



# "Personal" Robotics: through a Game to the Science

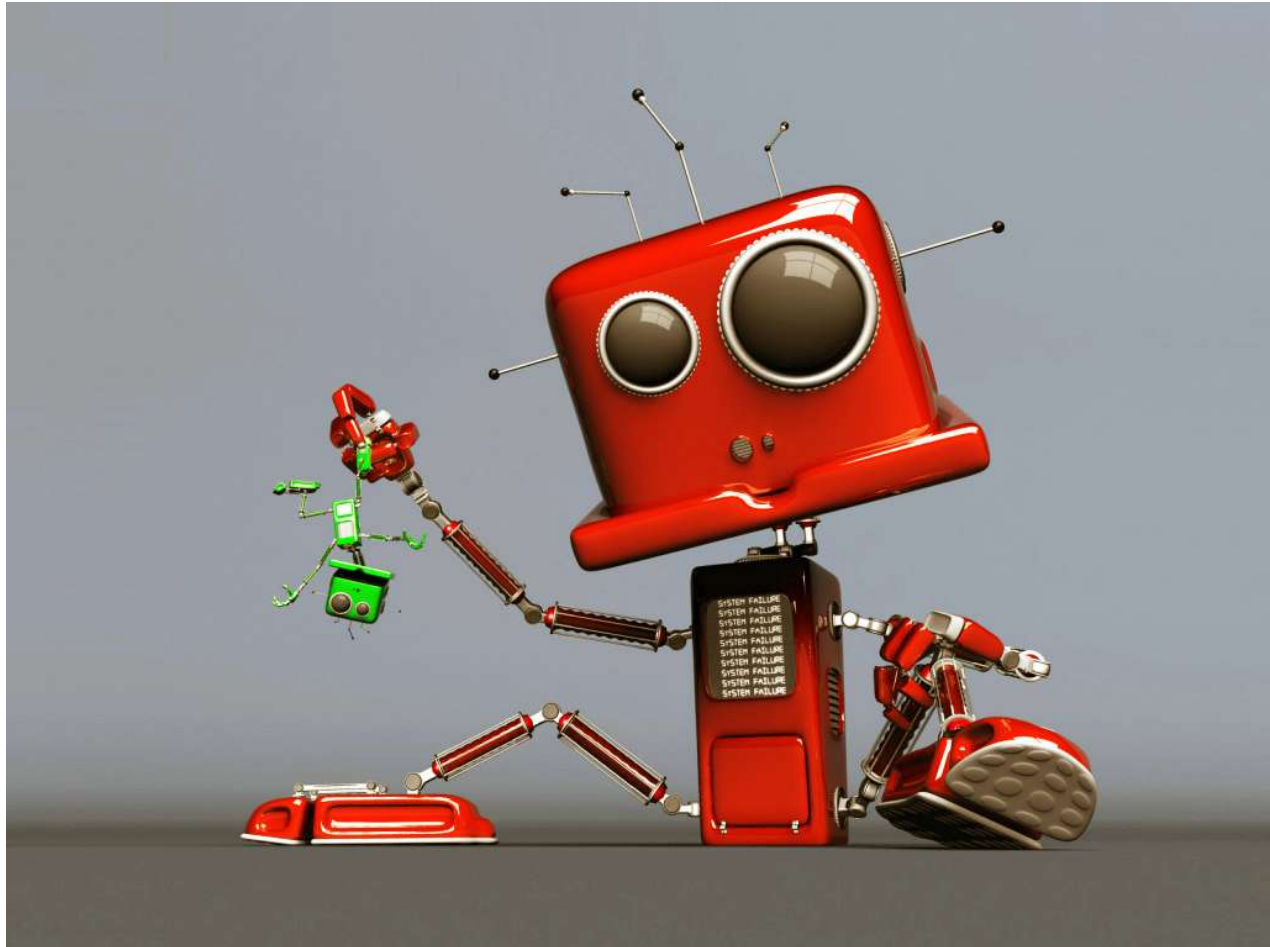
Roman M. Lutchin, Vladimir I. Kiyayev  
Saint-Petersburg State University

9-th Conference of Open Innovations  
Community FRUCT  
1-st Regional MeeGo Summit Russia-  
Finland  
AMICT 2011 Workshop

Petrozavodsk, Russia, 25-29 April  
2011



# "Personal" Robotics – What is it?





# Cybernetics and Robotics at the Universities

Training directions of specialists,  
bachelors and masters:

010500 - Applied Mathematics and Computer  
Science

010600 - Applied Mathematics and Physics

011000 - Mechanics. Applied Mathematics

160400 - Traffic Control and Navigation  
Systems

220200 - Automation and Control

220400 - Mechatronics and Robotics





# Cyber-Physical Systems

Cyber-Physical System integrates the abilities to computing, communication and storage of information for monitoring and/or facilities control of the physical world objects.

Such System should do it safely, securely, efficiently and do it in real time.

Cyber-Physical Systems must be mobile, extensible, efficient and adaptive.

Workshop of the National Science Foundation for cyber-physical systems: «NSF Workshop On Cyber-Physical Systems»,

Oct. 16 - 17, 2006, Austin, TX, USA

<http://varma.ece.cmu.edu/cps/>





# National Science Foundation (NSF) Programs of Cyber-Physical Systems



## Economic Context: Calibrating US Competitiveness

- Goals of a CPS research program
  - A new science for future engineered and monitored systems (10-20 year perspective)
  - Physical and cyber design that is deeply integrated

3

Cyber-Physical Systems.

[http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=13385](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13385)





# Educational & Research Cyber Physical Laboratory

Transport Vehicles  
Driving and  
Universal  
Regulators  
(Principal - RSA  
corr.- member,  
professor  
V.A.Yakubovitch)

4-th wheels TV  
3-th wheels TV  
Walking and  
unconventional TV

Control in network  
systems and group  
control  
(Principal -  
professor  
A.S.Matveev)

Groups of mobile  
robots and  
ensembles of  
unmanned aircraft  
(together with the  
System Programming  
Chair,  
Principal - professor  
O.N.Granitchin)

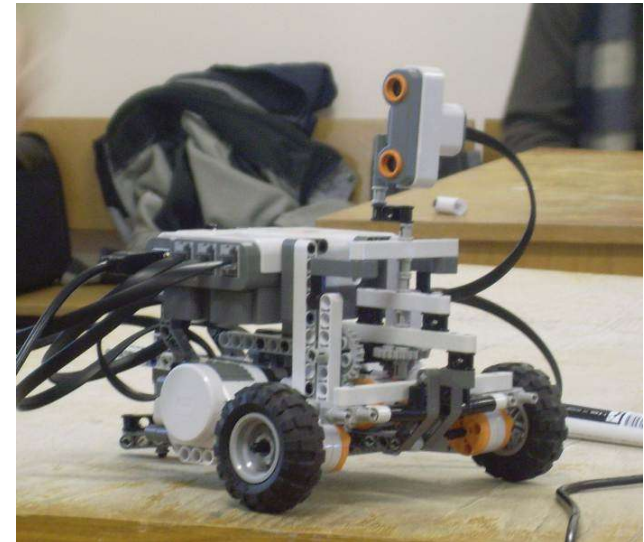
Nonlinear  
systems,  
oscillations and  
chaos control  
(Principal -  
professor  
A.L.Fradkov)

Pendulum on a  
cart  
Furuta pendulum  
Robot-gymnast  
Vibration  
thrusters



# Sample tasks and research topics for 2-year students of Mathematics and Mechanics Department of Saint- Petersburg State University

1. Stabilization of inverted pendulum on a cart
2. Robot-cyclist
3. Robot-motorist
4. Robot-lion and robot-antelope (the pursuit problem)
5. Controlling of the robot-segway
6. Controlling of the robot-gymnast
7. Controlling of the robot via Bluetooth
8. Managing of a mobile robots team







## Project: Real-time allocation of voice signal from the mixture with a microphone array and a camera

A stand and a prototype of a system for suppressing extraneous speech and music signals in the transmission of the speech signal from the Speaker sitting in front of a microphone array and camera is designed.

