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University of Maribor

FERI

Faculty of Electrical
Engineering
and Computer Science
Smetanova ulica 17
SI-2000 Maribor, Slovenia

Peter Planinšič and Rajko Svečko

Peter Planinšič
and
Rajko Svečko

Research and education activities at the faculty of Electrical Engineering and Computer Science in Maribor

Laboratory for Signal Processing and Remote Control

University of Maribor
www.um.si/en

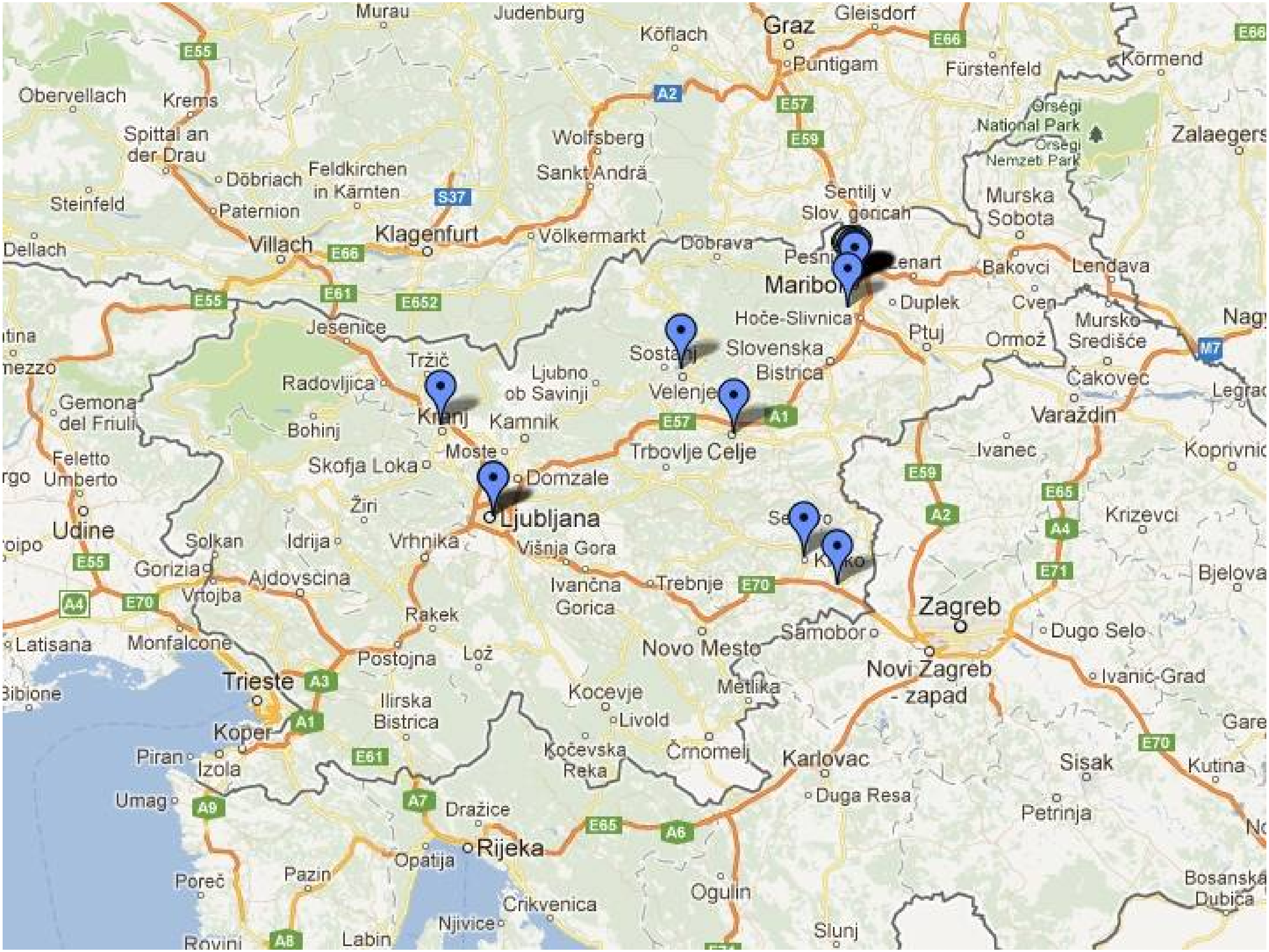
- *Key activities*
  - *Education*
  - *Research and development*
  - *Innovations*

- *Key figures*
  - University of Maribor is the second biggest and the second oldest university in Slovenia, composed by 17 faculties, offers undergraduate and postgraduate Bologna study programmes.
  - About 2000 employers
  - Around 18 000 students study at the University of Maribor. …

Rectorat building in city Maribor




Maribor and surrounding


Murau
Judenburg
Graz
Gleisdorf
Köflach
Puntigam
Fürstenfeld
Körmend
Obervellach
Krems
Spittal an der Drau
Wolfsberg
Sankt Andrä
Feldkirchen in Kärnten
Döbriach
Paternion
Steinfeld
Villach
Klagenfurt
Völkermarkt
Dobrava
Šentilj v Slov. goricah
Murska Sobota
Zalaegers
Lenart
Bakovci
Lendava
Dellach
Maribor
Duplek
Hoče-Slivnica
Ptuj
Ormož
Cven
Mursko Središće
Čakovec
Varaždin
Jesenice
Tržič
Radovljica
Ljubno ob Savinji
Velenje
Slovenska Bistrica
Gemona del Friuli
Bohinj
Kranj
Kamnik
Trbovlje
Celje
Ivanec
Koprivnic
Moste
Skofja Loka
Domzale
Feletto Umberto
Udine
Žiri
Ljubljana
Solkan
Idrija
Vrhnika
Višnja Gora
Krizevci
Gorizia
Ajdovscina
Vrtojba
Ivančna Gorica
Trebnje
Bjelova
Zagreb
Latisana
Monfalcone
Rakek
Novo Mesto
Samobor
Dugo Selo
Postojna
Lož
Novi Zagreb - zapad
Ivanić-Grad
Trieste
Ilirska Bistrica
Kocevje
Livold
Metlika
Koper
Piran
Izola
Kočevska Reka
Črnomelj
Karlovac
Sisak
Kutina
Umag
Dražice
Duga Resa
Petrinja
Rijeka
Opatija
Poreč
Pazin
Ogulin
Crikvenica
Njivice
Labin
Slunj
Rovinj
Bosanska Dubića
Bibione
E55
E66
A2
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S37
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E652
E65
A1
M7
E71
A4
E70
A3
A9
A7
A6
A8

Faculty of Electrical engineering and Computer Science www.feri.um.si/en

- *Key activities*
  - *Education*
  - *Research and development*
  - *Innovations*
- *History*
  - *The Faculty of Electrical Engineering and Computer Science (acronym FERI) has its origins in the two-year Junior Technical College founded in 1959*
- *Study programmes*
  - *Bachelor's Bologna programmes were introduced in the academic year 2007/2008. Two separate types of study programmes: academic and professional.*

The Faculty of Electrical Engineering and Computer Science
at the University of Maribor (UM FERI)
is one of the leading teaching
and research institution in the field of Electrical Engineering and Computer Science
in Slovenia.

- *Research and education*
  - *Academic and research work is conducted at the following institutes:*

    Institute of automation, *Institute of electronics and telecommunications,, Institute of power engineering, Institute of robotics, Institute of computer science, Institute of informatics, Institute of media communications, Institute of mathematics and physics*
- *Research*
  - *Registered also as Research organization incorporating 14 research units and 8 research programmes*
- *Key figures*
  - About 300 employers
  - About 2000 students in the academic year 2015/2016

Teachers at CEEPUS III-program CII-BG-1103-01-16717

Prof. Rajko Svečko ,PhD(coordinator at UM FERI):
- **Modern Control Theory**
- **System Theory**

Prof. Peter Planinšič,PhD:
- **Modern Signal Processing**

Prof. Dušan Gleich,PhD:
- **Remote Sensing**

Prof. Marjan Golob,PhD:
- **Nonlinear Systems Identification**

Contact persons

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Research and education activities in the Laboratory for signal processing and remote control

Rajko Svečko

Courses:

-Control Theory

-System Theory

-Artificall inteligence in control

Researc Topics:

-Control and system theory

- Artifical inteligence in control

- **Robust contol theory**

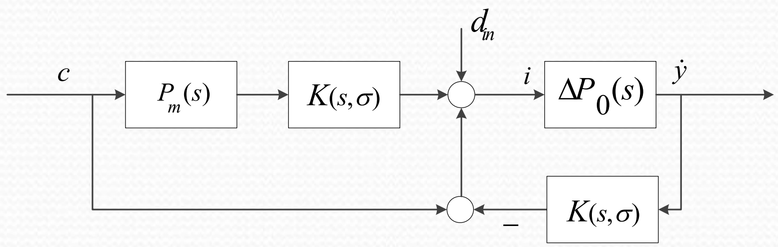
Robust Control Theory

Research interests:

- Adaptation of the robust control paradigms in to a classical control approaches and structures as a: industrial PID, PI, PD structures.
- Developing Mixed approach structure in light of robust theory with H_∞, H_2 matrices. Mixed structure with state space framework and I/O transfer functions.
- Design and analysis of the nonlinear controller structures with additional performances metrics as a; robust stability and time performances.
- Multi objective optimization procedure of the control structure based on different heuristic technique (Genetic Algorithm, Differential evolution, Particle swarm optimization etc..)
- Design and implementation of the proposed algorithms on the embedded system, MCUs with DSP capability and FPGAs.

