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Intelligent Computing at LUT

Arto Kaarna
Associate Professor, D.Sc. (Tech.)
LUT/Mathematics and Physics
Machine Vision and Pattern Recognition Laboratory

Outline

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LAPPEENRANTA UNIVERSITY OF TECHNOLOGY STRATEGY 2015: **TOGETHER**

LUT'S STRATEGIC FOCUS AREAS ARE AS FOLLOWS:

VALUES

Courage to succeed.
Passion for innovation through science.
Will to build well-being.

MISSION

We will contribute to the welfare and sustainable competitiveness of Finland with our expertise in science, technology and business.

VISION 2015

LUT will be an agile, international university combining technology and business. In its key areas of expertise, LUT will represent the top European level.

LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

Lappeenranta University of Technology (LUT) has served as a forerunner combining technology and business ever since its inception in 1969. Our international community is comprises 7 000 students and experts engaged in scientific research and academic education. By the beginning of 2012, LUT has produced over 10 000 graduates holding the degree of Master of Science in Technology or Master of Science in Economics and Business Administration. In addition, over 450 LUT students have the postgraduate degree of Doctor of Science in Technology, Doctor of Science in Economics and Business Administration, or Doctor of Philosophy.

Quantitative goals for 2015:

- 400 refereed publications in international science journals
- 50 degrees (in total) awarded for Doctor of Science in Technology, Doctor of Science in Economics and Business Administration, and Doctor of Philosophy
- 425 degrees awarded for Master of Science in Technology, and 190 degrees for Master of Science in Economics and Business Administration
- 380 degrees (in total) awarded for Bachelor of Science in Technology and Bachelor of Science in Economics and Business Administration
- 450 students participating in international student exchanges
- 380 international degree students

Current LUT Organization

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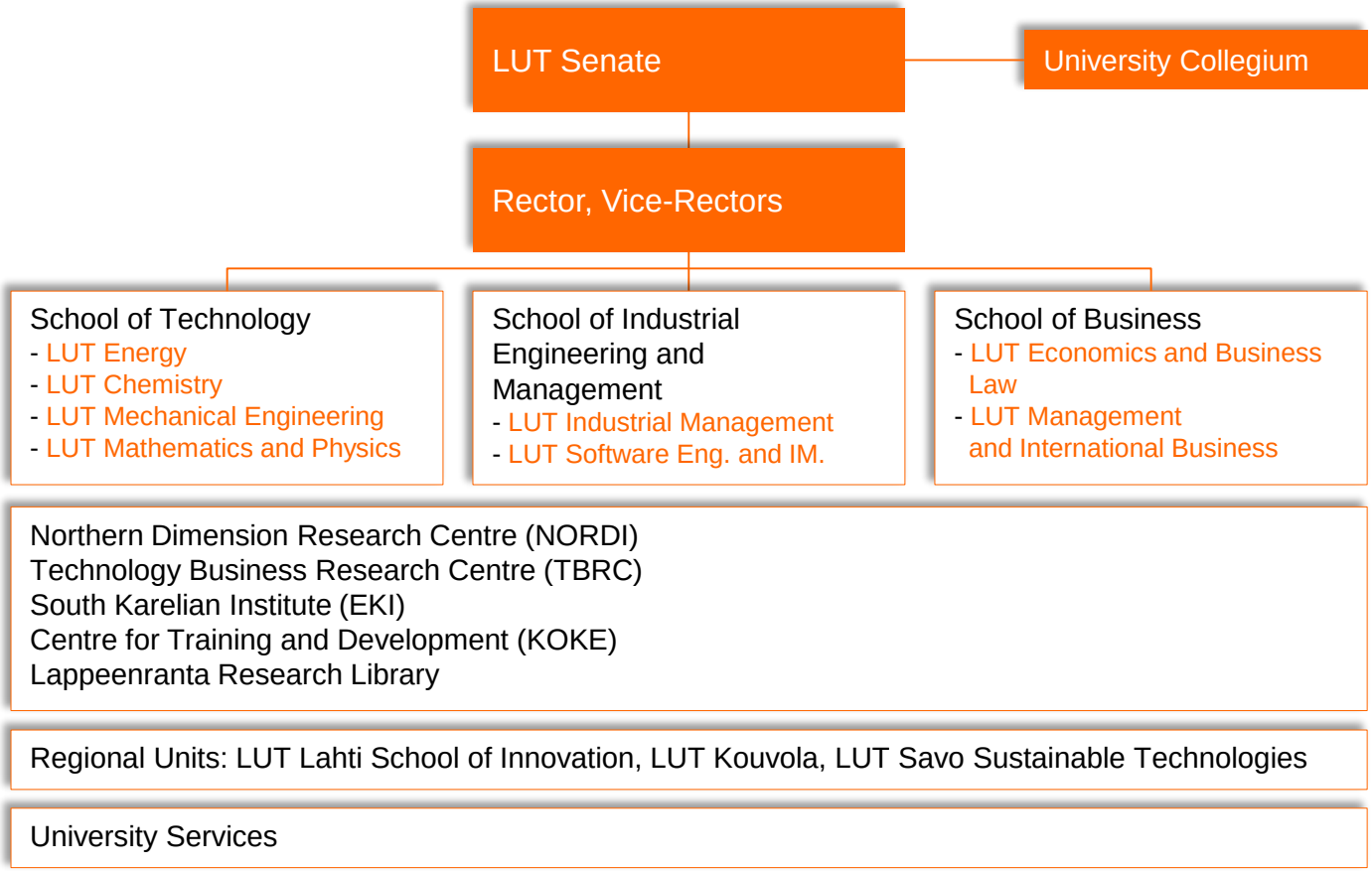