A laptop equipped with multiple microphones and cameras is the basic unit.

A program for separation of the votes from a mixture of signals is developed.



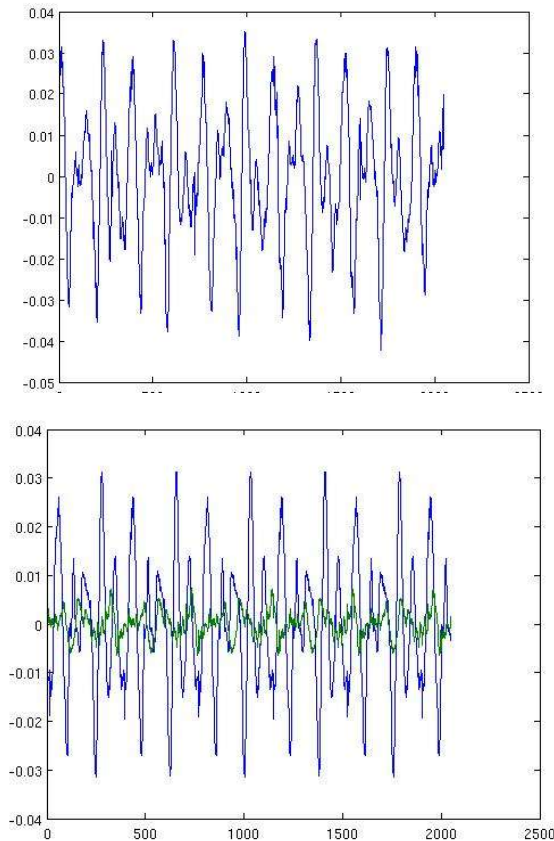
Principal - professor A.E. Barabanov





# Project: Real-time allocation of voice signal from the mixture with a microphone array and a camera

Principal - professor A.E. Barabanov



The program determines the position of Speaker over the phase shift of harmonics in the incoming signal. Red dots indicate the recognized position of mouth of students who have worked in the project. The system monitors their movements in real time.

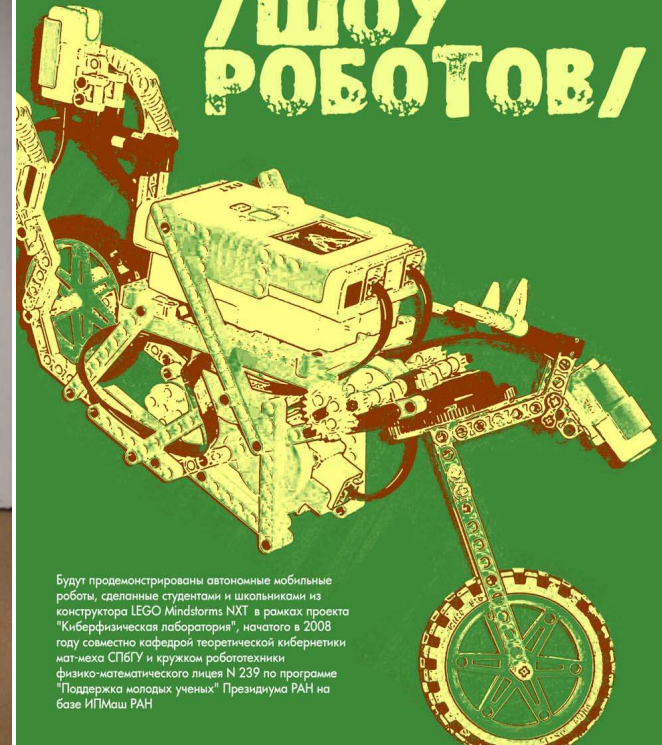
# Robot's Show as part of the 49-th Mathematics and Mechanics Department Week of of St. Petersburg State University



23 апреля, четверг,  
12:50 /Аквариум /

в рамках 49 недели Мат-Меха  
КАФЕДРА ТЕОРЕТИЧЕСКОЙ  
КИБЕРНЕТИКИ представляет

## /ШОУ РОБОТОВ/

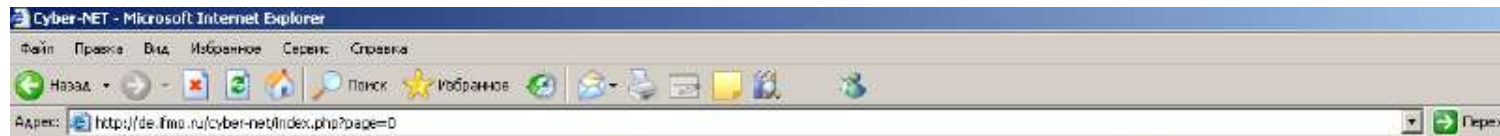


Будут продемонстрированы автономные мобильные роботы, сделанные студентами и школьниками из конструктора LEGO Mindstorms NXT в рамках проекта "Киберфизическая лаборатория", начатого в 2008 году совместно кафедрой теоретической кибернетики мат-меха СПбГУ и кружком робототехники физико-математического лицея N 239 по программе "Поддержка молодых ученых" Президиума РАН на базе ИПМаш РАН



# Cybernetics in school: science at the crossroads of mathematics, physics and computer science

School Olympiads on cybernetics in St. Petersburg: 10 Olympiads in 1999 – 2009 ([cyber-net.spb.ru](http://cyber-net.spb.ru))



## Олимпиада по кибернетике

- [Главная](#)
- [О кибернетике](#)
- [Правила проведения](#)
- [История олимпиады](#)
  - [Результаты олимпиад](#)
  - [Статистика олимпиад](#)
  - [Участники](#)
- [Задачи](#)
- [Оргкомитет](#)
- [Ссылки](#)
- [Текущая олимпиада](#)
  - [Регистрация команд](#)
  - [Участники](#)
  - [Результаты](#)

Логин:

Пароль:

[RUS](#) / [ENG](#)

