Sisteme de viziune in robotica

An2, Master Robotica - engleza

IPPRG

Image Processing and Pattern Recognition Research Center (**IPPRRC**) http://cv.utcluj.ro/

Lectures:

- **Bachelor:** Procesarea imagnilor / Image Processing, Pattern recognition systems, Human-Computer Interaction
- **Master:** Artificial vision, Artificial vision for mobile robots, Human-Computer interfaces

Research:

- Computer Vision based advanced driving assistance systems (ADAS)
- Computer Vision for industrial manufacturing
- Medical Imaging
- Automatic semantic image annotation

References

R.C.Gonzales, R.E.Woods, Digital Image Processing-Second Edition, *Prentice Hall, 2002.*

E. Trucco, A. Verri, Introductory Techniques for 3-D Computer Vision, *Prentice Hall, 1998.*

Procesarea imaginilor (note de curs si indrumator de laborator) - http://users.utcluj.ro/~tmarita/IPL

Image processing (lecture & laboratory notes) - http://users.utcluj.ro/~nedevski/IP/schedule.html

Sergiu Nedevschi, Radu Dănescu, Florin Oniga, Tiberiu Marita, *Tehnici de viziune artificială aplicate în conducerea automată a autovehiculelor*, Editura U.T. Press, Cluj-Napoca, 2012.

S. Nedevschi, T. Marita, R. Danescu, F. Oniga, R. Brehar, I. Giosan, C. Vicaș, *Procesarea Imaginilor - Indrumator de laborator*, Editura U.T. Press, Cluj-Napoca, 2013.

S. Nedevschi, **T. Marita**, R. Danescu, F. Oniga, R. Brehar, I. Giosan, S. Bota, A. Ciurte, A. Vatavu, „*Image Processing - Laboratory Guide*", UTPress Edition, 2016, ISBN 978-606-737-137-6, http://biblioteca.utcluj.ro/carti-online.html

R.C.Gonzales, R.E.Woods, S.L. Eddins, Digital Image Processing Using MATLAB, *Gatesmark Publishing*, 2nd Edition, 2009.

A. McAndrew, An Introduction to Digital Image Processing with MATLAB, Notes for SCM2511 Image Processing, 2004, School of Computer Science and Mathematics, Victoria University of Technology.

C. Solomon, T. Beckon, Fundamentals of digital image processing - a practical approach with examples in Matlab, *Wiley & Sons*, 2011.

Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010, http://szeliski.org/Book

Cuprins / Contents

Introducere / Introduction

Introducere / *Introduction*

What is Computer Vision?

Computer vision is the discipline that uses **statistical methods to disentangle data using models constructed with the aid of geometry, physics and learning theory.**

Computer vision relies on a solid understanding of cameras and of the physical process of image formation:

- to obtain simple inferences from individual pixel values and combine the information available in multiple images into a coherent whole
- impose some order on groups of pixels to separate them from each other or infer shape information, and recognize objects using geometric information.

Computer Vision is also known as:

• analiza de imagini (*image analysis*)
• analiza scenei (*scene analysis*)
• interpretarea imaginilor (*image understanding*)

Viziunea artificala / *Computer vision*

Discipline conexe / *Related disciplines*

- Inteligenta artificiala (*artificial intelligence*)
- Robotica (*robotics*)
- Procesarea semnalelor (*signal processing*)
- Recunoasterea de forme (*pattern recognition*)
- Teoria controlului (*control theory*)
- Psihologia (*psychology*)
- Neurostiintele (*neuroscience*)

Subdomenii / *Subdomains*

- Procesarea imaginilor (*image processing)*
- Recunoasterea formelor (*pattern recognition*)
- Fotogrametria (*photogrametry*)
- …….

Image processing

Procesarea imaginilor (Image Processing)

Concerned with image properties and image-to-image transformations

Most computer vision algorithms require image processing

Examples of image processing

- image enhancement (improving image quality through transforms, bring out detail that is obscured, highlight features of interest in an image)
- compression (compact representation of images for transmission)
- restoration (elimination of known degradations)
- feature extraction (locating specific image patterns like edges, corners)

Computer vision

Domenii de cercetare / *Research domains*

- Detectia de trasaturi (*Features Detection*)
- Reprezentarea contrurelor (*Contour Representation*)
- Analiza imaginilor de profunzime (*Range image analysis*)
- Modelarea si reprezentarea formelor (*Shape modeling and representation*)
- Stereo viziunea (*Stereo vision*)
- Viziunea color (*Color vision*)
- Analiza miscarii (*Motion analysis*)
- Viziunea activa (*Active/Purposive vision*)
- Invarianti (*Invariants*)
- Detectia obiectelor (*Objects detection*)
- Recunoastera obiectelor 3D (*3D object recognition*)
- Aritectura sistemelor de viziune (*Vision architectures*)

Computer vision

Domenii de aplicare / *Application domains*

- Inspectie industriala / controlul calitatii (*Industrial inspection/quality control*)
- Imginerie inversa (*Reverse engineering*)
- Supraveghere si securitate (*Surveillance and security*)
- Biometrica (ex. recunoastera fetei) (Biometrics (i.e. *Face recognition*))
- Recunoasterea gesturilor (*Gesture recognition*)
- Monitorizarea traficului (*Road monitoring*)
- Aplicatii spatiale (*Space applications*)
- Vehicule autonome (*Autonomous vehicles*)
- Realitate virtuala, teleprezenta si telerobotica (*Virtual reality, tele-presence, and tele-robotics*)
- Cartografiere automata, achizitie automata de modele (*Automated map making, model acquisition*)
- Analiza imaginilor medicale (*Medical image analysis*)
- Imagistica medicala (*Medical Imaging*)

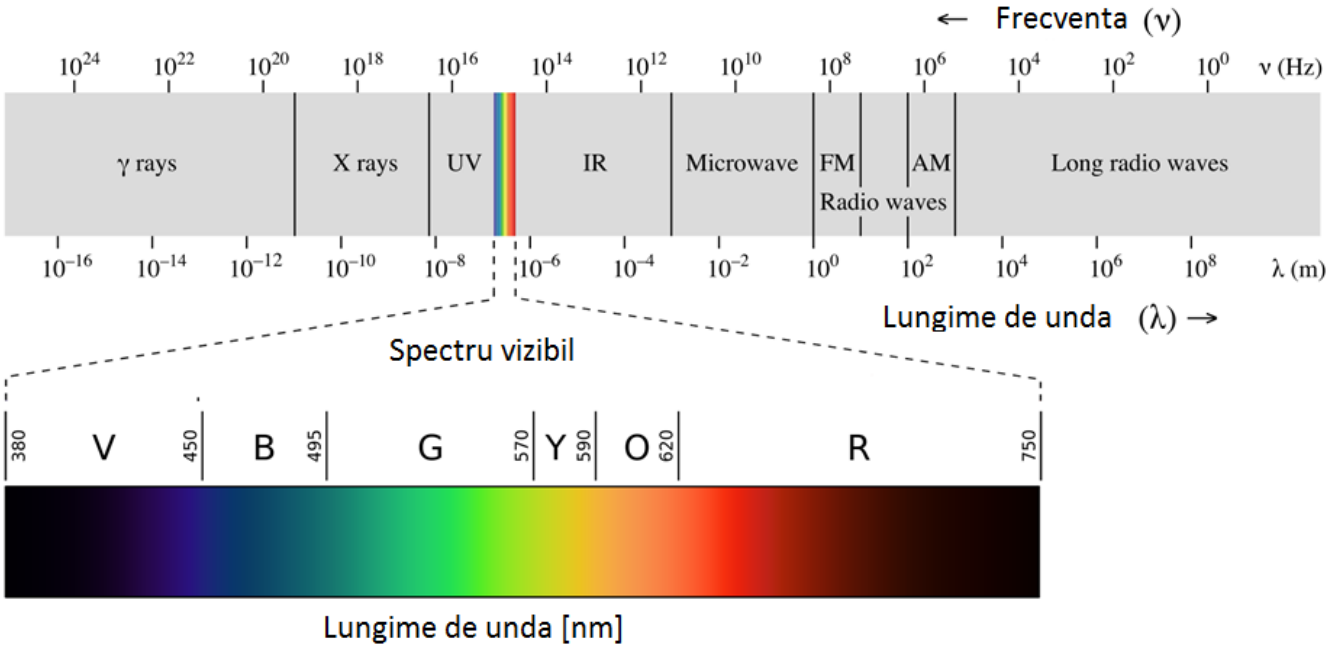
Computer vision

Date de intrare / *input data*

- Images captured with acquisition devices adapted for the whole spectrum of the electromagnetic waves

