Computer Vision Research at Faculty of Electrical Engineering Osijek

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Contents of the Presentation

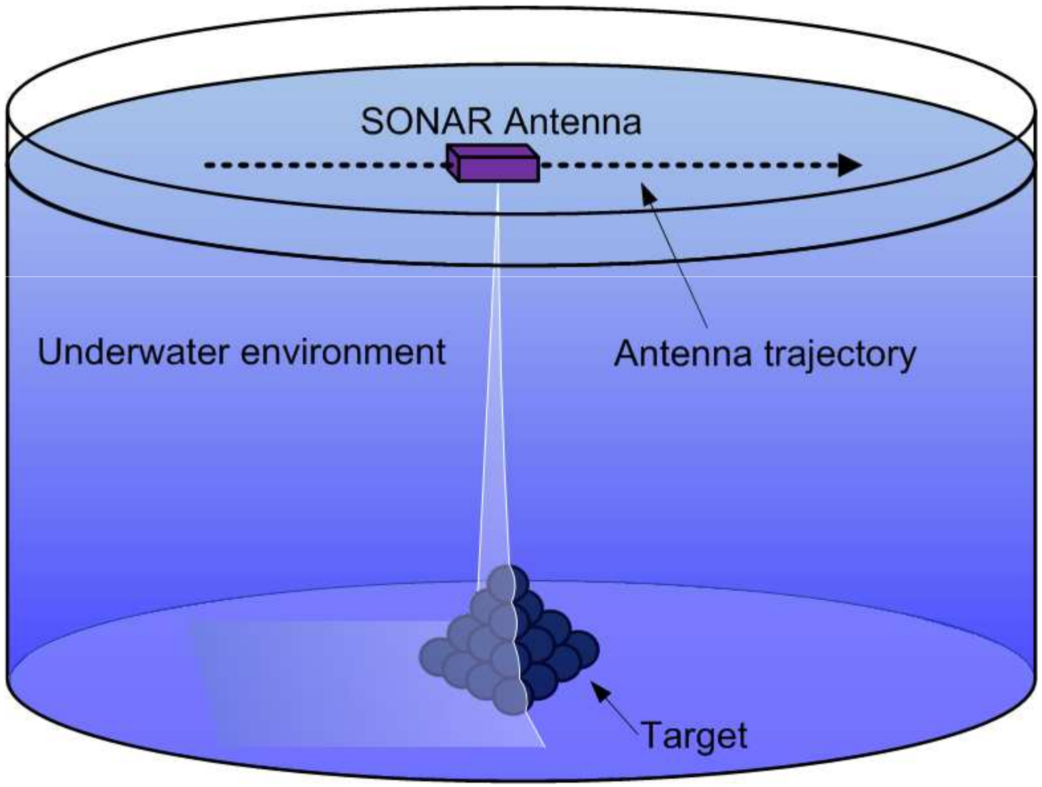
- Underwater surface reconstruction
- Visual quality control based on computer vision
- Robot localization based on planar surfaces detected by 3D camera
- 2.5D mesh segmentation to approximately convex surfaces
- PDE image compression
- Video quality evaluation

Ivan Aleksi, dipl.ing.
Prof. Dr.-Ing. Dieter Kraus
Prof. Dr. Sc. Željko Hocenski

Underwater Surface Reconstruction

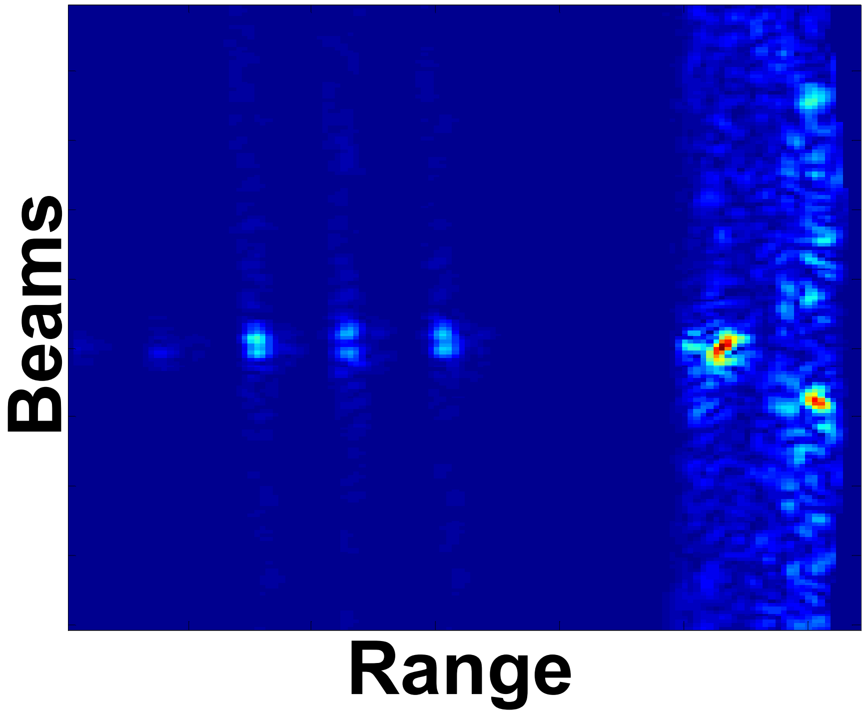
2D/3D Underwater Object Reconstruction

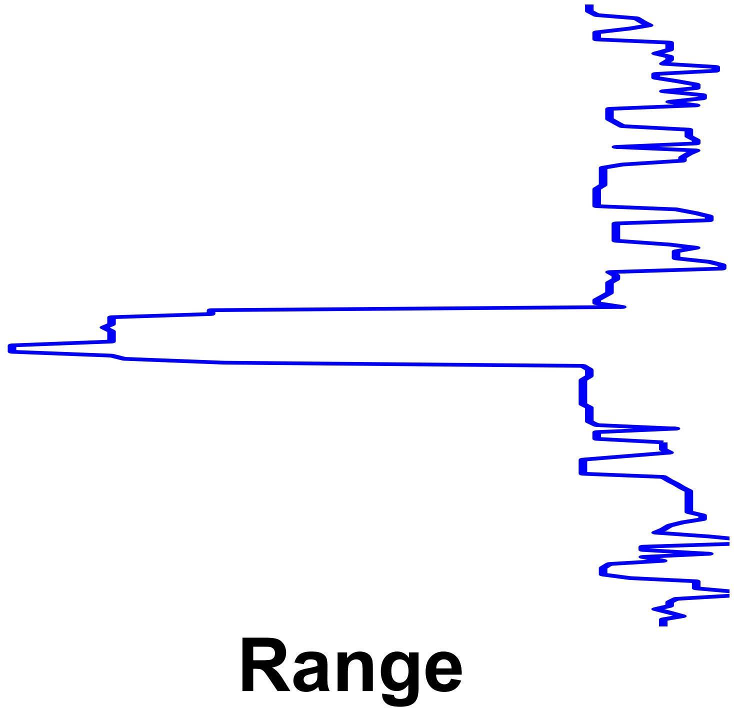
- Example of underwater inspection mission.



Range-finding in 1D beams

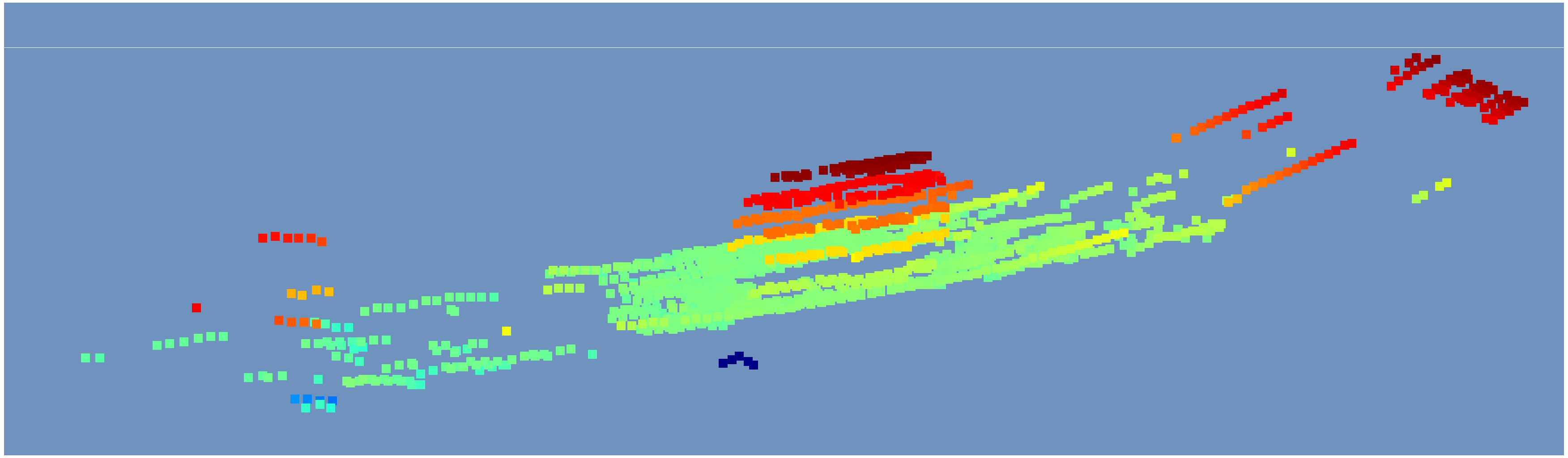
- Find appropriate time (range) sample in each 1D beam that corresponds to the first significant signal change denoting that an object is present.