New LUT Organization, 1.1.2015

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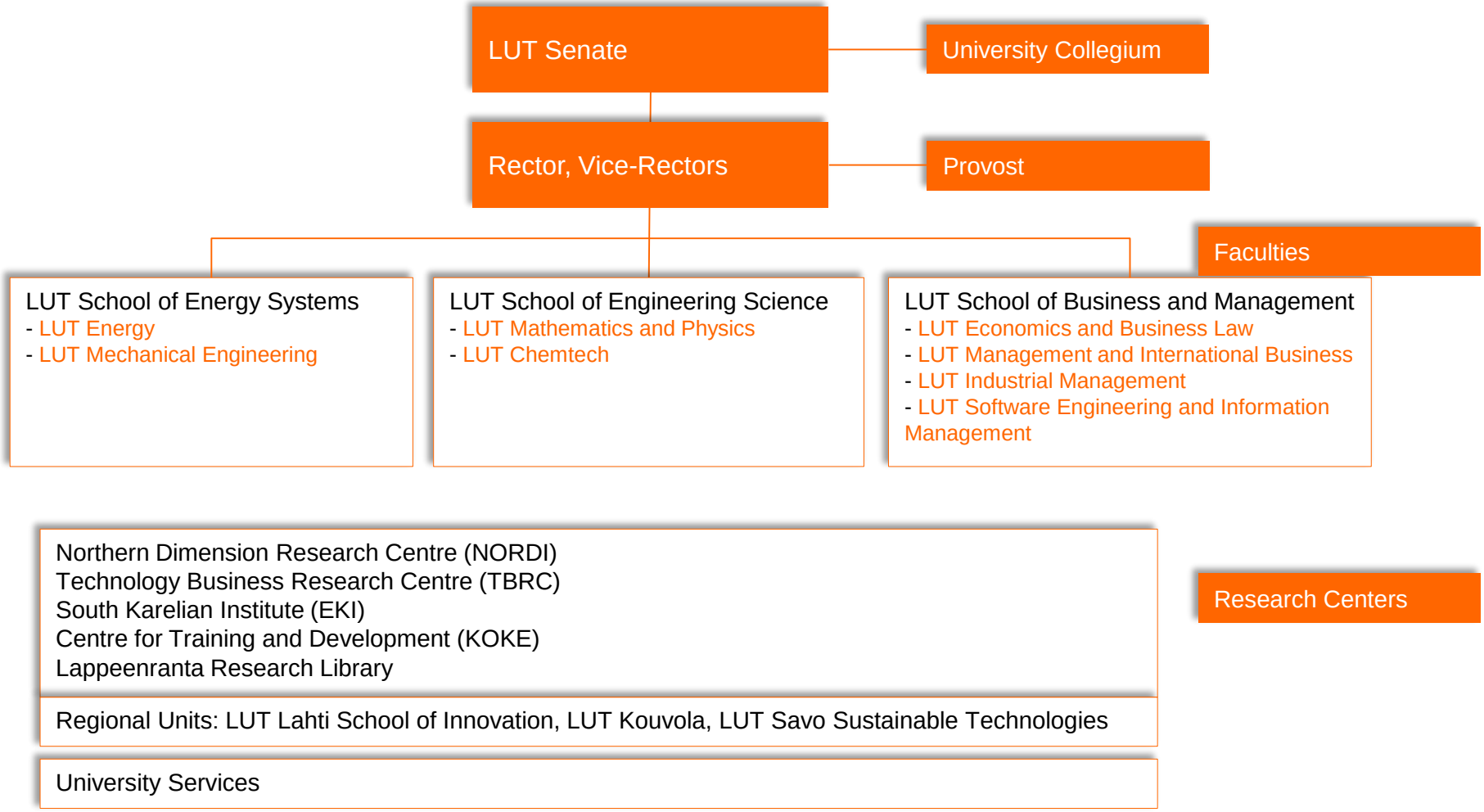

New LUT Organization, 1.1.2015

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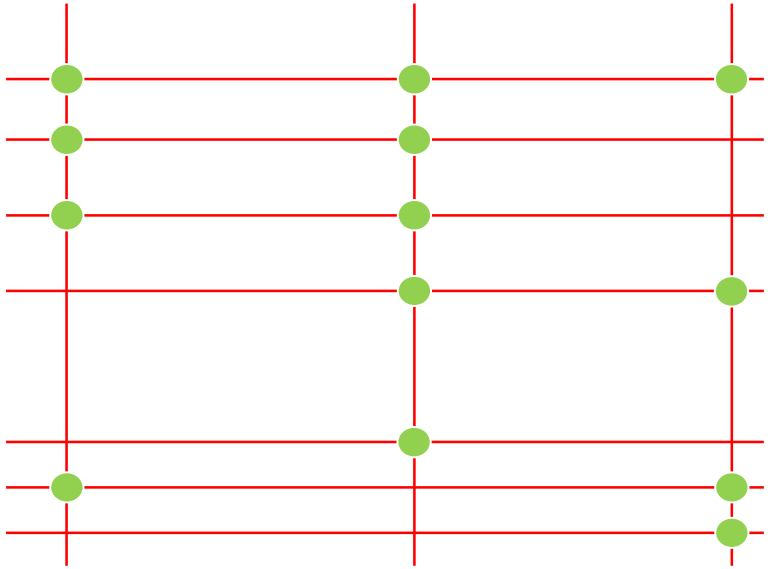
Matrix organization

LUT School of Energy Systems	LUT School of Engineering Science	LUT School of Business and Management



Research Questions for LUT:

- ✓ Are we burning out everything?
- ✓ Do we have to suffer from the water we have spoiled?
- ✓ Are we burying our future with waste?
- ✓ Do we allow our neighbourhood to regress to the backyard of the world?

Key actions, directions, trends in LUT

- ✓ Data mining and analysis,
- ✓ Business at Russia,
- ✓ Internationalization and growth of SME.

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versity of Technology

Computational Engineering and Physics [120 ECTS CREDITS]

Techno-mathematics	Credit transfer for double degree students (maximum of 50 ECTS)	Process modelling and ecomathematics	Numerical methods, optimization and scientific computing	MASTER'S THESIS 30 ECTS
		Computational materials science	Data driven modelling	Fuzzy methods and soft computing
Technical Physics		Applied Optics	Optoelectronics	Nanophysics
		Material Science	Microelectronics	Semiconductor and superconductor physics
Intelligent computing		Digital imaging and image preprocessing		Machine vision and digital image analysis
		Pattern recognition	Computer vision	Computer Graphics

Elective studies, General studies, Minor studies, Languages

Master's Programme in Computational Engineering and Physics

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The programme has three alternative major subjects: Technomathematics, Technical Physics and Intelligent Computing.

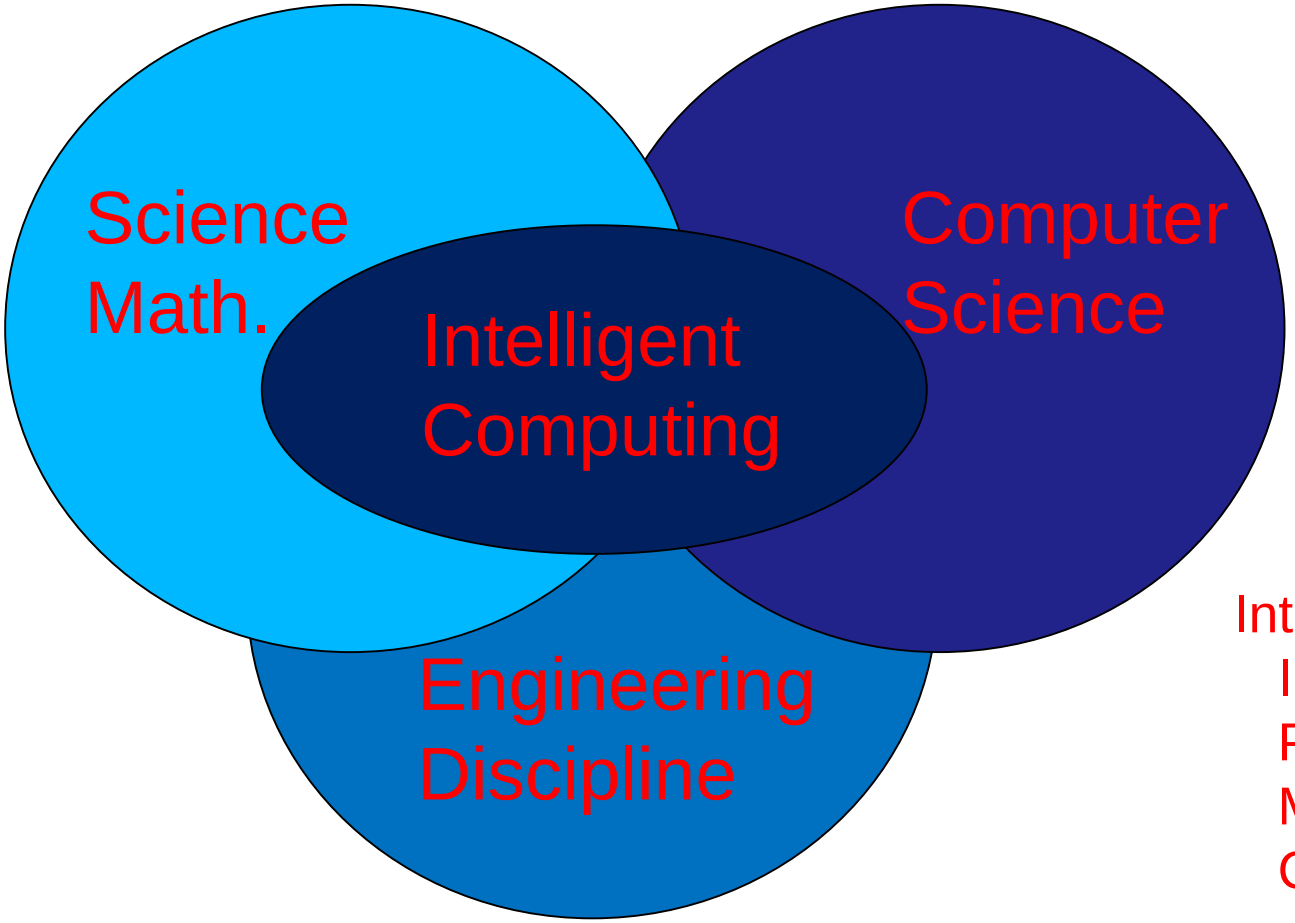
The research and study areas in the field of **technomathematics** include modelling of industrial and environmental processes, fuzzy systems, and developing mathematical methods. We focus on real-world applications, with active collaboration in the international community of industrial mathematics.

