Biomedical Sensor Signal Processing

A view from Erlangen

Moscow 12/28/2009

Kurt Höller

Pattern Recognition Lab (Computer Science 5)

Friedrich-Alexander-University Erlangen-Nuremberg

Department of Computer Sciences

- 1966:
  Foundation of the CS Department
- 12 institutes
- 18 professors
- 3 major research directions:
  - Medical engineering
  - Simulation and modeling
  - Embedded systems

The Medical Imaging Chair

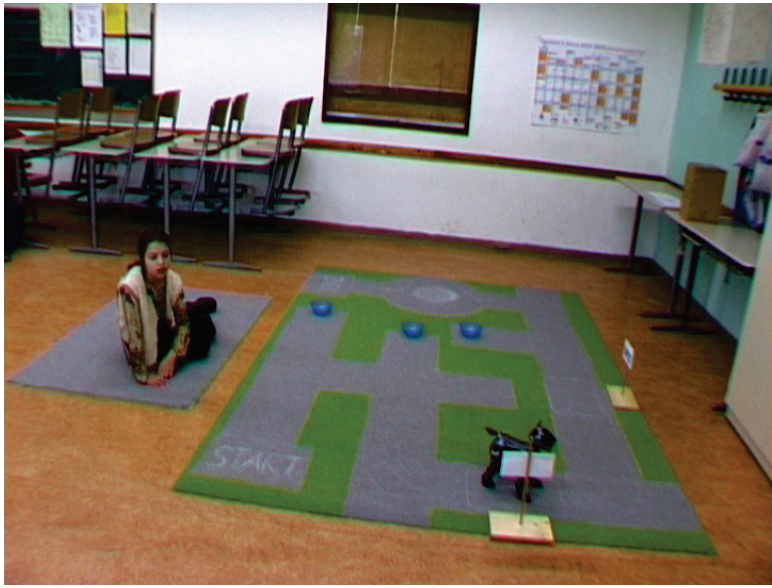
Pattern Recognition Lab

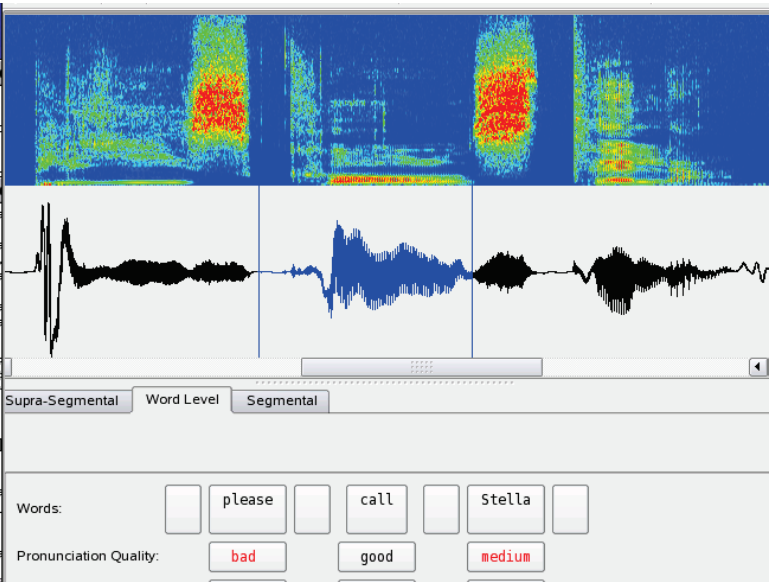
- Founded 1975 (Prof. Niemann)
- 2005: Headed by Prof. Hornegger
- 4 professors
  (full, associate, assistant, emeritus)
- 2 technicians
- 2 team assistants
- trainee
- 50 PhD students
- 7 external PhD students

Our Pattern Recognition Team

Four Research Teams:

Medical Image Processing



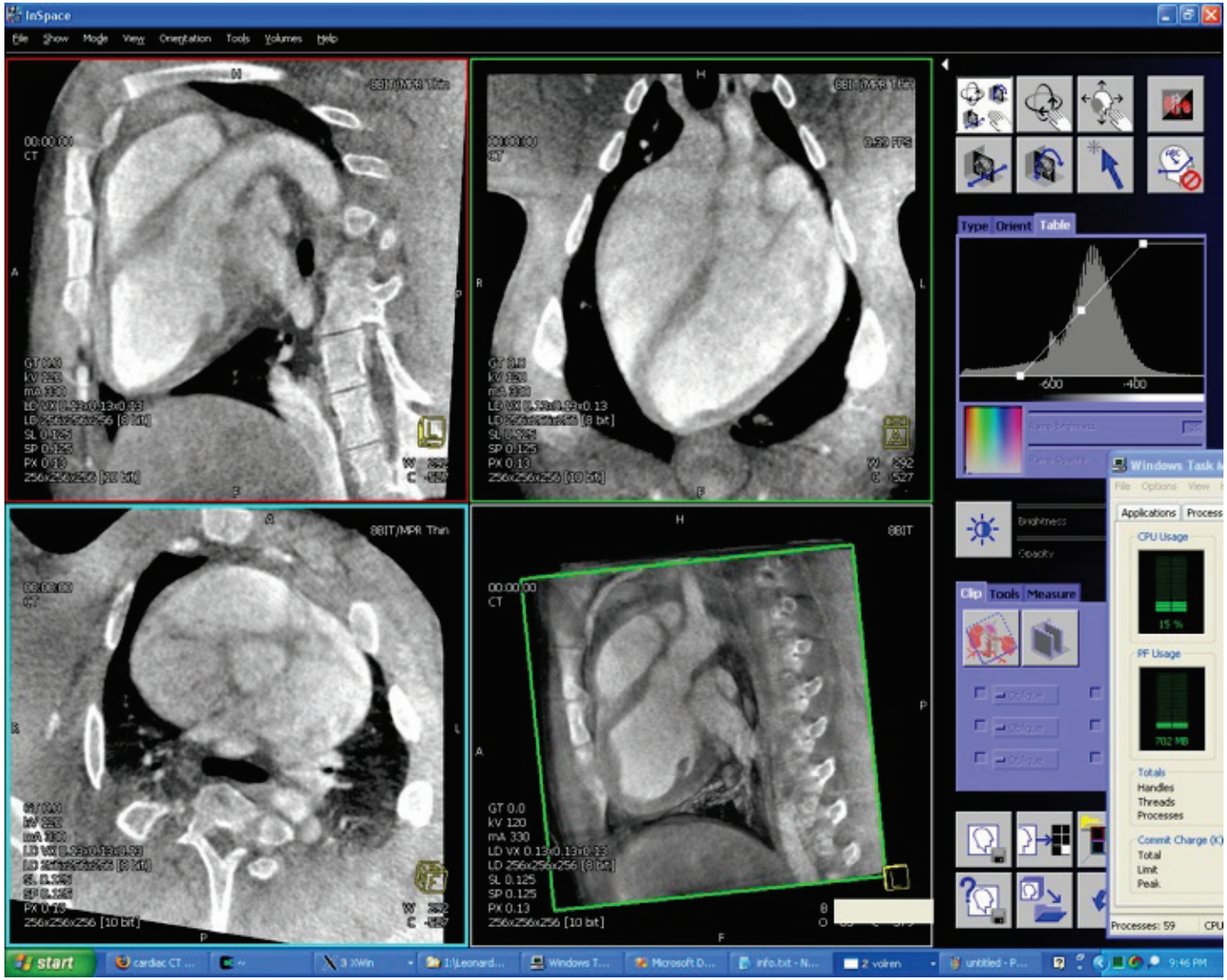


Computer Vision

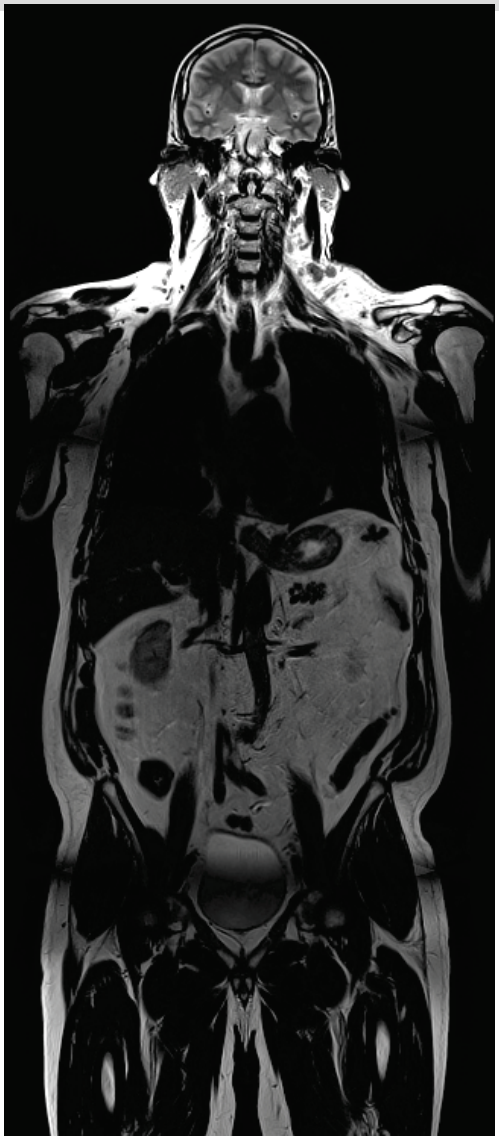
Speech Recognition

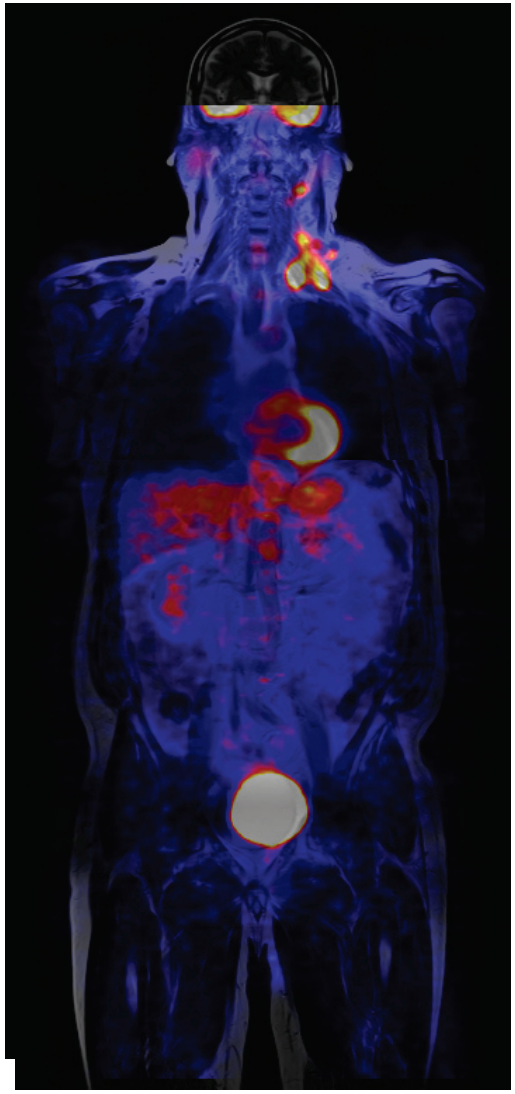
Digital Sports

Focus: Reconstruction



Focus: Image Registration

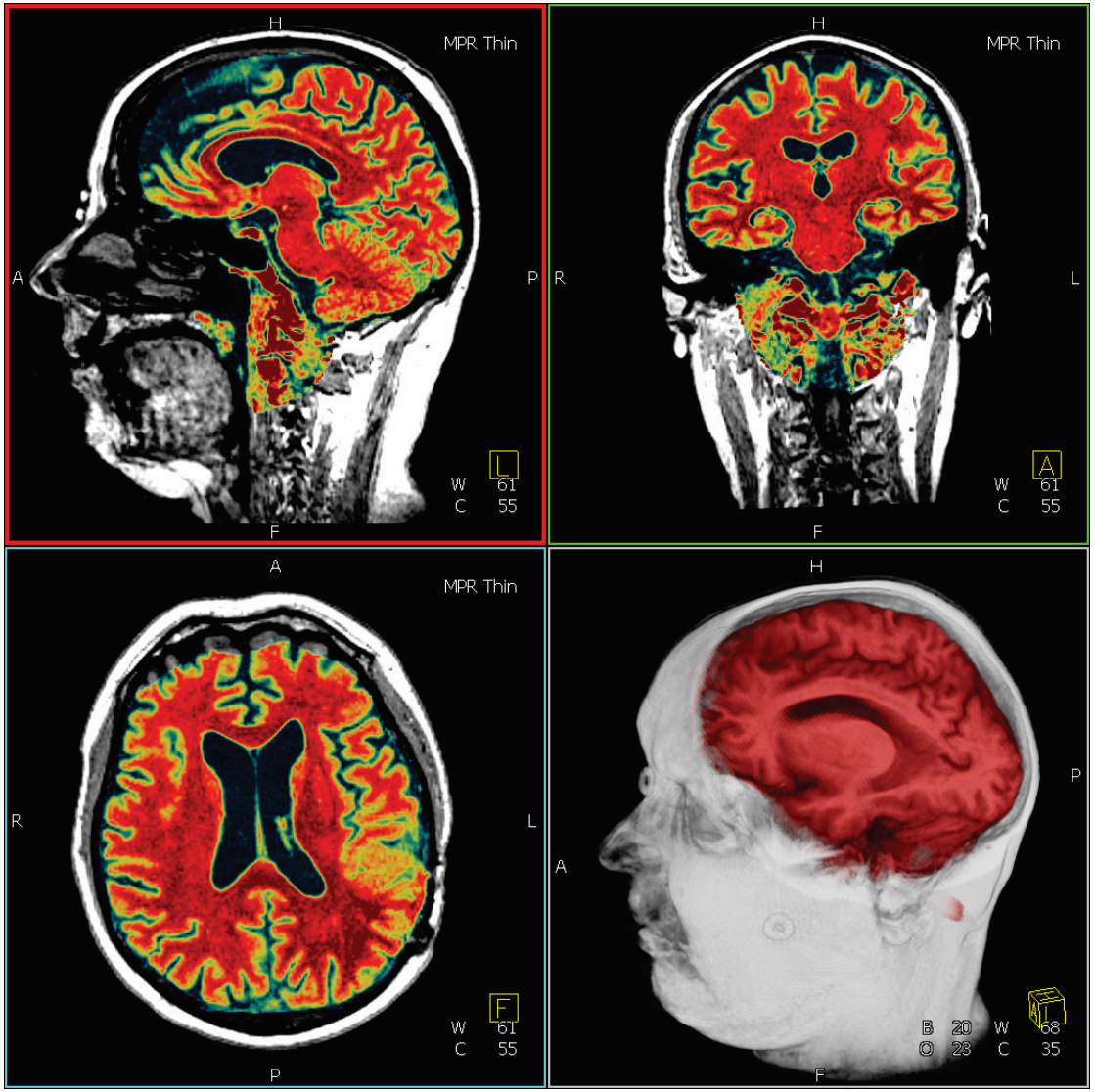




Today's Special Focus: Sensor Signals

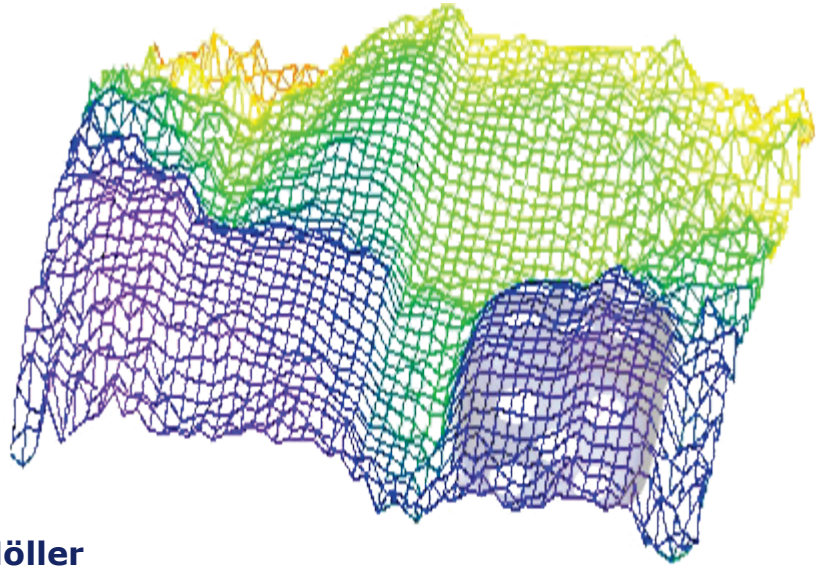
- Time-of-Flight Camera (Depth)
- Accelerometer (Gravity)
- Video
- Audio
- Electrocardiogram (ECG)
- Blood volume pulse
- Electromyogram
- Skin conductivity and skin temperature

