

Enerģijas taupība, un kur to ņemt kad baterijas tukšas

Leo Seļāvo

Projekta zinātniskais vadītājs

Projektu atbalsta ESF aktivitāte 1.1.1.2., projekta Nr.: 2009/0219/1DP/1.1.1.2.0/09/APIA/VIAA/020

ELEKTRONIKAS UN DATORZINĀTŅU INSTITŪTS
INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

ESF EIROPAS SOCIĀLAIS FONDS

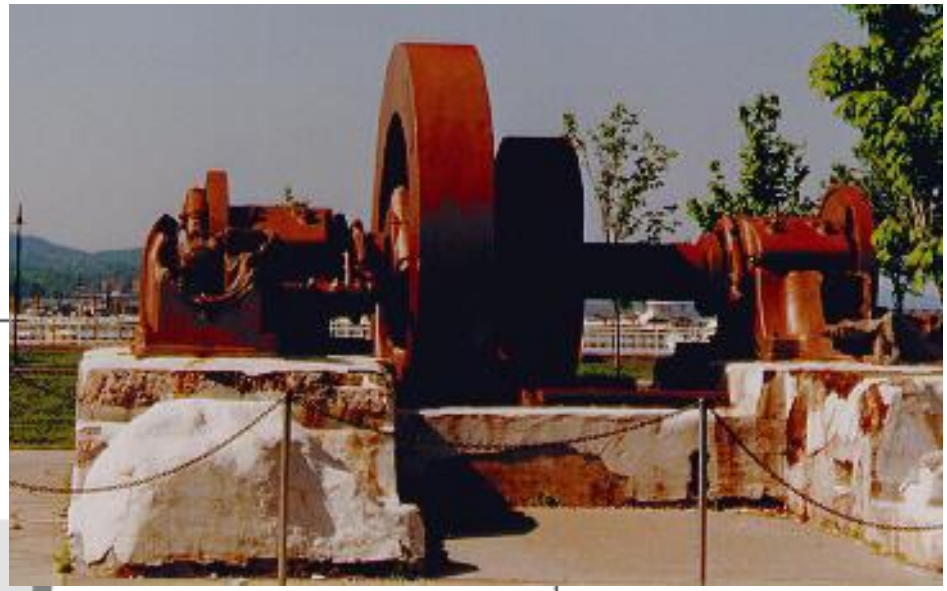
IEGULDĪJUMS TAVĀ NĀKOTNĒ

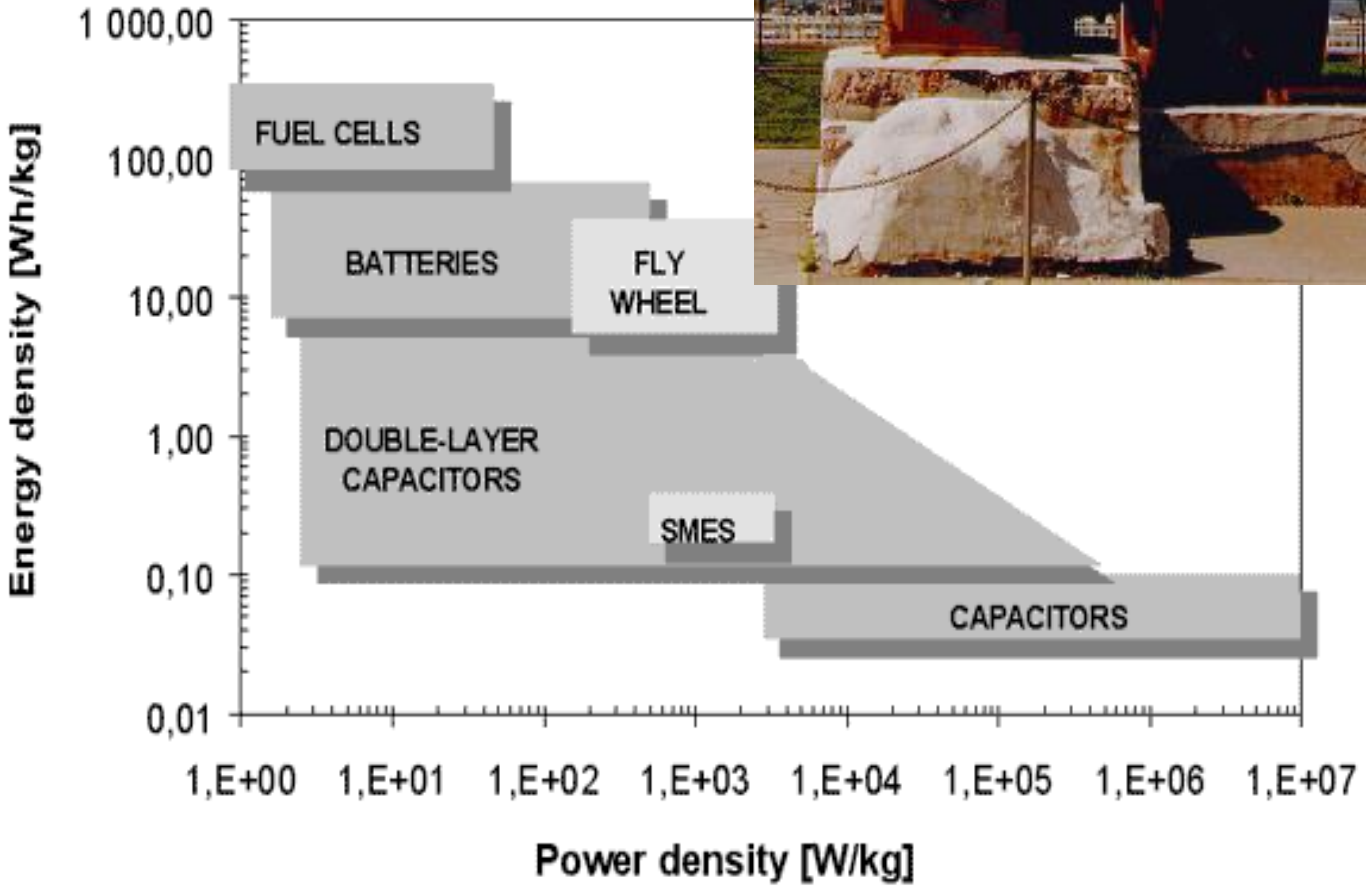
EIROPAS SAVIENĪBA

Pārskats

- Motivācija – baterijas
  - Papildus izmaksas
  - Var būt grūti vai bīstami mainīt (piem. Antarktīdā vai uz aktīva vulkāna nogāzes)
- Risinājums meklējam enerģiju apkārtējā vidē
- Enerģijas avoti
  - Vējš
  - Saule, gaisma
  - Vibrācija
  - Cilvēki, kustība
  - Citi?

Kur uzkrāt enerģiju?





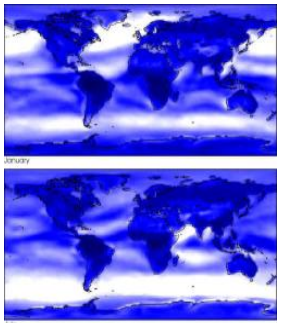
Kur ņemt enerģiju?



- Saule
- Saules baterijas (16-20% effektivitāte)
- Darbība:
  - 100 mW / cm^2 gaišā saulē
  - 100 uW / cm^2 birojā (0.1% no 100mW)
- Var ļoti mainīties dabā

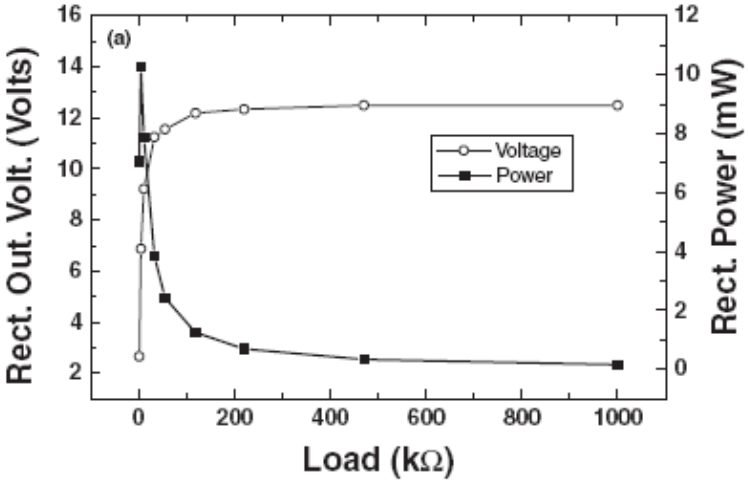


Vējš

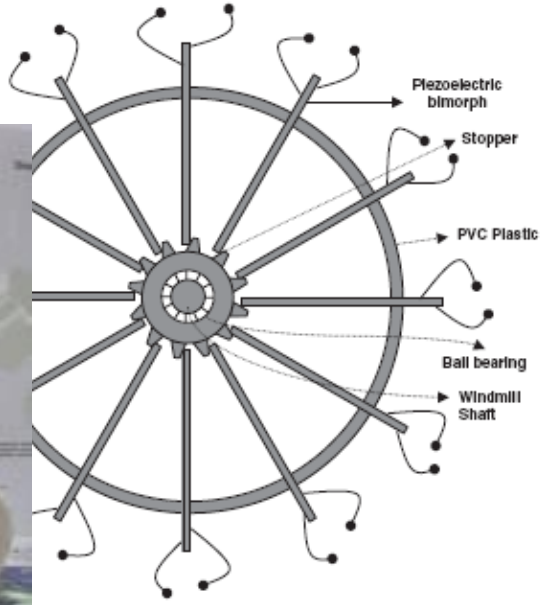


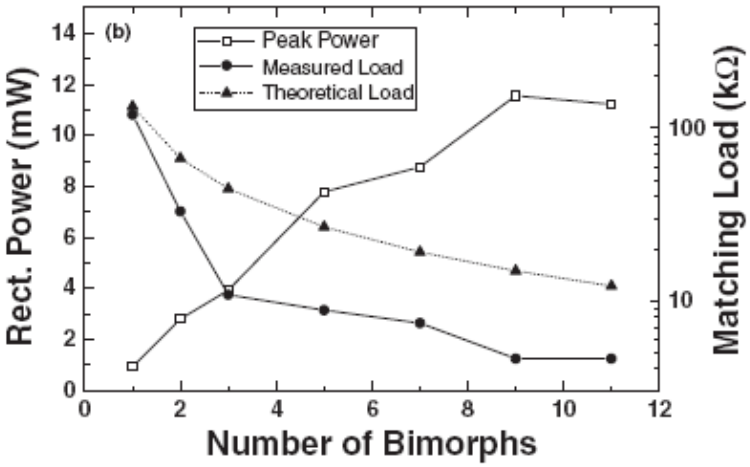


- 10cm vēja ģenerators
  - Parastā ģeneratore efektivitate ~1%
  - Piezoelektriskais ģenerators ~18%
  - 10mW pie 4.6kOhm









Termoelektriskā konversija

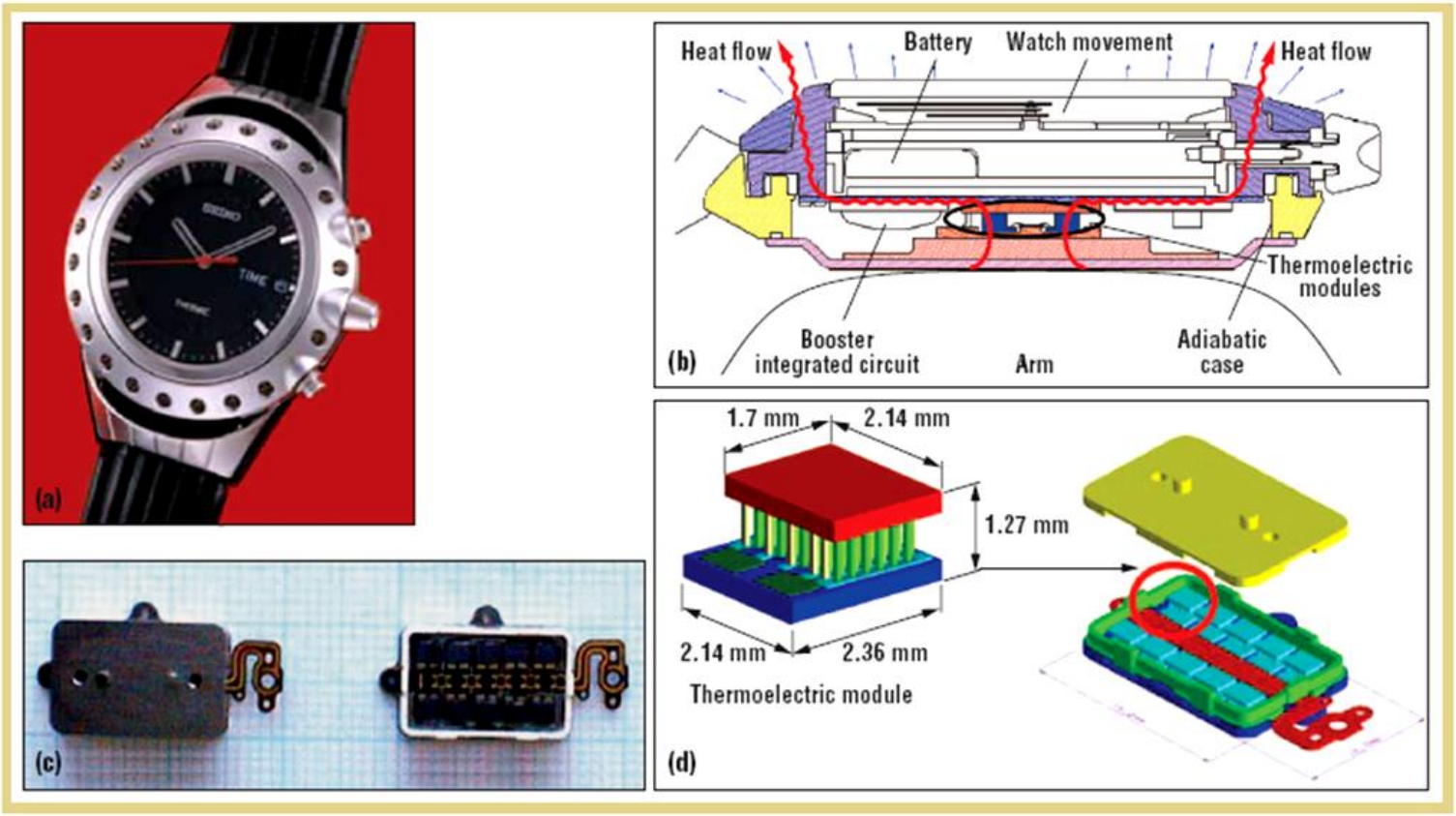


Figure 2. The Seiko Thermic wristwatch: (a) the product; (b) a cross-sectional diagram; (c) thermoelectric modules; (d) a thermopile array. Copyright by Seiko Instruments.

Seiko pulkstenim ir 10 thermoelectriskie moduļi: 0.5cm^2, 10μA @ 3V for ΔT=5C

Cilvēku ģenerēta enerģija



- Ķermenis ģenerē 0.1-1.5kW
- Staigāšana:

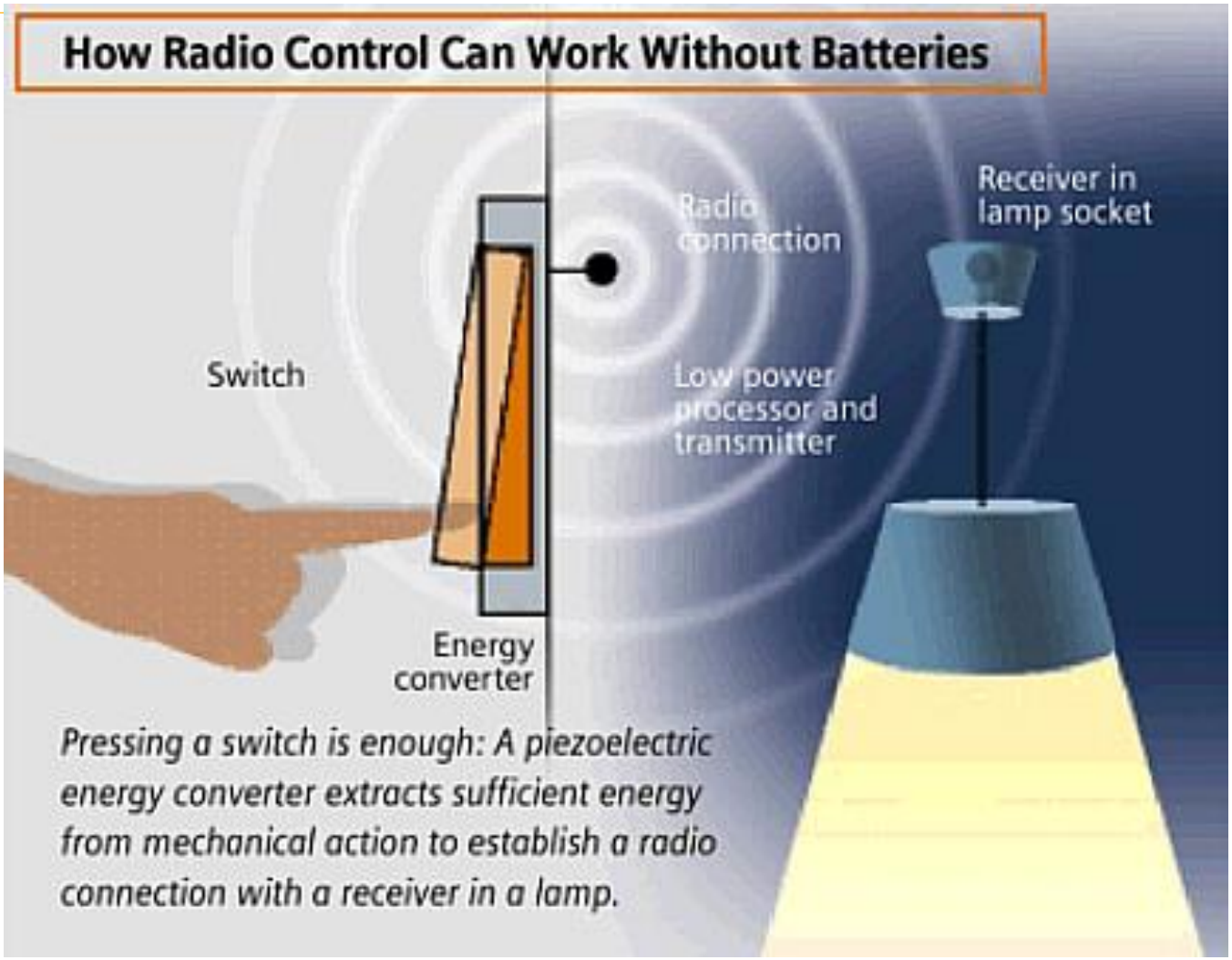
  75kg cilvēks, 1Hz solis kas rada 1cm spiedienu ģenerē 7W ar katru kāju!



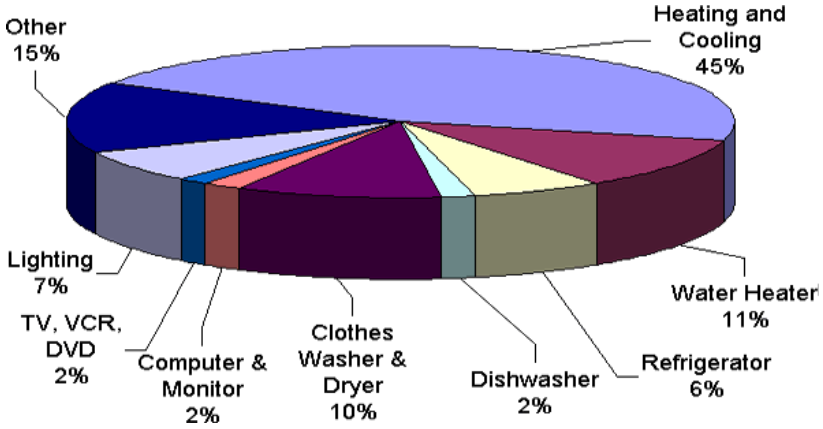


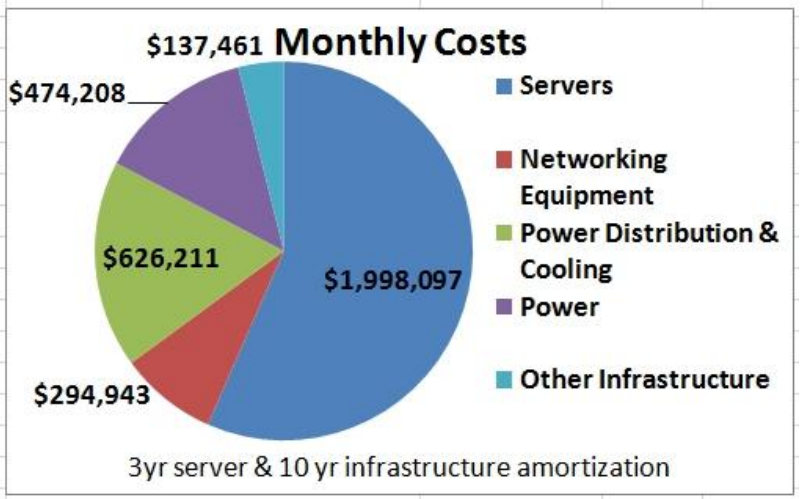
Magnētiskais ģenerators, 250mW (MIT Media Lab)

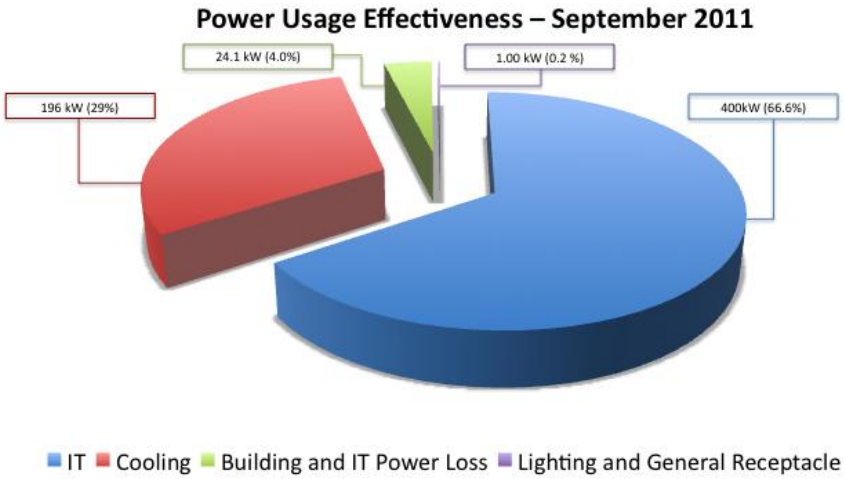
EnOcean


How Radio Control Can Work Without Batteries
Radio connection
Receiver in lamp socket
Switch
Low power processor and transmitter
Energy converter
Pressing a switch is enough: A piezoelectric energy converter extracts sufficient energy from mechanical action to establish a radio connection with a receiver in a lamp.

Mājas apsilde ar … datiem









Arī Baltijas jūrā…







IEGULDĪJUMS TAVĀ NĀKOTNĒ



EIROPAS SAVIENĪBA

Ne tikai inerciālā navigācijas sistēma viediem transporta līdzekļiem

Viedo sensoru un tīklotu iegulto sistēmu pētījumu un attīstības centrs

Georgijs Kanonirs

ESF līdzfinansētā projekta vienošanās Nr.2009/0219/1DP/1.1.1.2.0/APIA/VIAA/020



Mērķi

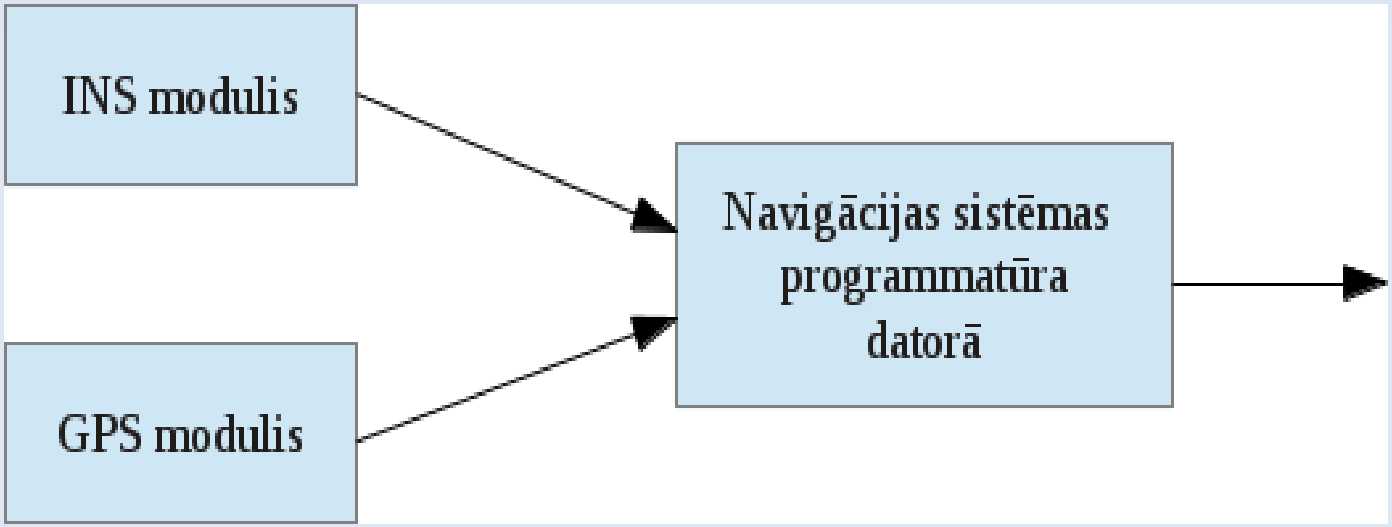
- Augstas precizitātes navigācijas sistēmas risinājums –
  - zemas izmaksas
  - kompakts un viegli pielietojams



GCDC @ http://www.gcdc.net

Risinājums (1)

- Integrētā GPS[1] un INS[2] navigācijas sistēma



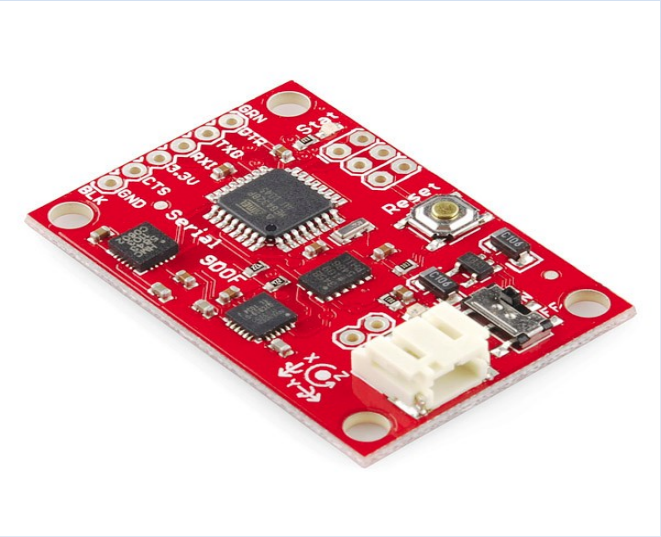
(1) GPS – Global Positioning System
(2) INS – Inertial Navigation System

Risinājums (2)

- Integrētā GPS, INS un digitālā kompasa navigācijas sistēma



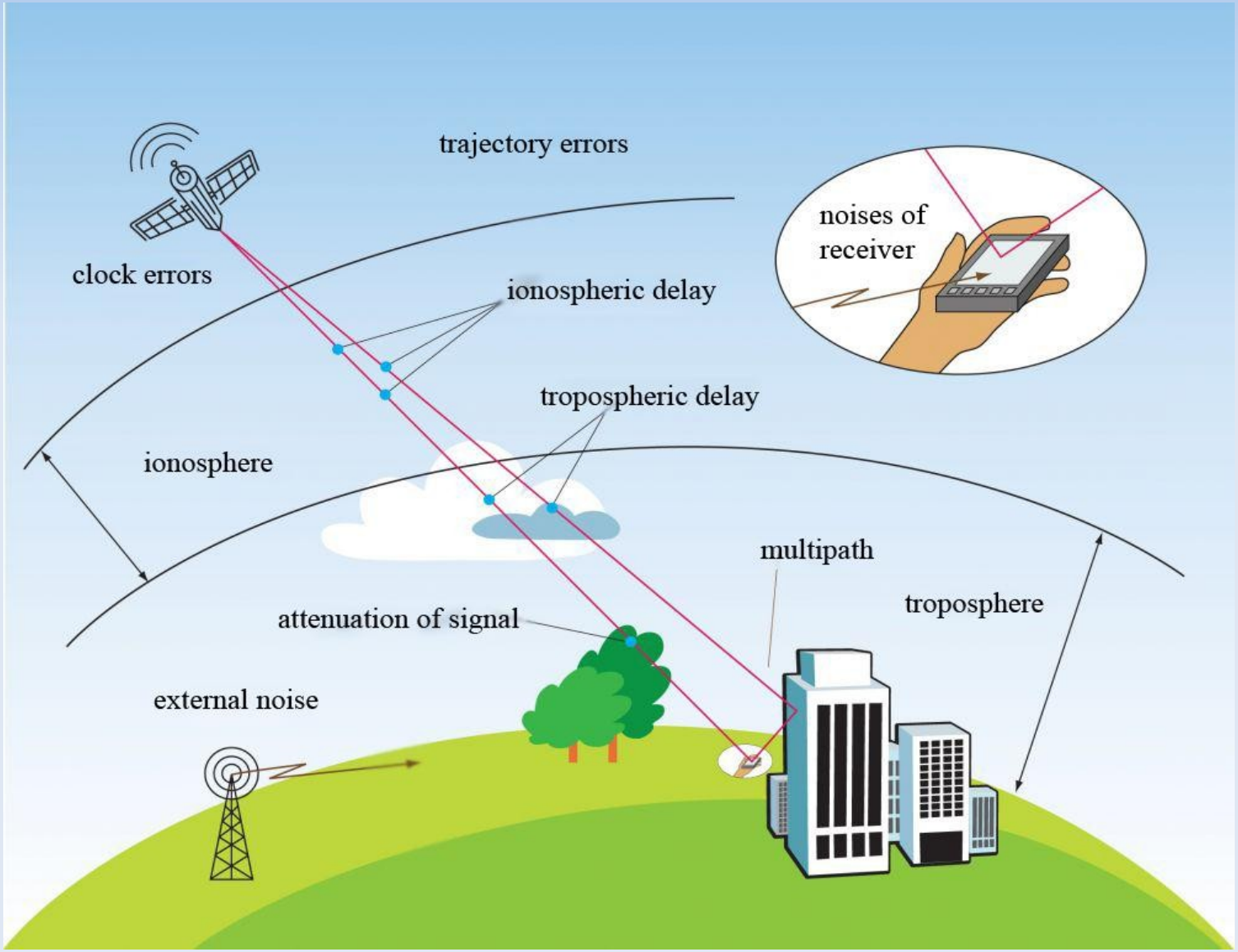
Holux M-1200E[1]
GPS uztvērējs



9DOF Razor IMU[2] modulis:
- 3-ass akselerometrs;
- 3-ass žiroskops;
- 3-ass magnetometrs (kā digitāls kompass).

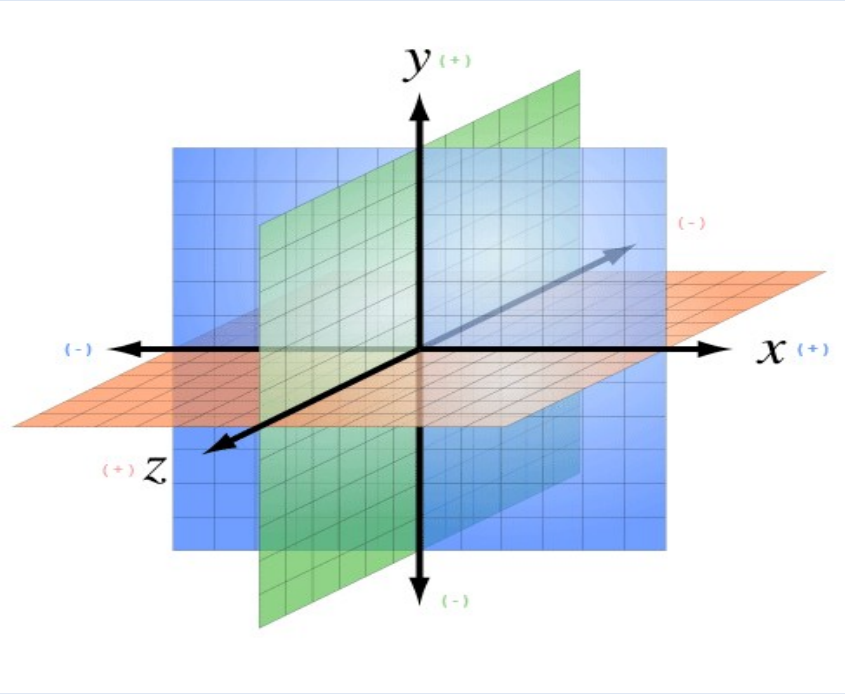
(1) Holux @ http://www.holux.com/JCore/en/aboutHolux/news-view.jsp?cno=35
(2) SparkFun @ http://www.sparkfun.com/products/9623

GPS kļūdas


trajectory errors
clock errors
ionospheric delay
noises of receiver
tropospheric delay
ionosphere
multipath
troposphere
attenuation of signal
external noise

IMU kļūdas

- Sensoru novietošanas kļūda (alignment error);
- Nobīdes un mērogošanas koeficientu kļūdas (bias, scaling factor errors).

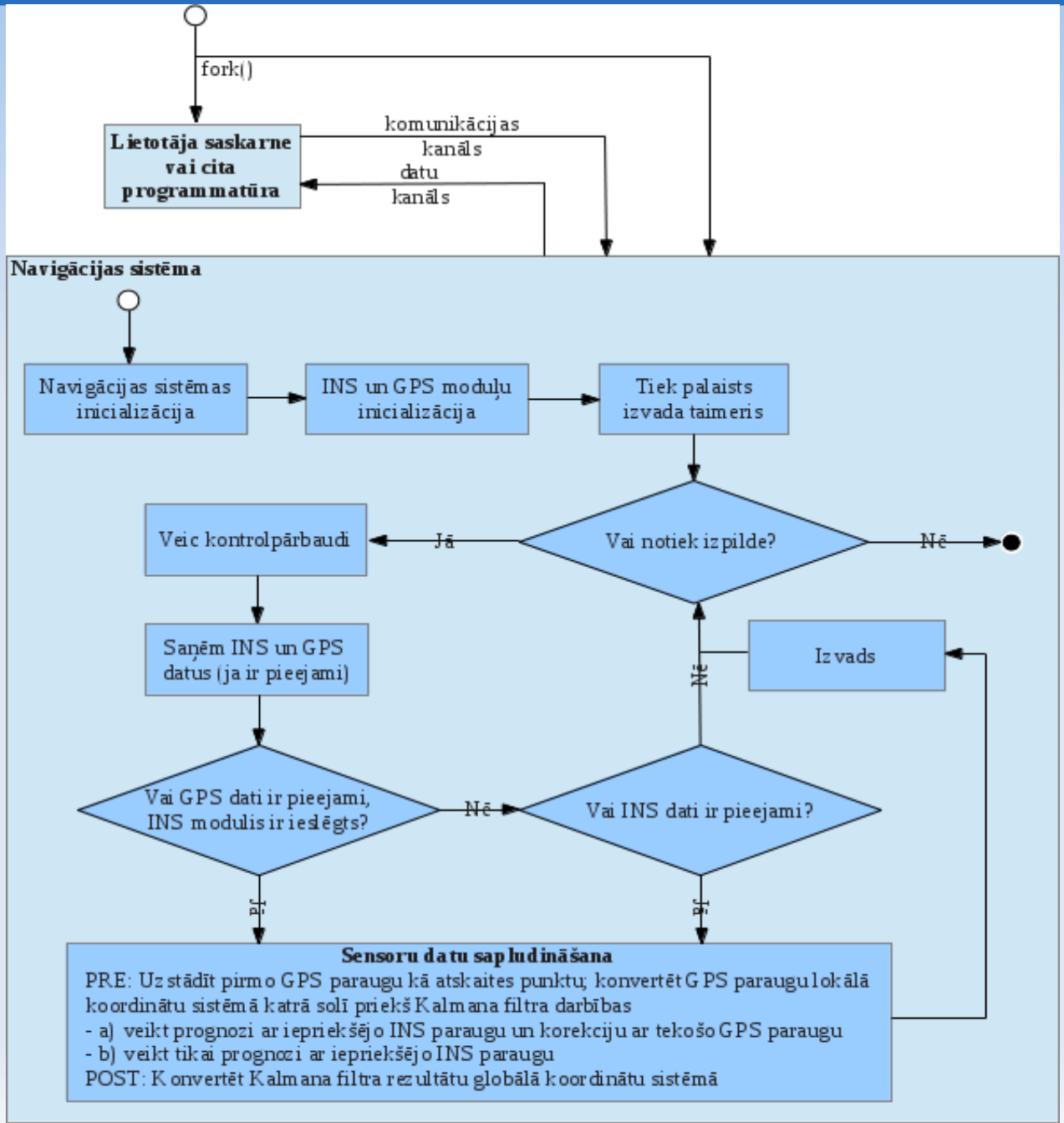


Brown University Wiki @ https://wiki.brown.edu/confluence/display/wdm/3D+Coordinate+System

Integrēta navigācija

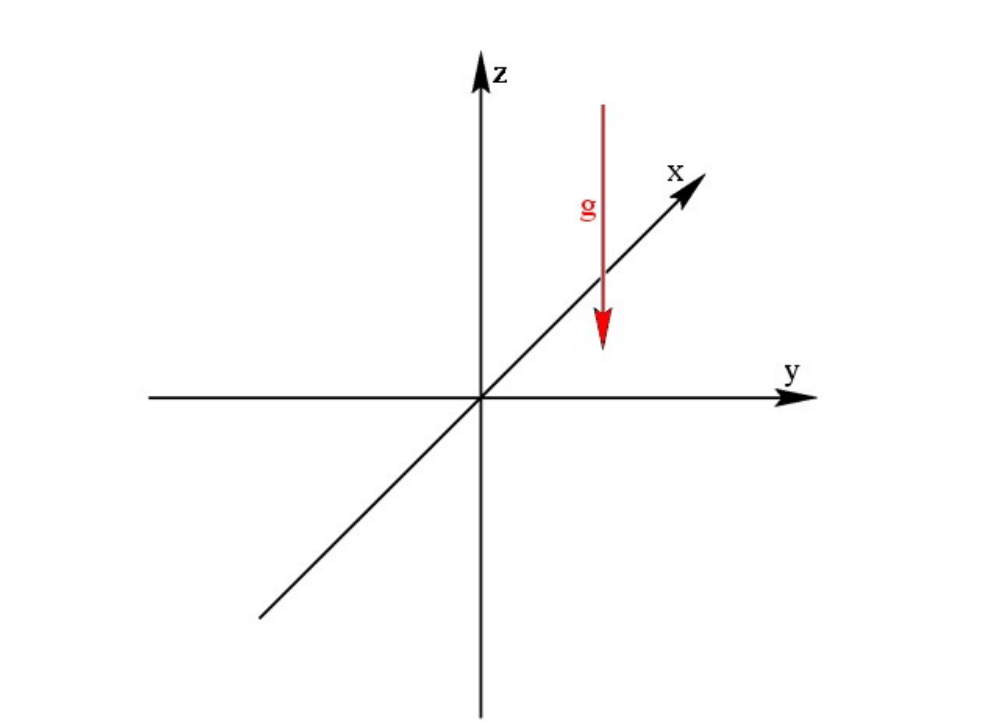
- **GPS īstermiņa pozīcijas kļūda** ir atkarīga no vairākiem faktoriem, tomēr rezultējošā vidējā kvadrātiskā pozīcijas kļūda ir ierobežota;
- **IMU īstermiņa pozīcijas kļūda** ir salīdzinoši neliela, tomēr vidējā kvadrātiskā pozīcijas kļūda ar laiku uzkrājas;
- **Integrēts navigācijas risinājums** apvieno labāko no abām pieejām.