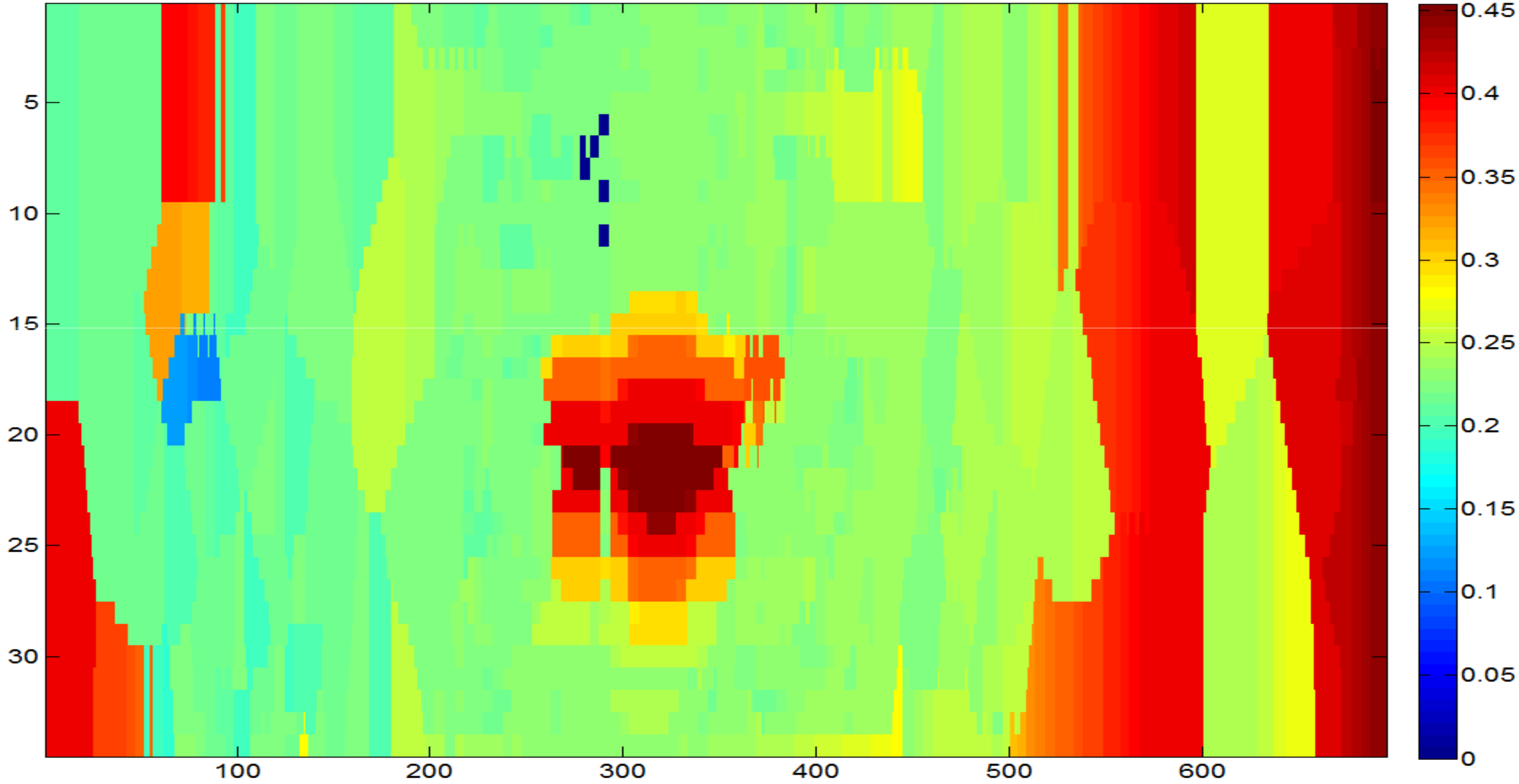
Reconstructed 3D Object Visualization

- 3D visualization with Point Cloud Library (PCL).
- On the dry end (monitor) user can view reco-nstructed 3D object as a 6D Point Cloud.
- Point Cloud = [3D location, color, range, intensity]



2D plane pointcloud projection (2D image)

- 2D image of reconstructed pointcloud.



HOCHSCHULE BREMEN - ERASMUS PROGRAMM Institut fur Wasserschall, Sonartechnik und Signaltheorie

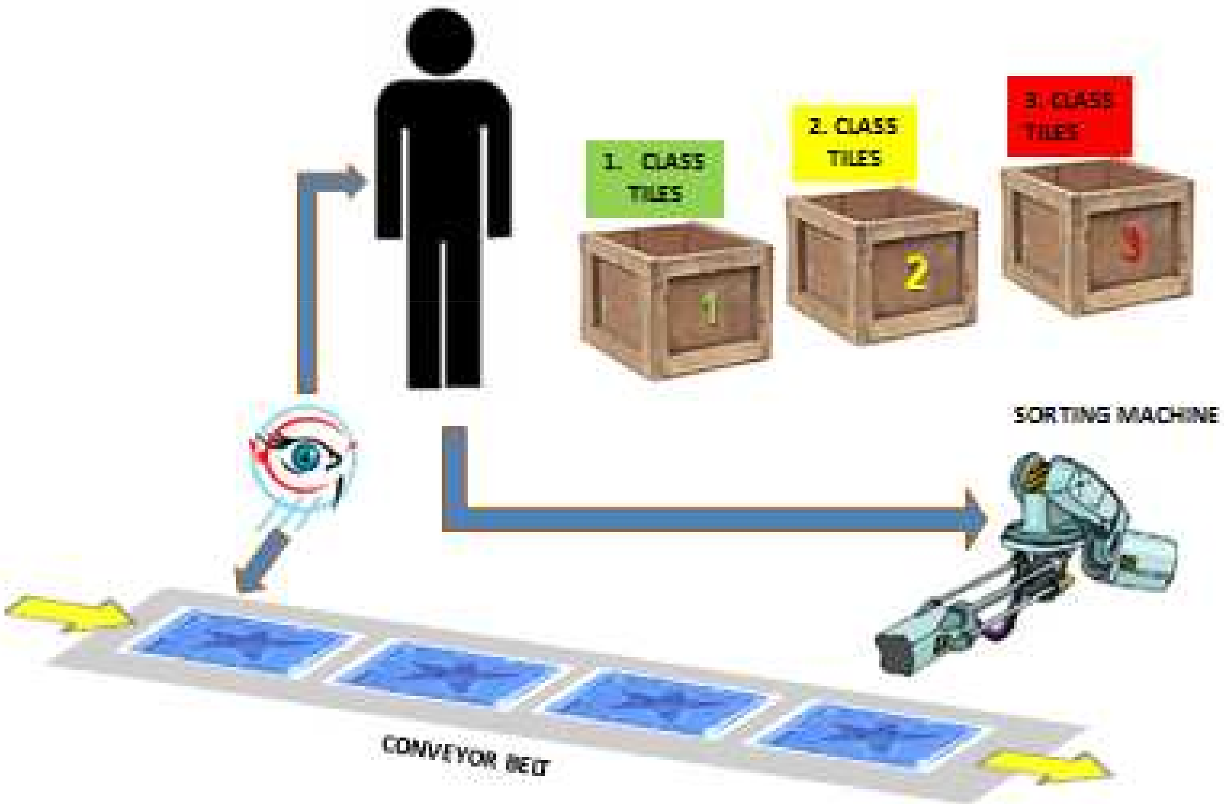
Department for Computer and Programming Engineering
prof.dr.sc. Željko Hocenski
doc.dr.sc. Tomislav Keser

Visual Quality Control Based on Computer Vision

Applied on

Ceramic Tiles Visual Quality Inspection and Classification

VISUAL INSPECTION

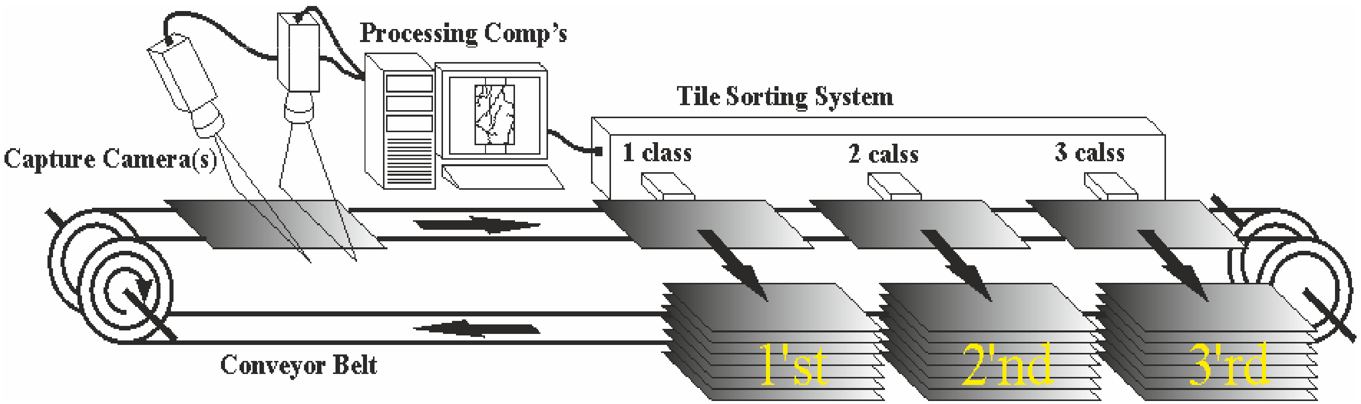


Concept and Goals…

- Replace man as visual controller with an automated system.
- Improve visual perception rate and rise detection accuracy.
- Rise system durability and availability.
- Lower production costs;
  - Lower ratio of falsely detected defects.
  - Rise classification accuracy.

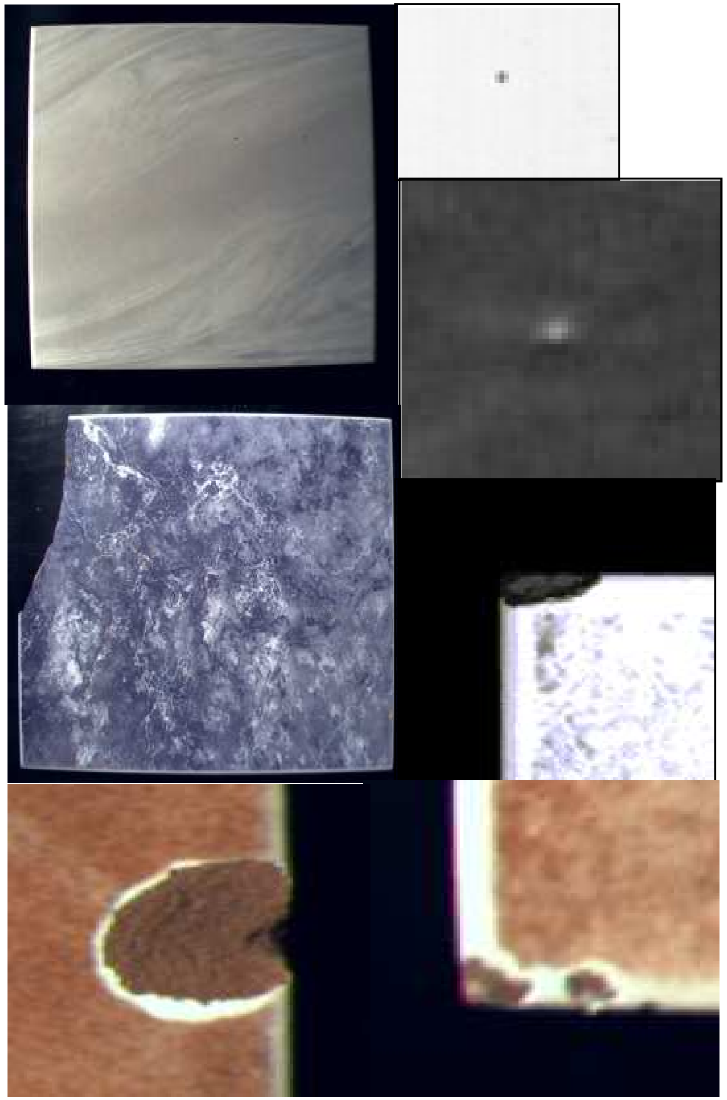
System structure and relations

- Structure section are
  - Object image capturing – utilize digital line scan camera or cameras
  - Image data crunching – utilize appropriate set of algorithms for tile fault detection, localization and quantization.