- Visible spectrum images (*visible light*) – most used / accessible

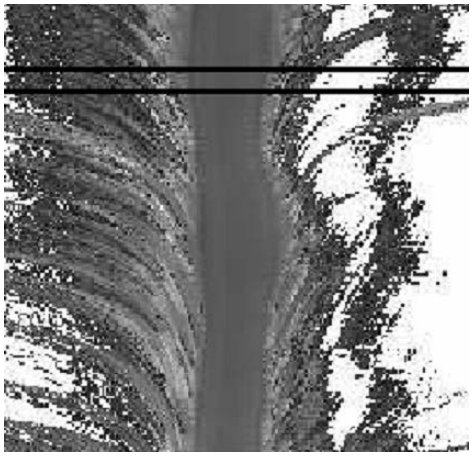
- Other sources of images: *infrared (IR), acoustic / ultrasonic waves (US), X ray images etc.*



Computer vision

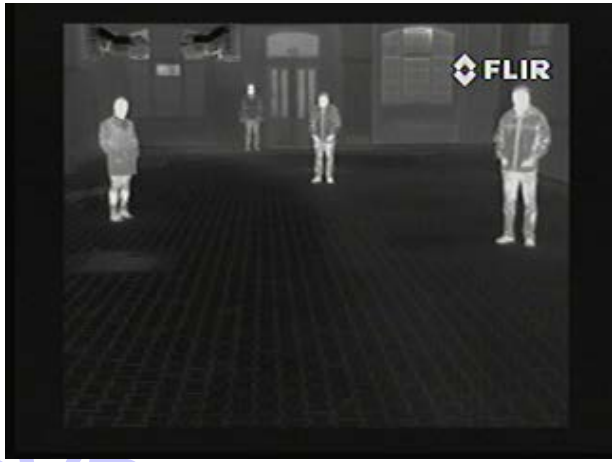
Date de intrare / *input data*

Visible spetra (380 – 750 nm)

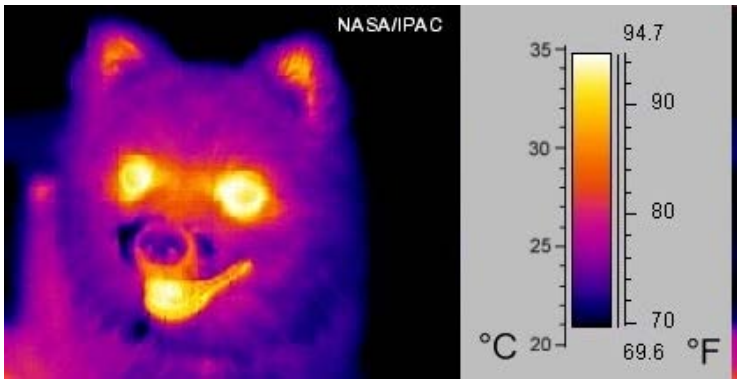


LiDAR RADAR reflectivity
(NIR : 0.75 .. 1.4μm)

RADAR reflectivity
24GHz (SRR) / 77 (LRR)



LWIR / Thermal (8-15μm)



LWIR / Thermal (heatmap)

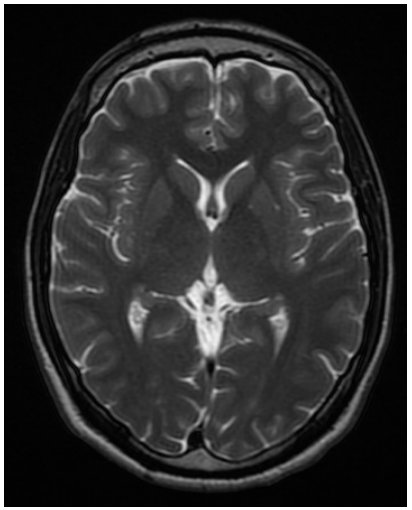
Viziunea artificiala

Date de intrare *I input data*

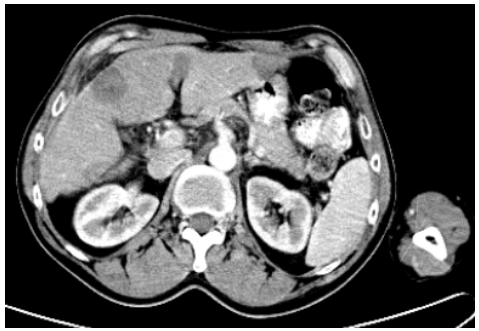
Other image sources: *acustic vawes (US), MRI, CT*

US 7–18 MHz: muscle, thiroid, ..
US 1–6 MHz: liver, kidney, …

X-ray (radiography)



MRI



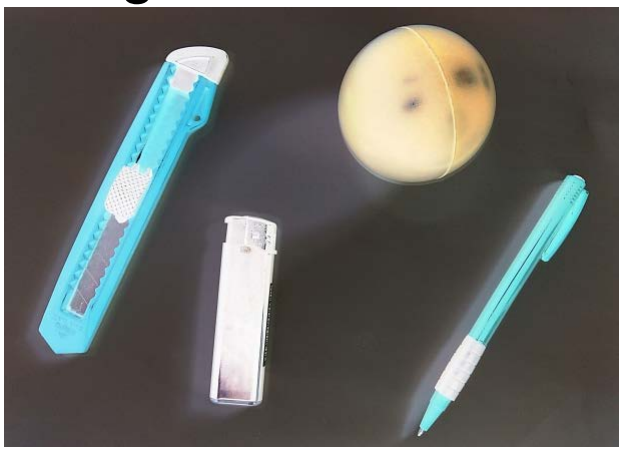
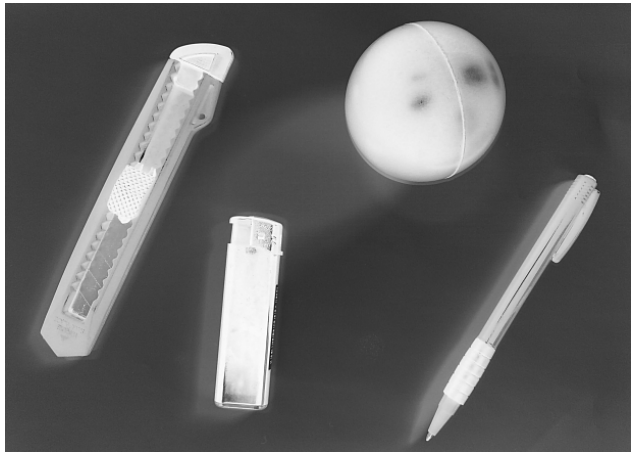
X-ray (CT slice)