Arhitektūra



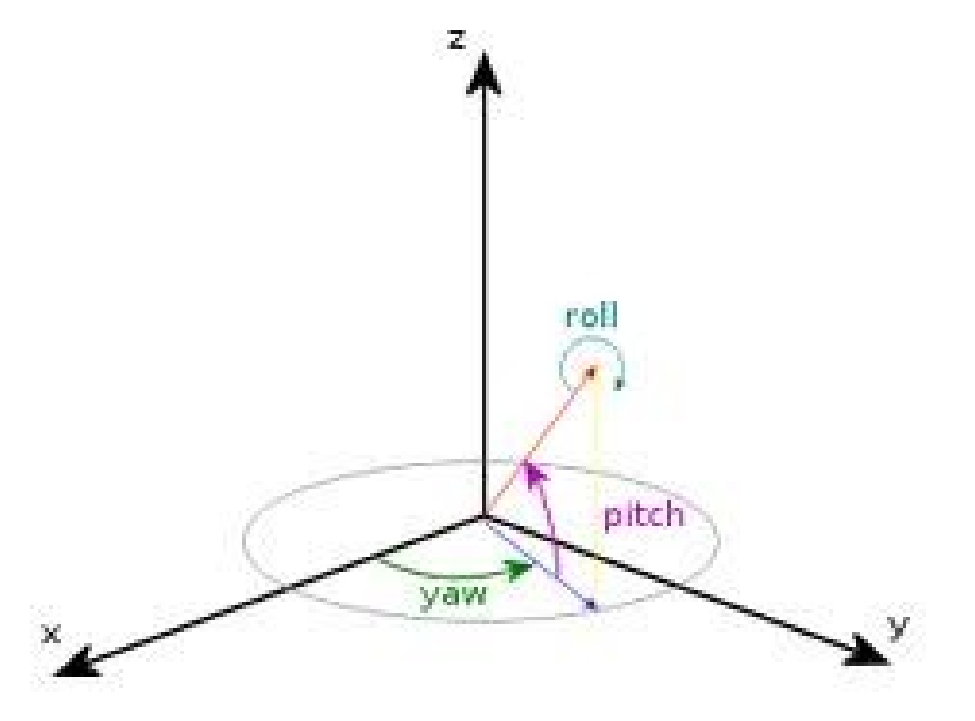
INS sensoru kalibrēšana (1)

- **Akselerometra kalibrēšana**
- Žiroskopa kalibrēšana
- Magnetometra kalibrēšana



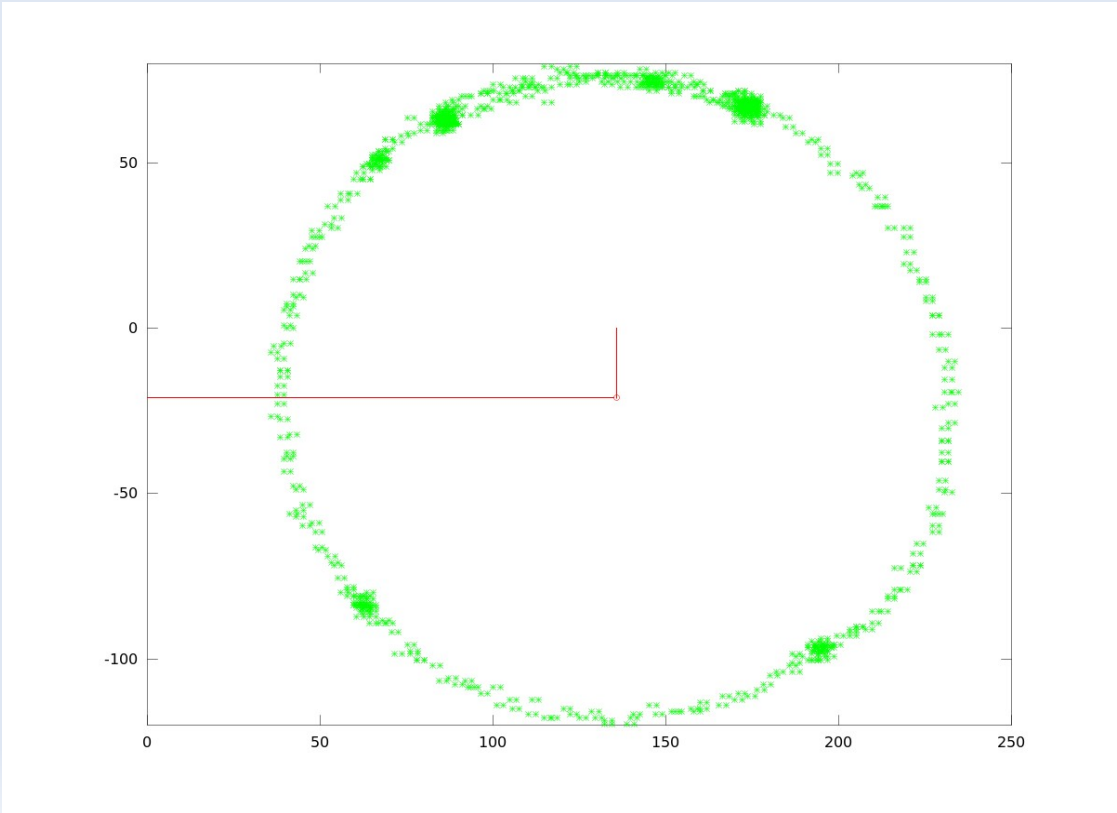
INS sensoru kalibrēšana (2)

- Akselerometra kalibrēšana
- **Žiroskopa kalibrēšana**
- Magnetometra kalibrēšana

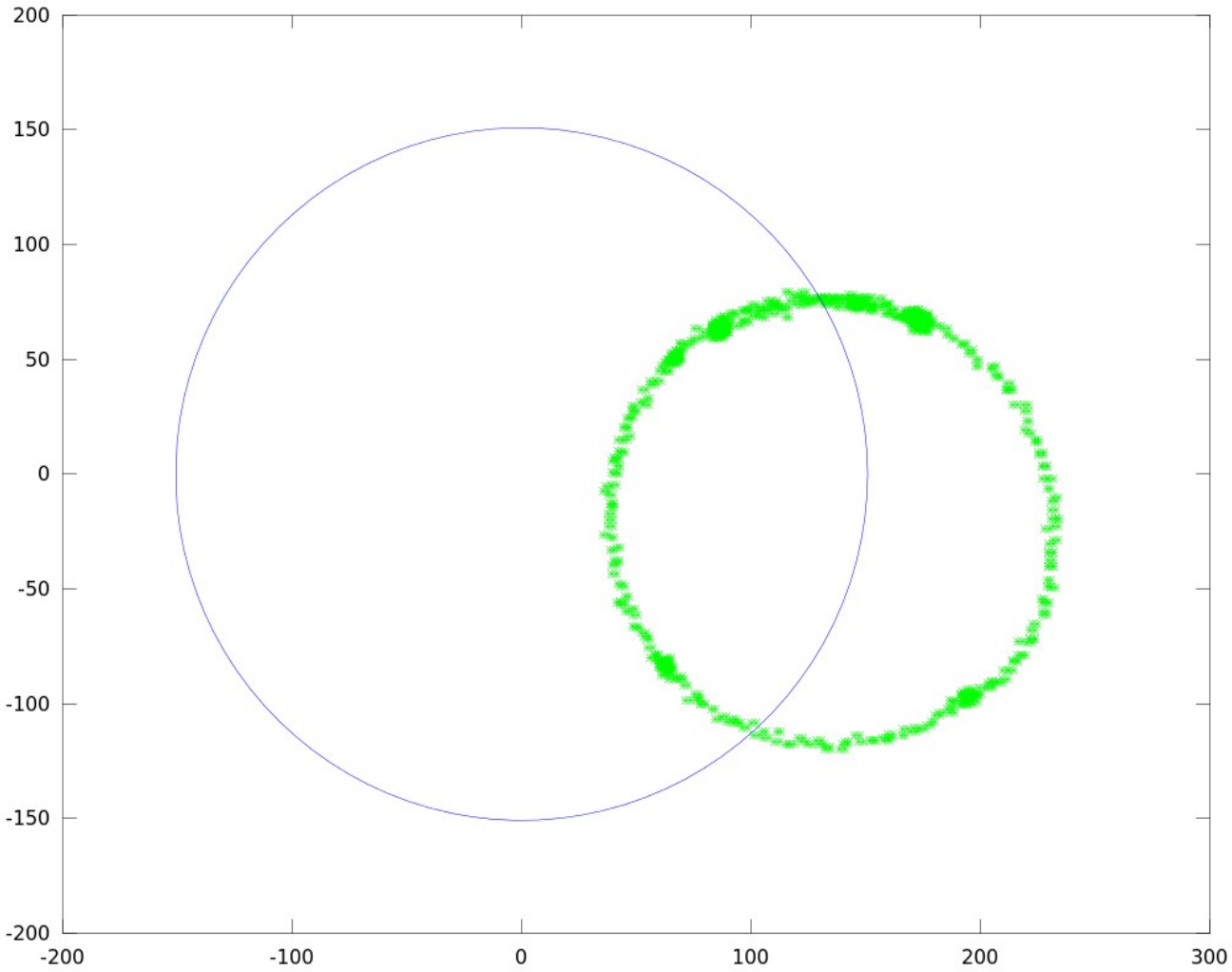


INS sensoru kalibrēšana (3)

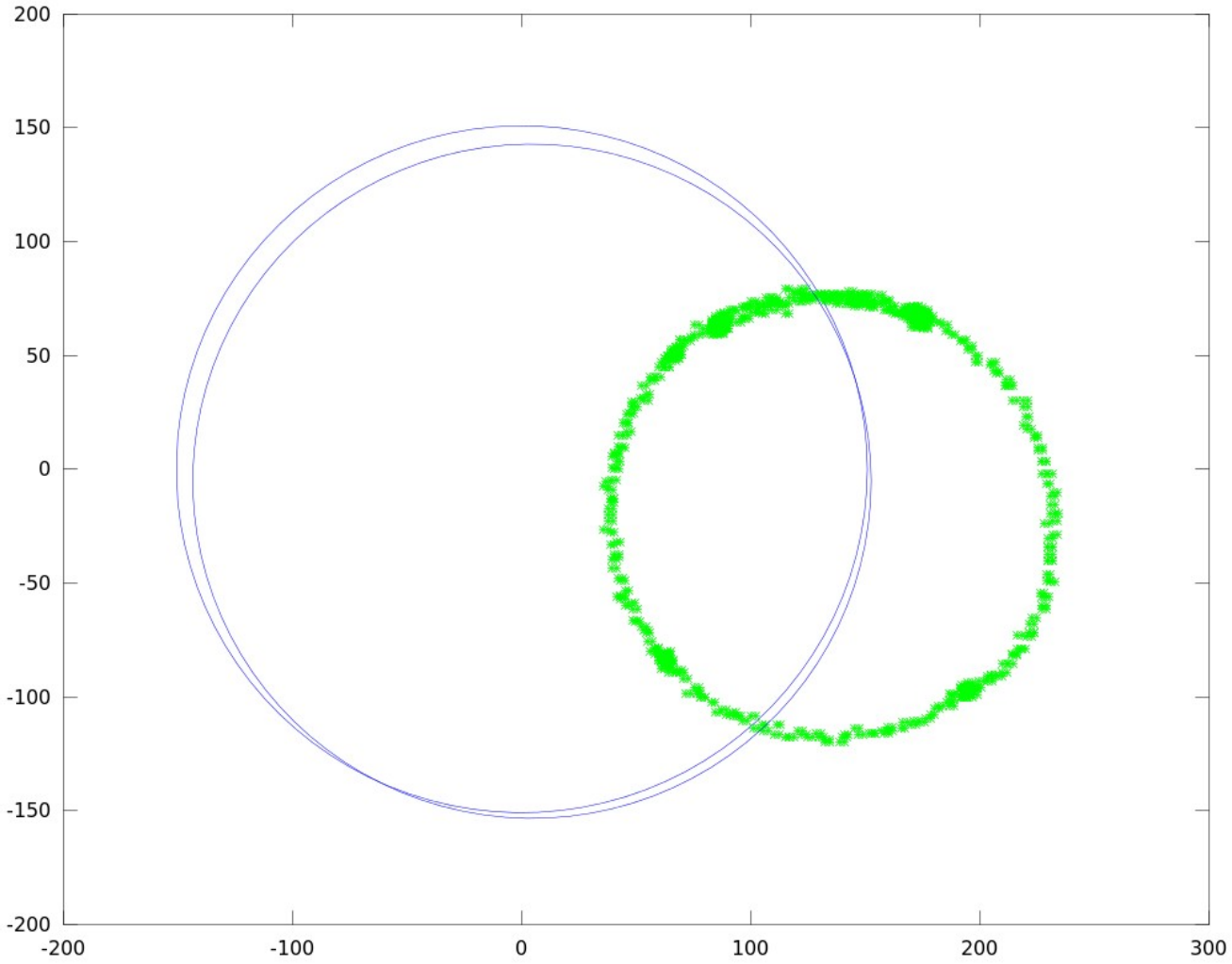
- Akselerometra kalibrēšana
- Žiroskopa kalibrēšana
- **Magnetometra kalibrēšana**



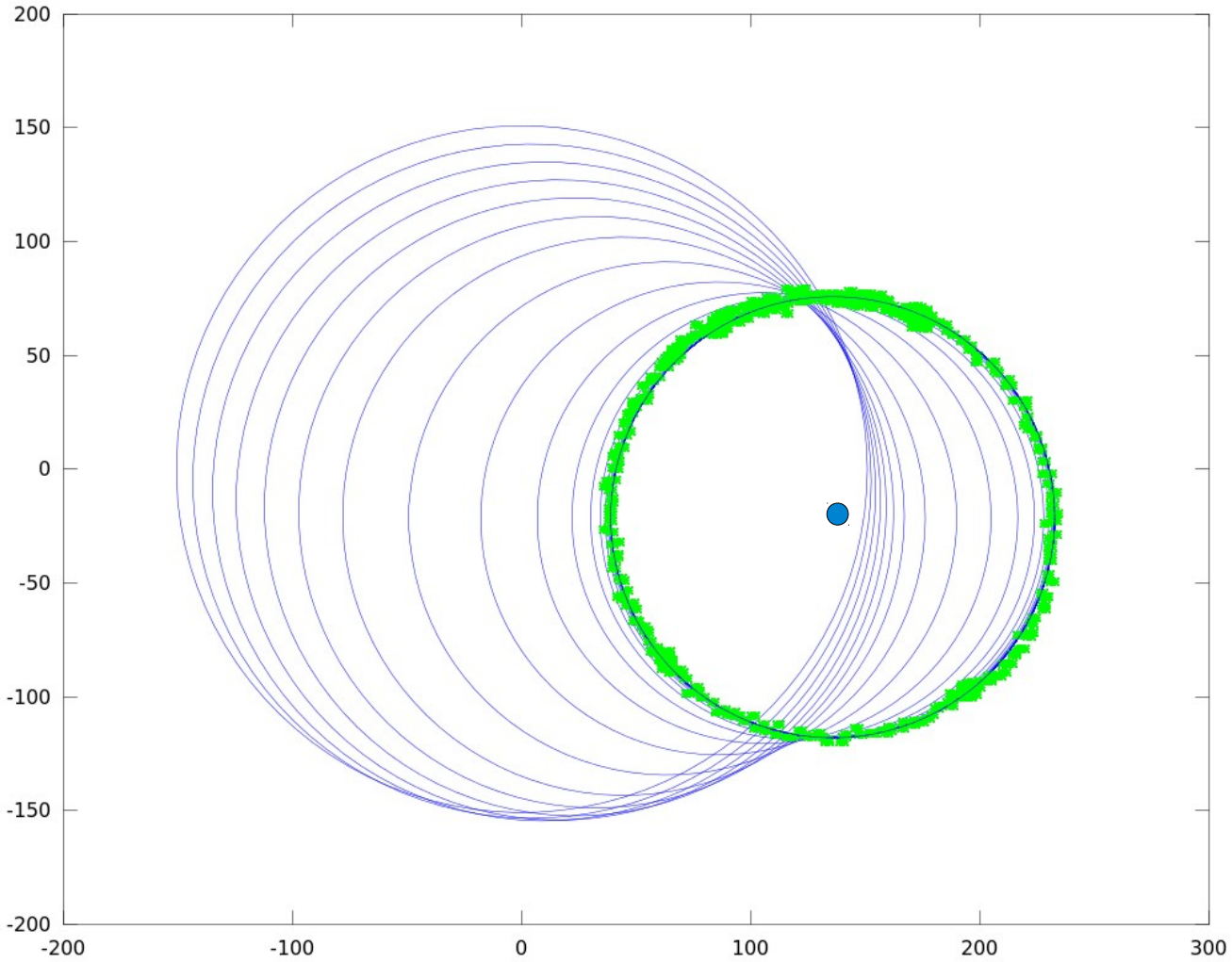
Magnetometra kalibrēšana



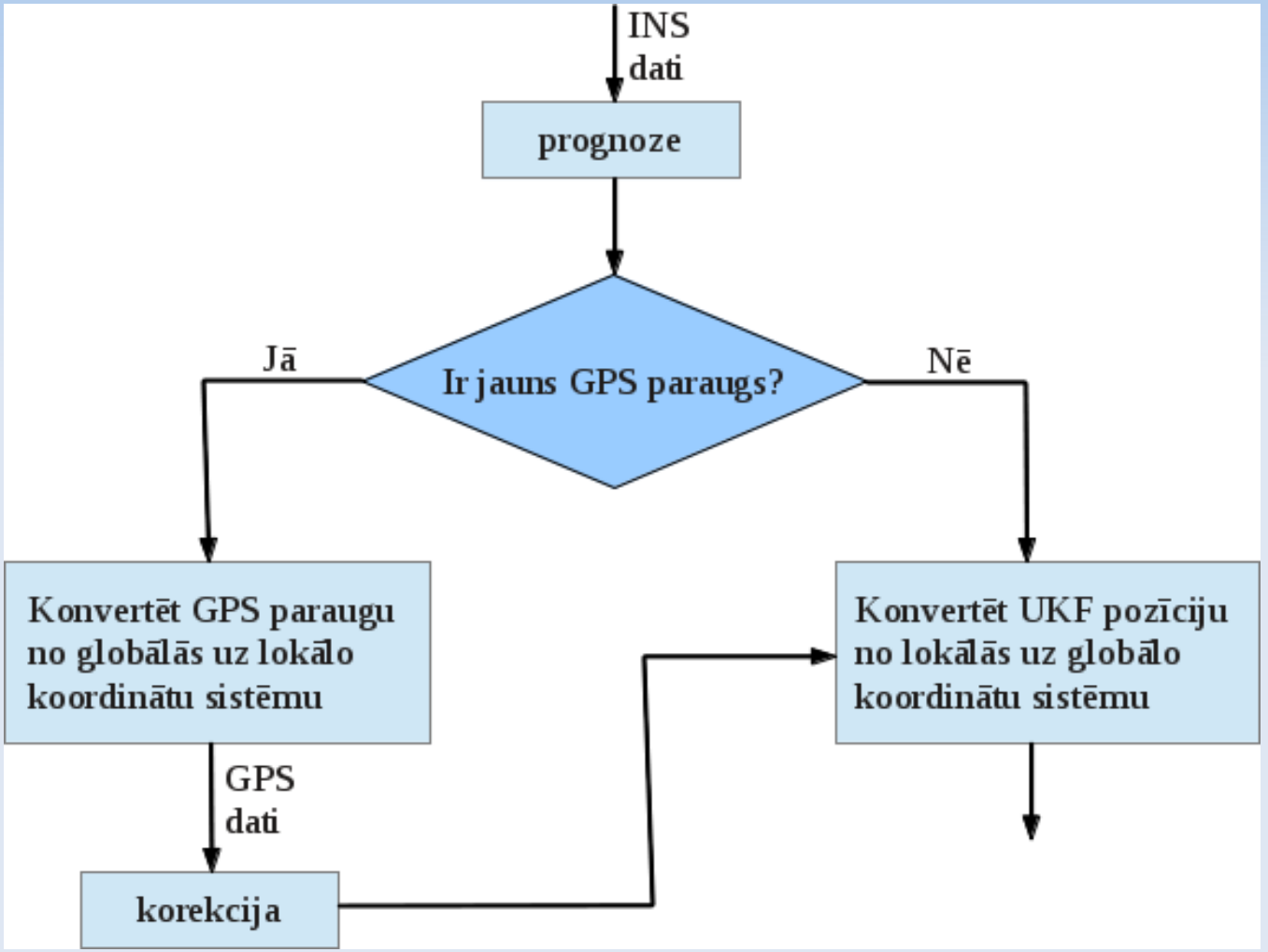
Magnetometra kalibrēšana



Magnetometra kalibrēšana

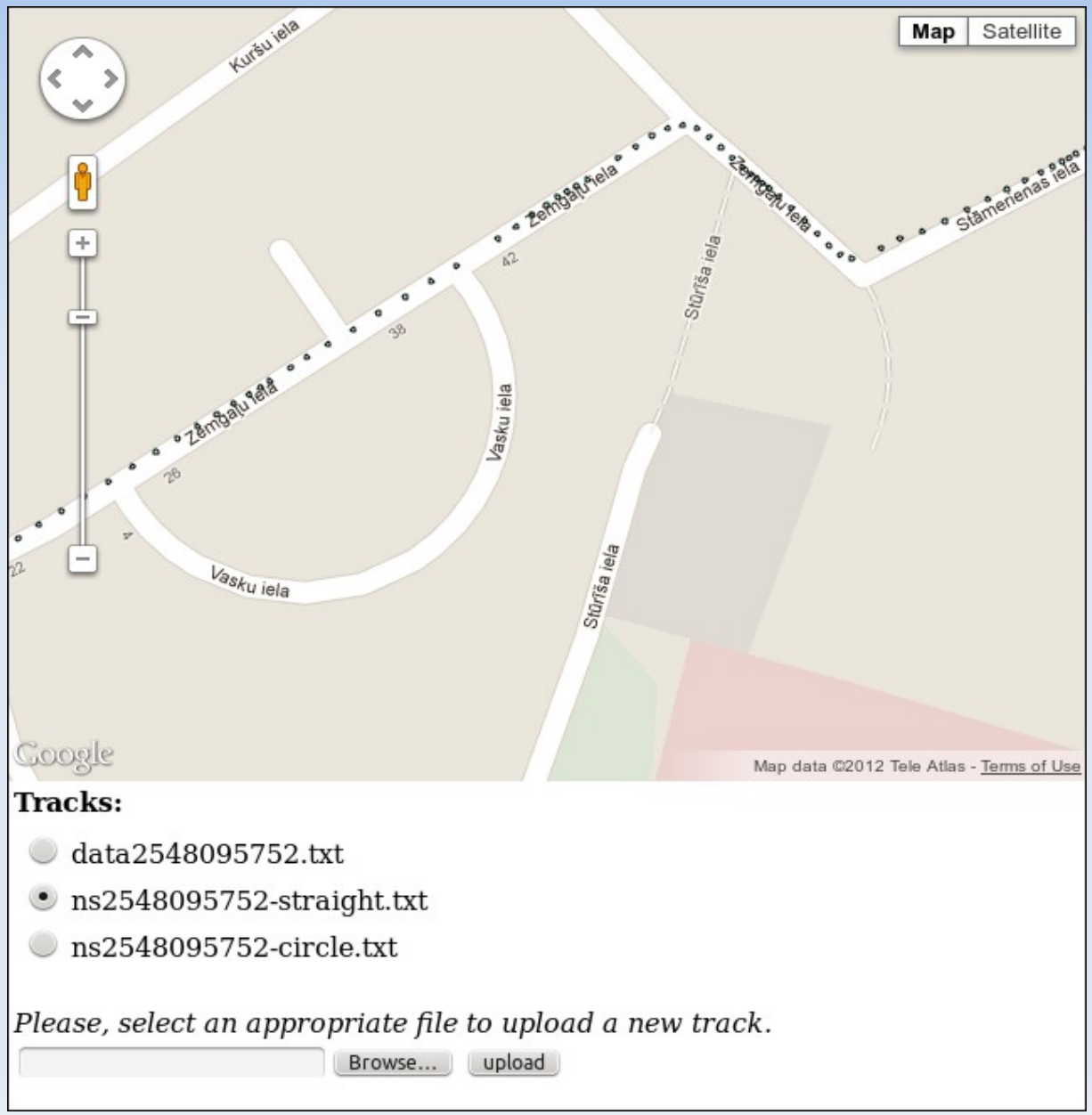


Datu sapludināšana

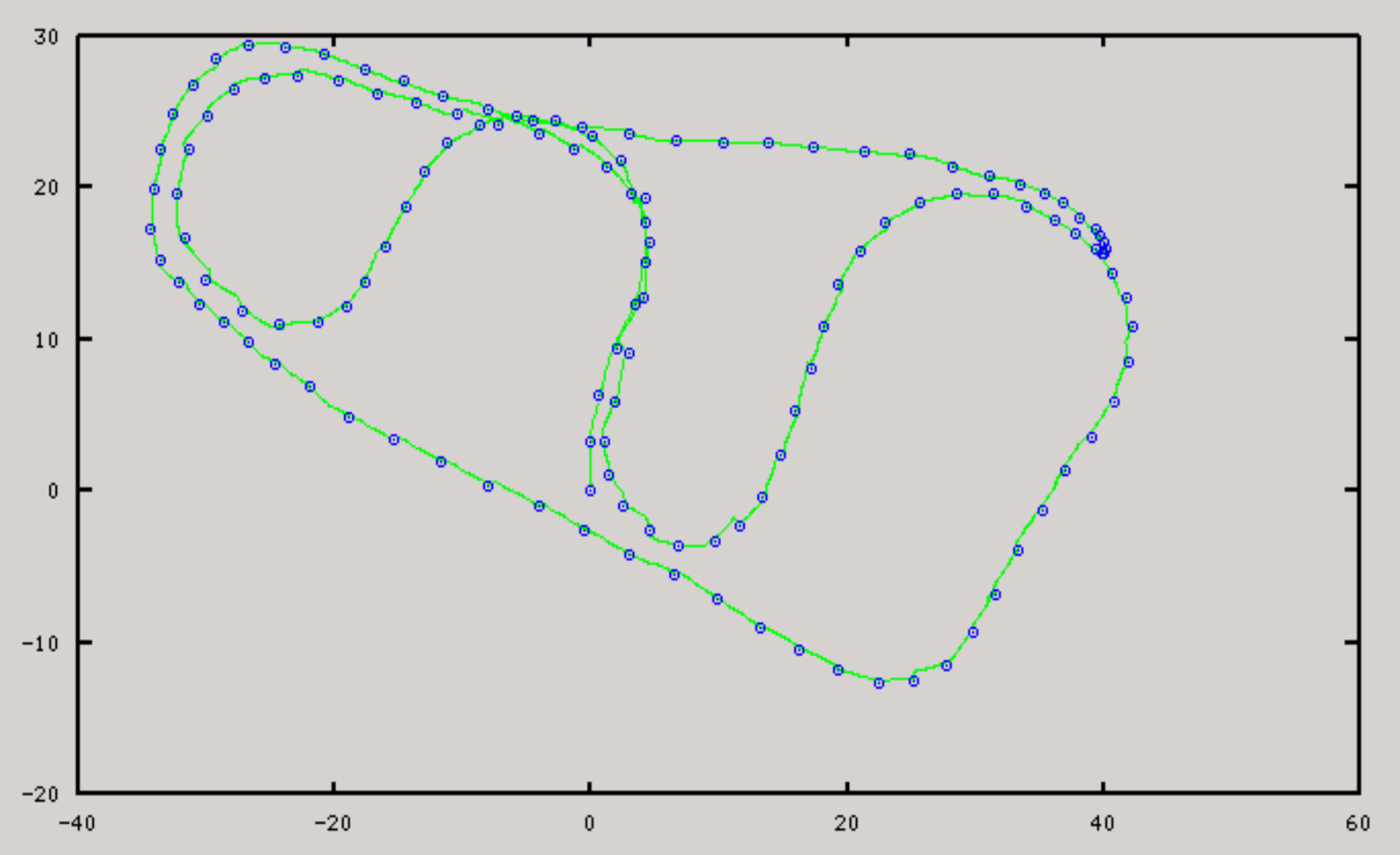


* UKF - Unscented Kalman Filter

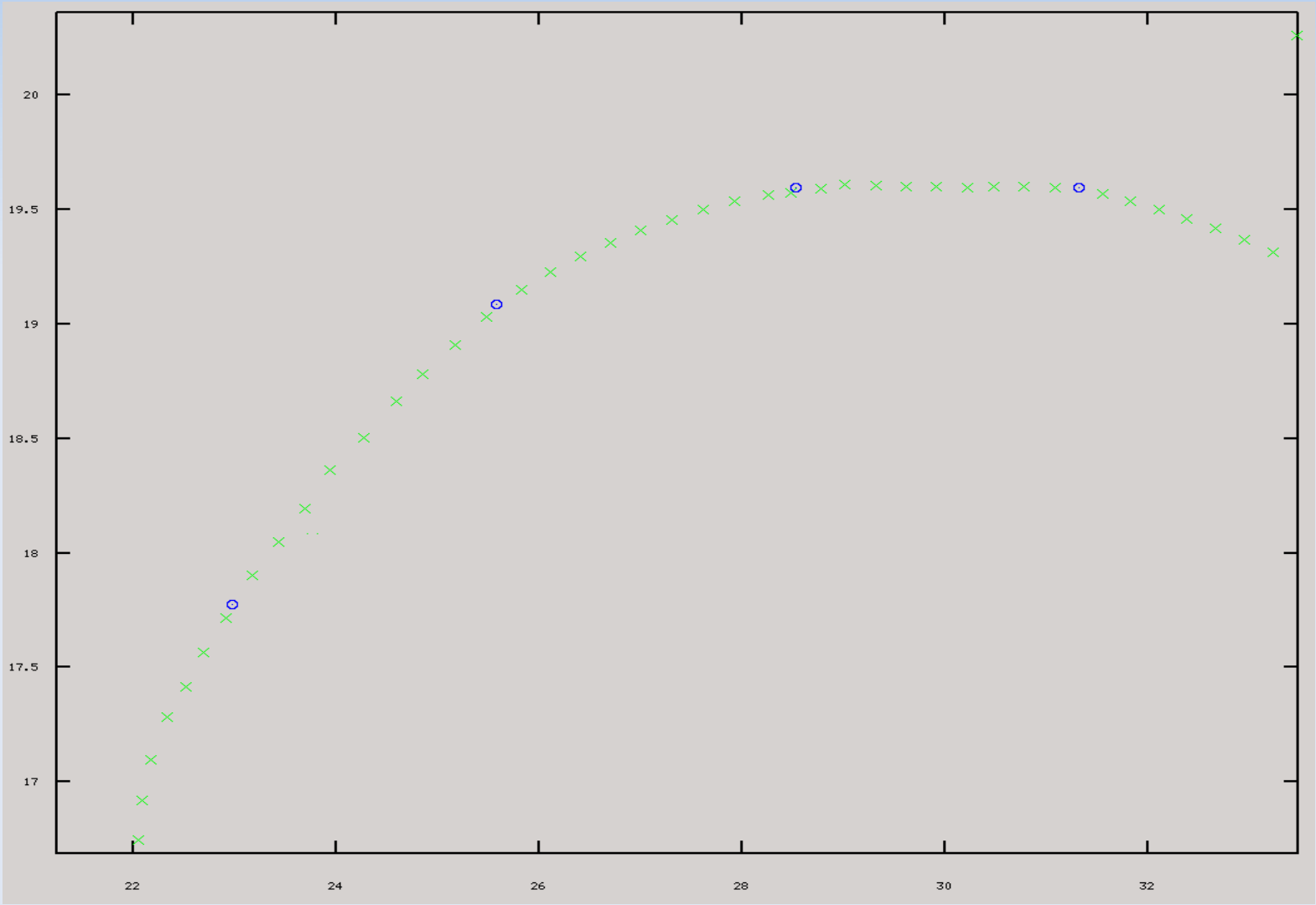
Lietotāja saskarne



Piemērs (1)



Piemērs (2)



Realizācija

- INS moduļa programmatūra, t.i. sensoru datu savākšana, sensoru kalibrēšana, datu pirmsapstrāde un pārsūtīšana (C++ programmatūra Arduino vidē)
- Navigācijas sistēmas lietojumprogrammatūra, t.i. datu saņemšana no INS un GPS moduļiem, pirmsapstrāde un sapludināšana ar UKF (C++ programmatūra datorā)
- Tīmekļa lietotāja saskarne + Google Map (Java programmatūra datorā)
- Programmatūra eksperimentu veikšanai (octave vidē)

Secinājumi

- Ir iespējami nedārgi izveidot navigācijas sistēmas (NS) risinājumu ITS uzdevumiem
- NS risinājuma cena ir atkarīga no izvēlētiem sensoru moduļiem
- Neliels [integrētas INS/GPS] NS izmērs ļauj to viegli un plaši pielietot
- Precizitāte ir atkarīga no pieejamiem sensoriem un izveidota kustību modeļa

Paldies par uzmanību!

Jautājumi?



GCDC 2011, Team Latvia

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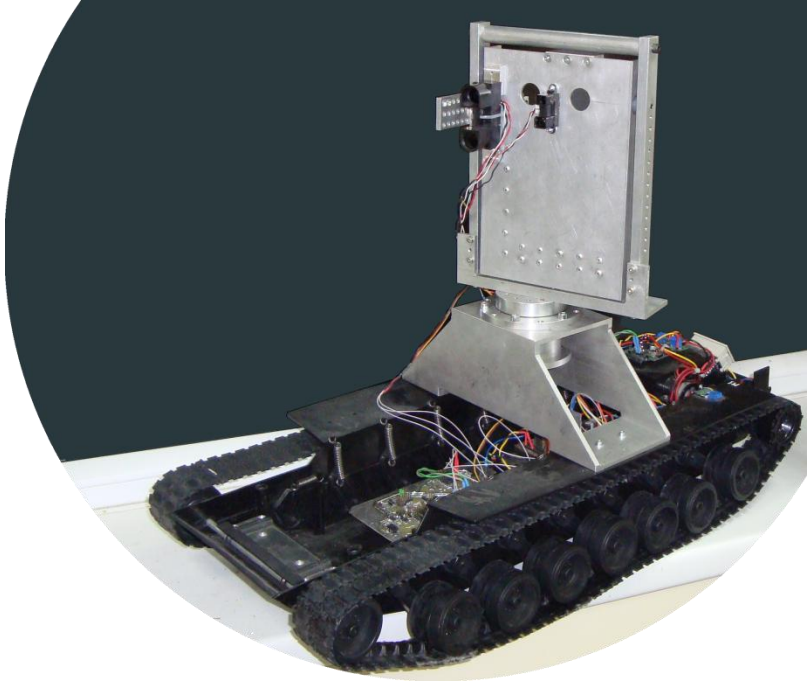
Attālinātās klātbūtnes robots ar Androida vadības sistēmu.

Dr.habil.sc.comp. Aldis Baums
Mg.sc.comp. Andris Gordjušins
Mg.sc.comp. Georgijs Kanonirs

ESF līdzfinansētā projekta vienošanās
Nr.2009/0219/1DP/1.1.1.2.0/APIA/VIAA/020

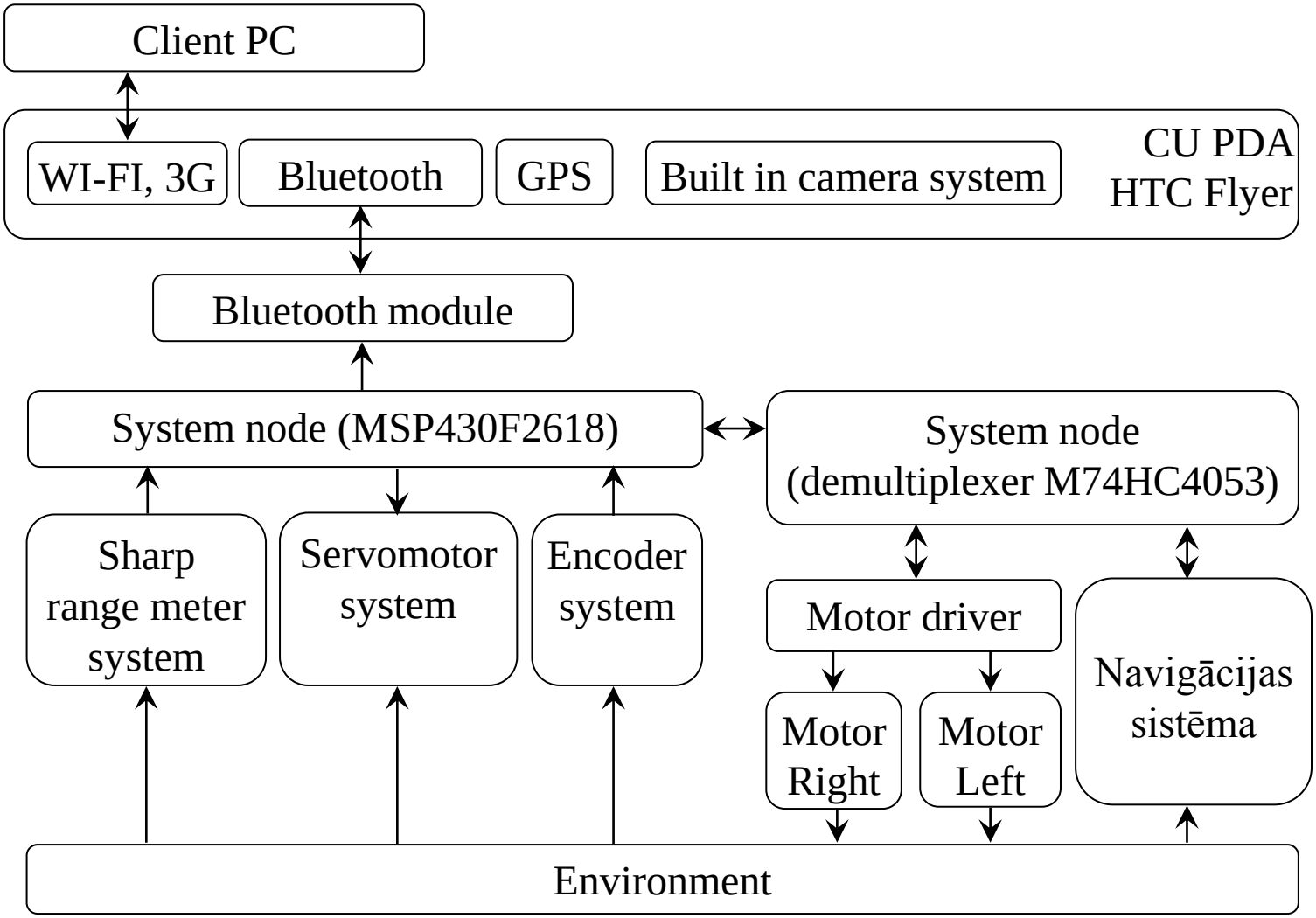
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IEGULDĪJUMS TAVĀ NĀKOTNĒ

Problēma



- Nepieciešama sistēma ar kuru var attālināti gūt informāciju par pētamo vidi un iedarboties uz to.
- Veicot zinātniskus pētījumus ir nepieciešama platforma prekš izmēģinājumiem un algoritmu testēšanas.
- Platformai ir jādarbojas gan autonomā gan vadāmā režīmā
- Platformai ir jābūt izveidotai no moduļem kurus turpmāk būs iespējams izmantot veidojot citas robotu konstrukcijās

Arhitektūra



Programmatūras arhitektūra

Sensoru datu nolasīšanas un izpildmehānismu vadības bloks (MSP430F2618 kontrollerī)

- Komunikācijas modulis
- Motoru vadības modulis
- Tureles vadības modulis
- Attāluma mērītāju signālu nolasīšanas modulis
- Navigācijas sistēmas datu nolasīšanas modulis

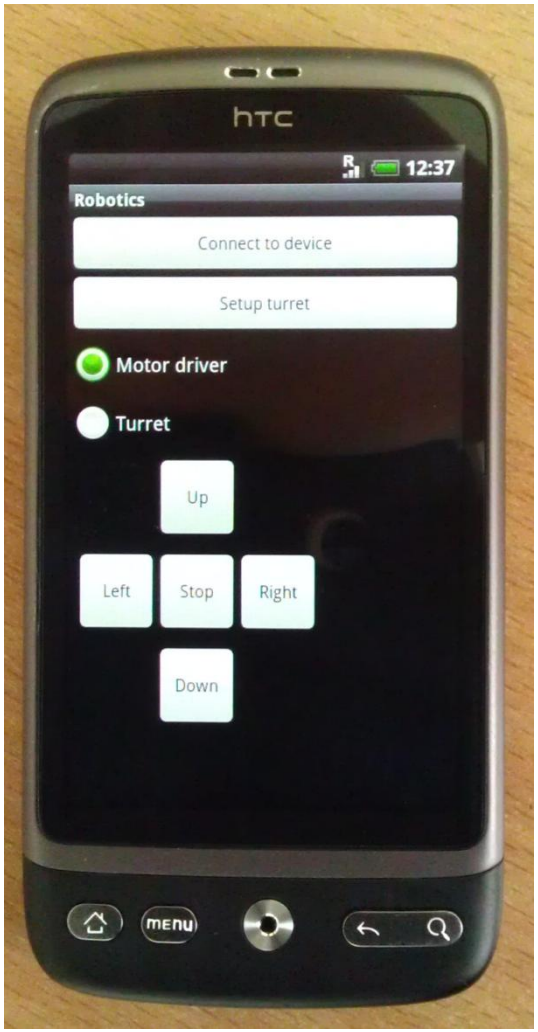
Datu apstrādes un komunikācijas modulis (PDA HTC Flyer Android OS vidē)

- Serveris
- Komunikācijas modulis
- Attēlu apstrādes modulis
- Sensoru datu apstrādes modulis
- Maršruta plānošanas modulis
- Lēmumu pieņemšanas modulis

Klients

- Robota vadības sistēma
- Robota sensoru datu attēlošana

Klienta daļas programmatūra

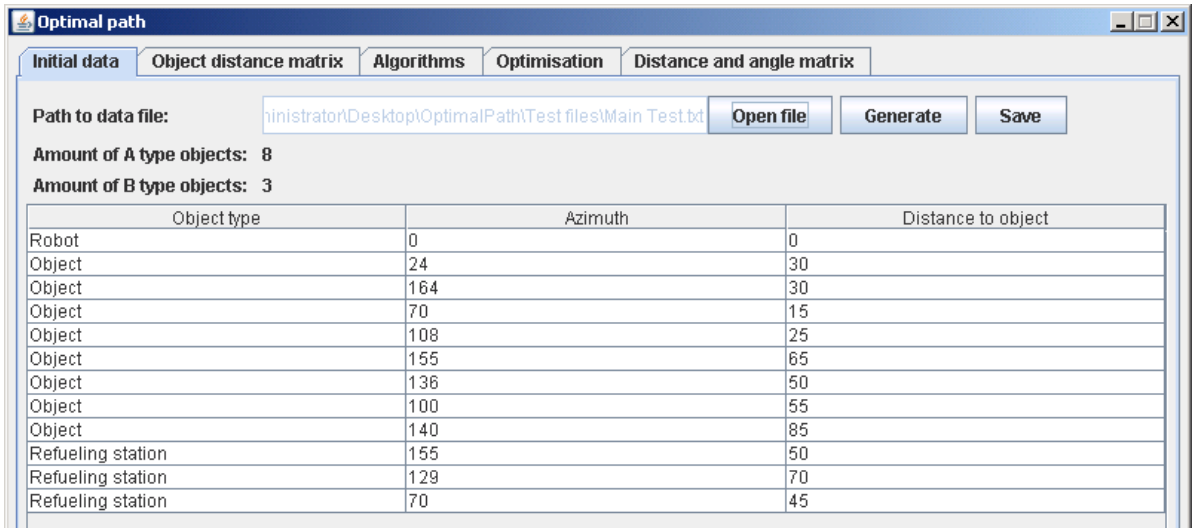


- Izstrādāta Android OS 2.4 videi
- Relizē robota tureles vadību.
- Relizē robota ritošas daļas vadību.