The research and study at the **Laboratory of Physics** focuses on materials physics, semiconductors, superconductors, spintronics and optical measurement technologies. LUT physics has extensive cooperation with Russian universities and wide contacts with Finnish and European physics laboratories.

The **Intelligent Computing** major subject offers specialization in information processing, both in systems and in their design. The major studies focus on imaging, machine vision systems and computer vision contributing to the current trends in automation. Graduates have career prospects in such areas as developing innovations in visual inspection, research based product development, and information processing systems in ICT companies.

Master's degree programme in Technomathematics and Technical Physics was inspected by ECMI - European Consortium for Mathematics in Industry.

Background for the major in IC



Intelligent Computing:
- Imaging,
- Pattern Recognition,
- Machine Vision,
- Computer Vision

What is it (in study guide)?

- Graduates from Intelligent Computing:
  - are able to analyze and find solutions for challenging problems in information processing through transforming them into algorithmic form
  - are able to apply mathematical methods in algorithms
  - are able to apply intelligent and learning approaches of information processing to solve problems in information technology
  - are able to use and rationally select solutions and methods in the fields of imaging, machine vision, computer vision, computer graphics.

What is it (as keywords)?

- Problem solving
- Algorithmic solutions
- Mathematical methods
- Strong skills in basic computer science

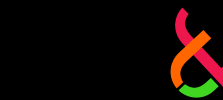
Computational Solutions

- Artificial intelligence: Image processing and analysis, pattern recognition
- Digital Imaging
- Machine learning
- Computer vision
- Computer graphics

Intelligent Methods

- (It is not traditional cognitive science, expert systems, mathematical reasoning, ...)

Intelligent Computing and the others



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- Mathematically and computer science oriented
  - Applying mathematical methods for real-world problems
  - Developing mathematical models for the problems
  - Presenting solutions as algorithms

  I.e.: Problem solving, finding engineering solutions, implementations.

- Proper background for doctoral studies
- Good opportunities to join the group already during the MSc studies
- Unified research group

- Coolest scientific applications!

Examples of what one learns

- How to build a machine vision based quality control system?
- How to automatically organize the photo collection?
- How to summarize the video collection?

- How to construct image processing systems?
- How to apply machine learning?
- How to apply computer graphics?

In general, how to make more intelligent solutions for the future.

Less is More!

MSc. Study Structures:

- Two-year program

Degree Structure		
General Studies	7-14	ECTS cr
Major Subject	70-74	ECTS cr
Minor Subject	20 (min.)	ECTS cr
Elective Studies	12-23	ECTS cr
Total	120 (min.)	ECTS cr

Major in Intelligent Computing 70 ECTS cr
[1)] Exchangeable

Obligatory Studies (60 ECTS cr)		year	per.	ECTS cr
BM10A0000	Master's Thesis and Seminar	M.Sc. (Tech.) 2	1-4	30
BM40A0600	Introduction to Computer Graphics	M.Sc. (Tech.) 1-2	2	5
BM40A0700	Pattern Recognition	M.Sc. (Tech.) 1	1-2	7
BM40A0800(1	Machine Vision and Digital Image Analysis	M.Sc. (Tech.) 1-2	3-4	7
BM40A0900(1	Computer Vision	M.Sc. (Tech.) 1-2	3-4	7
BM40A1000	Seminar on Intelligent Computing	M.Sc. (Tech.) 1	3-4	4
BM40A1200	Digital Imaging and Image Preprocessing	M.Sc. (Tech.) 1	1-2	7

MSc. Study Structures:

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- The Double Degree program (1st year at home university, 2nd year at LUT)

Degree Structure		
General Studies	4	ECTS cr
Major Subject	66	ECTS cr
Credit Transfer	50	ECTS cr
Total	120 (min.)	ECTS cr

General Studies

Obligatory Studies (4 op)		year	per.	op
FV11A8900	Academic Writing in English	TkK 3, DI 1-2, KTK 3, KTM 1-2	1-2, 3-4	4

Major in Intelligent Computing (for Double Degree Students) 66 ECTS cr

[1)] Exchangeable

Obligatory Studies (60 ECTS cr)		year	per.	ECTS cr
BM10A0000	Master's Thesis and Seminar	M.Sc. (Tech.) 2	1-4	30
BM40A0600	Introduction to Computer Graphics	M.Sc. (Tech.) 1-2	2	5
BM40A0700	Pattern Recognition	M.Sc. (Tech.) 1	1-2	7
BM40A0800(1	Machine Vision and Digital Image Analysis	M.Sc. (Tech.) 1-2	3-4	7
BM40A0900(1	Computer Vision	M.Sc. (Tech.) 1-2	3-4	7
BM40A1000	Seminar on Intelligent Computing	M.Sc. (Tech.) 1	3-4	4
BM40A1200	Digital Imaging and Image Preprocessing	M.Sc. (Tech.) 1	1-2	7