Robust pole assignment technique

The extended version of the pole assignment method with additional multi-objective optimization technique over spectral polynomials has been developed. The method provides higher degree of freedom in terms of selecting controller structure, robust stability assessment and preselected time performance. The method was already tested on different laboratory and industrial application.

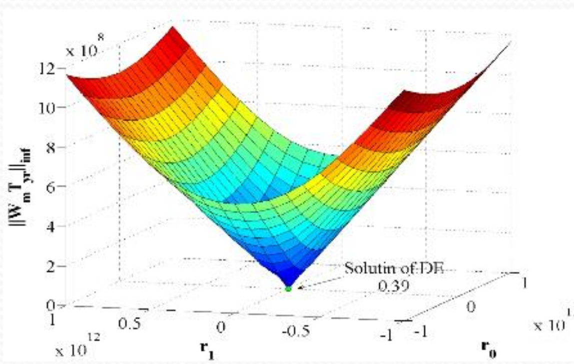


Extended pole assignment method with free parameters:

$$A_0(s)R_K{}'(s)\prod_{k=1}^{\tilde{p}}\left(s+\sigma_k\right)+B_0(s)L_K(s)=C_{in}(s),$$

$$A_0(s)R_K(s,\sigma)+B_0(s)L_K(s)=C_{in}(s).$$

Optimization space of the spectral polynomial:



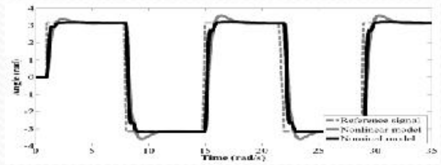
Robust stability criteria and derived spectral polynomial:

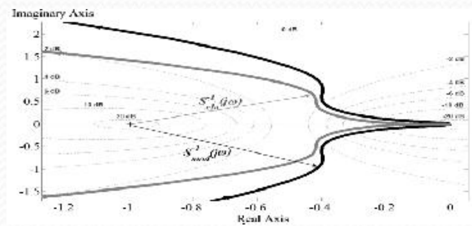
$$\left\|\Delta W_M \frac{K(\sigma)P_0}{1+K(\sigma)P_0}\right\|_\infty < 1 \quad \forall\left|\Delta(\omega)\right|<1 \quad \omega=\left\{\omega\in \quad \middle|\, 0\le\omega<\infty\right\}.$$

$$\pi_M\left(\omega^2,\sigma\right)=C_{in}w_{aM}(\omega^2)-B_0L_K w_{bM}(\omega^2,\sigma)>0,$$

Applications

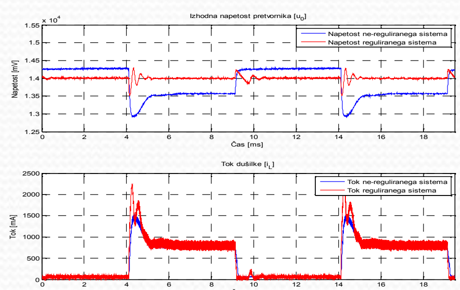
Design of the modified disturbance observer on the servo system.

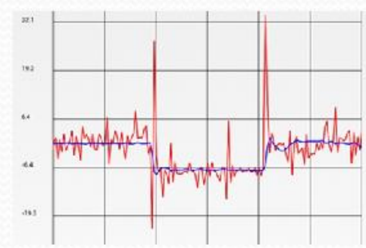




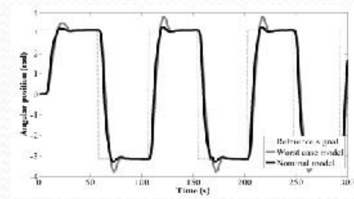
Balanced robot with 3dof IMU.

DC-DC boost controller on FPGA.

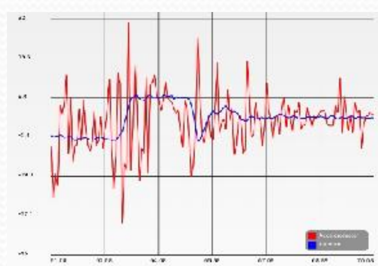


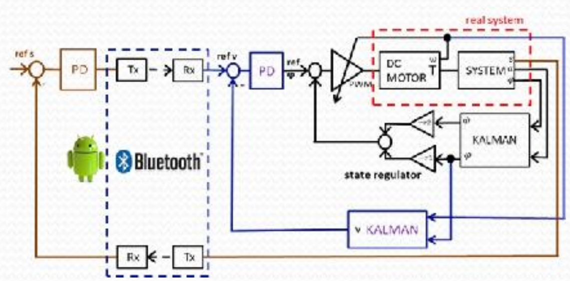


Ball on the plate with touch screen sensor.



Ballbot with 9dof IMU and robust 2dof controller.





Peter Planinšič
Dušan Gleich

Teaching Courses:

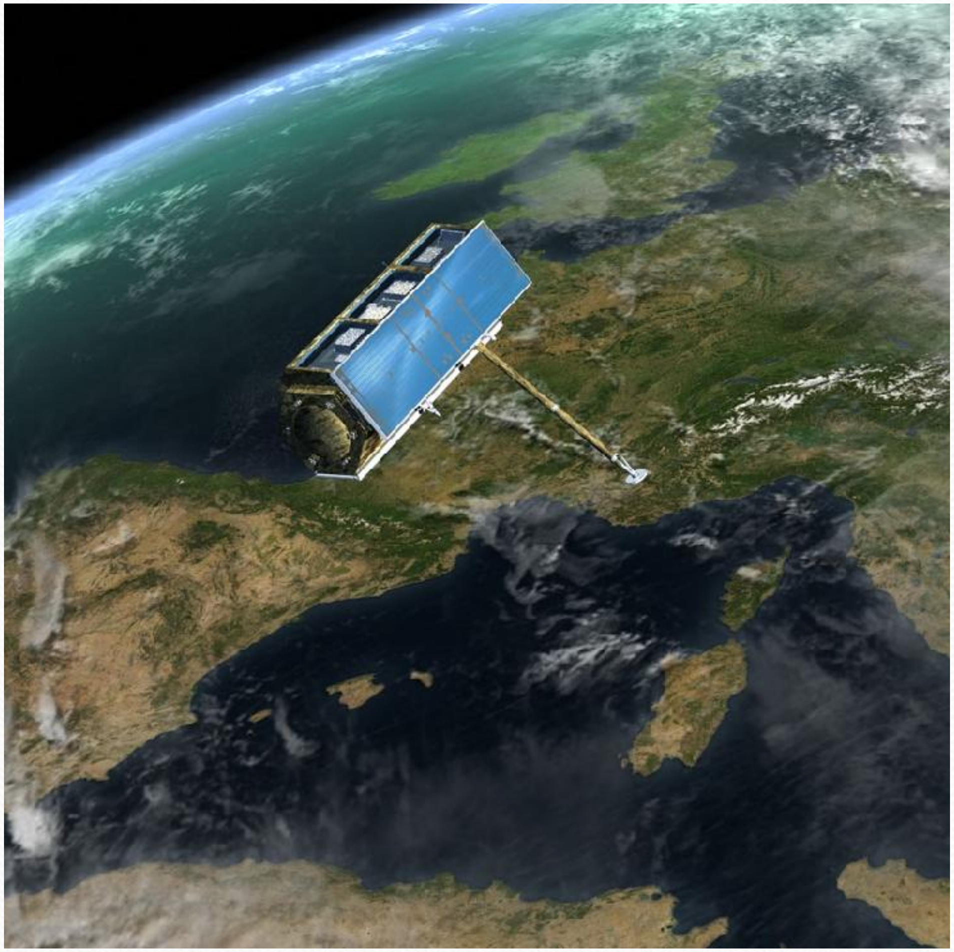
- Signal processing
- Machine vision
- Communication in Automation
- Machine vision
- Advanced signal processing
- Remote sensing

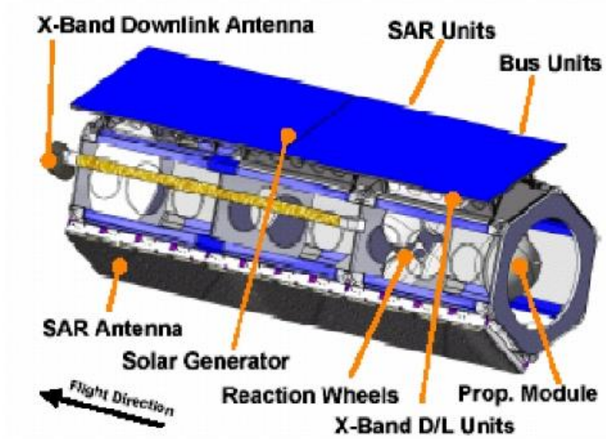
Key Research Topics:

- Signal and Image/Video Processing and Coding
- **Remote sensing using satellite SAR (Synthetic Aperture Radar)- images analyses**
- **Localization techniques using RF radars**
- Localization techniques usin wireless sensor networks (WSN)