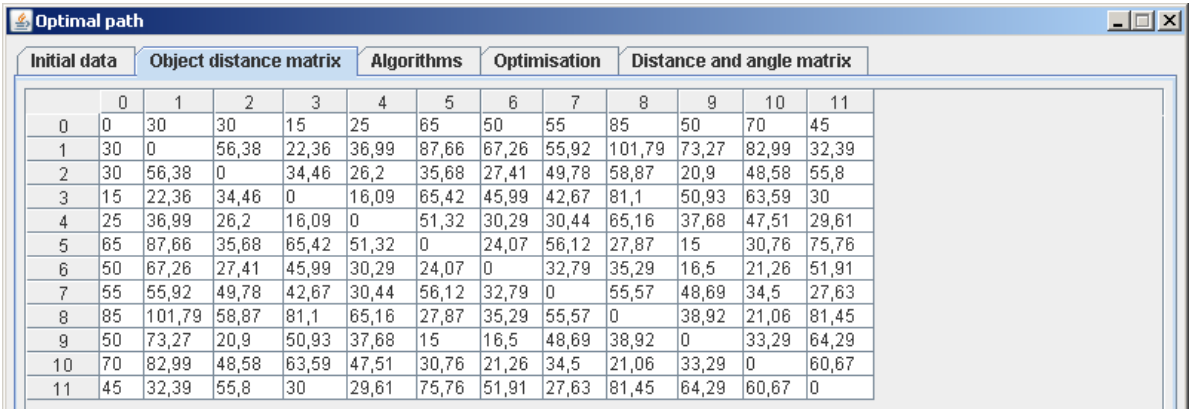
Uzdots testa uzdevums autonomam režīmam

- Veikt darbības telpas izpēti meklējot novietotus marķierus.
- Noteikt koordinātes atrastiem marķieriem
- Izveidot marķieru izvetošanas karti
- Aprēķināt īsāku noslēgtu maršrutu
- Realizēt aprēķinātu īsāku noslēgtu maršrutu

Robota darbības simulators

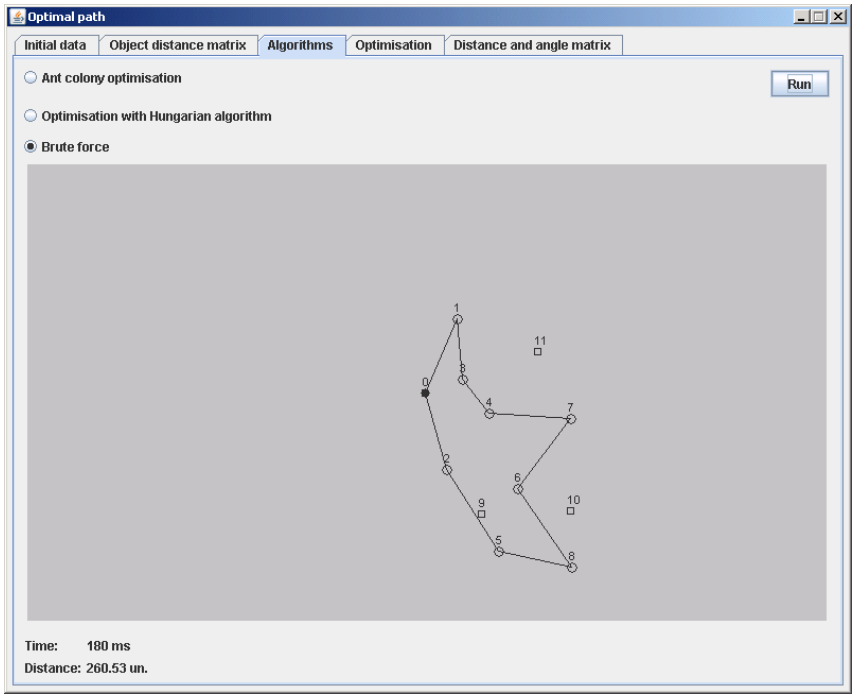


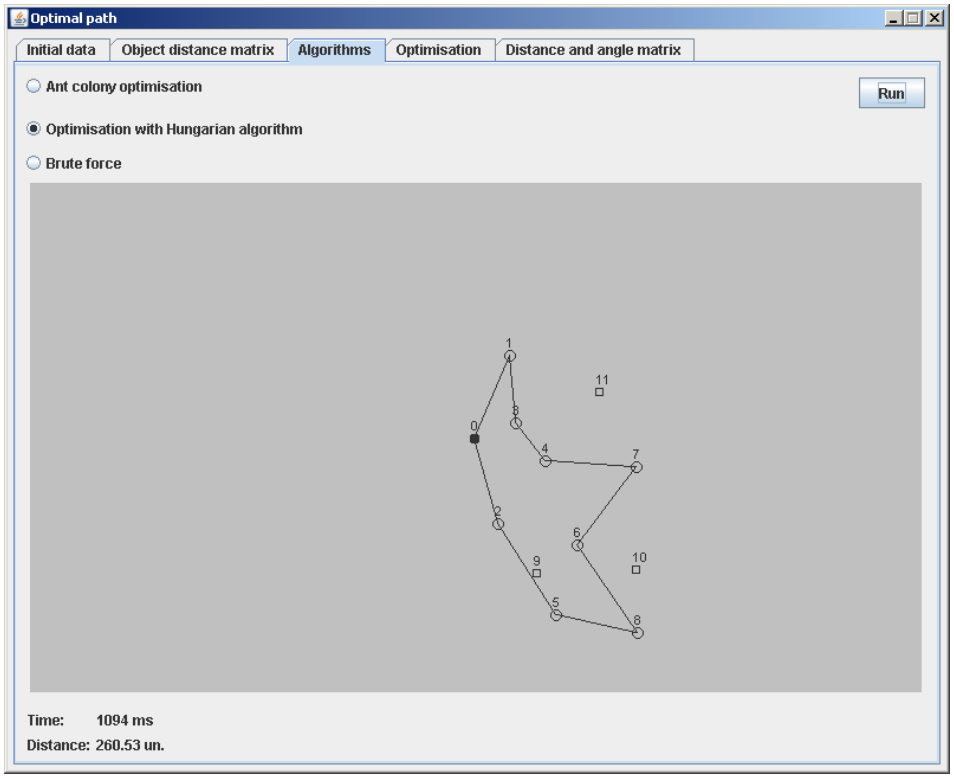
Object type	Azimuth	Distance to object
Robot	0	0
Object	24	30
Object	164	30
Object	70	15
Object	108	25
Object	155	65
Object	136	50
Object	100	55
Object	140	85
Refueling station	155	50
Refueling station	129	70
Refueling station	70	45



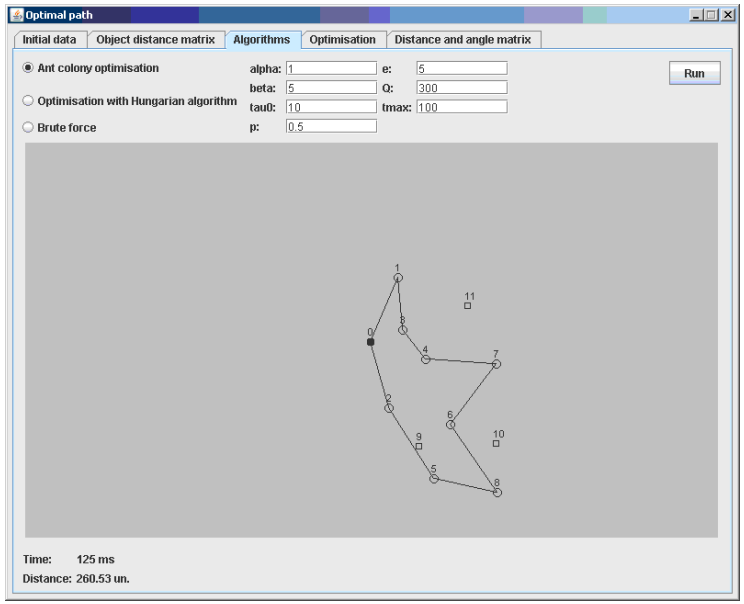
	0	1	2	3	4	5	6	7	8	9	10	11
0	0	30	30	15	25	65	50	55	85	50	70	45
1	30	0	56,38	22,36	36,99	87,66	67,26	55,92	101,79	73,27	82,99	32,39
2	30	56,38	0	34,46	26,2	35,68	27,41	49,78	58,87	20,9	48,58	55,8
3	15	22,36	34,46	0	16,09	65,42	45,99	42,67	81,1	50,93	63,59	30
4	25	36,99	26,2	16,09	0	51,32	30,29	30,44	65,16	37,68	47,51	29,61
5	65	87,66	35,68	65,42	51,32	0	24,07	56,12	27,87	15	30,76	75,76
6	50	67,26	27,41	45,99	30,29	24,07	0	32,79	35,29	16,5	21,26	51,91
7	55	55,92	49,78	42,67	30,44	56,12	32,79	0	55,57	48,69	34,5	27,63
8	85	101,79	58,87	81,1	65,16	27,87	35,29	55,57	0	38,92	21,06	81,45
9	50	73,27	20,9	50,93	37,68	15	16,5	48,69	38,92	0	33,29	64,29
10	70	82,99	48,58	63,59	47,51	30,76	21,26	34,5	21,06	33,29	0	60,67
11	45	32,39	55,8	30	29,61	75,76	51,91	27,63	81,45	64,29	60,67	0

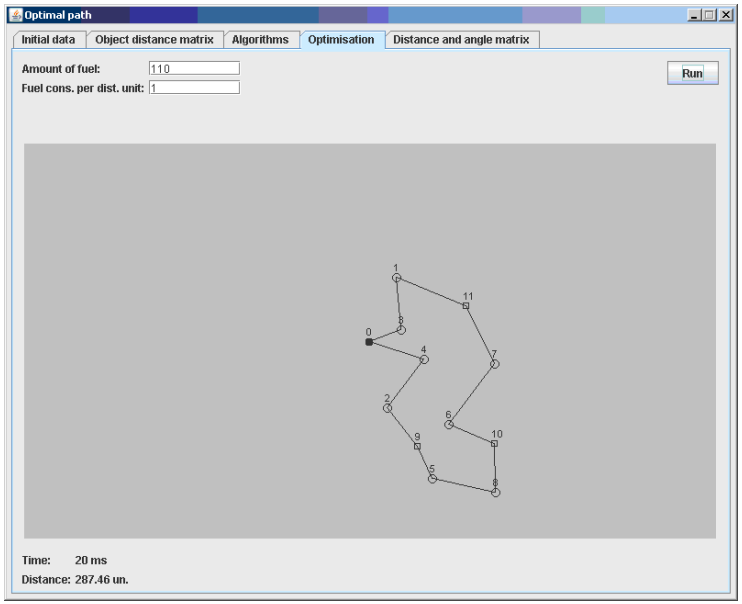
Robota darbības simulators

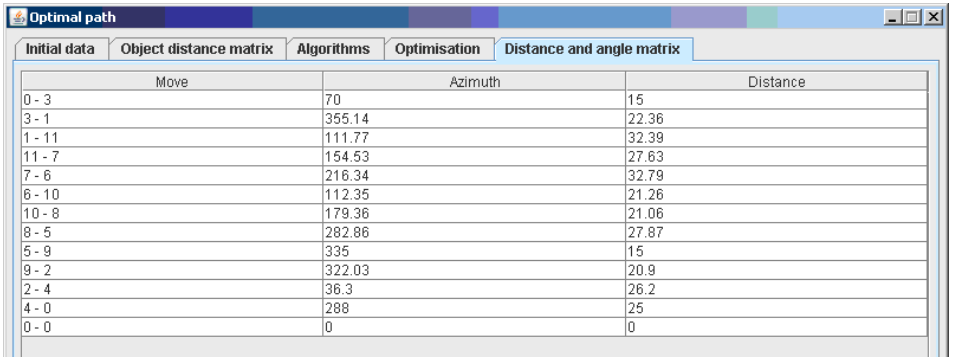




Robota darbības simulators





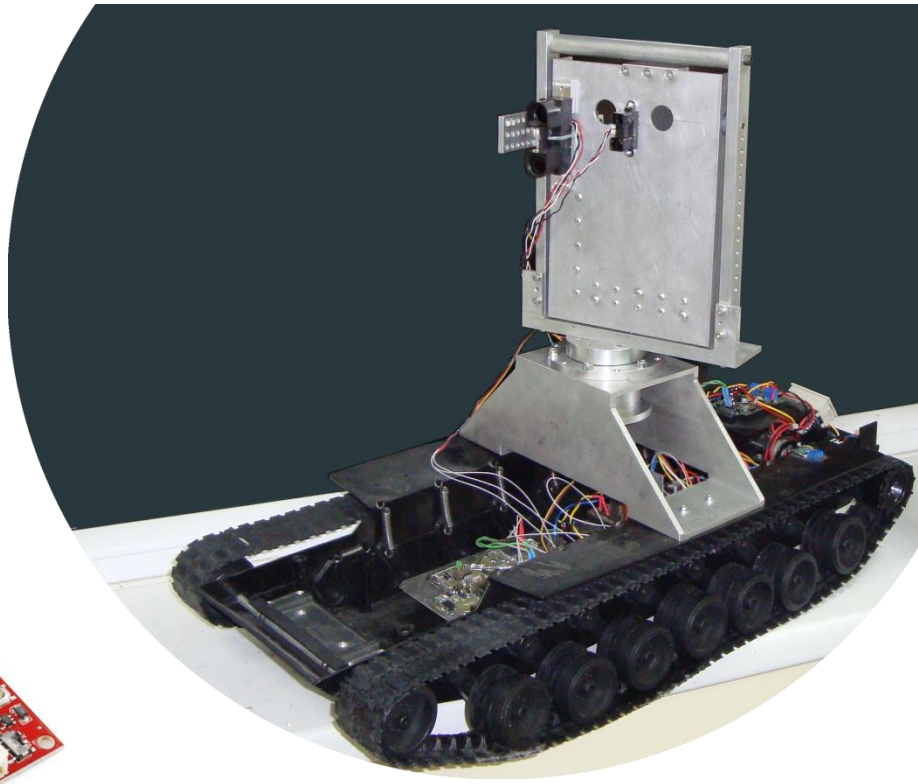


Move	Azimuth	Distance
0 - 3	70	15
3 - 1	355.14	22.36
1 - 11	111.77	32.39
11 - 7	154.53	27.63
7 - 6	216.34	32.79
6 - 10	112.35	21.26
10 - 8	179.36	21.06
8 - 5	282.86	27.87
5 - 9	335	15
9 - 2	322.03	20.9
2 - 4	36.3	26.2
4 - 0	288	25
0 - 0	0	0

Modulāra robota konstrukcija

















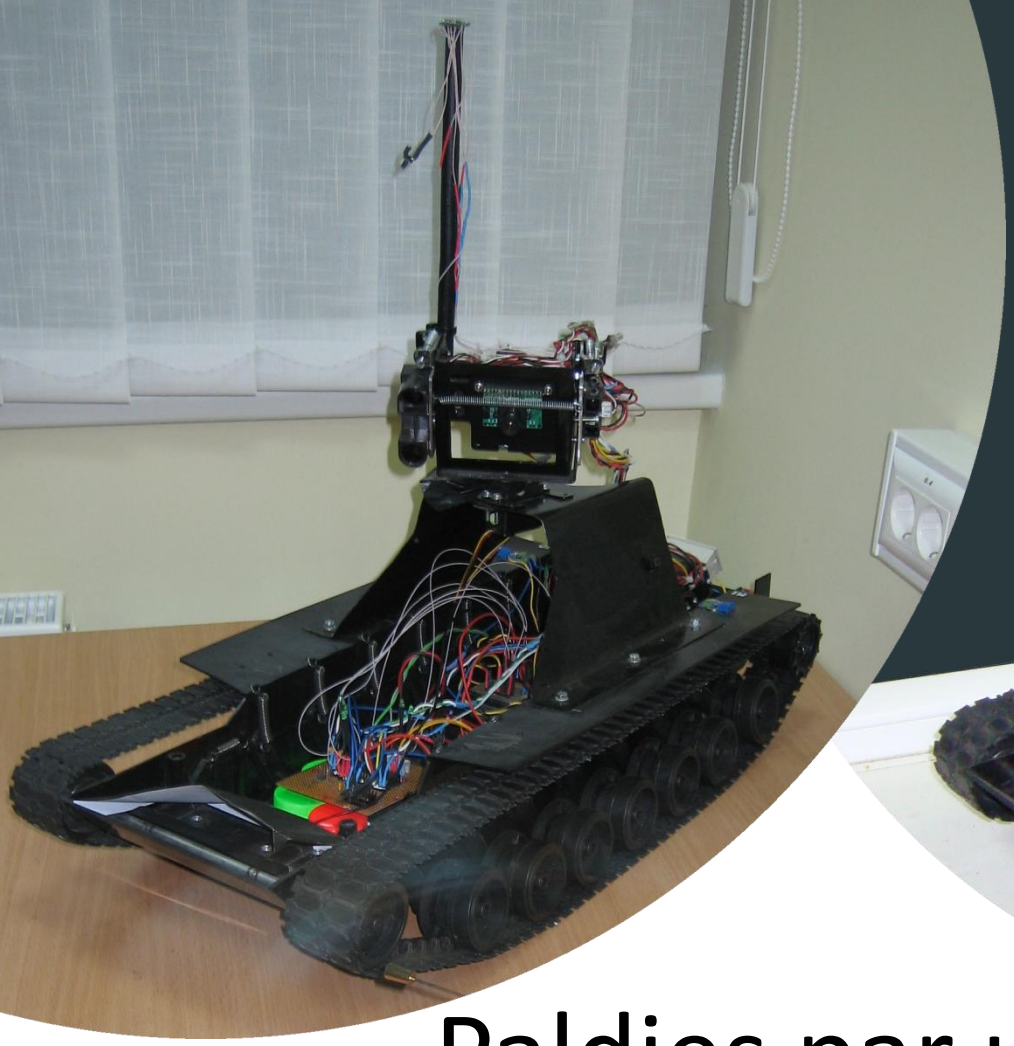


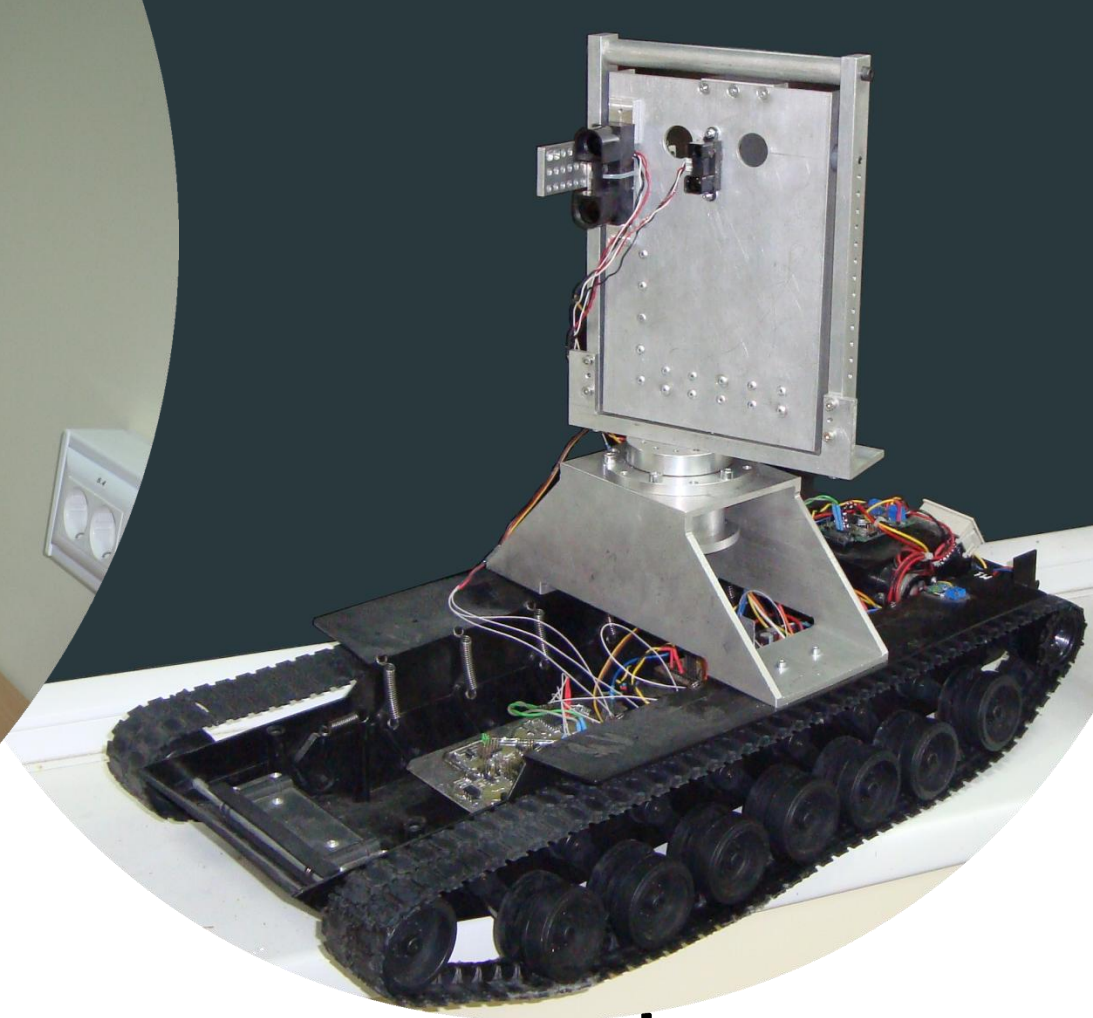
Sistēmas lietojumi

- Attālinātās klātbūtnes robots
- Algoritmu testēšana
- Sistēmas laika / enerģijas patēriņa novērtēšana izmantojot dažādus vadības algoritmus

Kopsavilkums

- Attēla iegūšana
- Marķieru atpazīšana attēlā
- Algoritmi notēmēšanai uz marķieriem
- Marķieru pozīciju noteikšanas algoritms
- Telpā novietoto marķieru attālumu matricas veidošana
- Īsākā noslēgta maršruta veidošana ar skudru algoritmu atrastajā marķieru kopā
- Veidotā noslēgta maršruta optimizācija - pēc nosacījumiem
- Virzienu un attālumu secību noteikšana kurai ir jāseko robotam, lai izbraukt noslēgtu maršrutu
- Robota navigācijas un pārvietošanās telpā algoritms





Paldies par uzmanību!

EIROPAS SOCIĀLAIS FONDS

IEGULDĪJUMS TAVĀ NĀKOTNĒ

EIROPAS SAVIENĪBA

Sejas detektēšana un lokalizācija ar Neironu Tīkliem un Lokāliem Bināriem Tēliem

Local Binary Patterns and Neural Network based Technique for Face Detection and Localization

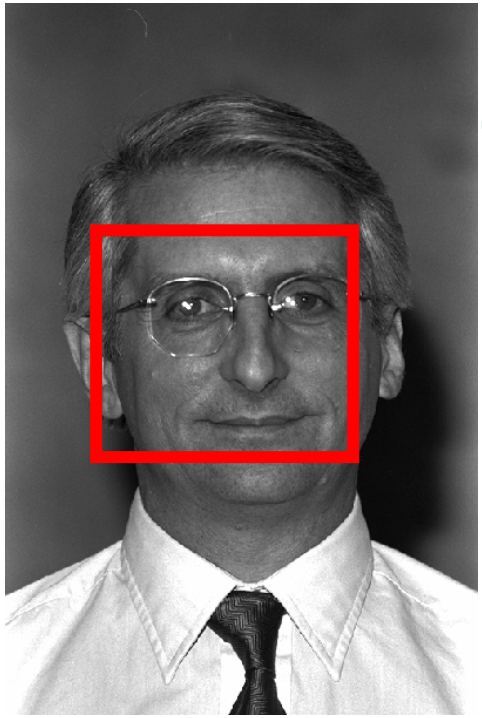
Presenter: Oļegs Ņikišins (BioSen)

Project: R&D Center for Smart Sensors and Networked Embedded Systems.
ESF grant No. "2009/0219/1DP/1.1.1.2.0/09/APIA/VIAA/020".

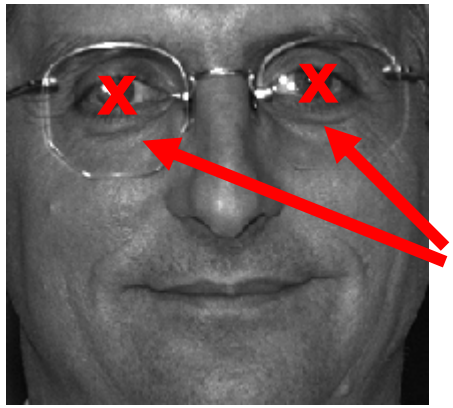
Local Binary Patterns and Neural Network based Technique for Robust Face Detection and Localization

Objective and terminology

- **Face Detection** - position of the face is determined **approximately** with small detection offsets



- **Face Localization** - determine **precise** face position based on reference points



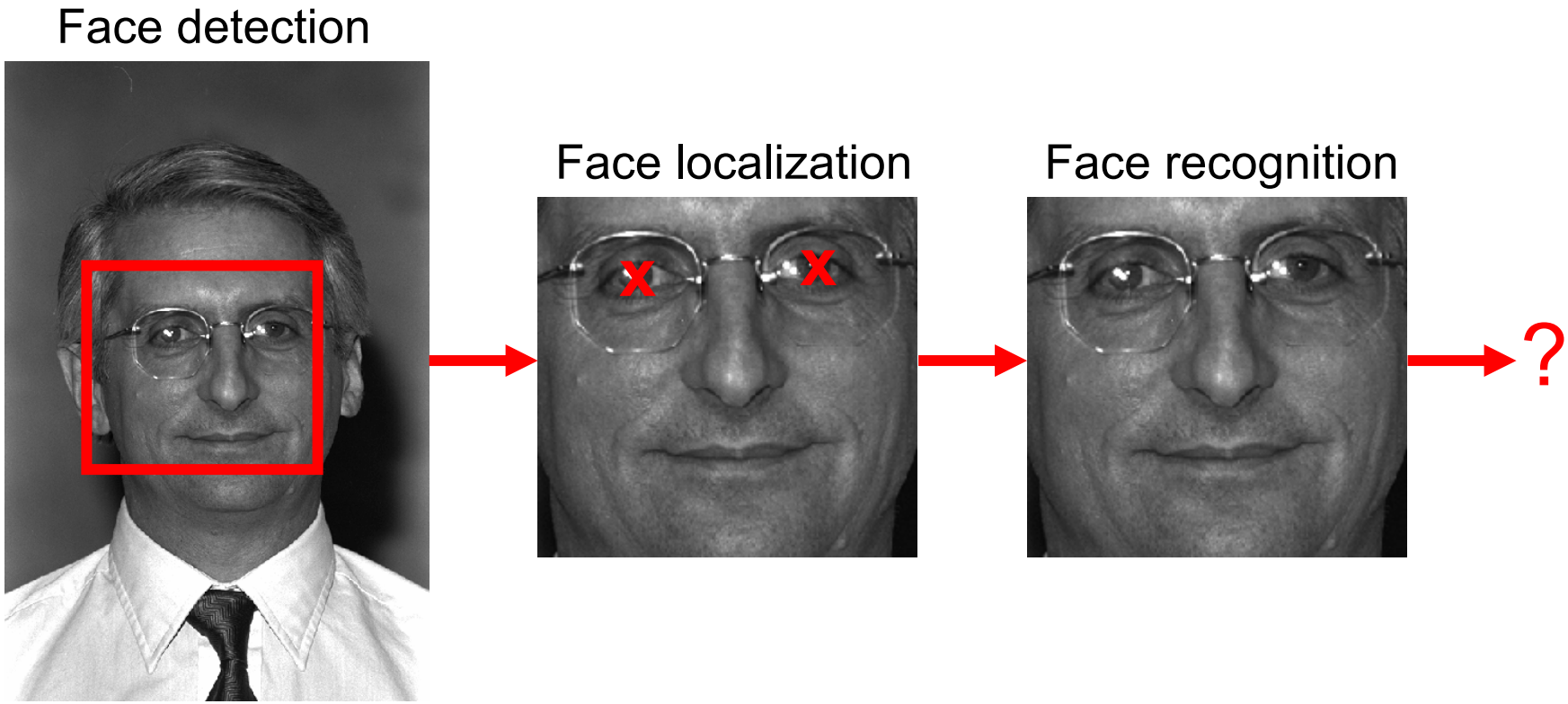
In our case:
reference points = eye pupils

• Sejas lokalizācija

• Sejas detektēšana

LBP-based Face Detection: motivation

The process of automatic face recognition:



LBP-based Face Detection: motivation

Significant papers about LBP-based face detection:

2004 – [1] → LBP + SVM for face detection

2006 – [2]
2007 – [3]
2008 – [4]
} LBP + boosting

LBP - Local Binary Patterns =
Lokālie Binārie Tēli

[1] A. Hadid, M. Pietikäinen, and T. Ahonen. A discriminative feature space for detecting and recognizing faces. In *CVPR (2)*, pages 797--804, 2004.

[2] H. Zhang, W. G., X. Chen, and D. Zhao. Object detection using spatial histogram features. *Image Vision Comput.*, 24(4):327--341, 2006.

[3] L. Zhang, R. Chu, S. Xiang, S. Liao, and S. Z. Li. Face detection based on multi-block lbp representation. In Seong-Whan Lee and Stan Z. Li, editors, *ICB*, volume 4642 of *Lecture Notes in Computer Science*, pages 11--18. Springer, 2007.

[4] S. Yan, S. Shan, X. Chen, and W. Gao. Locally assembled binary (lab) feature with featurecentric cascade for fast and accurate face detection. In *CVPR*. IEEE Computer Society, 2008.

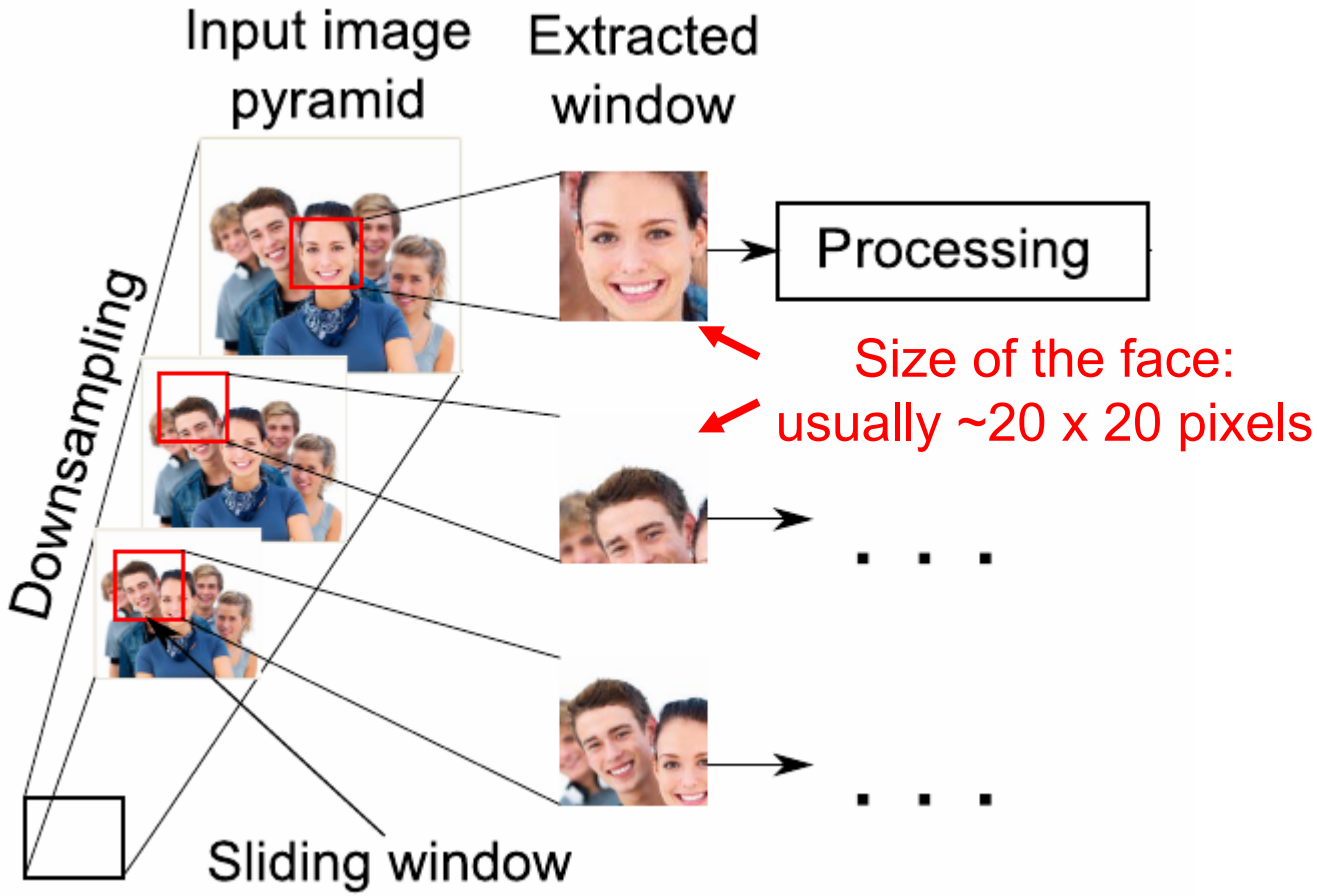
LBP-based Face Detection: motivation

2004 – [1]

2006 – [2]

2007 – [3]

2008 – [4]



Downsampling is needed because of the nature of classifiers + timing constraints.

Downsampling = LOSS of STATISTICAL DATA about the object.

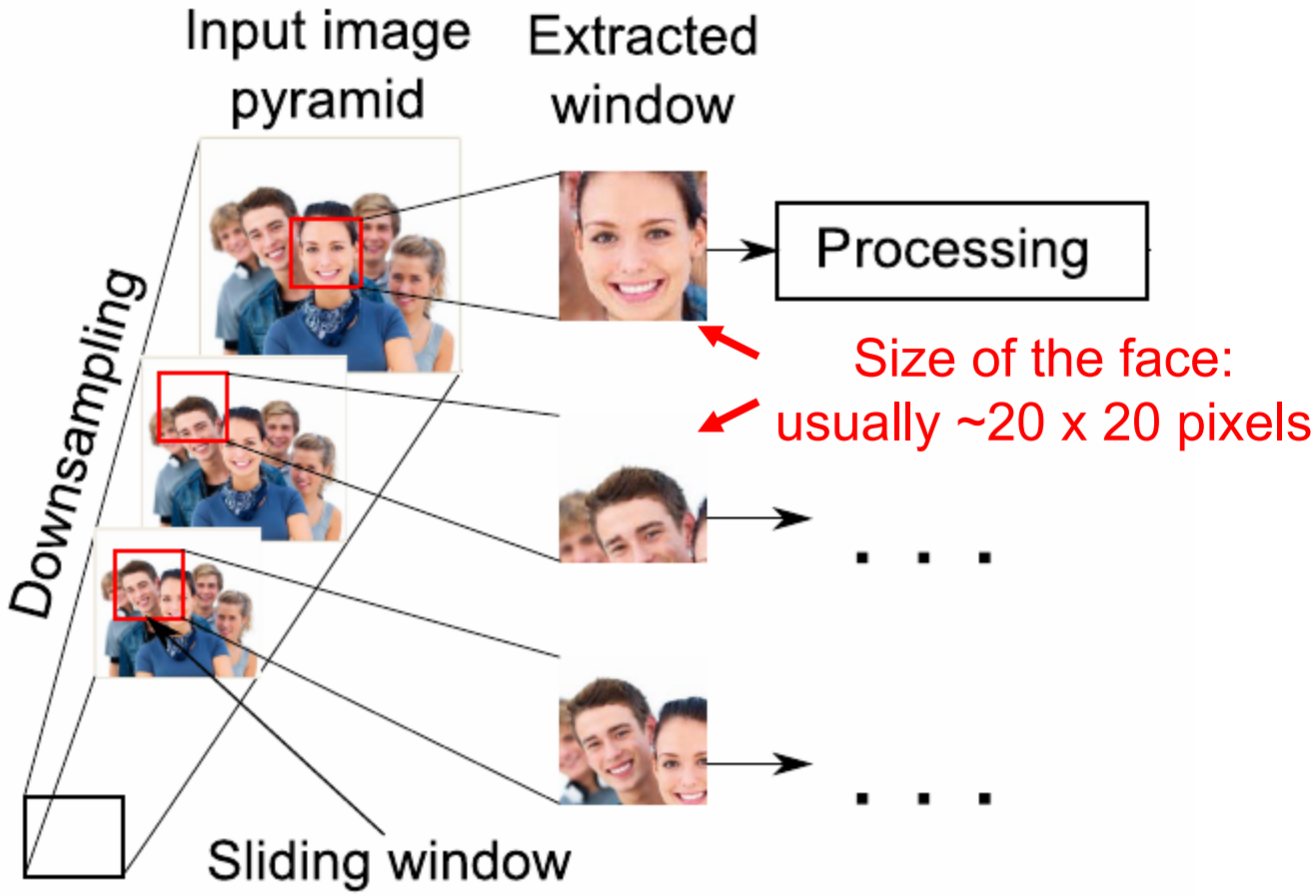
LBP-based Face Detection: motivation

2004 – [1]

2006 – [2]

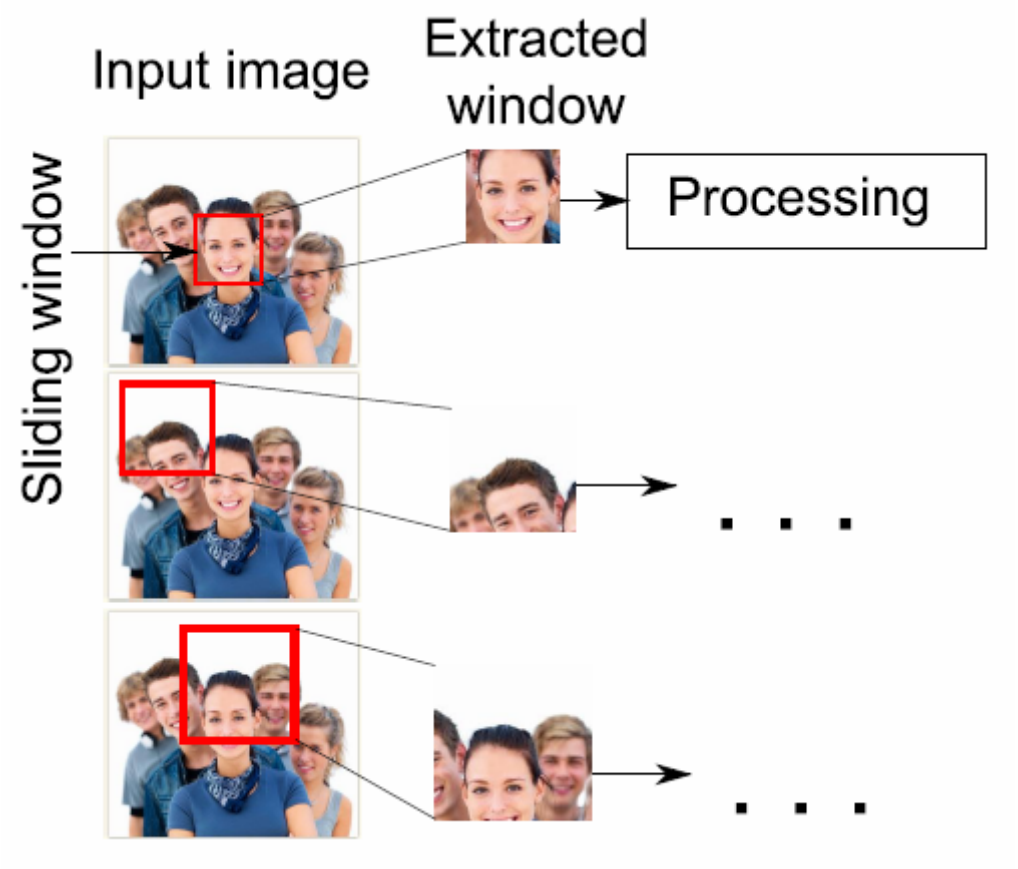
2007 – [3]

2008 – [4]



LOSS of STATISTICAL DATA about the object. → Degrades the performance of the detector

LBP-based Face Detection: motivation



Our approach:

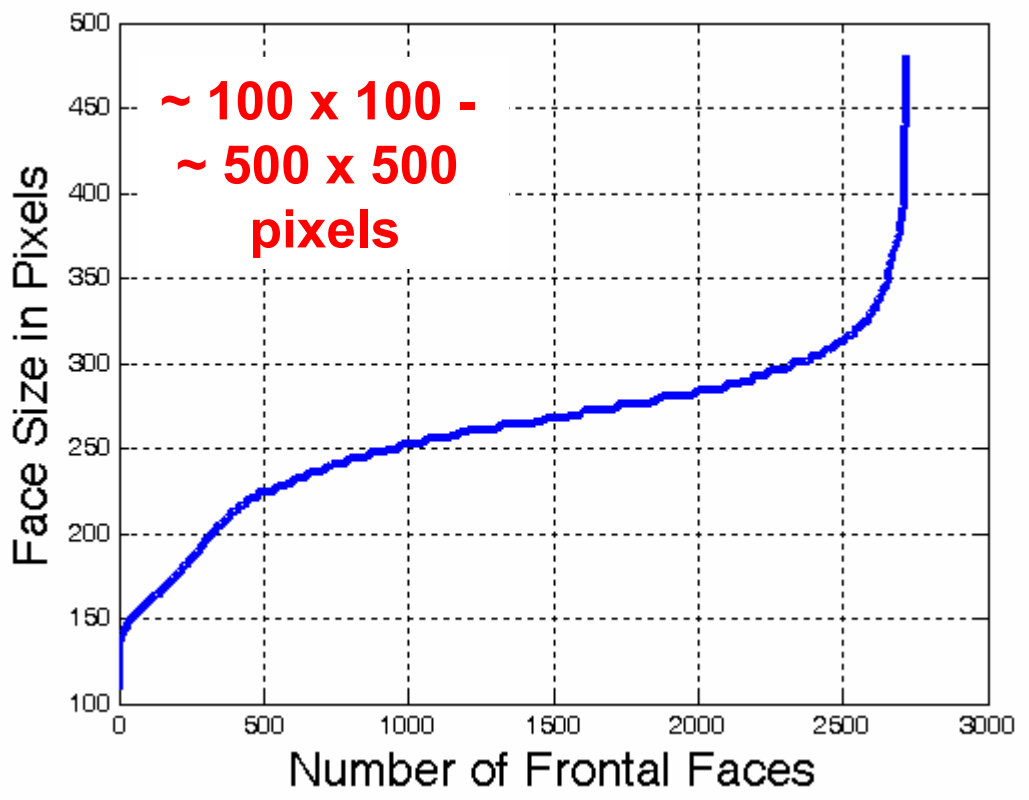
- ~~downsampling~~
- **increasing size of the sliding window**

Don't loose statistical data on the first stage of the algorithms

We can possibly come up with more informative features and better precision?

Possible problems:

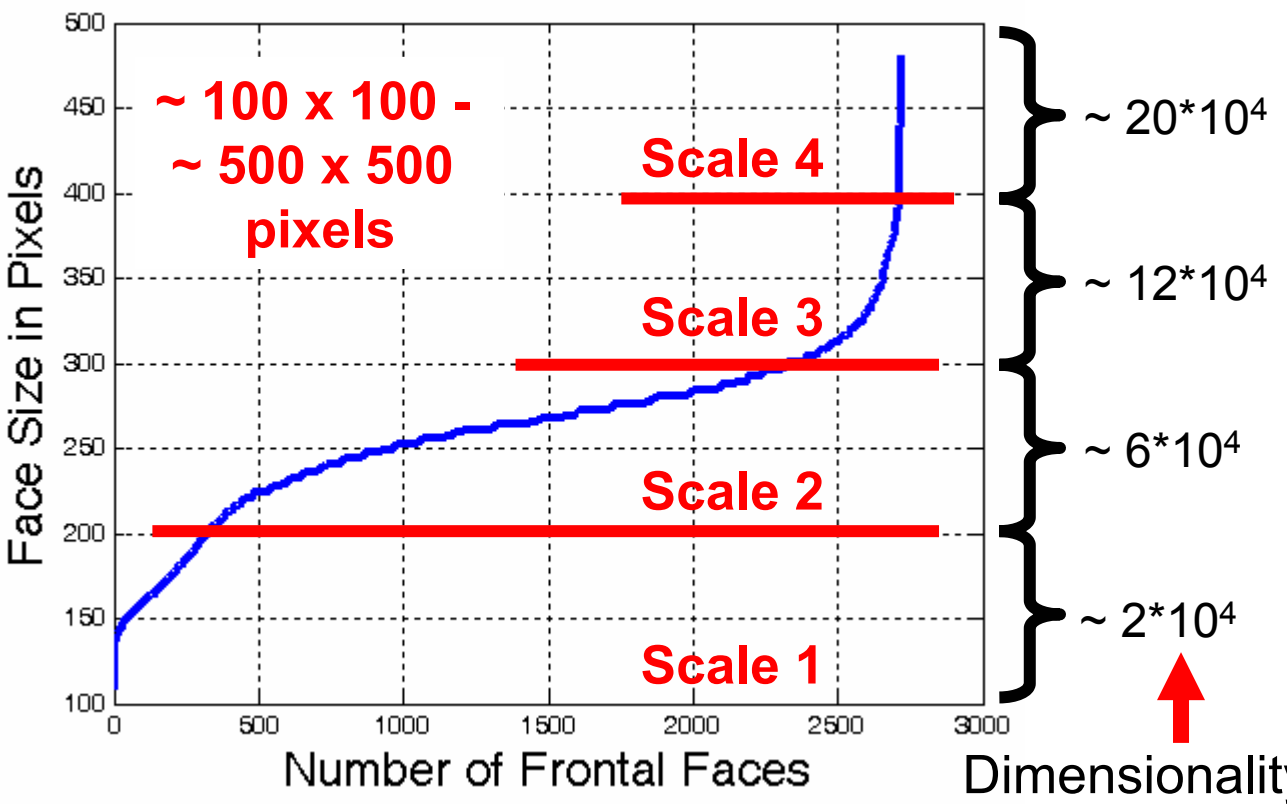
Distribution of face sizes in FERET database:



Possible problems:

If straightforward (on pixel-level) face detection technique is applied:

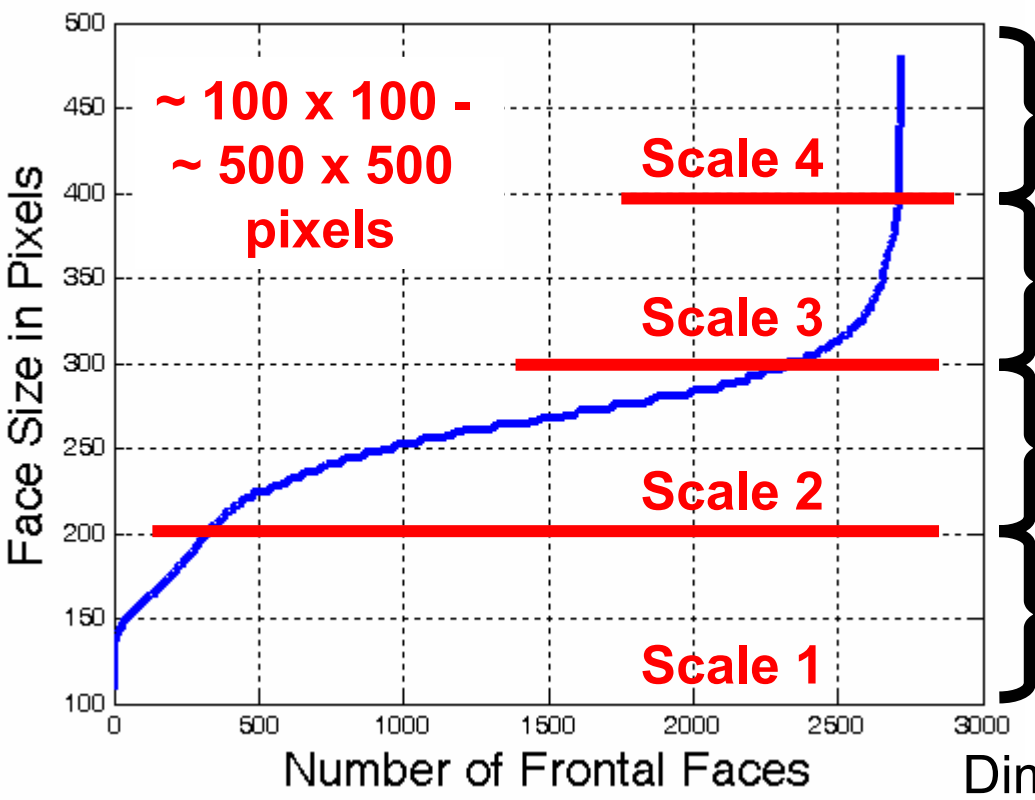
Distribution of face sizes in FERET database:



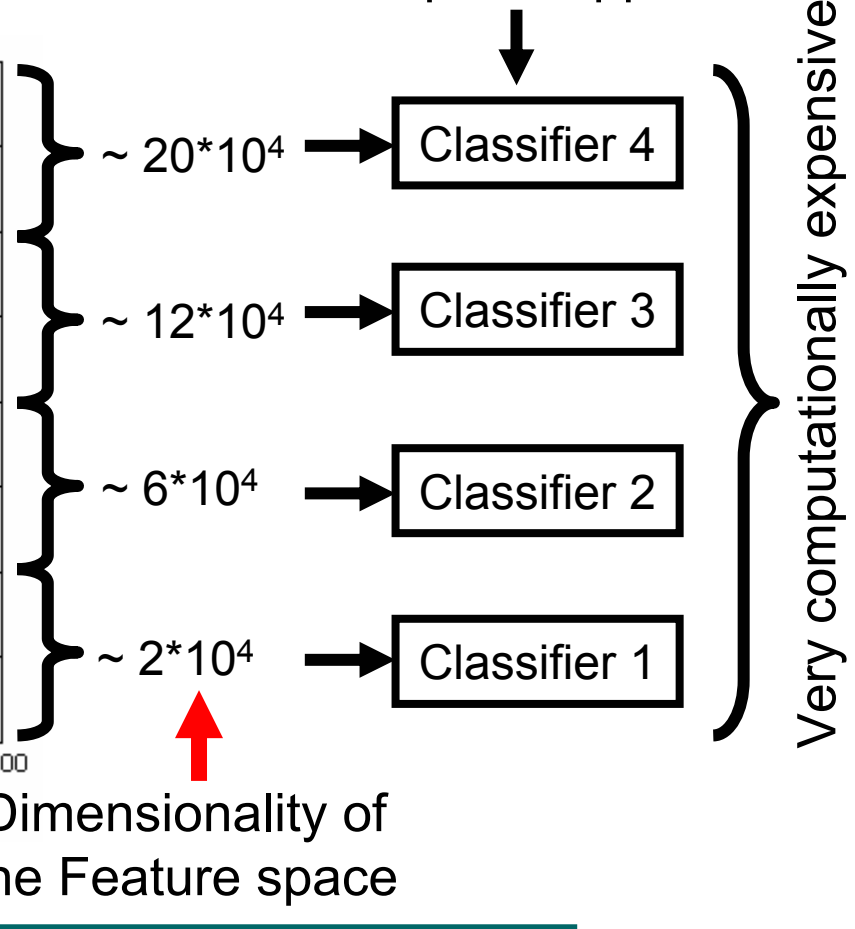
Dimensionality of the Feature space

Possible problems:

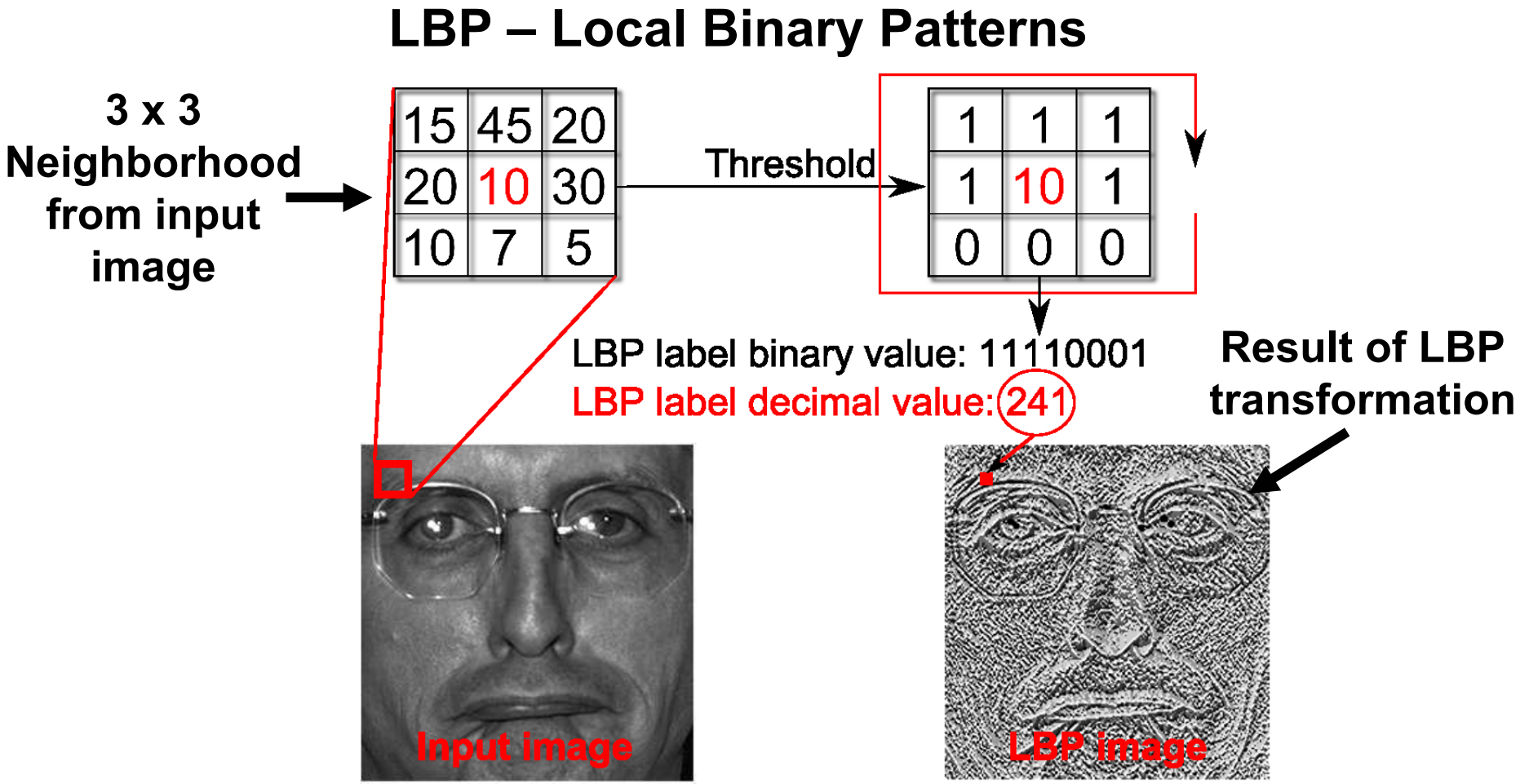
Distribution of face sizes in FERET database:



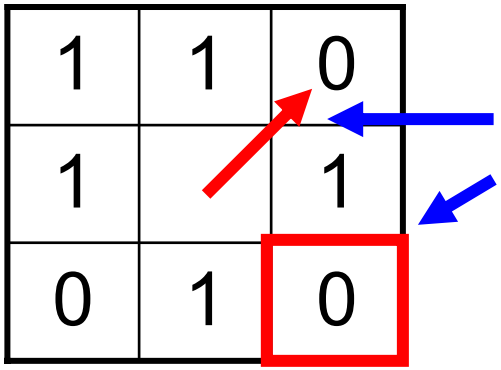
If straightforward (on pixel-level) face detection technique is applied:



LBP-based Face Detection: Theory



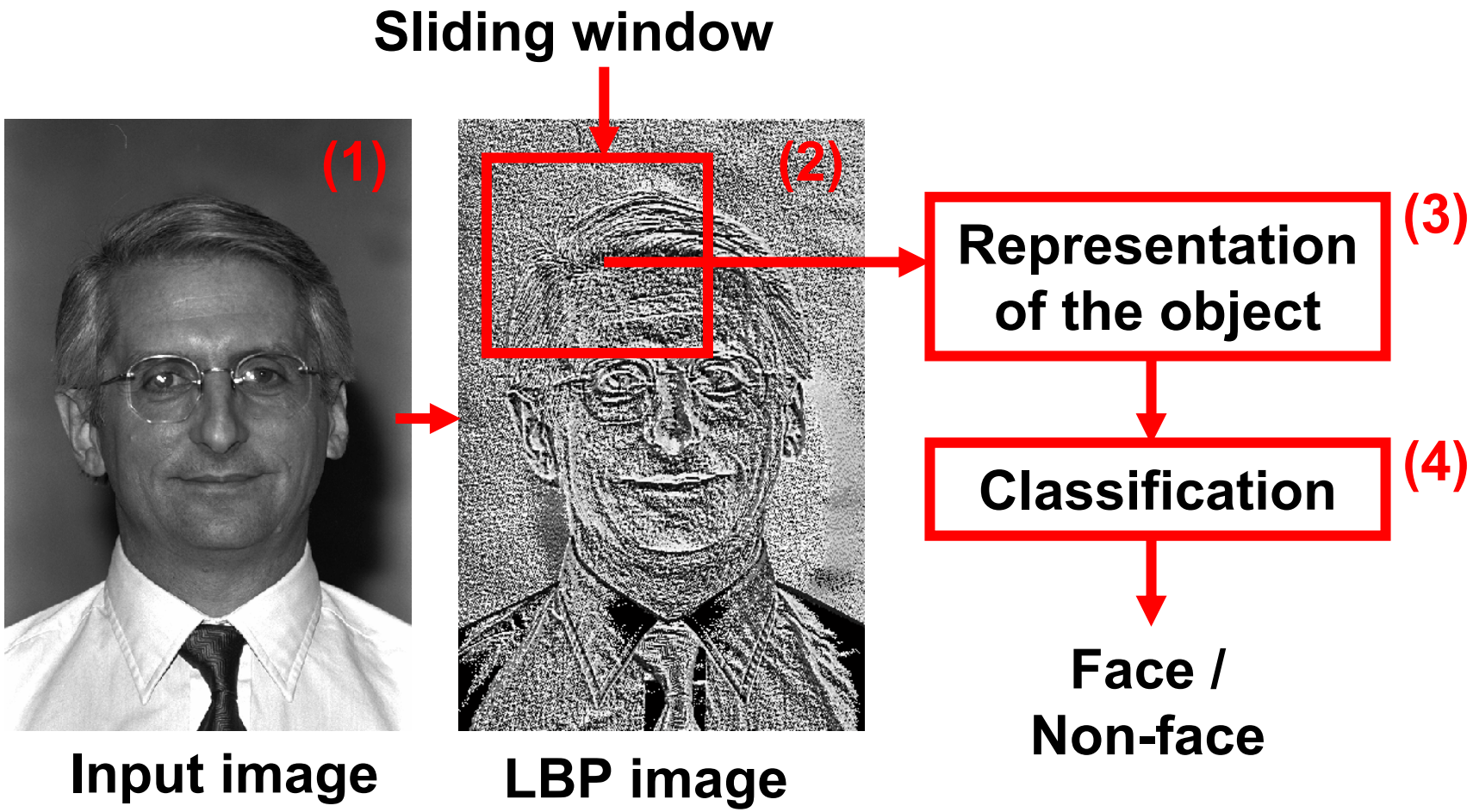
LBP-based Face Detection: Theory



Parameters of LBP operator:
R – radius (R = 1)
P – number of sampling points (Here: P = 8)

Number of possible LBP values: $n = 2^P$

LBP-based Face Detection: Theory



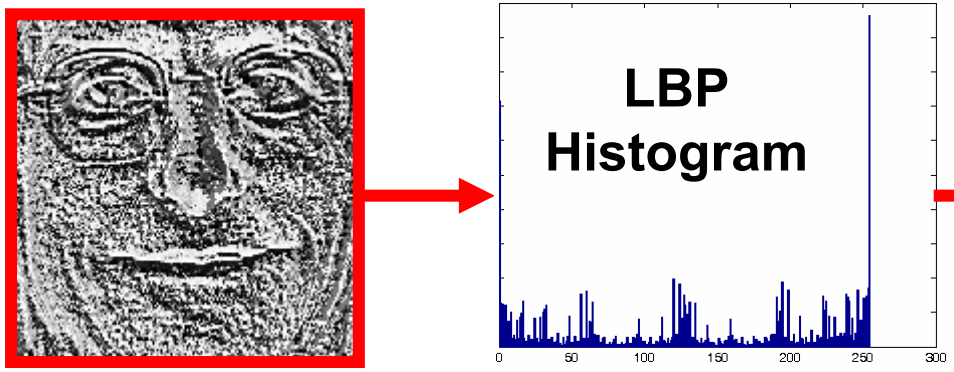
A lot of parameters to be optimized / evaluated !

LBP-based Face Detection: Theory

Representation of the object / face:

Possible approaches:

(1)



"+" – the length of the feature vector is independent from the size of the input image:

$N = 2^P$

"-" – the spatial information about the face is lost

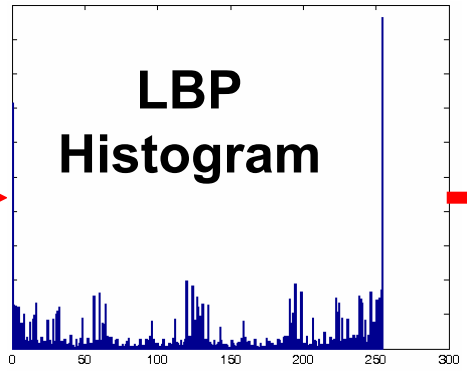
LBP-based Face Detection: Theory

Representation of the object / face:

Possible approaches:

(1)



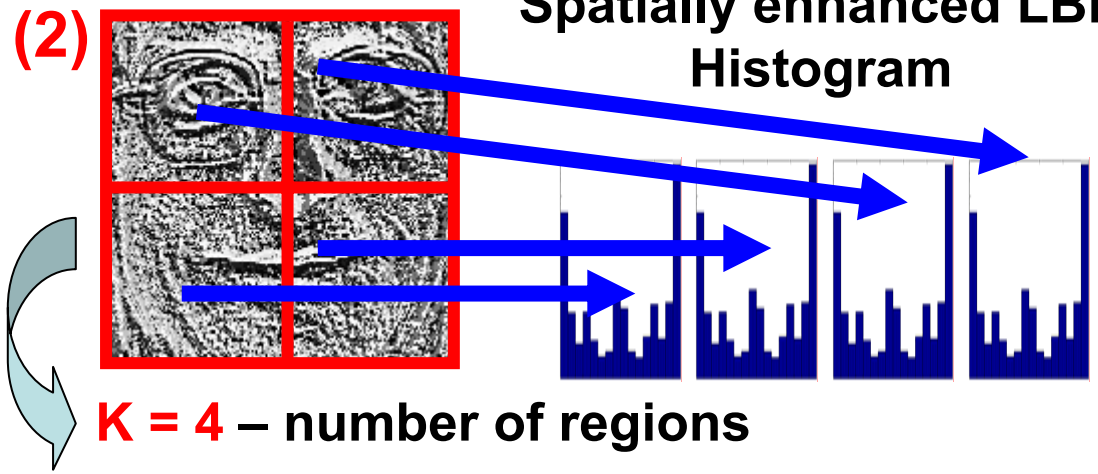


"+" – the length of the feature vector is independent from the size of the input image:

$N = 2^P$

"-" – the spatial information about the face is lost

(2)



K = 4 – number of regions

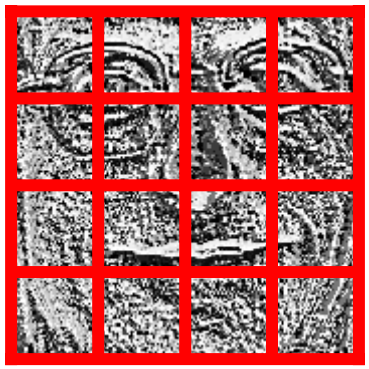
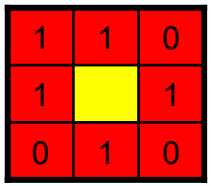
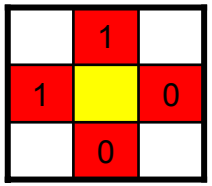
"+" – the length of the feature vector is independent from the size of the input image:

"+ / -" $N = K * 2^P$

"+" – the spatial information about the face is present

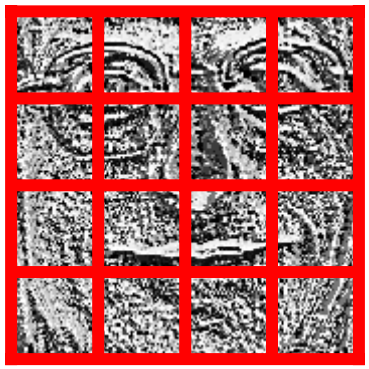
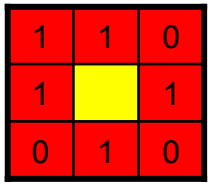
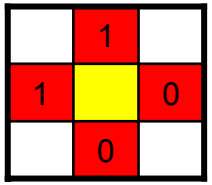
LBP-based Face Detection: Theory

Dimensionality of the feature space: $N = K * 2^P$

	K = 1	K = 4	K = 9	K = 16
				
P = 8 	N = 256	N = 1024	N = 2304	N = 4096
P = 4 	N = 16	N = 64	N = 144	N = 256

LBP-based Face Detection: Theory

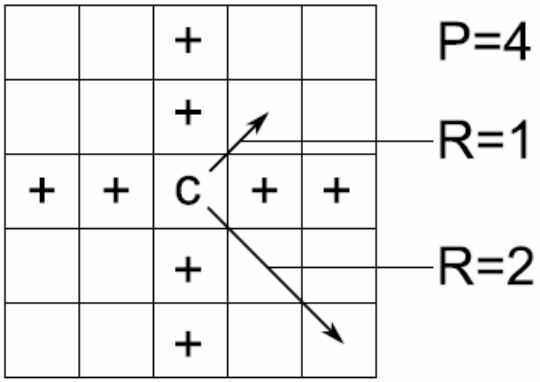
Dimensionality of the feature space: $N = K * 2^P$

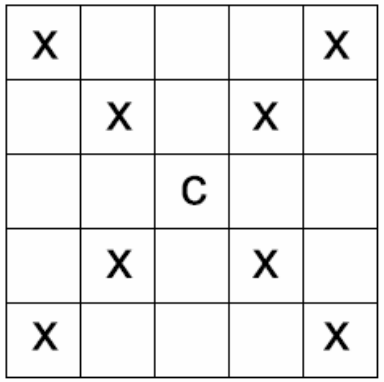
	K = 1	K = 4	K = 9	K = 16
				
P = 8 	~~N = 256~~	~~N = 1024~~	~~N = 2304~~	~~N = 4096~~
P = 4 	~~N = 16~~	N = 64	N = 144	N = 256

LBP-based Face Detection: Theory

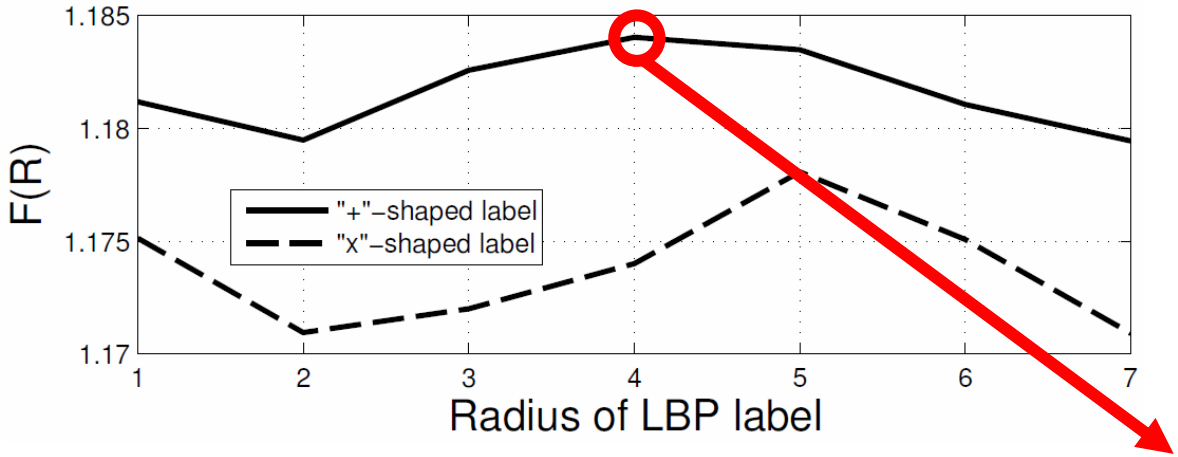
Parameters of LBP operator: P = 4, R = ?, structure - ?

"+" - shaped LBP label structure





"x" - shaped LBP label structure

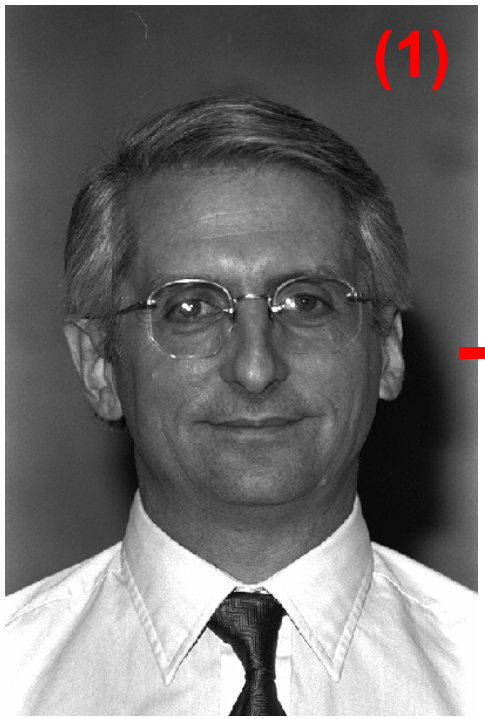


Maximize the ration between average face-class and nonface-class Euclidean distances

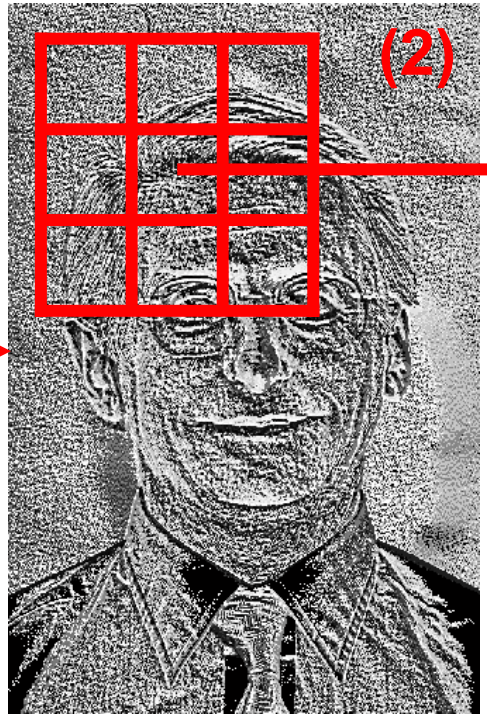
P = 4, R = 4, structure – "+" shaped

LBP-based Face Detection: Theory

LBP operator parameters are known → P = 4, R = 4, "+" shaped structure



Input image



LBP image

Representation of the object

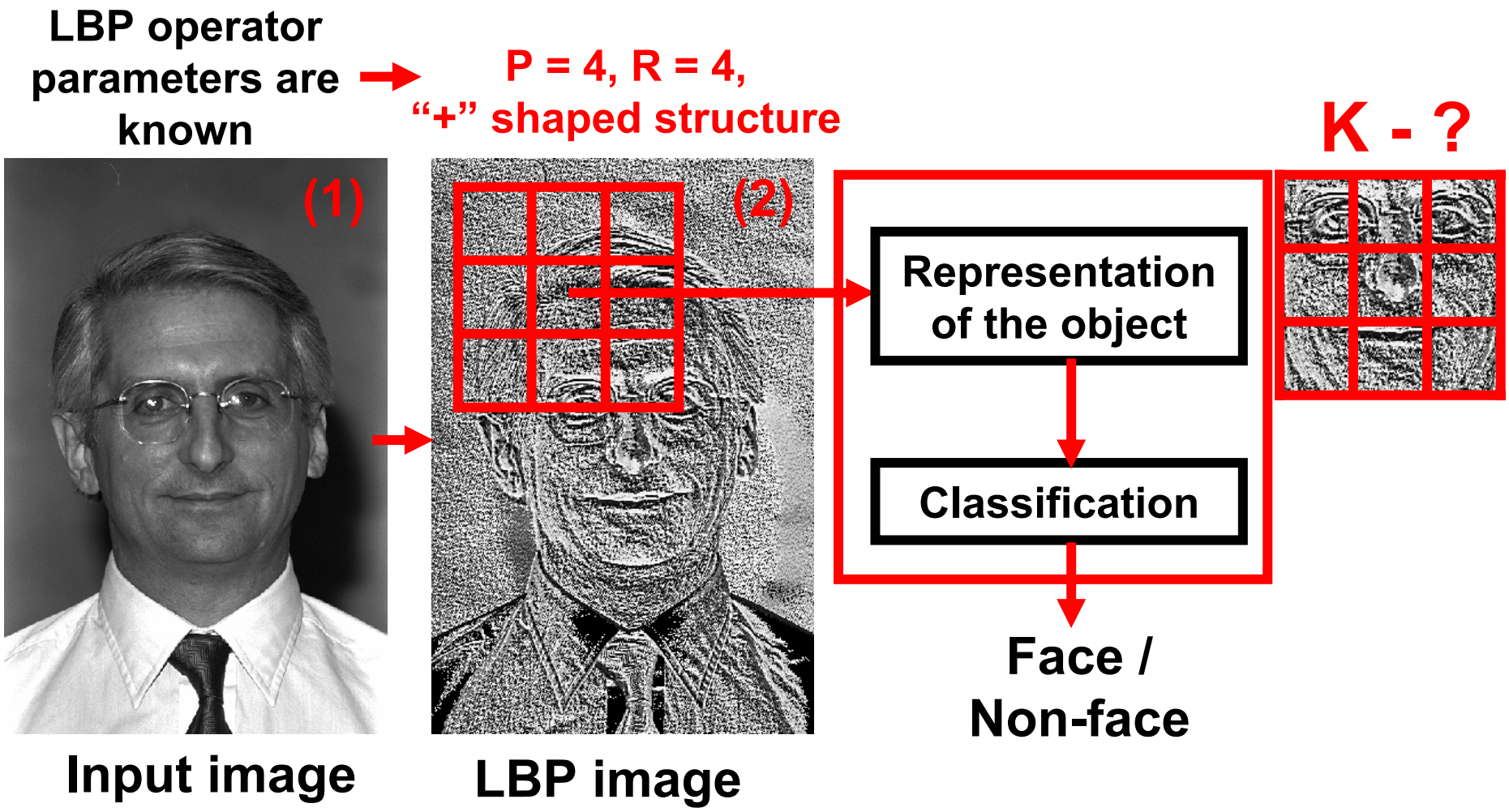
Classification

Face / Non-face

K - ?



LBP-based Face Detection: Theory



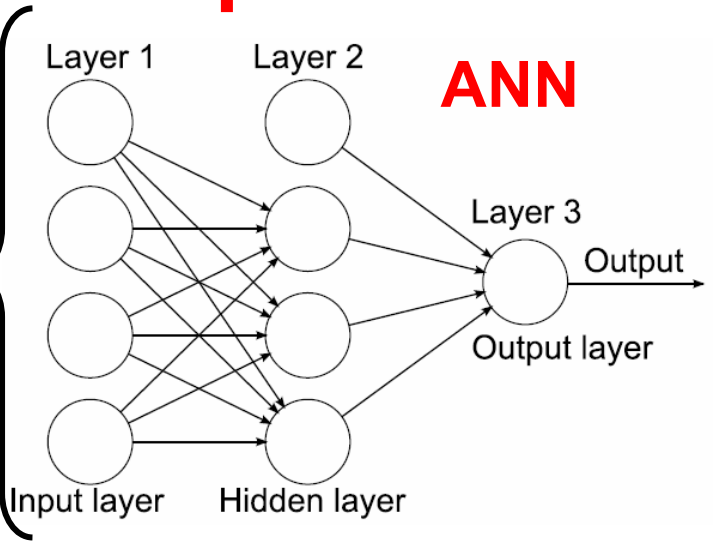
LBP-based Face Detection: Theory

K = 4



+

N = 64



Variable number of neurons in hidden layer

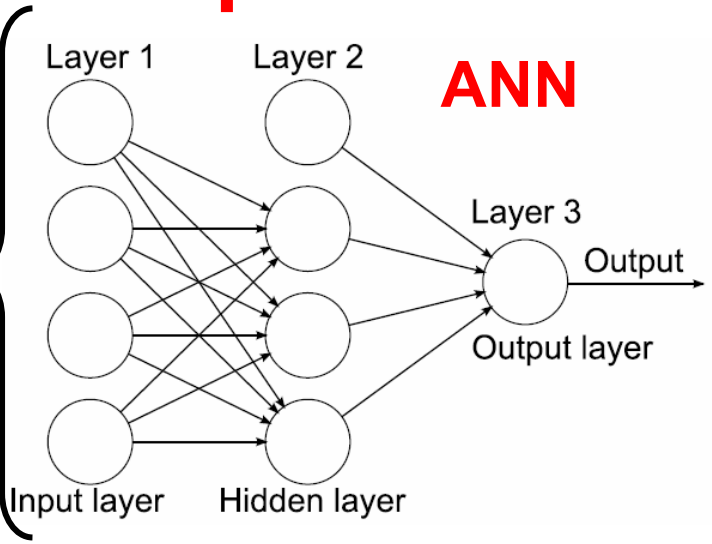
LBP-based Face Detection: Theory

K = 4

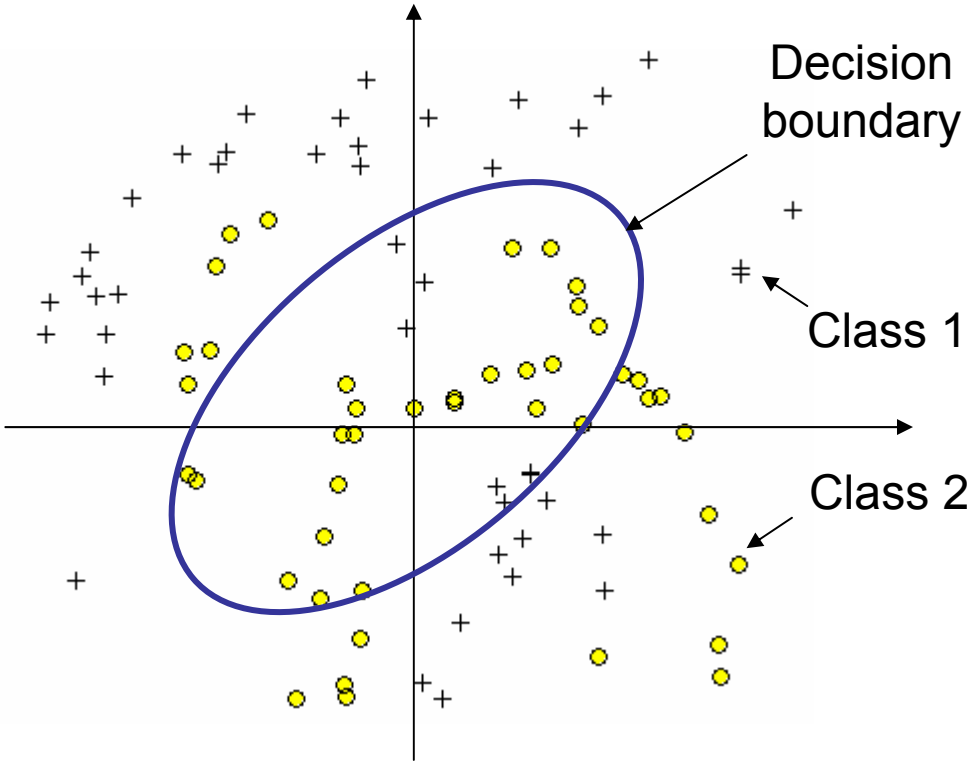


+

N = 64



High bias problem



Variable number of neurons in hidden layer

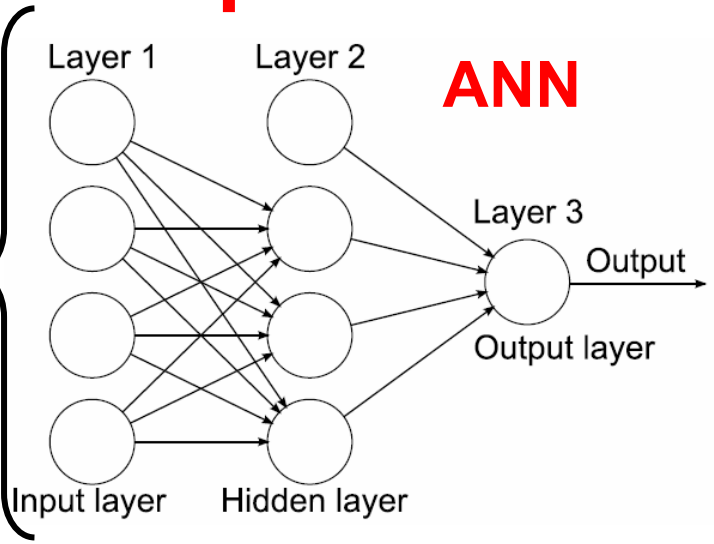
LBP-based Face Detection: Theory

K = 4

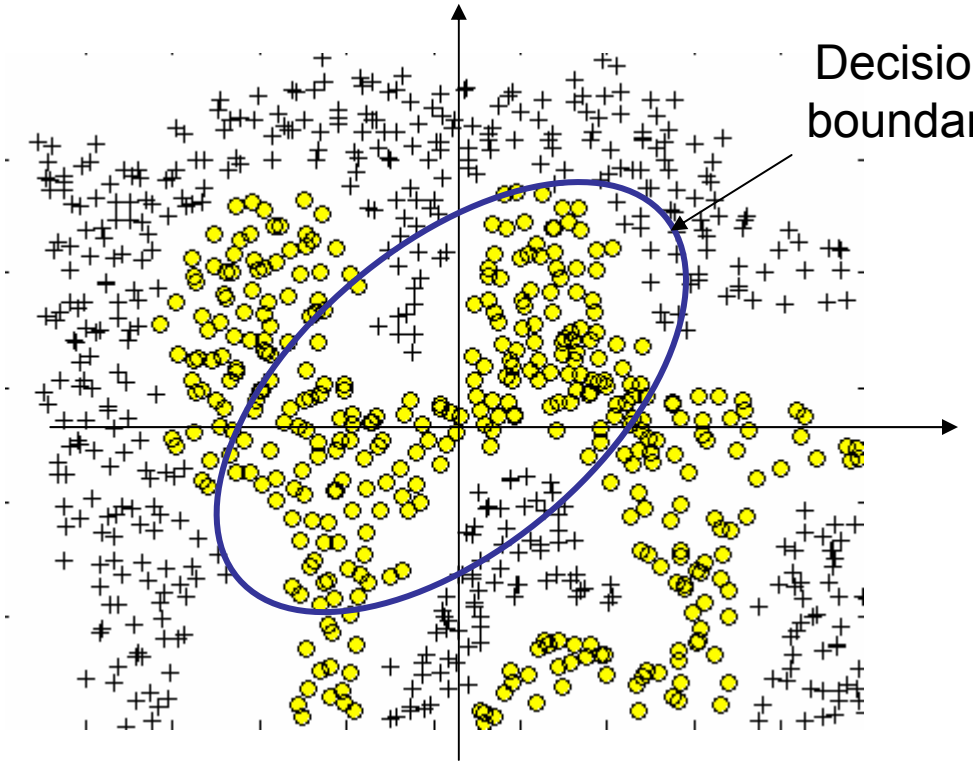


+

N = 64



High bias problem



Variable number of neurons in hidden layer

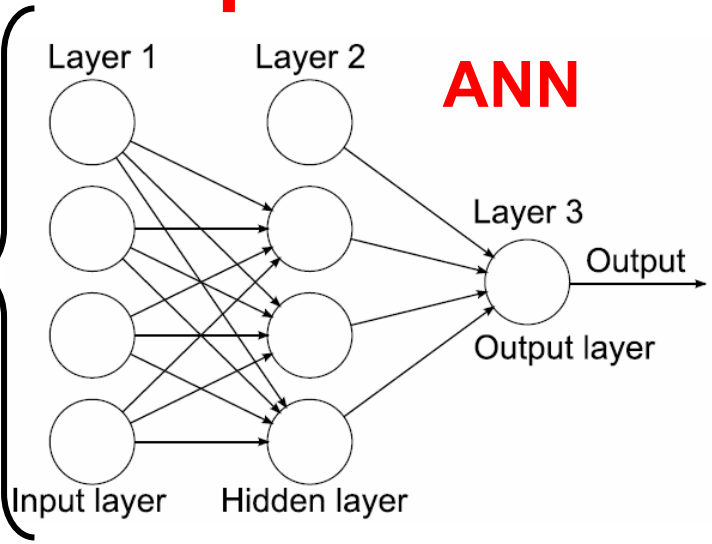
LBP-based Face Detection: Theory

K = 4

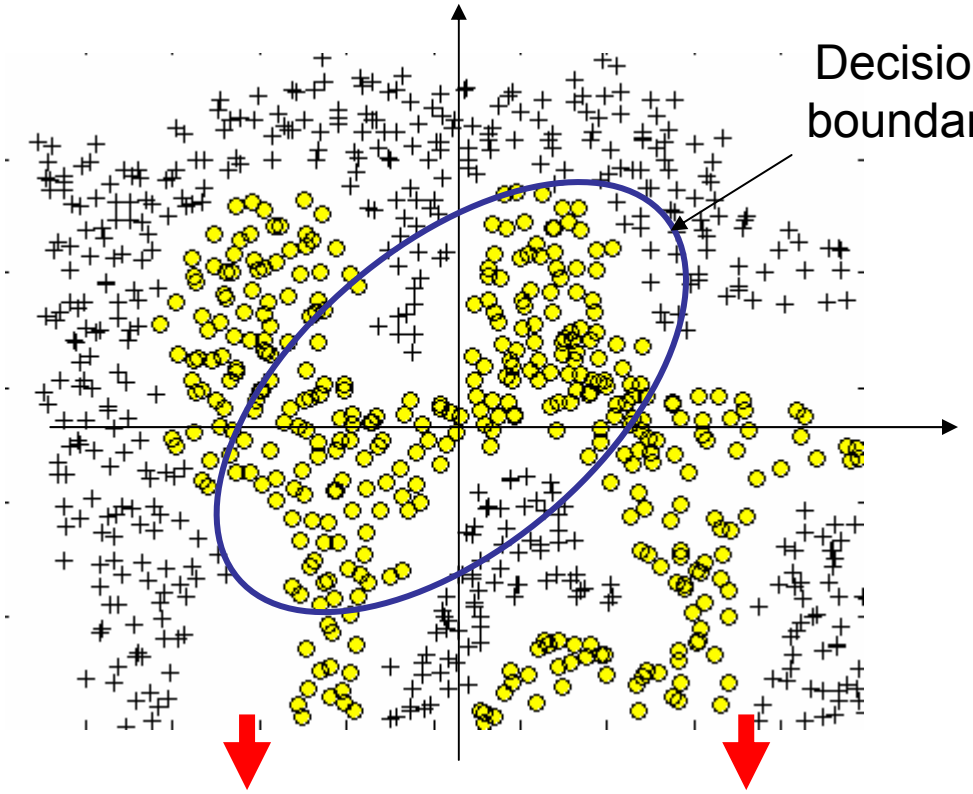


+

N = 64



High bias problem

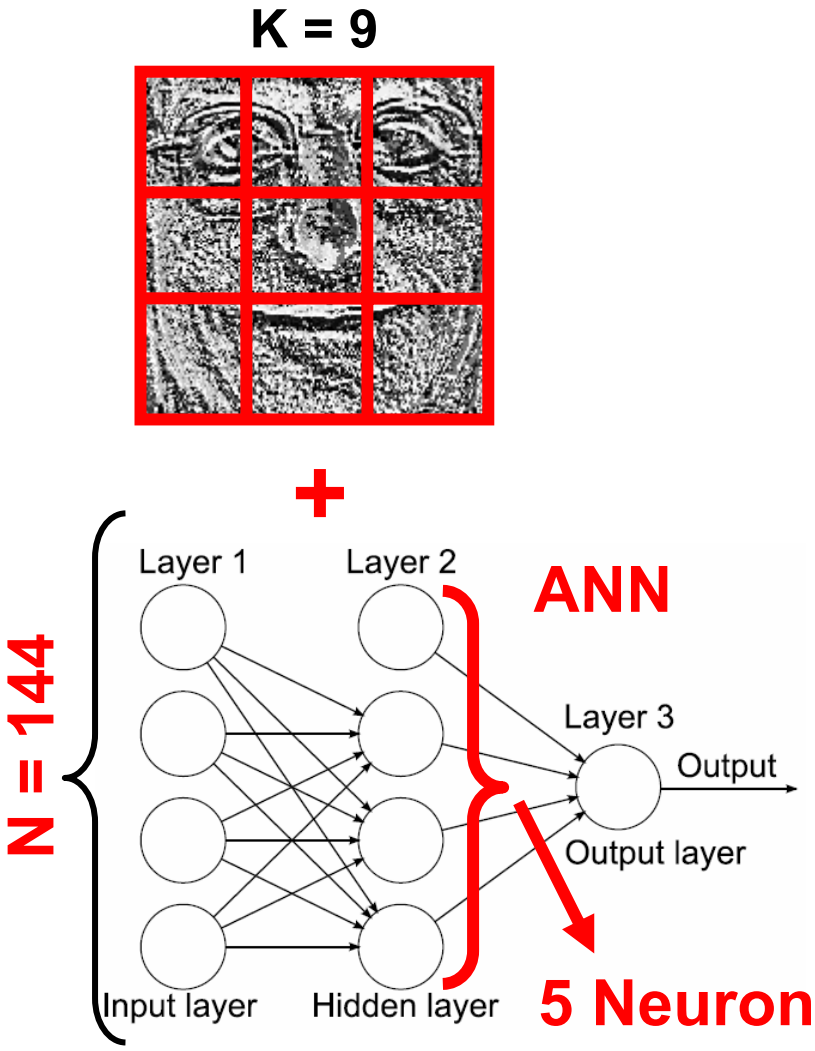


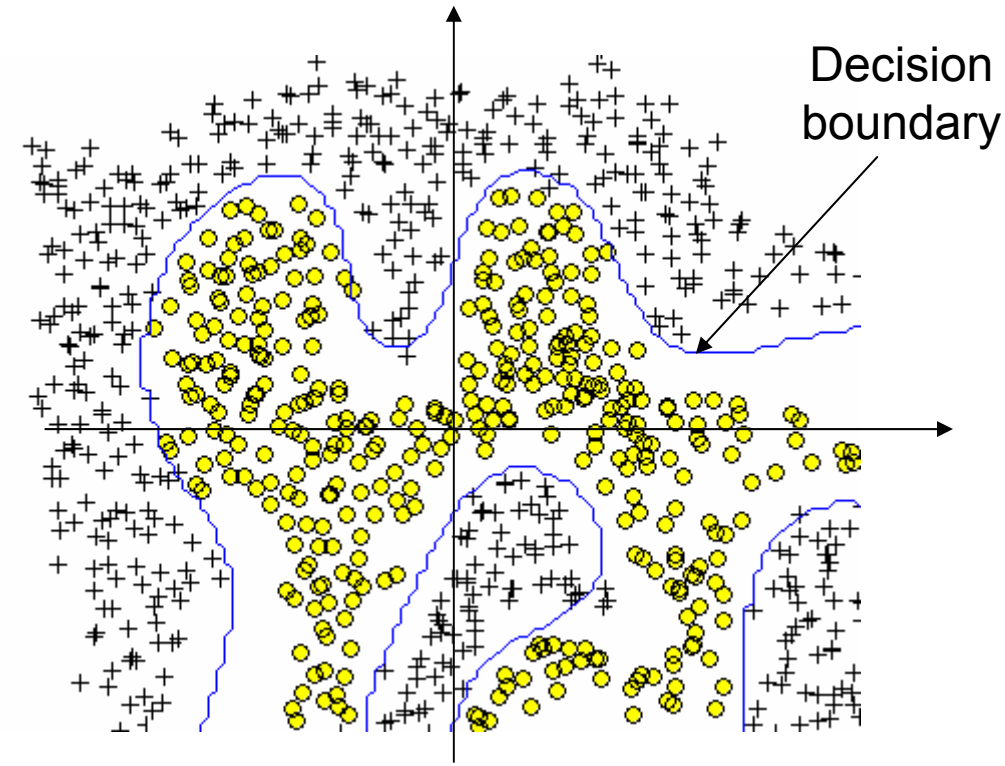
1) More features: Increase N

2) More complex ANN

Variable number of neurons in hidden layer

LBP-based Face Detection: Theory





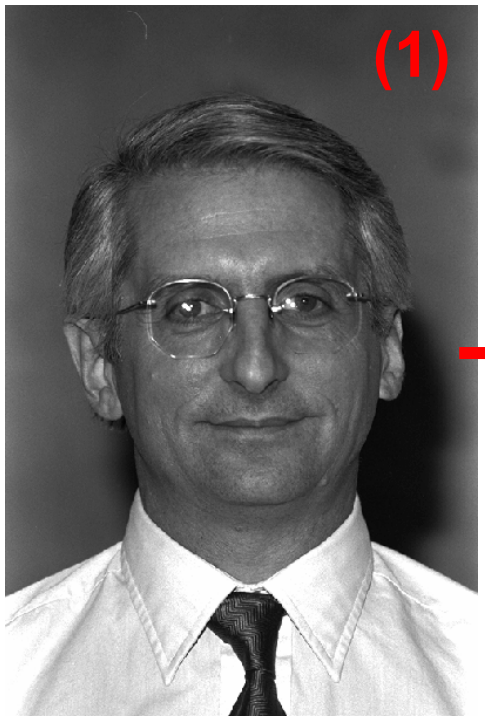
LBP-based Face Detection: Theory

LBP operator parameters are known

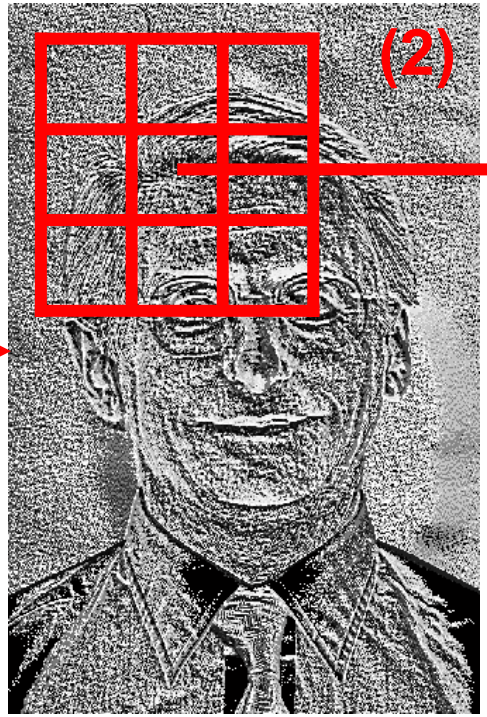
P = 4, R = 4, "+" shaped structure

K = 9

N =144



Input image



LBP image

Representation of the object



Classification

Face / Non-face

ANN with 5 neurons in the hidden layer

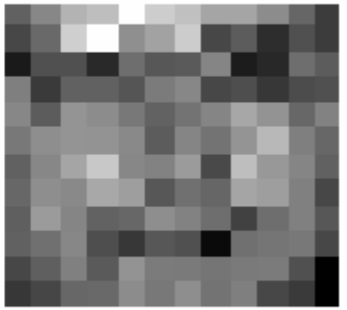
LBP-based Face Detection: Theory

Is it the best solution? – no
These are just minimum requirement
for reasonable (?) performance:

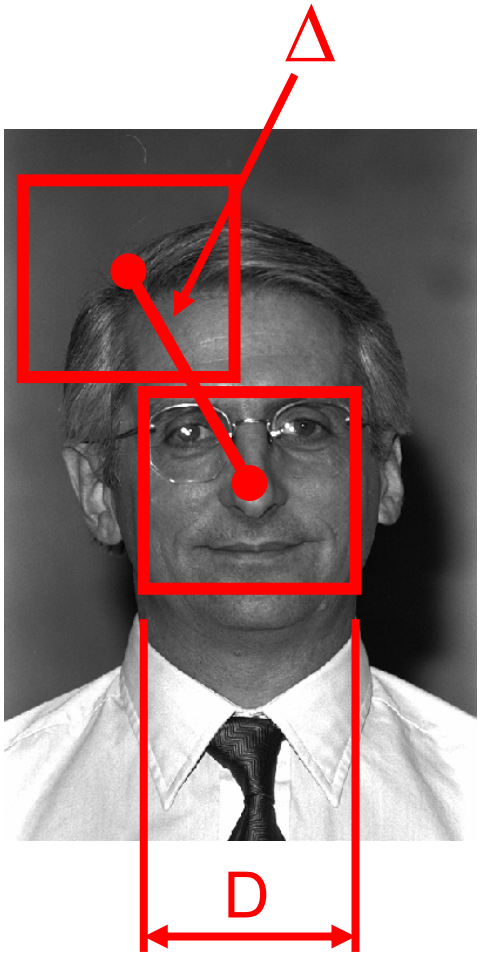
- **144** LBP features for face / non –face representation
- **5 neurons** in the hidden layer of an ANN

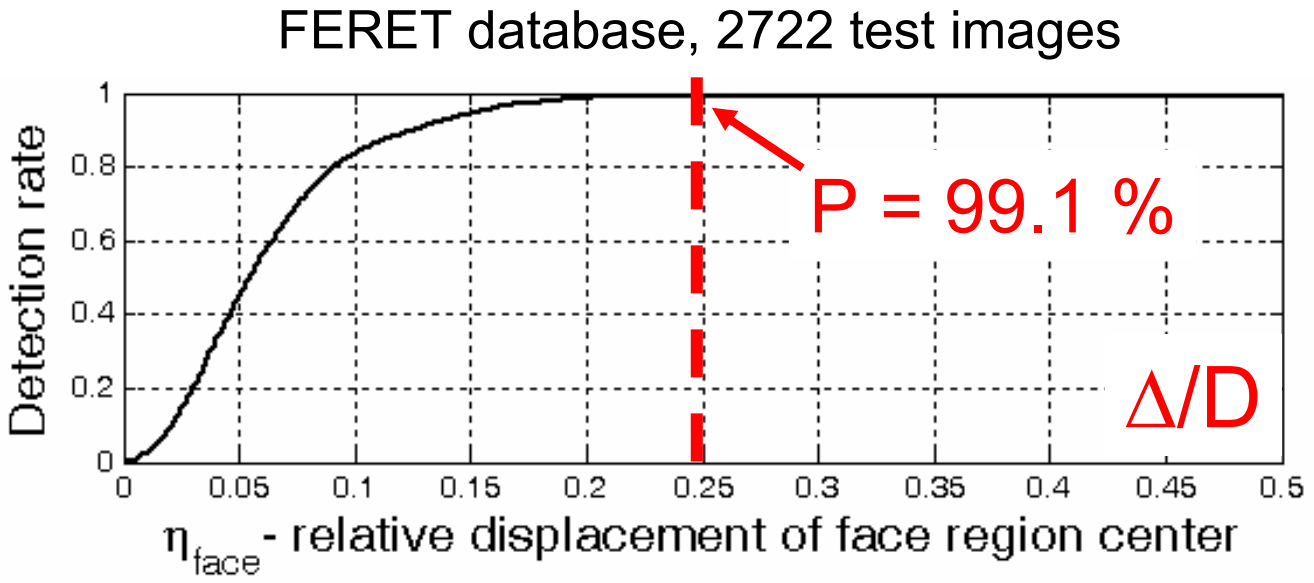
Are the LBP features informative?