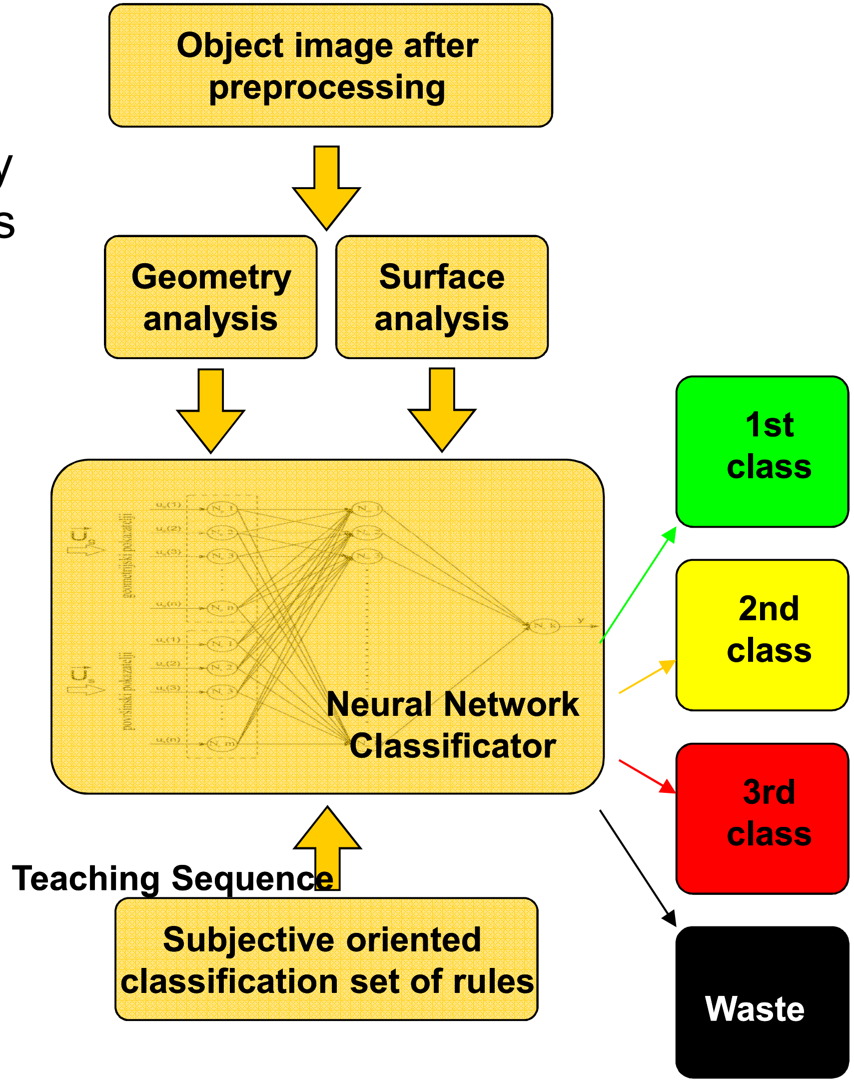
Types of Defects… what to search for?

- There are two types of defects:
  - **Geometry related defects** – type of defects tightly related to geometry properties of tile, such: width, heigth, edge linearity, surface planarity and warping ratio
  - **Surface related defects** –
    - *Morphological defects* – planar type of defects, such: spotted dots, blobs, textural inconsistence, tonality, other morph featured defects.
    - *Geometrical surface defects* - defects that are significantly noticeable and have measurable 3D components, such: spotted dots, lumps, bumps, 3D texture morph defects.

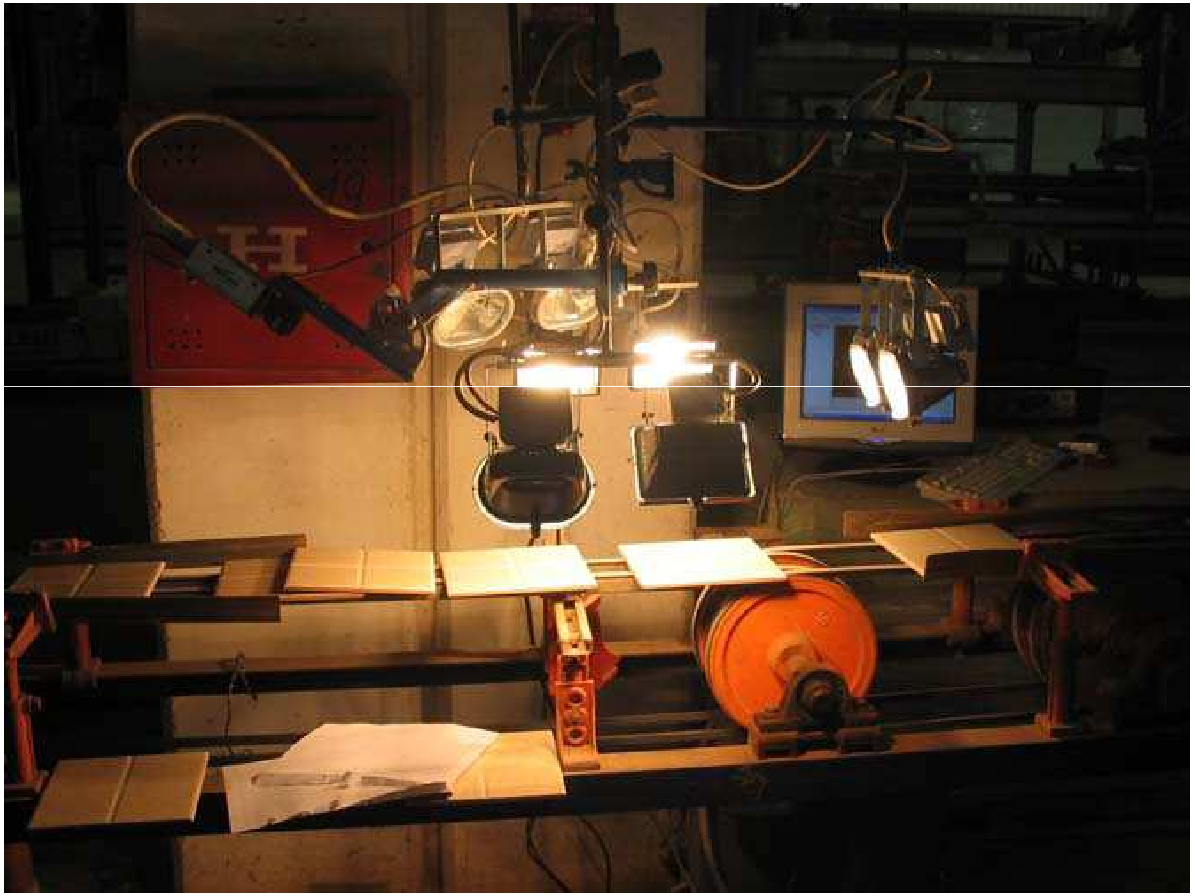


Quality Estimation…rules, is there any?

- Quality estimation bases on:
  - Presence and amount of geometry related and surface related defects
  - ***Subjective opinion of visual analyzer***
- After all… **Classification rules are very stretchable!**
- Solution -> Neural Network Classificator.



Industrial plant prototype



Robot Localization Based on Planar Surfaces Detected by 3D Camera

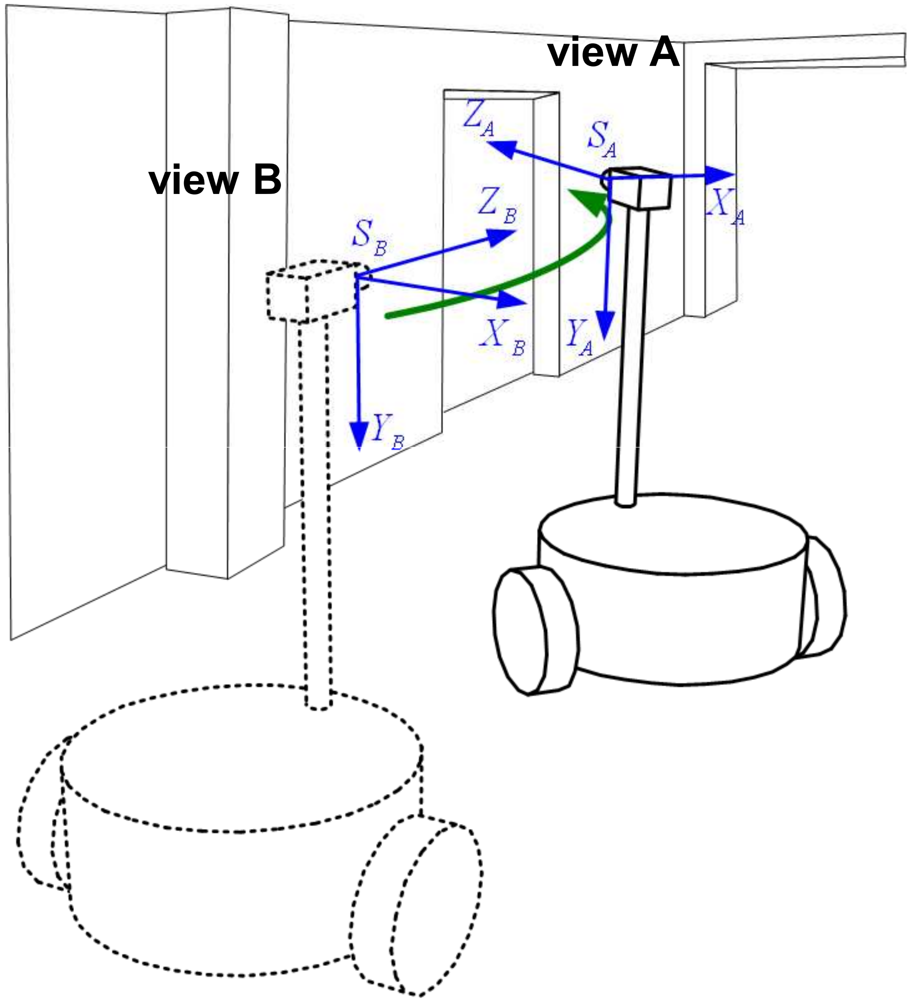
Robert Cupec,

Emmanuel Karlo Nyarko,

Damir Filko

Ivan Petrović (FER, Zagreb)