Examples of simple processings

Color conversion: color -> grayscale -> binary image

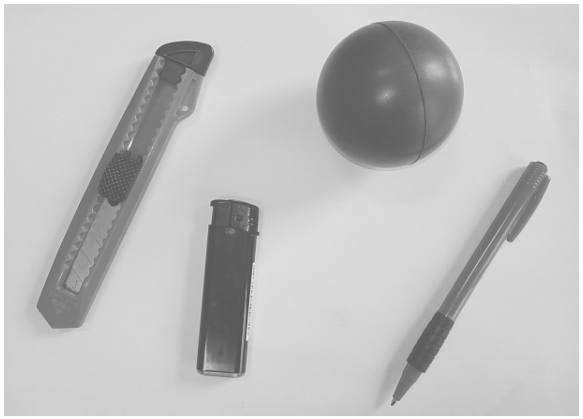


Negative

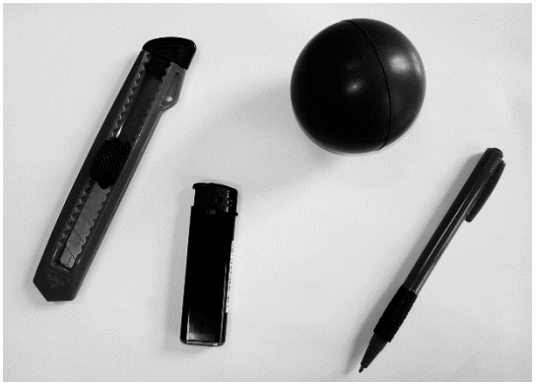

Examples of simple processings

Brightness and contrast change



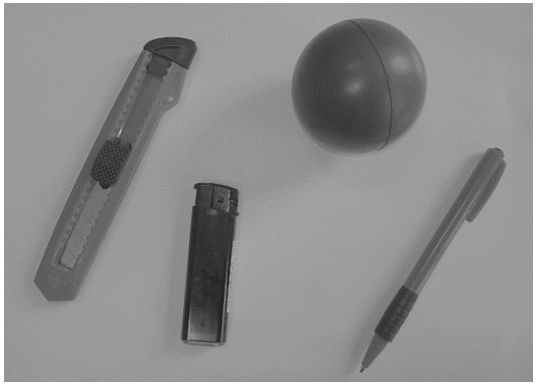
Brightness ++

Source image



Contrast ++

Brightness --



Contrast --

Examples of simple processings

Noise reduction

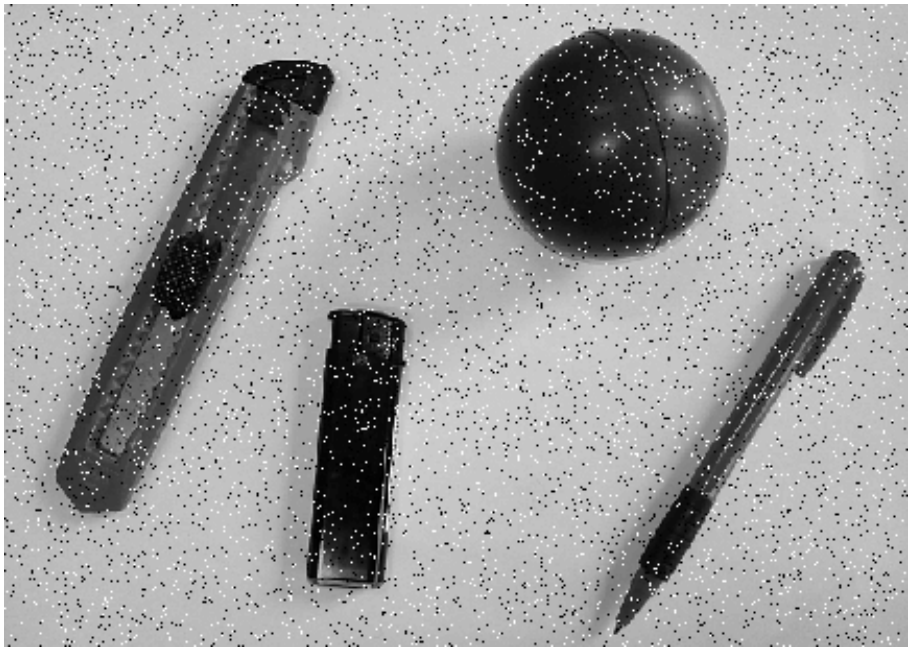


Image corrupted by Salt&Pepper noise

Filtered image (median filter)

Examples of simple processings

Noise reduction

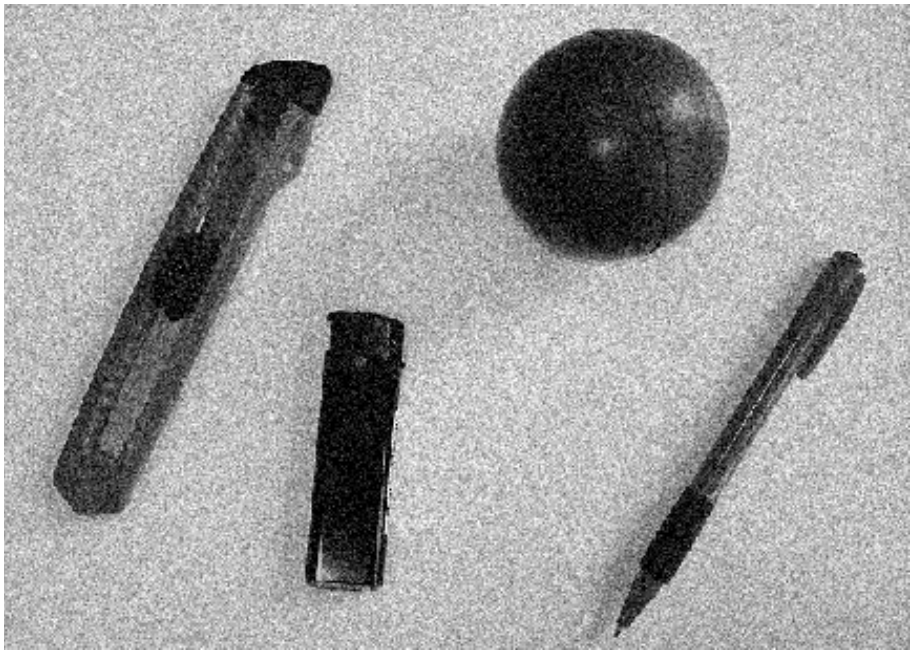
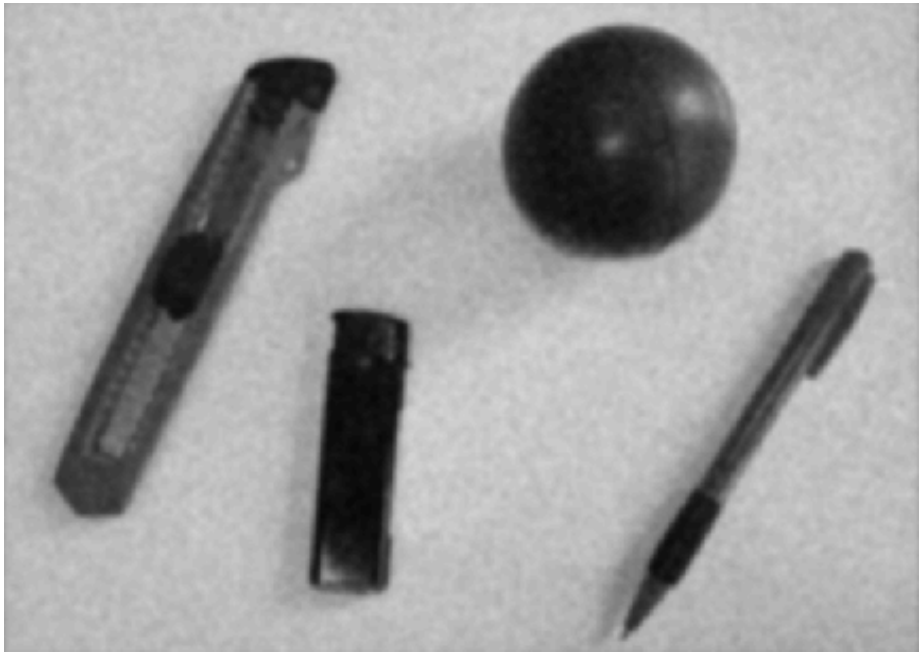


