Robotics DSIG Final Agenda ver.1.02 (robotics/2005-09-01)

OMG TC Meeting - Atlanta, GA, USA -- September 12-16 , 2005

		TF/SIG				
		Host	**Joint (Invited)**	**Agenda Item**	**Purpose**	**Room**
Monday (Sept. 12)						
9:30	10:30	MARS	Robotics, RTESS, SDO	MARS Pleanary (Robotics Technology Components RFP)	RFP Review and voting?	**Georgia 11**, Level 1
12:00	13:00	**LUNCH**				
13:00	18:00			Architecture Board Plenary		**Georgia 6**, Level 1
Tuesday (Sept. 13) SDO Plenary (PM)						
9:00	11:00	SDO	(Robotics)	RFP drafting WG	hammer out RFP	**Georgia 7**, Level 1
11:00	12:00	SBC	Robotics, SDO	SBC Pleanary (Robotics Technology Components RFP)	RFP discussion	**Georgia 3**, Level 1
12:00	13:00	**LUNCH**				
13:00	13:20	SDO	(Robotics)	Welcome and Review Agenda	Meeting Kick-off	**Georgia 7**, Level 1
13:20	14:45	SDO	(Robotics)	Review for Robotics Techinology Components RFP (part 1)	RFP review	
				Break		
15:15	16:30	SDO	(Robotics)	Review for Robotics Techinology Components RFP (part 2)	RFP review	
16:30	17:00	SDO	(Robotics)	Voting RFP recommendation Next Meeting Agenda Discussion, etc	SDO Closing session	
17:00				Adjourn		
Wednesday (Sept. 14) Robotics Plenary						
9:00	9:20	Robotics	(SDO)	Welcome and Review Agenda	Meeting Kick-off	**Georgia 8**, Level 1
9:20	9:50	Robotics	(SDO)	"Implementing and Teaching Emerging Robotics Standards at the University Level" - Bruce Boyes (Systronix)	Technology Exchanges	
9:50	10:20	Robotics	(SDO)	"Common Robot Interface Framework for Device Abstraction" - Seung-Ik Lee (ETRI)	Technology Exchanges	
				Break		
10:40	11:10	Robotics	(SDO)	"Standards in Action: Prototype Robots at Aichi International Exposition 2005" - Masayoshi Yokomachi (NEDO)	Technology Exchanges	
11:10	12:00	Robotics	(SDO)	*<Special Talk>* "Machine vision and actuators for robotics and automation" - Kok-Meng Lee (Georgia Institute of Technology)	Informative	
12:00	14:00	**LUNCH and OMG Plenary**				
14:00	14:50	Robotics	(SDO)	"Slashing development time with component-based programming" - Hung Pham (RTI)	Technology Exchanges	**Georgia 8**, Level 1
14:50	15:20	Robotics	(SDO)	"Korean intelligent robot standardization status" - Yun Koo Chung (ETRI)	Technology Exchanges	
				Break		
15:40	16:10	Robotics	(SDO)	"Introduction to Toshiba Home Robots and Our Approach to RT Standardization" - Fumio Ozaki (Toshiba)	Technology Exchanges	
16:10	16:40	Robotics	(SDO)	Robotic Systems RFI (mars/2005-06-12) promotion		
16:40	17:00	Robotics	(SDO)	Next Meeting Agenda Discussion, etc	Robotics Closing	
17:00				Adjourn		
18:00	20:00	**OMG Reception**				
Thursday						
9:00	9:30	MARS	Robotics, RTESS, SDO	MARS Pleanary (Robotics Technology Components RFP)	RFP final review and voting	**Georgia 11**, Level 1
12:00	13:00	**LUNCH**				
13:00	18:00			Architecture Board Plenary	RFP final review	**Georgia 6**, Level 1
Friday						
8:30	12:00			AB, DTC, PTC	RFP voting?	Capitol North, Level
12:00	13:00	**LUNCH**				
Other Meetings of Interest						
Monday						
8:00	8:45	OMG		New Attendee Orientation		
9:00	12:00	OMG		Tutorial - Introduction to UML 2.0		
13:00	17:00	OMG		Tutorial - Introduction to the Data Distribution Service		
18:00	19:00	OMG		New Attendee Reception (by invitation only)		
Tuesday						
9:00	12:00	OMG		Tutorial - Introduction to the Knowledge Discovery Metamodel		
13:00	17:00	OMG		Tutorial - Introduction to OMG's Modeling and Middleware		
Wednesday						
9:00	12:00	OMG		Leveragingg IT Standards for Regulatory Compliance		
Thursday						

Robotics-DSIG Meeting Minutes – Boston, MA, USA (robotics/2005-09-02)

Overview and votes

We completed the Robotic Systems RFI and voted to issue the RFI. It was approved to issue in PTC sponsored by MARS.

OMG Documents Generated

robotics/2005-06-01	Final Agenda (Tetsuo Kotoku)
robotics/2005-06-02	Opening Presentation (Tetsuo Kotoku)
robotics/2005-06-03	SDO-DSIG and Robotics-DSIG Roadmap (Tetsuo Kotoku)
robotics/2005-06-04	Presentation: “Special Talk: Introduction to JAUS” (Jeff Kotora)
robotics/2005-06-05	Presentation: “Robotics Needs of the Oilfield Industry” (Mike Barret and Claude Baudoin)
robotics/2005-06-06	Revised RFI draft (Olivier Lemaire)
robotics/2005-06-07	Comments from AB buddy (Tetsuo Kotoku)
robotics/2005-06-08	Presentation: “Toward a Reference Model for Robotic Standards” (Hui Min Huang)
robotics/2005-06-09	Presentation: “Middleware Technology for Robotics: Robot Software Communications Architecture (RSCA)” (Jaesoo Lee)
robotics/2005-06-10	Robotic Systems RFI [mars/2005-06-12] (Olivier Lemaire)
robotics/2005-06-11	DTC Plenary presentation (Tetsuo Kotoku)
robotics/2005-06-12	Draft Meeting Minutes (Tetsuo Kotoku)

Agenda

09:00-09:15 Welcome and Review robotics Agenda
09:15-10:15 Special Talk: “Introduction to JAUS” (Jeff Kotora, JAUS Chair)
10:30-11:10 “Robotics Needs of the Oilfield Industry” (Claude Baudoin, Schlumberger)
11:10-12:00 RFI discussion (part 1): Robotic Systems RFI (Olivier Lemaire, JARA)
14:00-15:00 RFI discussion (part 2): Robotic Systems RFI (Olivier Lemaire, JARA)
15:30-16:00 “Toward a Reference Model for Robotics Standards” (Hui Min Huang, NIST)
16:00-16:30 “Middleware Technology for Robotics: Robot Software Communications Architecture” (Jaesoo Lee, Seoul National Univ.)
16:45-17:00 Next meeting agenda discussion

Minutes

22 June, Wednesday

Tetsuo KOTOKU, presiding co-chair

Meeting Week – Kick-off

- Meeting was called to order at 9:00
- Tetsuo Kotoku provided a brief guidance about Robotics-DSIG.
  - ✓ robotics/2005-06-02 Opening presentation
- Tetsuo Kotoku presented the Draft Roadmap.
  - ✓ robotics/2005-06-03 Roadmap for Robotics Activities

Special Talk “Introduction to JAUS”

- Jeff Kotora (Dept. of Defense / TITAN), JAUS Chair, introduced us the activity of JAUS.
  - ✓ robotics/2005-06-04 “Special Talk: Introduction to JAUS”

Presentation: “Robotics Needs of the Oilfield Industry”

- Claude Baudoin (Schlumberger) presented current status of robotics technology in the Oilfield Industry.
  - ✓ robotics/2005-06-05 “Robotics Needs of the Oilfield Industry”

RFI discussion “Robotic Systems RFI”

- Olivier Lemaire (JARA) presented the revised RFI draft.

- There were some changes in the technical wording.
  - ✓ robotics/2005-06-06 Revised RFI draft
  - ✓ robotics/2005-06-07 Comments from AB buddy
- ***Action:*** The motion of recommendation to issue “Robotic Systems RFI” allowing minor amendments in MARS

Presentation: “Toward a Reference Model for Robotics Standards”

- Hui Min Huang (NIST) presented the brief review of Generic Framework for robot architecture and made points about the importance of performance metrics and standards.
  - ✓ robotics/2005-06-08 “Toward a Reference Model for Robotics Standards”

Presentation: “Middleware Technology for Robotics: Robot Software Communications Architecture”

- Jaesoo Lee (Seoul National Univ.) presented Korea’s national project, Ubiquitous Robotic Companion. About 20 million dollars a year is funded by the government.
  - ✓ robotics/2005-06-09 “Middleware Technology for Robotics: Robot Software Communications Architecture (RSCA)”

Meeting Wrap-up, Plan for Atlanta

- There is a small discussion about the organization of our Robotics-DSIG.
- Tetsuo Kotoku proposed that we should ask for volunteers as liaisons between the related organizations for active information exchanges.
- There were some volunteers as below;
  - JAUS: Hui Min Huang
  - ORiN: Makoto Mizukawa
  - URC: YunKoo Chung
  - RTmiddleware: Tetsuo Kotoku
- Tetsuo Kotoku presented the draft Agenda for the next meeting.
- Robotics Plenary meeting will be held on Wednesday in Boston.
  - ✓ robotics/2005-06-02 Opening presentation
- ***Action:*** Keep up finding liaisons between related organizations.

ADJOURNED @ 17:00 pm

Participants (Sign-in)

- Yun Koo Chung (ETRI)
- Tom Hein (Deere)
- Takashi Suehiro (AIST)
- Masayoshi Yokomachi (NEDO)
- Stephanie (OMG)
- Dana Morris (OMG)
- Duane Clarkson (Deere)
- Hideo Shindo (NEDO)
- Brad Kizzort (Harris)
- Hui-Ming Huang (NIST)
- Jeff Kotora (Dept. of Defense / TITAN)
- Olivier Lemaire (JARA)
- Claude Baudoin (Schlumberger)
- Jaesoo Lee (Seoul Natioanl Univ.)
- Back Michael (Seoul National Univ.)
- Hung Pham (RTI)
- Makkoto Mizukawa (Shibaura Institute of Technology)
- Gerardo Pardo (RTI)
- Hiroki Kamata (OTI / OMG)
- Joe Jacob (Objective Interface)
- Tetsuo Kotoku (AIST)

Prepared and submitted by Tetsuo Kotoku

Robotics DSIG
Plenary Meeting

September 14, 2005

Atlanta, GA, USA

Sheraton Atlanta Hotel
Georgia 8, Level 1

Approval of Boston Minutes

- Ask for a volunteer (minutes taker)
  - Fumio Ozaki (morning)
  - Olivier Lemaire (afternoon)
- Boston Minutes review
  - We completed the Robotic Systems RFI and voted to issue the RFI. It was approved to issue in PTC sponsored by MARS.