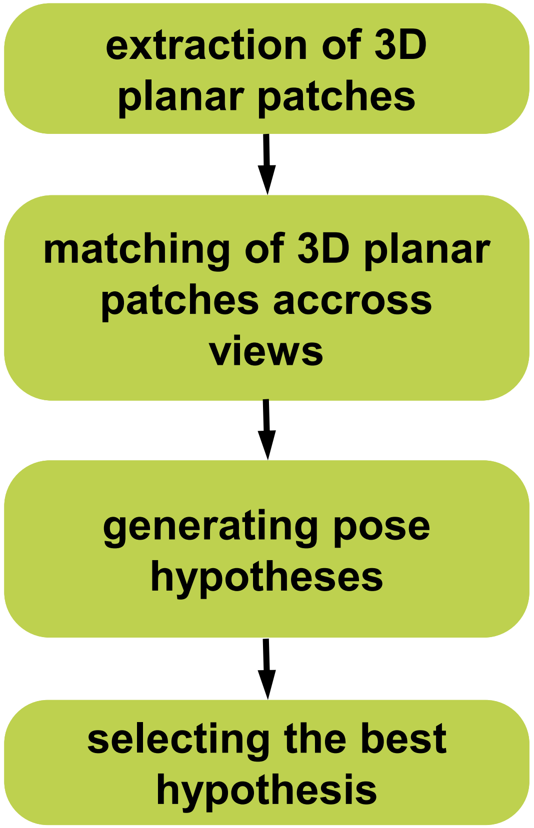
Fast Pose Tracking Based on Ranked 3D Planar Patch Correspondences,
10th IFAC Symposium on Robot Control (SYROCO), Dubrovnik, Croatia, 2012



Task

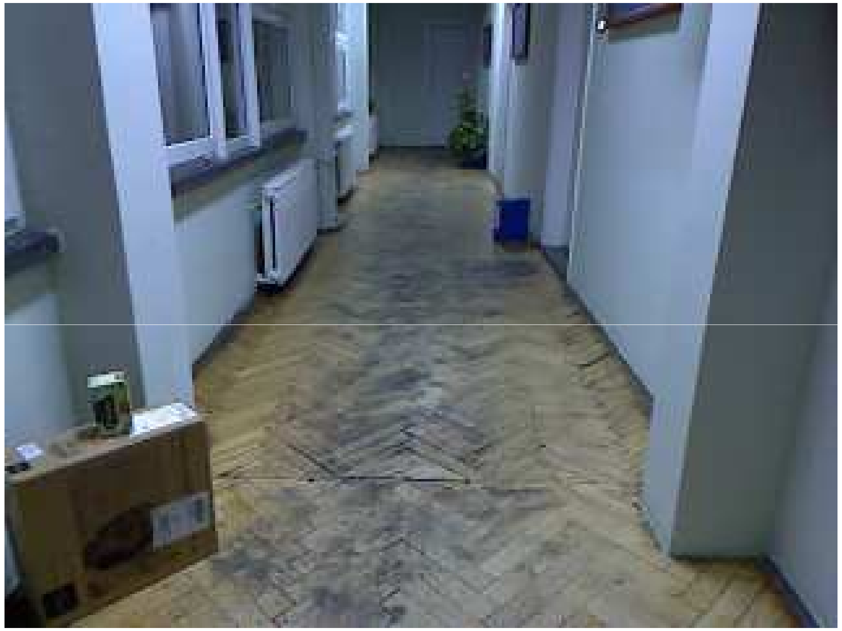
- given sensor data acquired by a 3D camera from 2 different views, determine the relative pose of these two views

Concept

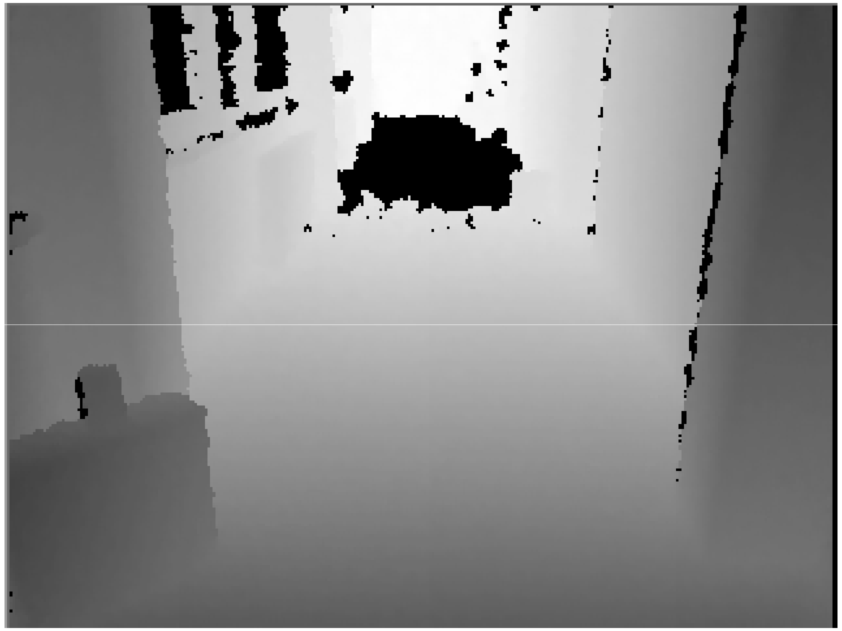

extraction of 3D planar patches
matching of 3D planar patches accross views
generating pose hypotheses
selecting the best hypothesis

Extraction of Planar Patches from 3D Point Cloud

- Microsoft Kinect 3D camera → 3D point cloud



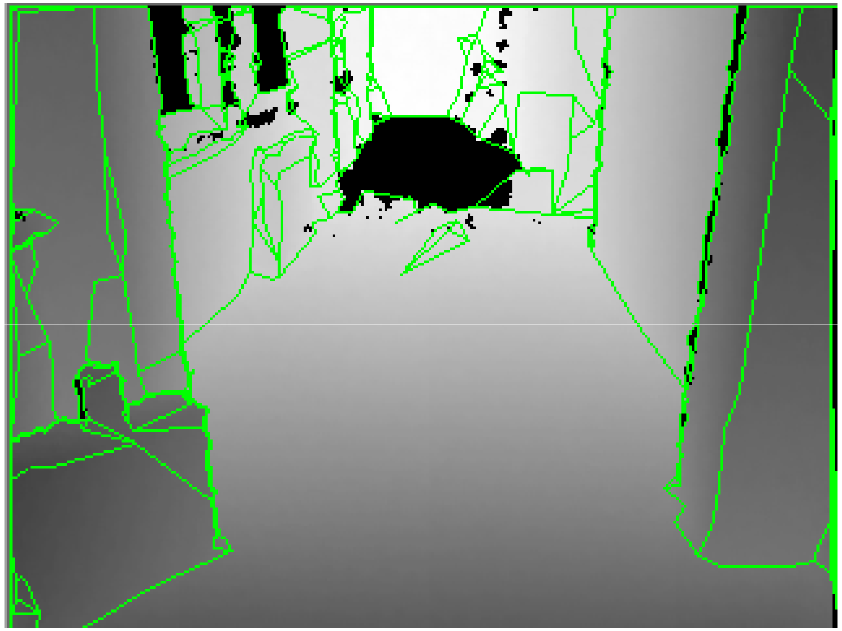
RGB image



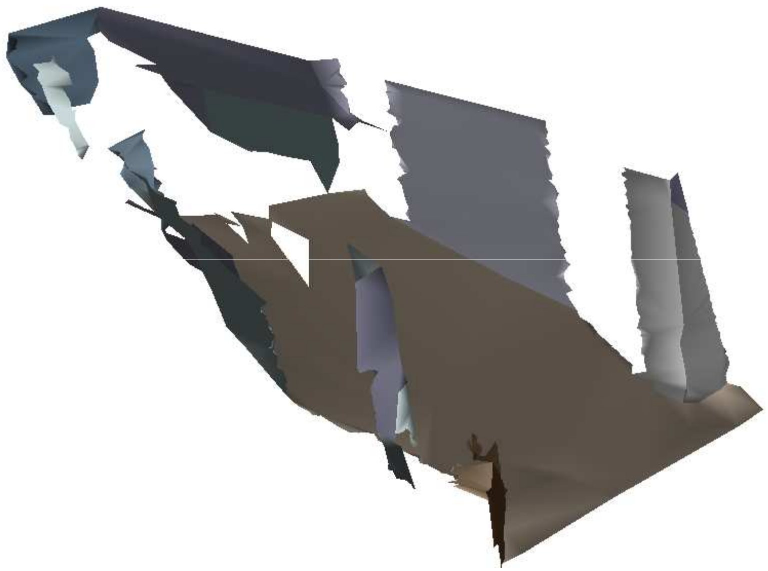
depth image

Extraction of Planar Patches from 3D Point Cloud

- iterative Delaunay triangulation + merging of triangles [Schmitt, Chen (1991)] → set of 3D planar surface patches



segmented depth image



3D model consisting of planar patches

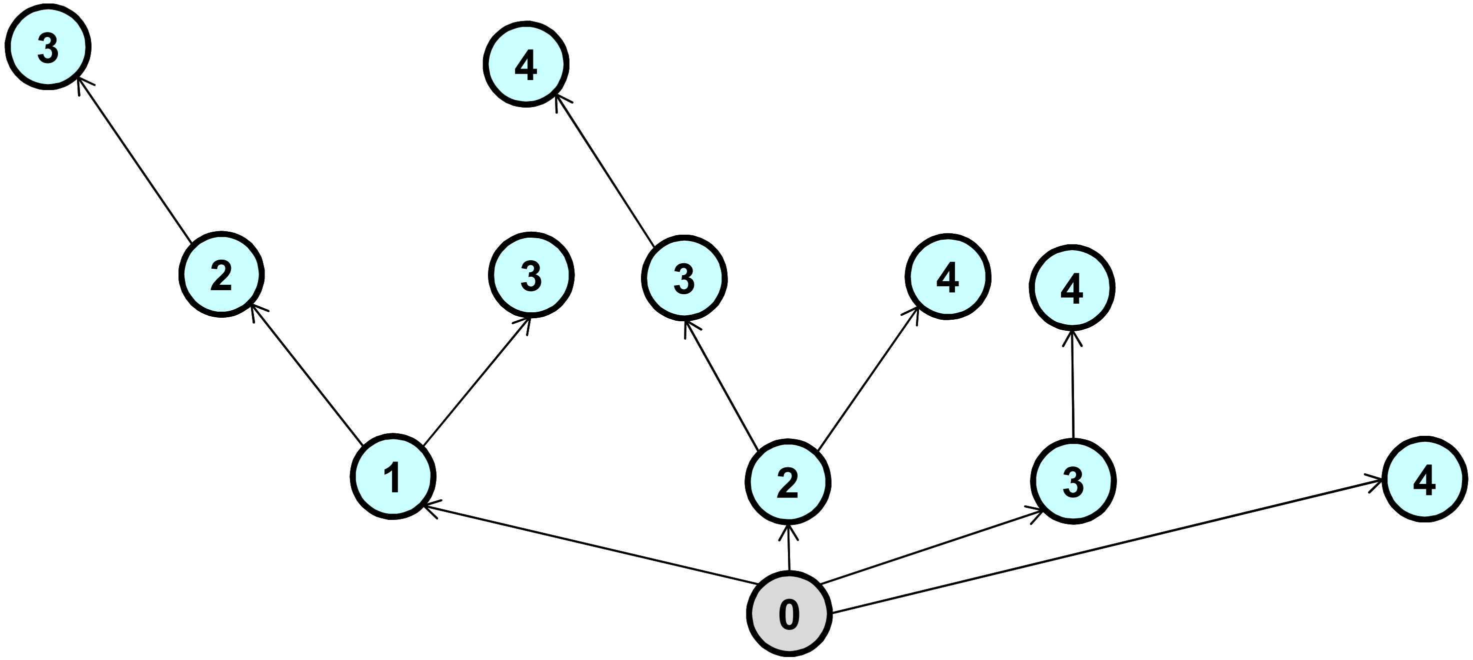
Matching of Planar Patches

- Problem – no descriptors like in the case of point-features
  - large number of combinations
  - large number of hypotheses
  - high computational reqirements

