workspace of 2D Multifingered Manipulation", *Proc. 2003 IEEE International Conference on Intelligent Robots and Systems*, Las Vegas, USA, October 27-31, 2003, pp. 3705-3710.

Yisheng Guan and Hong Zhang, "Feasibility Analysis of 2D Grasps", *Proc. 2003 IEEE International Conference on Intelligent Robots and Systems*, Las Vegas, USA, October 27-31, 2003, pp. 3435-3440.

Parker, Chris A. C., Zhang, Hong and Kube, Ronald C., "Blind Bulldozing: Multiple Robot Nest Construction", *Proc. 2003 IEEE International Conference on Intelligent Robots and Systems*, Las Vegas, USA, October 27-31, 2003, pp. 2010-2015.

Matthew McNaughton and Hong Zhang, "Color Vision for RoboCup with Fast Lookup Tables", *IEEE International Conference on Robotics, Intelligent Systems, and Signal Processing*, Changsha, China, October 8-13, 2003, pp. 399-404.

Dana Cobzas, Hong Zhang, and Martin Jagersand, "Image-Based Localization with Depth Enhanced Image Map", Proc. 2003 IEEE International Conference on Robotics and Automation, Taipei, Taiwan September 14-19, 2003. pp.1570-1575.

BOOKS AND CHAPTERS

C. Ronald Kube, Chris A. C. Parker, Tao Wang, and Hong Zhang, "Biologically Inspired Collective Robotics", in *Recent Developments in Biologically Inspired Computing*, editors Leandro Nunes de Castro and Fernado J. Von Zuben, Publisher Idea Group Inc. (IGI), 2005, pp. 367-397.

SPECIAL/INVITED PRESENTATIONS

Plenary Speaker, International Conference on Control Science and Engineering, "Granulometry with Mathematical Morphology and Motion Stereo", Harbin, China, 18-20, December 2003.

Keynote speaker, AI 2004 Workshop on Agents Meet Robots, the Seventeenth Canadian Conference on Artificial Intelligence, London, Ontario, May16, 2004.

Keynote speaker, The 1st Canadian Conference on Computer and Robot Vision, "Machine Sensing for Mining Optimization", London, Ontario, May 17-19, 2004.