Review Agenda

Wednesday, Sept. 14, 2005

SDO DSIG
Tue, Sept. 13, 2005
13:00 – 17:00

09:00-09:20 Welcome and Review Agenda

09:20-09:50 "Implementing and Teaching Emerging Robotics Standards at the University Level"- Bruce Boyes (Systronix)

09:50-10:20 "Common Robot Interface Framework for Device Abstraction" - Seung-Ik Lee (ETRI)

<break>

10:40-11:10 "Standards in Action: Prototype Robots at Aichi International Exposition 2005 " - Masayoshi Yokomachi (NEDO)

11:10-12:00 Special Talk:"Machine vision and actuators for robotics and automation " - Kok-Meng Lee (Georgia Institute of Technology)

<lunch>

14:00-14:50 "Slashing development time with component-based programming " - Hung Pham (RTI)

14:50-15:20 "Korean intelligent robot standardization status" - Yun Koo Chung (ETRI)

<break>

15:40-16:10 "Introduction to Toshiba Home Robots and Our Approach to RT Standardization"- Fumio Ozaki (Toshiba)

16:10-16:40 Robotic Systems RFI promotion

16:40-17:00 Next Meeting Agenda Discussion,

17:00 Adjourn

Joint Meeting with MARS/RTESS
Thursday, Sept.15, 2005
09:00-16:30 (Georgia)

Document Number

robotics/2005-09-01 Final Agenda
robotics/2005-09-02 Boston Meeting Minutes [approved]
robotics/2005-09-03 Opening presentation
robotics/2005-09-04 Robotics-DSIG Roadmap
robotics/2005-09-05 **Bruce Boyes** presentation
robotics/2005-09-06 **Seung-Ik Lee** presentation
robotics/2005-09-07 **Masayoshi Yokomachi** presentation
robotics/2005-09-08 **Kok-Meng Lee** presentation
robotics/2005-09-09 **Hung Pham** presentation
robotics/2005-09-10 **Yun Koo Chung** presentation
robotics/2005-09-11 **Fumio Ozaki** presentation
robotics/2005-09-12 DTC Report Presentation
robotics/2005-09-13 Meeting Minutes – Draft

http://robotics.omg.org/robotics_info.htm#documents

Organization

- Steering Committee
  the day before plenary (open meeting)
  next meeting agenda adjustment
  SIG co-chairs and candidates, WG co-chairs, etc.
- Co-chairs election
  at the next Burlingame meeting
  three co-chairs from different countries
  regular attendance is requested
- mediator between related organizations
  call for volunteers
  one page PowerPoint presentation

We needs volunteers

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mediator between the related organizations

Call for volunteers

One page PowerPoint presentation

post it robotics@omg.org 3weeks before the meeting

Two-minute presentation at the meeting

- **JAUS**: Hui-Ming Huang (NIST)
- **ORiN**: Makoto Mizukawa (Shibaura Institute of Technology)
- RTmiddleware: Tetsuo Kotoku (AIST)
- KRISF: Yun Koo Chung (ETRI)

FYI:

OMG official liaisons will have a privilege of OMG resource access.
Contact to the Liaisons Sub Committee, please.

Next Meeting Agenda

December 5-9, 2005 (Burlingame, CA, USA)

Monday :

Steering Committee [Dec.5]

Tuesday :

Robotics-DSIG Plenary Meeting [Dec.6]

- RFP promotion (SDO-DSIG joint meeting)
- RFI response presentation
- guest & participants presentation
- mediator reports
- co-chairs election

Roadmap for Robotics Activities

robotics/05-09-04 & sdo/05-09-04

Item	Status	Boston Jun-2005	Atlanta Sep-2005	Burlingame Nov-2005	Tampa Feb-2006	St. Louis Apr-2006	Boston Jun-2006	POC / Comment
Charter on Robotics WG in SDO	done							Kotoku(AIST), Mizukawa(Shibaura-IT)
Robot Technology Components (SDO model for robotics domain)	Planned	draft RFP	RFP		Initial Submittion		Revised Submittion	Suehiro(AIST), Sameshima(Hitachi), Kotoku(AIST)
SDO model for xxx Domain	no plan				discussion	draft RFP	RFP	TBD
Charter on Robotics SIG	done							Kotoku(AIST), Mizukawa(Shibaura-IT)
Robotics Information Day [Technology Showcase]	done							Yokomachi(NEDO), Kotoku(AIST)
Robotics: Initial Survey [Clarification of Target Item]	Planned	RFI		RFI due Presentation	Presentation	review RFI response	review RFI response	Lemaire, Chung, Lee, Mizukawa, Kotoku
								,
(Robot Middleware for Controller)	Future		Official Start of WG	discussion	draft RFP	RFP		to be discussed
(Robot Middleware for Specific Applications)	Future							to be discussed
(Robot Middleware Common Services)	Future							to be discussed
(Robot Middleware for Common Data Structures)	Future							to be discussed
etc…	Future							to be discussed

Implementing and Teaching Current- Technology Robotics at the University Level

OMG Robotics DSIG – Atlanta 2005

Autonomous Java™ Robots in University of Utah CE/CS Senior Projects ...and how that led to OMG Atlanta

Bruce Boyes

University of Utah
and Systronix Inc
www.jcx.systronix.com

JCX at the University of Utah

A new hardware and software paradigm for teaching at the University level

Using real-time, native-execution Java and the JCX system architecture in the CE/CS 4710 Senior Project class...

... and how robotics standards could improve such efforts.

CE4710 Class Overview

Past History

- Required of all senior CE students
- Approx eight teams of two to four students
- Prior to 2001 was using 68HC11 Handyboards
- C and assembly
- Most could not complete in one semester
- No machine shop facilities

Big changes

New paradigm in 2001 – 2002 - 2003

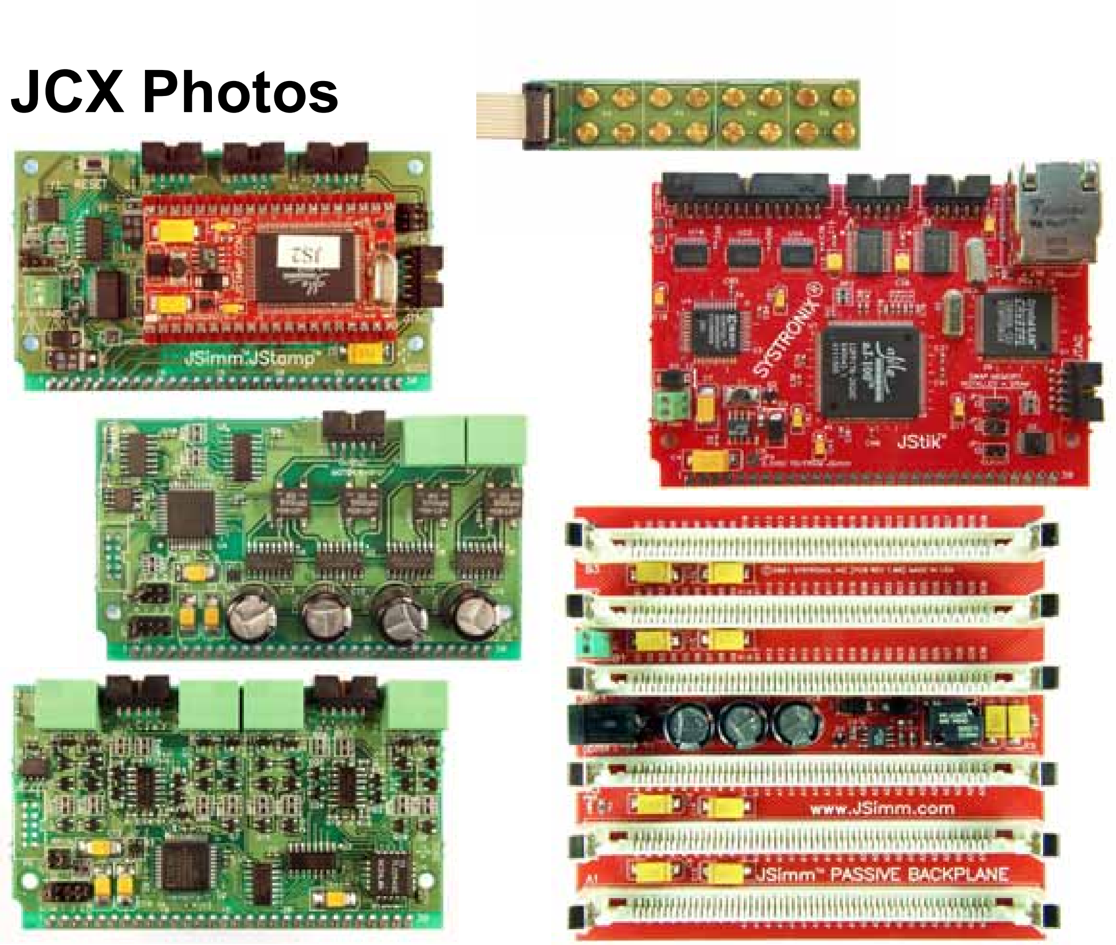
- Embedded Java
- “JCX” hardware architecture
- Lego Technics for mechanics
- Ant for project builds
- You *will* complete in one semester

JCX

System Hardware

- Controller
- Six-slot backplane
- Quad motor driver
- Octal sensor inputs
- RF Modem
- Prototyping board

JCX Photos



I/O Devices Used in 4710

Lego and others

- Sensors
  - Lego touch, light, rotation
  - CMUcam color vision with primitives
  - Sonar modules SRF04
- Motors
  - Lego DC motors with PWM control in JCX
  - R/C servo motors
  - Heavy duty gearhead motors
- UI - Amulet ¼ VGA with touchscreen
- RFModem prototypes

JCX

Architecture - Signals

- SPI is the main expansion interface
- Asynch serial
- 1-Wire
- I2C
- HSIO on JStik
- Ethernet

JCX

Architecture – Why Tagging

- One code base on heterogeneous robots
- Multiple instances of same hardware board
- Auto configuration
- Enumeration (discovery)
- Label use of I/O
- Runtime class binding
- Versioning information

JCX

Architecture – What is a Tag?