- Generate pose hypotheses by building a tree structure

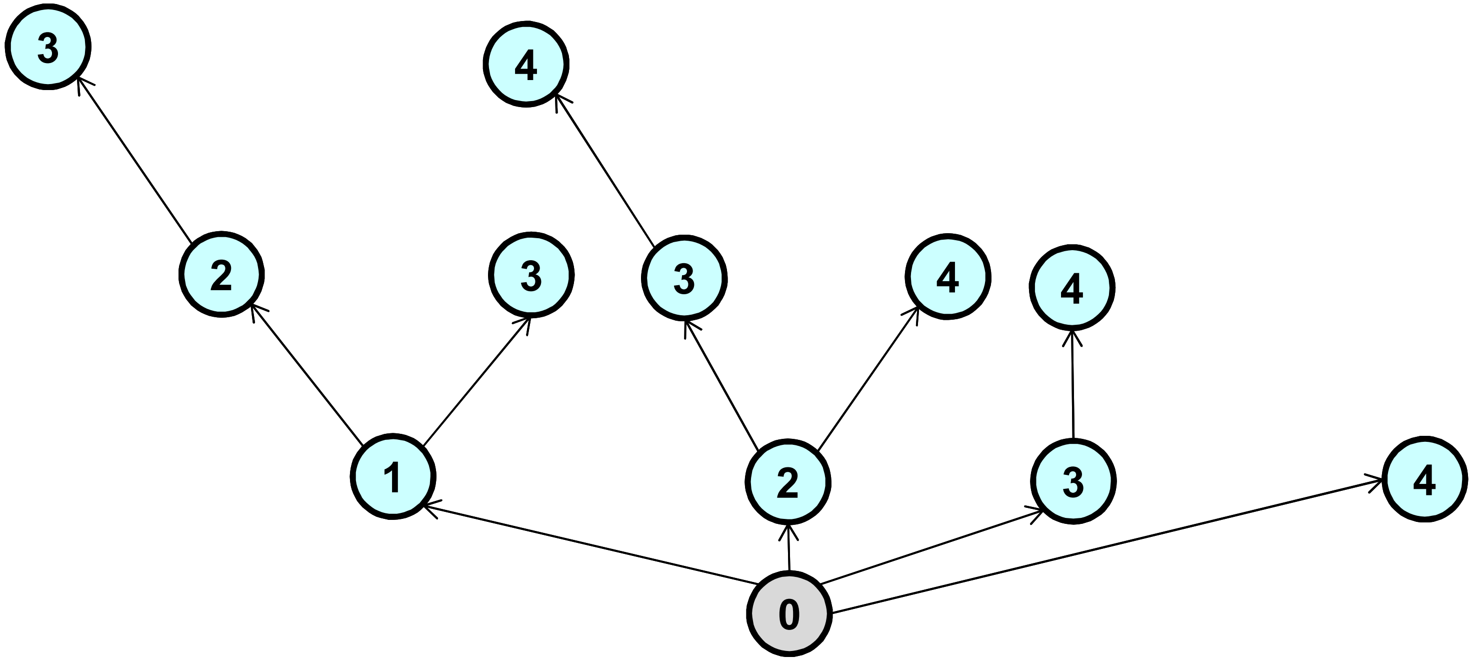
Tree structure:

- Node – pair of matched surfaces from Q
- Path from a leaf node to the root node – pose hypothesis
- Node is assigned the pose obtaned by EKF update of the pose assigned to the parent node.



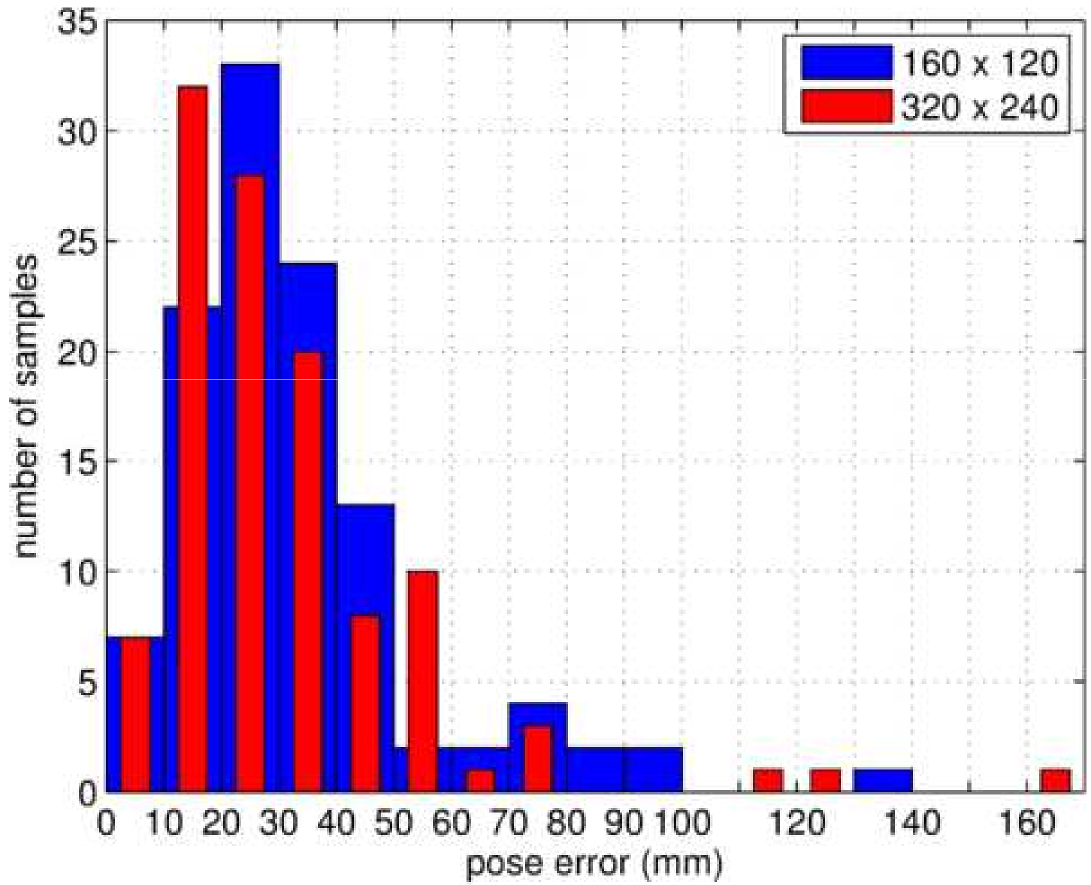
- Generate pose hypotheses by building a tree structure

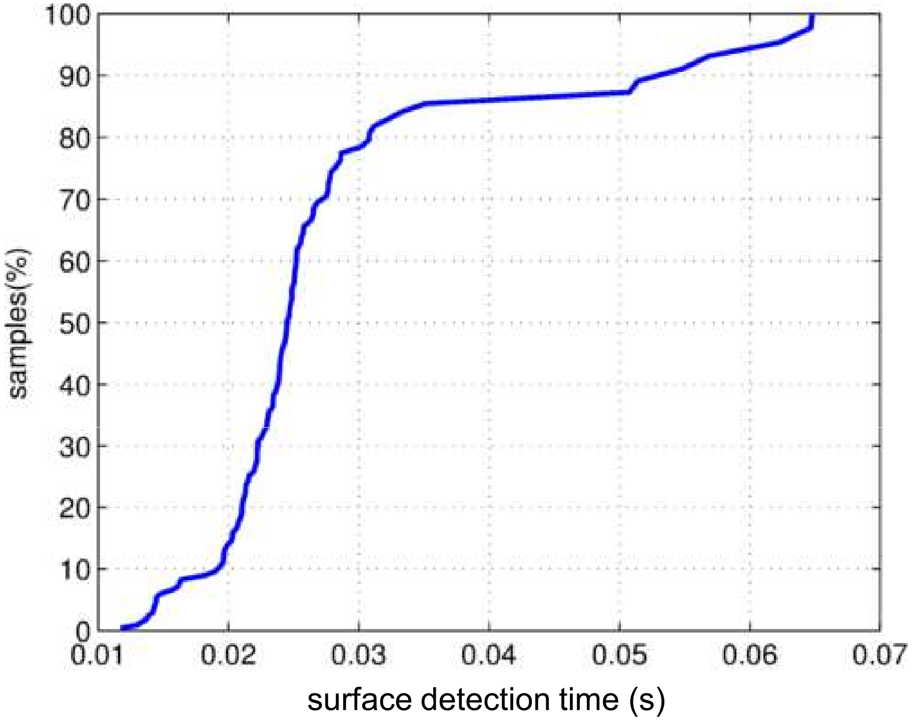
More probable hypotheses are generated before the less probable ones.