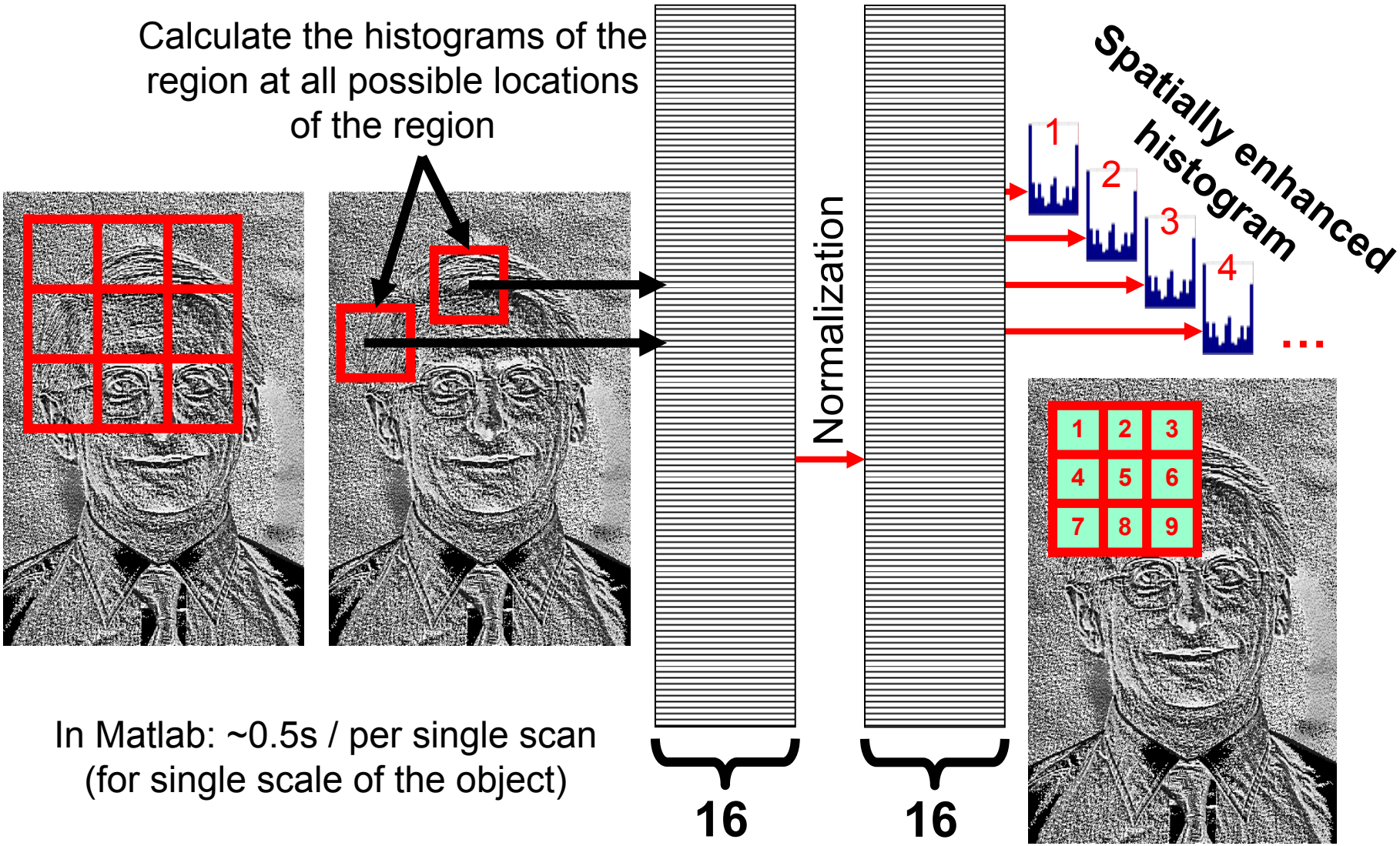
LBP-based Face Detection: Performance





- **144** LBP features for face / non –face representation
  - **5 neurons** in the hidden layer of an ANN
- training set size **~ 50 000** face & non-face patterns

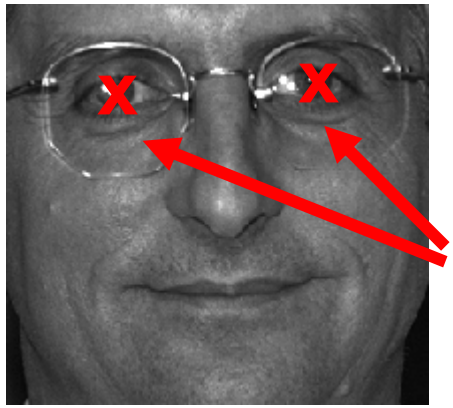
LBP-based Face Detection: Timing



In Matlab: ~0.5s / per single scan
(for single scale of the object)

LBP-based Face Localization: Theory

Face Localization - determine precise face position based on reference points



In our case:
reference points = eye pupils

Face Localization = Detection of Eye Pupils

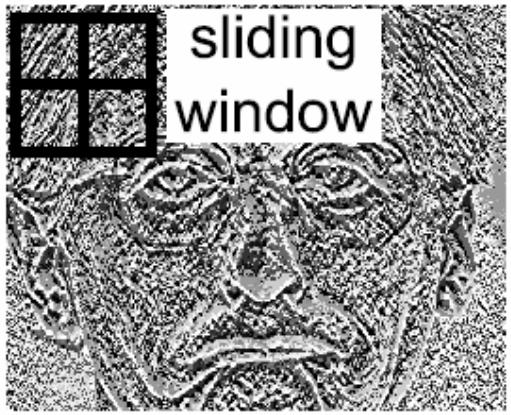
LBP-based Face Localization: Theory

The principle is the same as in face detection

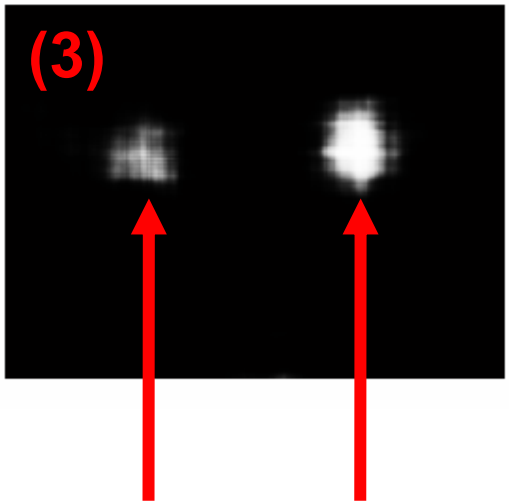
Face region



LBP face



ANN output

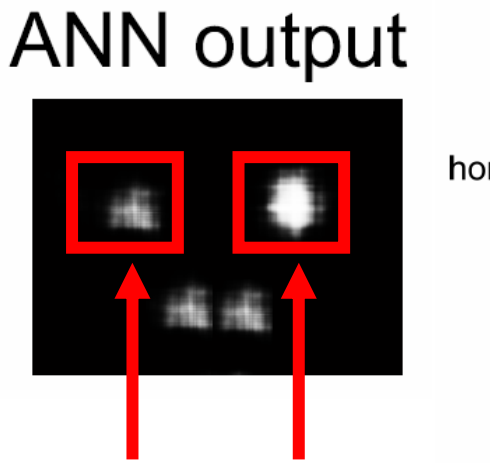


Parameters of the system:

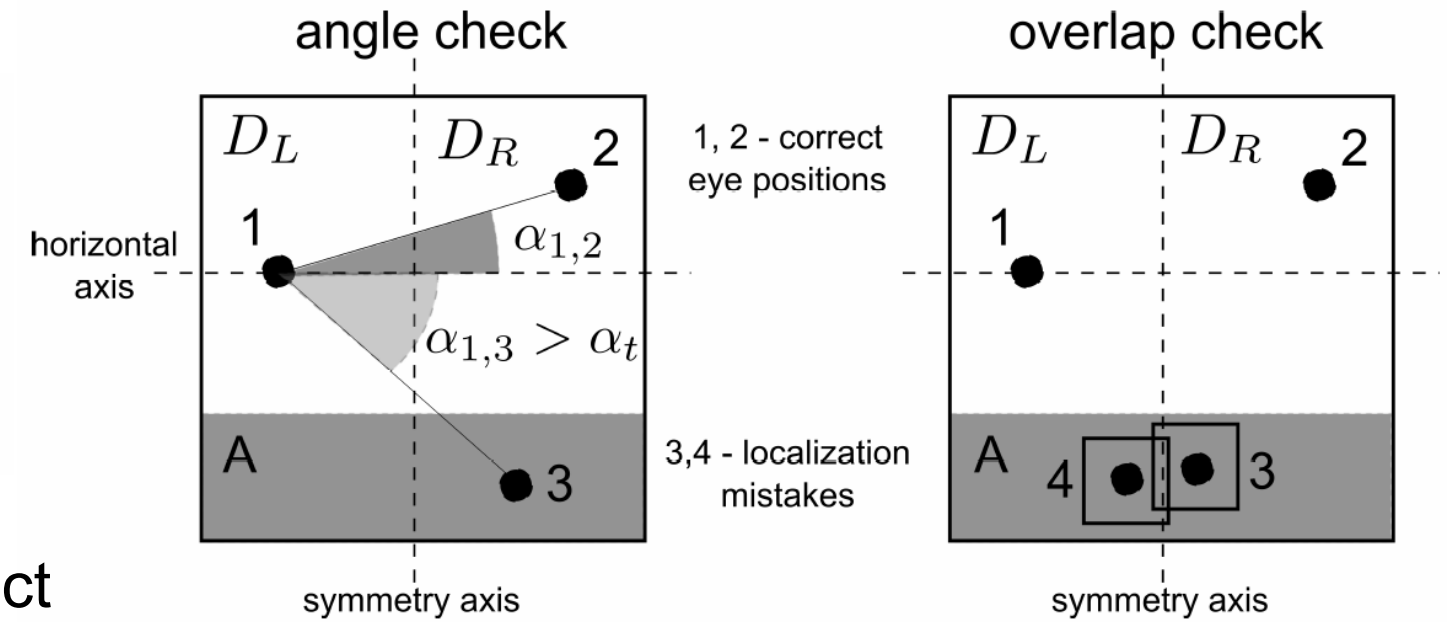
- **K = 4** – number of regions
- **64** LBP features for eye / non-eye representation
- **5 neurons** in the hidden layer of an ANN

Locations of eyes with highest probability

LBP-based Face Localization: Theory

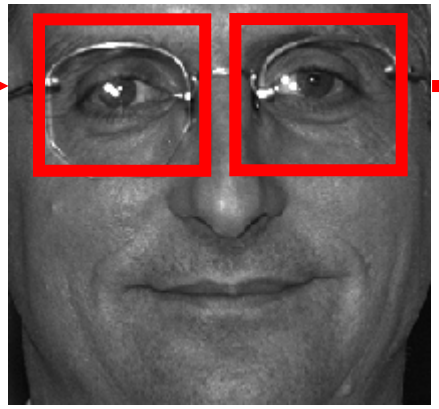


Need to detect correct eye positions



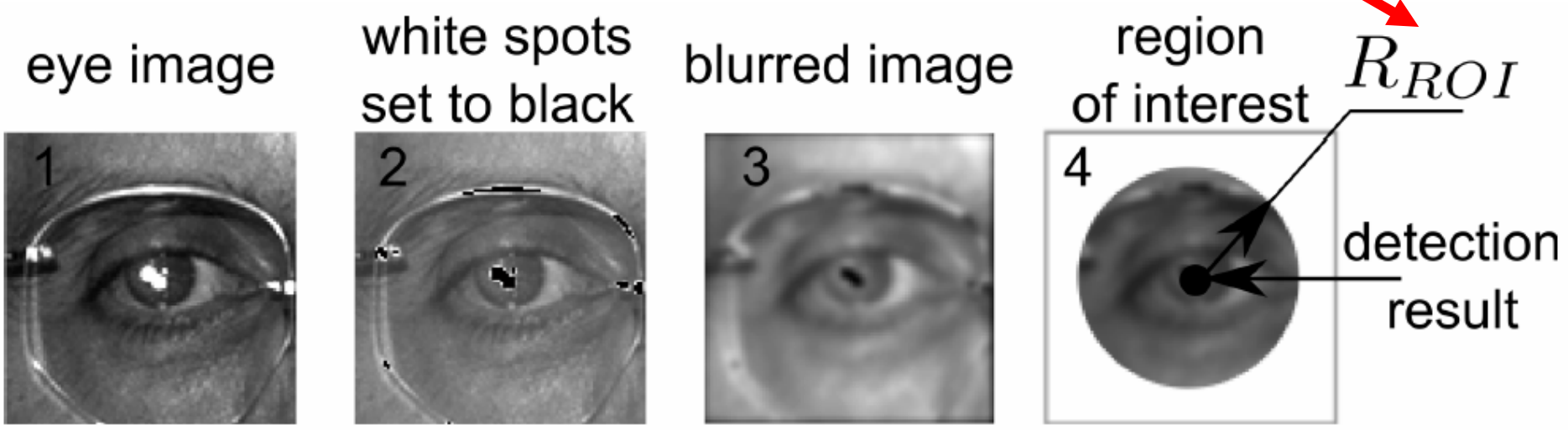
LBP-based Face Localization: Theory

Eye regions are determined

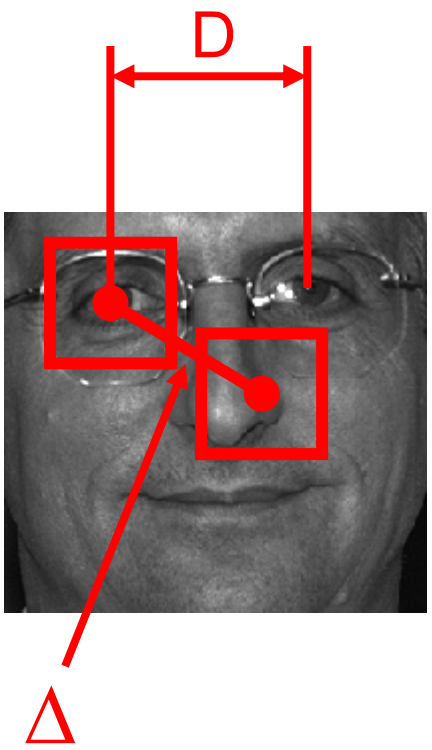


Need to find eye pupils ?

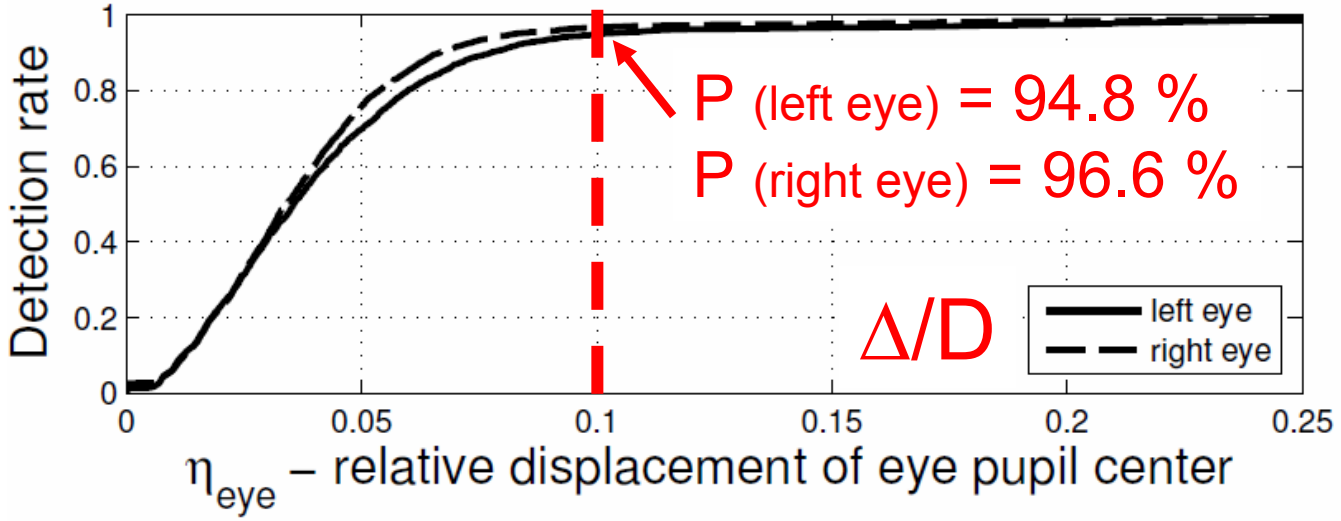
The precision of eye detector is now known and it determines the region of interest



LBP-based Face Localization: Performance



FERET database, 2722 test images



- **64** LBP features for eye / non – eye representation
  - **5 neurons** in the hidden layer of an ANN
- training set size **~ 100 000** eye & non-eye patterns

Face localization rate (both eyes are detected with precision Δ/D = 0.1):

Method:	Haar	ASEF	NNC+LBP	PSEF	**OUR**
P_L, Both eyes	44.7	66.1	74.3	83.0	92.8

LBP-based Face Localization: Performance

First 10 images with significant localization errors (displacements > 20% of inter-ocular distance):

- 7 out of 10 are with glasses



Summary

- Proposed face detection and localization techniques don't need downsampling for detection of objects in multiple scales.

- Potentially well applicable for the tasks of face detection and localization in high resolution images.

- Low dimensionality feature space and simple classifier:

Minimum requirements for **face detection:**
- 144 LBP features
- 5 Neurons in the hidden layer of an ANN

Minimum requirements for **face localization / eye detection:**
- 64 LBP features
- 5 Neurons in the hidden layer of an ANN

Thank You!





Praktiskas sarunas ar viediem sensoriem valodā SEAL

Atis Elsts

Seminārs 29.09.2012, Viedo sensoru un tīklotu iegulto sistēmu pētījumu un attīstības centrs (VieSenTIS), Projekta Nr. 2009/0219/1DP/1.1.1.2.0/09/APIA/VIAA/020

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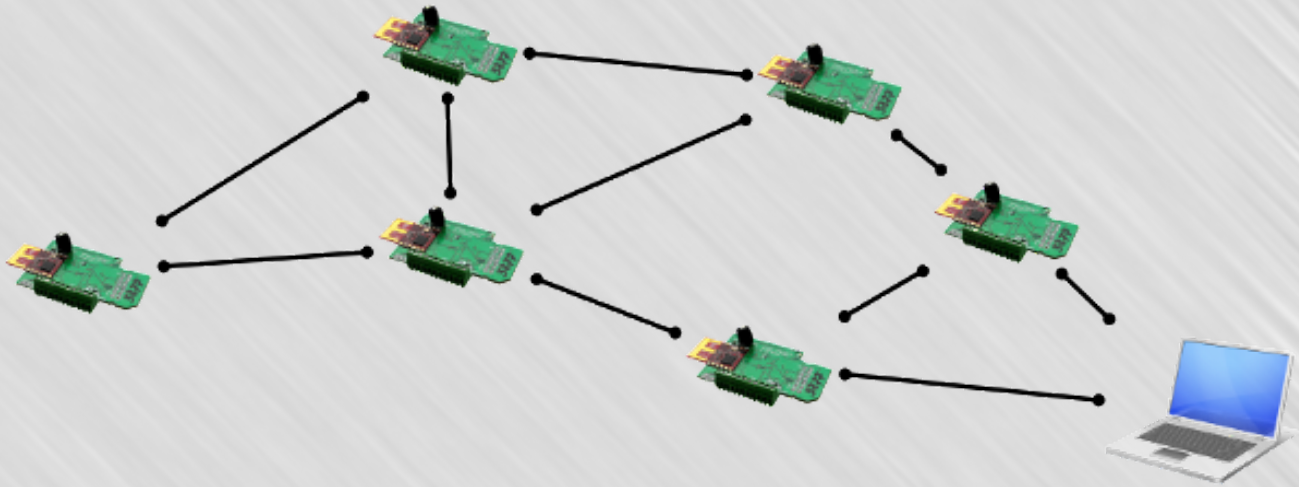
Wireless sensor networks (WSN)

What is a WSN?

- Network: system is interconnected
- Sensor: it has devices for measusing environmental parameters
- Wireless: remote communication is possible
- WSN is a “macroscope” that allows to measure complex phenomena

Typical WSN challenges:

- energy efficiency
- resource scarcity



WSN hardware ("sensor mote")

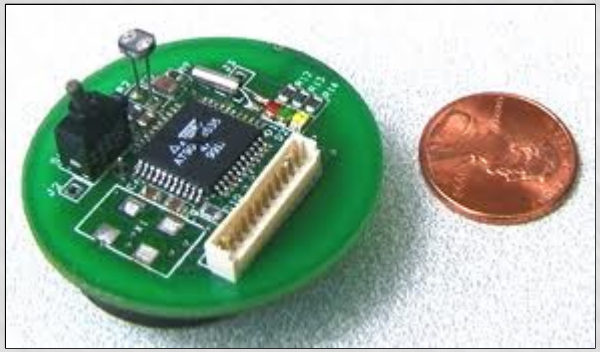
Typical components:

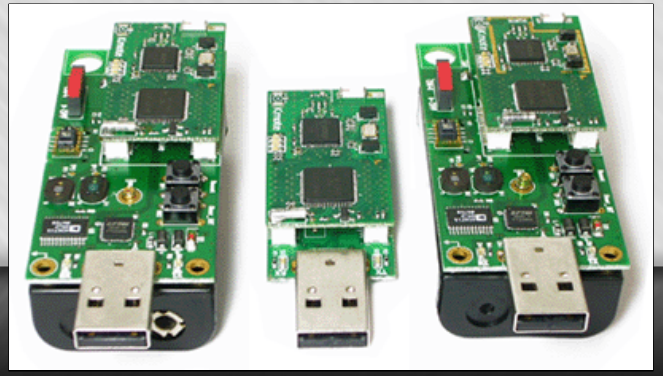
- Microcontroller
- Radio transceiver
- Local storage flash chip or SD card
- Sensor connectors and/or integrated sensors
- Connectors for programming and debugging

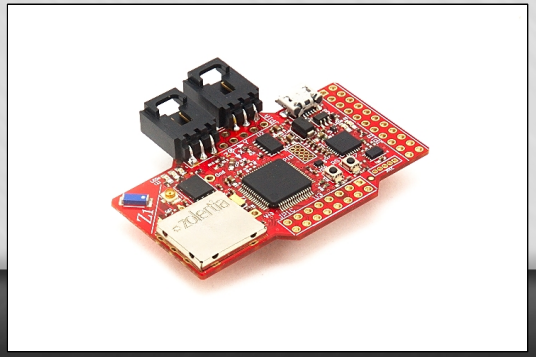


Resources are limited!

- Typical code memory sizes: 1 – 200 kb
- Typical RAM sizes: 512 bytes – 10 kb
- Typical power source: two AA batteries





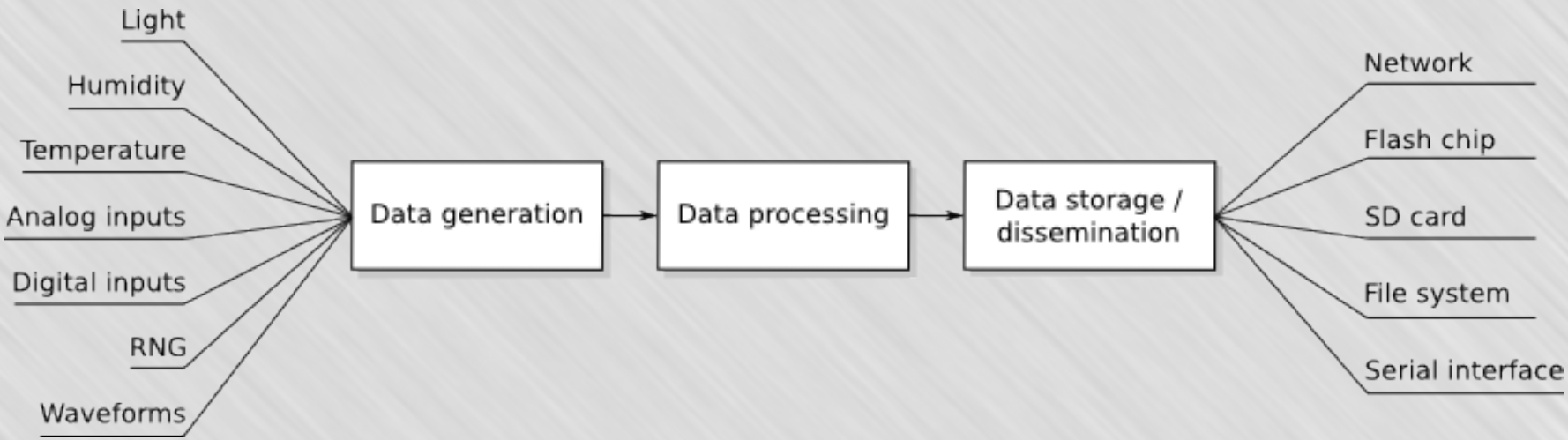




Data flow in a WSN node

The typical tasks of a WSN mote are:

- Data **collection** from sensors and pseudo-sensors
- **Processing** of the collected data
- Data **output** to the network or local storage



State of art: summary

- Programming sensor networks is diffucult
  - Resource constraints
  - Distributed algorithms
  - Unreliable hardware & signal transmission medium
- Users are not ready for the complexity
  - WSN users include scientists, engineers, hobbyists
- Existing WSN programming approaches focus on expert users
  - *"focusing on expert TinyOS users and making it possible to write larger software, TinyOS 2.x became less accessible to new users [..] modern [TinyOS] code heavily uses many nesC features, making the learning curve very steep"* [Levis 2012]
- Real world WSN deployments are still difficult, large scale adoption has yet to happen

Author's vision

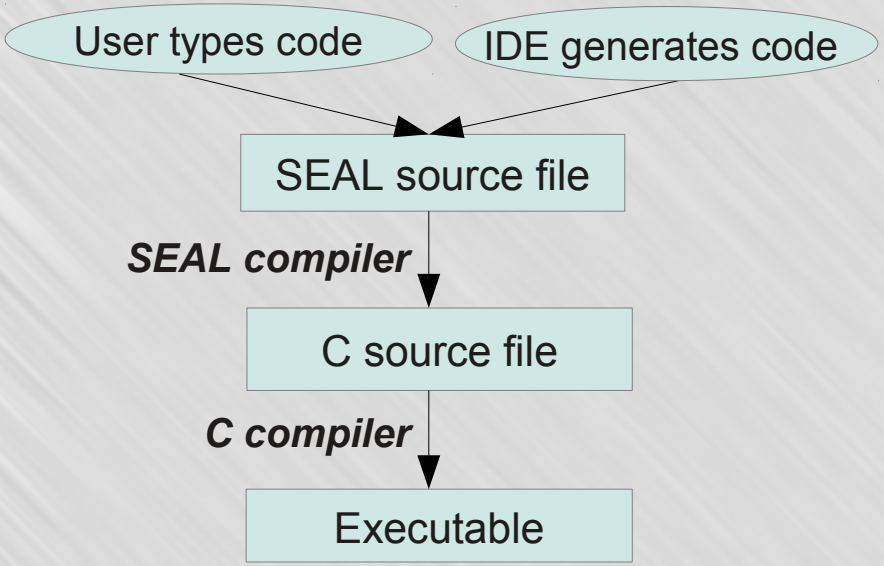
It is possible to create WSN software that is easier to use than the existing options, while remaining comparably powerful & efficient.

- WSN software abstractions must be targeted towards novice programmers and nonprogrammers
- Software development tools (e.g. IDE) can be used facilitate WSN application programming
- Real-world evaluation is critically important

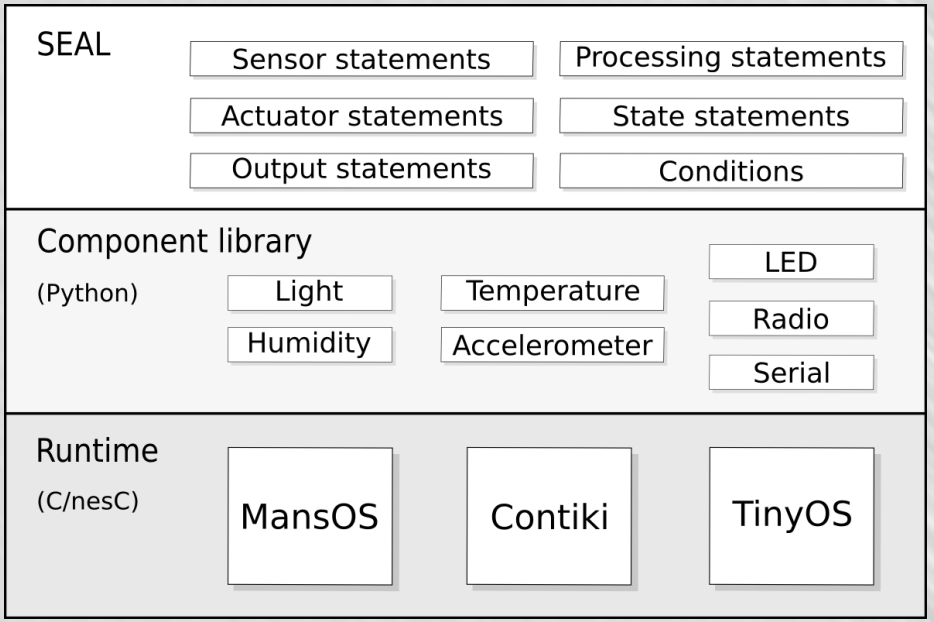
By using the correct approach, WSN can become a useful tool to broad range of purposes and target audiences!

SEAL architecture

- SEAL – **Se**nsor **A**pplication Development **L**anguage
- Three levels: 1) application, 2) component library, 3) runtime



SEAL application development



SEAL conceptual architecture

Elements of SEAL

Component use cases:

```
use RedLed;
read Humidity;
output Radio;
```

New component definitions:

```
define MaxLight max(Light);
```

Conditional statements:

```
when MaxLight > 1000: ...
```

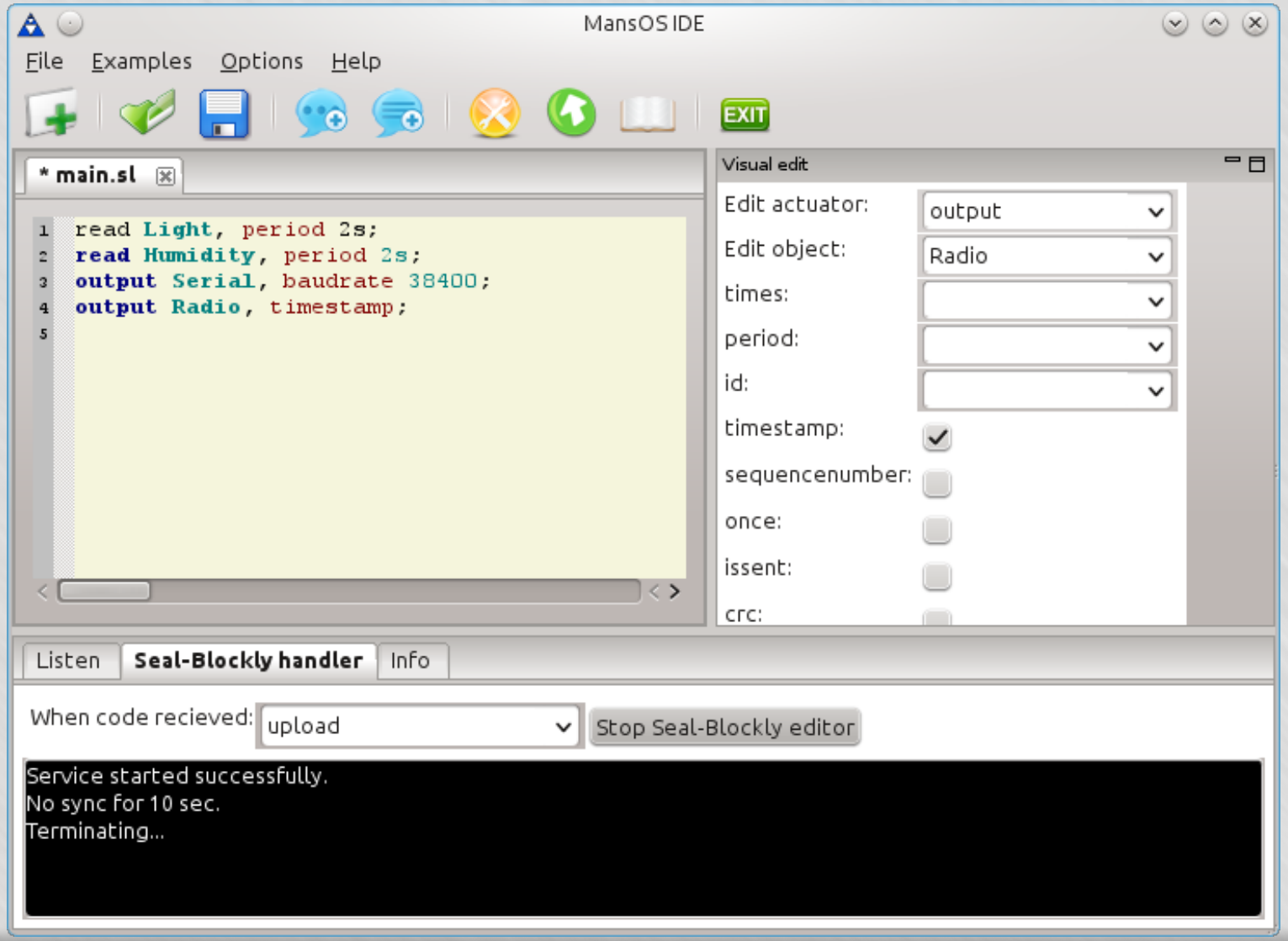
Constants and variables:

```
const INTERVAL 10s;
set IsLedOff True;
```

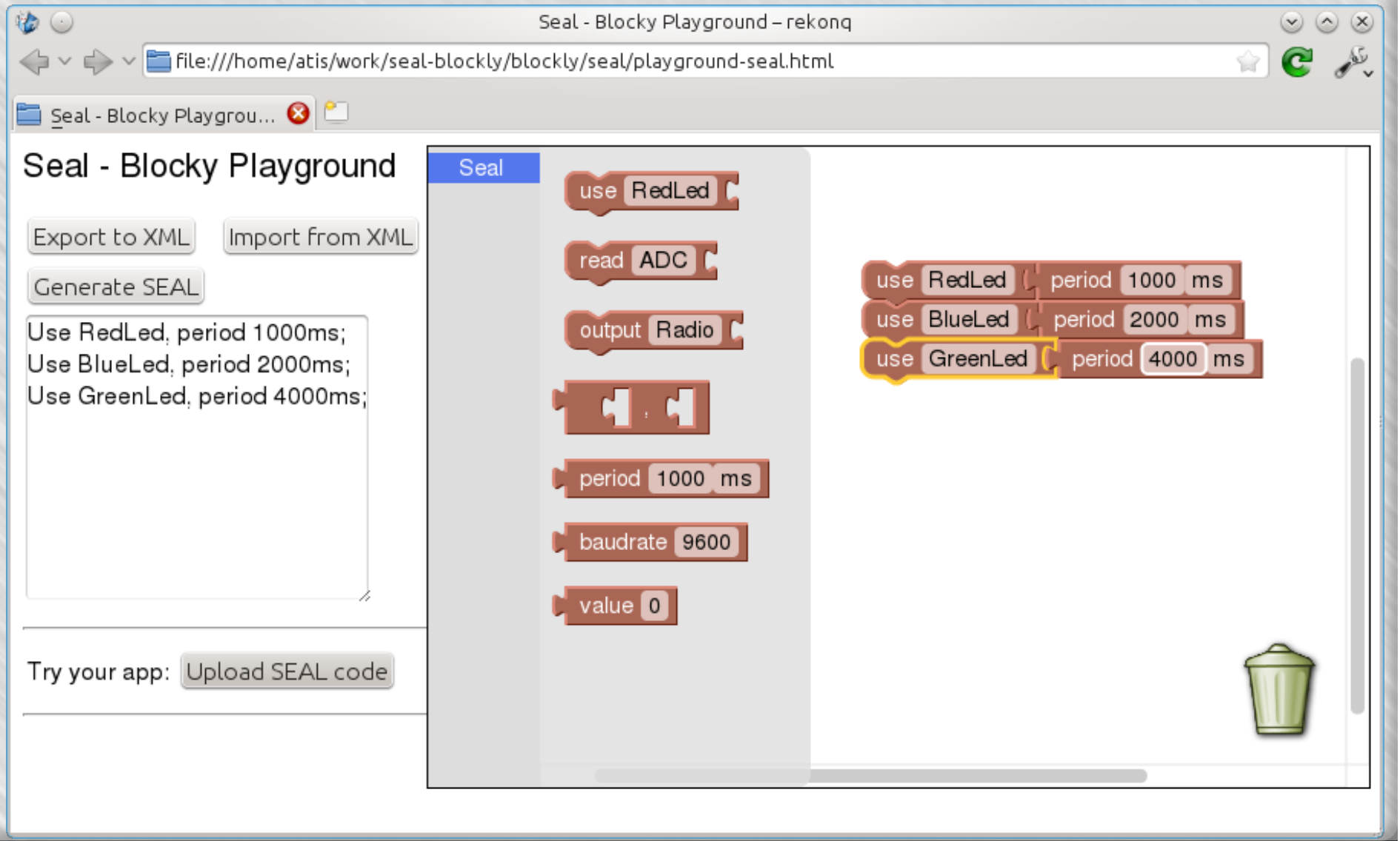
SEAL implementation

- Compiler implemented in Python
- Approx. 5000 lines of code
- Parser: Python-Lex-Yacc (PLY) used
- Code generator: generates MansOS C code
- All source code publicly available as part of MansOS (NewBSD licence)
- 113 regression test cases are included

SEAL/MansOS IDE



SEAL programming using a browser



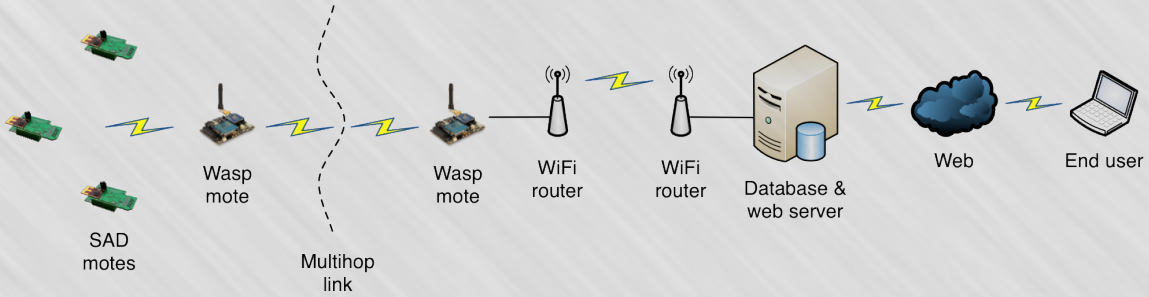
SEAL use cases

Scenario	Class	Feature demonstrated
Measuring microclimate [Elsts 2012]	Env. monitoring	Periodic sampling
Controlling a watering system [Elsts 2012]	Env. monitoring	Distributed processing
Calibrating sensors [LUMII 2011]	Env. monitoring	Intra-node processing
Collecting light measurements [Selavo 2007]	Env. monitoring	Interactive query support
Detecting seismic activity [Werner-Allen 2006]	Env. monitoring	Event-driven processing
Building a backup controller [Zviedris 2010]	Wild animal mon.	Imperative elements
Controlling an external device [Strazdins 2011]	Automotive	Basic intra-node processing
Light monitoring in tunnels [Ceriotti 2011]	Env. monitoring	Adv. intra-node proc. (using C)
Detecting potholes #1 [Mednis 2011]	Mobile agents	Adv. intra-node proc. (using SEAL)
Detecting potholes #2 [Mednis 2011]	Mobile agents	Signal filtering
Detecting target area [Mednis 2012a]	Mobile agents	Localization
Generating a signal [Mednis 2012b]	Electronics	Multiplatform support

Environmental monitoring use case

- Environmental monitoring in precision agriculture
- Distributed microclimate measurements in an orchard:
  - temperature, humidity, light
- The users are agroscientists in Latvia State Institute of Fruit-Growing (*http://lvai.lv*)



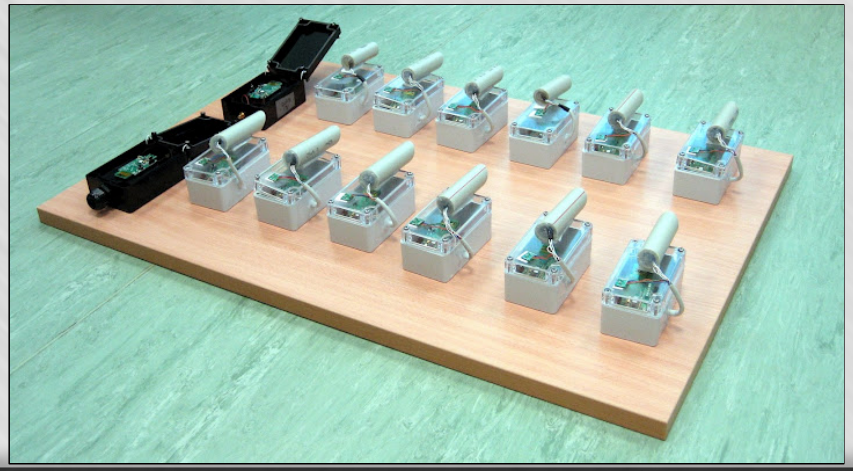


- *Test network architecture*



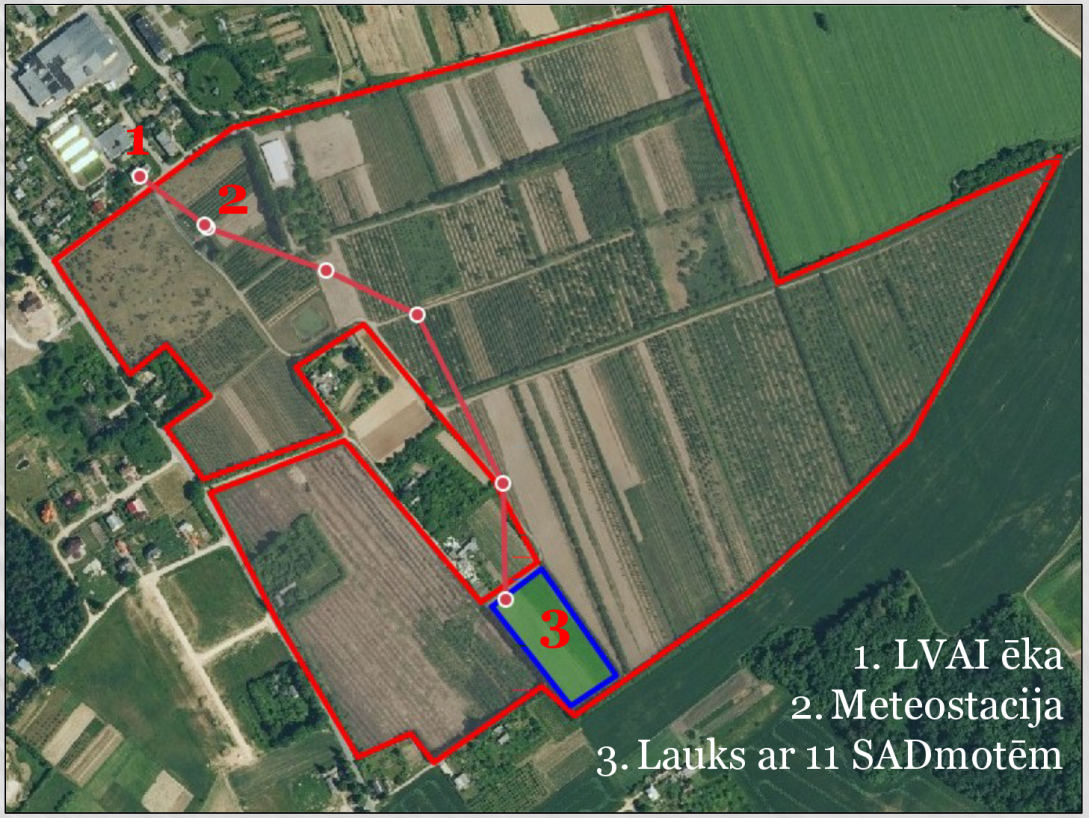
Environmental monitoring use case

- Collaboration with LVAI started in 2009
- ERAF project work started in LU in April/May 2011
- *19 September – 2 November, 2011*: experimental 12+5 mote WSN deployed with custom hardware & software
- *30 August, 2012 – now*: experimental 16+3 mote WSN deployed with new versions of custom hardware & software
- Datus izmantojot tiek izstrādāts promocijas darbs “Zemeņu ražību limitējošie faktori un to ietekmes mazināšanas iespējas audzējot zemenes zem segumiem Latvijas apstākļos”





Environmental monitoring use case











Solution in SEAL

Conceptual prototype:

```
read Light, period 10min;
read Humidity, period 10min;
read Temperature, period 10min;
output SdCard;
output Network, protocol CSMA;
```

Solution in SEAL

Real world application:

```
config "USE_LONG_LIFETIME=y"; // use 64-bit counter

define HelperLed RedLed, blink;
define Battery AnalogIn, channel constants.ADC_INTERNAL_VOLTAGE;

when Variables.localAddress != 0x0796:
    define MyLight Light; // use default light sensor
else:
    define MyLight SQ100Light; // use high-precision light sensor
end

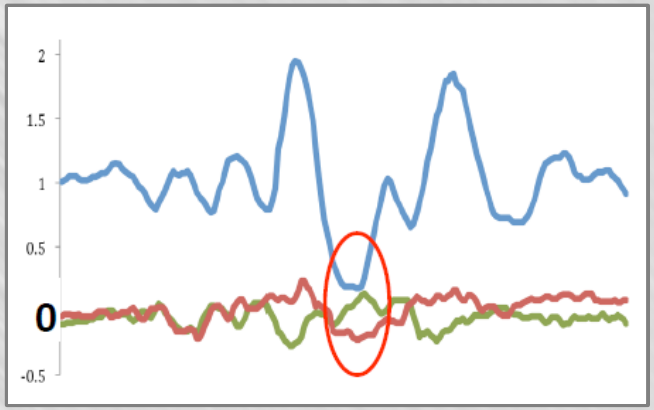
define AllSensors sync(MyLight, Humidity, Temperature, Battery);
read AllSensors, period 10min, associate HelperLed, turnOnOff;

output SdCard;
output Network, protocol SAD, routing SAD;
```

19-node sensor network deployed with this code in LVAI orchard in Dobele, Latvia on August 30, 2012!