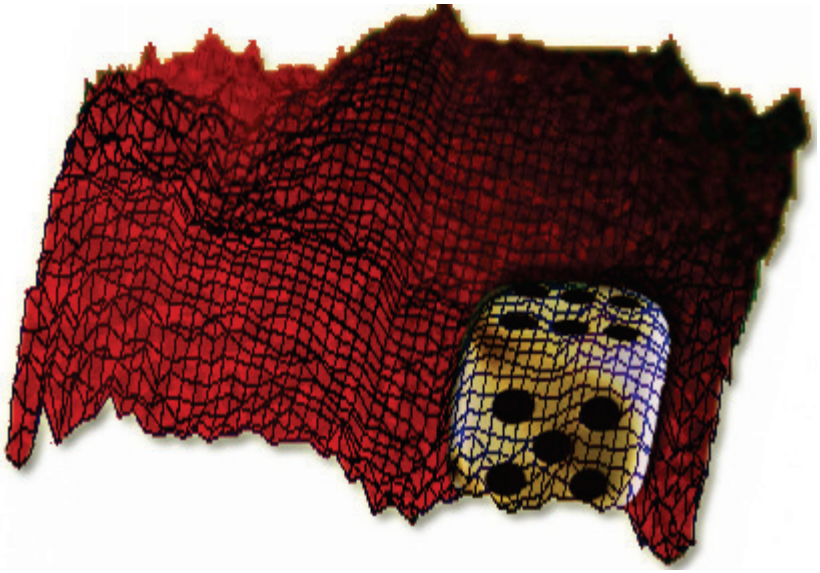
Group1: Medical Imaging



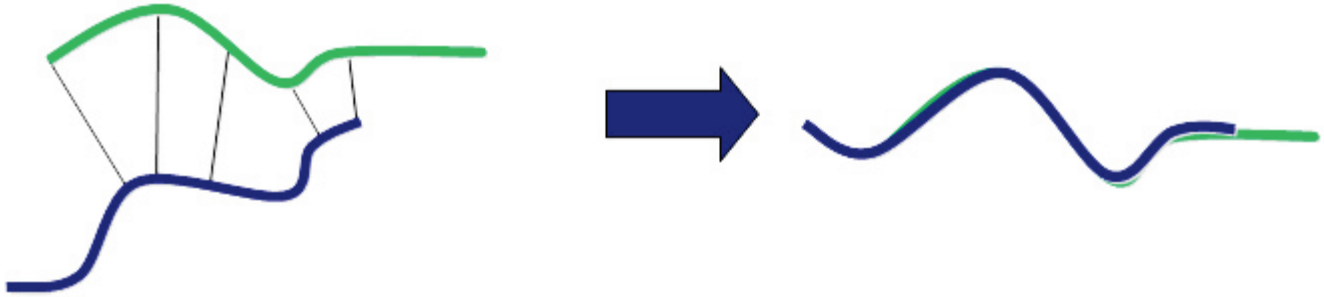
Time-of-Flight 3-D Camera

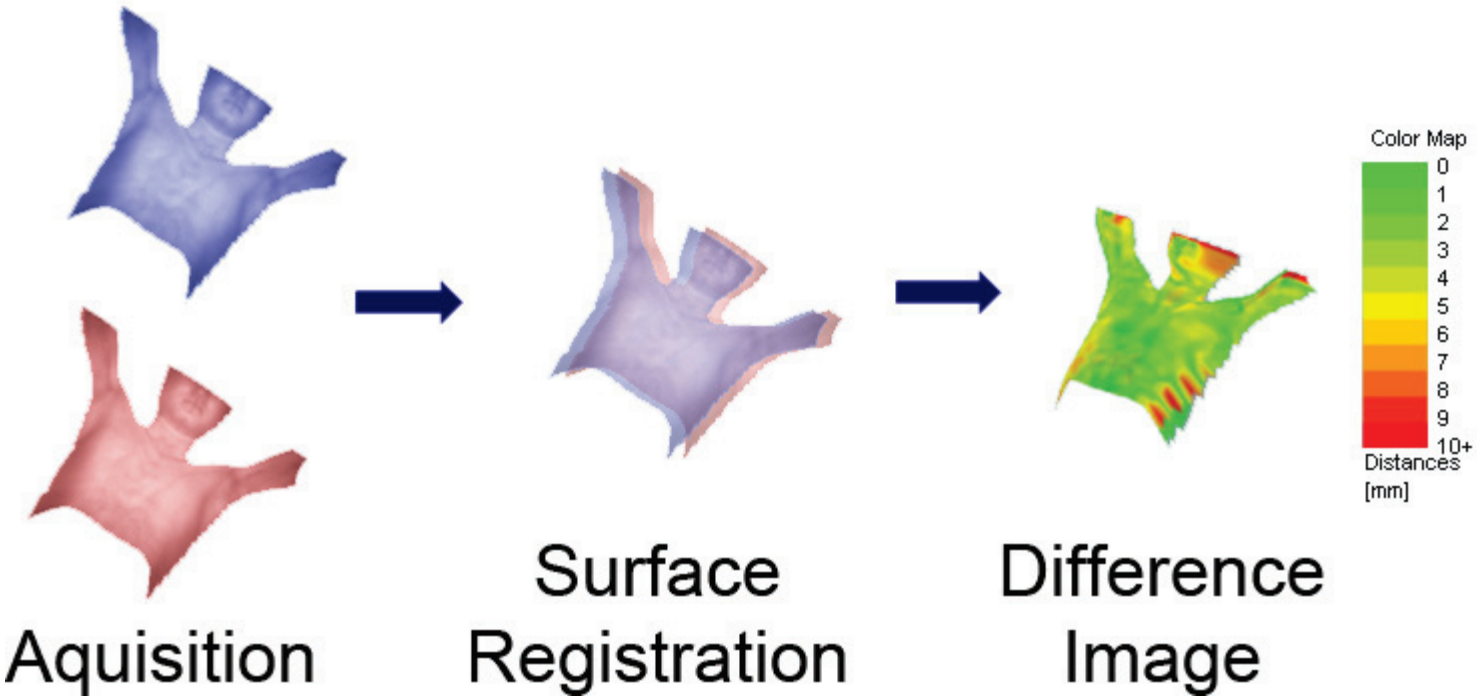
Fast	• up to 25 Hertz
Dense	• more than 40k 3D points
Safe	• eye-safe infrared light / no exposure