X Открытая олимпиада Санкт-Петербурга по кибернетике среди школьных команд	Новости
<b>Уважаемые коллеги!</b>	<b>27.04.2009 13:04</b>
Приглашаем Вас принять участие в заочном отборочном туре X Открытой олимпиады Санкт-Петербурга по кибернетике среди школьных команд (CYBER-NET'2009).	Заочной тур Олимпиады ...-->
В соревнованиях могут принять участие ученики средних и средних специальных учебных заведений (первого и второго курсов) в возрасте до 18 лет включительно. Состав команды - 3 человека.	<b>15.04.2009 16:04</b>
Заявка для участия в Олимпиаде направляется от имени учебного заведения. Подать заявку можно на сайте <a href="http://cyber-net.spb.ru">http://cyber-net.spb.ru</a> в разделе «Регистрация команд». <b>Регистрация заканчивается 28 апреля 2009 года в 10:00 часов по московскому времени.</b>	С 15 апреля открыт доступ к системе ...-->
После регистрации команда получает по электронной почте пароль для входа в систему. Используя пароль, Вы можете ознакомиться с системой и потренироваться (с 15 апреля 2009 года).	<b>09.04.2009 13:04</b>
Принять участие в заочном туре олимпиады команда может в любой из дней в период с 14 часов по московскому времени 28 апреля 2009 года до 18 часов по московскому времени 30 апреля 2009 года. Дополнительная информация находится на странице «Правила проведения».	С 9 апреля 2009 года начинается регистрация ...-->
	<b>Архив новостей</b>
	<a href="#">Перейти к архиву новостей --&gt;</a>

# LEGO Mindstorms NXT – a new generation of Cyber Construction Set

LEGO Mindstorms NXT:

- ❖ extensible set of sensors and actuators (motors, lamps, loudspeakers)
- ❖ control from the PC and stand-alone control
- ❖ communication via infrared or Bluetooth to PC, video camera, smartphones, mobile phones



# LEGO Mindstorms NXT – a new generation of Cyber Construction Set

The Robot  
Brain -  
block NXT





1. Intelligent LEGO ® block  
NXT controlled by a computer  
- Robot's Brain

2. Touch sensors - allow the  
robot to react to the  
surrounding obstacles.

3. Sound sensor (microphone)  
- allows the robot to react to  
the sound level.

4. The ambient light sensor -  
allows you to respond to  
changes in lighting or color.

5. Ultrasonic sensor - enables  
to determine the distance to  
the object and respond to the  
motion.



# Programming Systems

## 1. NXT-G

Introduction course: <http://learning.9151394.ru/course/view.php?id=280#Constr1>

## 2. Robot C

## 3. Microsoft Robotics Studio

## 4. Robolab 2.9

## 5. Control with MATLAB:

- ECRobot (Monami Ltd, Japan)
- RWTH - Mindstorms NXT Toolbox (Aachen TU, Germany)





# A seminar of Theoretical Cybernetics Chair



Students, post graduate students and  
students  
of Physics and Mathematics Lyceum № 239

# And what is moving over there?

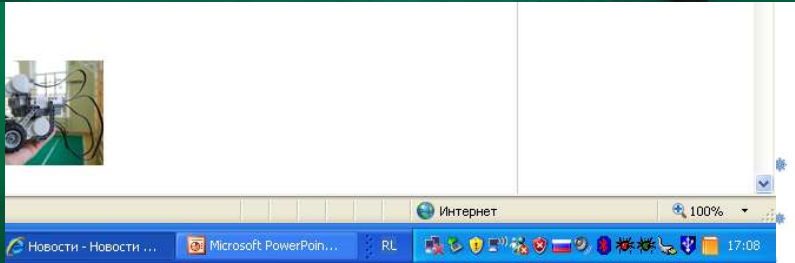
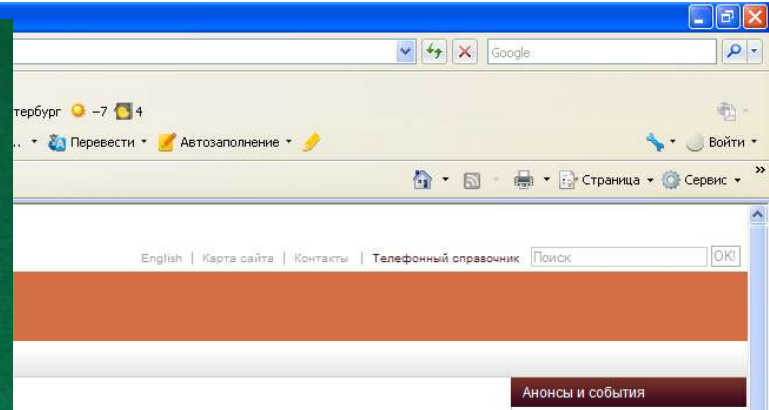
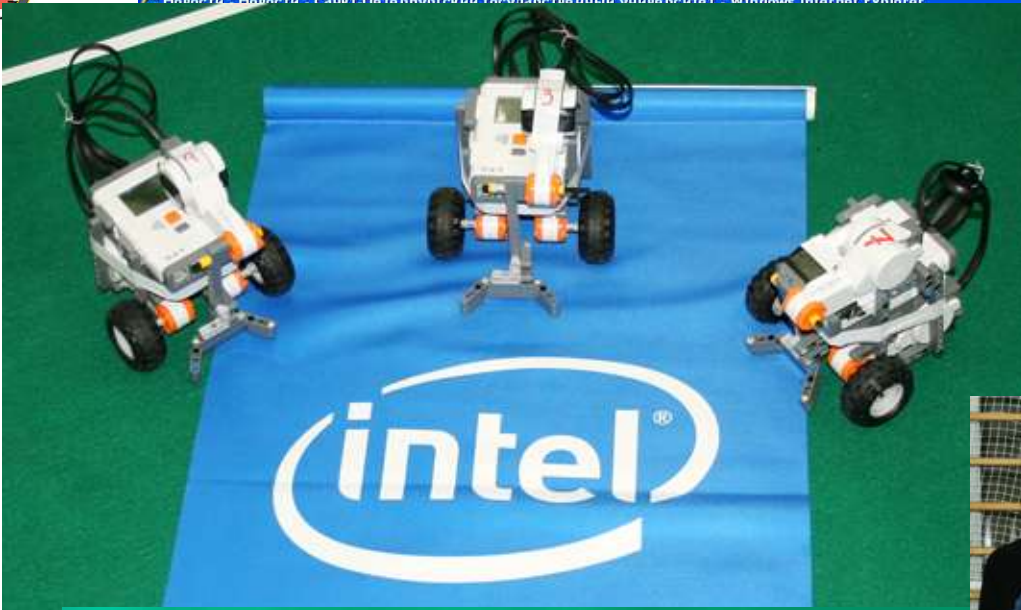




Schoolchids of 8-th class of PhML №  
239  
Olga и Anna Bogdanoff



# Robot soccer players of MMD



There are little TV-shows about us!