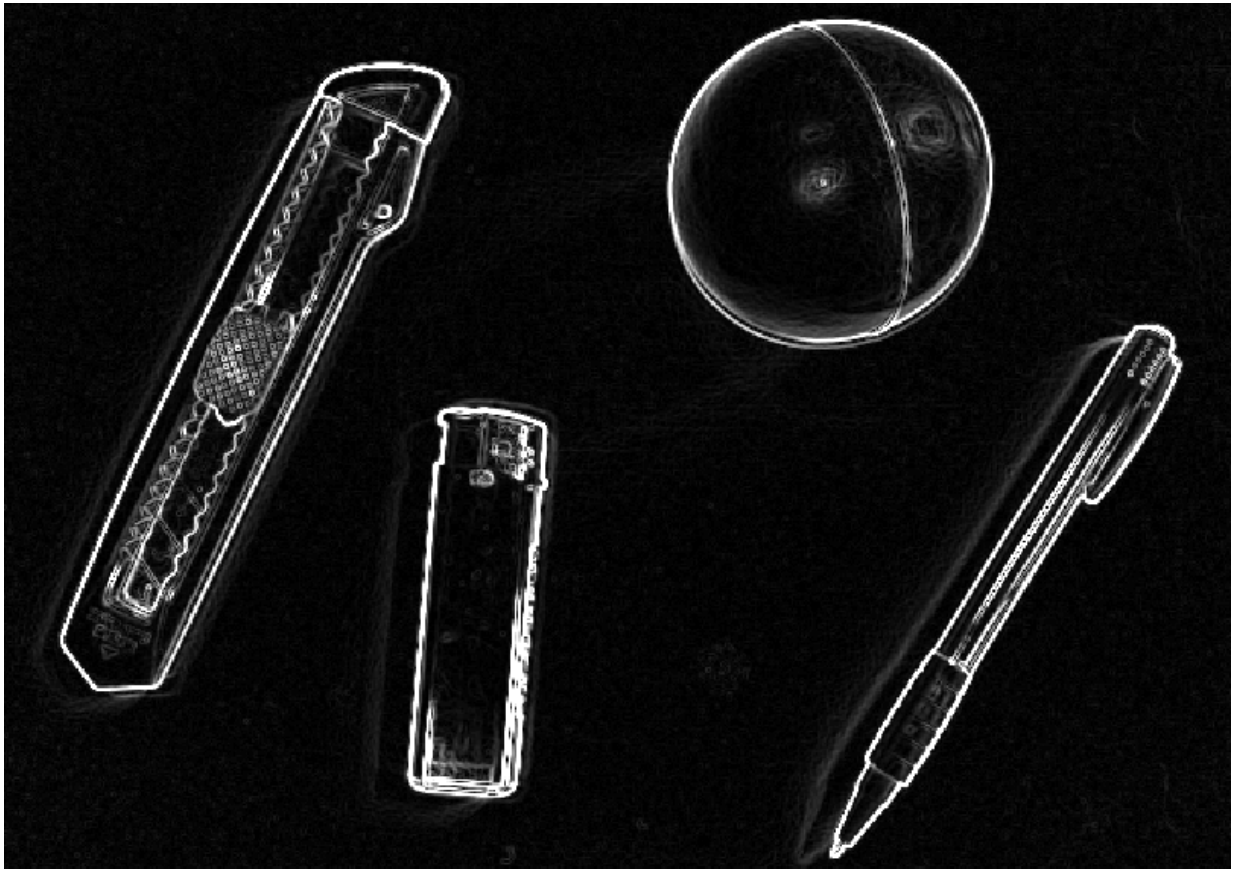
Image corrupted by Gaussian noise



Filtered image (median filter)

Examples of simple processings

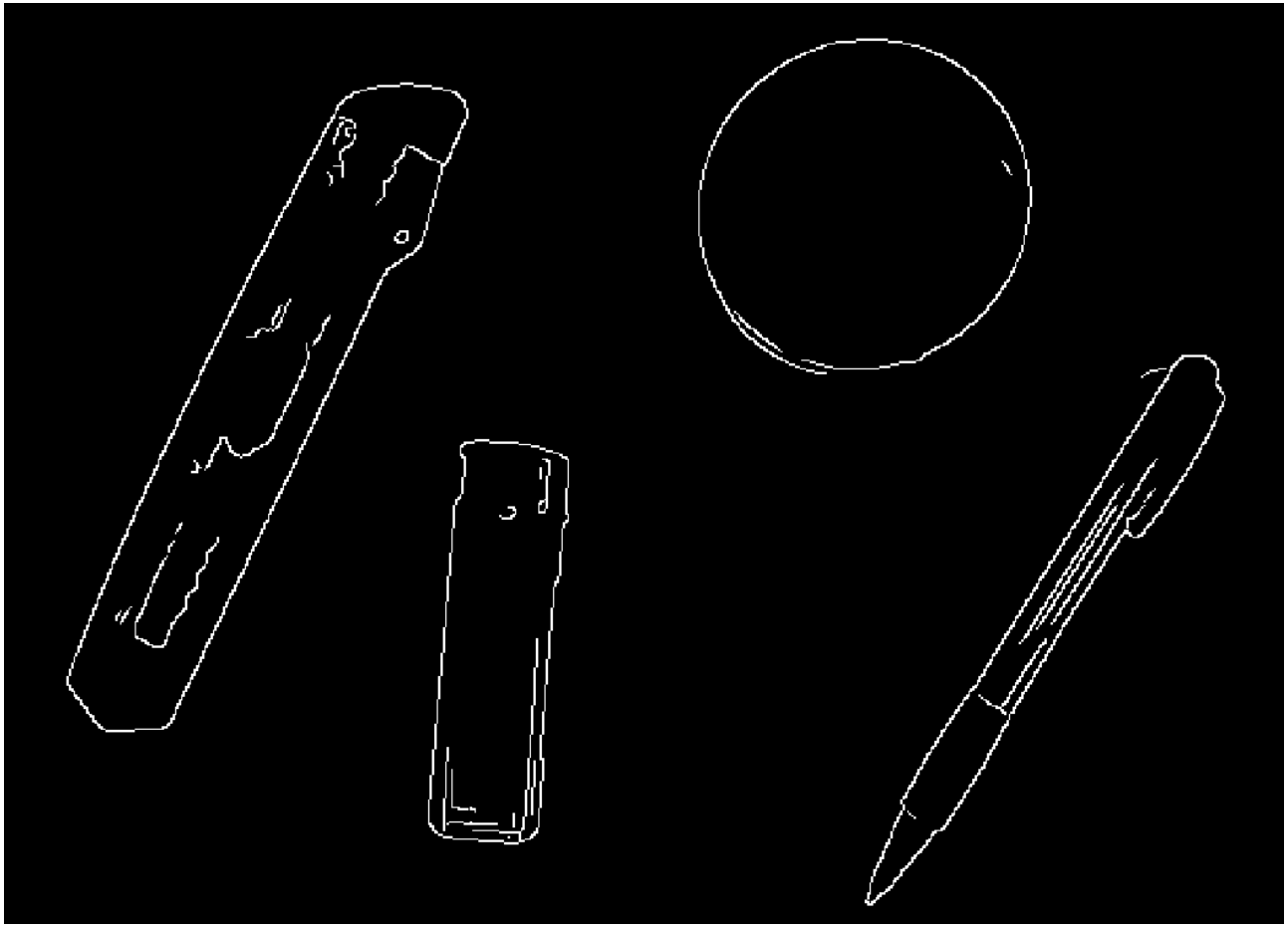
First order derivative (image gradient)