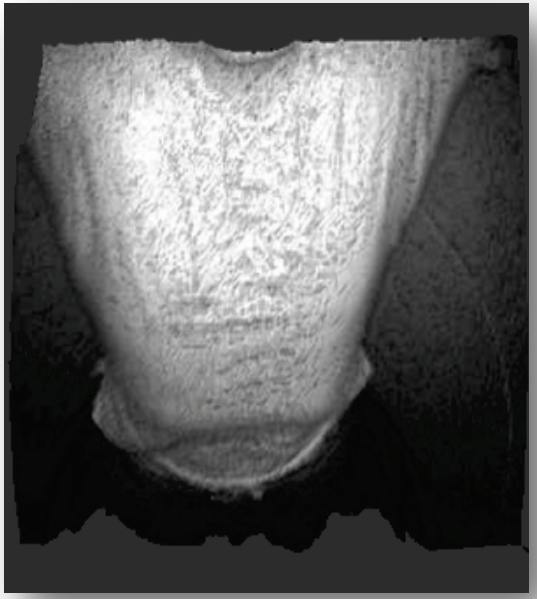


ToF Application: Patient Positioning

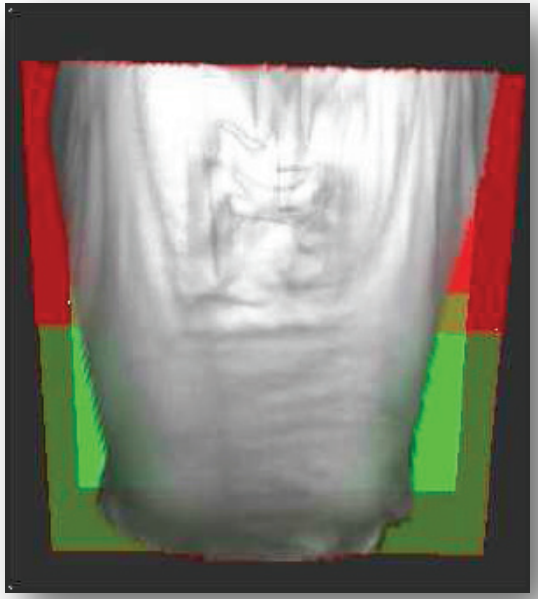




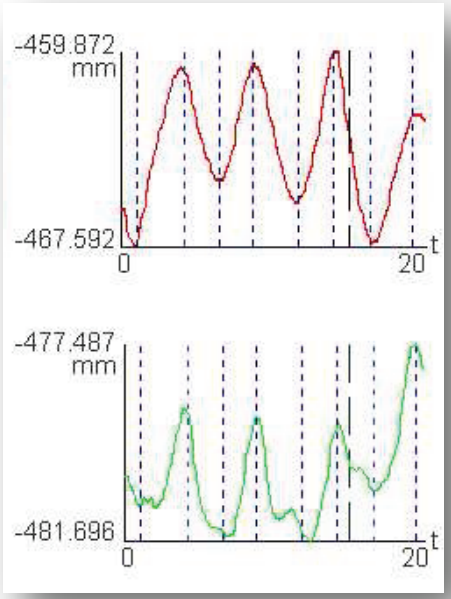
ToF Application: Respiratory Motion



Aquisition
(Thorax / Abdomen)



Preprocessing
(Thorax / Abdomen)



Realtime Signal
(Thorax / Abdomen)

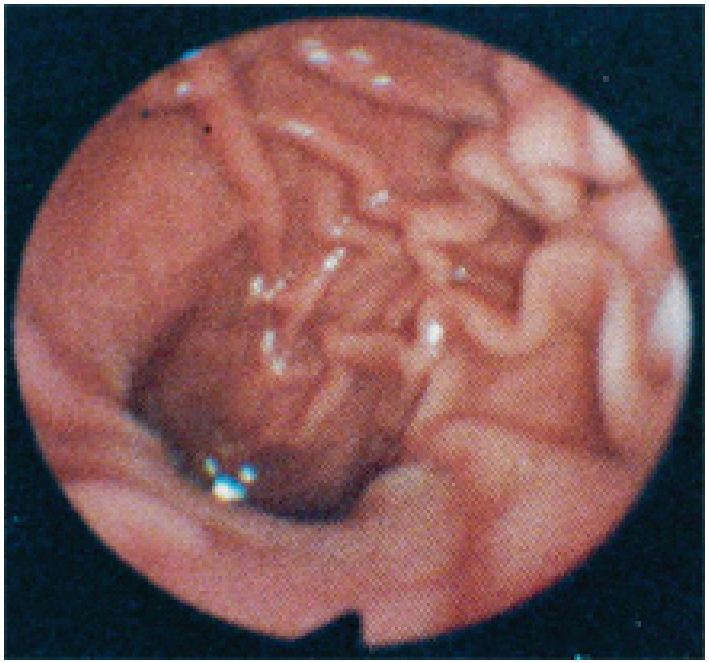
ToF Application: Respiratory Evaluation

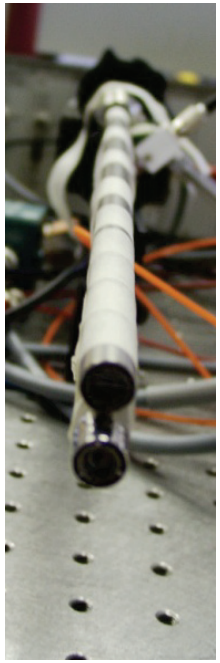
PET Scanner

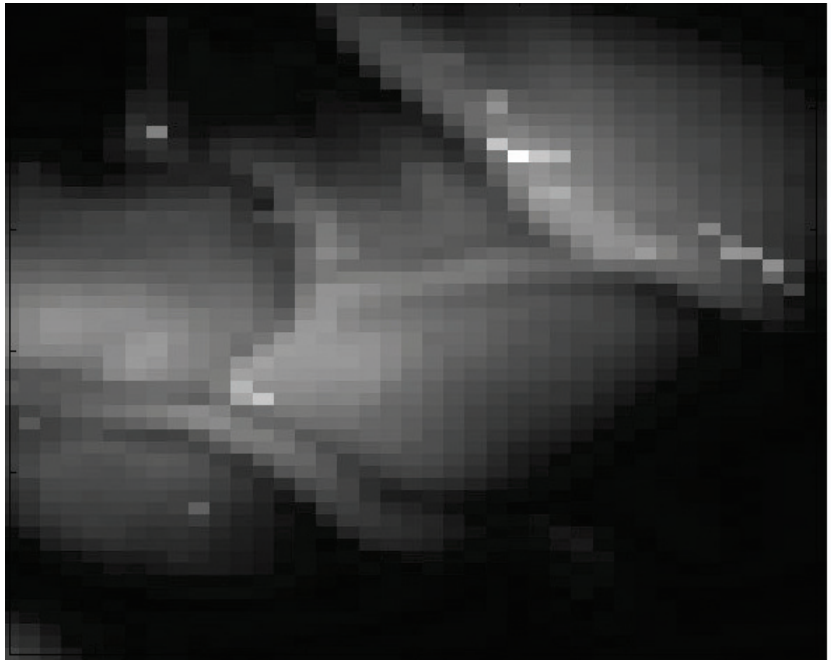
Lab Setup

ToF Application: In-vitro 3-D Endoscopy

Color vs. ToF data:



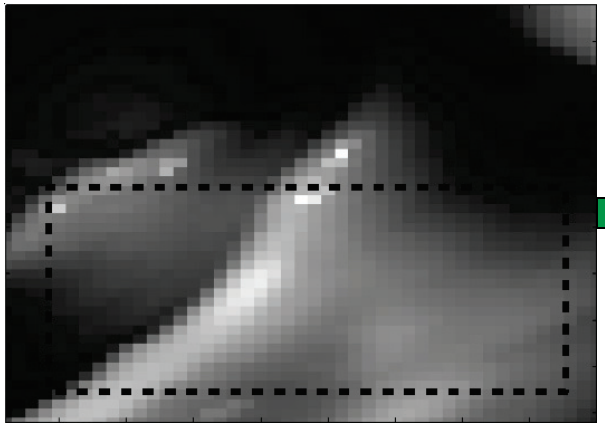




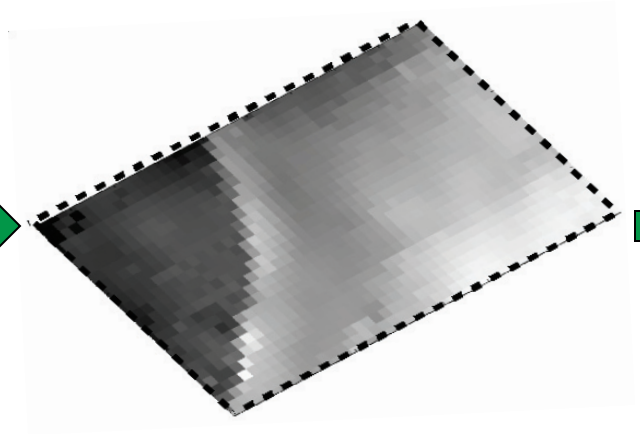
(color endoscopic data) (ToF endoscopic data)