RF, 5-th channel

SPb, Piter TV

SPb, STO

RF, NTV

RF, RIA «News»

RF, ITAR TASS

# Robo Cup-2010 and Regional stage of Robotics 2011





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# Robo Cup-2010 and Regional stage of Robotics 2011

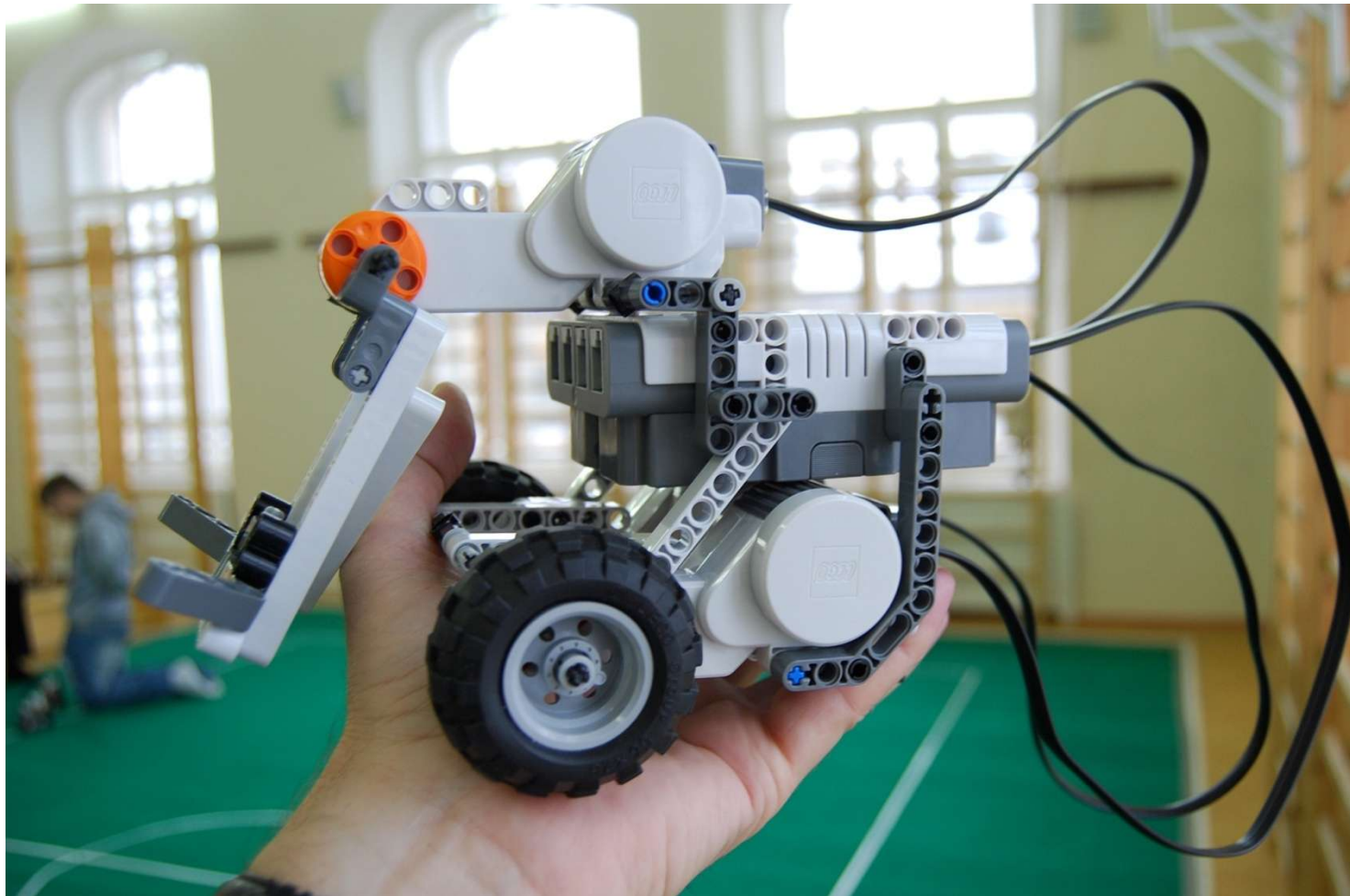




# Robo Cup-2010 and Regional stage of Robotics 2011



# Robo Cup-2010 and Regional stage of Robotics 2011



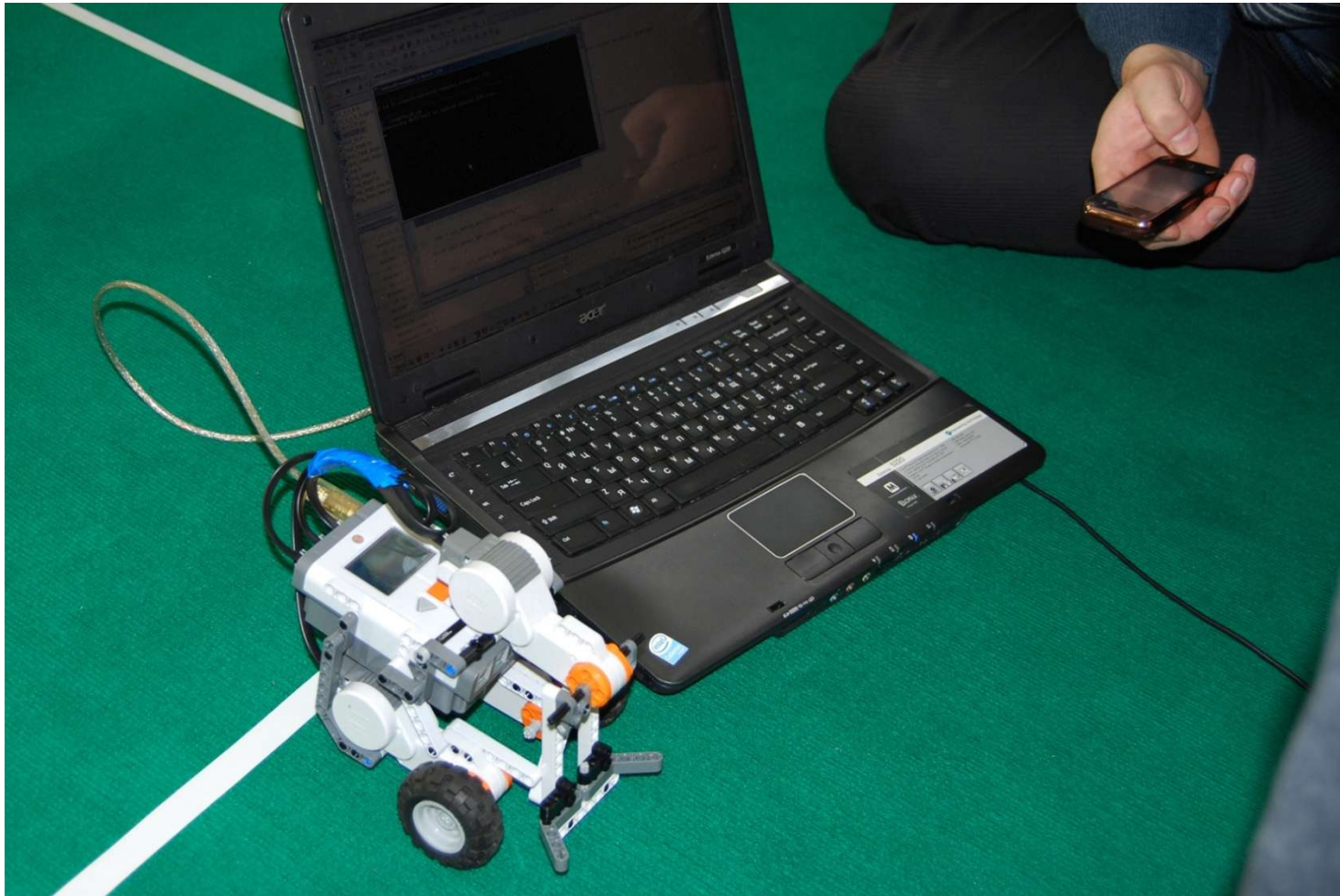


# Robo Cup-2010 and Regional stage of Robotics 2011





# Robo Cup-2010 and Regional stage of Robotics 2011

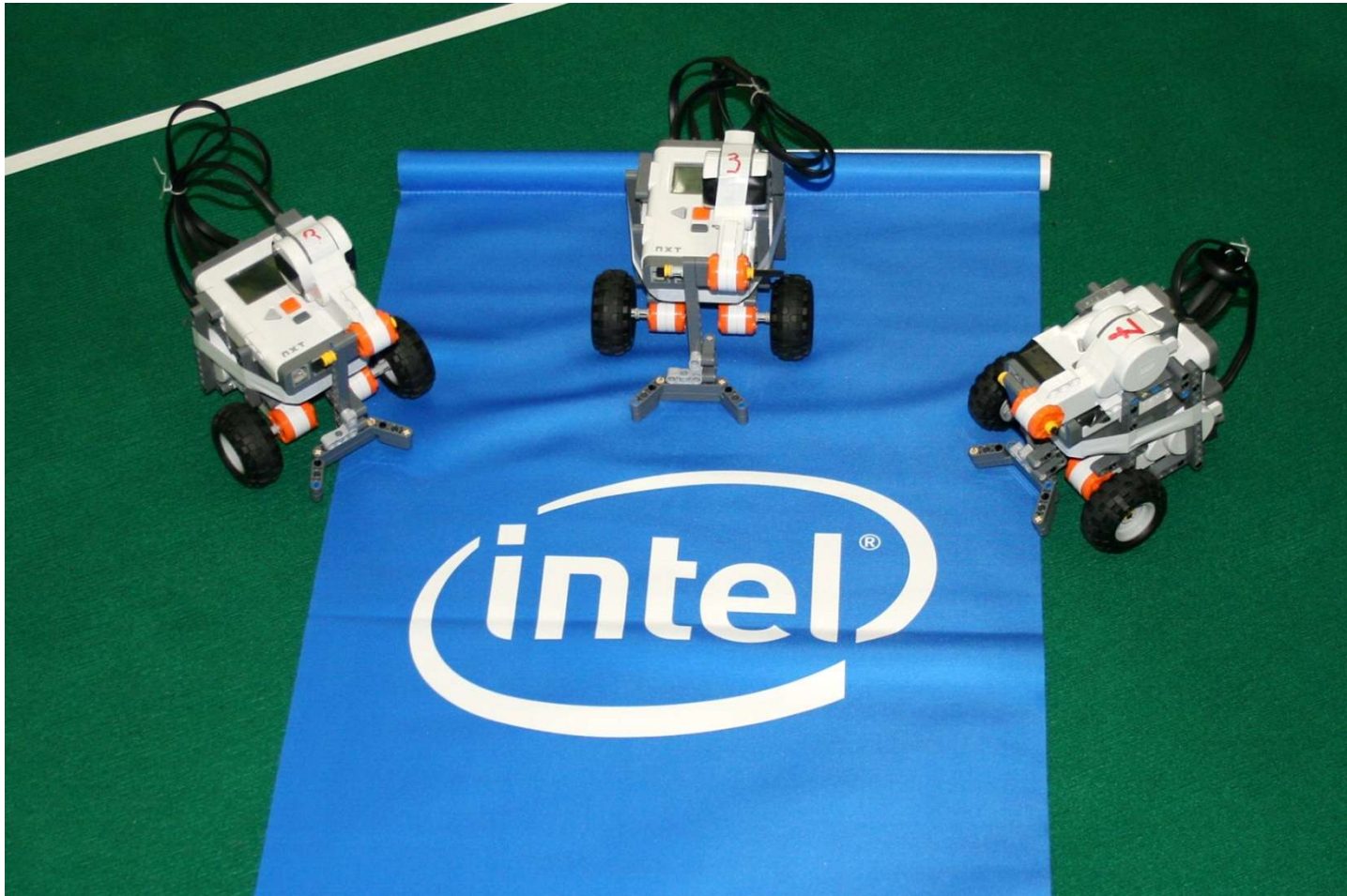


# Robo Cup-2010 and Regional stage of Robotics 2011





# Robot Cup-2010 and Regional stage of Robotics 2011



# The winners of the SPb Robot Soccer Cup - 2010





# The Awardees of Robo Cups



# Robot Soccer – what is it?

- Sport competitions