Gradient magnitude

Examples of simple processings

Edge detection



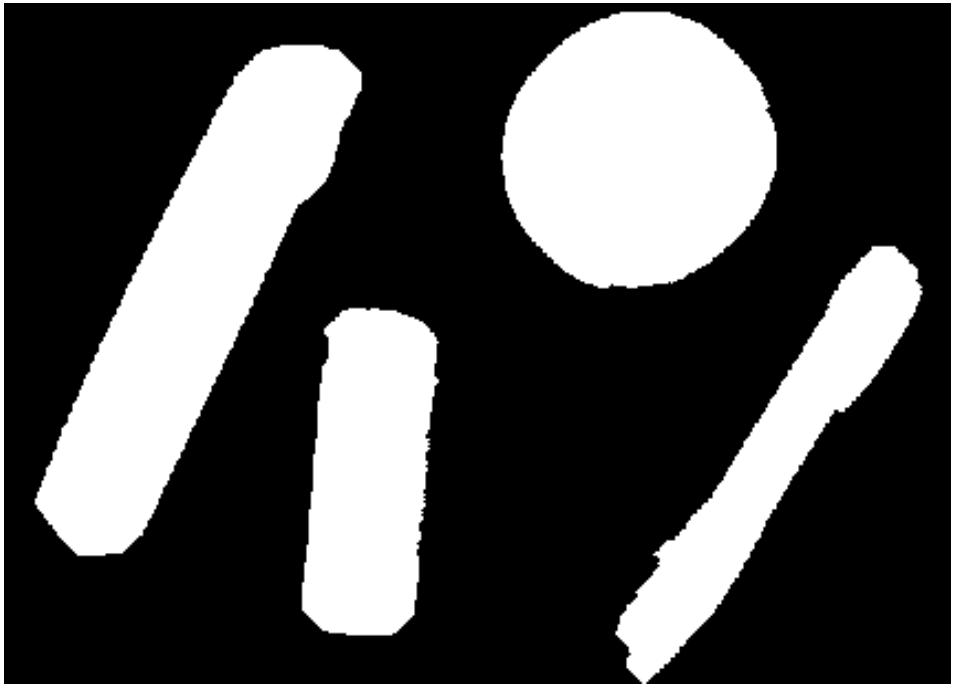
Canny edge detection method

Examples of simple processings

Morphological operations: dilation

Examples of simple processings

Morphological operations: erozion

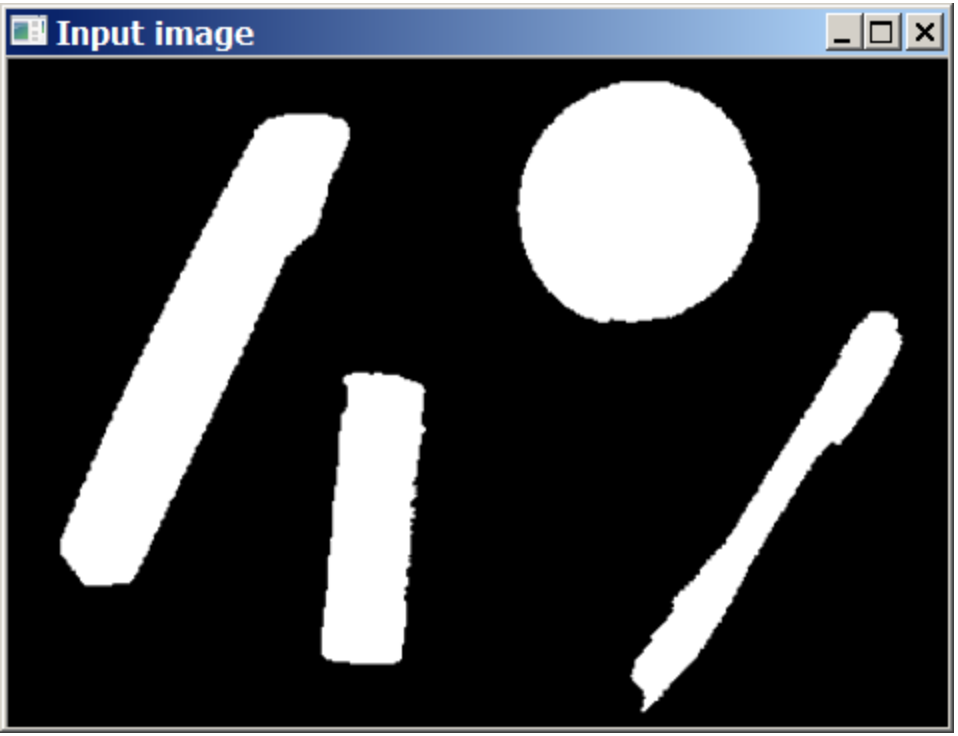


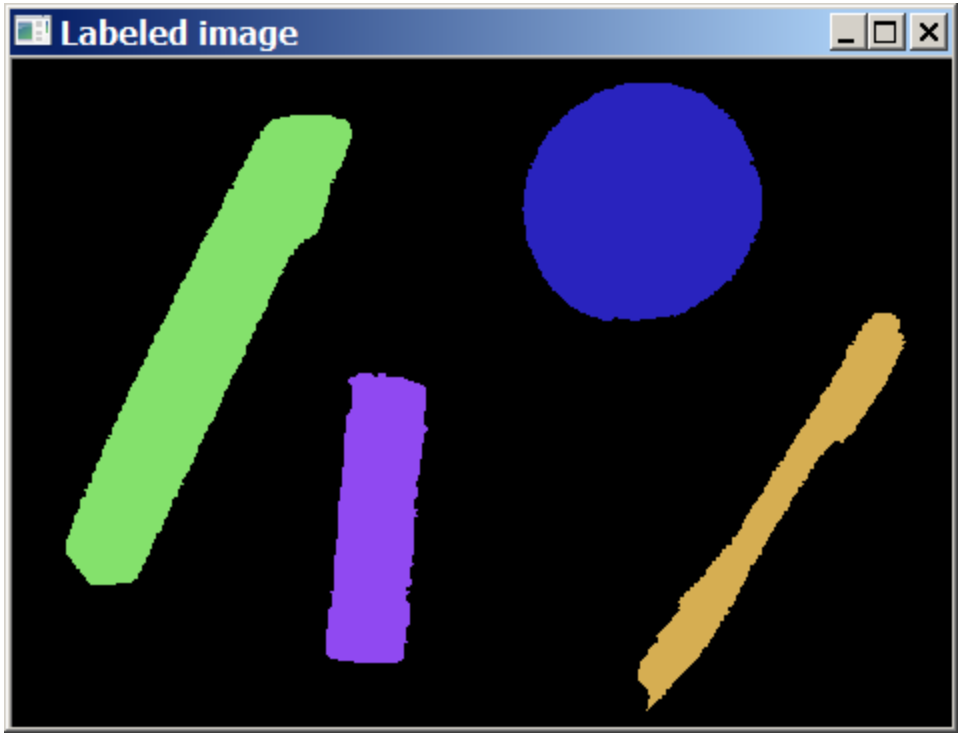
Examples of simple processings

Closing (dilation + erosion): hole filing (preserves area)