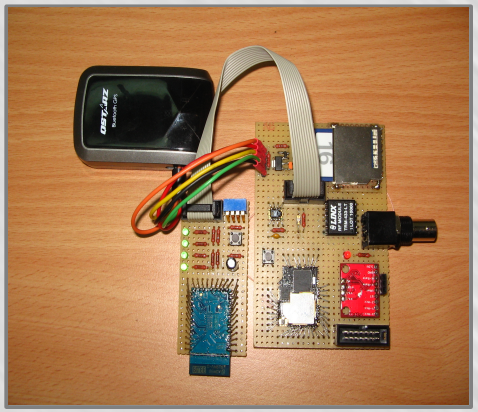
Mobile agent use case

- Sensing devices mounted to cars
- Communicate with other cars and road-side units
- *Application 1:* detect potholes on road surface
- *Application 2*: detect whether the car is moving
- The users are hardware developers and (potentially) car owners



Pothole detection via accelerometer measurements





Sensor device prototype

Potholes: solution in SEAL

Using Z-axis STDEV thresholding:

```
const ACCEL_Z 2; // define channel number

const THRESHOLD 100; // define threshold

define AccelZ AnalogIn, channel ACCEL_Z;
define Deviation stdev(take(AccelZ, 10));

when Deviation > THRESHOLD:
   use RedLed, on;
   use Beeper, on, duration 200, frequency 1000;
else:
   use RedLed, off;
end
```

Movement: algorithm

1. Acquisition of 3-axis accelerometer data 100x per second.
2. Storage of all accelerometer data acquired during last second using appropriate data structure:

$$X[] = \{X_{n-99}, \ldots, X_n\}; Y[] = \{Y_{n-99}, \ldots, Y_n\}; Z[] = \{Z_{n-99}, \ldots, Z_n\} \quad (1)$$

3. Calculation of all 3 axis standard deviation values as well as their aggregation:

$$STDEV(X[]) + STDEV(Y[]) + STDEV(Z[]) \quad (2)$$

4. If aggregation of all 3-axis standard deviation values is

   a. > 0.1g (above T_{high}) then vehicle mode is set to driving;
   b. < 0.05 g (below T_{low}) then vehicle mode is set to standing;
   c. ≥ 0.05 g and ≤ 0.1 g (between T_{low} and T_{high}) then previous set vehicle mode is preserved.

[Mednis 2012]

Movement: solution in SEAL

```
const THRESHOLD_LOW  50;
const THRESHOLD_HIGH 100;

set IsDriving False; // vehicle mode

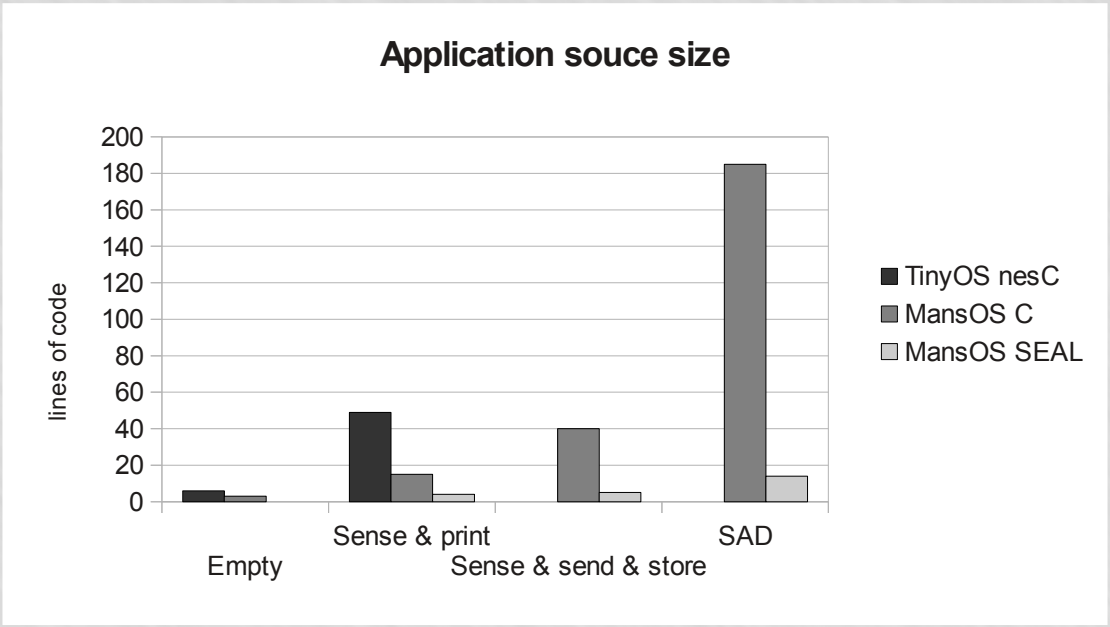
define AccelX AnalogIn, channel 1, period 10ms;
define AccelY AnalogIn, channel 2, period 10ms;
define AccelZ AnalogIn, channel 3, period 10ms;

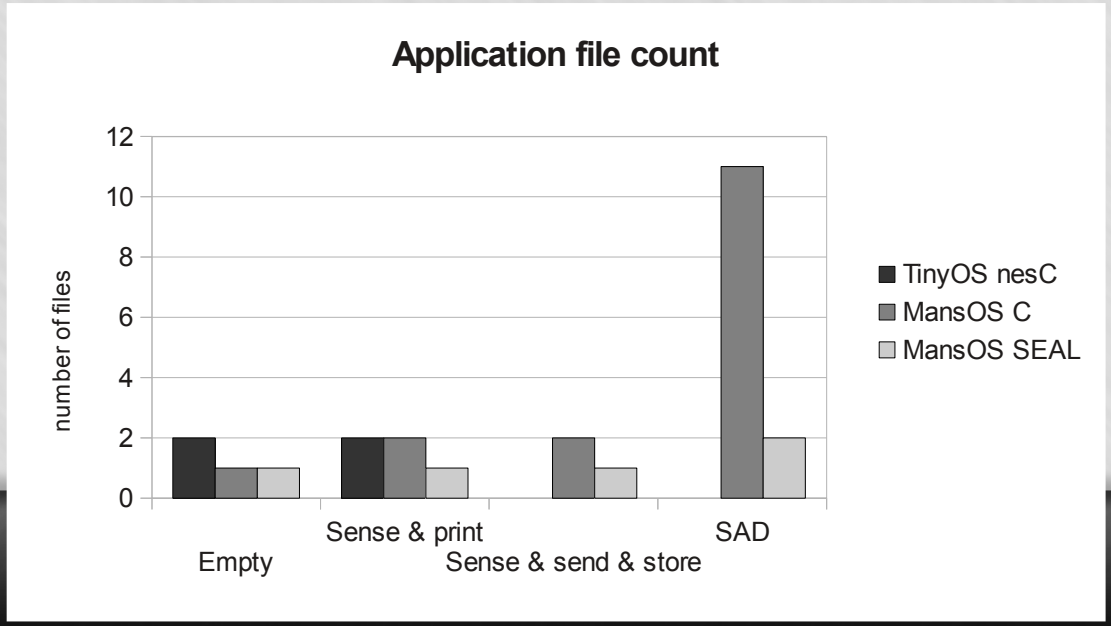
define X_dev stdev(take(AccelX, 100));
define Y_dev stdev(take(AccelY, 100));
define Z_dev stdev(take(AccelZ, 100));

define SDev sum(X_dev, Y_dev, Z_dev), lazy;

when SDev > THRESHOLD_HIGH:
    set IsDriving True;   // movement detected!
elsewhen SDev < THRESHOLD_LOW:
    set IsDriving False;  // absence of movement detected!
end
```

SEAL analytical evaluation

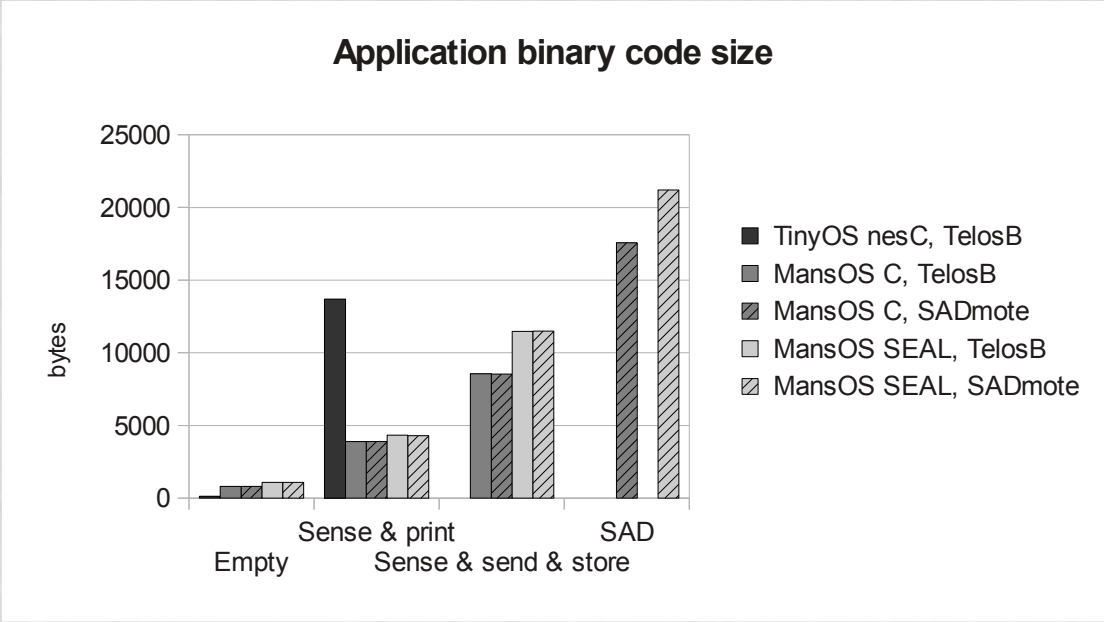


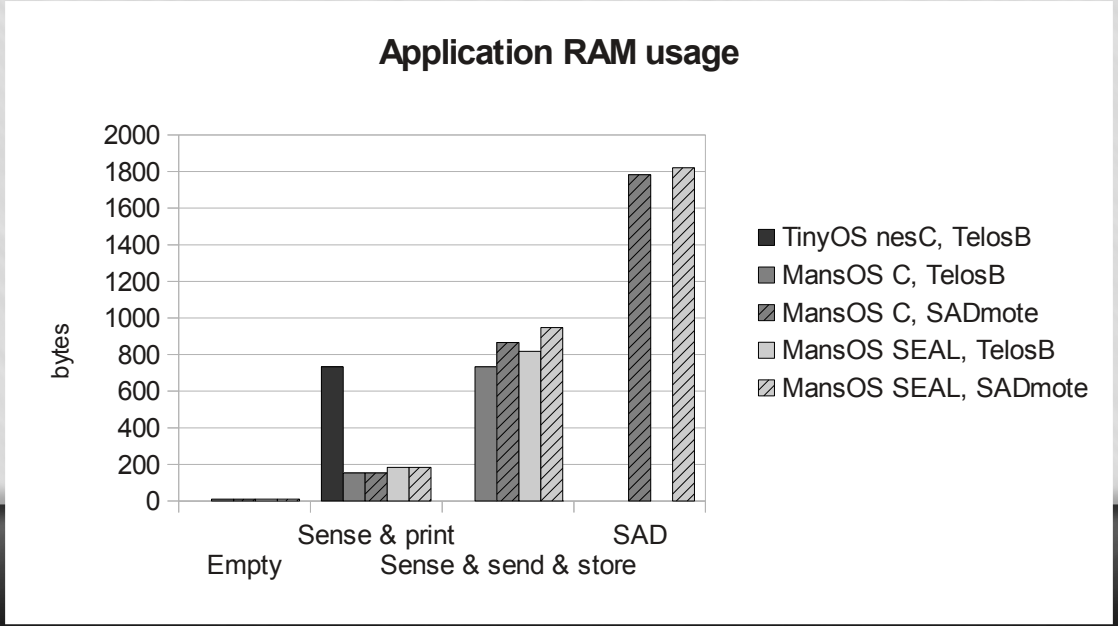


SEAL analytical evaluation

- Compared to MansOS C code:
  - TinyOS source code size is much larger (approx. 3.5x)
    - For more complex applications this proportion can be expected to remain
  - SEAL source code size is much smaller (approx. 10x)
  - For more complex applications SEAL allows to use much fewer files (1-2 vs 11)

SEAL feasibility evaluation





SEAL feasibility evaluation

- Conclusions:
  - TelosB and SADmote resource usage differences are small (0-20%)
  - TinyOS applications use significantly more (2-3x) resources
    - This difference can be expected NOT to remain for more complex applications
  - SEAL uses a little (10-20%) more resources than native C code
  - **SEAL is feasible on low power MCUs!**

Conclusion

- Programming in SEAL is simpler than using C or nesC directly
- SEAL has support for many typical WSN and embeded progamming use cases
- SEAL is feasible on low-power microcontrollers and has only 10-20% resource usage overhead over native code
- Future plan: more user tests
- Future plan: energy usage evaluation

Paldies par uzmanību!
Jautājumi?

EIROPAS SOCIĀLAIS FONDS

IEGULDĪJUMS TAVĀ NĀKOTNĒ

Cepumu recepte iegulto sistēmu testēšanai tīklā

Rinalds Ruskuls

Atis Elsts

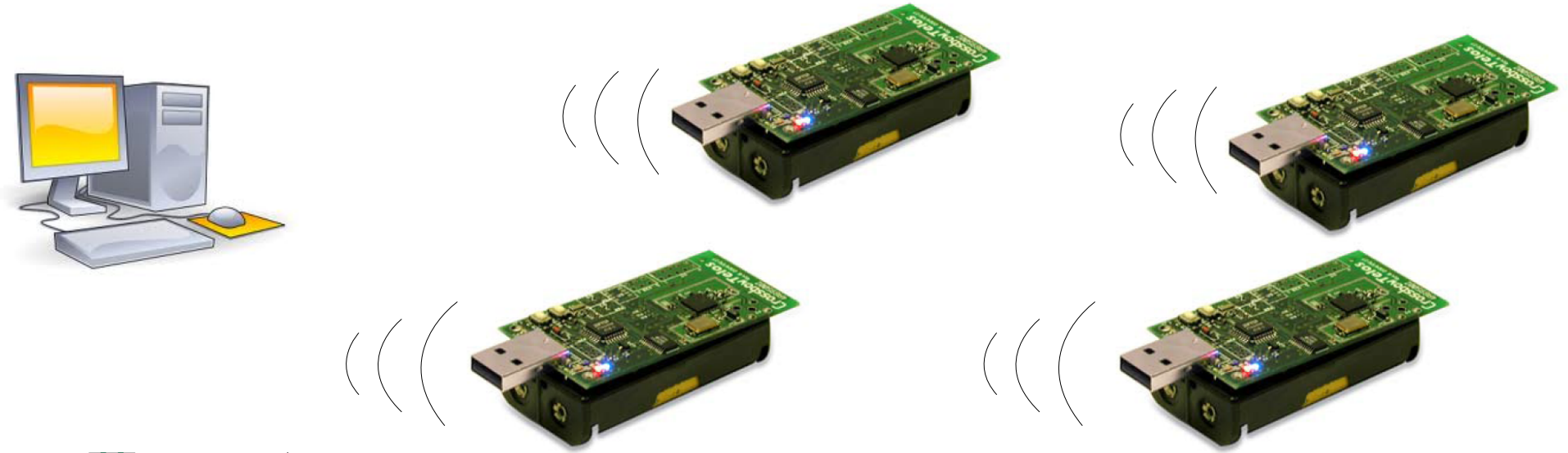
Artūrs Seļivanovs

Leo Seļāvo

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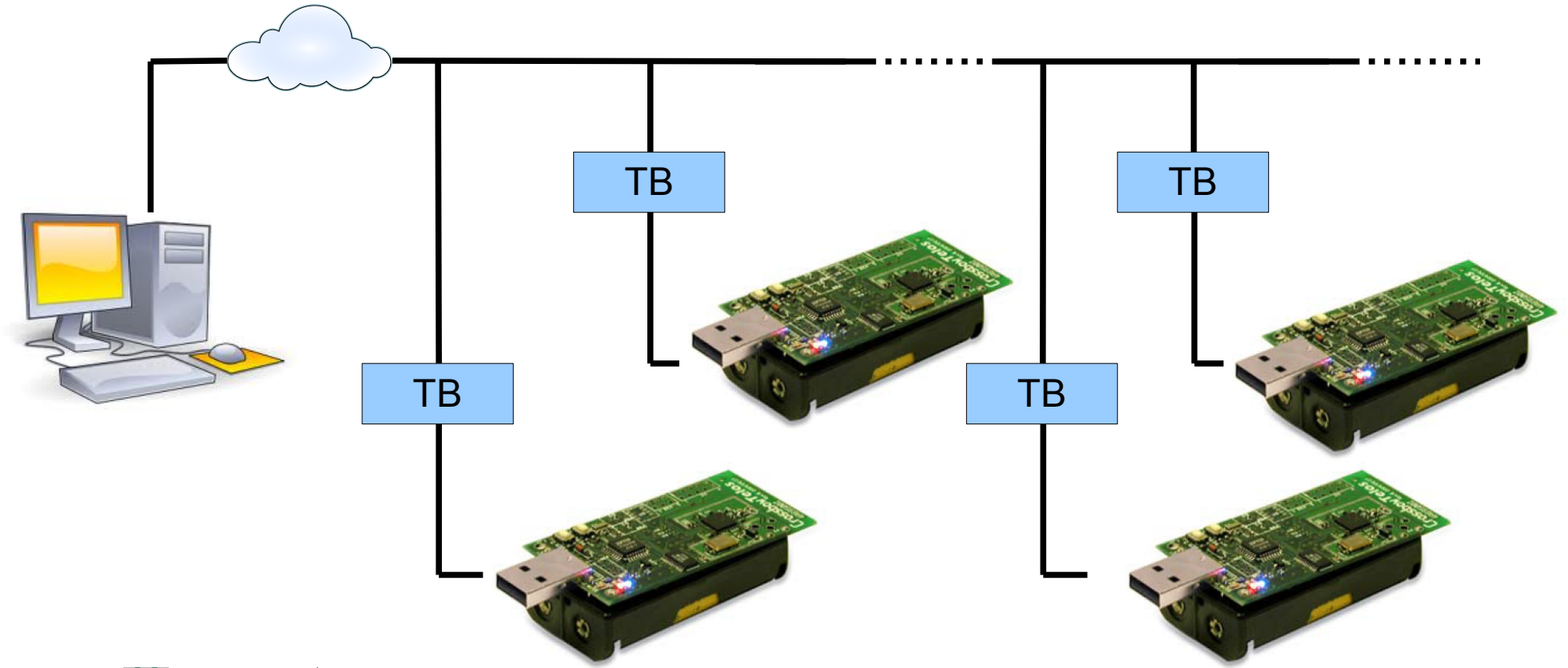
Problēmas

- Bezvadu sensoru tīklu (BST) testēšana lielos apmēros (100+ motes)
  - pārbaudīt BST algoritmus un programmatūru
  - pārbaudīt izmantoto aparatūru



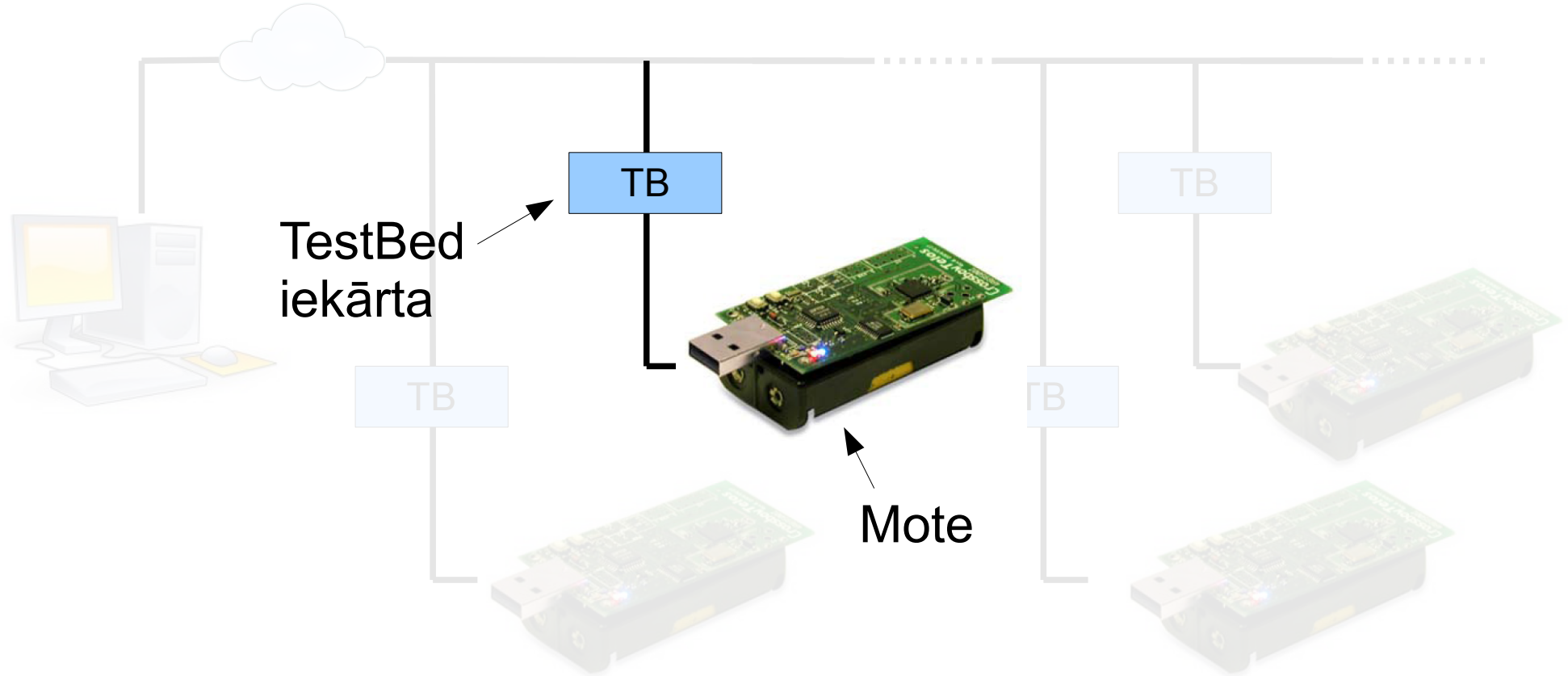
Mērķis

- Izveidot iekārtu, kas nodrošinātu BST algoritmu, programmatūras un aparatūras atkļūdošanu



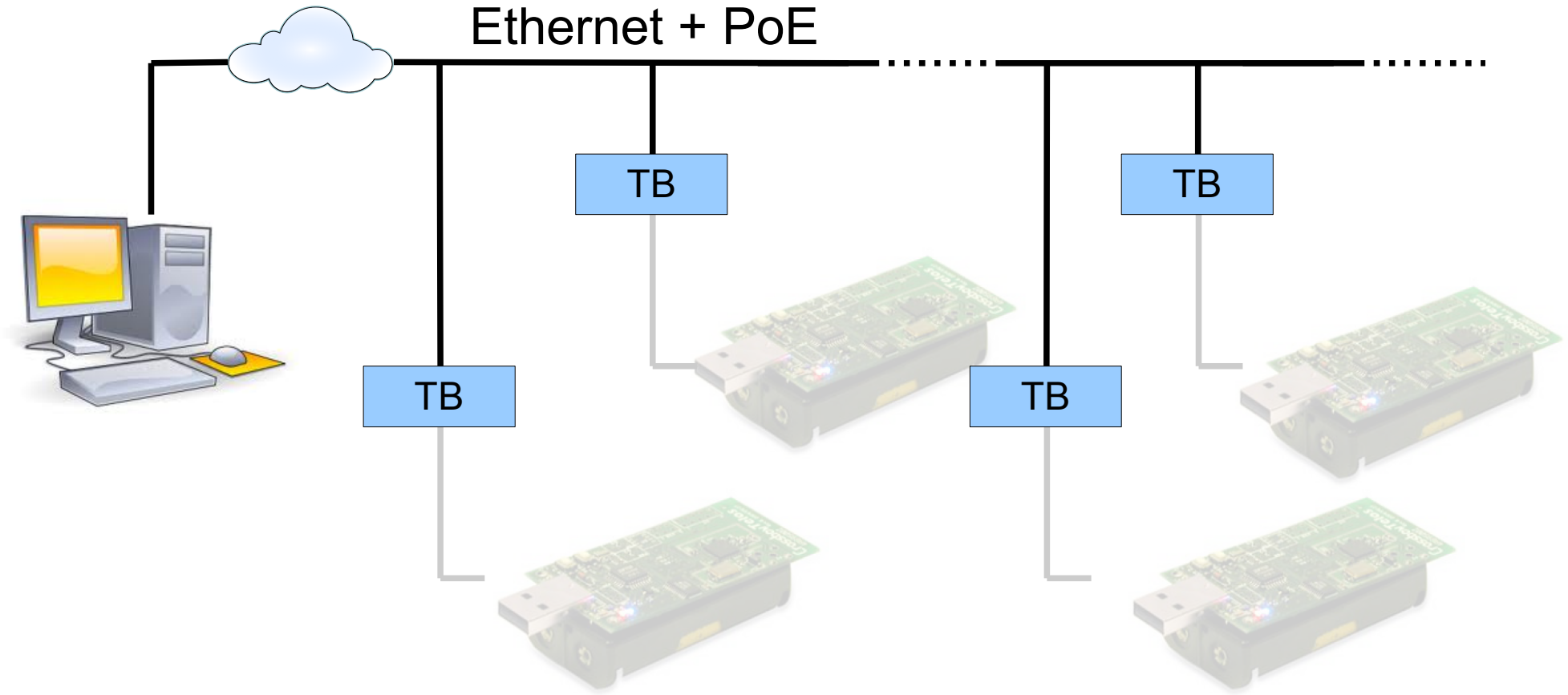
Mērķis

- Izveidot iekārtu, kas nodrošinātu BST algoritmu, programmatūras un aparatūras atkļūdošanu



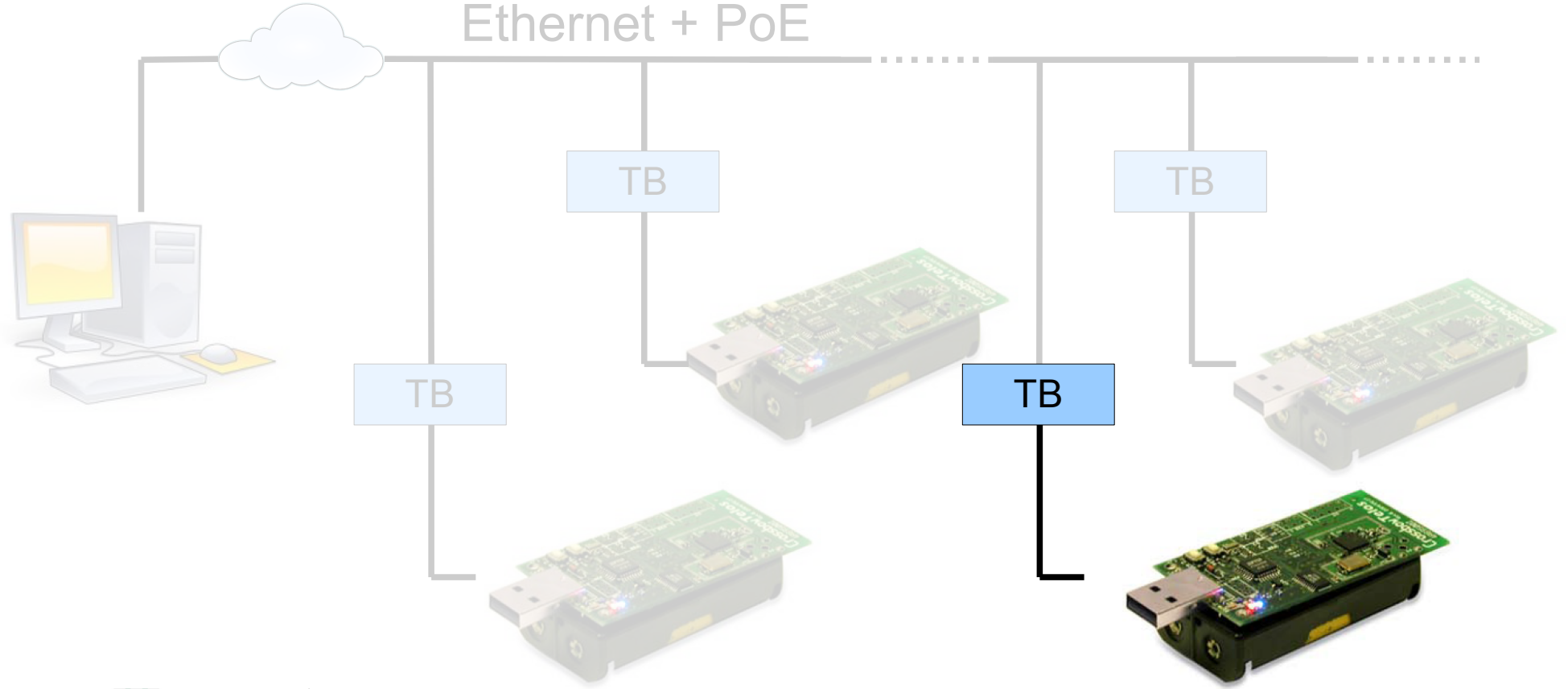
Uzdevumi

- Nodrošināt TestBed iekārtu sasaisti ar datoru



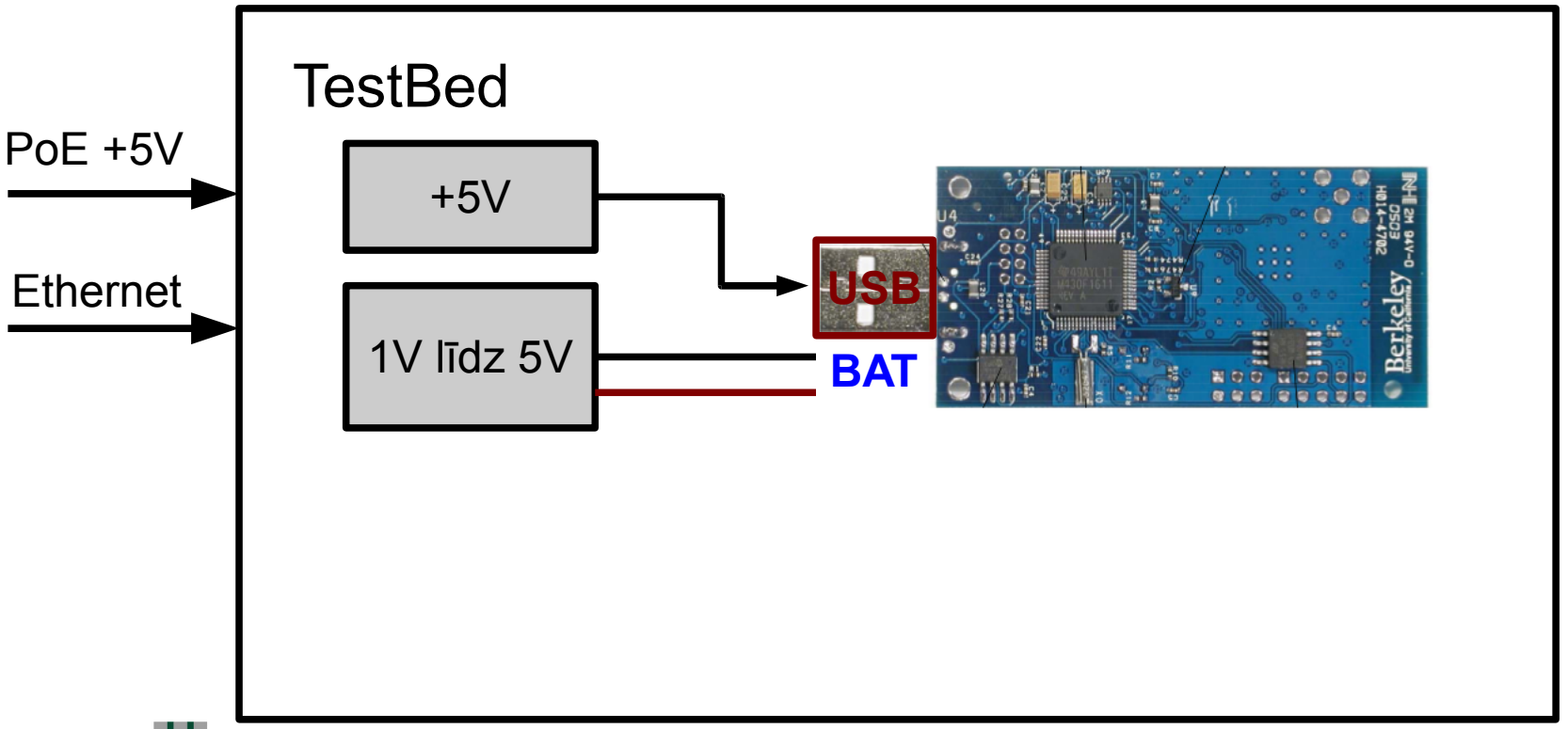
Uzdevumi

- Nodrošināt TestBed iekārtas sasaisti ar testējamo iekārtu



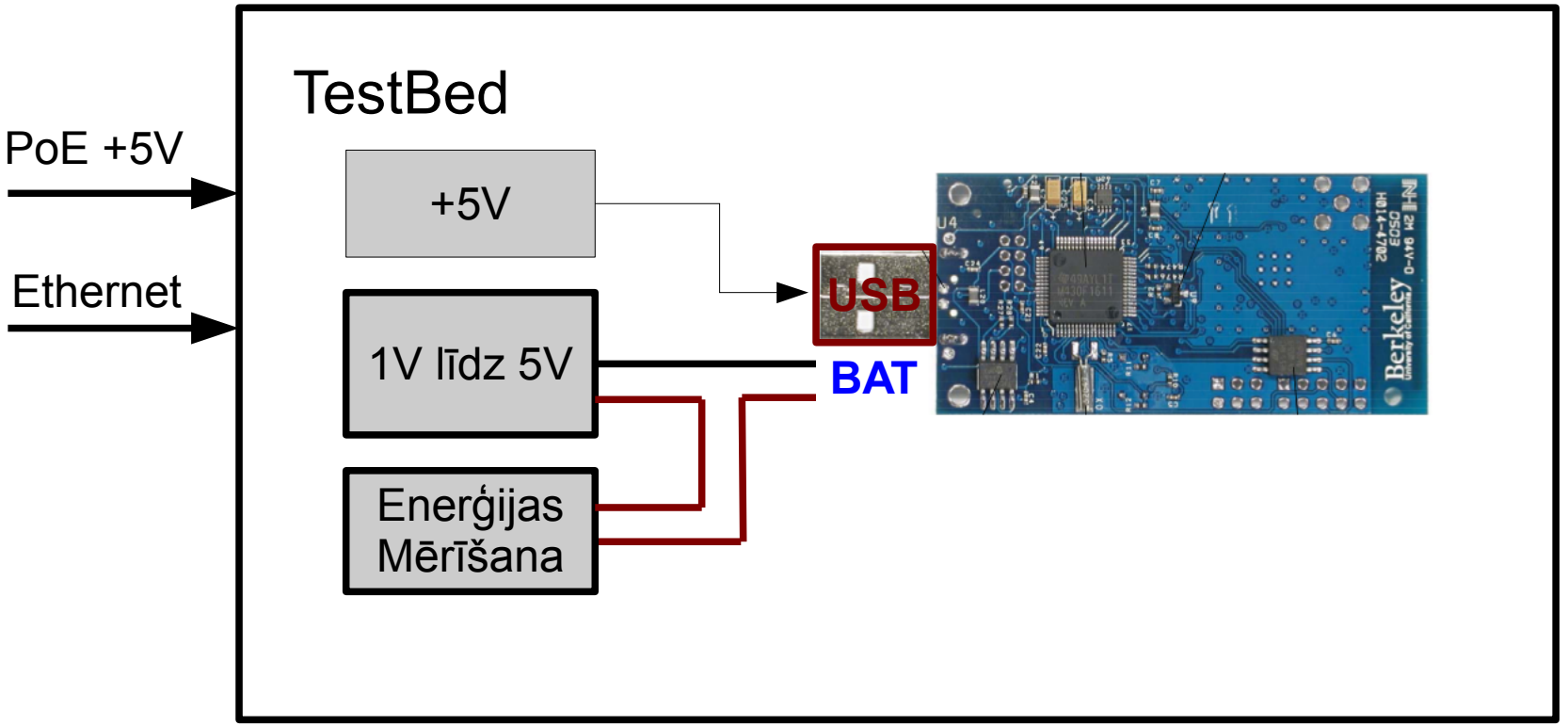
Barošanas sprieguma kontrole

- Izmantojot USB pieslēgvietu
- Izmantojot bateriju pieslēgvietu
  - **Bateriju izlādes simulācija**
  - Enerģijas mērīšana



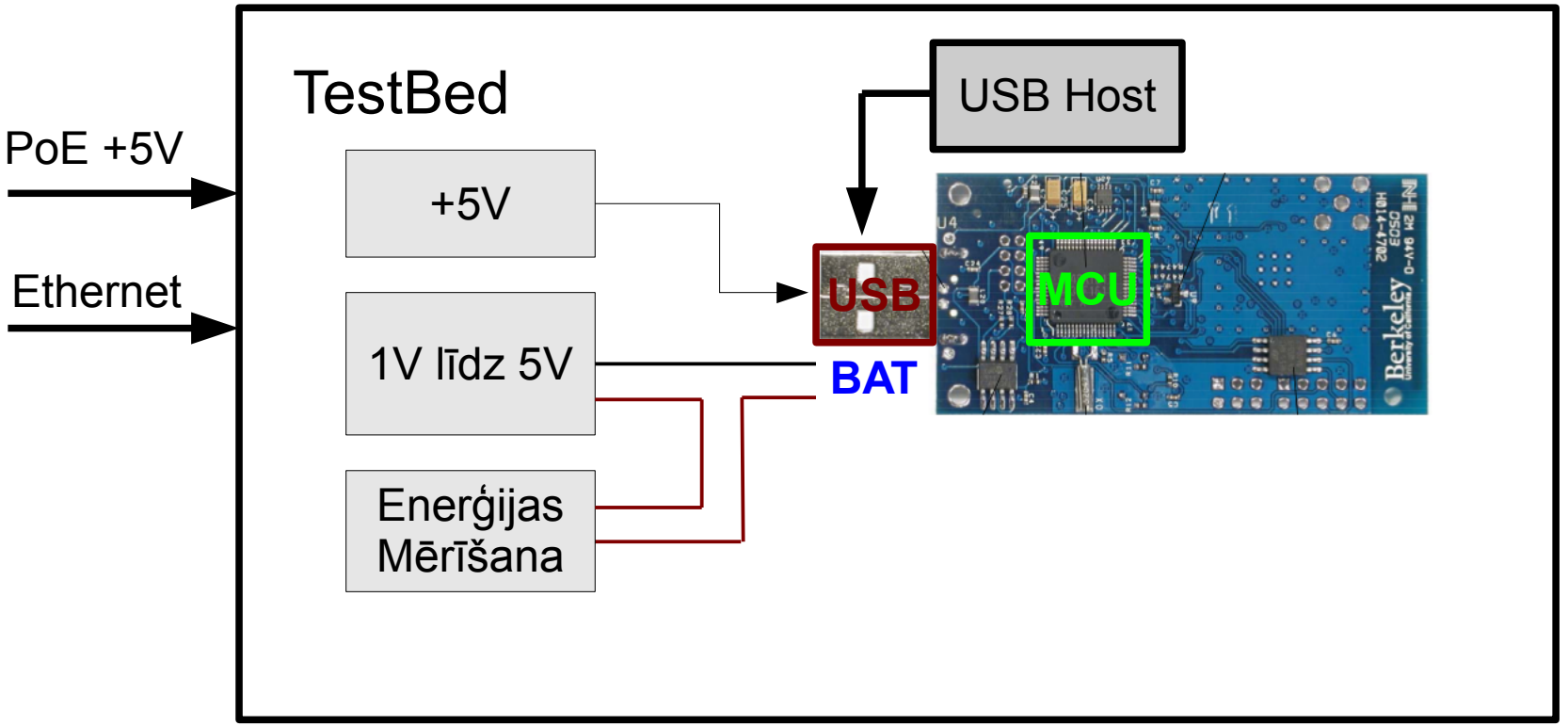
Barošanas sprieguma kontrole

- Izmantojot USB pieslēgvietu
- Izmantojot bateriju pieslēgvietu
  - Bateriju izlādes simulācija
  - **Enerģijas mērīšana**