Courses and teachers

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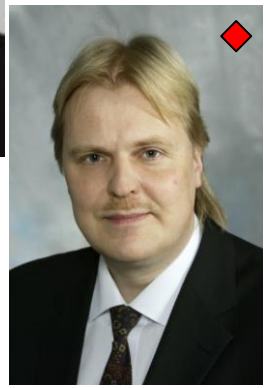
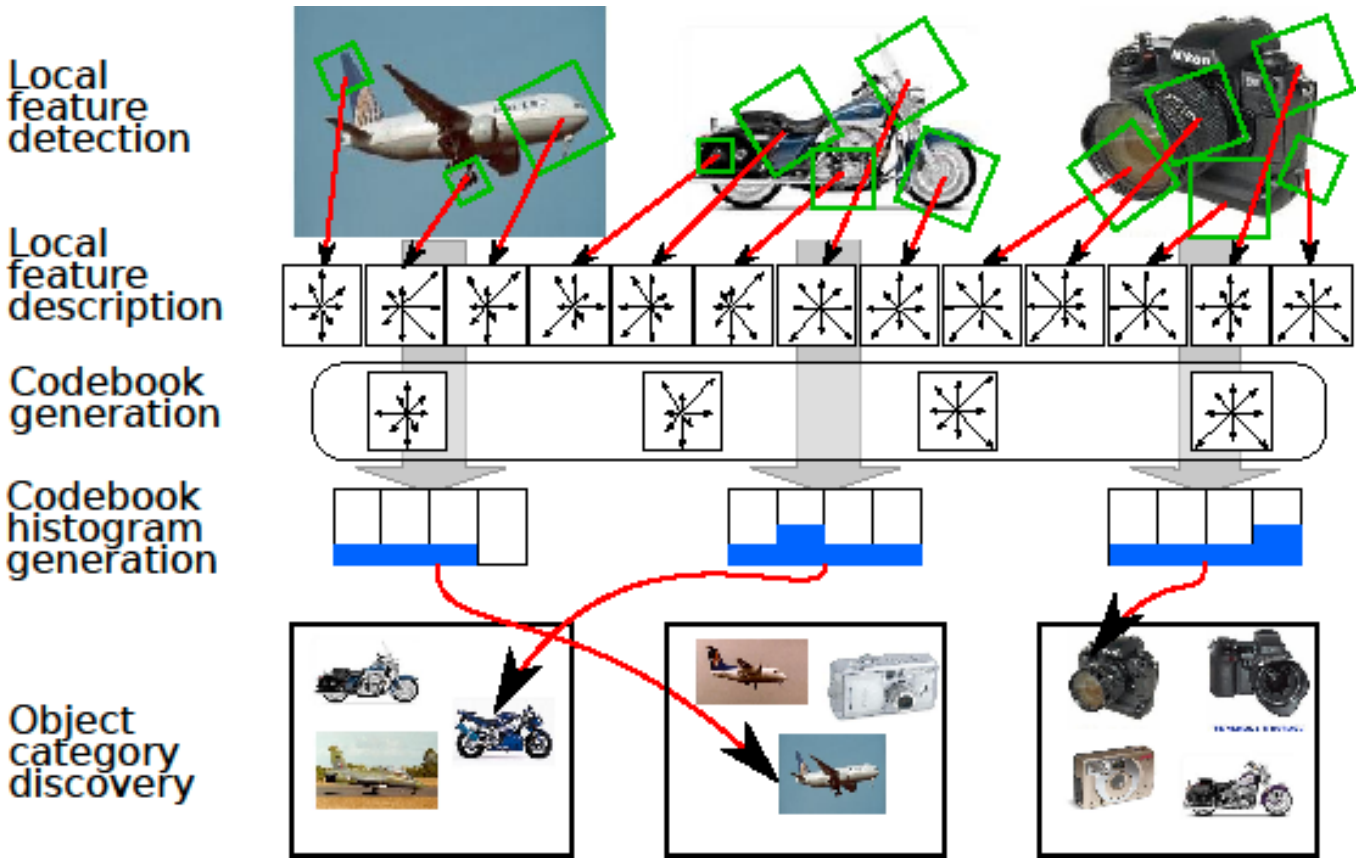
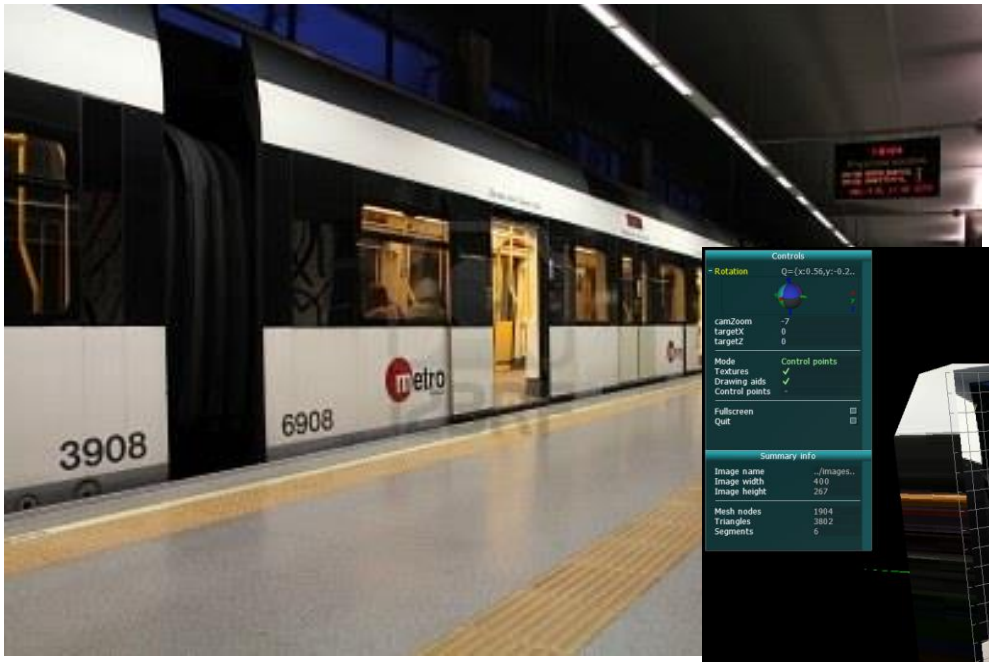
- Classes given by experienced teachers with the doctoral degree:
  - 2 professors (Heikki Kälviäinen, Lasse Lensu)
  - 1 associate professor (Arto Kaarna)
  - 2 D.Sc. (Technology) (Tuomas Eerola, Leena Ikonen)
- Master level program: 6 obligatory courses + Master thesis + electives
  - Introduction to Computer Graphics
  - Digital Imaging and Image Preprocessing
  - Pattern Recognition
  - Machine Vision and Digital Image Analysis
  - Computer Vision
  - Seminar on Intelligent Computing
  - Master's thesis and seminar

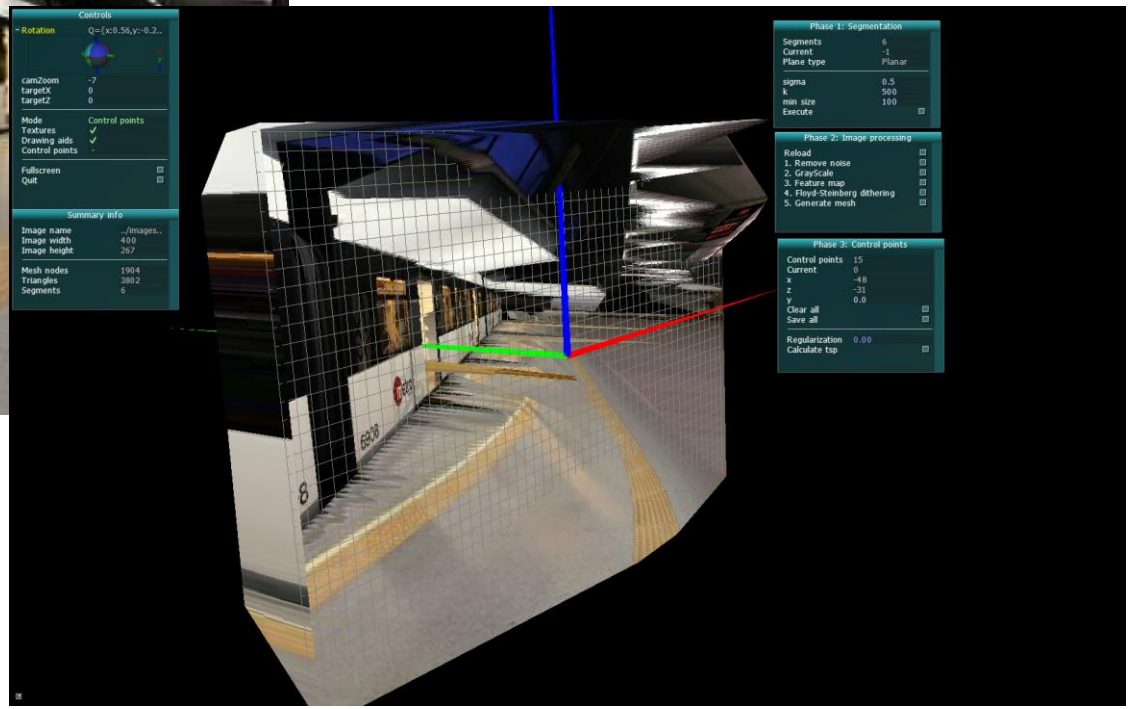


Unsupervised visual object categorization (Teemu Kinnunen)