Examples of simple processings

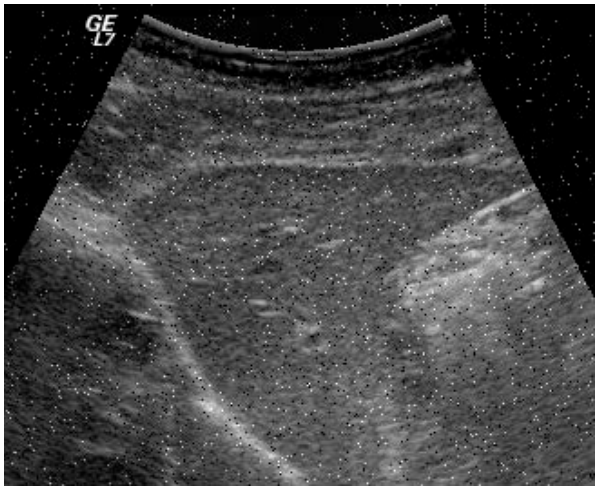
Objects labeling

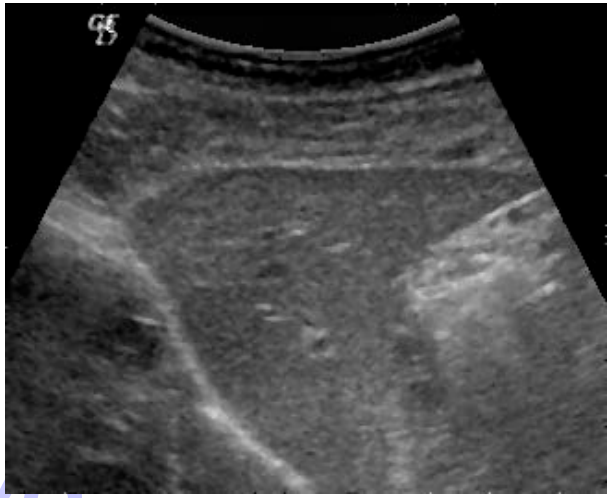


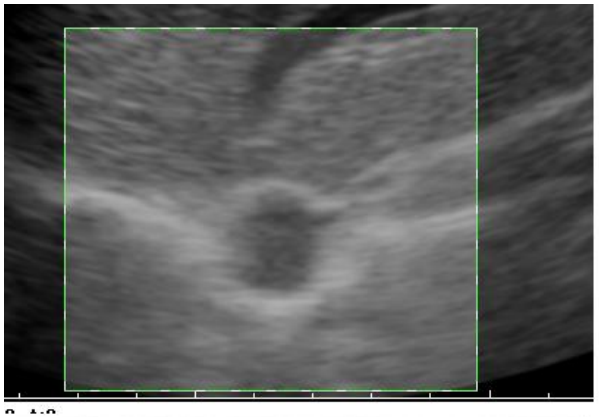


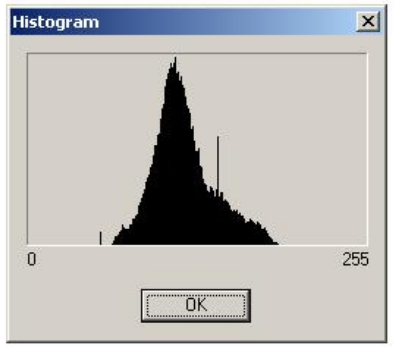
Examples of simple processings

Image enhancement (medical images)

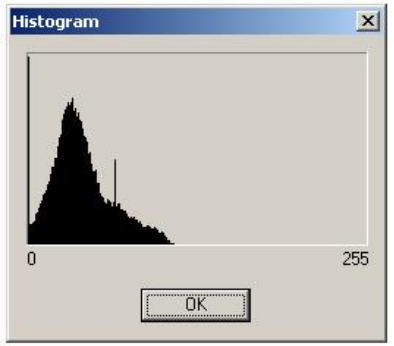








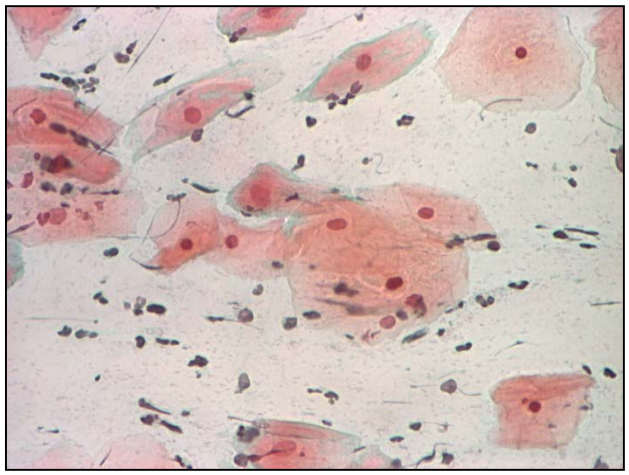
offset > 0

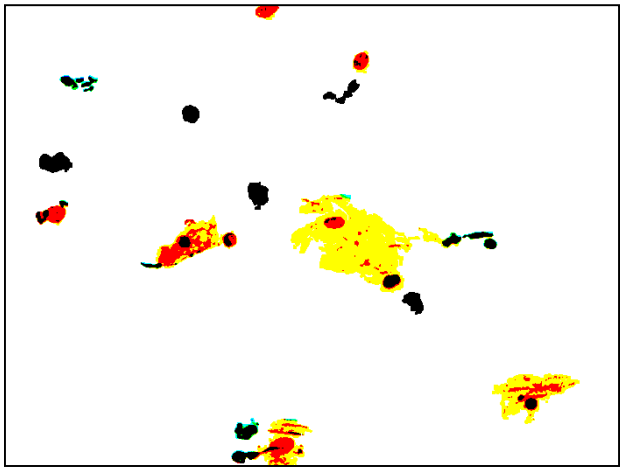


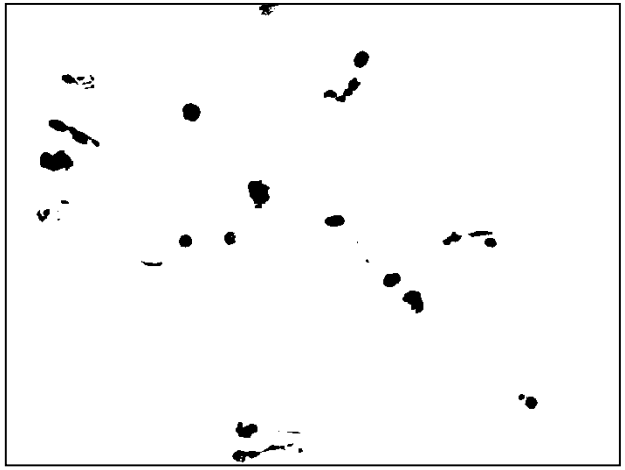
offset < 0

Examples of applications

Image segmentation (medical images)







Features

The features extracted from the abnormal nuclei found in the image are:

Nucleus	Entropy	Homogeneity	Coarseness	Busyness	Fractal dimension	No. clusters	No. colors
0	2.53647	0.450885	0.0131579	0.661315	1.96163	20	2441
1	2.57566	0.404834	0.0227273	0.611727	4.71926	12	1027
2	2.78164	0.438416	0.013245	0.660755	2.14959	19	2436
3	2.47713	0.454494	0.0168067	0.639943	4.65406	16	1230
4	2.51205	0.435782	0.016	0.644344	2.2737	16	1548
5	2.48444	0.442439	0.018018	0.633624	4.3415	12	1310

The execution times for the operation mentioned below are:

Operation	Time elapsed
KSW on RGB	00:00:735
KSW and Minimum Error	00:04:422
MultiSpace thresholding	00:02:156
HMT	00:00:390
Texture-related features	00:13:750

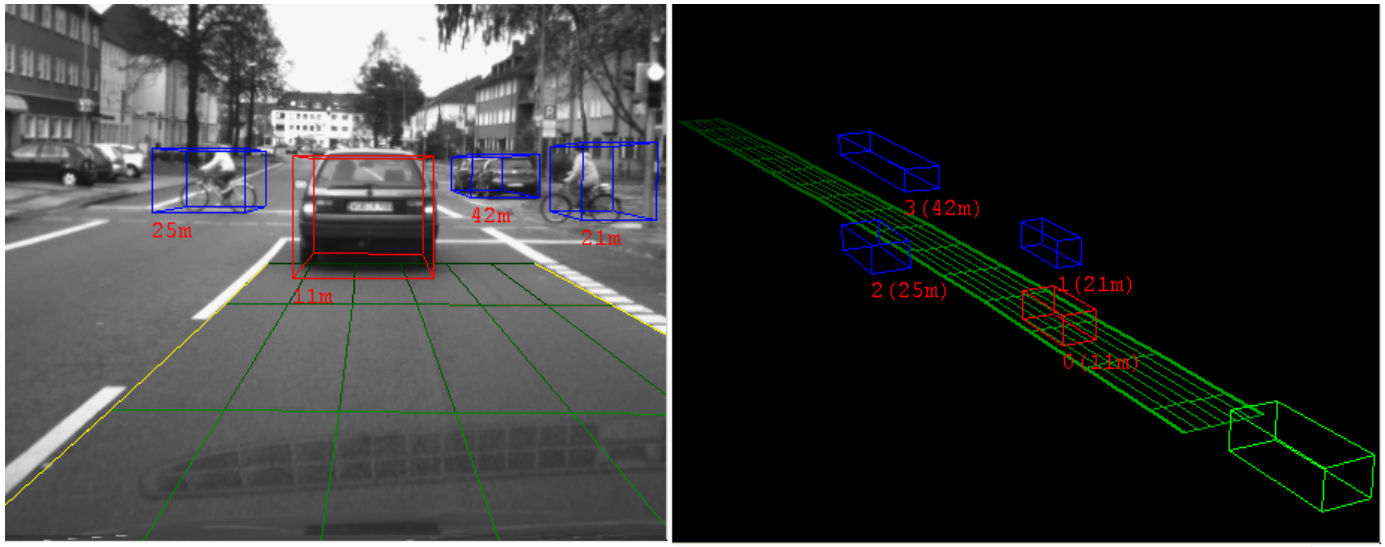
SVR

oca

ent

Examples of applications

Objects detection and road modeling in automotive scenarios

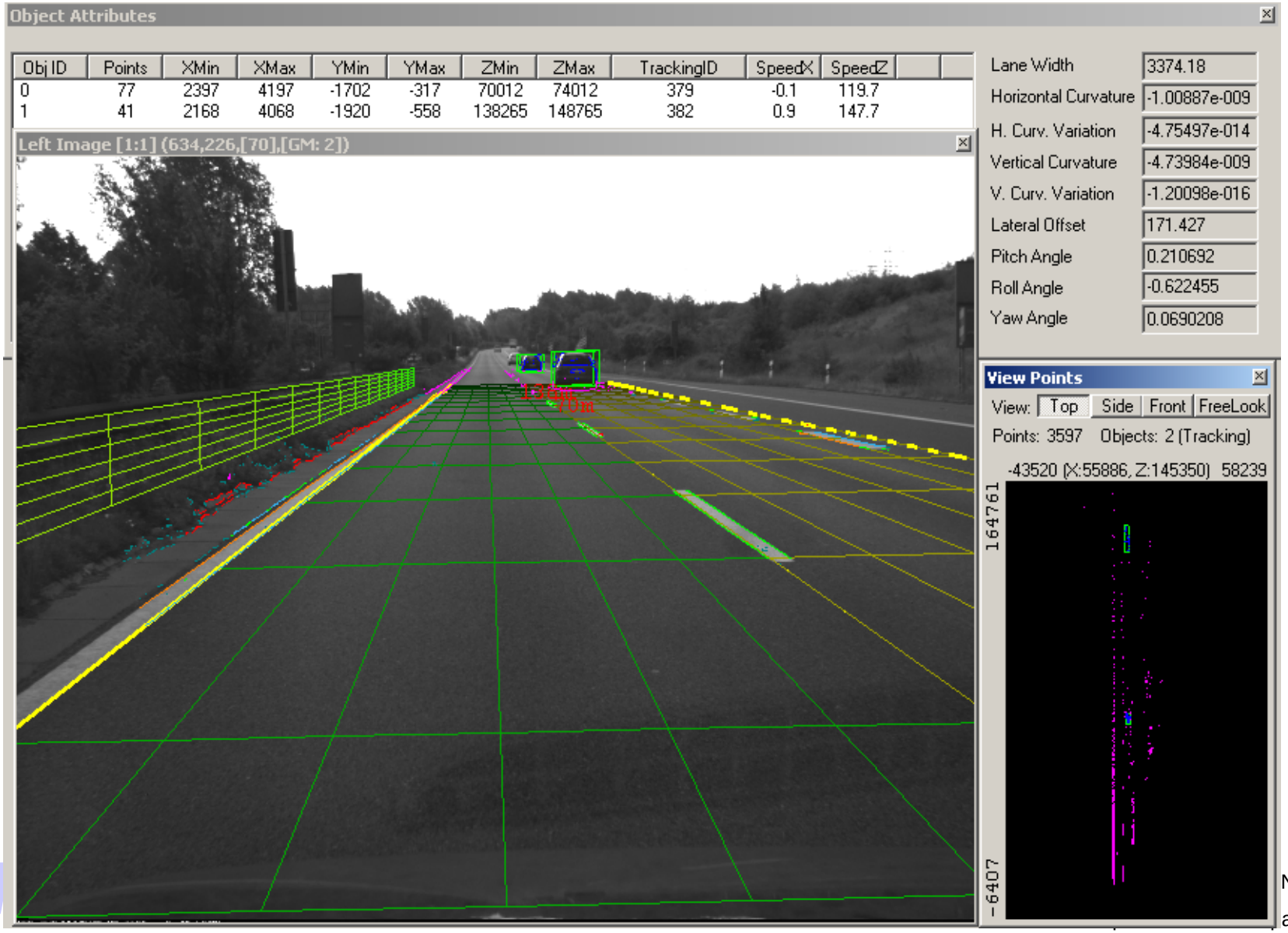


Object Attributes

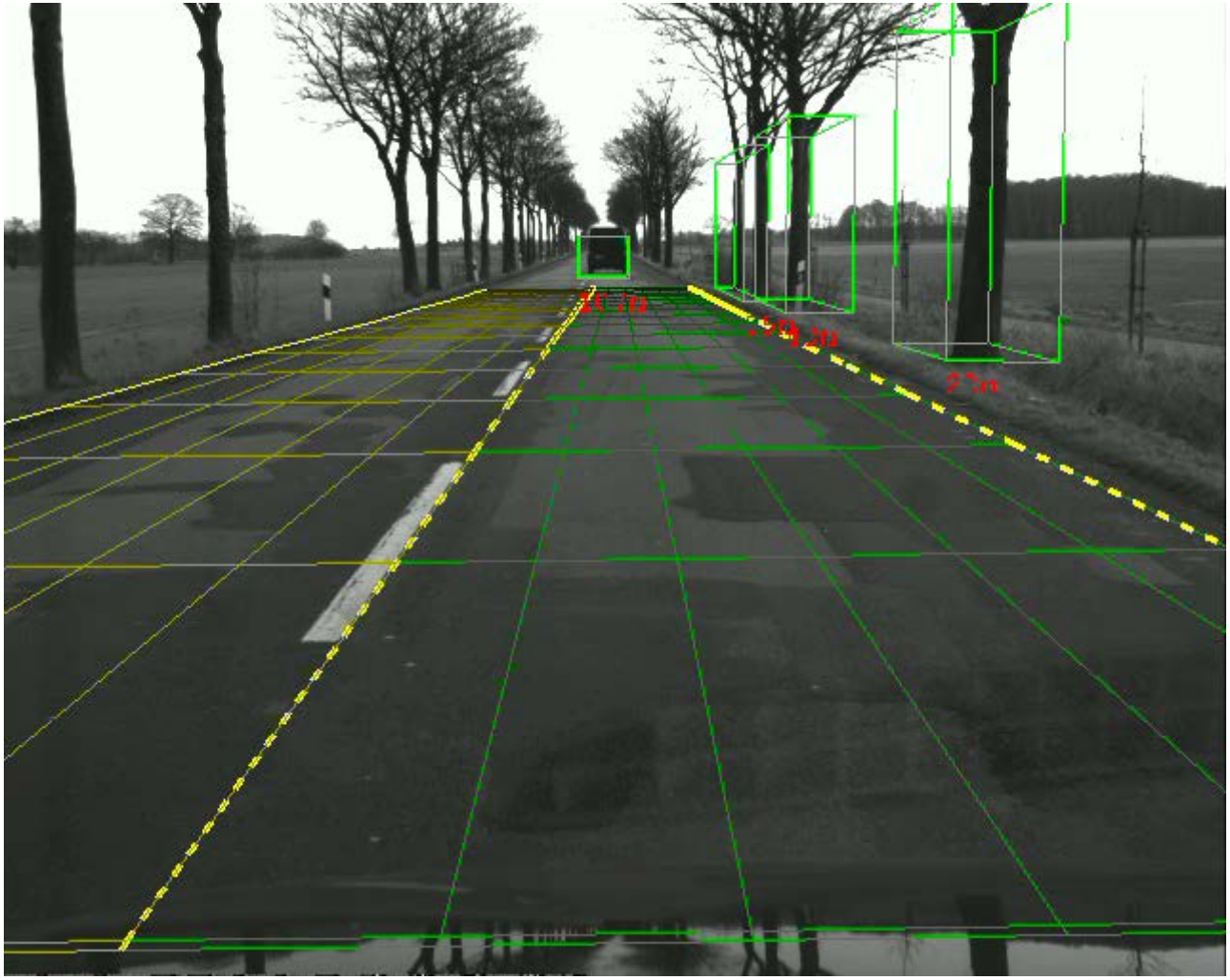