- Research tools
- Educational tools





# Robot Soccer – what is it?

International organizations:

- Robot Soccer World Cup (RoboCup )
- Federation of International Robot-soccer Association (**FIRA**)

Junior international organizations:

- First LEGO League (**FLL**)
- RoboCup Junior





# RoboCup - Robot Soccer World Cup

Four competitive sections consisting of several leagues

- Soccer
- Simulation
- Small Size
- Middle Size
- Standard Platform
- Humanoid
- Rescue Robot
- Rescue Simulation
- Junior Soccer
- Dance
- Rescue
- Common
- @Home





# And what we have in Russia?

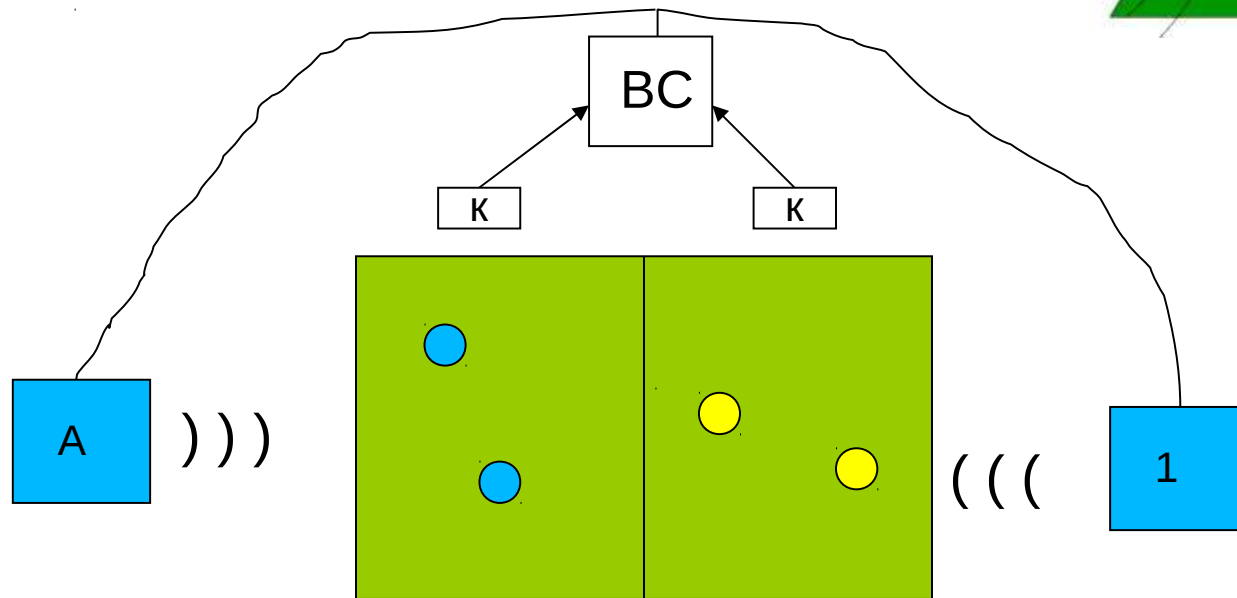
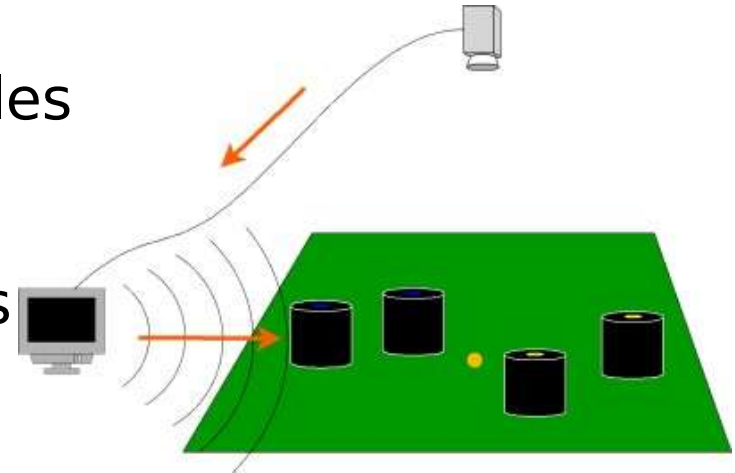
Two or three  
Universities  
bought the  
FIRA team