ToF Application: In-vitro Endoscopy

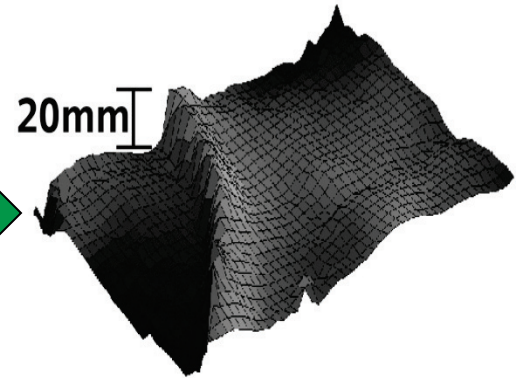
Data available from ToF endoscope:



(Amplitude data)

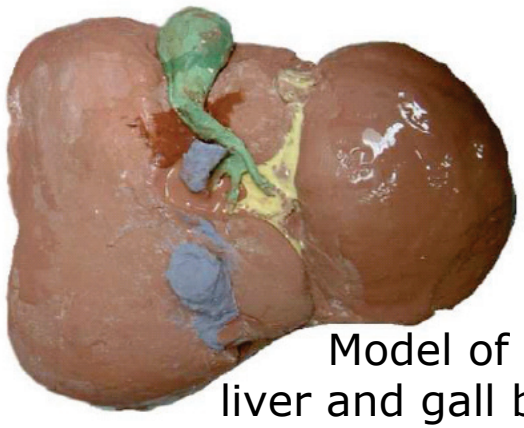


(Depth map of ROI)

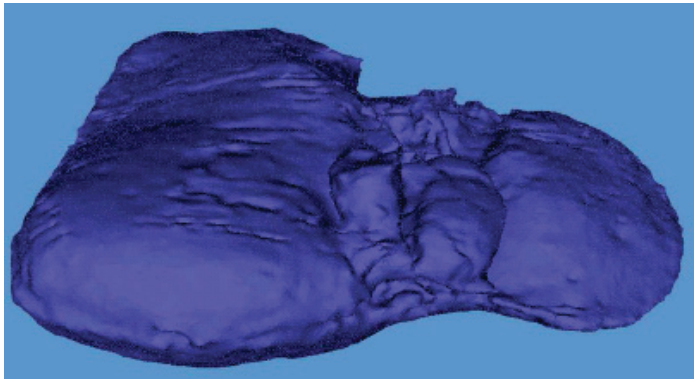


(3D view of ROI)

ToF Application: Color, Depth and CT Fusion

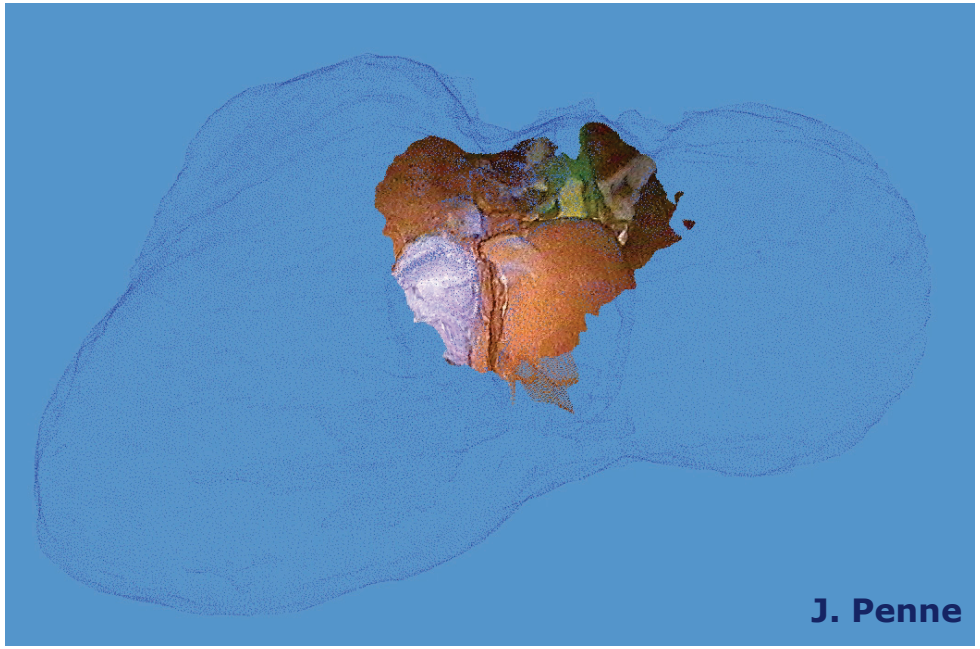


Model of human liver and gall bladder



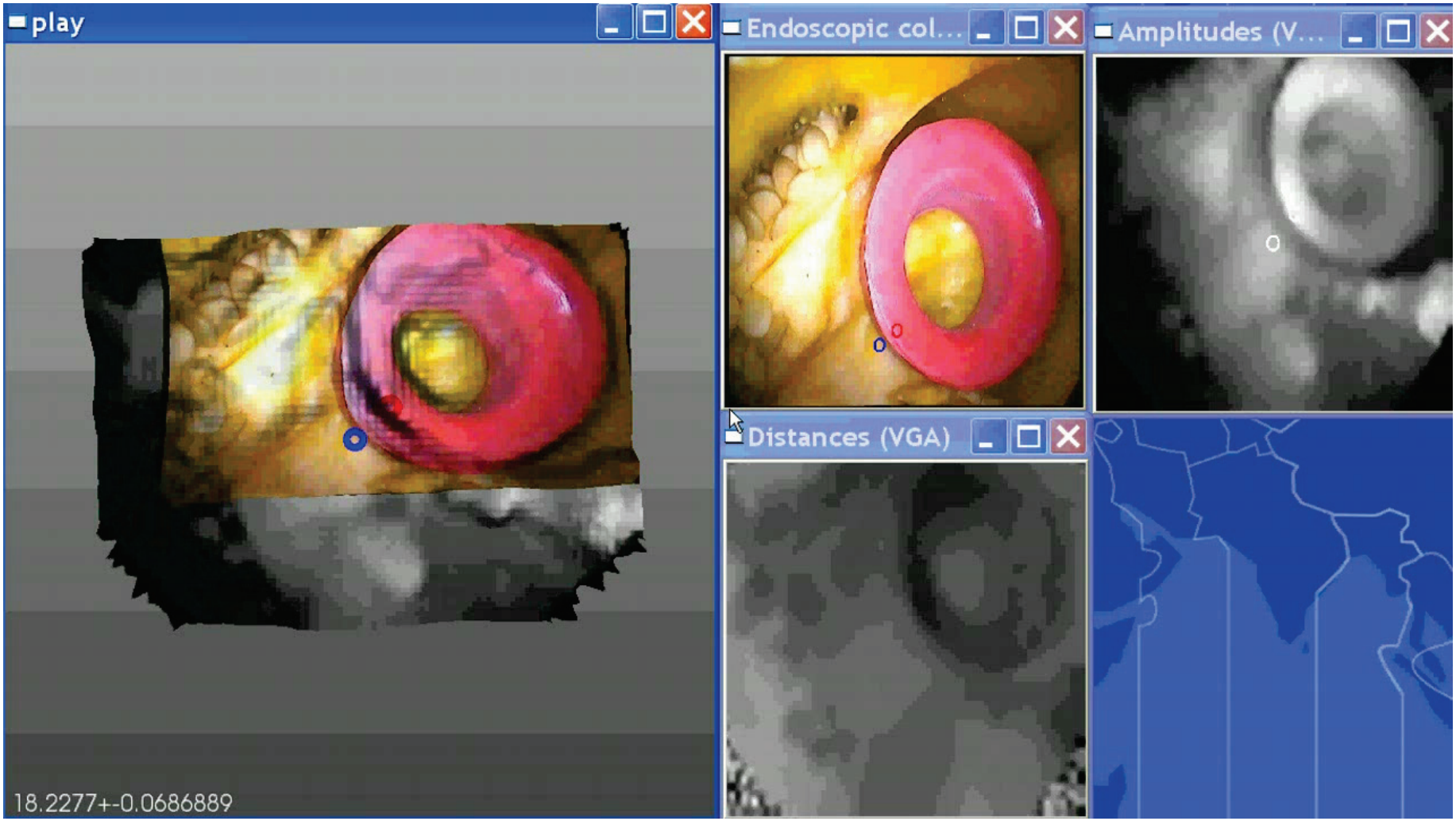
3D surface data extracted from CT data

Fusion of ToF and color and CT data using ICP on CT and ToF 3D point cloud (average registration error: 1.68mm)