Obj ID	Points	XMin	XMax	YMin	YMax	ZMin	ZMax	TrackingID	SpeedX	SpeedZ
0	0	-1232	367	-1366	33	11980	15980	1	0.2	-0.9
1	459	3600	5020	-1716	-229	21720	26260			
2	312	-5440	-3340	-1685	-220	25320	30120			
3	366	2940	5420	-1707	-146	42660	56840			

		Units
Lane Width	3548.7	mm
Horizontal Curvature	-8.28237e-007	rad/mm
H. Curv. Variation	0	rad/mm^2
Vertical Curvature	0	rad/mm
V. Curv. Variation	0	rad/mm^2
Lateral Offset	-226.14	mm
Pitch Angle	-0.155341	tan(Ang)
Roll Angle	-0.0736862	tan(Ang)
Yaw Angle	0.466067	tan(Ang)

Examples of applications

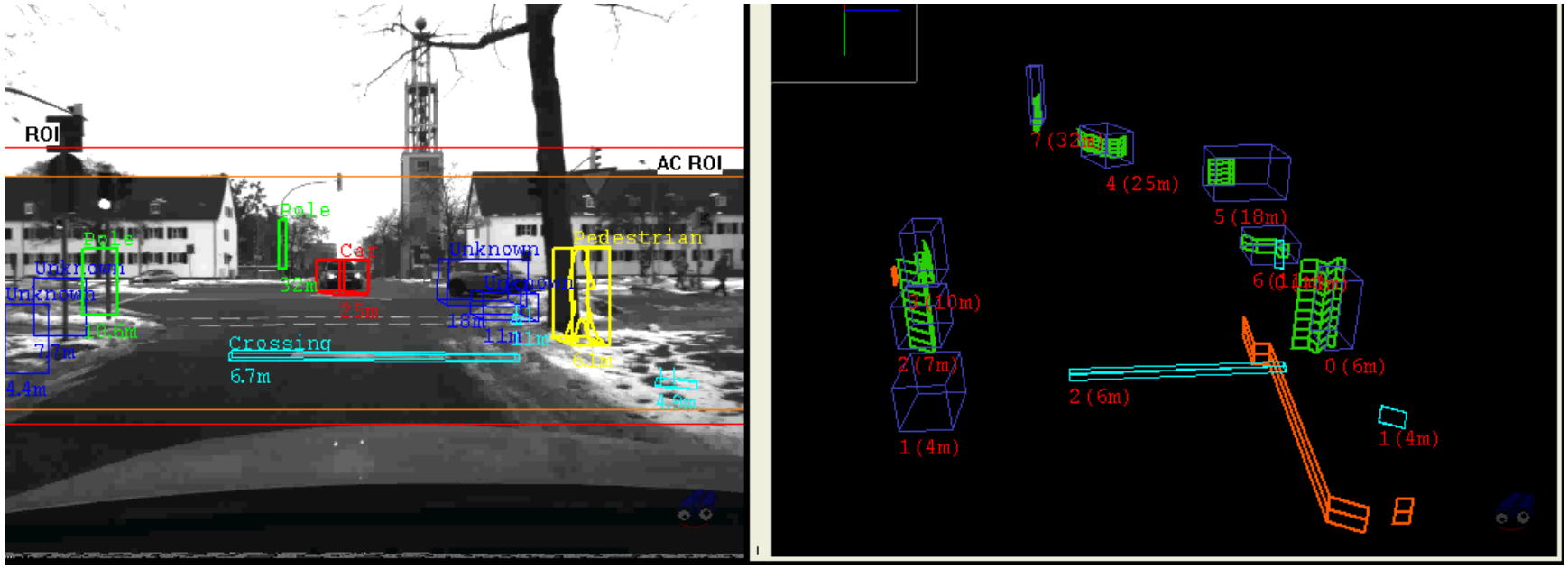


Examples of applications



Examples of applications

Objects detection and road modeling in automotive scenarios



Examples of applications

Perceptual interfaces – HCI /Human Computer Interaction)

Pranav Mistry at TED; The Sixth Sense

http://www.ted.com/talks/pranav_mistry_the_thrilling_potential_of_sixthsense_technology.html