In 2004 a team from  
St-Petersburg  
Polytechnic  
University took 2-nd  
place in the league  
RoboCup Simulation



# Progress Directions

- Controlled robots soccer
- Soccer over RoboCup Junior Rules
- Semiautomatic Soccer
- Soccer over RoboCup SSL Rules






# SSL-Vision

SSL-Vision System, released as GPLv3, Windows version by Piyamate Wasuntapichaikul

**Variable** | **Value**

- Vision System
  - RoboCup SSL Multi-Cam
    - Global
      - Publish Geometry
      - Camera 0
        - Global
        - Image Capture
          - Capture Control
            - start capture: Start
            - stop capture: Stop
            - reset bus: Reset
            - auto refresh params:  True
            - re-read params: Refresh
            - Capture Module: Read from files
  - DC1394
    - Read from files
  - Generator
  - DVR Settings
    - YUV Calibrator
  - Camera Calibrator
  - Blob Finding
  - Robot Detection
  - Visualization
  - Camera 1
    - Global
    - Image Capture
      - Capture Control
        - start capture: Start
        - stop capture: Stop
        - reset bus: Reset
        - auto refresh params:  True
        - re-read params: Refresh
        - Capture Module: Read from files
  - DC1394
    - Read from files
  - Generator
  - DVR Settings
    - YUV Calibrator
  - Camera Calibrator

**Camera 0**



Capture: 26.19 fps | Display: 24.74 fps | 50.34 its/s

**Calibration Steps:**

- Do initial calibration
- Detect additional calibration points
- Do full calibration
- Reset

**Calibration Parameters:**

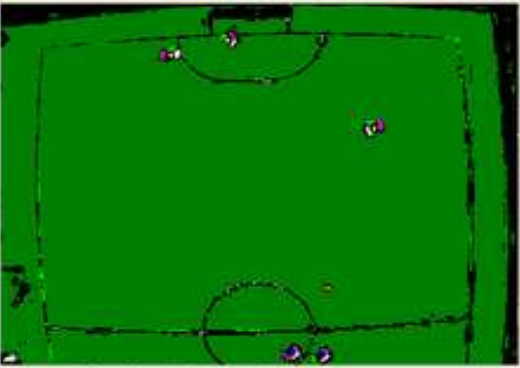
Line Search Corridor Width (in mm): 124

**Initial Camera Parameters:**

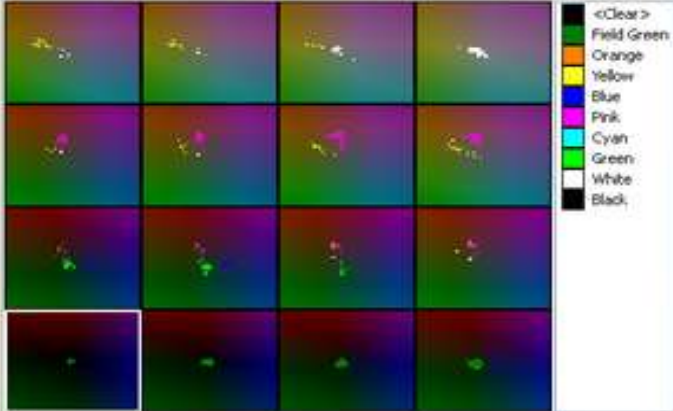
Camera Height (in mm): 3500

Distortion: 0.16

**Camera 1**



Capture: 7.42 fps | Display: 8.54 fps | 40.60 its/s



- <Clear>
- Field Green
- Orange
- Yellow
- Blue
- Pink
- Cyan
- Green
- White
- Black



# Science Objectives

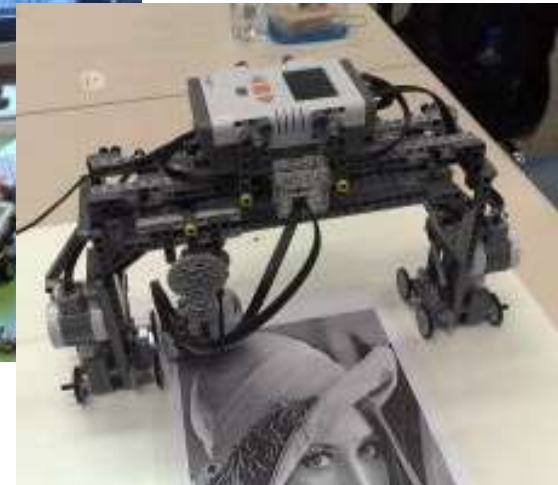
- Identification of the gaming locations
- Zoning
- Command transfer to executing objects
- Collision avoidance
- Holding up to the point
- Lead to the position
- Situation "Pass / Shock"

# The use of the LEGO cyber building blocks in Education



LEGO Laboratory  
Technical University in Aachen,  
Germany

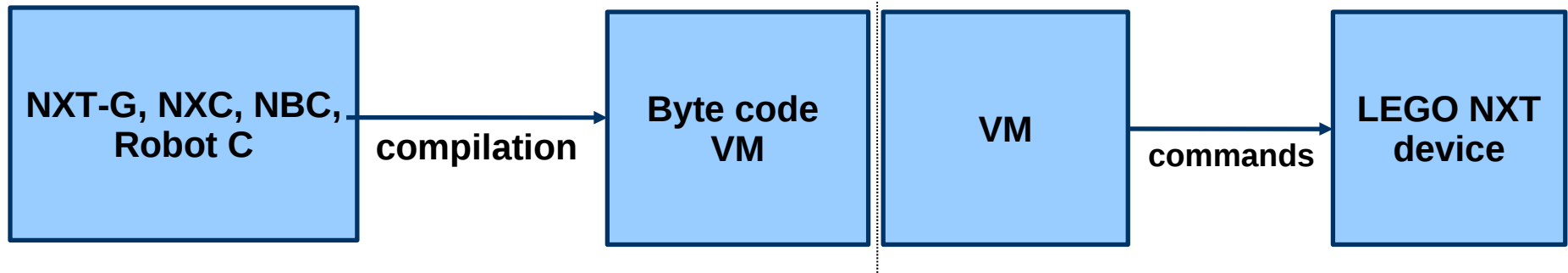
<http://www.mindstorms.rwth-aachen.de/>







# Strategies of operation with VM



Plus :

- + universality
- + availability of drivers
- + autonomy

Minus:

- productivity loss
- RAM is a busy
- ROM is a busy

Alternative: contact with the commands directly?