Research activities using Synthetic Aperture Radar (SAR) Images analysis

Synthetic Aperture Radar satellite – TerraSAR-X (june 2007)

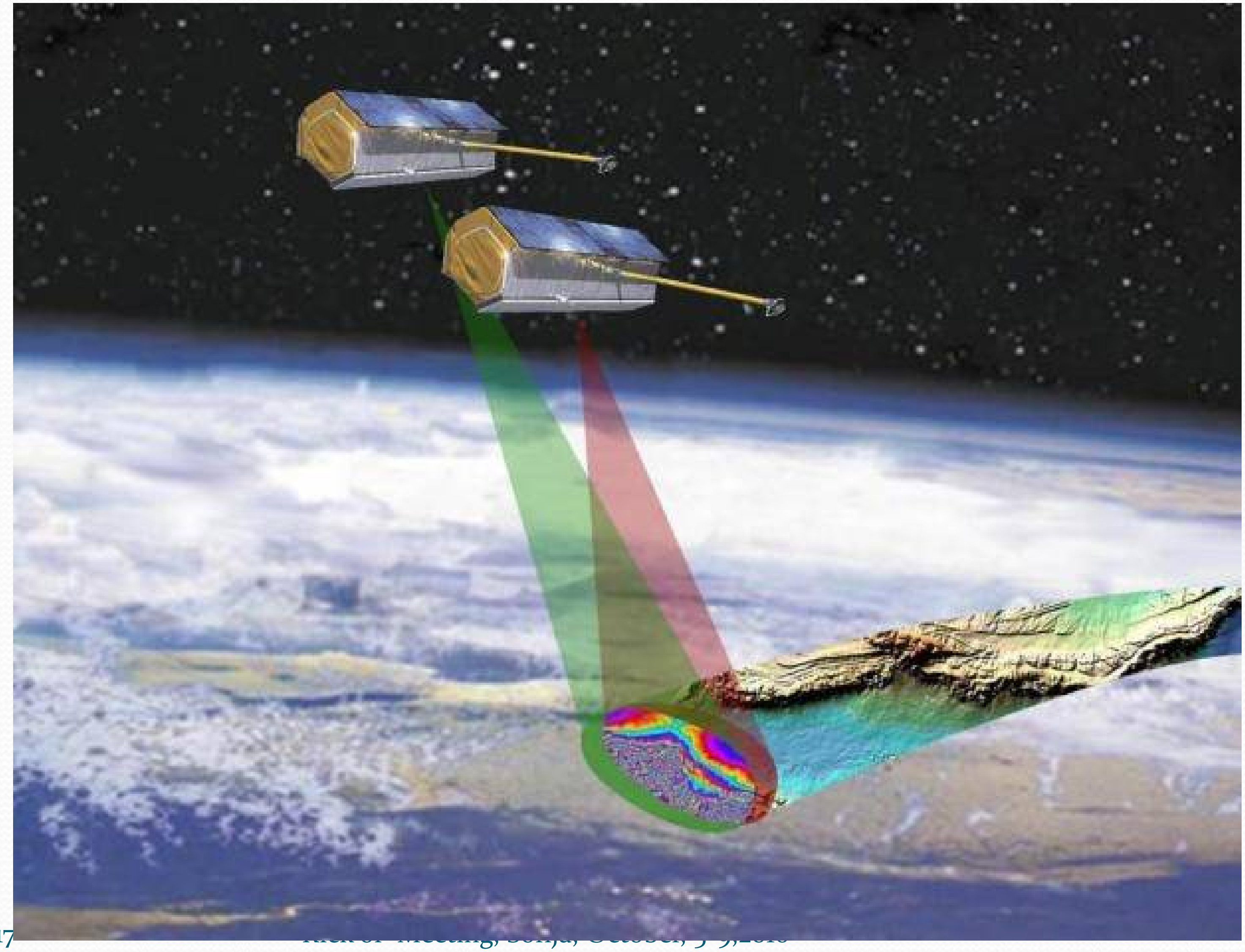




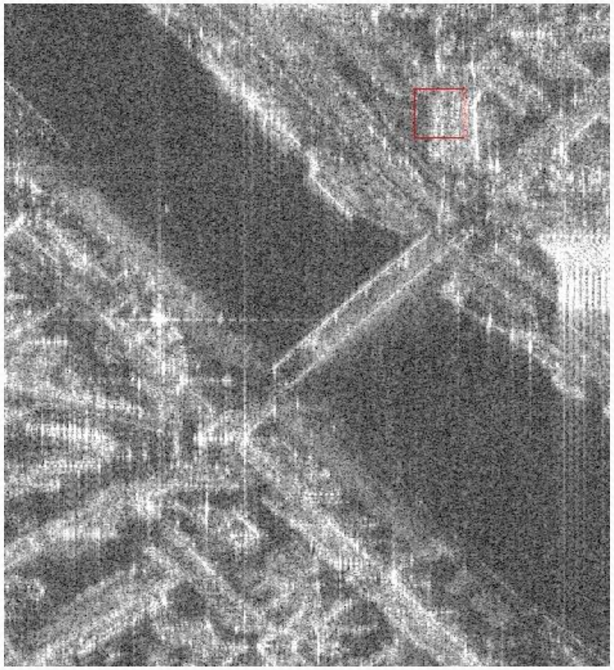
Height 5.0 m
Weight 1.230 kg
incl. payload mass 394 kg
SAR Antenna 4.8 m x 0.7 m x 0.15 m
Resolution 1 m @ 5 x 10 km Scene
Power consumption 800 W average
Data storage 256 Gbit Data
transmission 300 Mbit/s X-Band
Repetition rate 11 days
Life time 5 years
Altitude 514 km
Repeat Cycle 11 days
Max. Resolution 1 m (HR spotlight)

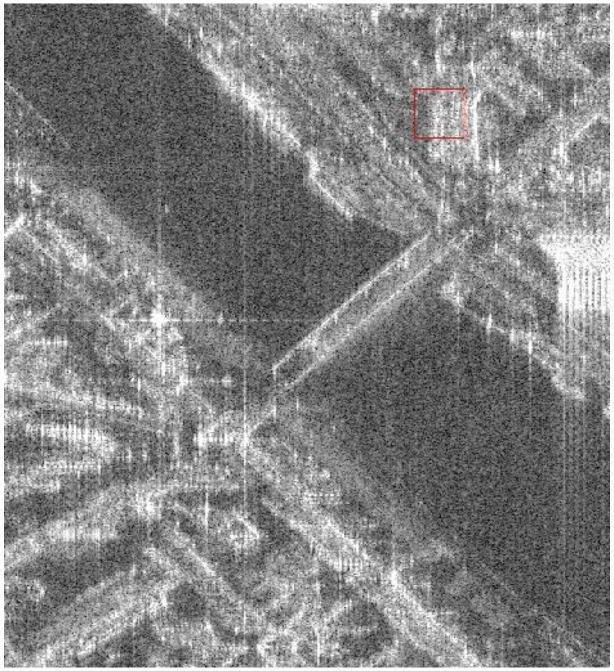
Satellite SAR-image of city Maribor

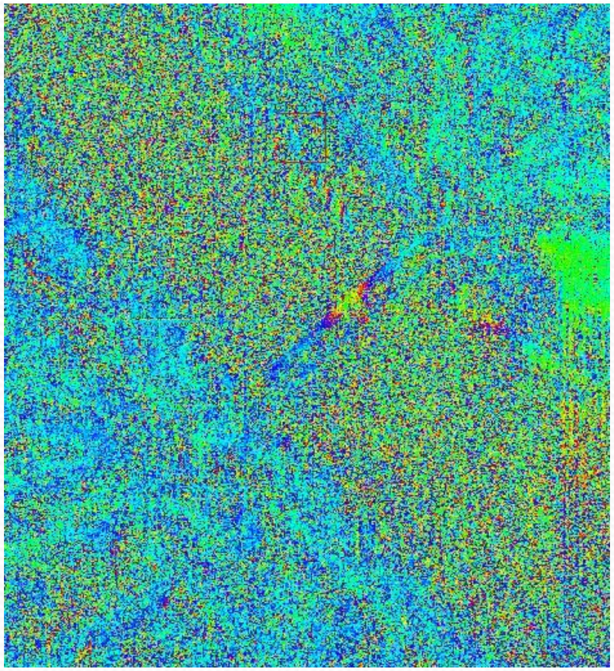
Tandem-X (2010)



Repeating pass interferometry using TerraSAR-X, Doris







- 11 days difference, Paris, January 11th and 22nd 2010

Researc projects

1996-2000: Compression of complex-valued – focused - SAR data

- Colaboration with German Aerospace Center
    - Developed Wavelet based encoder

2004-2005 Marie Curie felllowship at German Aerospace Center, Oberpffafenhofen

DAAD Fellowships in 2009 and 2012

Projects:

2005-2007: Remote sensing laboratory, MORS

2007-2009: Complex-valued scene classification, ARRS

2009-2011: Detection of wet zones using SAR, DEM

2011-2013: Scene categorization, DLR

2009-2014: Monitoring of hydropower station‘s canal using georadar, DEM

2012-2013: Localization accuracy using GPS and SAR data

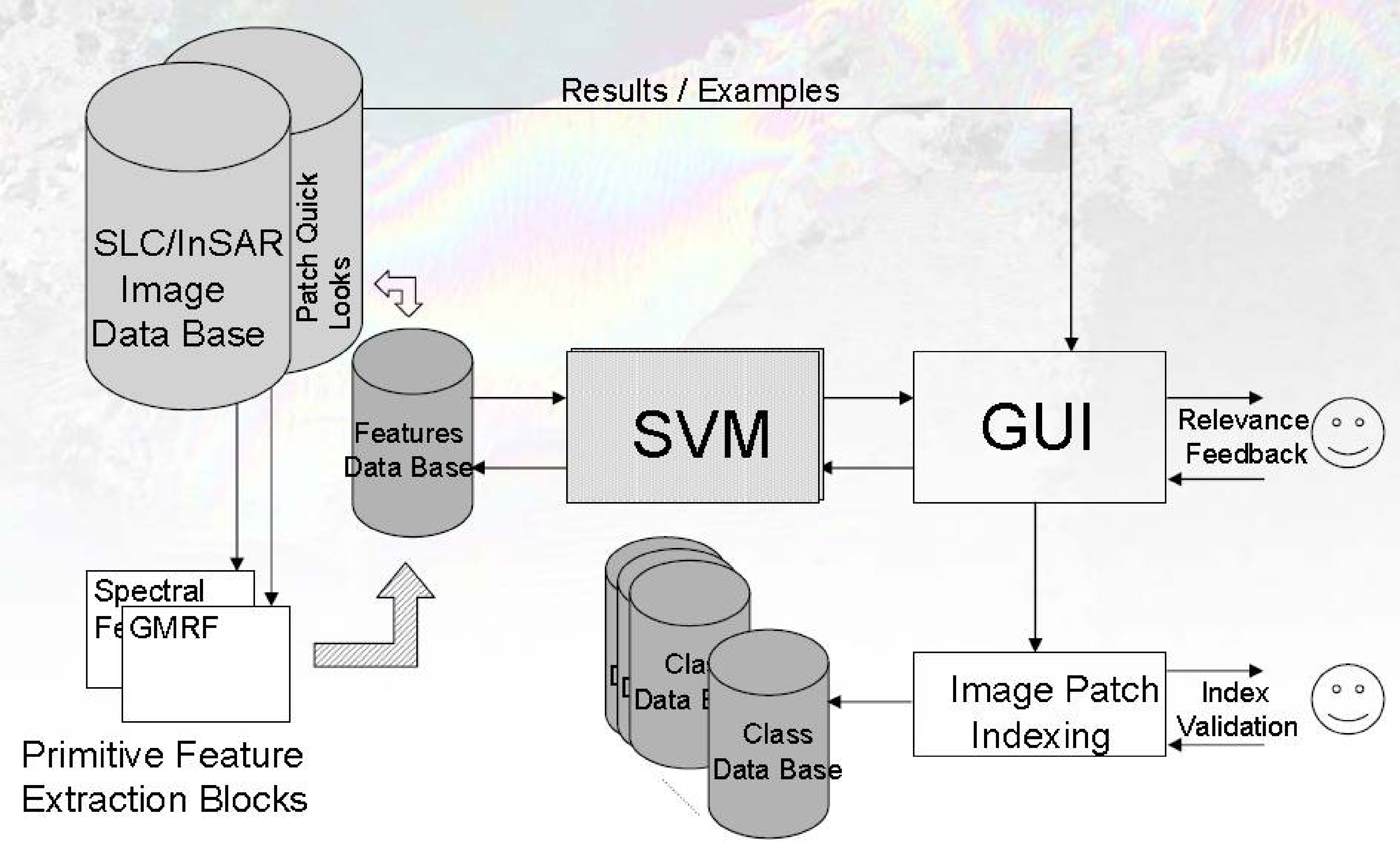
2013-2015: EU projects and computer vision projects

2016- Expression of interests H2020 Space Information Day, Ljubljana

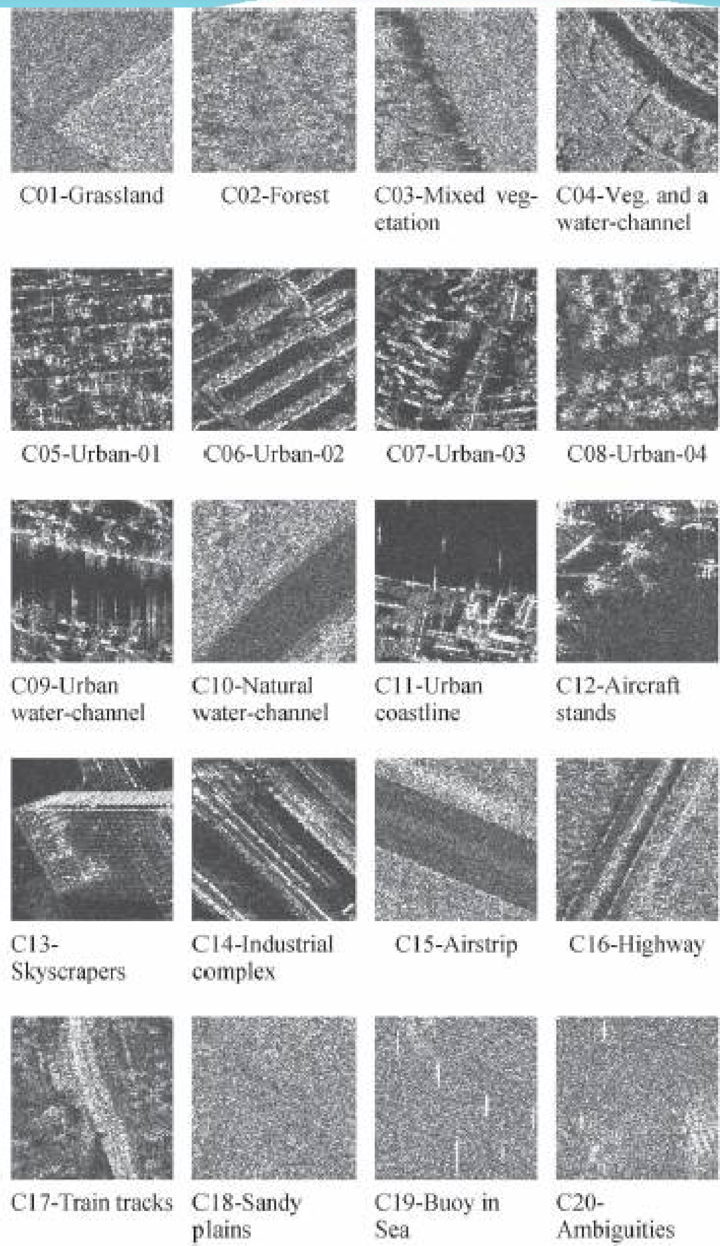
2016- Accepted NASA-project for ground SAR