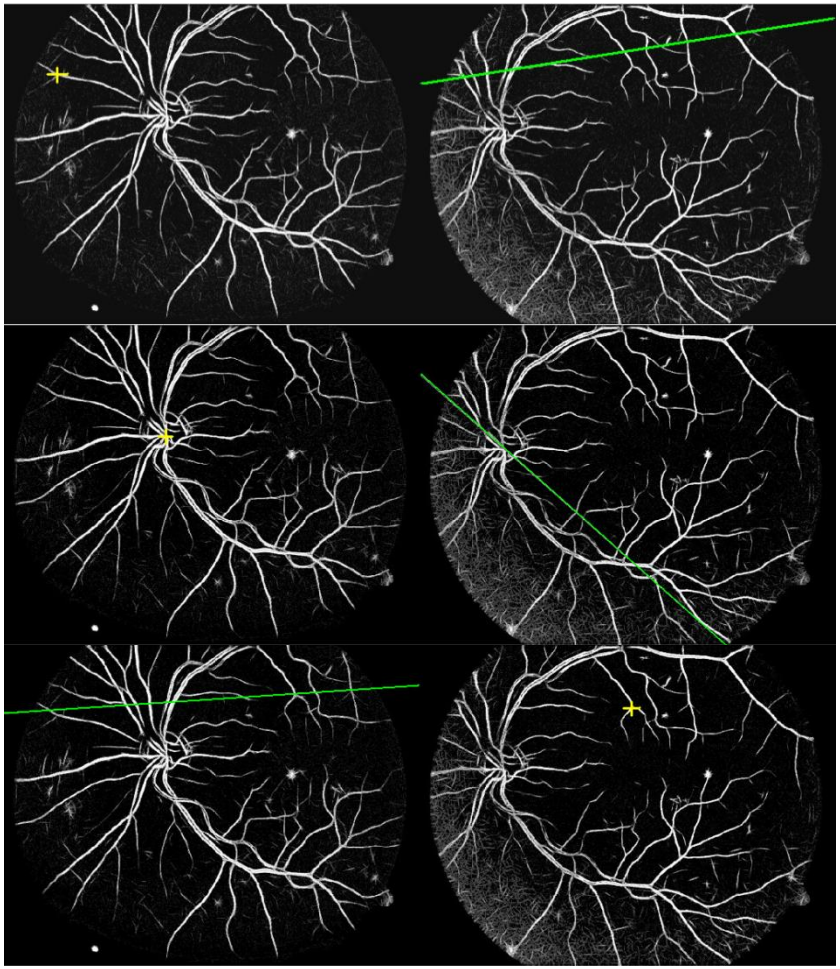


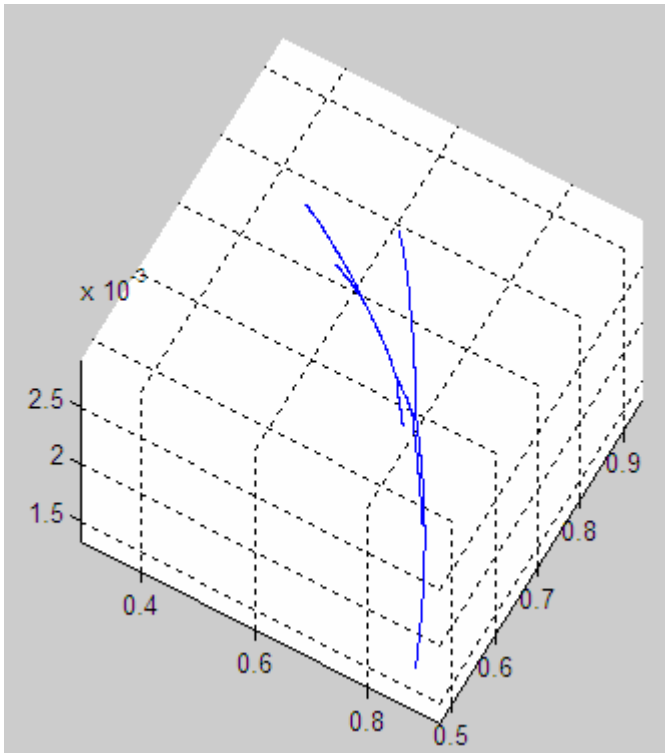
Assisted 3D reconstruction from a single view (Teemu Tarkiainen)





Automated work flow for blood flow simulation in aorta and retinal vessels (Seyed Mahmoud Mortazavi)





TrafficVision (Petri Hienonen, 2014)

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Liikennevirasto

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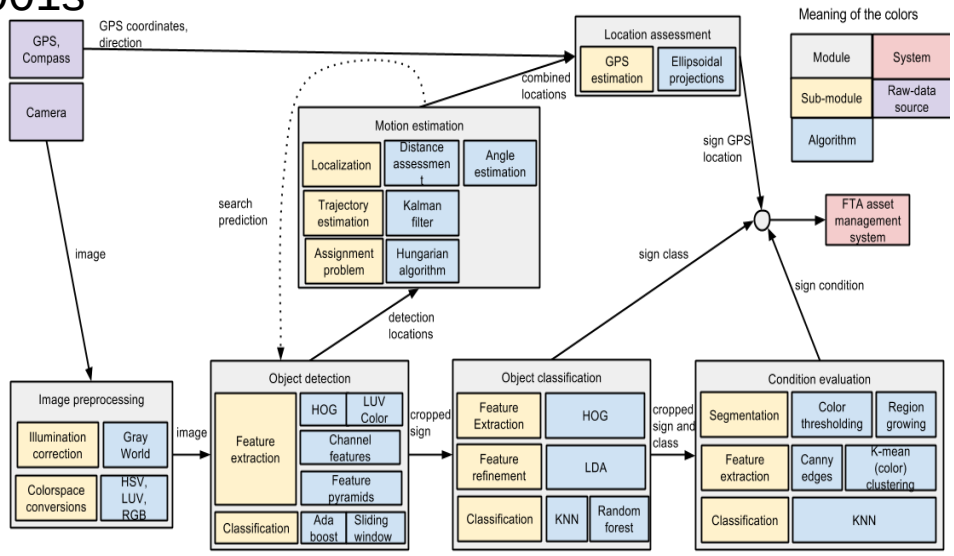
- Goals, actions
  - Realtime information from traffic signs: quality, location
  - Quality rating from 1 to 5
- Results — accuracy/time
  - Recognition — 96%, 0.06s
  - Classification — 99%, 0.001s
  - Quality estimation — ∓ 0.57, 0.45s
  - Location — ∓ 0.3 m, 0.001s



Photoelectric measurements and modeling of bacteriorhodopsin (Teemu Tukiainen)