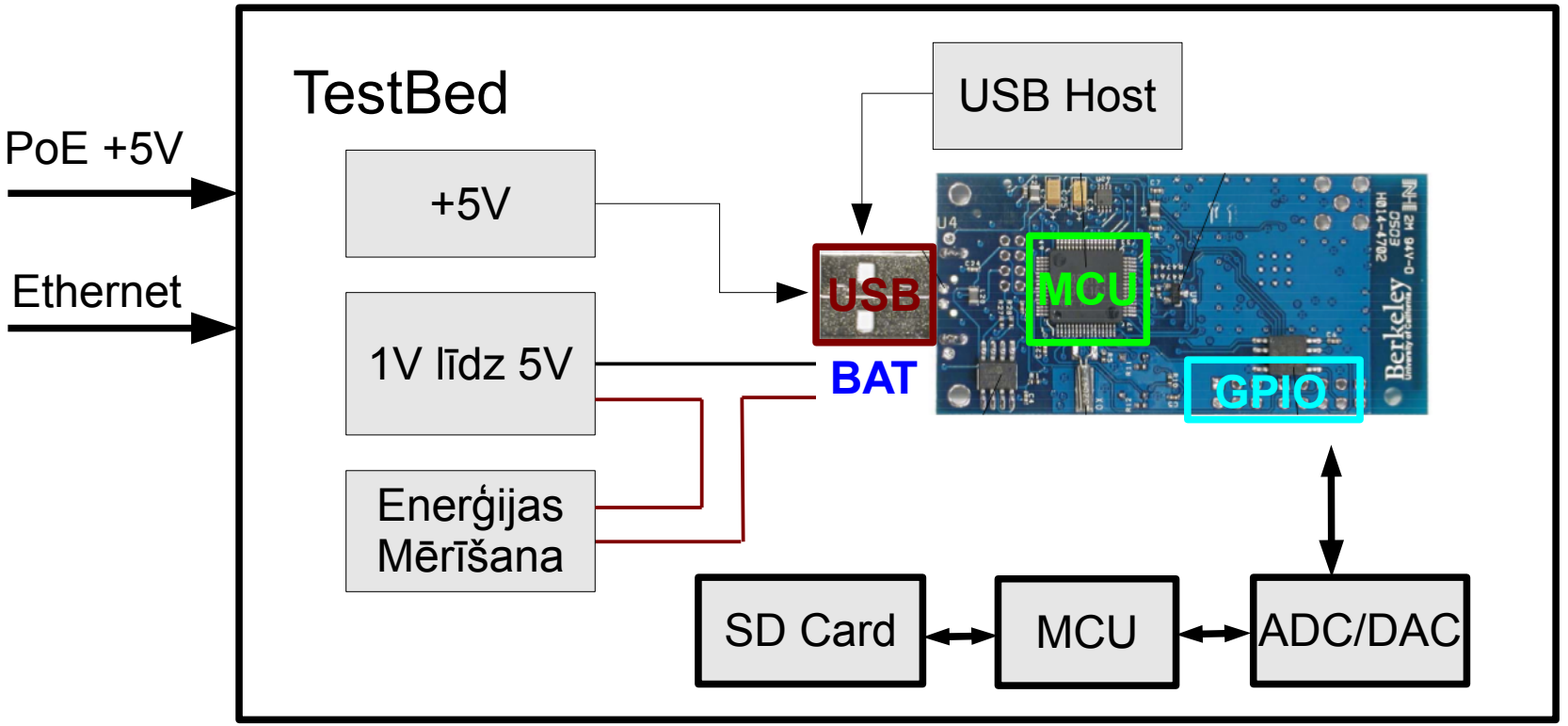
Darbs ar programmām

- Ieprogrammēt
- Atkļūdot



Darbs ar datiem

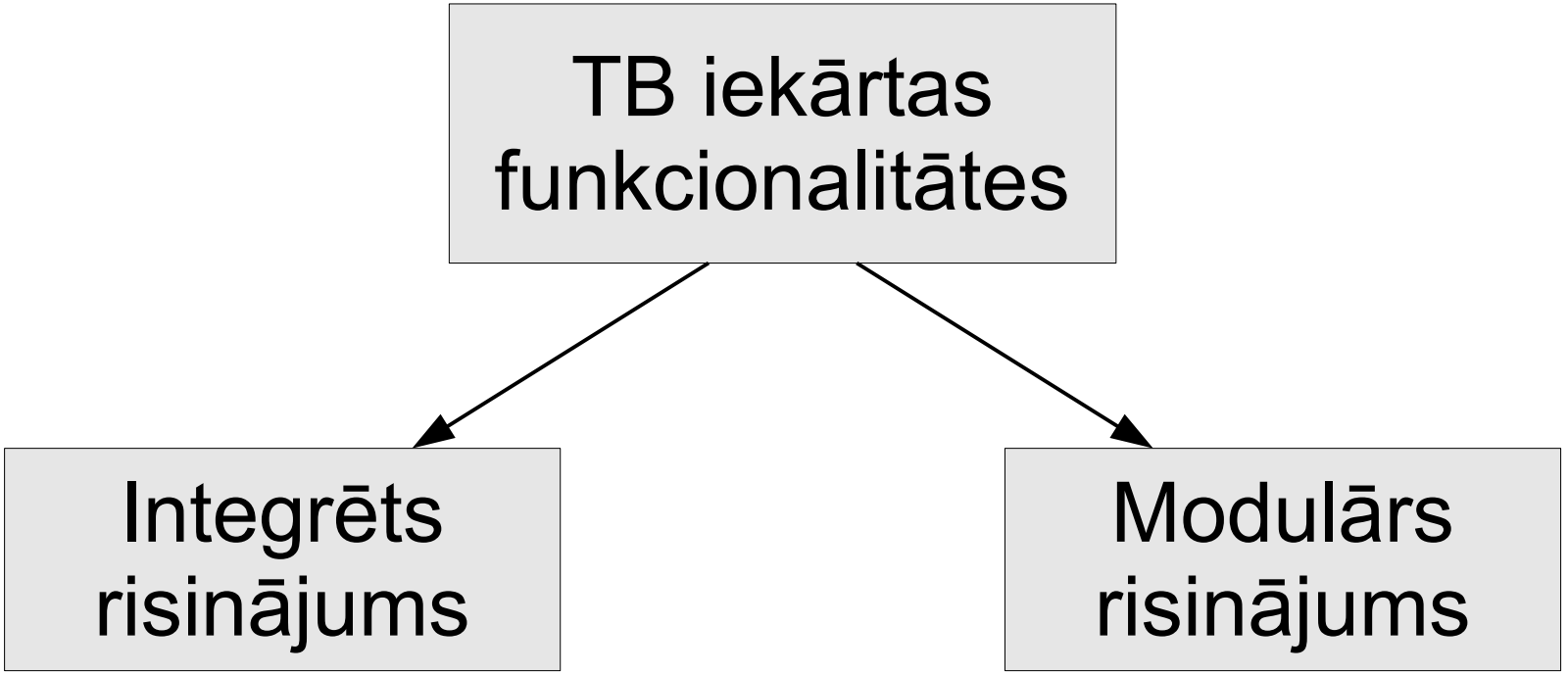
- Ierakstīt / Atspēlēt
- Saglabāt – SD karte



TestBed iekārtas funkcionalitāte

- Nodrošināt saskarni ar datoru
- Ieprogrammēt pieslēgto moti (TelosB, TmoteSky,...)
- Nomērīt enerģijas patēriņu pieslēgtai motei
- Simulēt motei reālus apstākļus
- Piekļūt pie motes GPIO signāliem - ierakstīt vai atspēlēt tos

TestBed iekārtas realizācija



- + Izmērs
- + Optimizēts vienam risinājumam
- + Vienkāršāka arhitektūra

- + Mērogojams
- + Maināmas, papildināmas funkcionalitātes
- + Moduļu atkārtota izmantošana

TestBed arhitektūras specifikācija

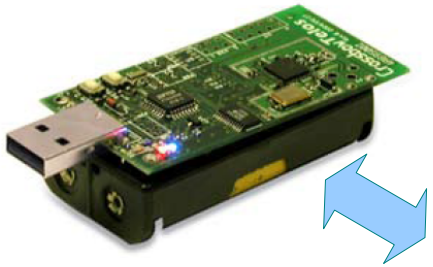
- Jābūt mērogojamai
  - Moduļu bāzēta
  - Moduļiem jābūt vienotai saskarnei (interface)
- Funkcionalitātes dalīšana grupās
  - Galvenais modulis – komunikācijas modulis (kontrolē pārējos)
  - Perifērijas moduļi (tiek kontrolēti)
    - Barošanas kontroles
    - Signālu apstrādes
    - Saskarnes

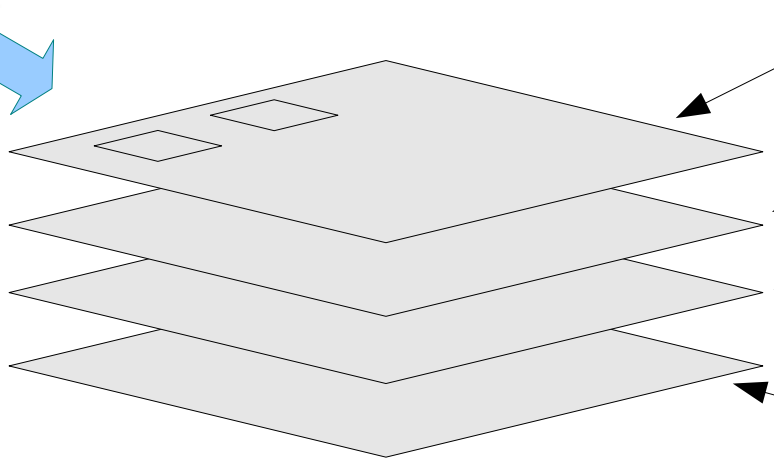
Moduļu bāzēta pieeja

- Pirmajā iterācijā funkcionalitātes tiek sagrupētas pēc izvēlēta pamata pa moduļiem
- Tiek izveidotas moduļu principiālās elektriskās shēmas
- Tiek izveidots standarts, kas ļautu savienot moduļus savā starpā – ja nepieciešams moduļu shēma tiek papildināta ar komponentiem, kas nepieciešami saskarnes nodrošināšanai

TestBed iekārtas reprezentācija

Testējamā iekārta





Saskarnes modulis

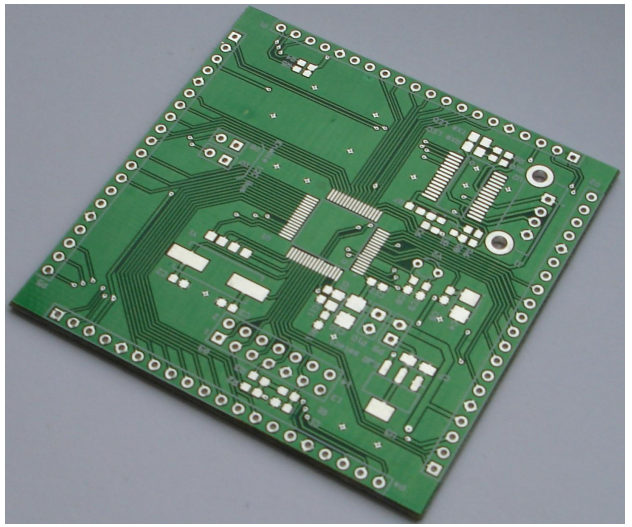
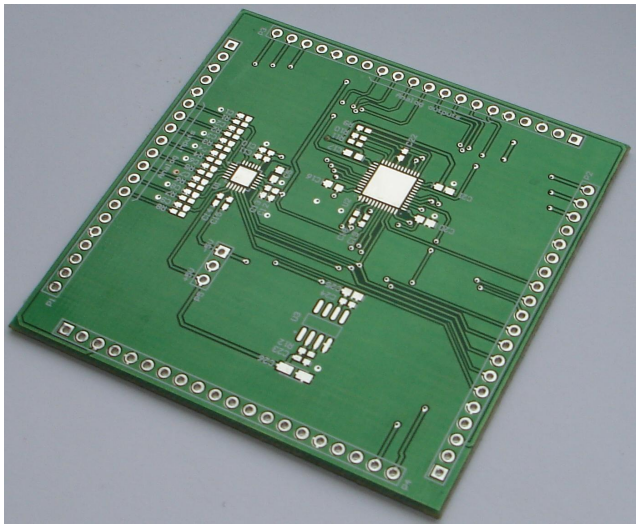
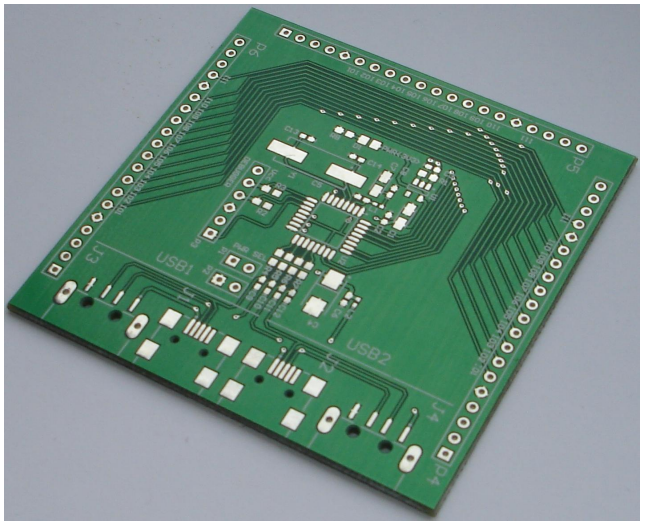
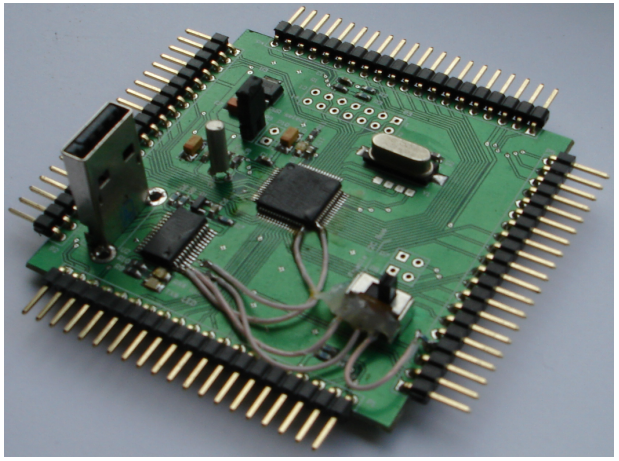
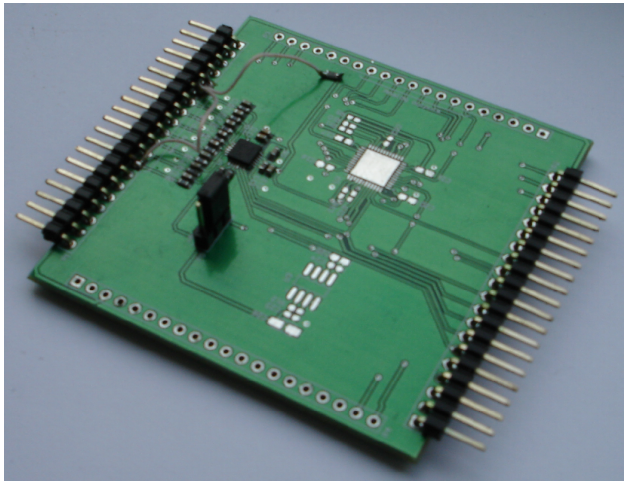
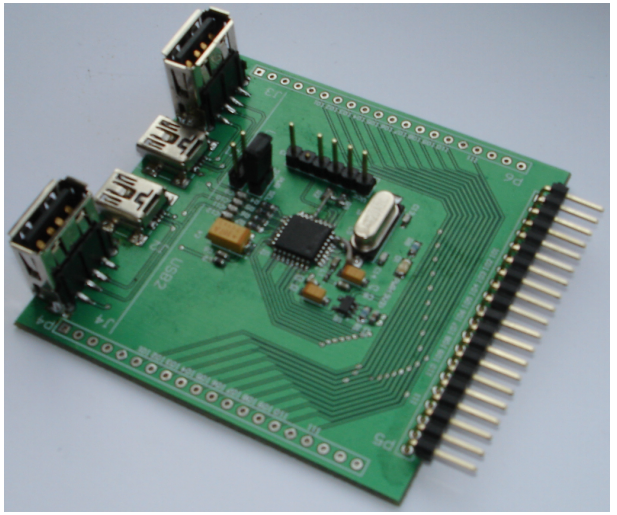
Komunikācijas modulis

Barošanas kontroles modulis

Signālu apstrādes modulis

TestBed iekārta

Izveidotie moduļi

Kopsavilkums

- Mērogojama arhitektūra
- Dažādu sensoru mezglu atbalsts
- BST programmatūras un aparatūras atkļūdošana

Paldies par uzmanību!
Jautājumi?

Virziena darbības skaņošana: kā panākt lai radio nerunā apkārt

Ivars Driķis, Leo Seļāvo

Elektronikas un datorzinātņu institūts

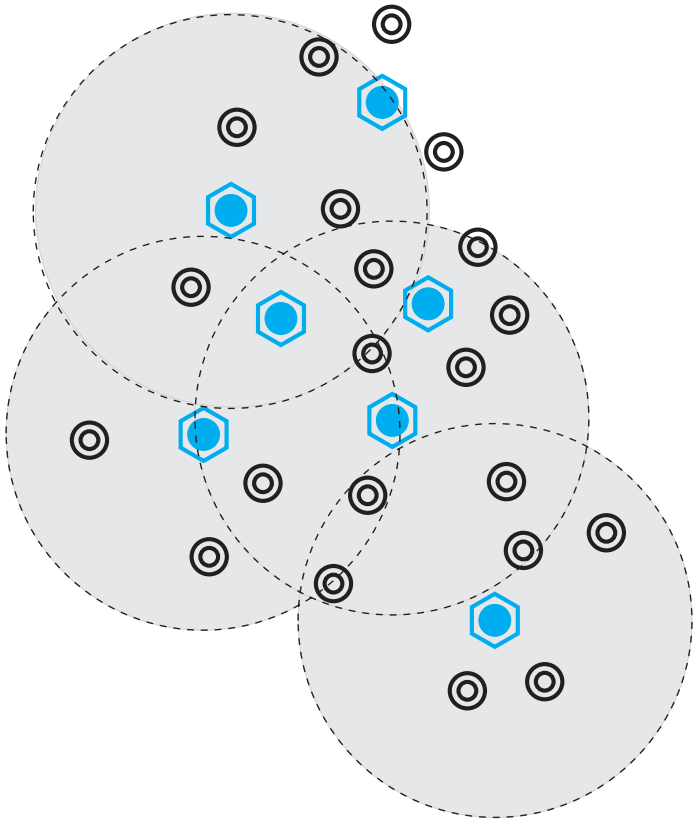


IEGULDĪJUMS TAVĀ NĀKOTNĒ



Vienošanās Nr. 2009/0219/1DP/1.1.1.2.0/09/APIA/VIAA/020

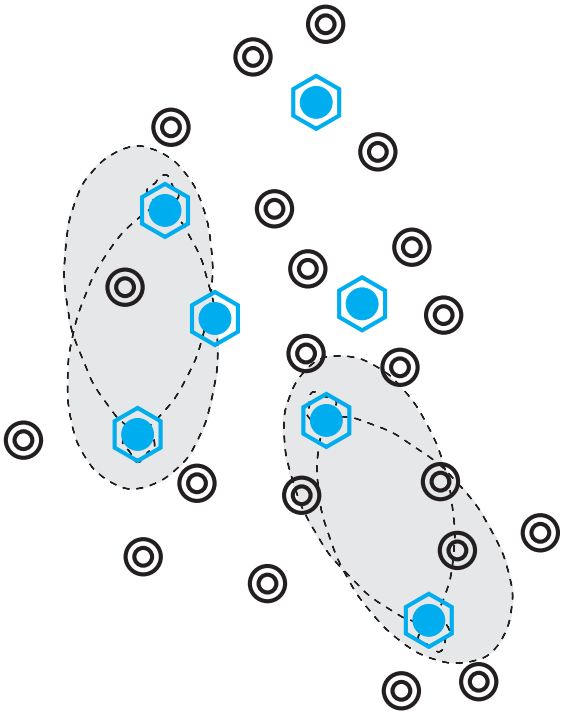
Parastās antenas sensoru tīklos



Parasti sensoru mezgliem lieto antenas, kuras visos virzienos izstaro vienādu jaudu. Attiecīgi arī ir vienādi jūtīgas visos virzienos

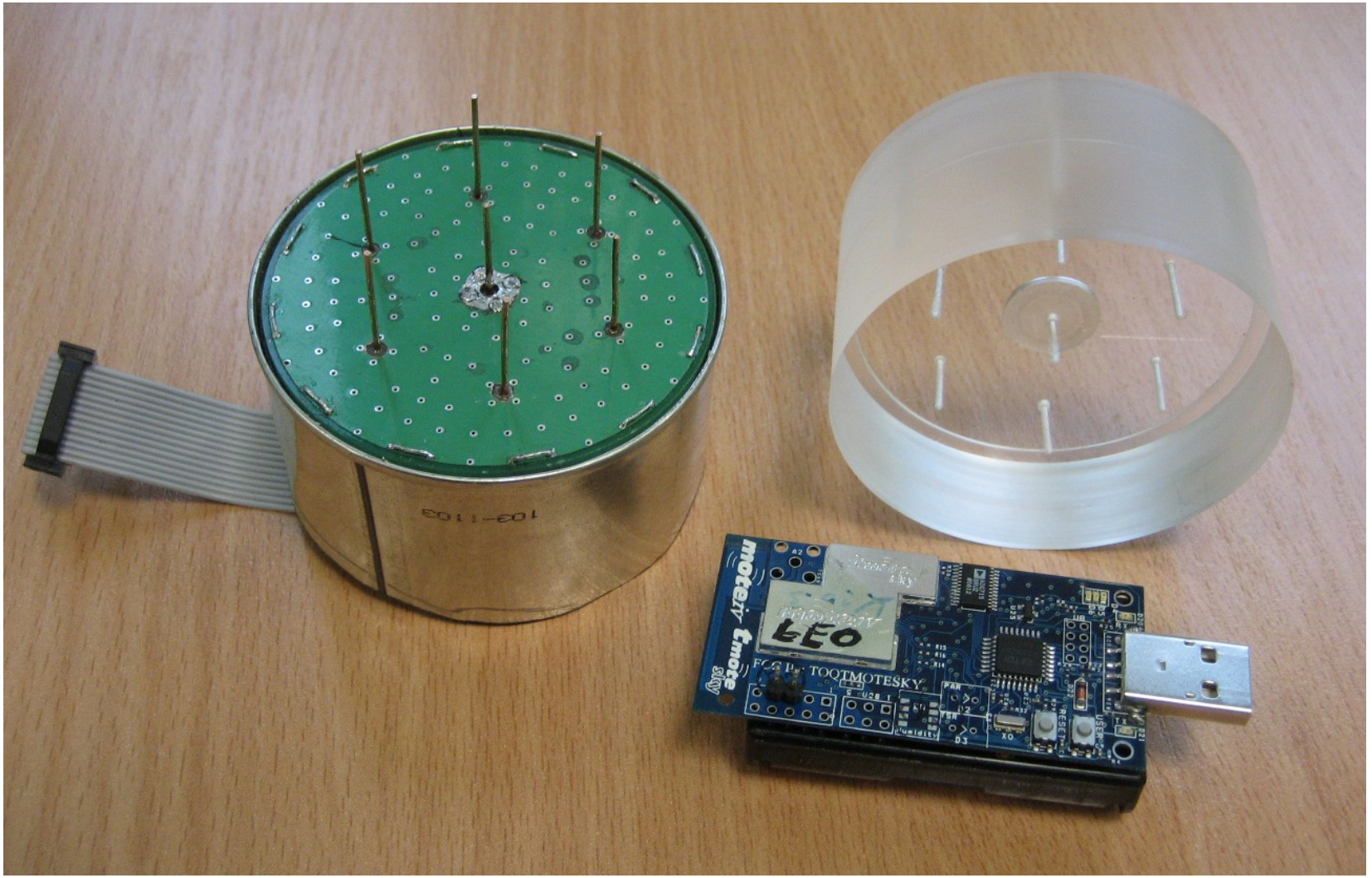
Vienkārša gan izgatavošanā gan ekspluatācijā

Virziendarbības antenu priekšrocības

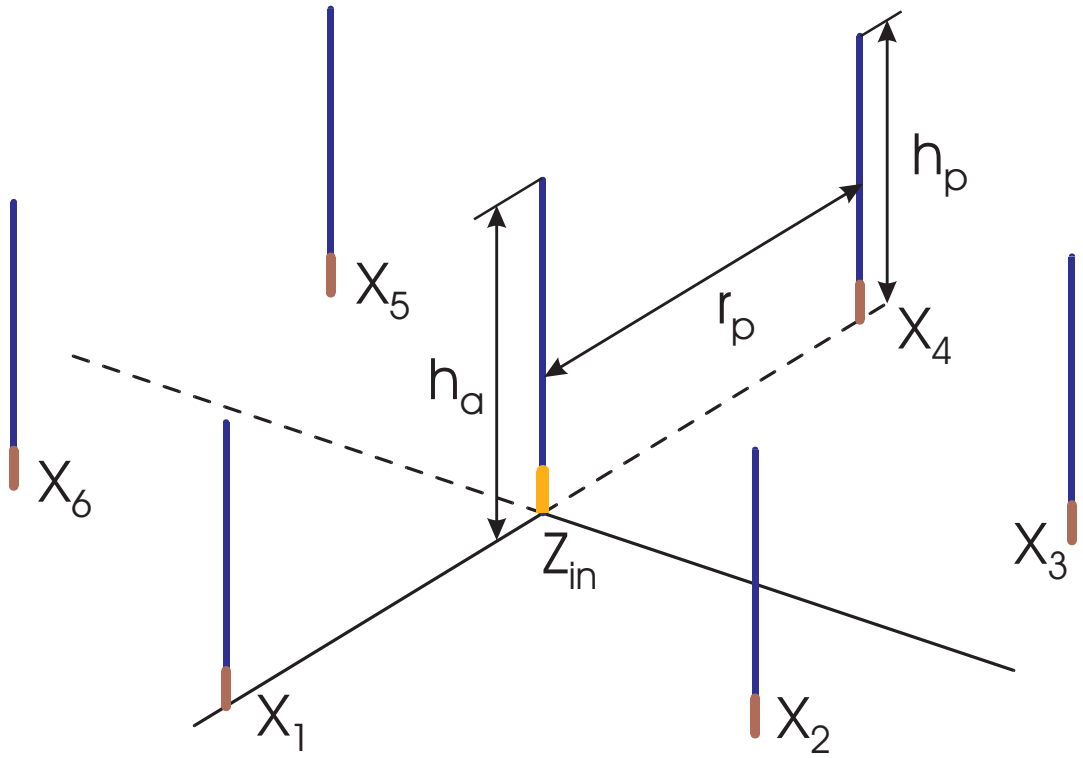


- Informācijas pārraidei starp diviem sensoru mezgliem būtu nepieciešams mazāks enerģijas patēriņš
- Sensoru mezgls varētu raidīt, tikai tajos laika momentos, kad pret viņu "vērsta" uztverošā antena
- Iespējams, ka vairaki sensoru mezglu pāri *vienlaikus* varētu lietot vienu un to pašu sakaru kanālu

Dielektriķī iegremdēta ESPAR antena



Kā šī antena strādā



Izmēri viļņa garumos

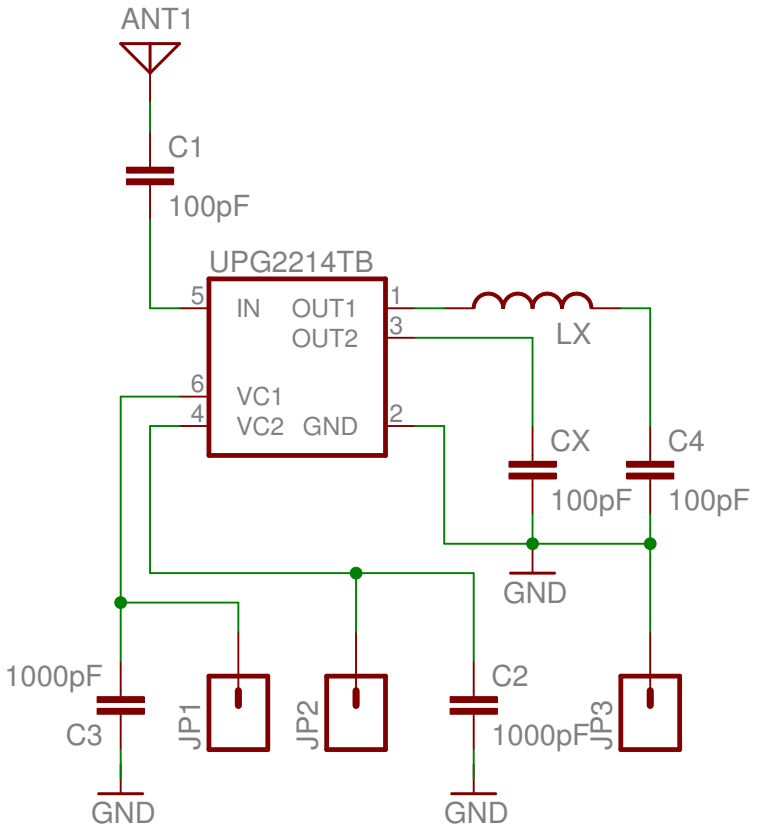
$$r_p \approx 0.25 \ldots 0.5\,\lambda$$
$$h_a \approx 0.25\,\lambda$$
$$h_p \approx 0.25\,\lambda$$

Antenas vadība

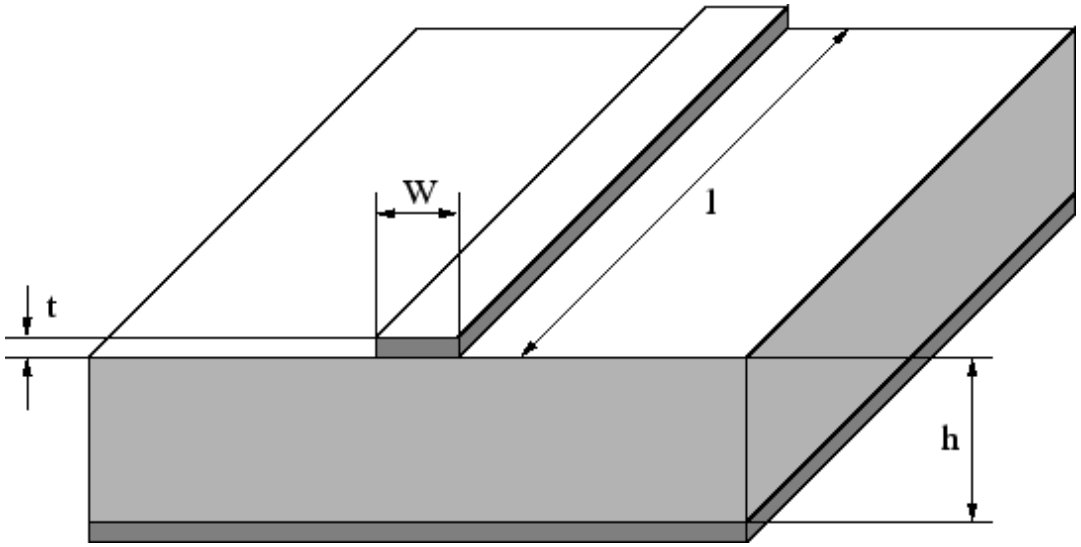
Izmanto pasīvo elementu slodzes rezistorus:
$\{X_1, X_2, X_3, X_4, X_5, X_6\}$

Antenas konstrukcija un vadības elementa shēma





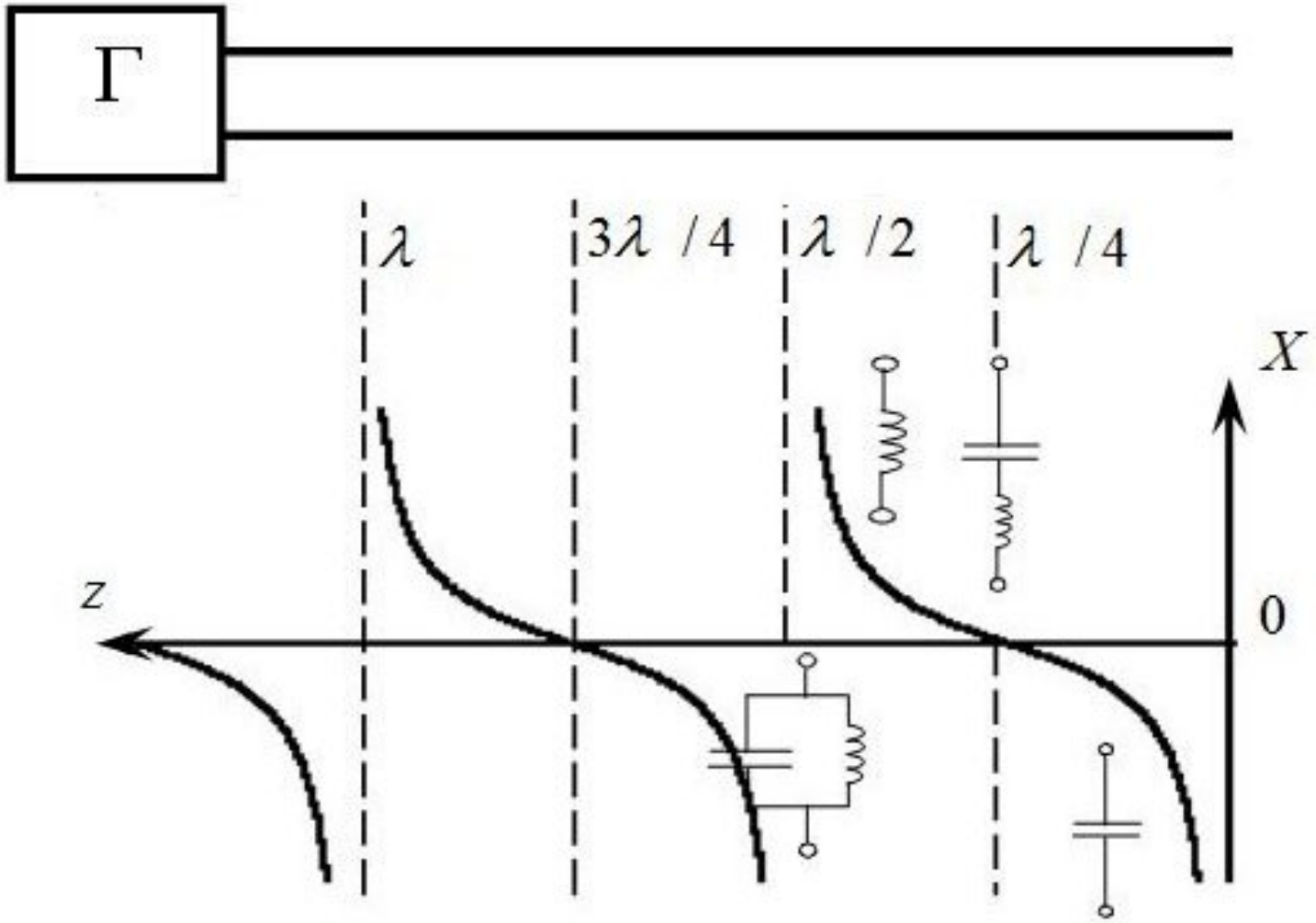
X_i - pārvades līnijas posms uz montāžas plates



Z_0	50 Ω
ϵ_r	4.6
h	1.5 mm
t	35 μm
f	2.44 GHz
w	2.699 mm
0.25λ	16.58 mm

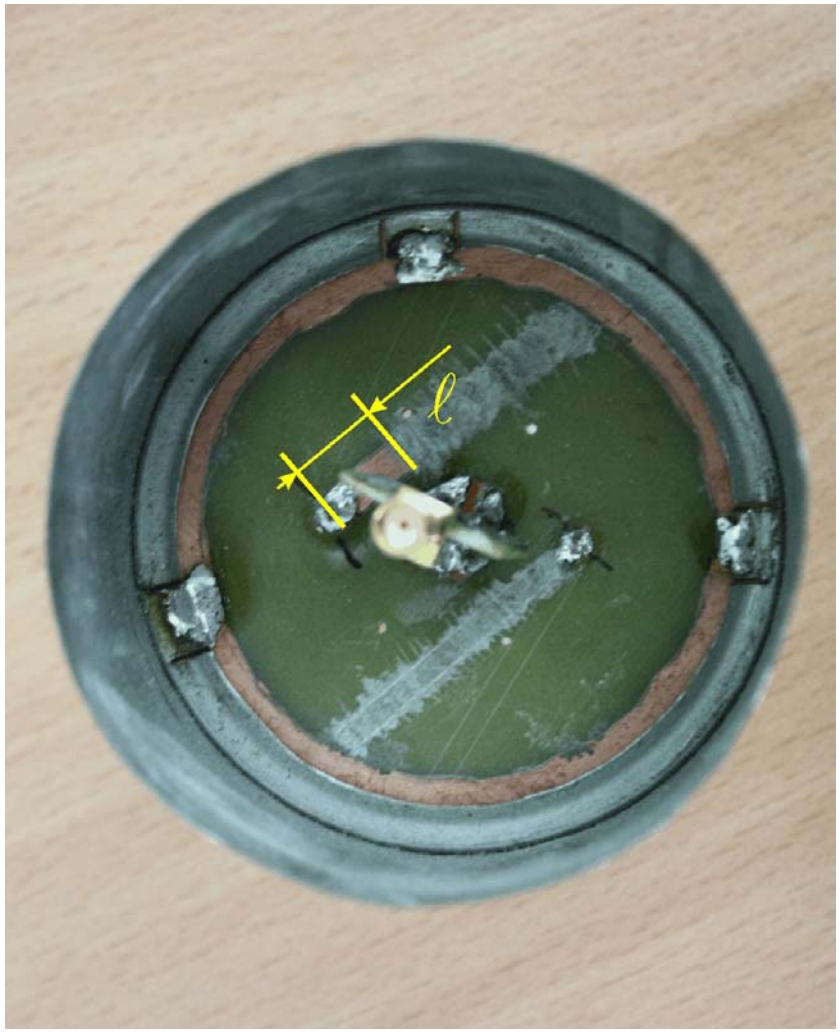
`http://www1.sphere.ne.jp/i-lab/ilab/tool/ms_line_e.htm`

Nenoslēgta pārvades līnija, ieskats teorijā

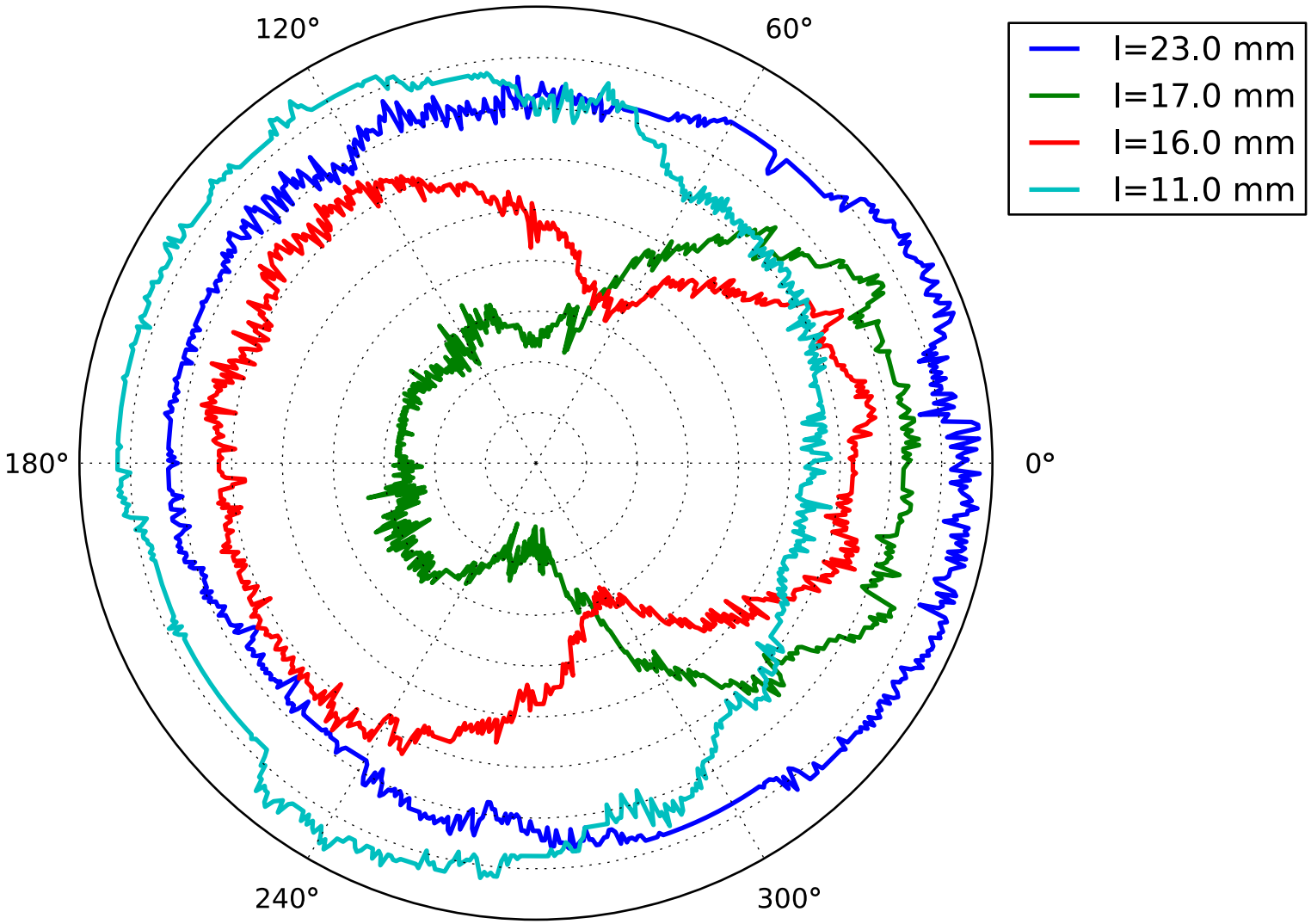


Modeļa eksperimenti





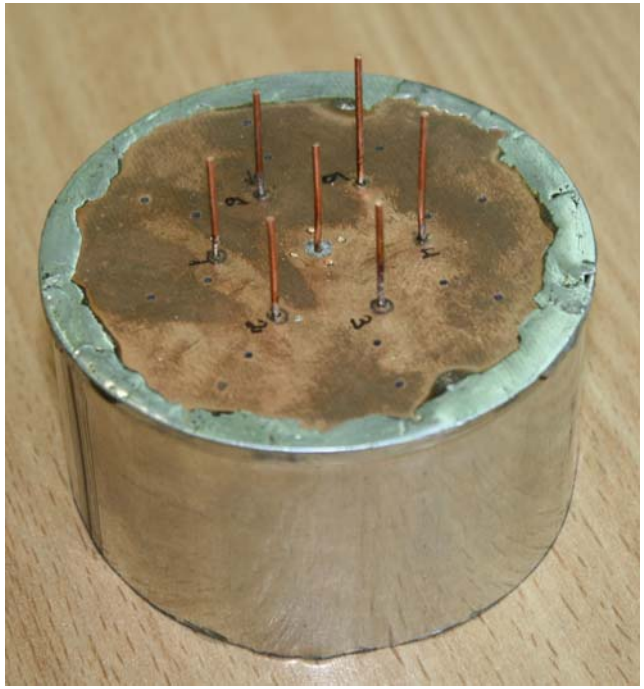
Mērījumu rezultāti

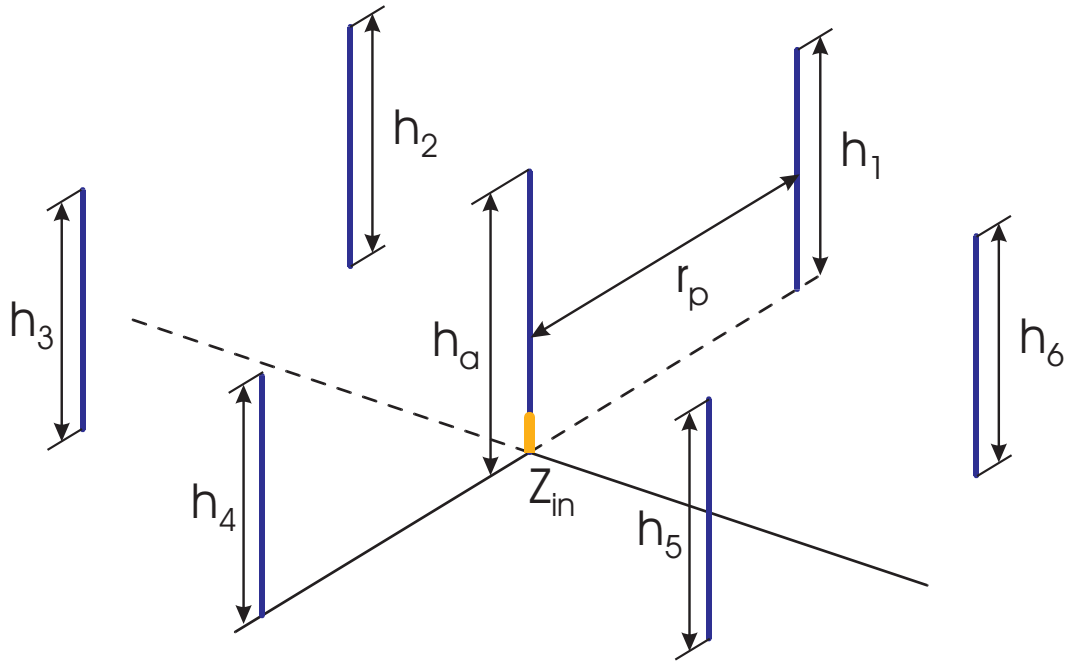


Secinājumi

- Nenoslēgtu pārvades līniju var izmantot ESPAR antenas pasīvā elementa vadībai.
- Pašreizējai antenas konstrukcijai taisna līnija ir parārāk gara
- Nav skadrs cik liela ir signāla “aizture” elektroniskajā komunikācijas elementā
- Tāpēc jāizveido plate tālākiem testiem