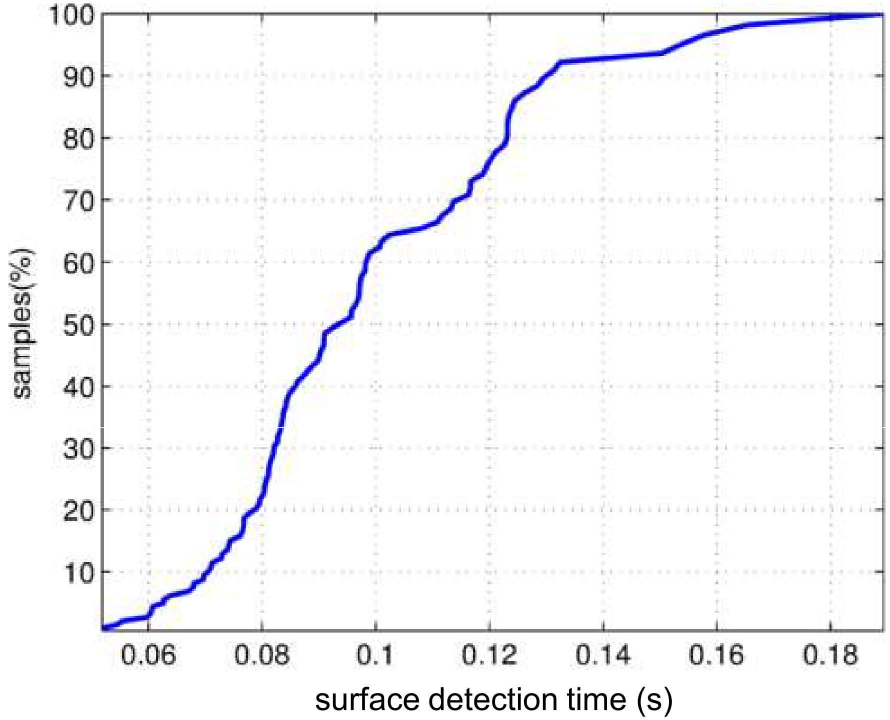
Experimental Evaluation

- the estimated relative pose is compared to the pose obtained by odometry





160 × 120



320 × 240

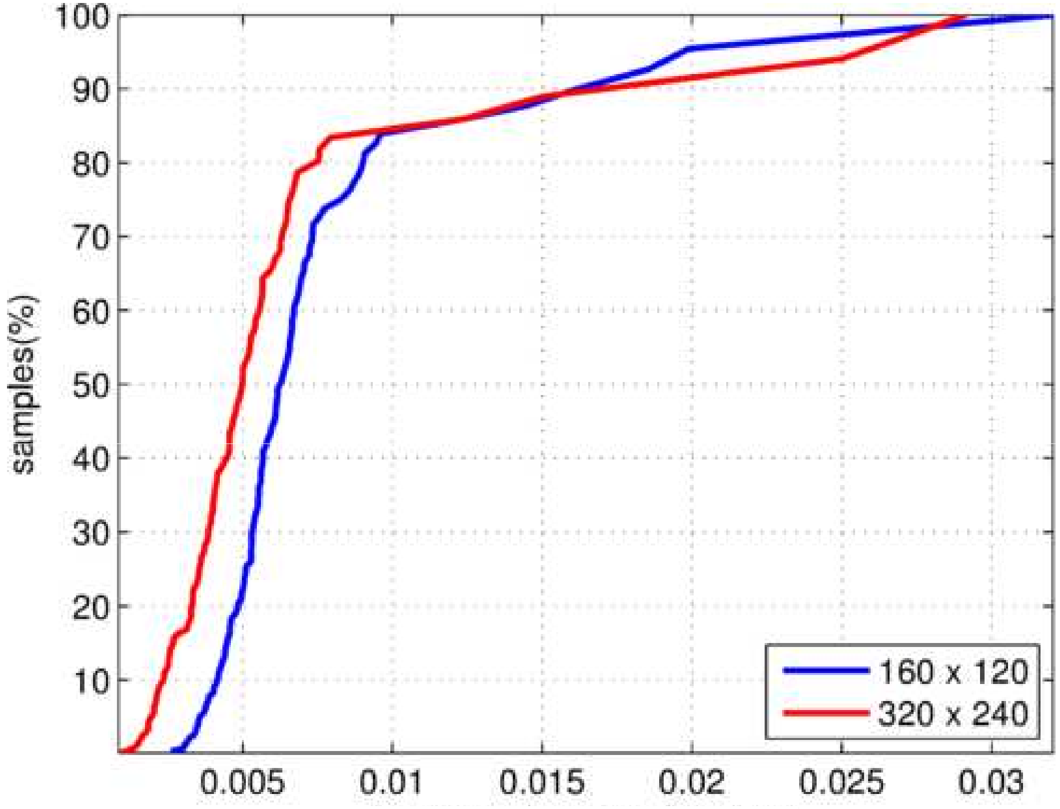


image registration time (s)

- Comparison with the method presented in Pathak et al. (2010)

	Pathak et al. (2010)	Proposed method
Image resolution	176×144	160×120
No. of samples	5	108
Mean surface detect. time (ms)	430	24.88
Mean registration time (ms)	159.8*	6.30

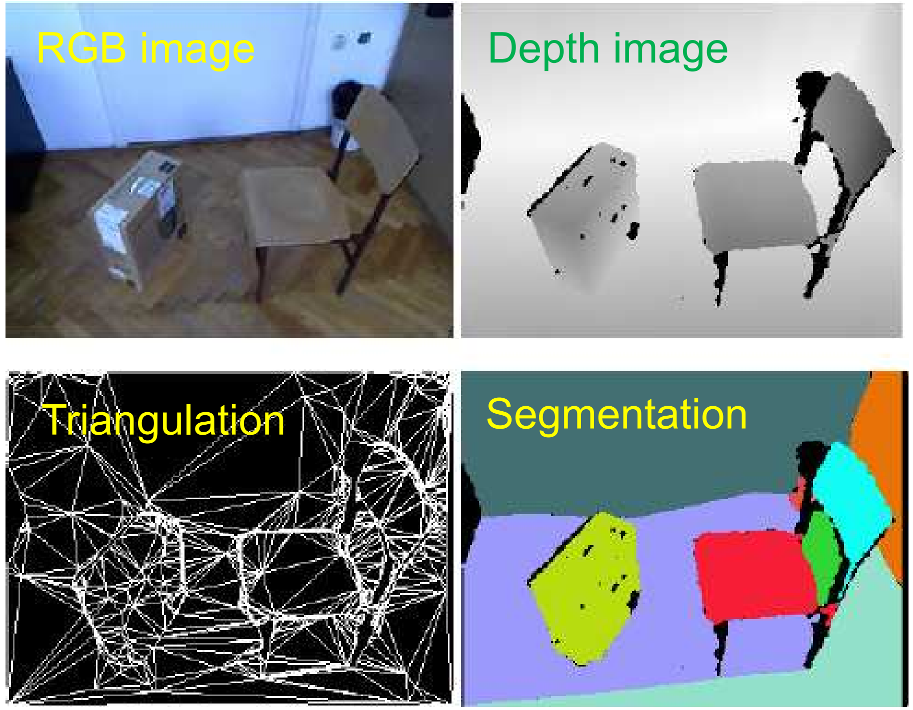
*Mean image registration time is calculated for the situation where 50% of the total number of planar surfaces obtained was used in image registration.

SACS – Segmentation to Approximately Convex Surfaces

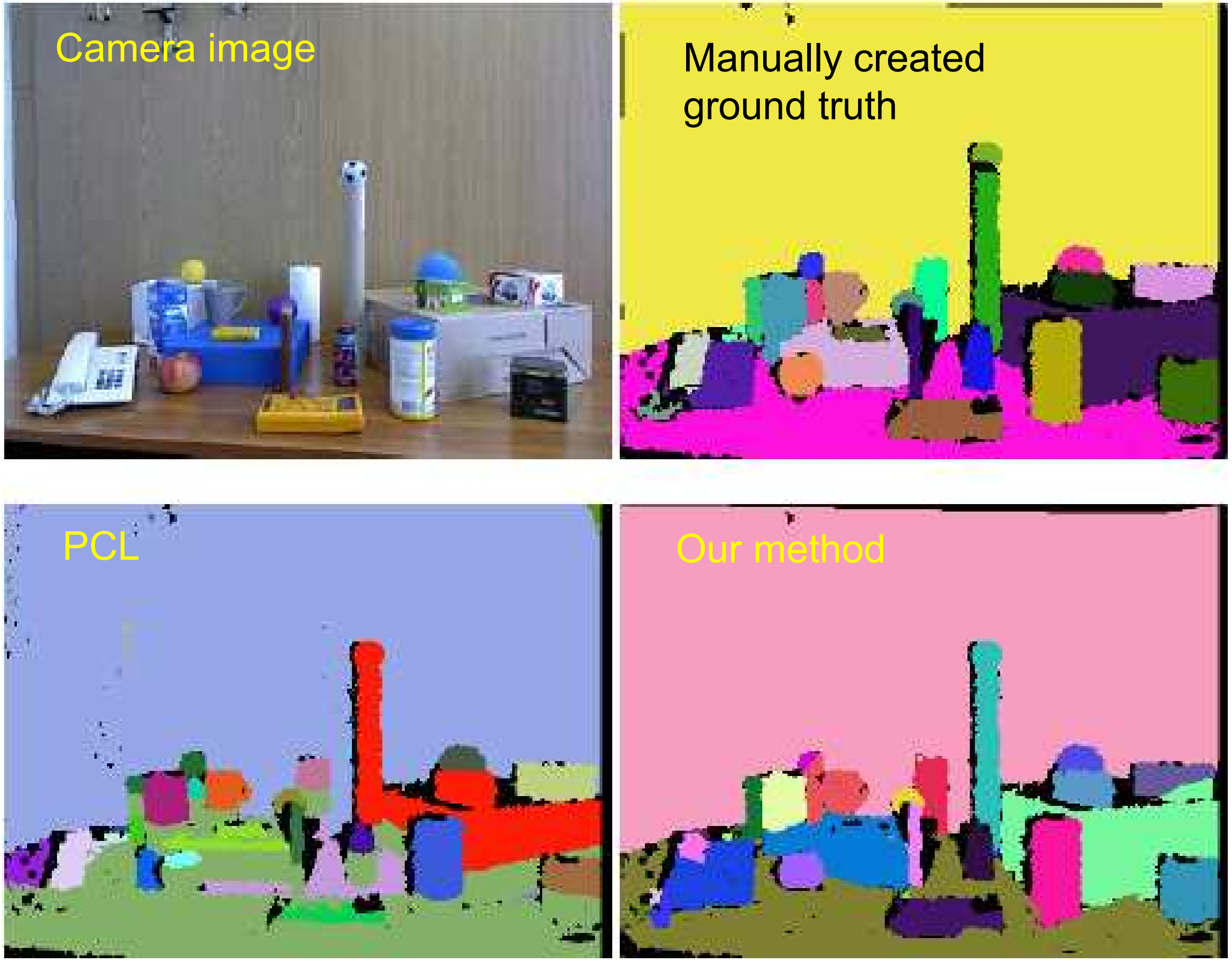
R. Cupec, E. K. Nyarko, D. Filko

D. Fast 2.5D Mesh Segmentation to Approximately Convex Surfaces, Proceedings of the 5th European Conference on Mobile Robots , Örebro, Švedska, 2011. str. 127-132.