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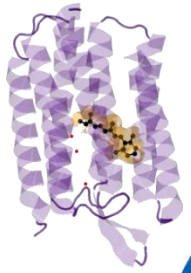
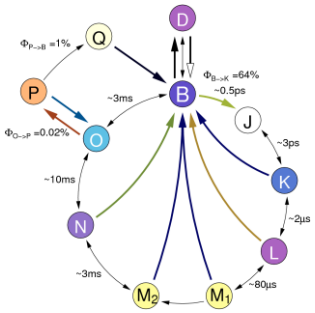
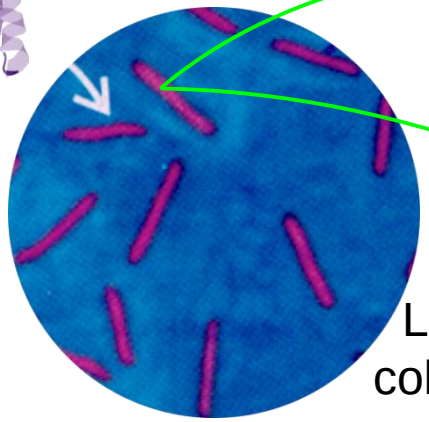
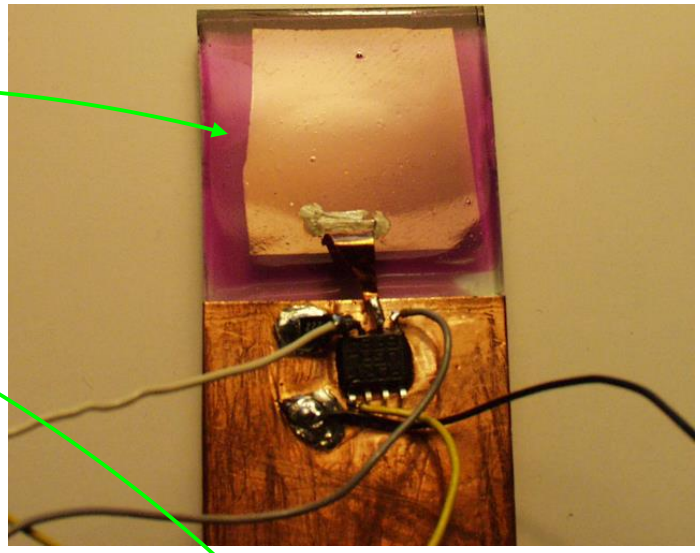


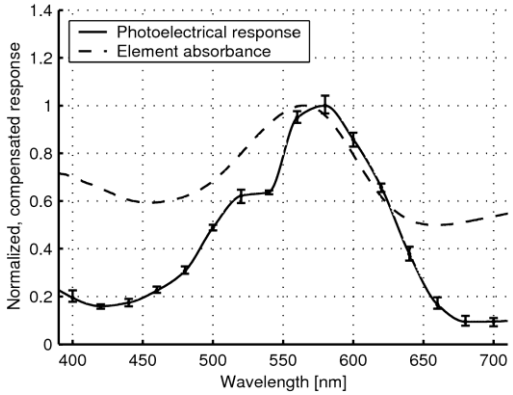


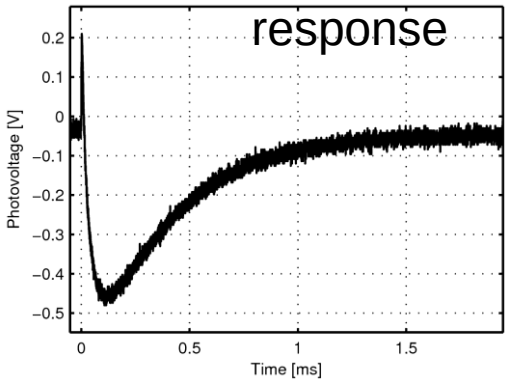


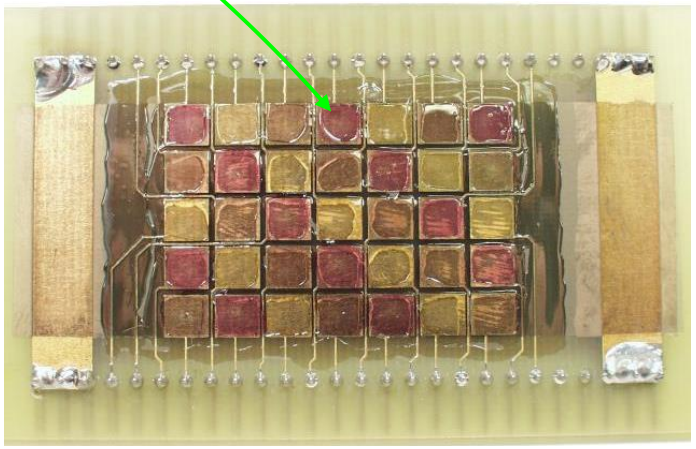
Cultivation/ extraction/ preparation



Light-induced color-dependent photoelectric response







After graduation:
Where to apply your knowledge

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- Problem solving; algorithmic and computational approach; practical implementations
  - Industrial systems (machine vision), business (big data)
  - Medical technology (features, patterns from imaging)
  - Education
  - User interfaces, Information systems (e.g. comp. graphics)

- Research as a doctoral student
  - Graduation as a Doctor of Science, Technology (D.Sc. (Tech.))
  - 3.5 years of full-time research
    - Studies 40 ECTS credits
    - Research, doctoral thesis

Doctoral Thesis: 3D Vision and AR
Tommi Tykkälä, 2013

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Tommi Tykkälä: Camera Motion Tracking and Environment Mapping using RGB-D Sensor, 2013.

Cooperation in MSc. Double Degree studies

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Required to be admitted: lower university degree (B.Sc.) in engineering technology.
The studies corresponding to the degree of B.Sc. (180 credits) must be completed at the student's home university.

Master's degree in engineering technology
120 credits of studies
of which

A minimum of 70 credits of advanced studies need **to be completed at LUT.**
(40 cr. of studies + 30 cr. diploma thesis)

A maximum of 50 credits may be transferred from the student's earlier degree.

Timetable of the DD studies

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Application time December – February, decision about new students in the end of April. Classes start in the beginning of September (end of August).

Usually DD-students study one winter. Lectures and exams in Autumn term, Masters Thesis in Spring term.

Some students study 1.5 years, if Masters Thesis is delayed.

Graduation statistics in DD studies

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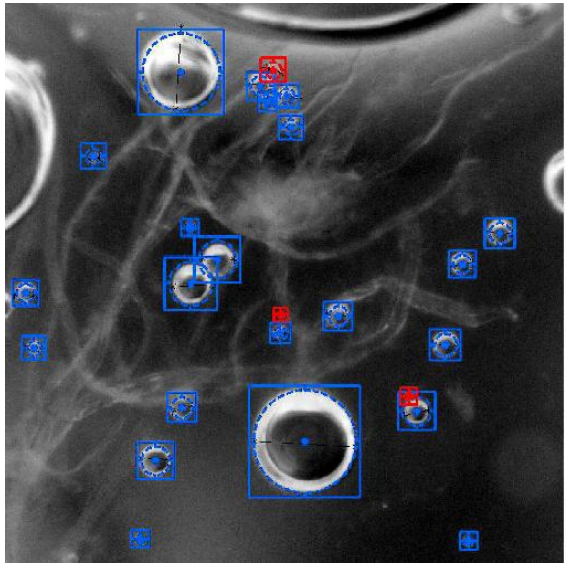
About 30 students graduate annually, about 10 in each subject.