- Physical eeprom in SPI address space
- XML data format
- Sacred and user spaces
- Generally a *device*, not a *board* perspective
- Helps debug configuration

Two phases

Get a toolkit - then apply it

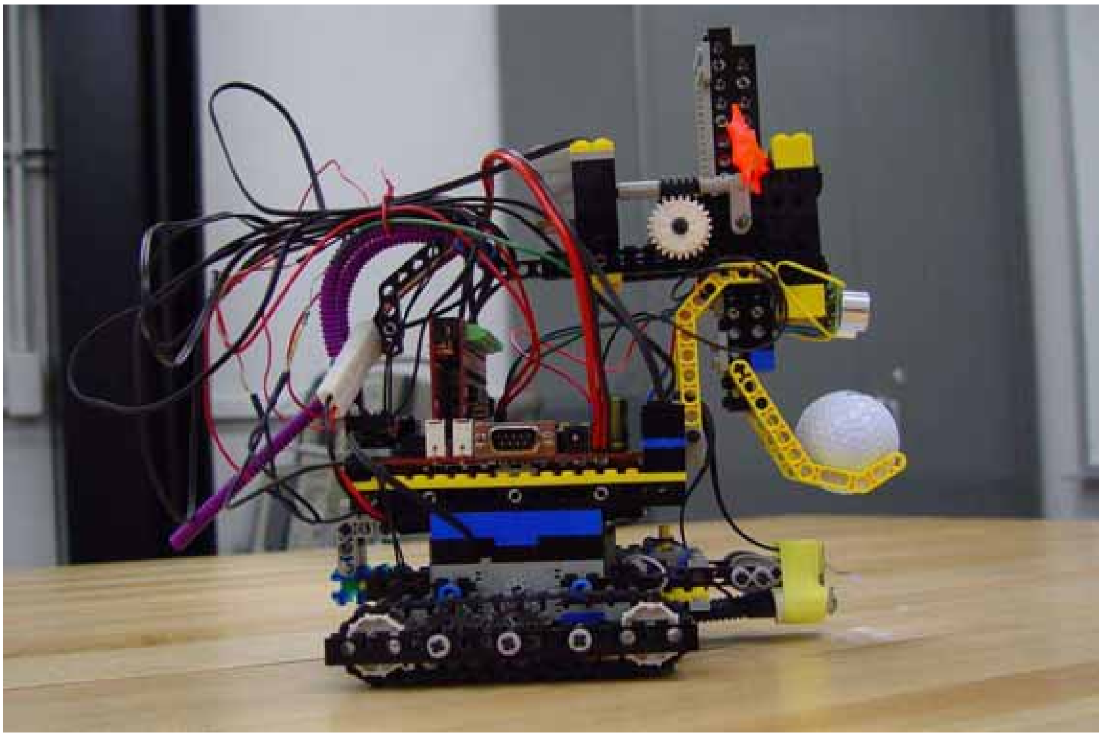
- Lecture phase
  - Incremental assignments
  - Plan project as a team
  - 7 weeks
- Project phase
  - Weekly status meetings
  - Final presentation
  - Six weeks

Special Topics

Approach to rapid development

- Top down spec
  - Functional partition
  - Simple state diagrams & flowcharts
- Use efficient tools
  - Java, eclipse, Ant, javadoc, team website, email
- XP Techniques
  - Team programming
  - Documentation first! Use of javadoc
  - Start simple, iterate, test, save versions as you go
- Frequent reviews
  - Weekly team/prof/TA meetings, part of grade

Using JCX (videos)



What were the hard bits?

Some landmines/speed bumps

- First order reasonableness test
- Task partitioning & team coordination
- Documentation & communication
- Threading tough to grasp, esp PT
- Debugging
- Writing simple, robust serial comm protocols

Outcomes

Successes, changes, reversion

- Lego mechanical bits for fast prototyping
- Java
- Teamwork and cross-team code sharing
- No incompletes three years in a row
- Real projects are hard
- Basic engineering principles still count
- One semester may not be enough
- This class is not currently using Java robotics (but lots of others are)

What does this have to do with OMG?

- What can help get us out of the programming Stone Age? Modern tools & architectures?
- Good standards are good for everyone
- Discovery is essential
- Much of robotics is realtime
- Robotics is really just embedded control

Java and community

- java.net robotics (and other) communities
- Java is the best and most obvious choice for a reference implementation language
- Existing standards & communities can help
- Universities are ready to embrace Java and robotics
- Systronix and JCX are already moving, after four years of development.

Where will this (hopefully) lead?

- Universal robot simulator
- Portable and self-scaling algorithms
- Better educational systems
- Collaborative, wireless, realtime systems
- Smart sensor nets and industrial controls
- Practical robot swarms, n>1000

For More Information

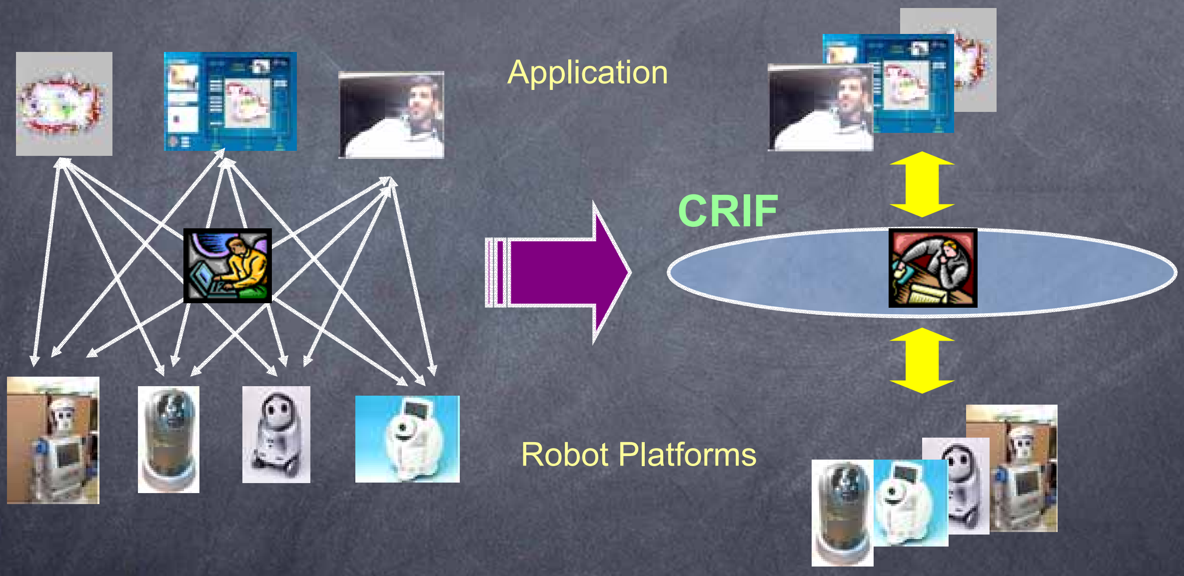
- Technologies
  - http://www.jcx.systronix.com
  - http://www.cs.utah.edu/classes/cs4710/
  - http://www.amulettechnologies.com/
  - http://www.java.sun.com
- Techniques
  - *Debugging: The Nine Indispensable Rules for Finding Even the Most Elusive Software and Hardware Problems,* David J. Agans, 2002
  - *The Java Language Specification,* http://java.sun.com/docs/books/jls/second_edition/html/j.title.doc.html
  - http://www.practicalembeddedjava.com/

Common Robot Interface Framework for Device Abstraction Layer

Sep. 14, 2005
Seung-Ik Lee

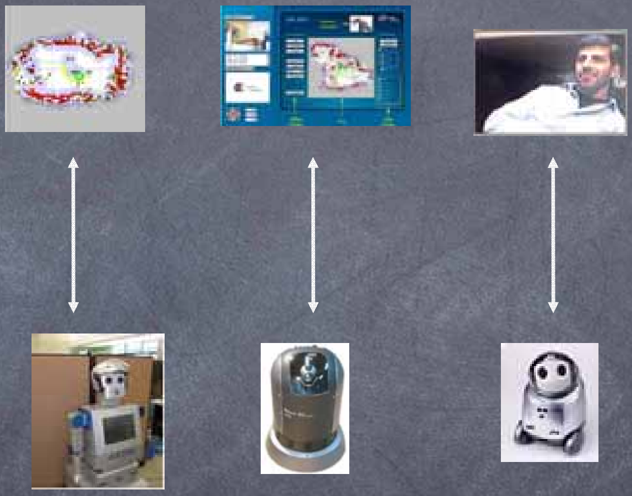
ETRI

CRIF is a Device Abstraction Layer for various robot platforms



CRIF is a very basic standardized API set
to control robots and acquire information from robots

Current Status

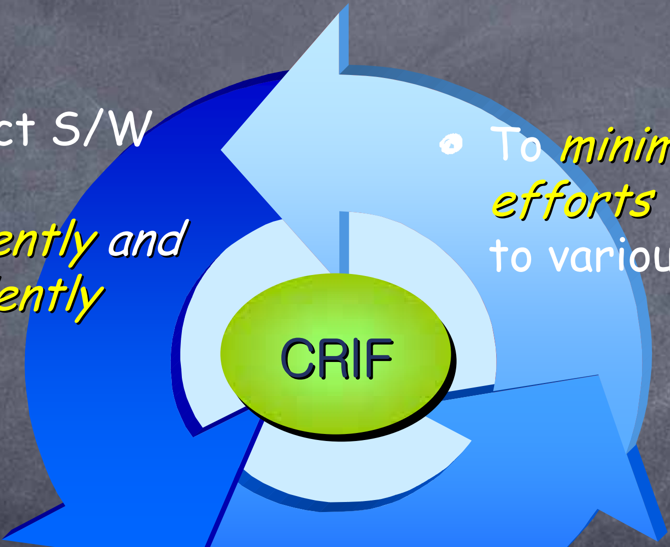


Application

Robot Platforms

Each robot developer writes an application for his/her own robot in their own way (Everyone makes their own CRIF)

Purpose of CRIF



- To connect S/W and H/W *transparently and independently*
- To *minimize the efforts for porting* to various platforms
- To establish something for everyone to *access commonly*