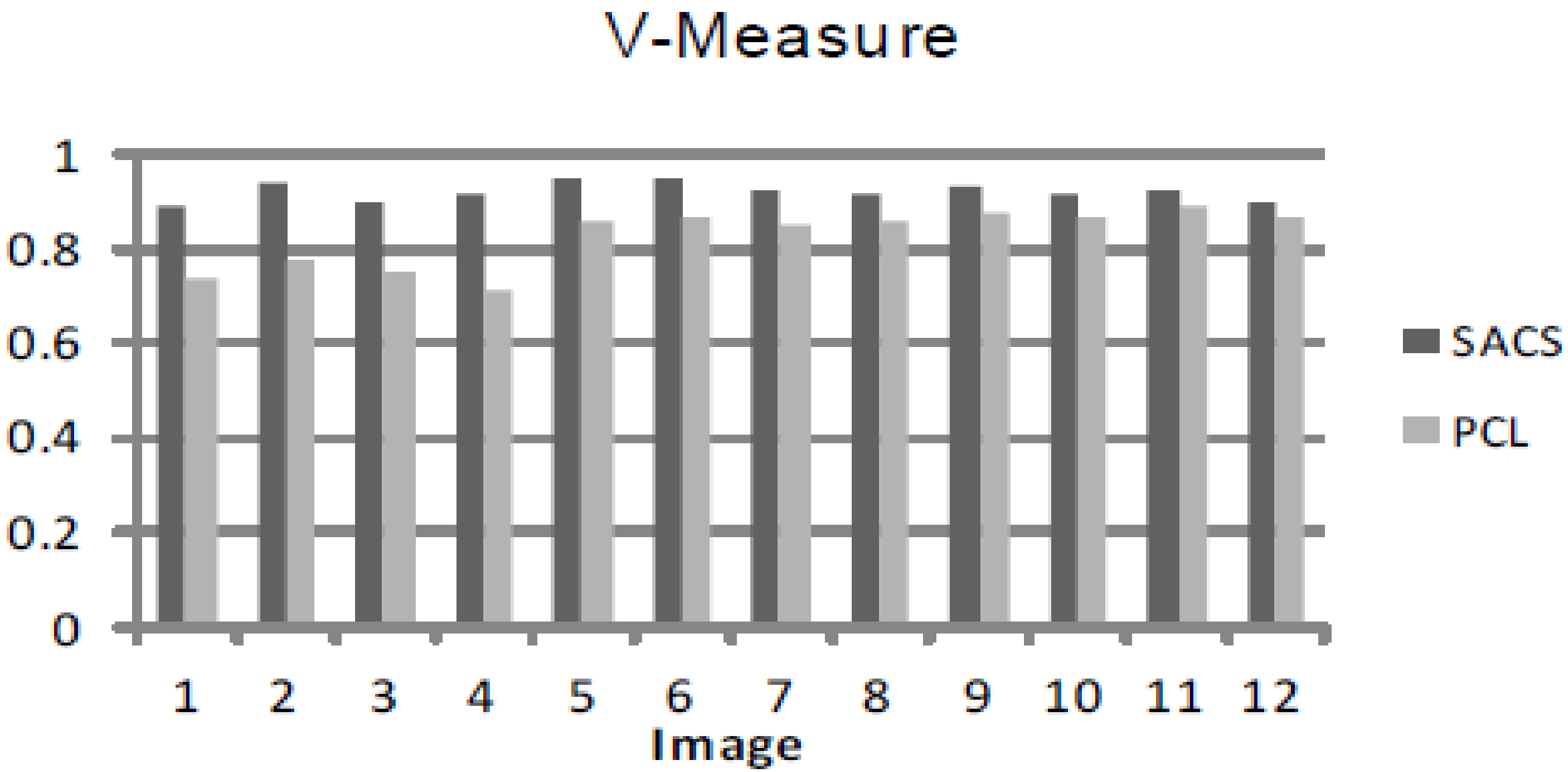
1. Create a 2.5D mesh of the range image using iterative Delaunay triangulation [Schmitt & Chen, 1991].
2. Starting from the largest triangle, perform region growing by successively appending adjacent triangles as long as the obtained triangle set represents an approximately convex surface.
3. Remove all triangles belonging to the obtained segment from the further processing.
4. Repeat from step 2 until all triangles are considered.



Experimantal Evaluation



- We evaluated developed segmentation by using V-measure [Rosenberg & Hirschberg, 2007] across 12 scenes and comparing our method to the segmentation obtained by implemented tools from Point Cloud Library (PCL).



- Execution time of the proposed method (SACS) and PCL in seconds.

Exec. time	SACS			PCL
	mesh building	segment.	total	
min.	0.119	0.036	0.155	1.293
max.	0.176	0.128	0.278	2.492
average	0.146	0.066	0.212	1.626

PDE IMAGE COMPRESSION

Irena Galić

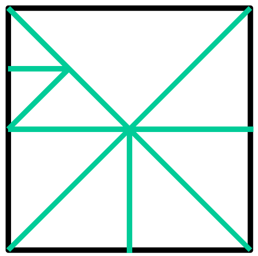
Introduction

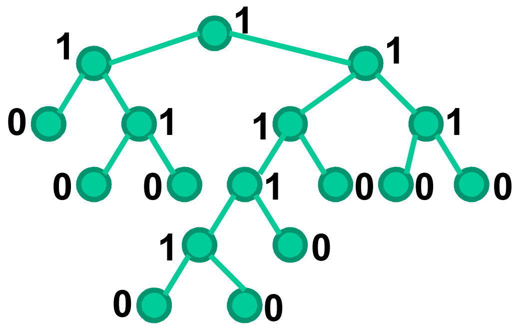
PDEs for Image Compression:

- diffusion-like partial differential equations (PDEs) for image compression
- driving inpainting to the extreme
- keep only a small fraction of the pixels
- encode the selected data in an efficient way
- reconstruct the remaining data with PDE-based interpolation

PDE Compression

- Coding:
  - adaptive triangulation that can be coded in a binary tree BTTC (Distasi et al. 1997)
    - split area along one diagonal into two triangles
    - if plane on a each triangle approximates image not well enough: subdivide the triangle



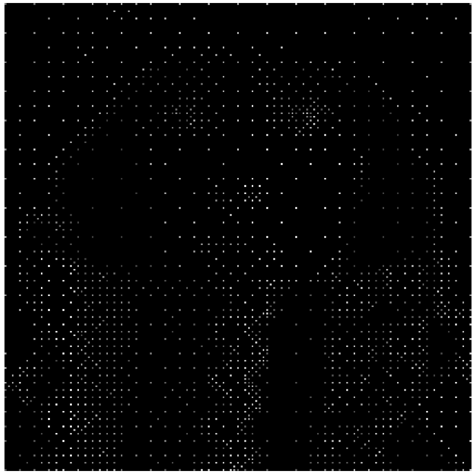


  - adaptive error threshold
  - EED in the encoding step
  - brightness rescaling
  - specific quantisation strategy

PDE Compression

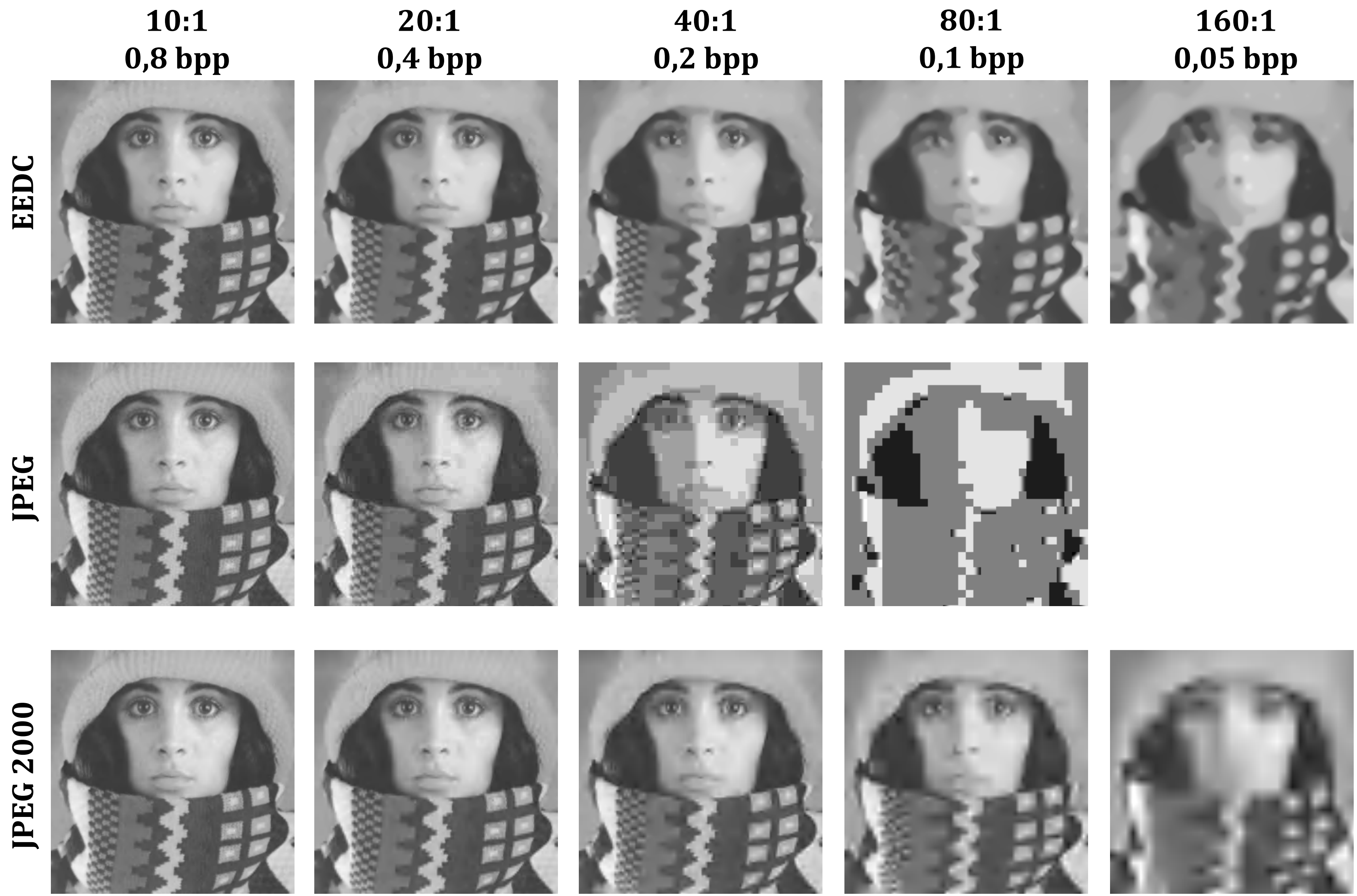
- Decoding:
  - sparse image is recovered from the binary tree representation
  - reconstructing missing data by Edge-enhancing diffusion (EED)(Weickert 1996)