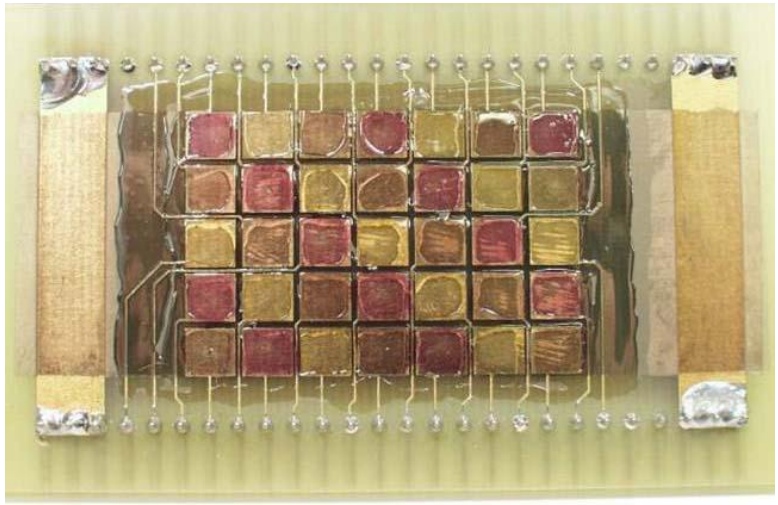
More than 20 students graduate annually from our DD-programme.

DD-programmes with universities
from Russia, Africa, India.

Research Topics at MVPR

- Main areas
  - Visual Inspection, Quality Control
  - Medical Imaging and Processing
  - Biosensors
  - Computational Vision
  - Colour Science



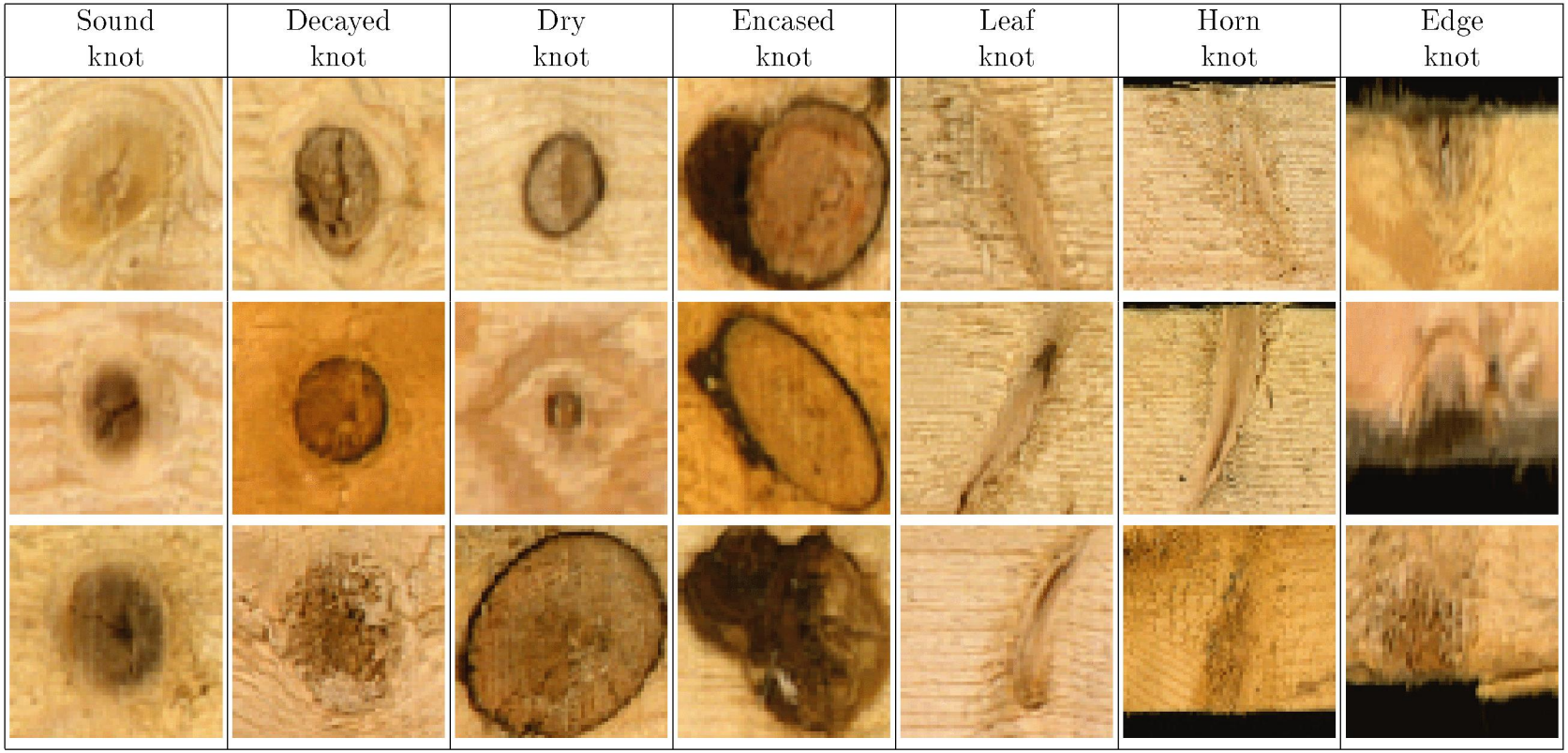


Automatic Cheese Production (MAG, Ltd.)

Get rid of human interaction (vision and hands).

Also check the quality of a product.

Classification of Knots: Visual Inspection for Automation



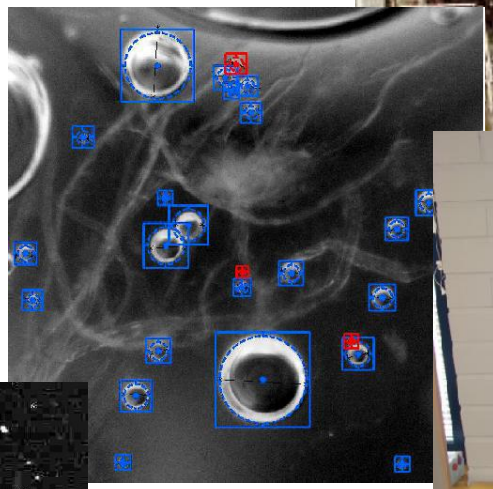
Visual Inspection

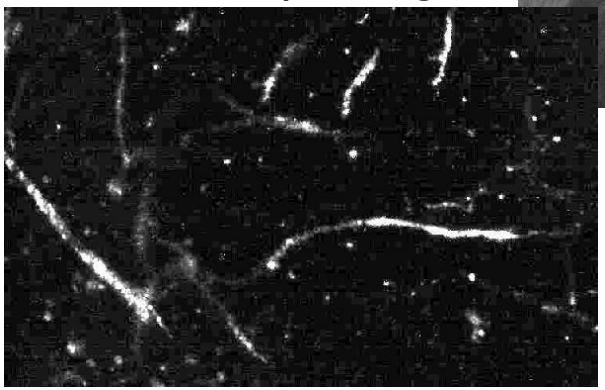
Motivation: Image-based quality control and resource efficient production.

Actions: Imaging, image processing, and image analysis methods for industrial machine vision.

Laboratory as well as online and inline measurements of processes for characterization.

Special focus on forest and printing industry.