J. Penne

Quantitative Endoscopy II

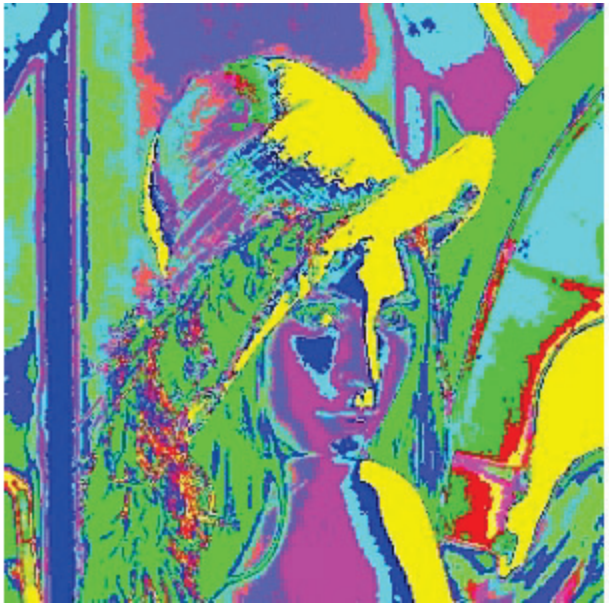


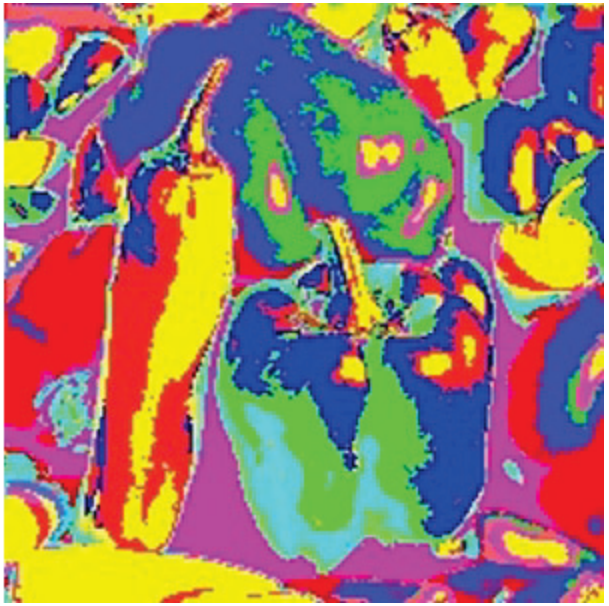
Endoscopic Image Rectification by Gravity

Original

Rectified

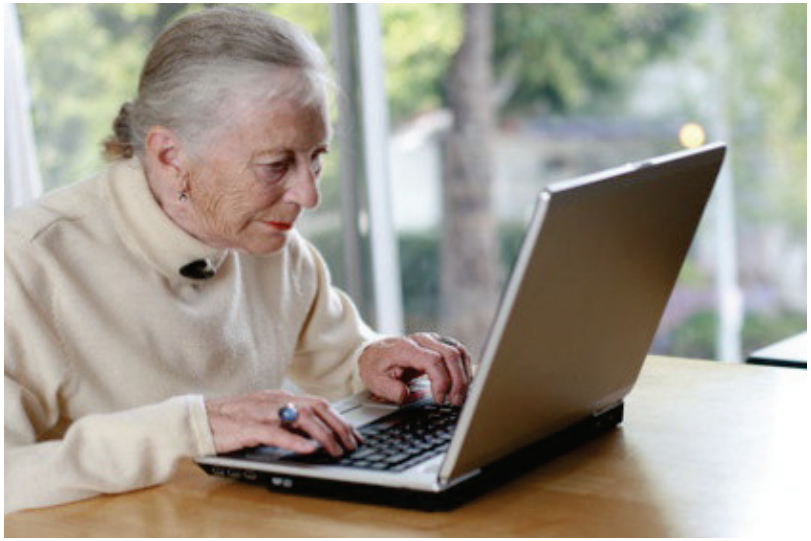
Group 2: Computer Vision





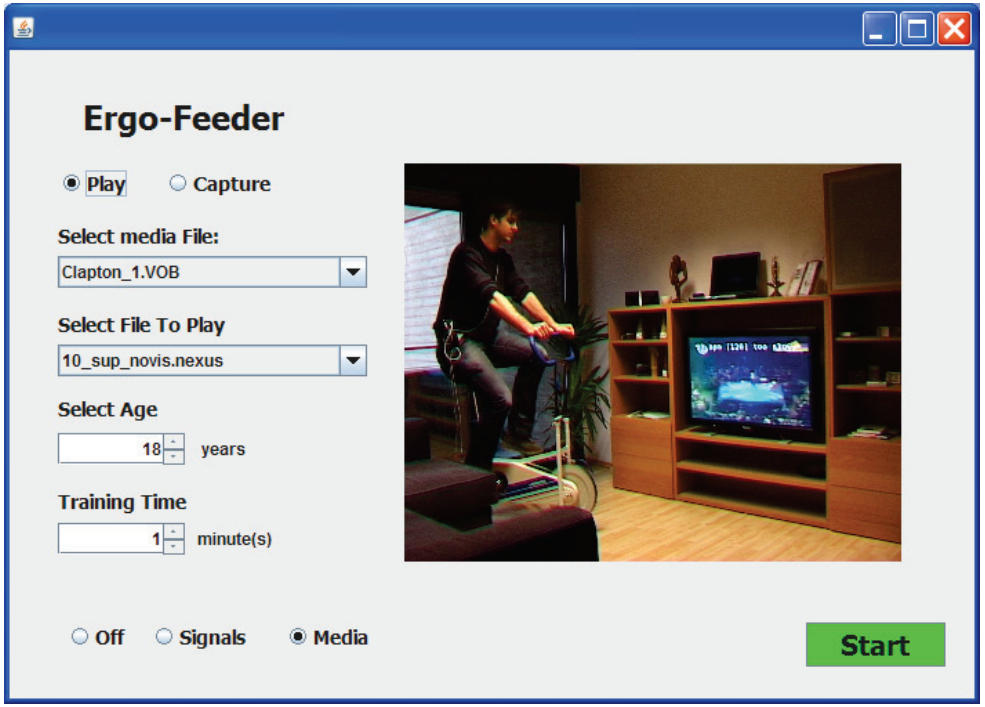
Audio-Visual Feedback System

- Intelligent home environments increase independence and comfort
- Elderly people are able to live self-determined for a longer time
- But: High standard of assistance and comfort often comes with physical laziness
- Motivate the elderly to move and practice physical activities