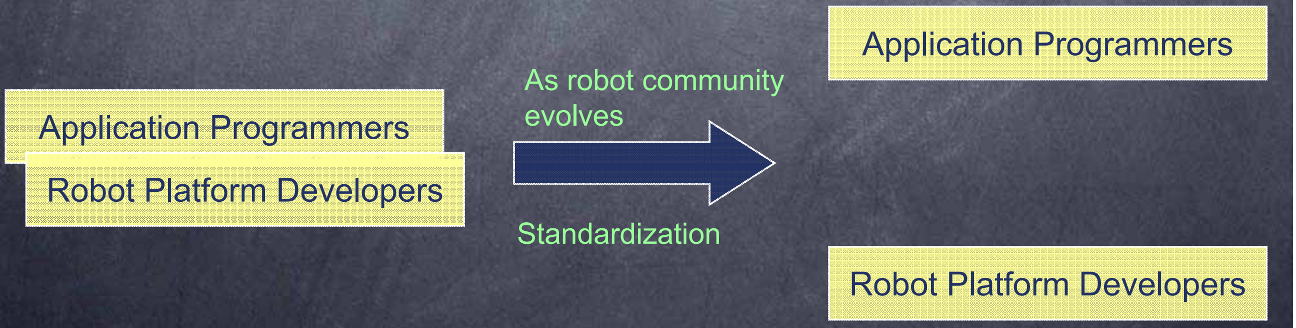
Two Users of CRIF

Application Programmers

- They want to write a good service S/W for robots without considering target platform

Robot Platform Developers

- They want as many applications on their platform as possible



By Introducing CRIF

Application Programmers

⬆ their applications run on various robot platforms

⬇ their control is restricted by the APIs of the framework

⇒ make the framework more general

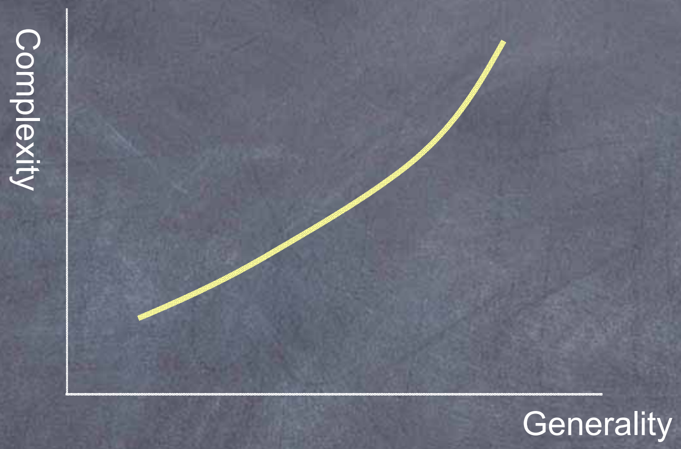
Robot Platform Developers

⬆ many applications are available for their robots

⬇ they don’t like to take a burden of implementation

⇒ make the framework more simple

Generality vs. Complexity



If generality increases, application programmers are happy
But complexity also increases, which make the robot platform developers unhappy

If market is sufficiently mature, the robot platform developers may take the burden, which is not the case for the robots unfortunately

The good and famous frameworks like ERSP or Shappire was hard to implement for our platforms → We want to separate higher level functionalities from CRIF

Strategy in Designing CRIF

Simplicity comes First

We do NOT cover all kinds of robot platforms

⇨ Focusing on Wheel-type robot, probably typical for service robots

We focus on general functionalities rather than sophisticated ones

⇨ It is sufficient for most applications of service robots

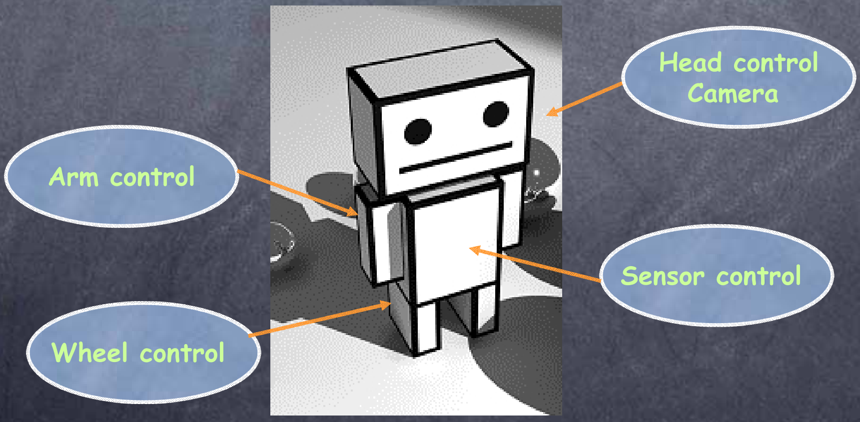
We provide developer's kit for robot platform developers

⇨ Minimum efforts for robot platform developers

CRIF Design Flow

- Building Virtual Robot
- Defining the functions for controlling Virtual Robot and its components

  →Constructing API set



Head control
Camera

Arm control

Sensor control

Wheel control

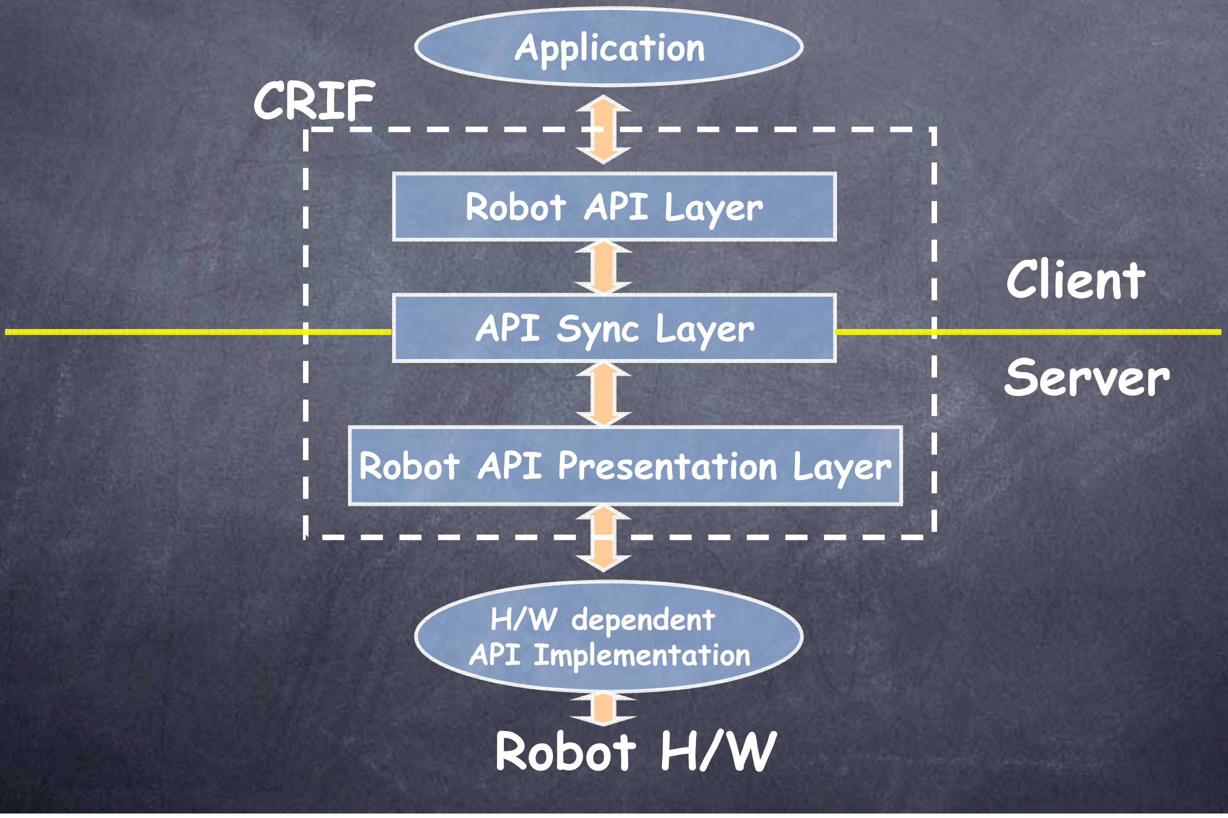
Assumptions

- Wheel type Robot

  → Robot Abstraction Model(RAM)
- Client/Server structure

  to solve the problem of resource monopoly
  - Client : Applications
  - Server: Robot H/W platform

CRIF Structure



Application

CRIF

Robot API Layer

API Sync Layer

Robot API Presentation Layer

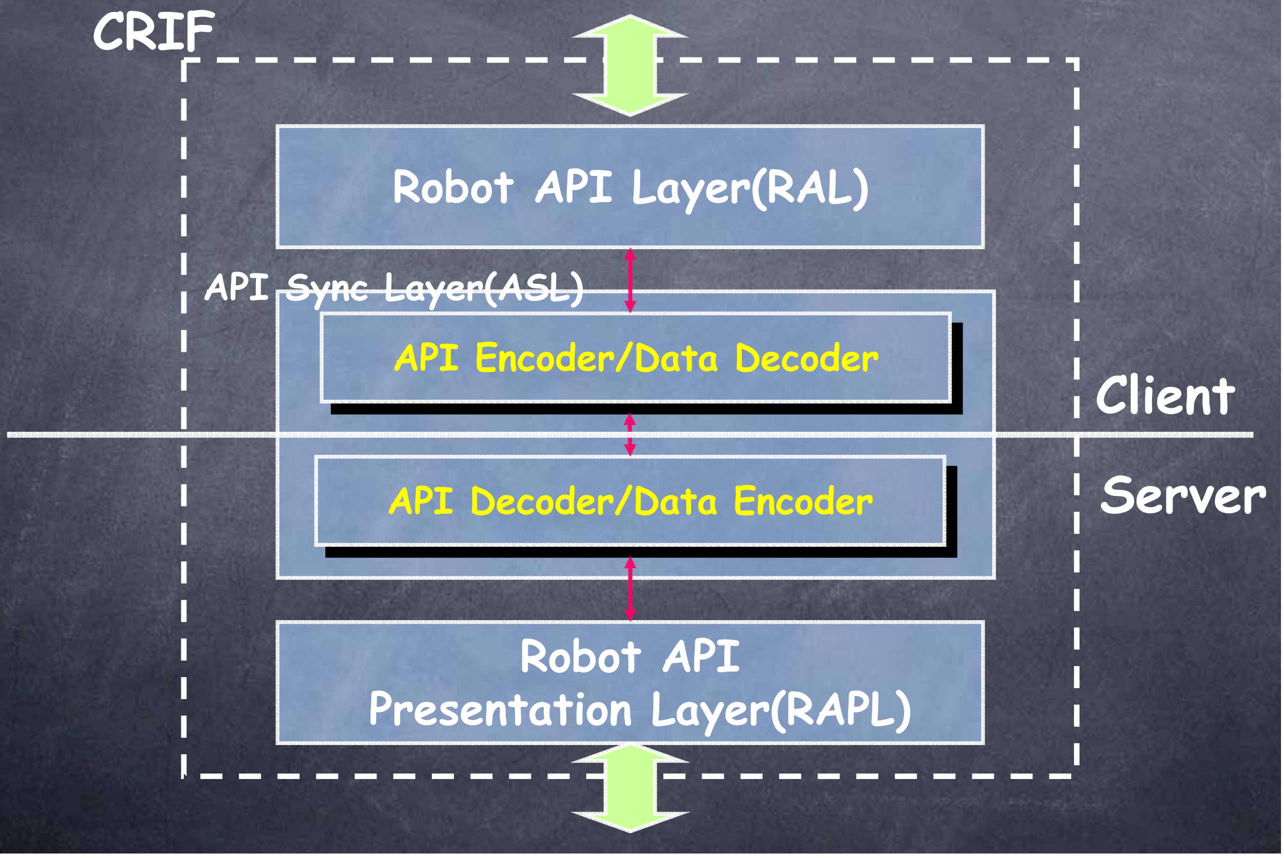
Client

Server

H/W dependent
API Implementation

Robot H/W

CRIF Structure(II)