Do not use a virtual machine!

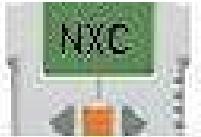


# LEGO NXT Software

- NXT-G



- NXC



- NBC



- RobotC



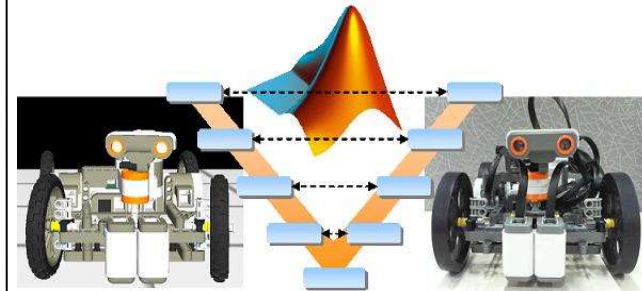
- Lejos



- RWTH  
MatLab  
Toolbox



## ECRobot



## nxtOSEK

**nxtOSEK/JSP**

ANSI C/C++ with OSEK/ $\mu$ ITRON RTOS

# Stages of embedded systems programming



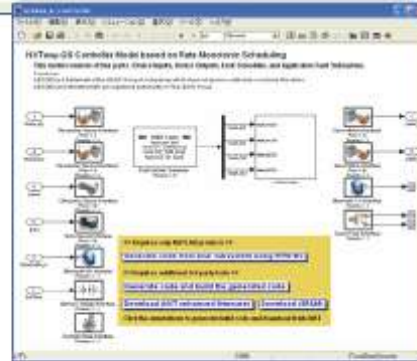
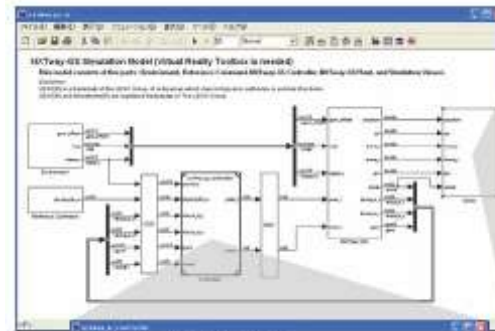
## Benefits of MOP:

- early detection of control system errors
- relieving the burden to the installation
- performance testing by imitation modelling
- it is easier to improve the modules when we verify control system
- it is easier to optimize the interaction between modules
- code autogeneration leads to saving of time

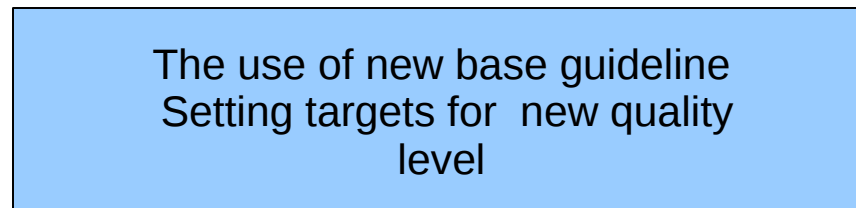
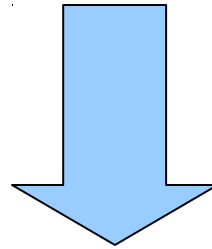
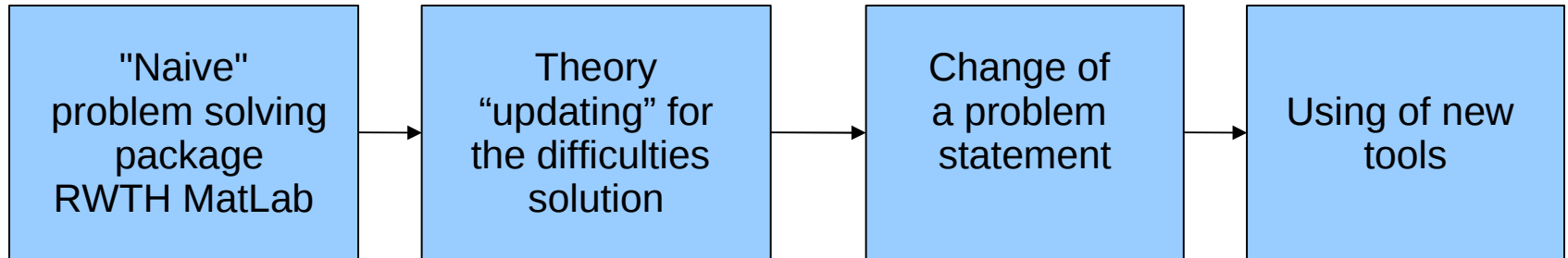


# Industrial use of MOP

Embedded Success **dSPACE**



# Training model





# Graphical instrument QReal

GI QReal is developed as a scientific research project on object-oriented modeling

GI has a wide application using the platforms and programming languages:

- ❖ UML 2.2
- ❖ Hardware description language
- ❖ Programming language for the Android and MeeGo platforms
- ❖ Parallel program description language for OpenMP







# Graphical instrument QReal

- ❖ Quickly creating and modifying of visual programming languages
- ❖ Technology for industrial projects
- ❖ Friendly user interface
  - ❖ - mouse gestures
  - ❖ - visual debugger
- ❖ Integration with version control systems





# Graphical instrument QReal

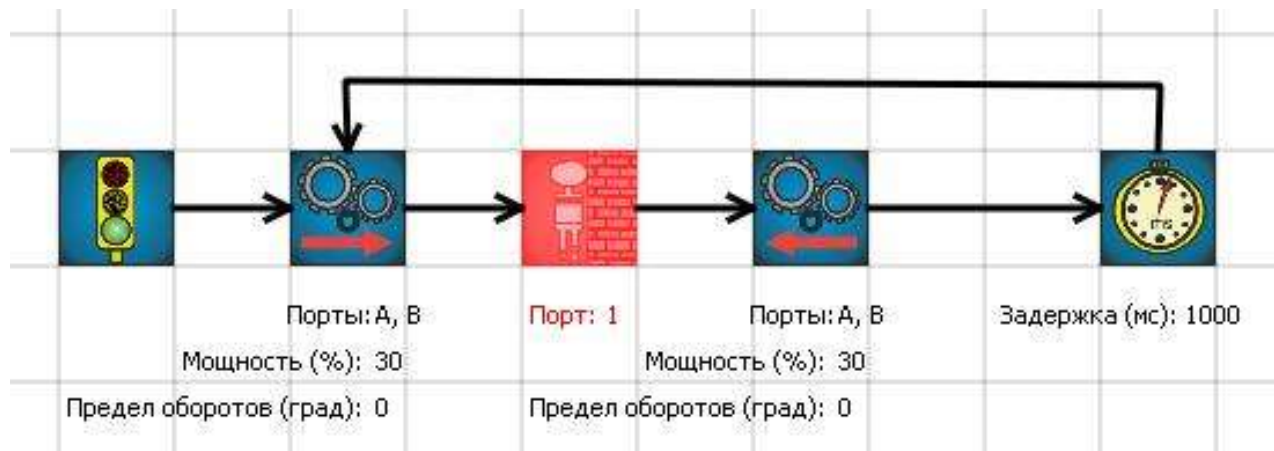
- ❖ Runs under Windows ®, GNU Linux, Mac OS X
- ❖ Distributed as Open Source under GNU GPL
- ❖ Has a Russian language user interface
- ❖ Supports the standard firmware NXT, works with OS Embox