Making better paper

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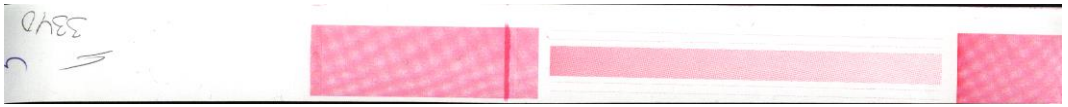


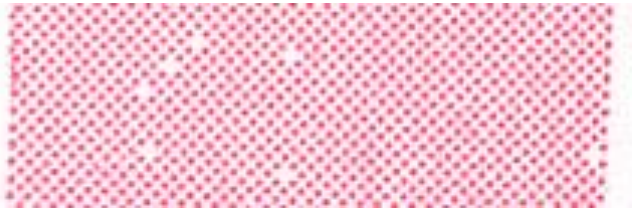
PAPVISION

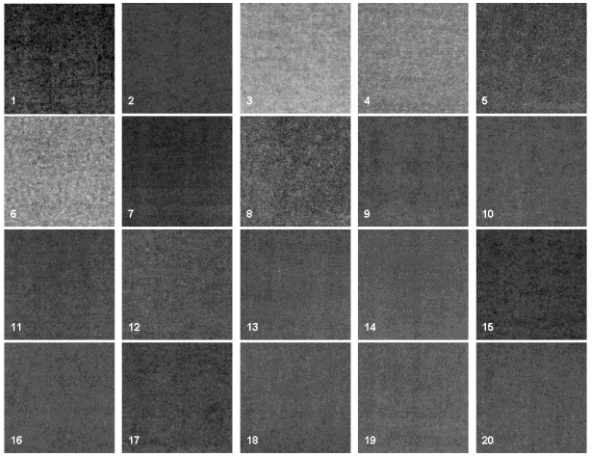
(http://www.it.lut.fi/project/papvision)

Paper and Board Printability Testing Using Machine Vision

Q: Can printability tests of paper and board be automated by machine vision?

Where is the 20th missing dot from the beginning?





DIGIQ

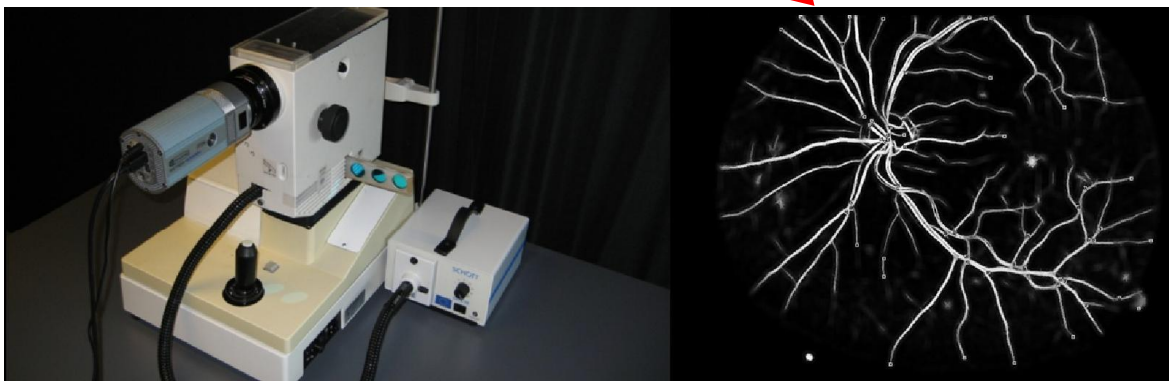
(http://www.media.hut.fi/digiq/)

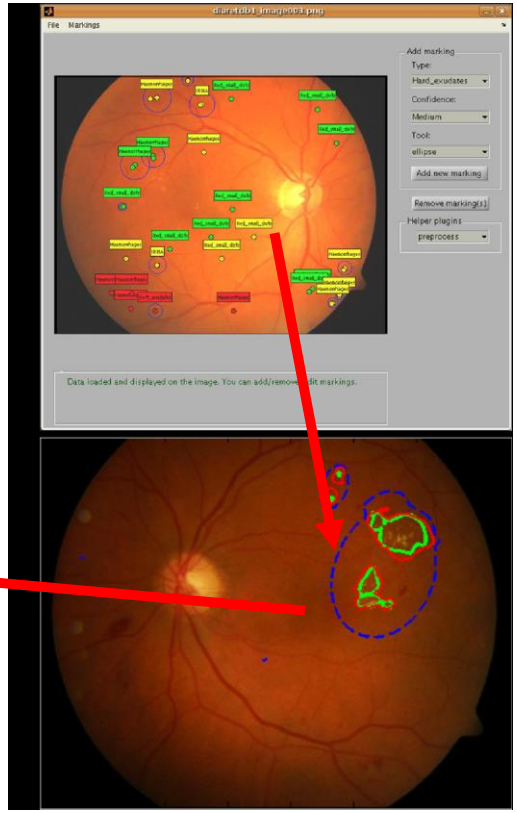
Fusion of Digital and Visual Print Quality

Q: Can Visual Quality Index (VQI) be estimated?

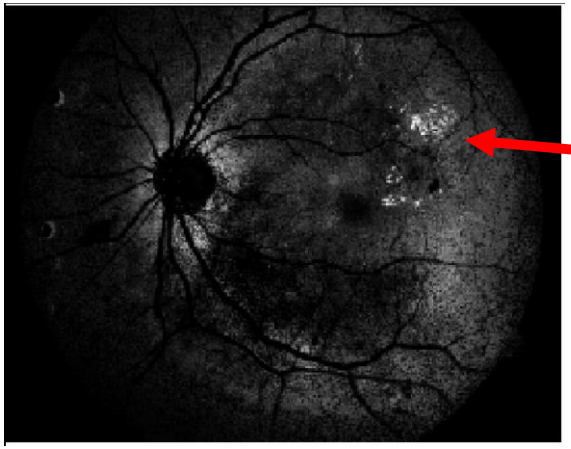
Medical Image Analysis

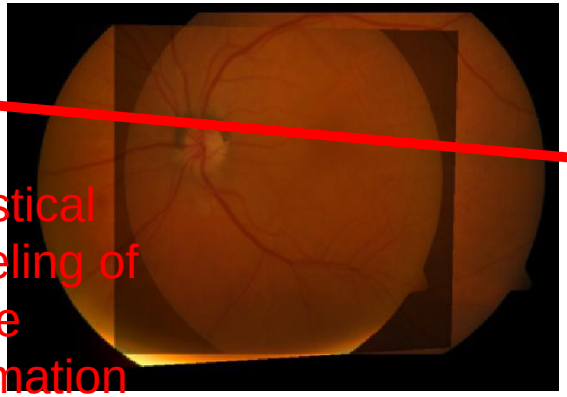
Imaging and pre-processing





Expert knowledge





Statistical modeling of image information

Environmental Monitoring Using Image Analysis

- Change Detection: changes in vegetation in Lake Saimaa (a sound at Soinilansalmi).
- LUT, Saimaa Water Protection Association, Kymijoki Protection Association, UPM-Kymmene, NORDI, European Union.

ENVISION – Cross-border environmental monitoring using image analysis.

http://www.it.lut.fi/project/envision/

Colour Science

Main objective:
How to enhance color discrimination?

Collaboration:
Color Research Group, University of Eastern Finland, Finland.
Toyohashi University of Technology, Japan.

Main results:
- Optimized optical filters designed through modeling.
- Application fields include make-up and medical imaging.