CRIF

Robot API Layer(RAL)

API Sync Layer(ASL)

API Encoder/Data Decoder

API Decoder/Data Encoder

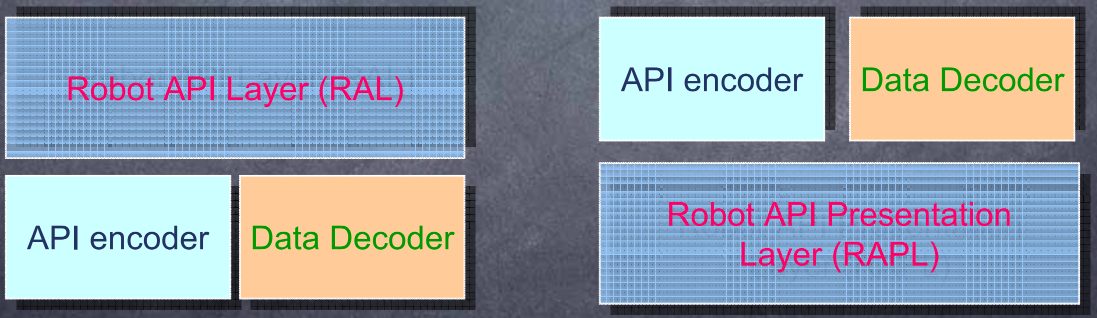
Client

Server

Robot API
Presentation Layer(RAPL)

Implementing CRIF

- two libraries are provided
  - CRIFApp library: for application developers
  - CRIFBase library:for H/W developers



CRIFApp Library

Application programmers simply use this library

CRIFBase Library

Robot Platform developers should Implement the H/W dependent parts

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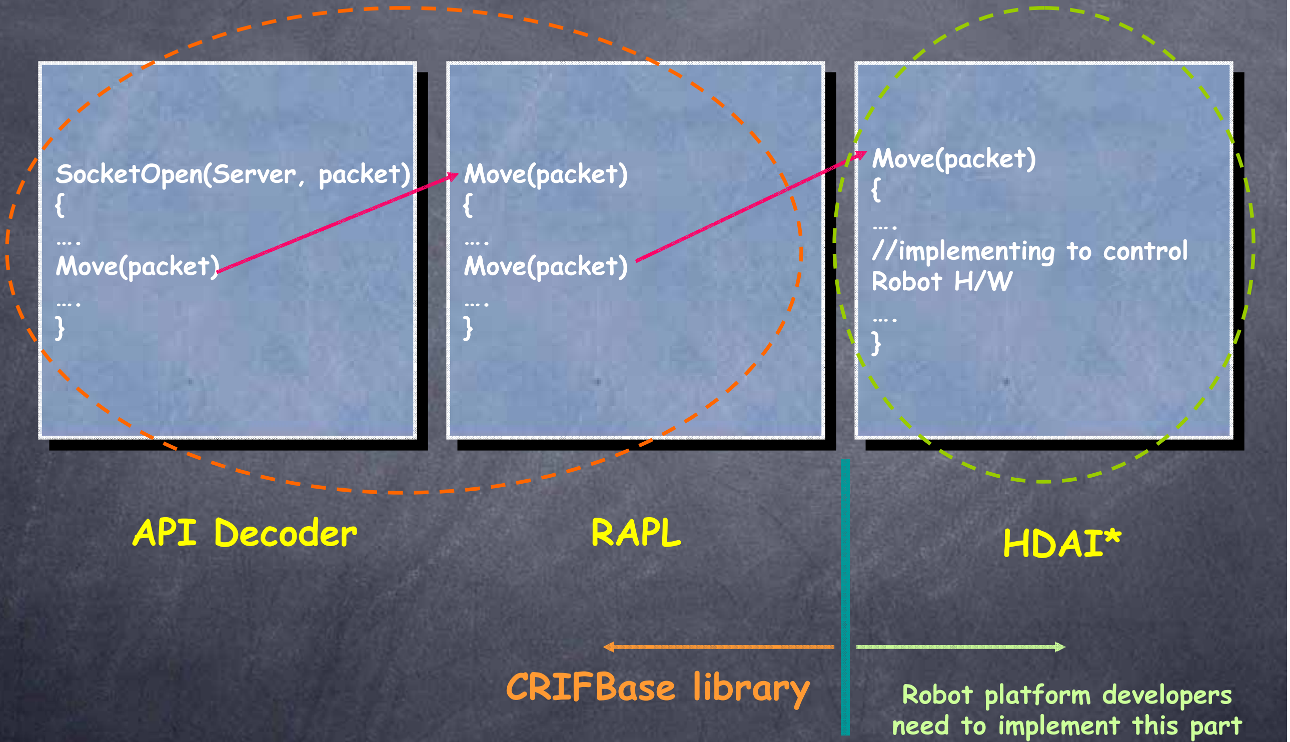
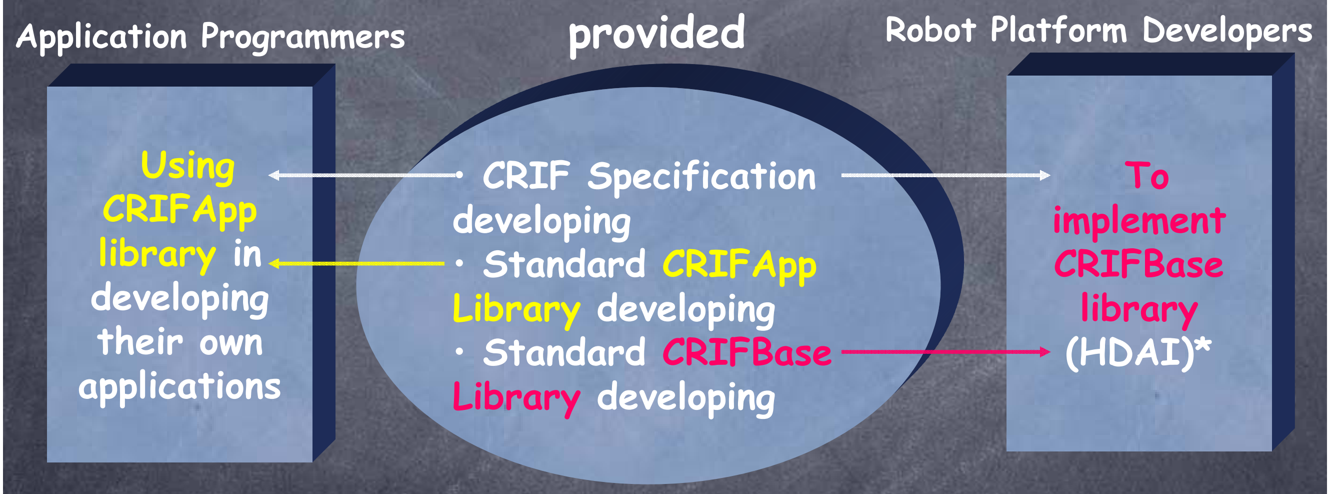
CRIFBase Library



*HDAI(H/W Dependent API Implementation)

Who makes it?