$$Lu=div(g(\nabla u_\sigma \nabla u_\sigma^T)\ \nabla u).$$

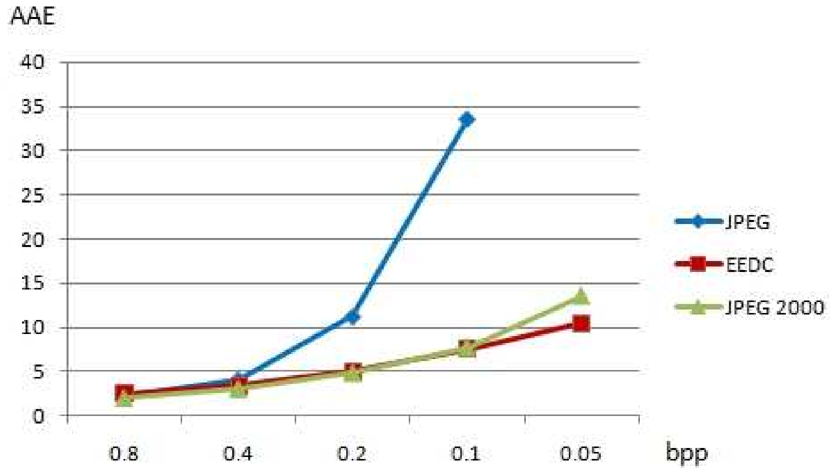


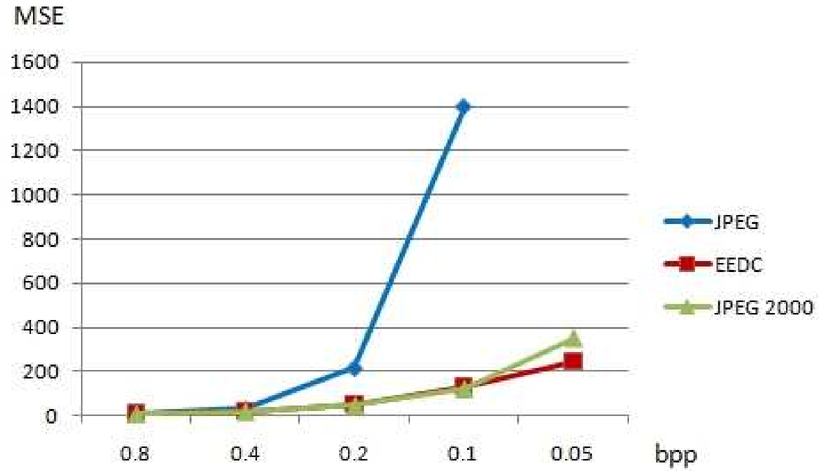
sparse image

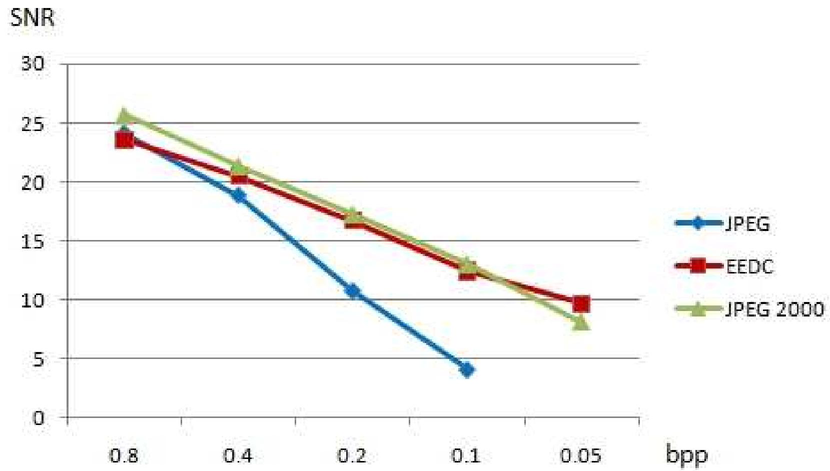
reconstructed image

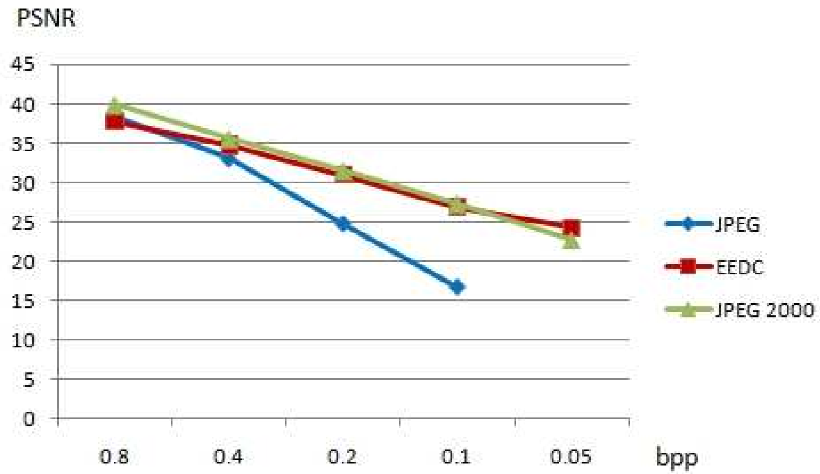

10:1
0,8 bpp
20:1
0,4 bpp
40:1
0,2 bpp
80:1
0,1 bpp
160:1
0,05 bpp
EEDC
JPEG
JPEG 2000

Comparison of compression methods

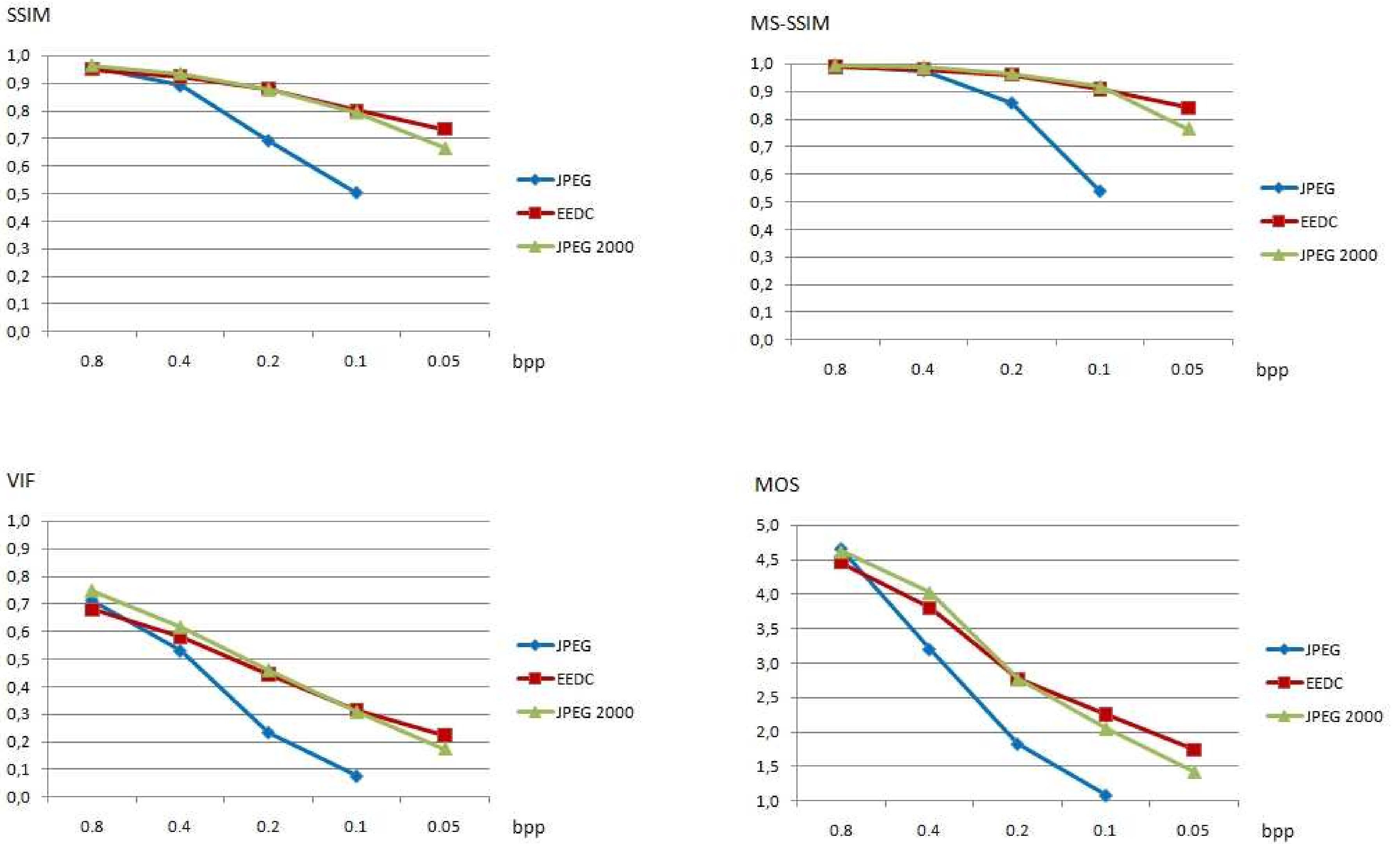








Comparison of compression methods



References

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- Č. Livada, I. Galić, B. Zovko-Cihlar: *EEDC Image Compression Using Burrows-Wheeler Data Modeling*. Proc. 54th International Symposium ELMAR- 2012, Zagreb, ITG, 2012.
- I. Galić, J. Weickert, M. Welk, A. Bruhn, A. Belyaev, H.-P. Seidel: *Image compression with anisotropic diffusion.* Journal of Mathematical Imaging and Vision, Vol. 31, 255–269, 2008.

  (adaptive triangulations with EED-based interpolation)
- I. Galić, J. Weickert, M. Welk, A. Bruhn, A. Belyaev, H.-P. Seidel: *Towards PDE-based image compression.* Variational, Geometric, and Level Set Methods in Computer Vision. Lecture Notes in Computer Science Vol. 3752, Berlin, Springer, 37-48, 2005.

Video Quality Group at Faculty of Electrical Engineering in Osijek (VQG@ETFOS)

- VQG@ETFOS
  - Prof. dr.sc. Snježana Rimac-Drlje, dipl. ing.
  - Dr.sc. Mario Vranješ, dipl.ing.
  - Denis Vranješ, mag.ing.
- Research areas
  - Image & Video Processing
    - Image and Video Coding
    - Transmission over Heterogeneous Networks
  - Human Vision Modelling
  - Video Quality Evaluation
    - Objective Video Quality Evalutaion
    - Subjective Video Quality Evaluation

- Creation of Subjective Video Quality Databases [1], [2]
  - ETFOS CIF Video Quality (ECVQ) Database (resolution 352 x 288)







[1] M. Vranješ, S. Rimac-Drlje, D. Vranješ, *ECVQ and EVVQ Video Quality Databases*, Proceedings of 54th International Symposium ELMAR-2012, Zadar, 2012, pp. 13-17

[2] M. Vranješ, S. Rimac-Drlje, K. Grgić, *Review of Objective Video Quality Metrics and Performance Comparison using Different Databases*, in review process in Signal Processing: Image Communication, submission sent 08.02. 2012.

- Creation of Subjective Video Quality Databases [1], [2]
  - ETFOS VGA Video Quality (EVVQ) Database (resolution 640 x 480)







[1] M. Vranješ, S. Rimac-Drlje, D. Vranješ, *ECVQ and EVVQ Video Quality Databases*, Proceedings of 54th International Symposium ELMAR-2012, Zadar, 2012, pp. 13-17

[2] M. Vranješ, S. Rimac-Drlje, K. Grgić, *Review of Objective Video Quality Metrics and Performance Comparison using Different Databases*, in review process in Signal Processing: Image Communication, submission sent 08.02. 2012.

- Design of Objective Video Quality Metrics
  - Foveated Mean Squared Error (FMSE) [3]
  - Foveation-based content Adaptive Root Mean Squared Error (FARMSE) [4]

- Competitive with the best published objective video quality metrics

- Calculation complexity significanty reduced with respect to the best published objective video quality metrics

[3] S. Rimac-Drlje, M. Vranješ, D. Žagar, *Foveated mean squared error – a novel video quality metric*, Multimedia Tools and Applications, vol. 49, 2010, pp. 425-445

[4] M. Vranješ, *Objective image quality metric based on spatio-temporal features of video signal and foveated vision*, Ph.D. thesis, Faculty of Electrical Engineering in Osijek, Croatia, 2012

Thank you for your attention.