# Graphical instrument Qreal for robots programming

## Qreal Robots – base facilities:

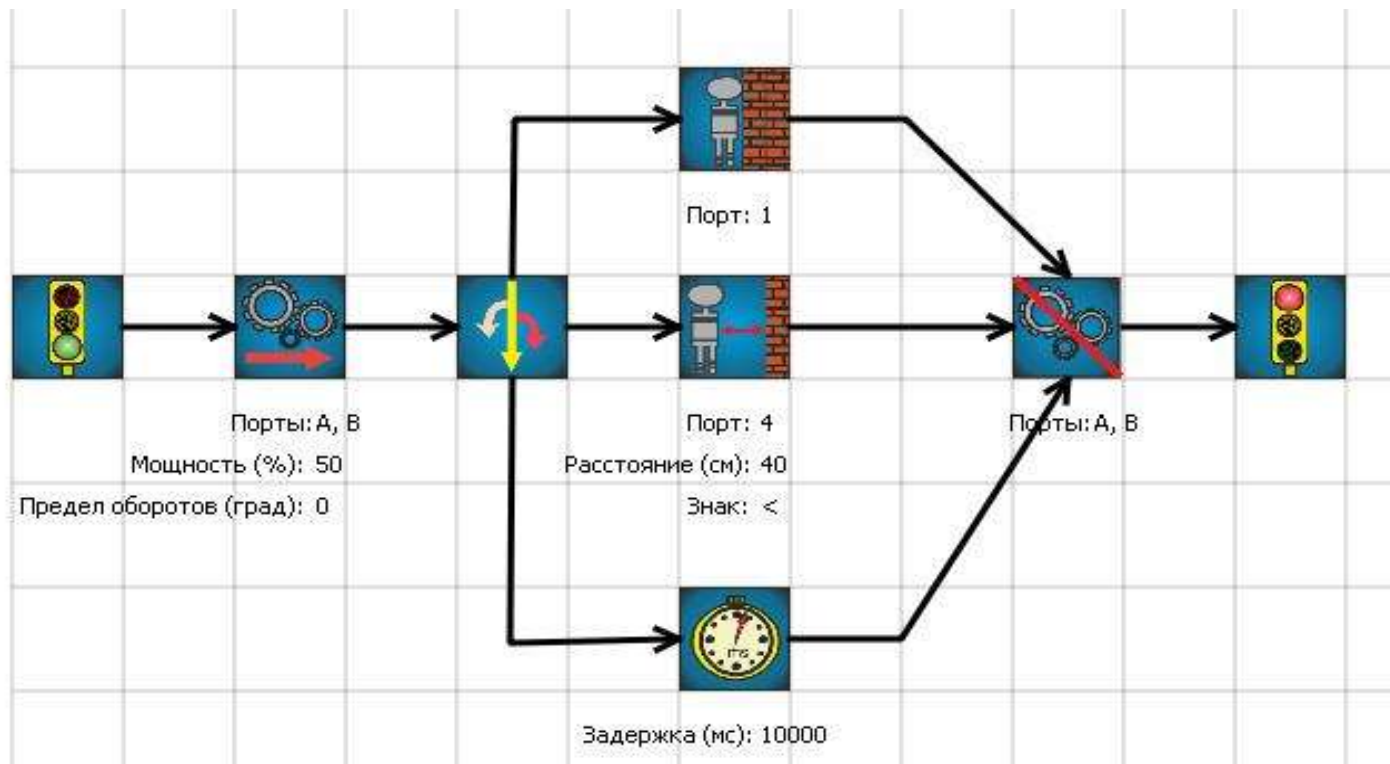
- ❖ Controlling of the Lego Robot ® Mindstorms ® NXT 2.0
- ❖ Work on the Bluetooth ® with the mapping of the program implementation
- ❖ The program is a set of blocks relating to control flow





# Supported units

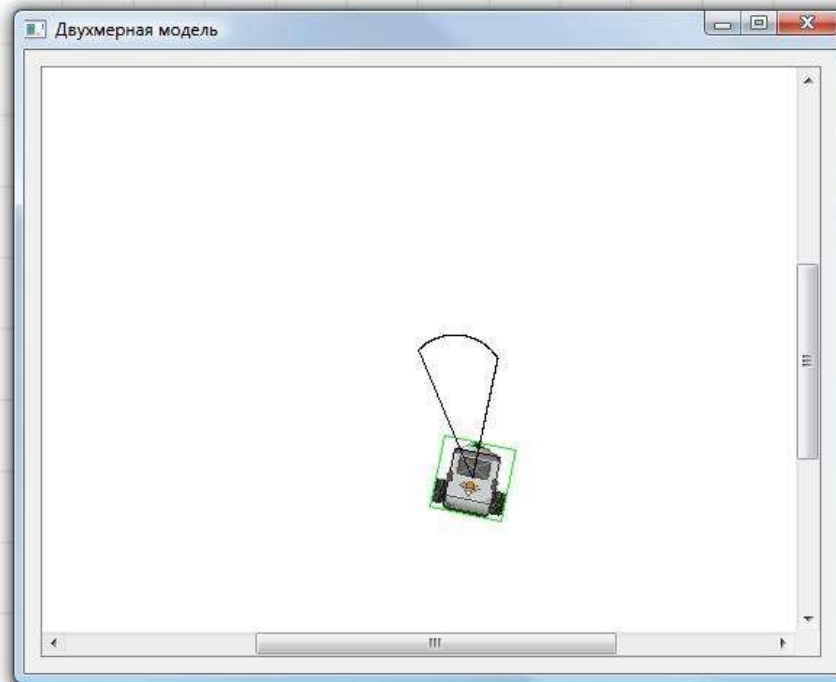
- ❖ Three types of sensors from the set of NXT 2.0
- ❖ Motors and speakers control
- ❖ Branching, loops, parallel execution



# Mathematical expressions



# Model of the robot on the screen



# What's next in future?

As a part of the SPRINT Laboratory activities:  
2011 - 2013 years.

1. Participation in "Atomosfera" competition
2. Implementation of semi-automatic control of multi-agent network of mobile devices (wheel robots)
3. Transferring robot control system to the MeeGo platform (Tablet PC)



робофутбол.рф



# What's next in future?

4. Development of works on the Video Vision
5. Design of the controller and visual programming instrument QReal implementation
6. Training of Mathematics and Mechanics Department Team (St. Petersburg State University) to participate in International RoboCup Competitions





# What's next in future?



# Instead of the conclusion!