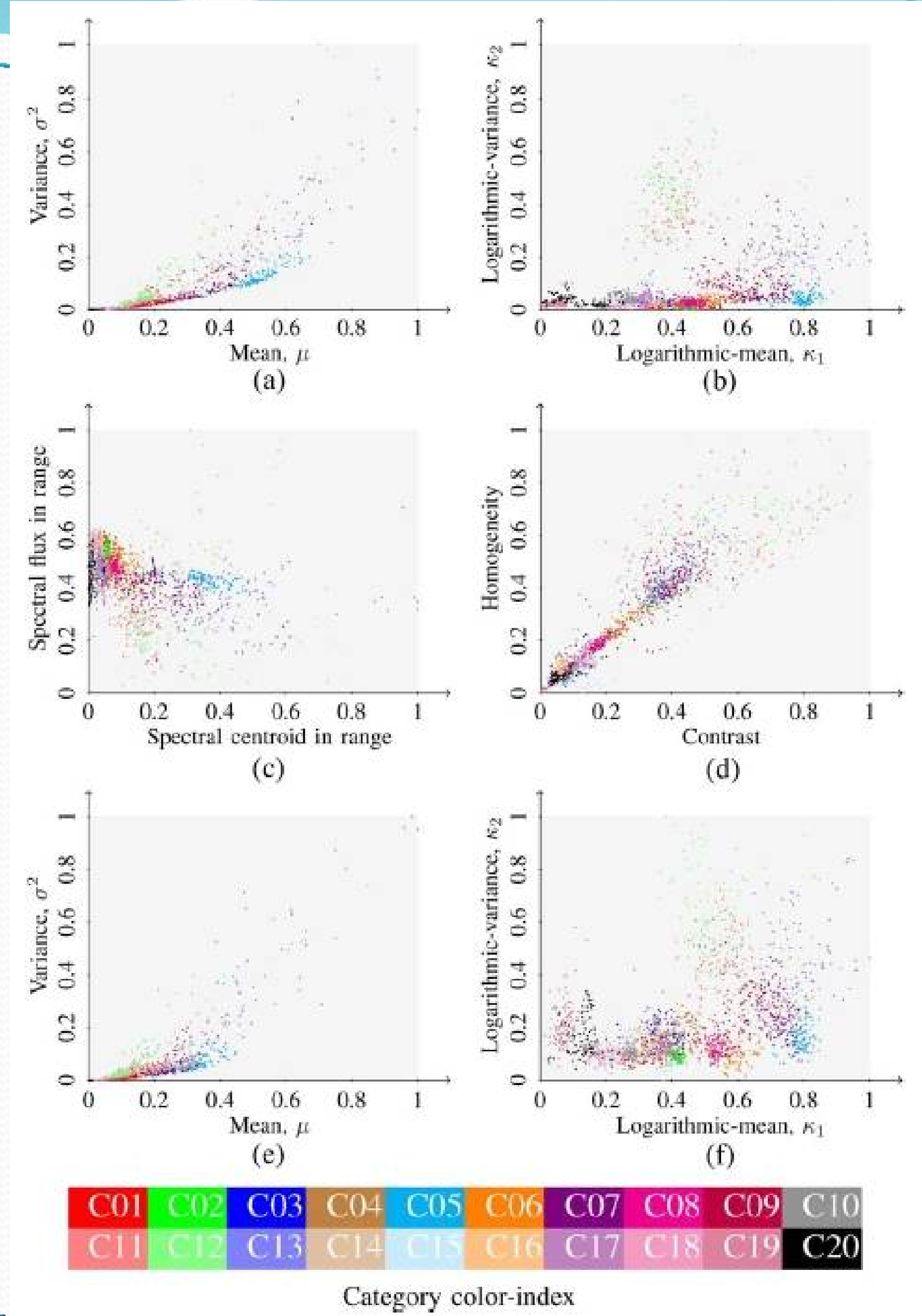
Research on SAR data categorization

Ctegorisation of patch images with 200 x 200 pixels



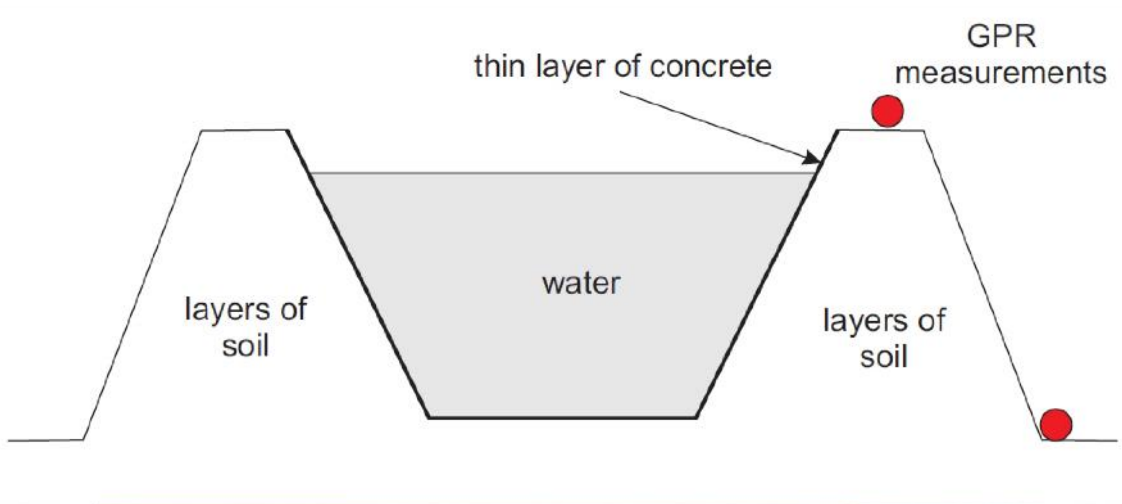
Results / Examples
SLC/InSAR
Image
Data Base
Patch Quick
Looks
Features
Data Base
SVM
GUI
Relevance
Feedback
Spectral
Fe
GMRF
Primitive Feature
Extraction Blocks
Class
Data Base
Image Patch
Indexing
Index
Validation


C01-Grassland
C02-Forest
C03-Mixed vegetation
C04-Veg. and a water-channel
C05-Urban-01
C06-Urban-02
C07-Urban-03
C08-Urban-04
C09-Urban water-channel
C10-Natural water-channel
C11-Urban coastline
C12-Aircraft stands
C13-Skyscrapers
C14-Industrial complex
C15-Airstrip
C16-Highway
C17-Train tracks
C18-Sandy plains
C19-Buoy in Sea
C20-Ambiguities

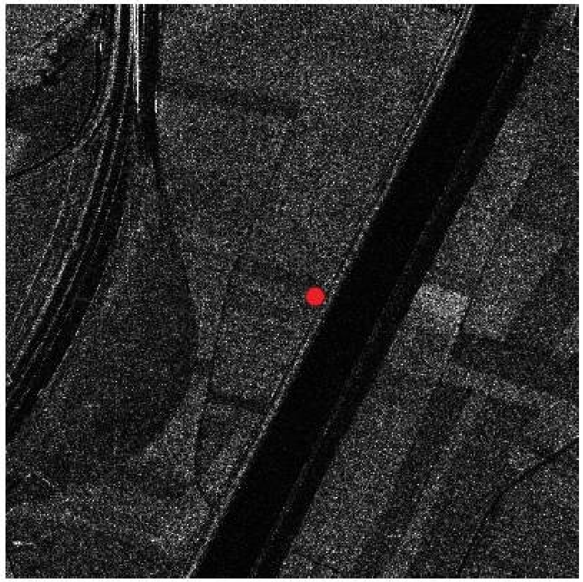

Variance, σ^2
Mean, μ
(a)
Logarithmic-variance, κ_2
Logarithmic-mean, κ_1
(b)
Spectral flux in range
Spectral centroid in range
(c)
Homogeneity
Contrast
(d)
Variance, σ^2
Mean, μ
(e)
Logarithmic-variance, κ_2
Logarithmic-mean, κ_1
(f)
C01 C02 C03 C04 C05 C06 C07 C08 C09 C10
C11 C12 C13 C14 C15 C16 C17 C18 C19 C20
Category color-index

Research on

Soil moisture estimation using wet zones detection with data fusion of Ground Penetrating Radar (GPR)-images and SAR-images

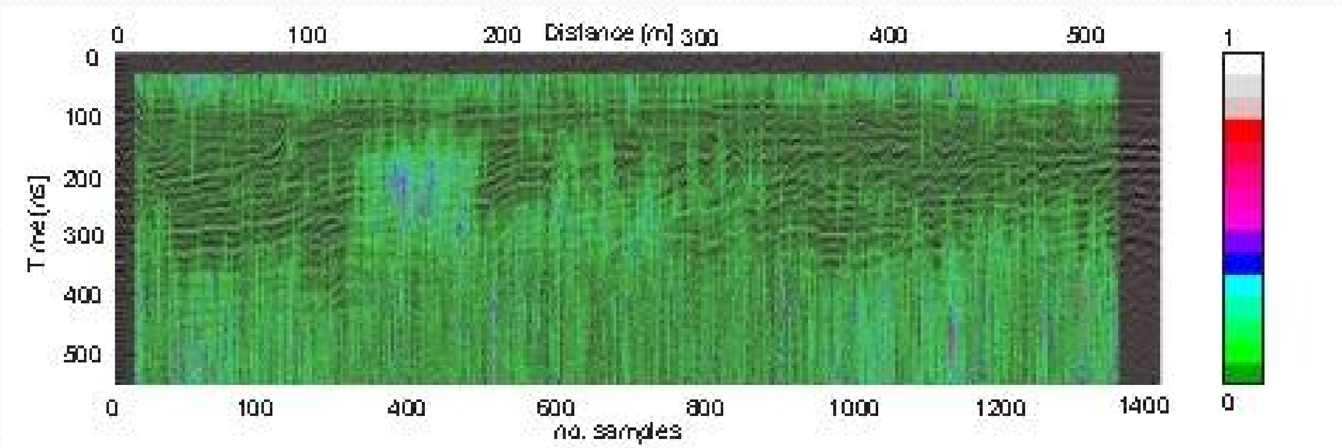


Satellite SAR-image

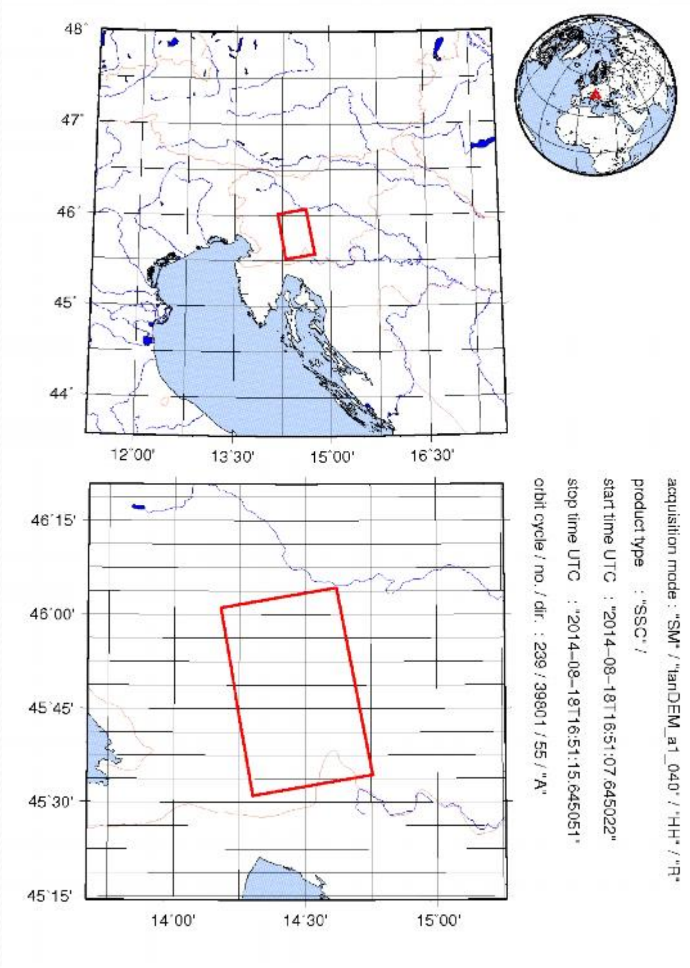


Ground Penetrating Radar (GPR)