Application Programmers

provided

Robot Platform Developers

Using CRIFApp library in developing their own applications

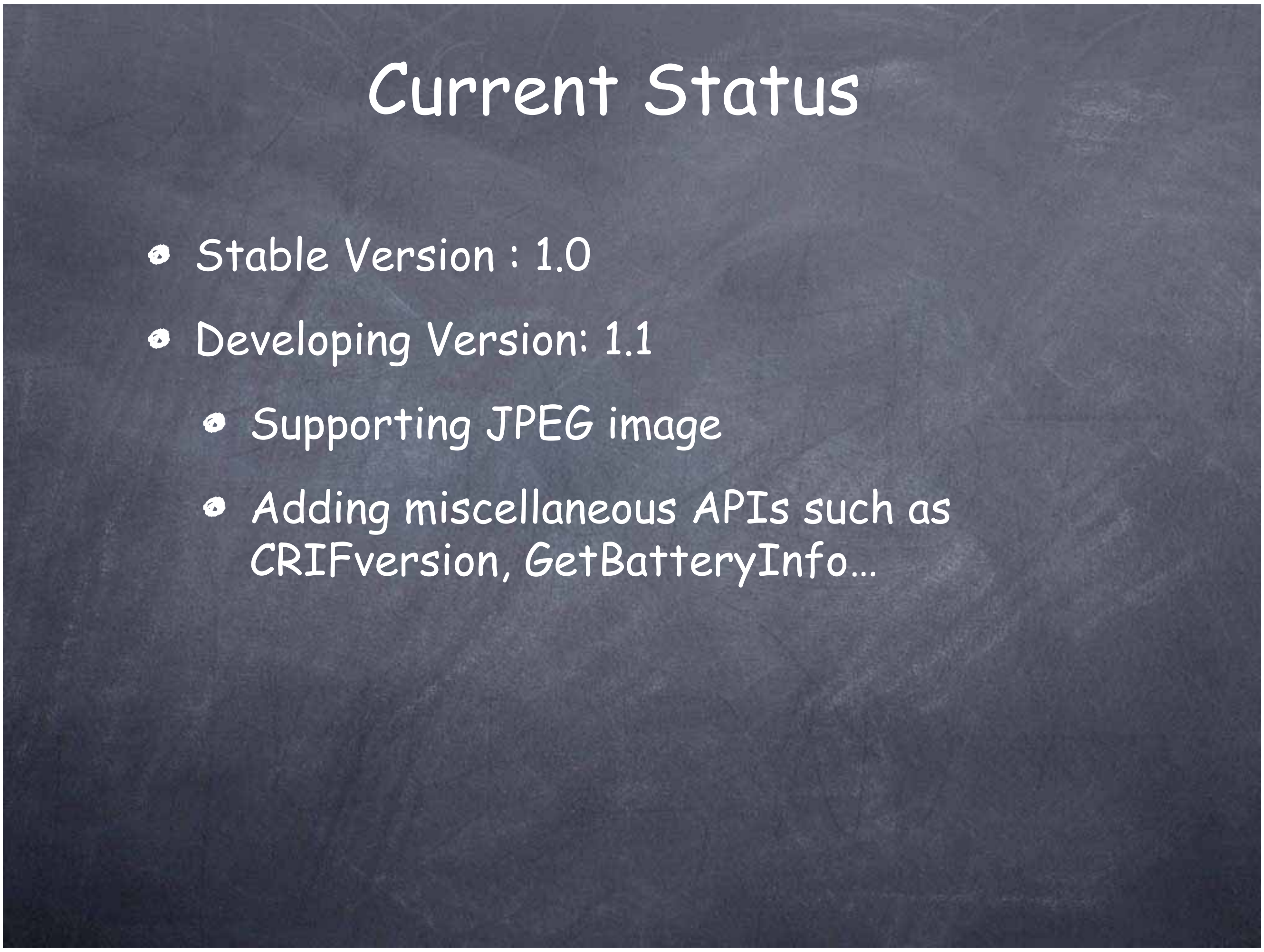
CRIF Specification developing
- Standard CRIFApp Library developing
- Standard CRIFBase Library developing

To implement CRIFBase library (HDAI)*

*HDAI(H/W Dependent API Implementation)

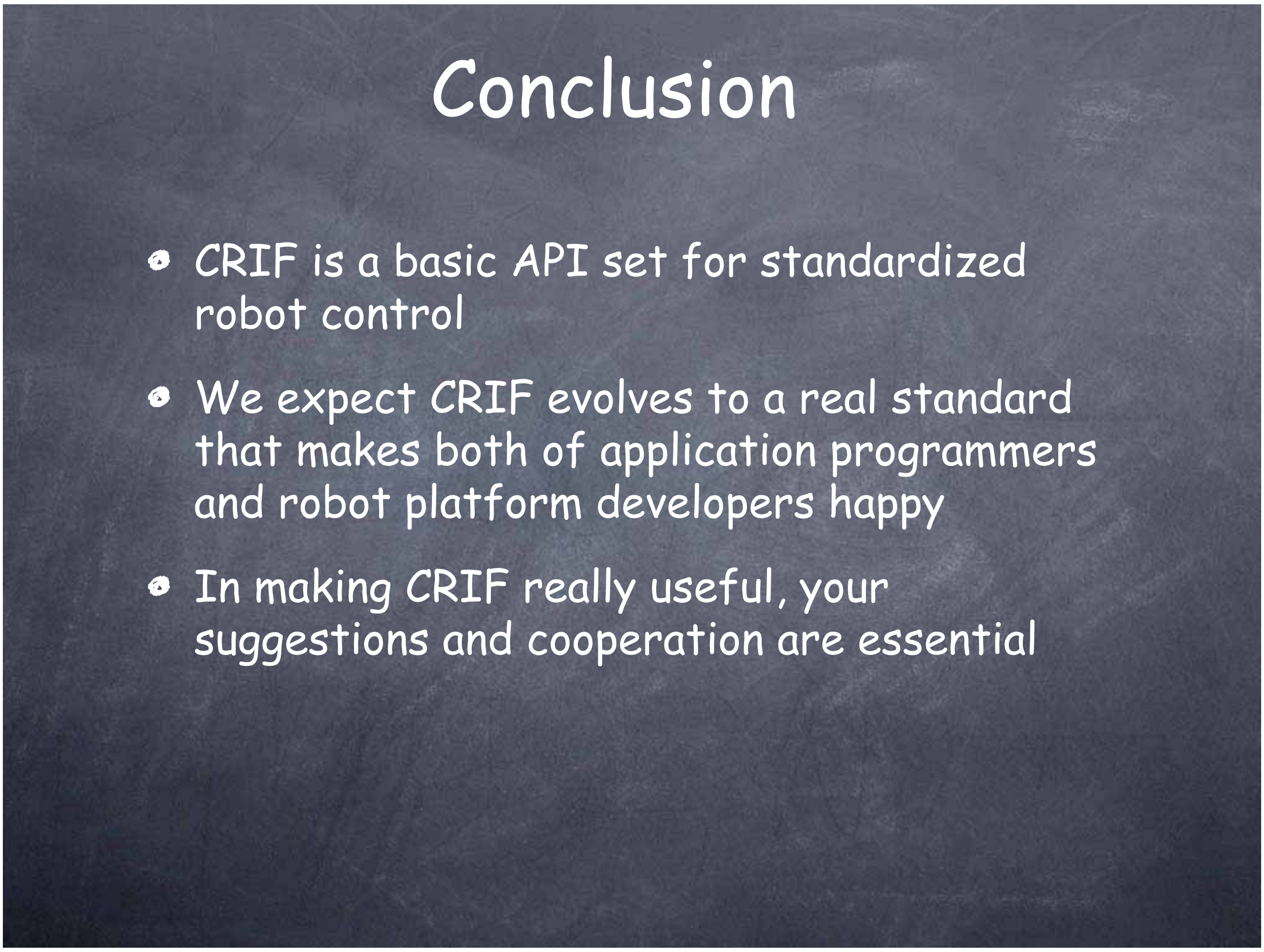
Current Implementation

Robot	Company	OS	Status
Wever-R1	ETRI	Windows	Implemented
ETRO	ETRI	Windows	Implemented
	LG Electronics	Linux	Implemented
Scorpion	Evolution Robotics	Linux	Implemented
iRobi	Yujin Robotics	Windows	On Going
Robo PC	ETRI	Windows	On Going
Robo Air Cleaner	ETRI	Windows	On Going



Current Status

- Stable Version : 1.0
- Developing Version: 1.1
  - Supporting JPEG image
  - Adding miscellaneous APIs such as CRIFversion, GetBatteryInfo…



Conclusion

- CRIF is a basic API set for standardized robot control
- We expect CRIF evolves to a real standard that makes both of application programmers and robot platform developers happy
- In making CRIF really useful, your suggestions and cooperation are essential

Prototype Robots at Aichi International Exposition 2005

～ A 2020 City: Living with Robots ～

MASAYOSHI YOKOMACHI
Project Coordinator
Machinery System Technology Development Dept.
NEDO
（New Energy and Industrial Technology Development Organization）

Background and Concept

【Background】

The NEDO exhibited a wide variety of robots at Expo 2005 as part of its “Project for the Practical Application of Next-Generation Robots.” This project is designed to demonstrate the technology that is expected to find its way into commercial robot applications in near future.

【Concept】

Each of the robots to be exhibited is based on the concept...

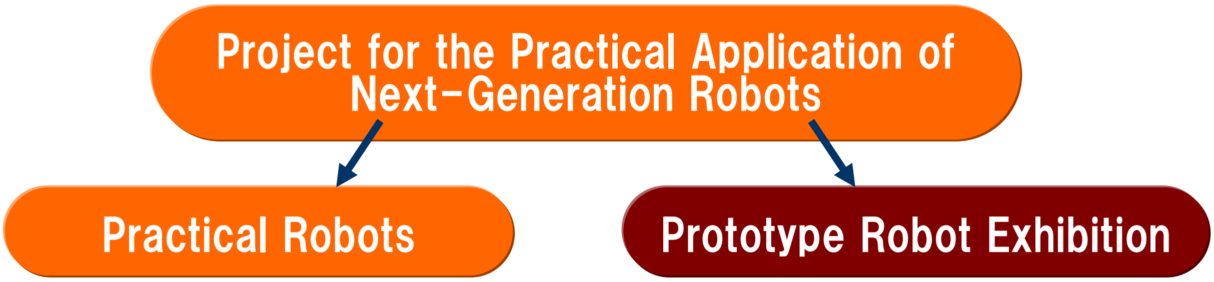
1) People and robots will coexist in the world of tomorrow.

2) Robots will become an integral part of our daily lives.

For this reason, Expo 2005 represents not only a proving ground for the technology behind the robots as they move closer to commercial reality, but also a place to consider the scope of the relationship between people and robots.

PROTOTYPE ROBOT EXHIBITION Overview

- The exhibition is one of the two pillars of the Project for the Practical Application of Next-Generation Robots to demonstrate next-generation robots that coexist in harmony with people, as is envisaged for the 21st century.



Project for the Practical Application of Next-Generation Robots

Practical Robots

Robots that have reached the level of practical use in terms of technologies and safety

- ・Cleaning robots
- ・Security guard robots
- ・Childcare robots
- ・Customer service robots
- ・Wheelchair robots

Prototype Robot Exhibition

Prototype robots that are expected to be in practical use by around 2020

- ・Robots that work in shops, factories, hospitals, etc.
- ・Robots that work in dangerous conditions such as disaster area.
- ・Robots that work in homes, etc.

Theme

A 2020 City: Living with Robots

- The demonstration area will show how a city will look like in year 2020, when the current prototype robots will have been put to practical use. The demonstrations will highlight how the robots will be useful in various aspects of life.
- The aim is not to educate the public on specific functionalities of the robots, but to inform how robots can be useful.
- In order to manufacture these life support robots efficiently, the assembly-based robot manufacturing should be realized by standardizing RT middleware in near future.

Robots to Be Demonstrated

The prototype robots are designed to show Expo 2005 visitors how robots will interact in our daily lives, how we will use them, and what role they will play in the future.

Service Robot (Network Robotics, RT Middleware) 8 Types	Service Robot (Robot for Interaction between Humans and Robot) 7 Types
Outdoor Robot (Skilled Work) 8 Types	Outdoor Robot (Special Environment Work) 10 Types
Medical Welfare Robot 10 Types	Partner Robot 8 Types
Performance Robot 5 Types	Humanoid Robot 9 Types

Total : 65 Types in 8 Categories

So many robots are now in action.