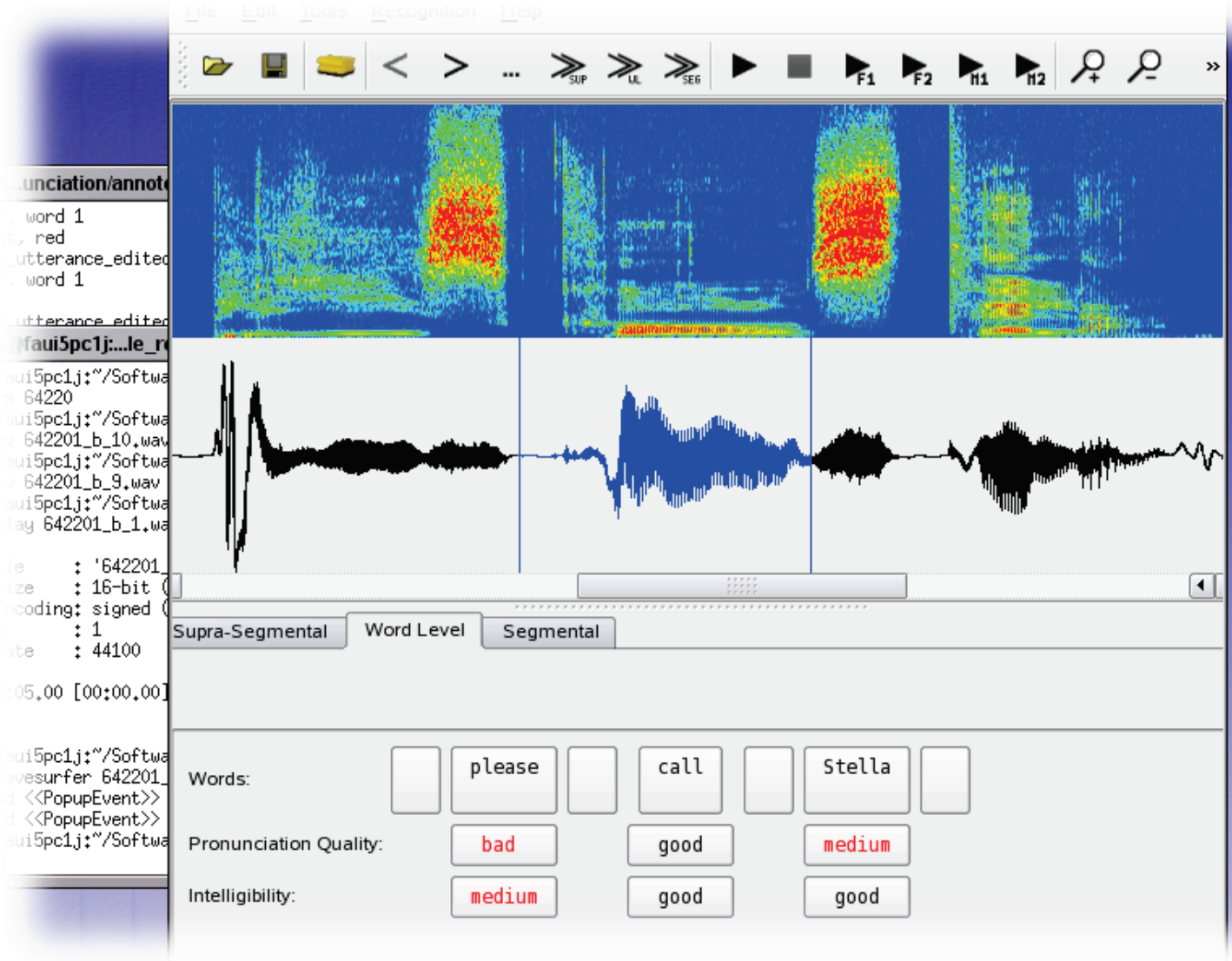
Ergo-Feeder: Results

- Currently 12 users
- Comparison of time within the optimal training range
- Survey: Ranking sessions concerning motivation



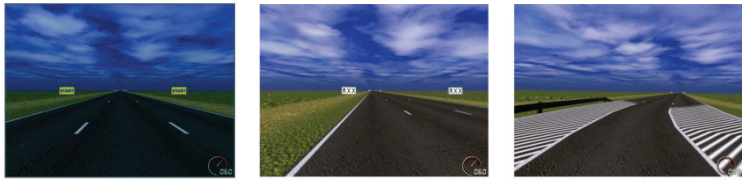
Session	Within optimal training range	Ranking
Without information	61,96 %	3
Only pulse	87,68 %	2
Pulse & visualization	88,28 %	1

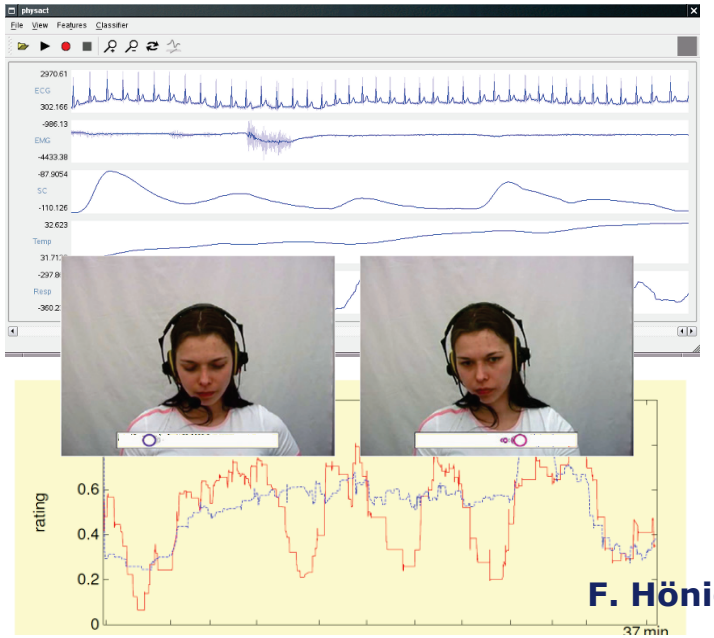
Group 3: Speech Processing



DRIVAWORK (Driving under varying workload)

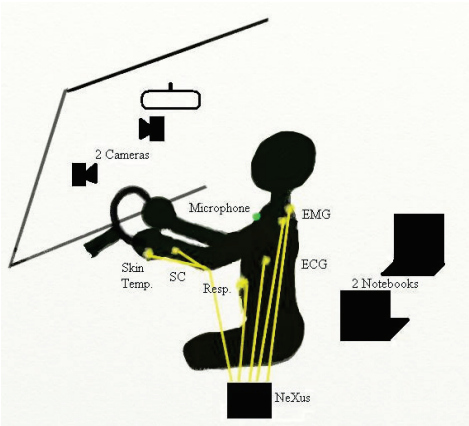
- Stress database of physio-logical signals, audio and video
- Simulated car scenario:
- Stress-Induction by structured design
- 24 subjects, recorded audio, video and 6 phys. signals: electrocardiogram, blood volume pulse, electromyo-gram, skin conductivity and skin temperature