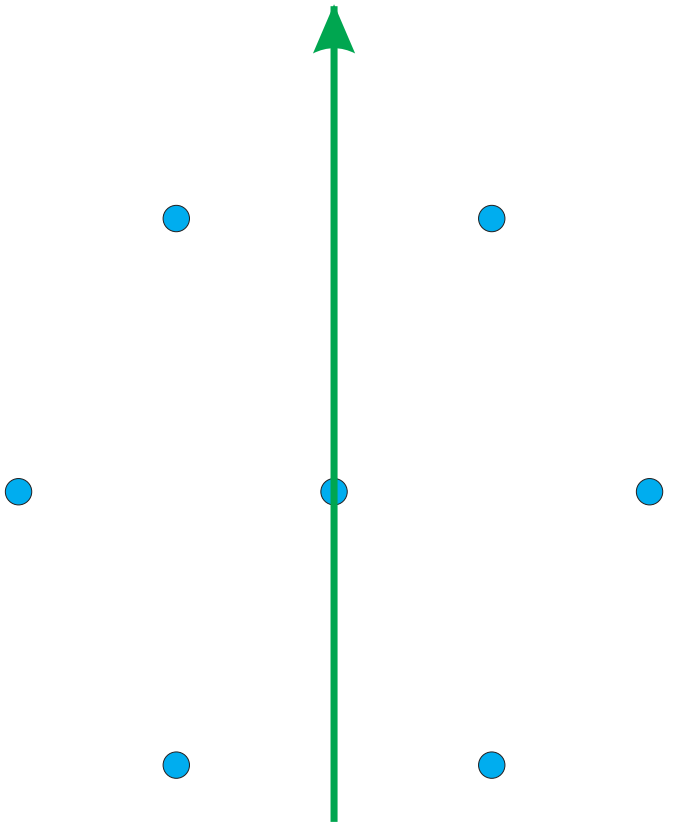
Pasīvas ESPAR7 antenas virziendarbības skaņošana





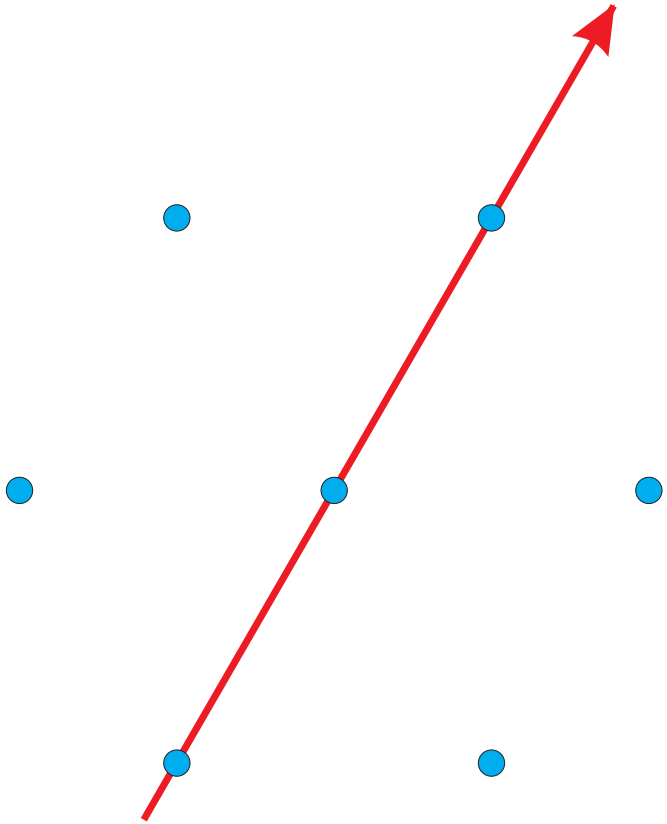
- Simetrijas īpašību izmantošana
- Optimālas ESPAR7 antenas izveide no vienkāršākām antenām

Simetrijas īpašību izmantošana



Trīs parametri:

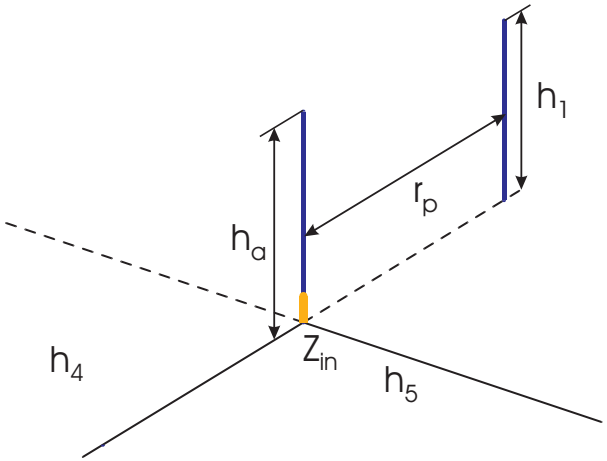
$h_1 = h_2,\ h_3 = h_6,\ h_4 = h_5$

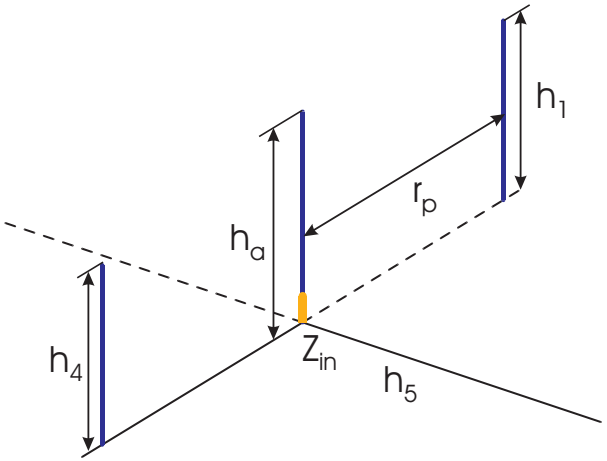


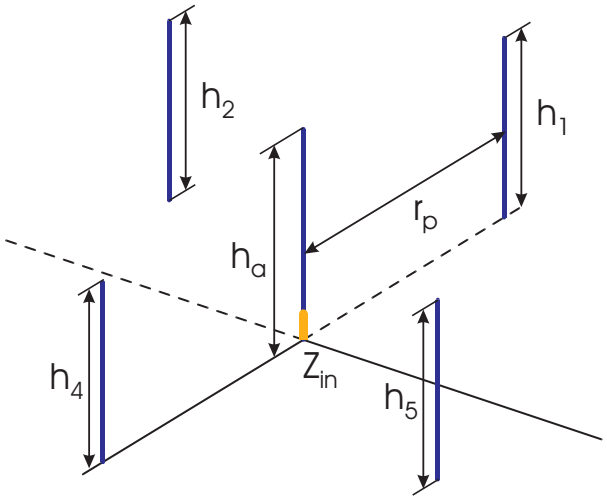
Četri parametri:

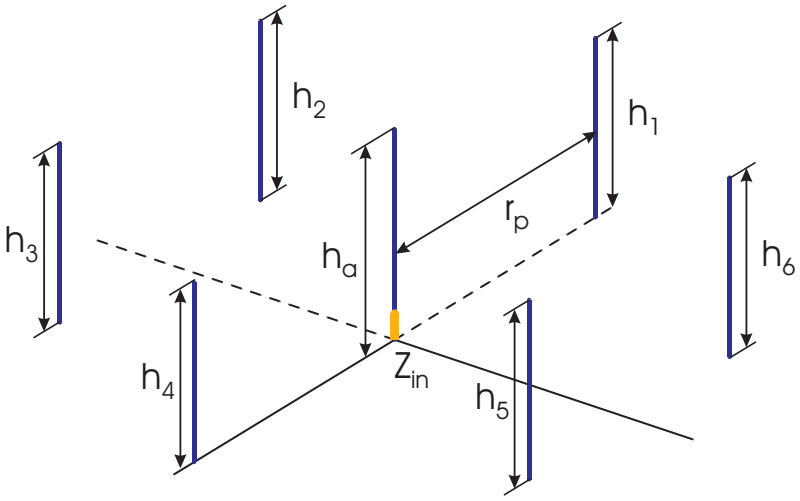
$h_1,\ h_2 = h_6,\ h_3 = h_5,\ h_6$

No vienkārša uz sarežģītāku: 3 parametru simetrijai

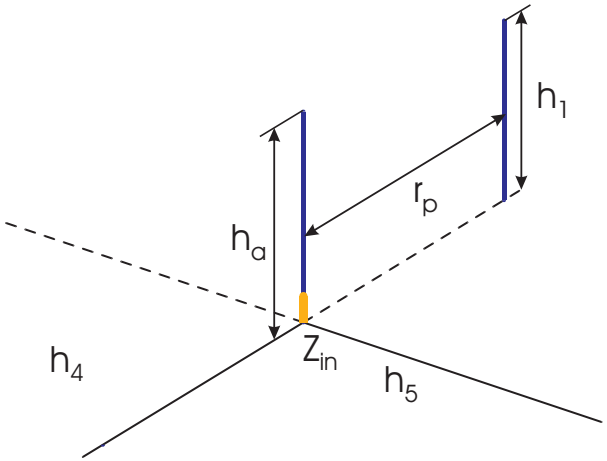


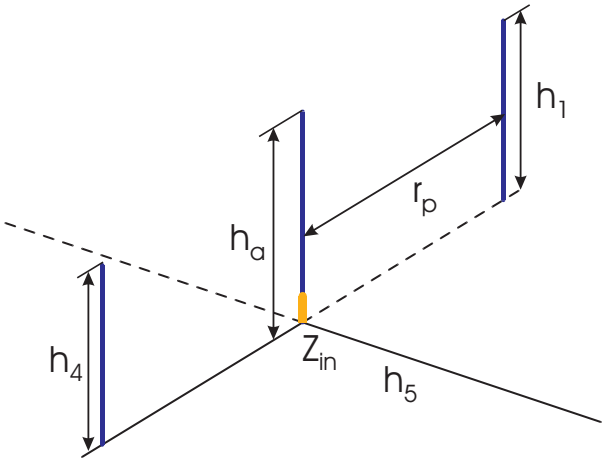


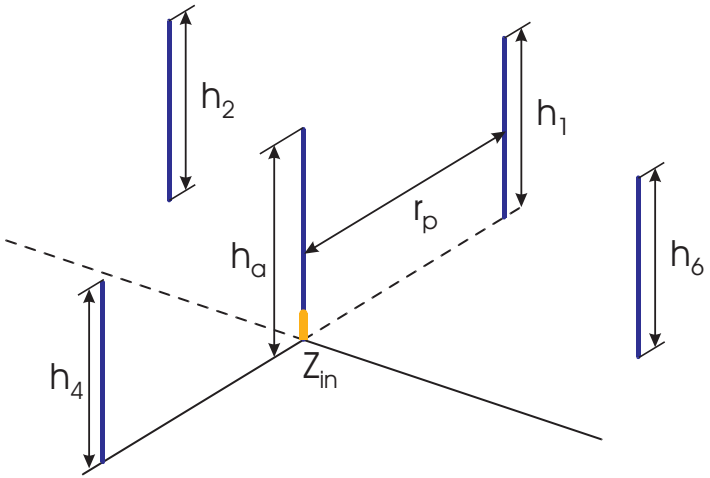


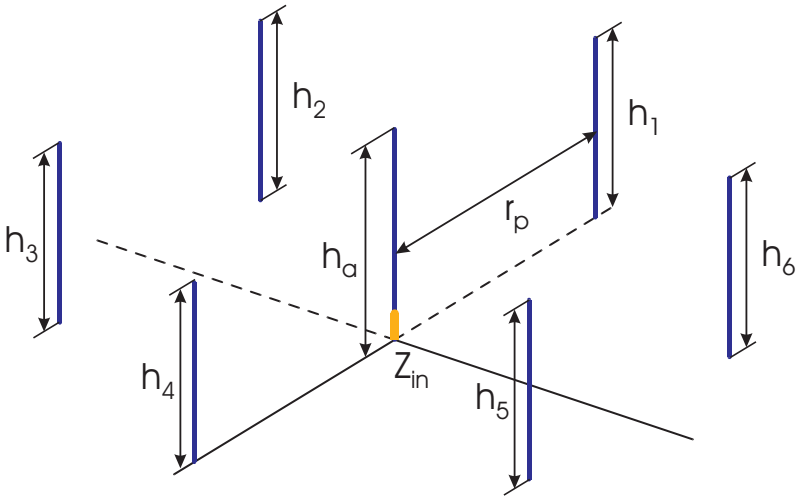


No vienkārša uz sarežģītāku: 4 parametru simetrijai

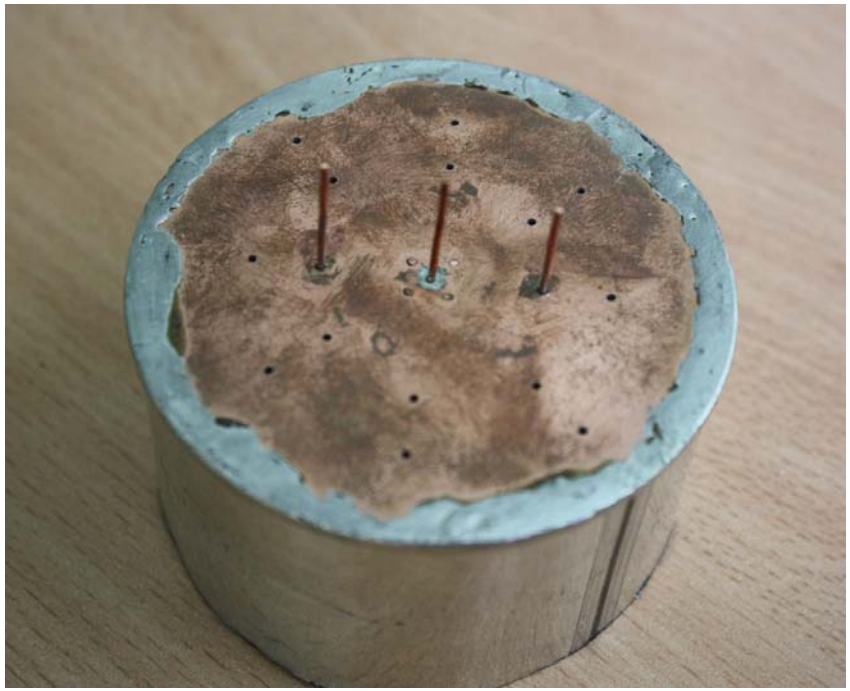


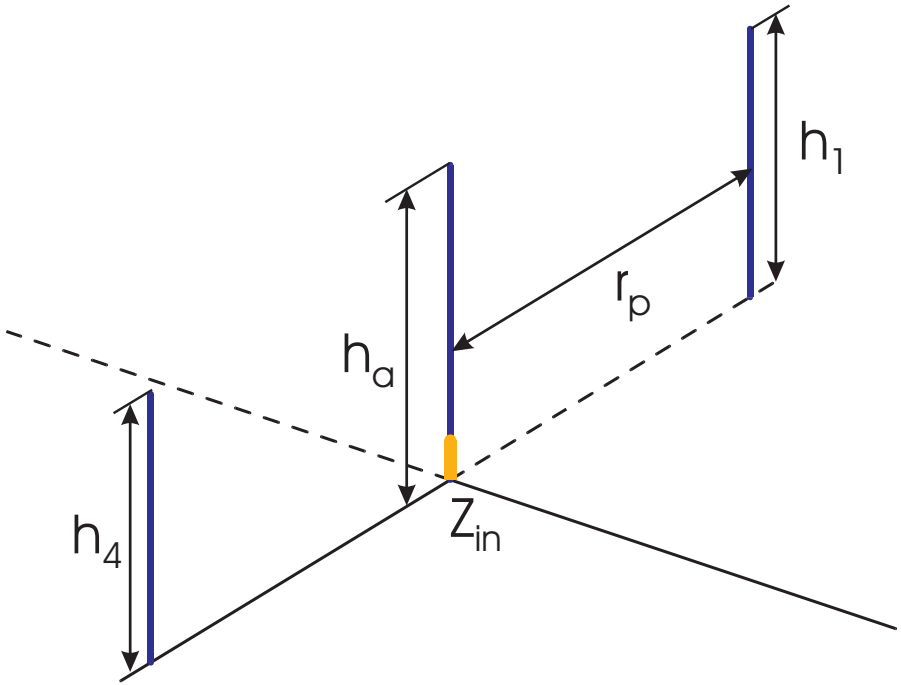






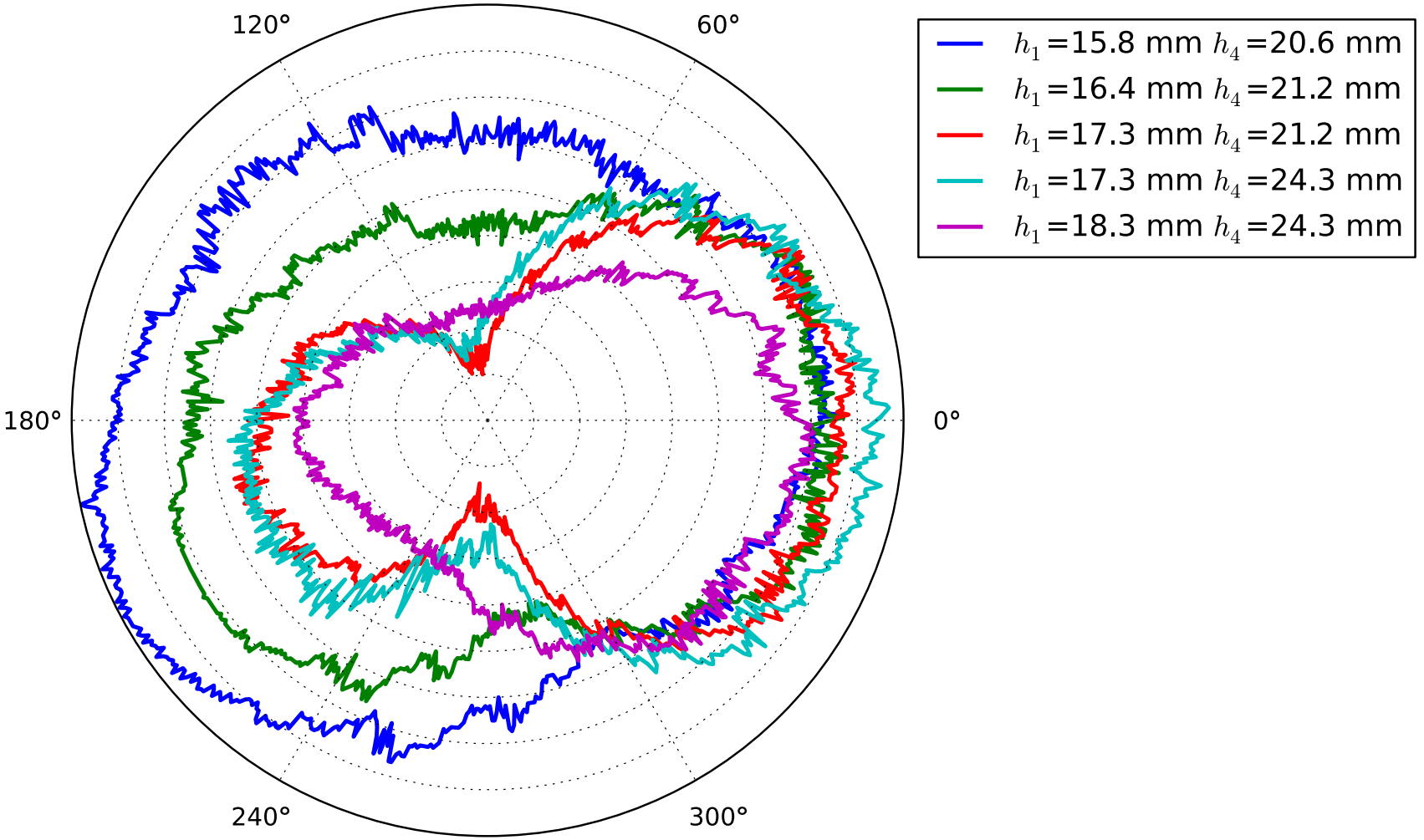
ESPAR3 antena



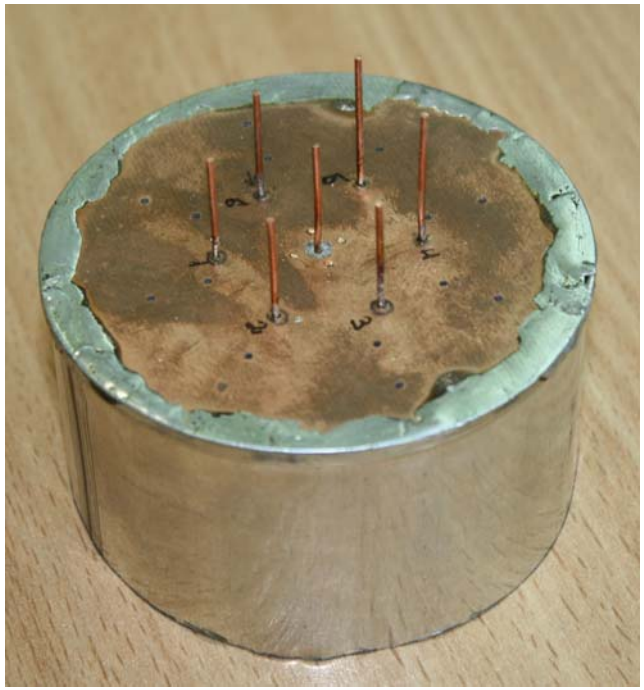


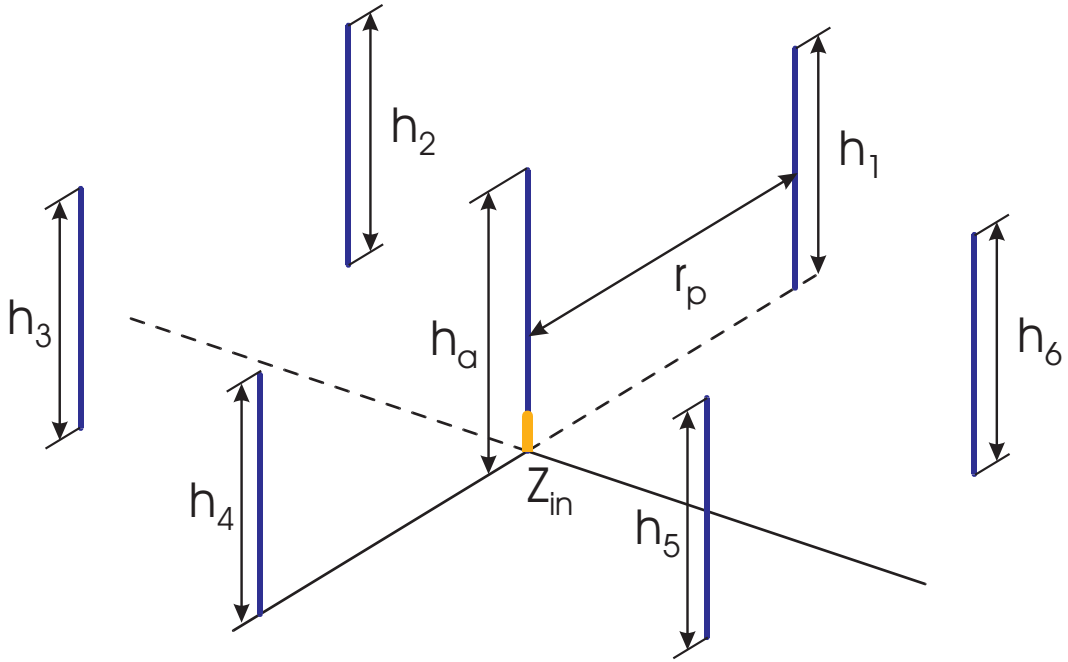
- Visos mērījums $h_a = 18.3\,mm$ un $r_p = 14\,mm$
- Mērījumos maina h_1 un h_4

ESPAR3 antenas mērījumu rezultāti



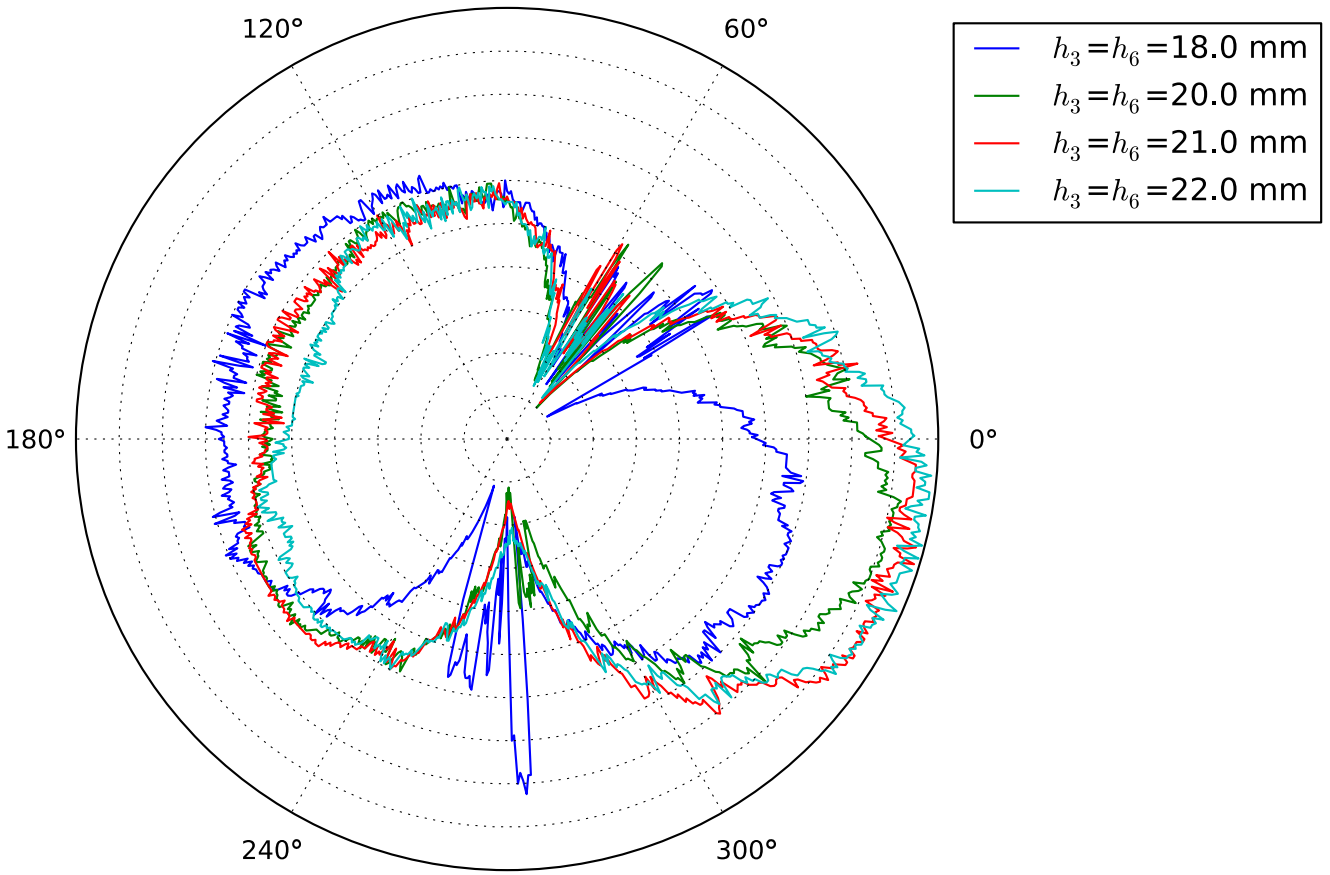
ESPAR7 antena





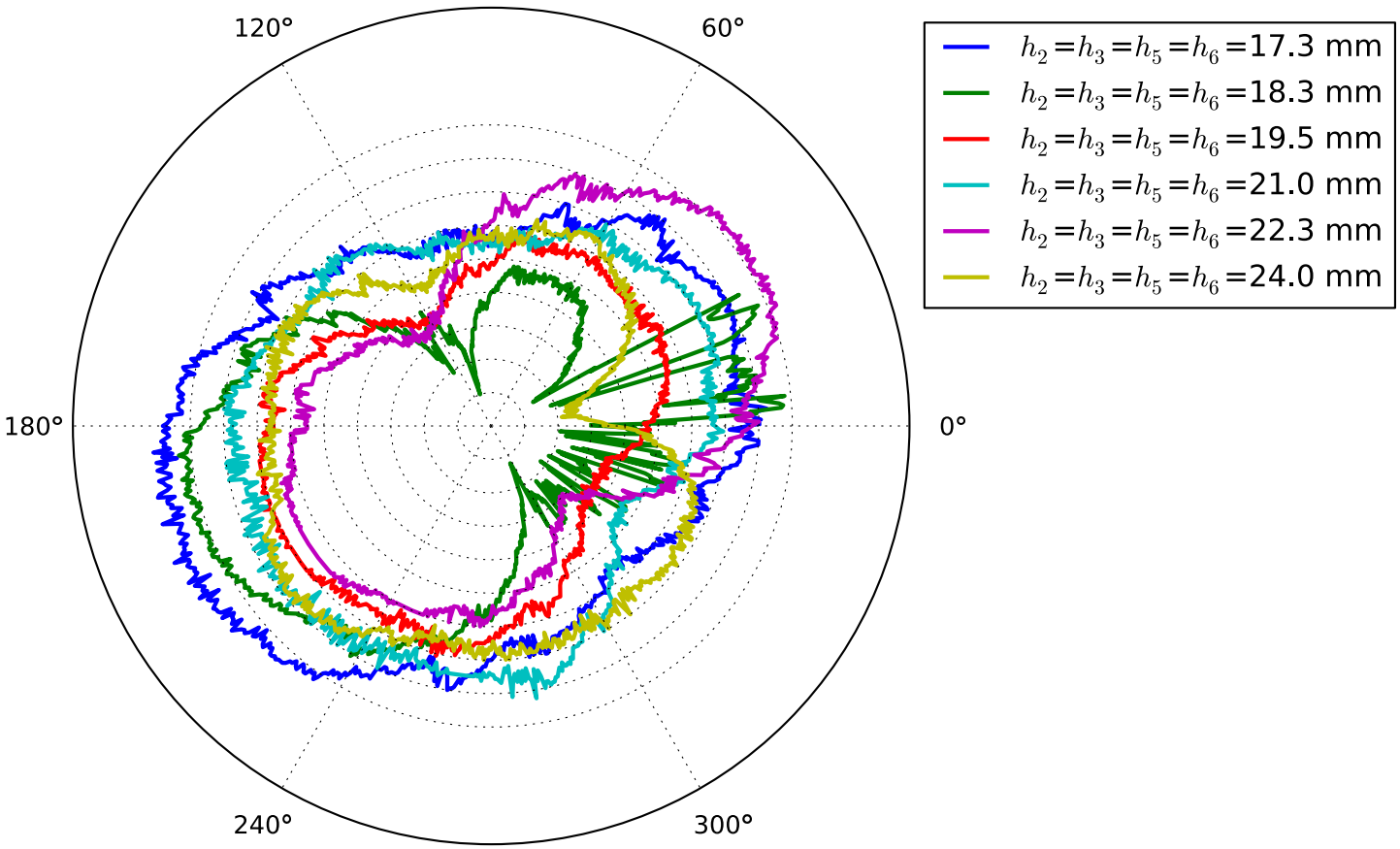
- Fiksējam $h_1 = 17.3\,mm$ un $h_4 = 21.2\,mm$ atbilstoši ESPAR3 antenas mērījumu rezultātiem

ESPAR7 ar 3 mainīgo simentriju



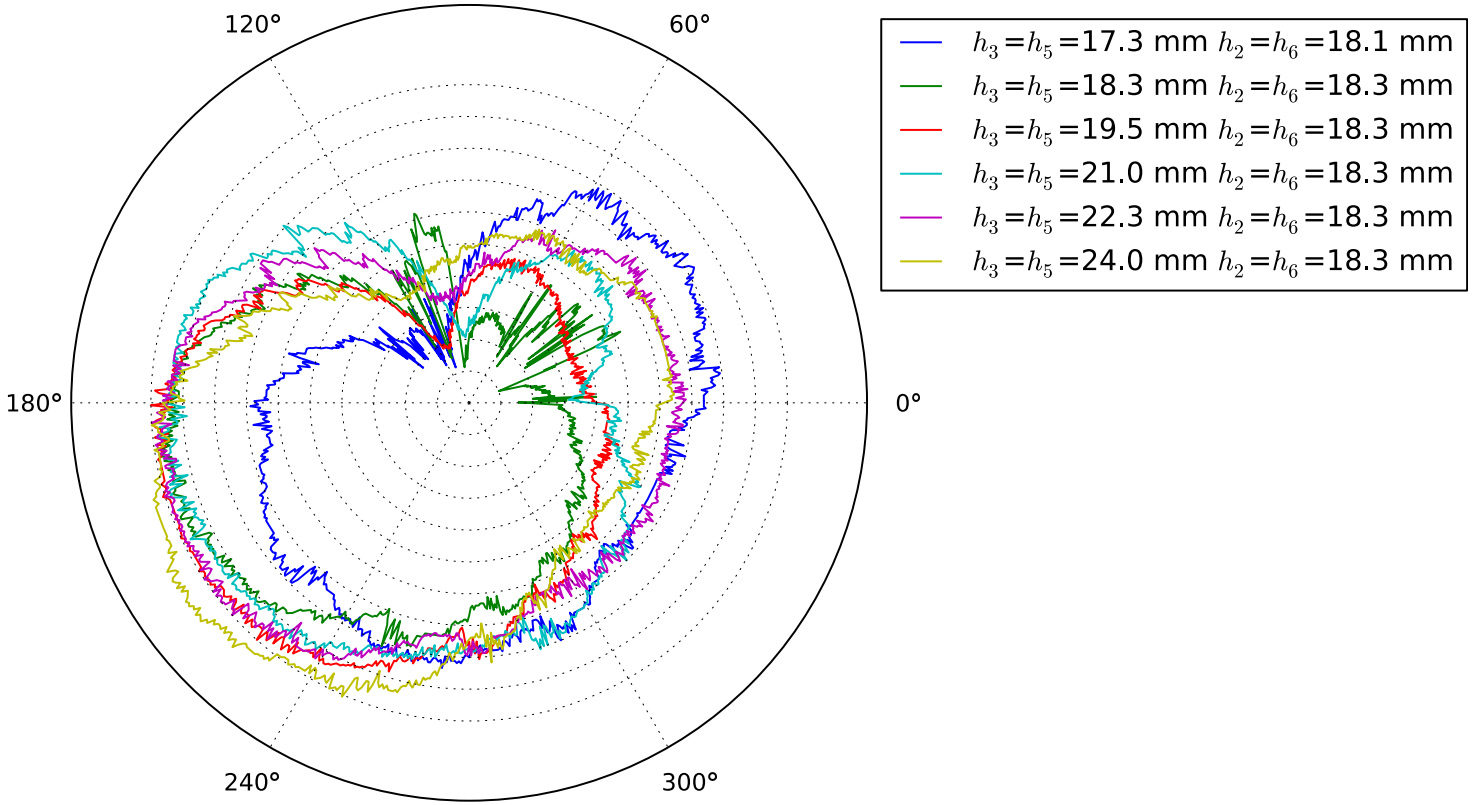
- Fiksē $h_1 = h_2 = 17.3\,mm$ un $h_4 = h_5 = 21.2\,mm$
- Maina $h_3 = h_6$.

ESPAR7 ar 4 mainīgo simentriju



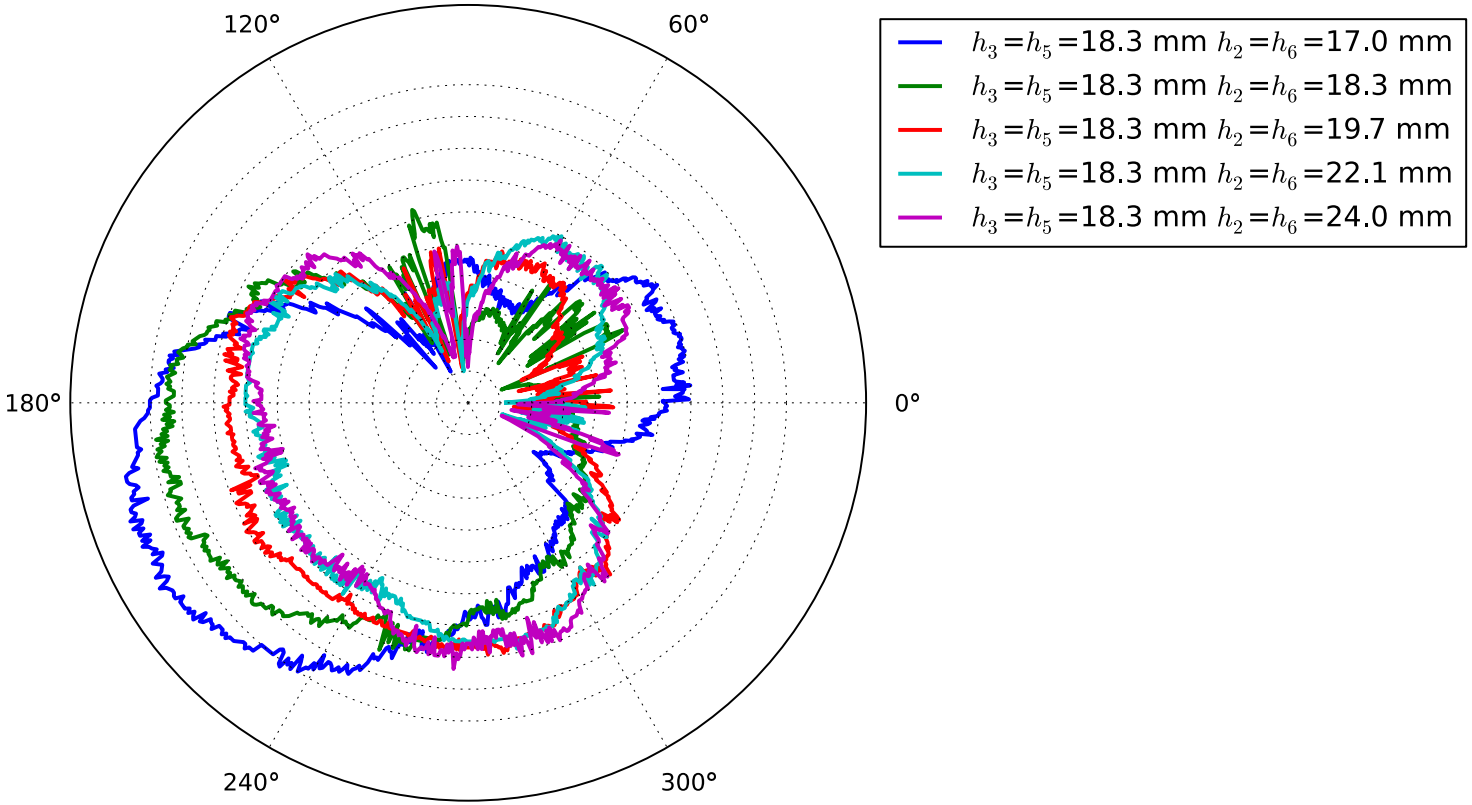
- Fiksē $h_1 = 17.3\,mm$ un $h_4 = 21.2\,mm$
- Maina $h_2 = h_3 = h_5 = h_6$.

ESPAR7 ar 4 mainīgo simentriju



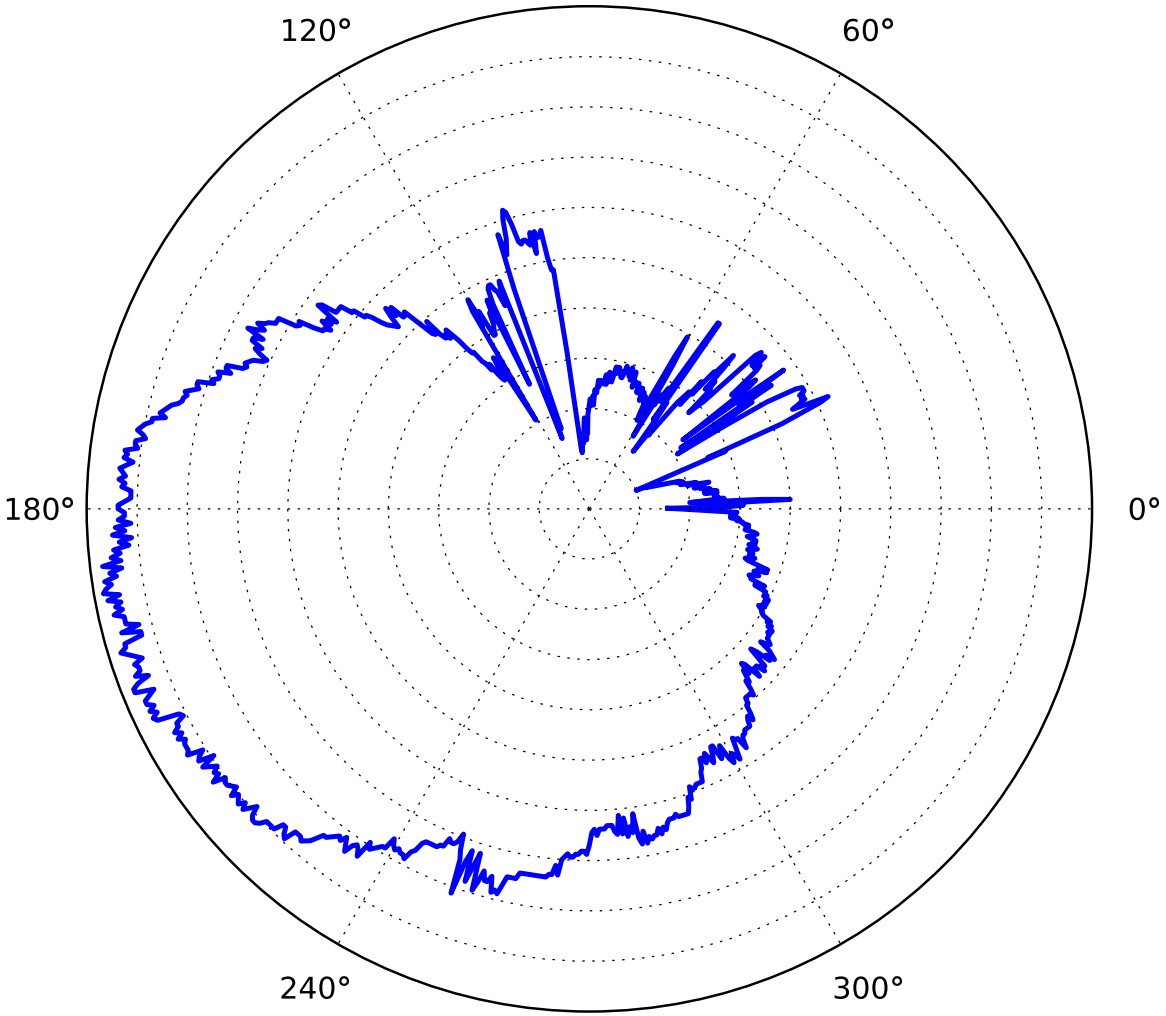
- Fiksē $h_1 = 17.3\,mm$ un $h_4 = 21.2\,mm$
- Fiksē $h_2 = h_6 = 18.3\,mm$
- Maina $h_3 = h_5$.

ESPAR7 ar 4 mainīgo simentriju



- Fiksē $h_1 = 17.3\,mm$ un $h_4 = 21.2\,mm$
- Fiksē $h_3 = h_5 = 18.3\,mm$
- Maina $h_2 = h_6$.

Rezultāti: optimālā antena



$$h_1 = 17.3\,mm$$
$$h_2 = 18.3\,mm$$
$$h_3 = 18.3\,mm$$
$$h_4 = 22.3\,mm$$
$$h_5 = 18.3\,mm$$
$$h_6 = 18.3\,mm$$
$$h_a = 18.3\,mm$$
$$r_p = 14.0\,mm$$

Rezultāti

1. Nenoslēgtas līnijasizmantošana ESPAR antenas pasīvā elementa vadīšanai
2. Pasīvas ESPAR7 antenas virziendarbības skaņošana