Industrial Robots ➡ Symbiotic Robots in human life

Caddie Robot
Candy-05

Playmate robot
NAGARA-3

Tag-playing robot
ASKA

Woodcutter Robot
WOODY−1

Reconfigurable Robot
with Authoring System

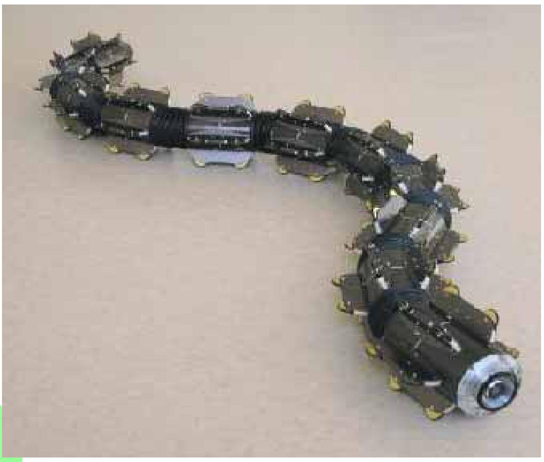
KINSHACHI ROBOT

Outdoor Work Robot
(Specific Environment)

Amphibious snake-like robot ACM-R5

This snake-like robot is highly dust-proof and water-proof, and is so resilient that it can adapt itself to the worst possible environment.

*Rescue operation in fallen houses and in the rubbles
*Inspection under water



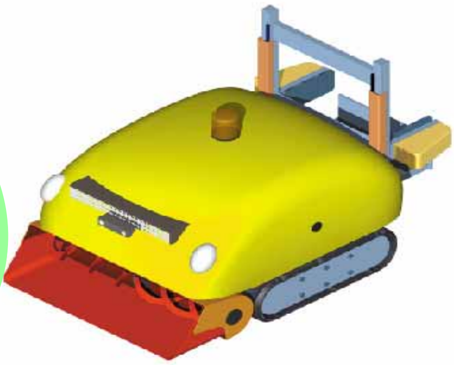
Tokyo Institute of Technology

Outdoor Work Robot
(Special Environment)

"Yuki-Taro" the autonomous snowplow

This snow-plow robot supports the lives of those in the areas of heavy snowfalls. It works autonomously, and compresses the snow into blocks as it plows the snow.

*Autonomous movement avoiding obstacles
*Self-location recognition technology using image recognition method combined with high accuracy GPS



Niigata Industrial Creation organization

Outdoor Work Robot

(Outdoor Skillful Work)

WallWalker

This cleaning robot climes a wall and freely walks the ceilings just like 21st Century Ninjya.

MIRAIKIKAI Inc., et al.

- ＊Replacement of a person to clean the building walls and window glasses as well as inspection and maintenance
- ＊Safe and effective operations

Service Robot

(Network Robotics)

ApriAlpha™ with omni-directional auditory function

This robot is equipped with refined hearing ability. When more than one person talk to it, it detects where the voice of each speaker came from and understands what was said.

Toshiba Corporation

- ＊Excellent hearing sense which identifies plural voices
- ＊Simultaneously inputs six microphones finds and identifies sounds from all directions

Service Robot
(Network Robotics)

EMIEW

This communication robot can make versatile and quick movements in accordance with human movements.

Hitachi, Ltd.

＊A robot that acts as a workmate

＊Operates in symbiosis with people

SmartPal

This wheel-based robot has highly flexible arms just like humans.

Yasukawa Electric Corporation

Service Robot

Hyper Robot

The distributed robots that together consist the entire room jointly provide the resident (s) various services.

The University of Tokyo

Hyper Robot orders distributed robots to provide service to the users.

＊Secretary robot: Projector, PC

＊Servant robot: Ceiling robot, Lighting appliances, Sensing floor

＊Friend robot: Humanoid robot

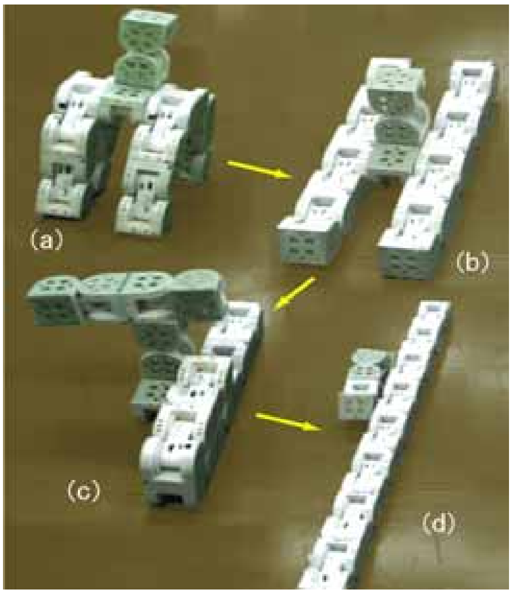
＊Pet robot: Plant type robot object

Performance Robot

Modular Transformer (M-TRAN III)

The connections between modules can freely be joined and separated, to transform the robot into various different shapes.

*A wide range of applicability from disaster rescue operations to educational and entertaining uses



National Institute of Advanced Industrial Science and Technology

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Humanoid Robot

WABIAN-2

WABIAN-2 is a congregation of sensors and has human-equivalent mobility.

*A humanoid robot that can move identically as a human being will be used for experiments of medical/welfare equipment development

Waseda University

Thank you very much for your attention!!

Please enjoy the succeeding movie.

If you have any question, please send your e_mail to Yokomachimsy@nedo.go.jp (NEDO)

Machine Vision for Robotics and Automation

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Presented at OMG Robotics-DSIG meeting
September 14, 2005

Outline

- Background
- Flexible Integrated Vision System (FIVS)
  - Sensor concept and prototype design
  - Algorithms (Theoretical basis and practice)
  - Applications in RA (Gauging and biological)
- Conclusions and Trends

Questions asked *FIVS developed* Algorithms for RA applications

1980 *1990* *2000* *2010*

1. Background

Some questions we asked in the 1980's

- Why a color video camera costs only US$1,500 but a gray-level machine vision system costs US$50K?
- Why a machine vision (MV) system take 0.5 second to compute the center of a small blob when the computer typically takes less than 10ms for even more sophisticated computation?
- We have long noticed that a human visual system (HVS) functions remarkably well even in the presence of significant noises. Can we effectively emulate some or all the HVS features to improve machine vision for automating the tasks of visual inspection?

Why a color video camera costs only US$1,500 but a gray-level machine vision system costs US$50,000?

- A color video camera (based on standard established by the TV industry) for human vision requires only *qualitative* information.
- Machine controlled system, like a robot, requires *quantitative* information to do work.

⇒ A primary difference between human visual perception and machine vision

Why do the we need 0.5 second to compute the center of a small blob?

- A frame-grabber is needed to convert the RS-170 video signal into a series of n bit brightness values (gray levels) via a flash A/D converter.
- Digitized image data must be stored in a memory buffer before processing, often only a few of these carry the information on which the vision system will base a decision.

⇒ RS-170 TV-standard established in the 1950's limits the image readout at a rate of 30 fps (frames per second) or 33ms.

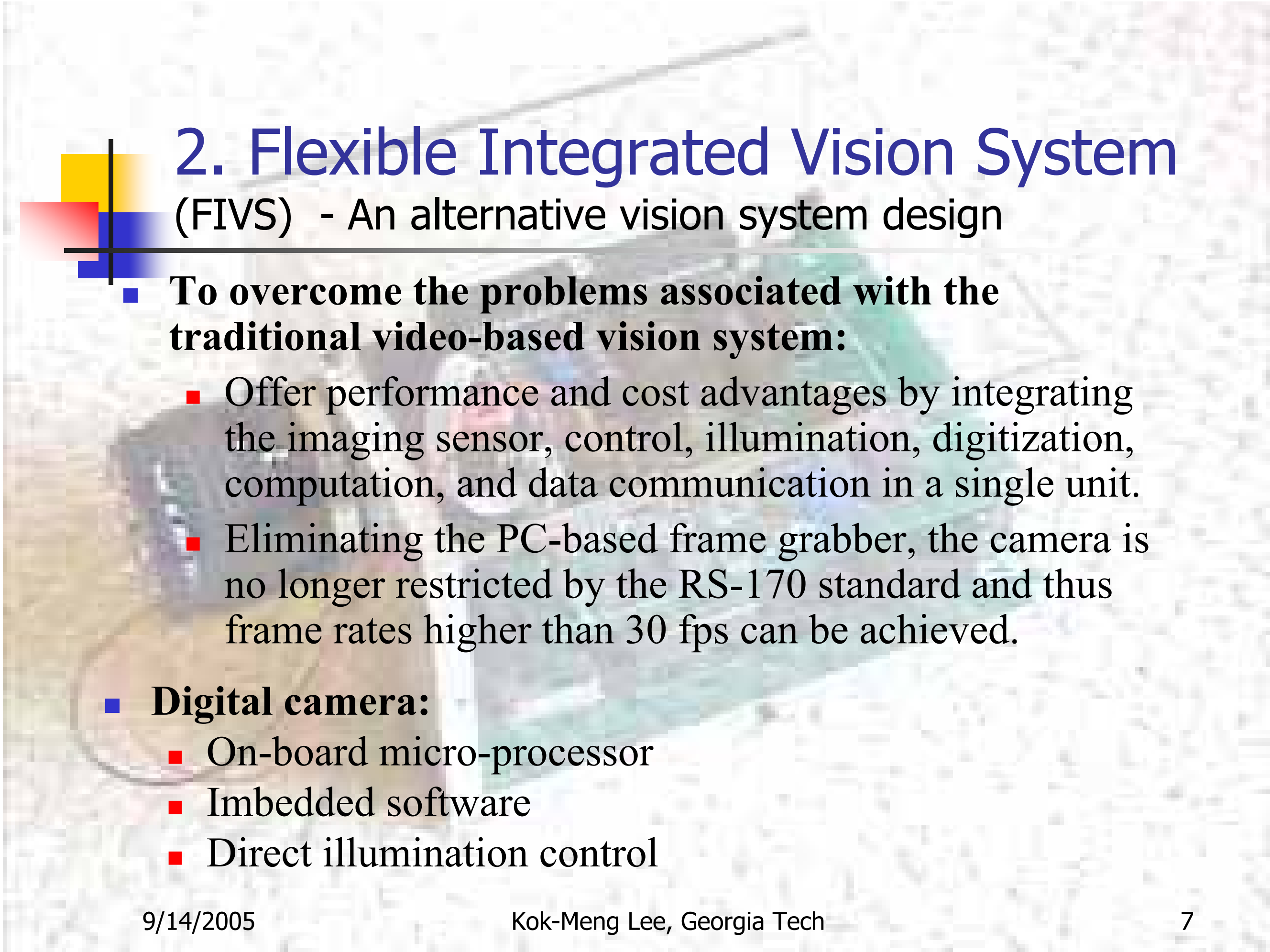
Why do the we need 0.5 second to compute the center of a small blob? … cont.