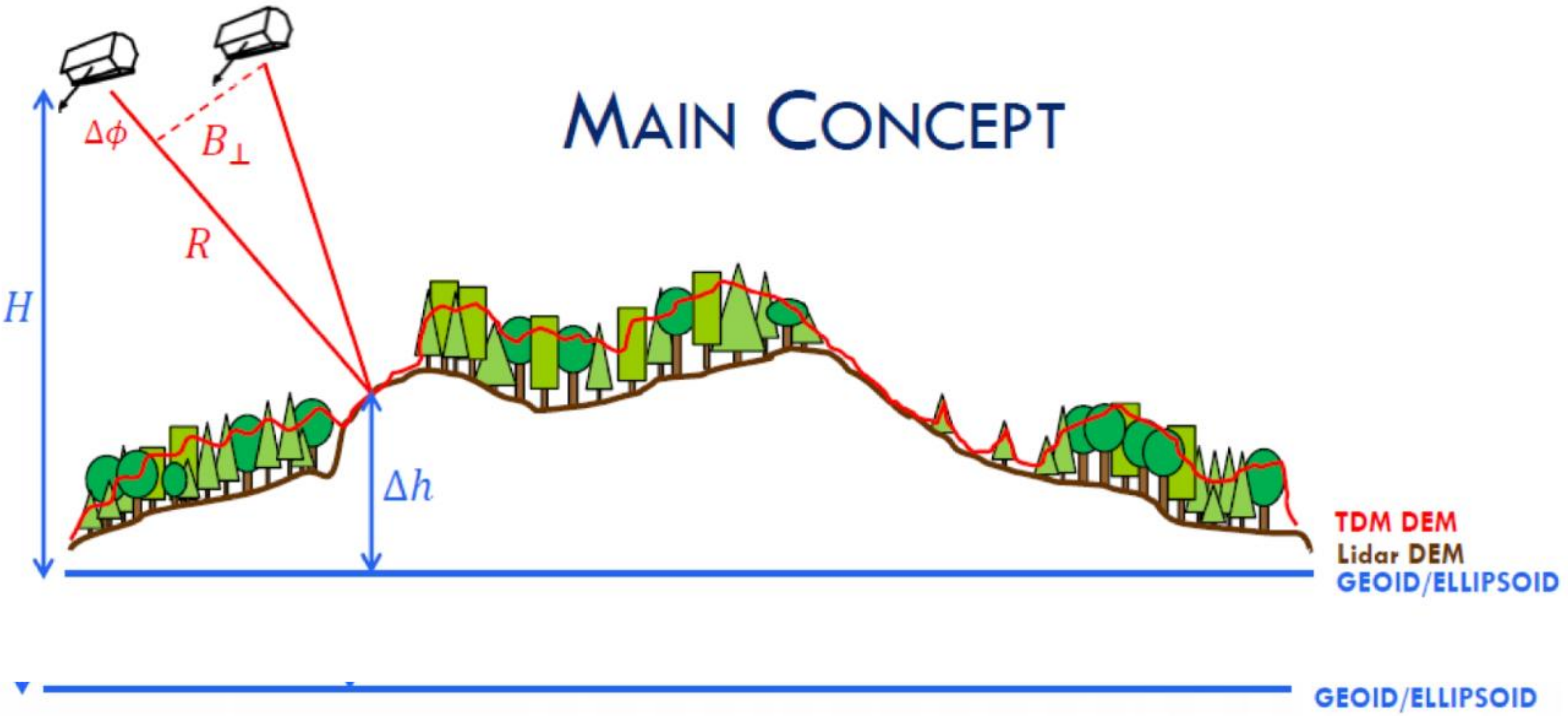
GPR-image



Research on
Change detection using DEM

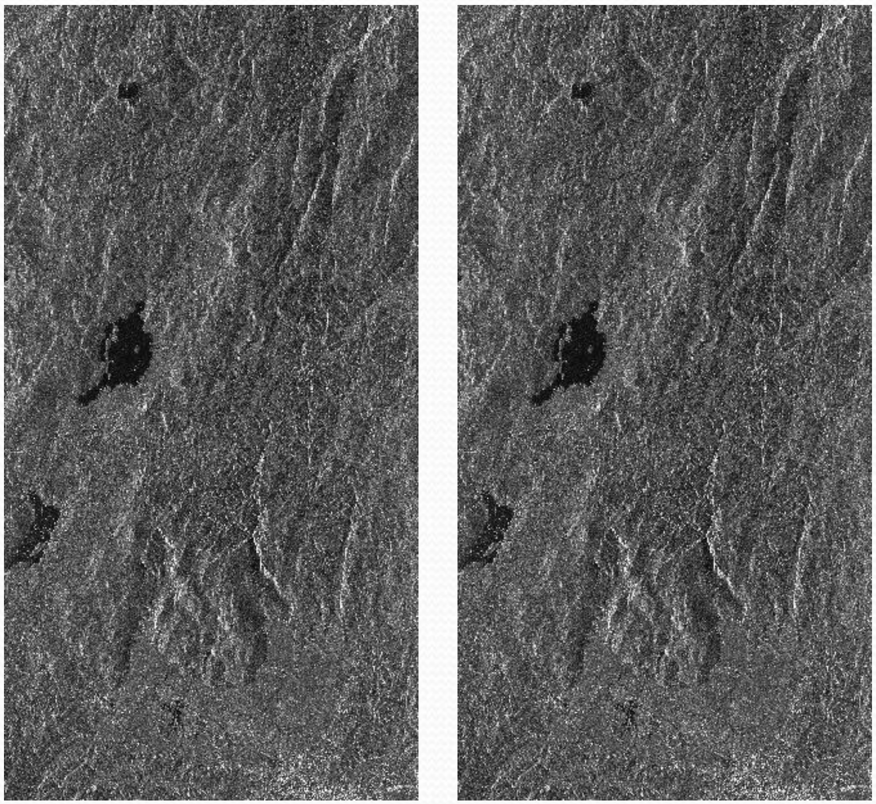


The Main Concept of Change detection using DEM

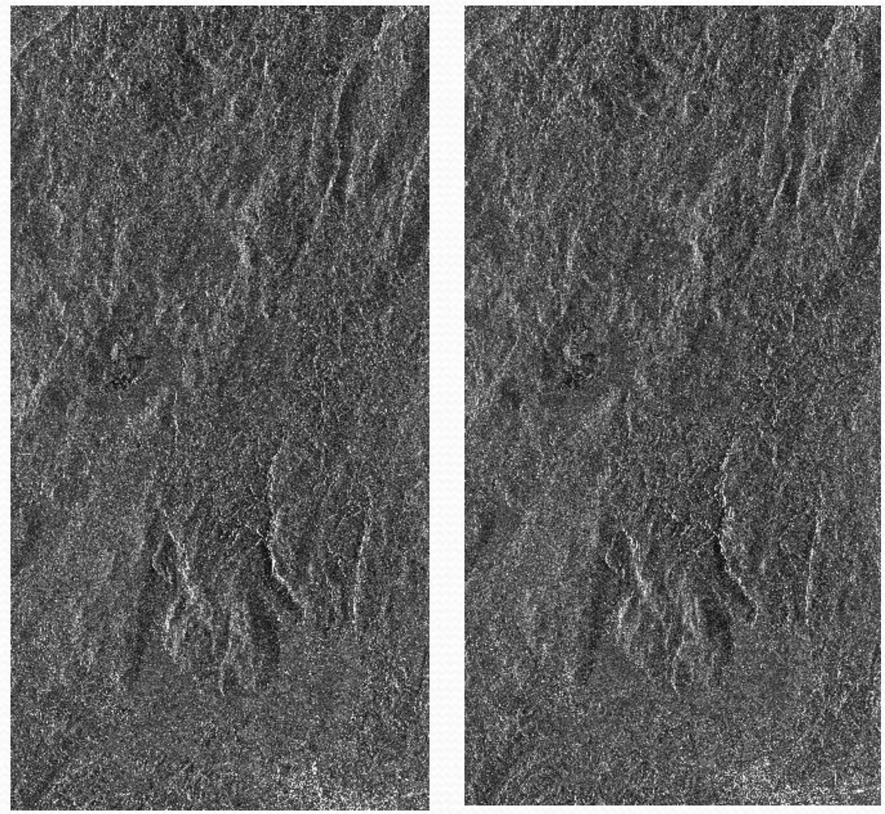


Maciej Soja at all, „Forest Canopy Mapping from Tandem-X Interferometry and High Resolution Lidar DEM“, Tandem-X Meeting, 2013