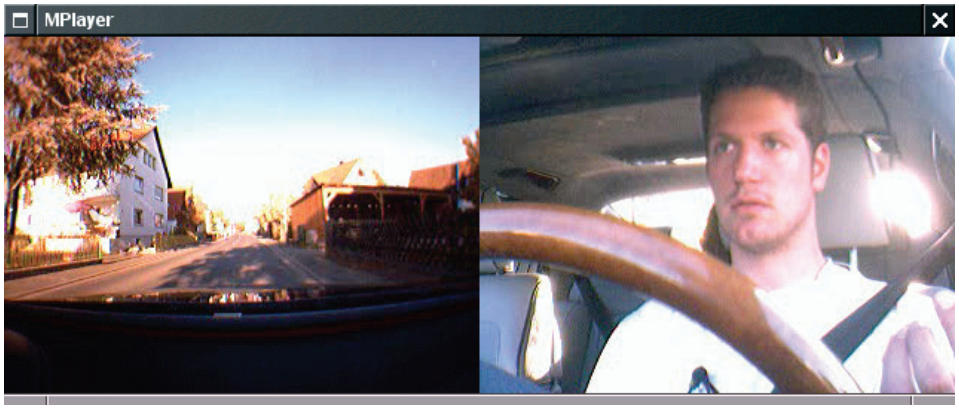


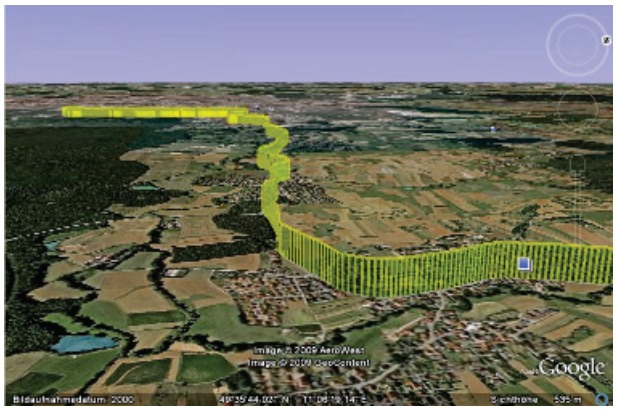


Driving School Corpus

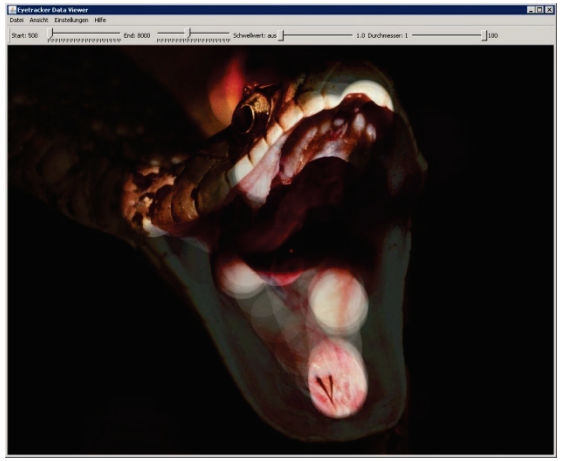
- Currently being collected: recordings during driving school lessons
- 5 phys. Signals, 2x Video, 2x Audio, GPS, Acceleration

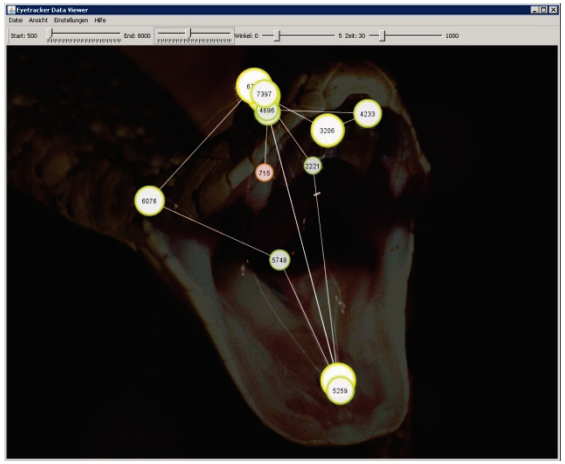


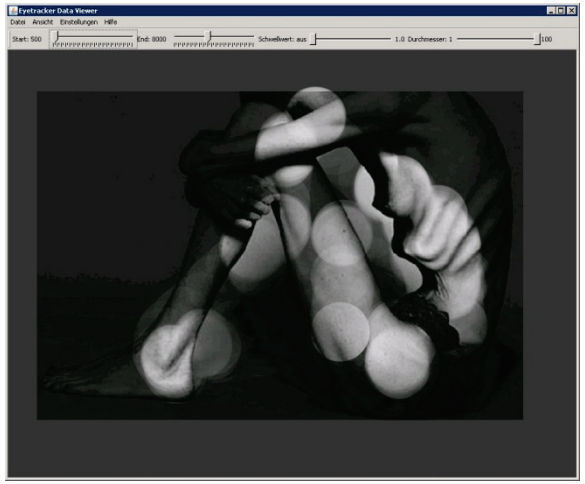


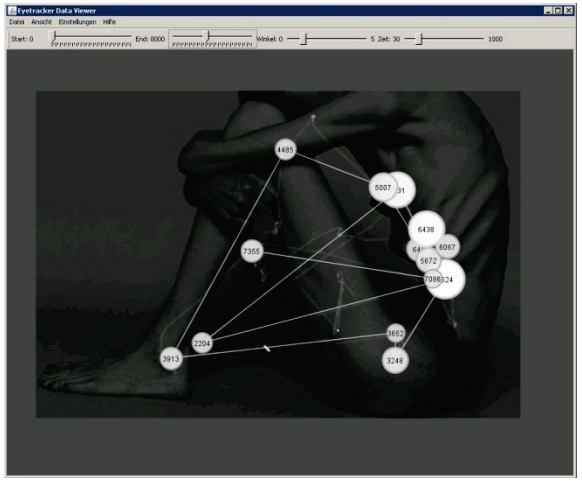


Eye Tracker Data: Attention maps, Fixations in 8s





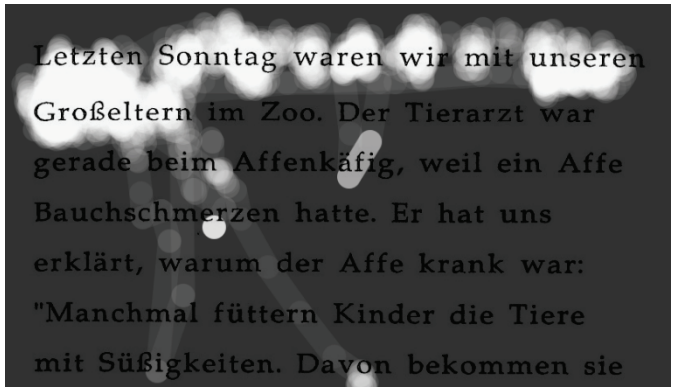




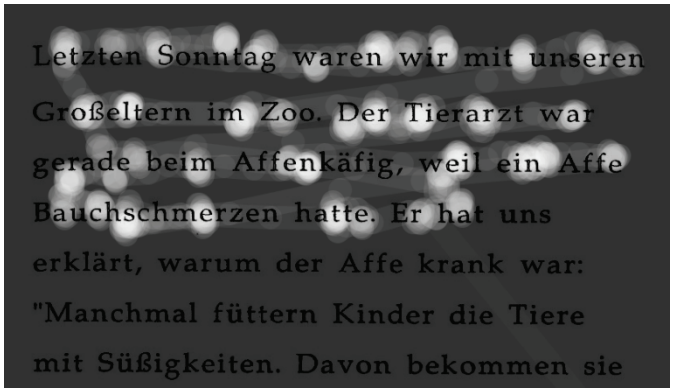
Reading Disorder Study

- With department of Child and Adolescent Mental Health:
- Conduct established reading tests for children
- Record audio, ECG, Skin conductivity and Eye tracking
- (extreme) examples for visual attention maps:

Bad reader (first 35 sec)



Good reader (first 10 sec)



Digital Sports

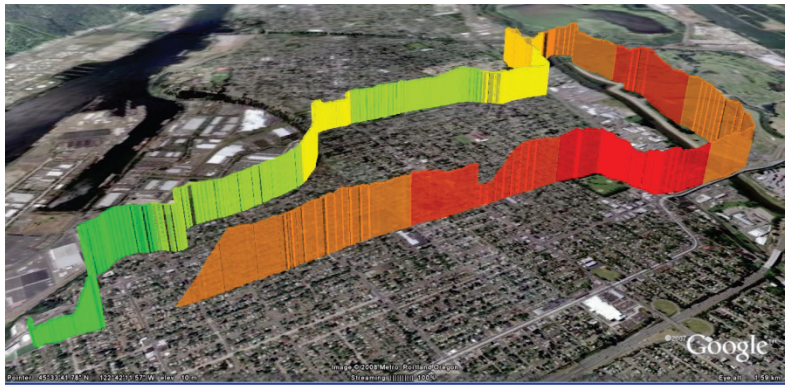
adidas_1

- adidas_1: worlds first intelligent shoe
- Three main parts
  - A cushioning element with a system for compression measurement
  - A microcontroller and user interface
  - A motor for cushioning adaptation
- Algorithm development
  - Speed detection
  - Surface classification
  - Inclination
  - Fatigue
- Classifier is in product

Embedded Data Acquisition

- Data acquisition system for outdoor running studies
- Cell phone software
  - Records GPS position, speed, altitude
  - Questions athlete's subjective state
  - 8 questions (energy, strength, …)

- Software development
- Feasibility study
- Psychological analysis
- Visualization of results



Summary

- 4 Groups: Medical Imaging, Computer Vision, Speech Processing , Digital Sports
- Bio-Sensors: Sensor Signal Processing in each Group
- Applications: Radiology and preoperative Imaging, Surgery, Elderly People, Car Safety, Psychotherapy, Runners' Training, etc…

The End

- Thank you for your kind attention!!
- Are questions left?
- Who wants to join us?