Tandem-X-images

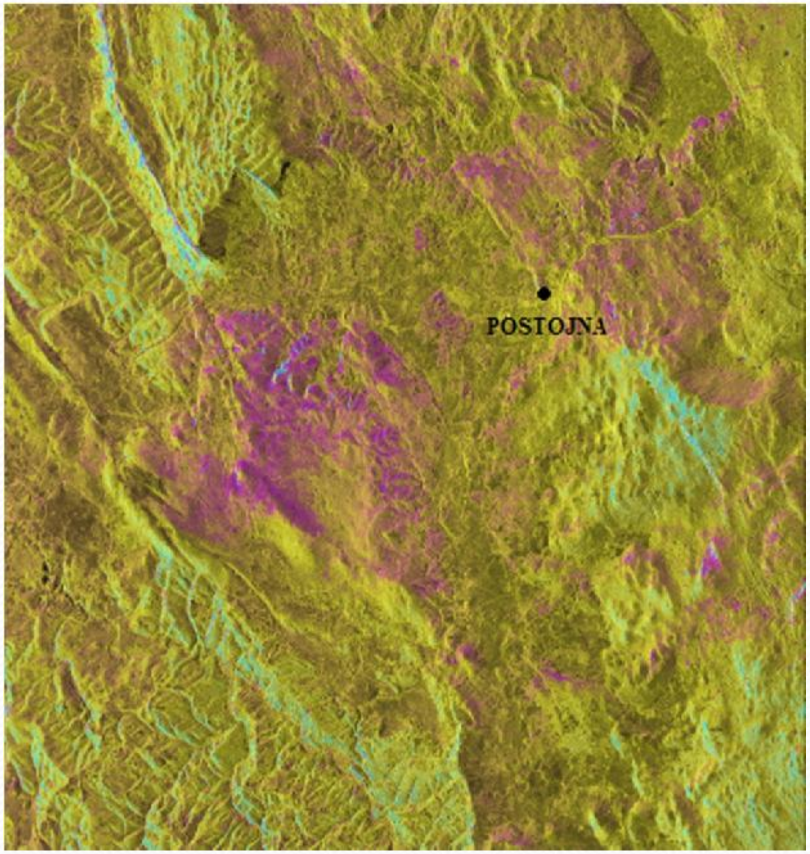


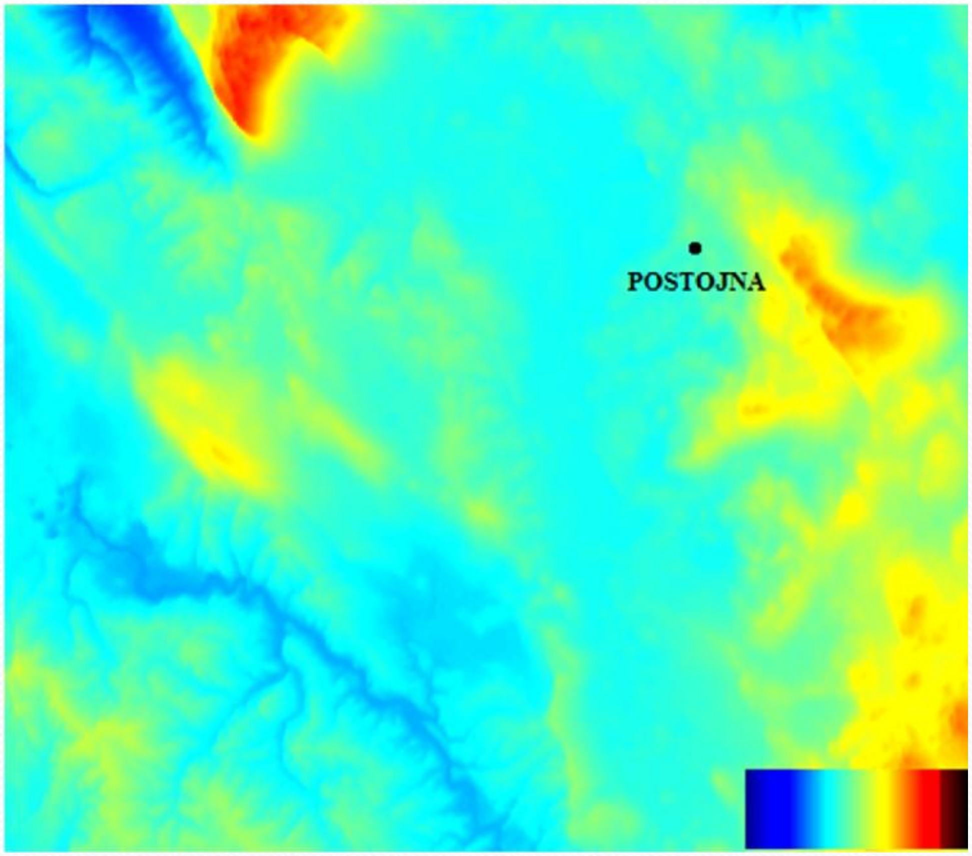
Tandem-x, April 2013



Tandem-x, August 2014

DInSAR



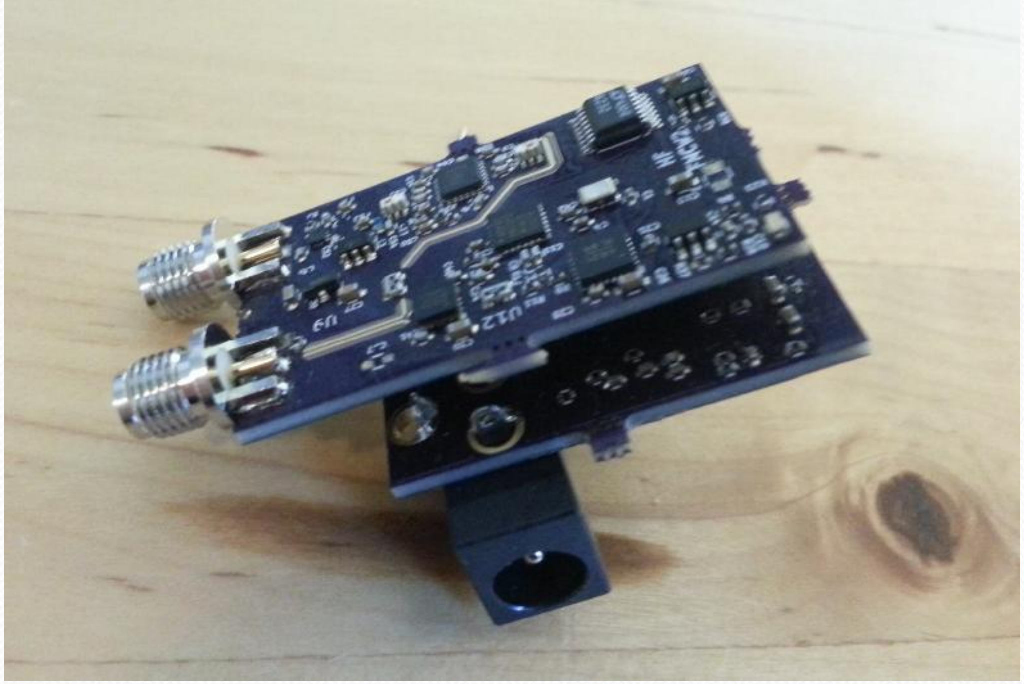


Phase difference

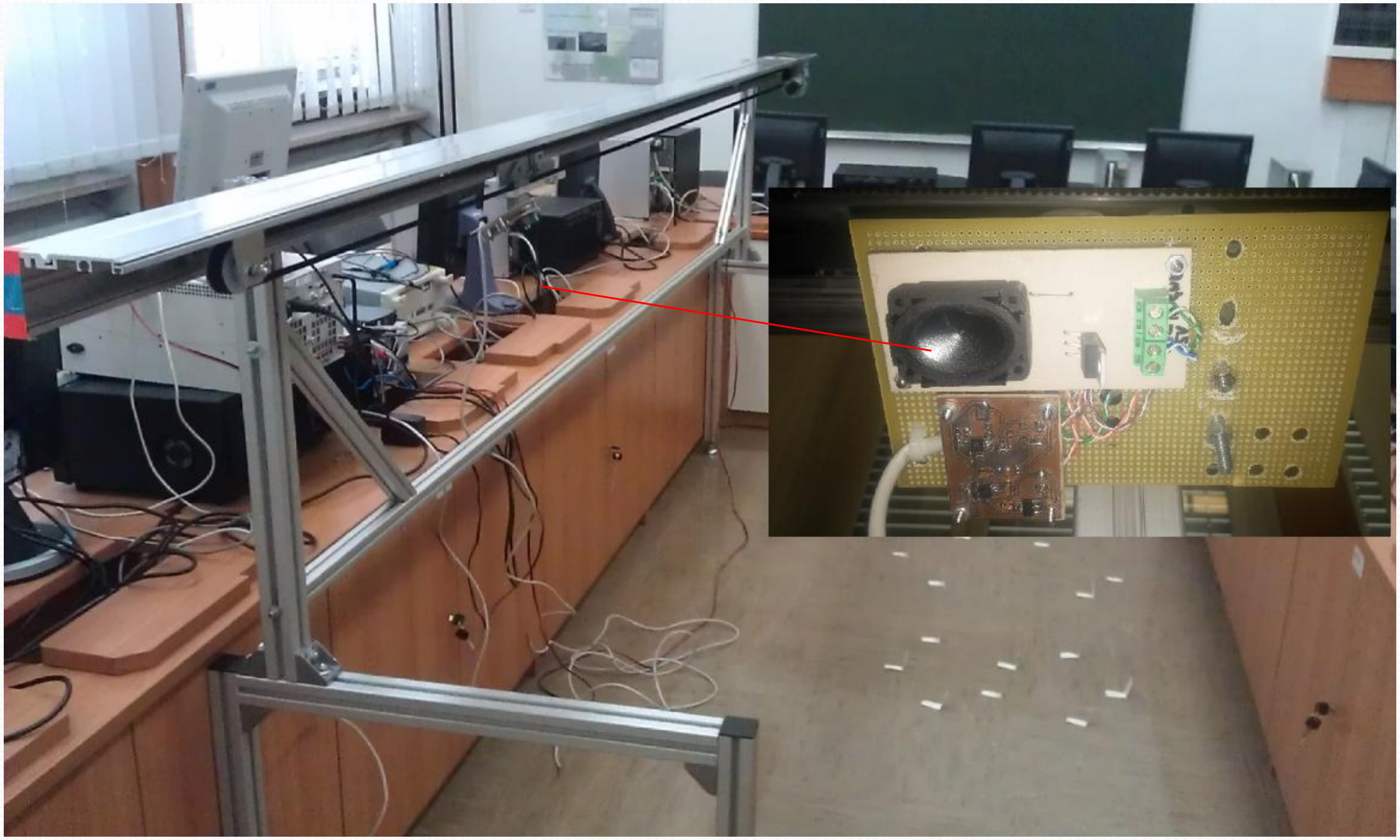
Unwraped phase

Research on
Miniature Ground Synthetic Aperture Radar

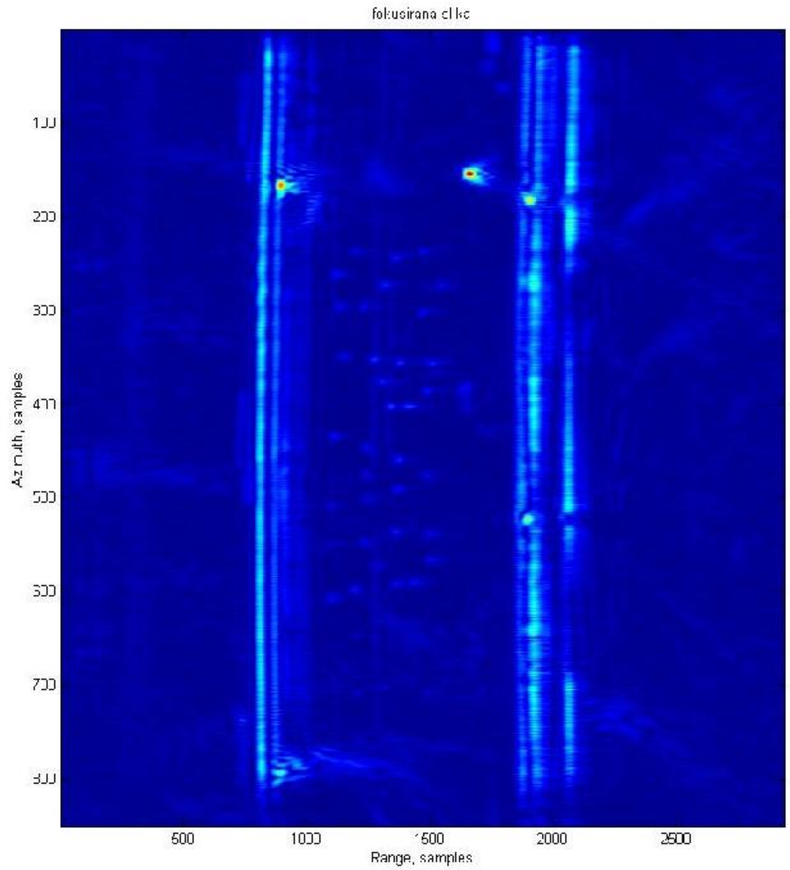
-Developing localization techniques using USRP
-Building Ground Synthetic Aperture Radar
  -Bandwidth 800 MHz
  -Under development



Education of Signal Processing and Remote Sensing:
Ultrasonic SAR built by students



Focused image



Target Localization using Dual Tone Frequency Radar

Dušan Gleich,

Marko Malajner,

Peter Planinšič

IWSSIP 2015, London

Radio Interferometric Positioning System

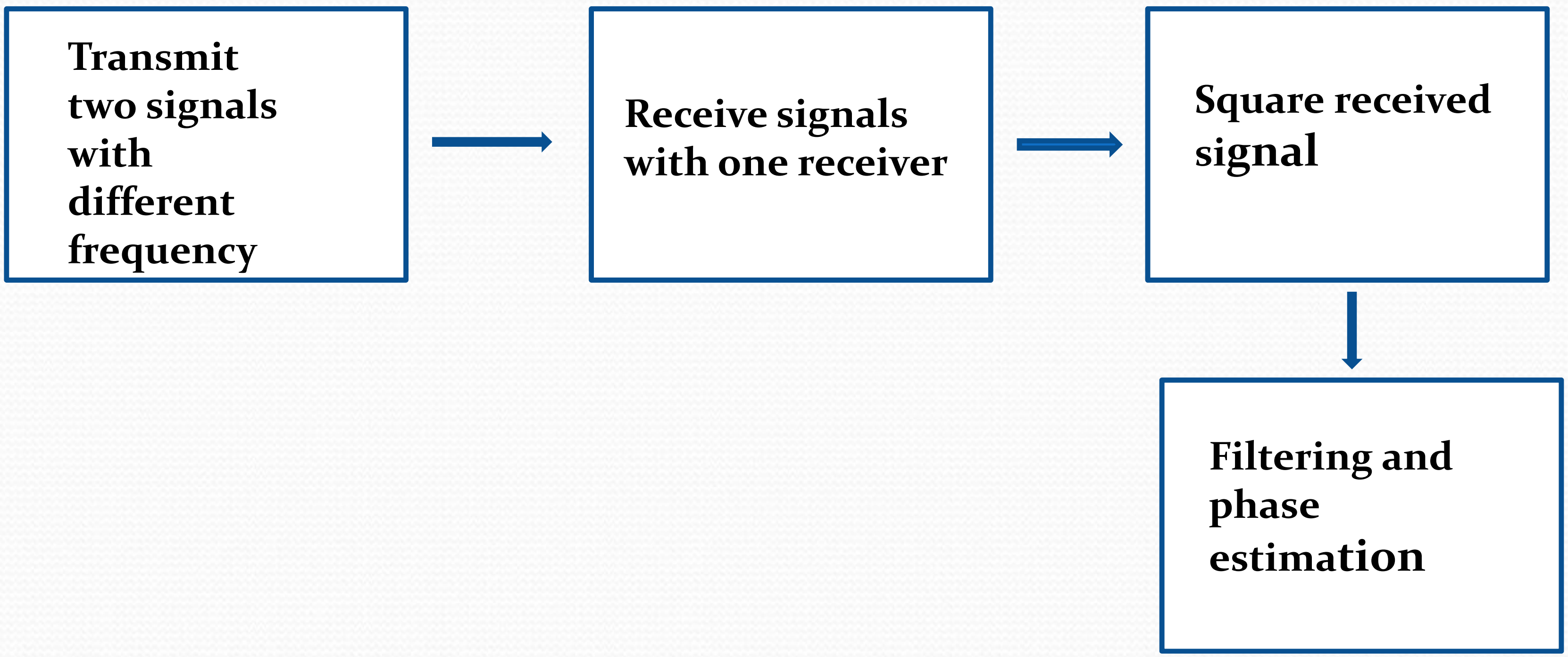


Fig. 1. Transmitting node using USRP X310.

- Transmit two signals:

$$s_1(t) = a_1 \cos(2\pi f_c t + \phi_1) + b_1 \cos(2\pi(f_c + f_d)t + \phi_1$$

$$s_2(t) = a_2 \cos(2\pi(f_c + f_0)t + \phi_2) + b_2 \cos(2\pi(f_c + f_d + 2f_0)t + \phi_2)$$

- Square received sig nals:

$$r^2(t) = s_1{}^2(t - \tau_1) + s_2{}^2(t - \tau_2) + m(t)$$

- Lowpass filtering:

$$\widetilde{r}(t) = a_1 a_2 \cos(2\pi(f_0 t + \theta_0 + \theta_1) + \phi_1 - \phi_2) + b_1 b_2 \cos(2\pi(2f_0 t + \theta_0 + \theta_1 + \phi) + \phi_1 - \phi_2) + \widetilde{m}(t)$$

Eksperiments

- Implementation using USRP platform
  - Fc=1 GHz, Fd=150 kHz, F0=120Hz
  - Error TDOA 2.7 ns, Distance error 8 m
  - Asynchronous communication

target	proposed method	DRIPS	uDRIPS
x1	1.86±0.65	7.5±1.6	2.5 ±0.66
x2	3.75±0.87	6.5 ±0.96	4.6±0.97
x3	2.68±0.93	5.5 ±1.21	3.6 ±1.58

Thank you for your attention