- The timing of the RS-170 standard video signal and the frame grabber must be synchronized. These errors, which may be insignificant for visual interpretation, would cause errors in the geometric measurement or coordinate computation of the parts.
- Once the image has been digitized, it must be transferred from the frame grabber over the data bus of the host computer, which has often restricted the through-put of the image processing.

⇒ A need for a direct, digital vision system for machine.

2. Flexible Integrated Vision System

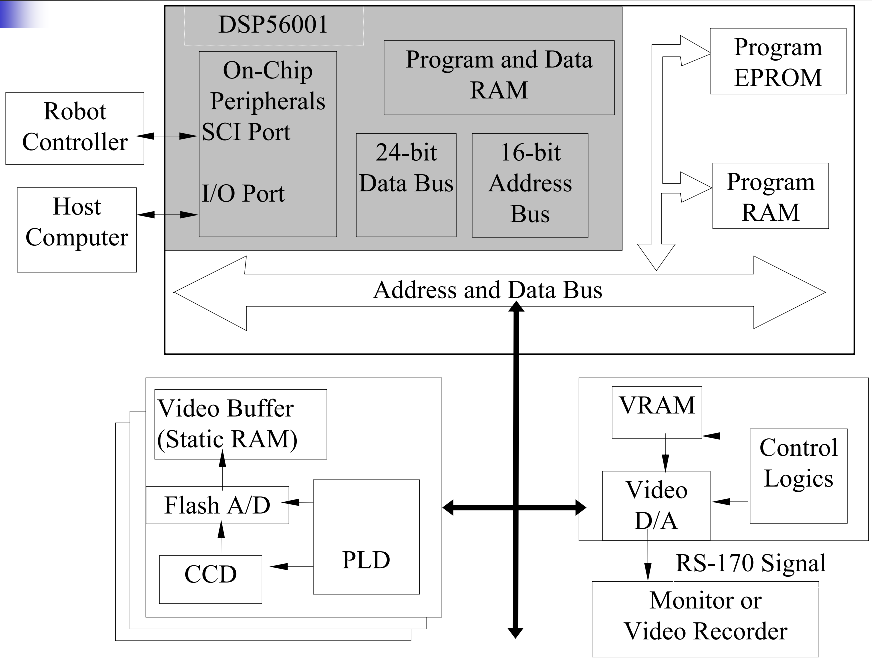
(FIVS) - An alternative vision system design



- **To overcome the problems associated with the traditional video-based vision system:**
  - Offer performance and cost advantages by integrating the imaging sensor, control, illumination, digitization, computation, and data communication in a single unit.
  - Eliminating the PC-based frame grabber, the camera is no longer restricted by the RS-170 standard and thus frame rates higher than 30 fps can be achieved.
- **Digital camera:**
  - On-board micro-processor
  - Imbedded software
  - Direct illumination control

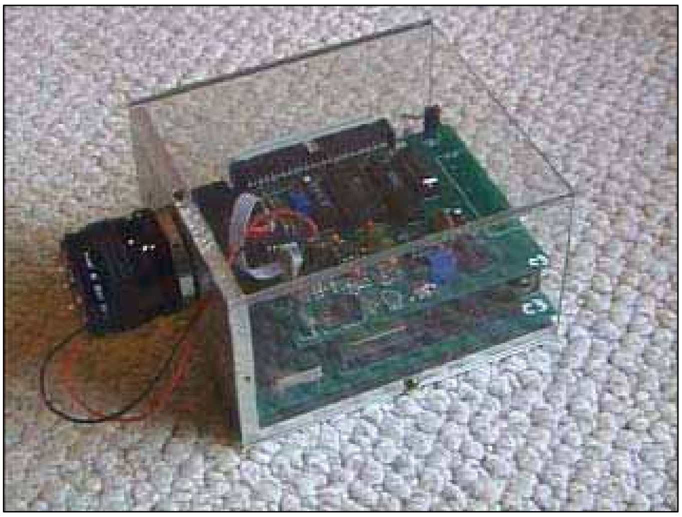
Flexible Integrated Vision System

FIVS Architecture



Prototype FIVS

developed at Georgia Tech (Lee and Blenis, 1992)



- Texas Instruments TC211 CCD (192X165)
- 25 MHz Motorola MC10319 8-bit A/D Converter.
- 20MHz Motorola DSP56001
- RS232 Serial Communication baud-rate (115.2 KB >20KB)
- Intel-386 33MHz Host PC

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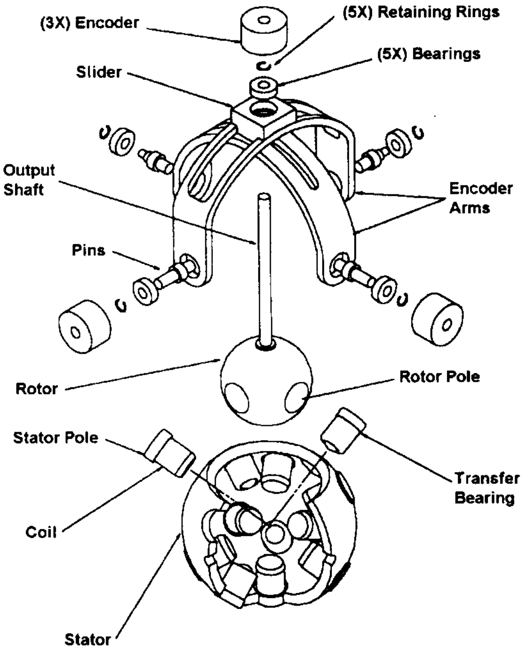
3. Vision-based Sensing

also called Optical Gauging

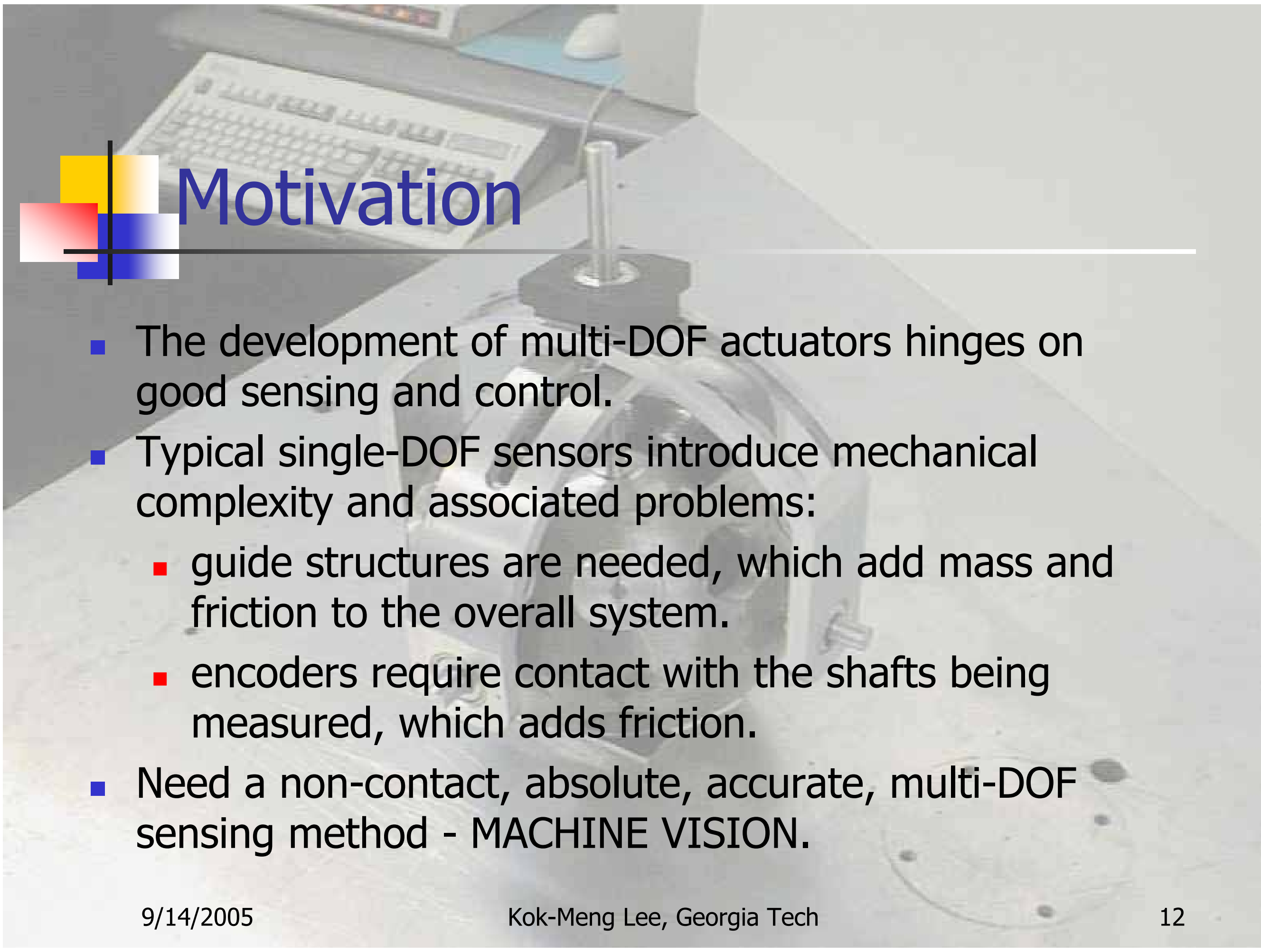
- Vision-based sensing is *a technique for making displacement measurements* based on the relative position of some type of pattern in the field of view of a vision sensor such as a CCD camera.
- This type of sensing is used in many areas of manufacturing such as alignment of printed circuit boards, robotic part pick-up, human motion analysis.
- Here, we extended for use in the absolute orientation measurement (of a spherical object) allowed to move with three degrees of freedom.

3. Opto-mechatronics

3.1 Multi-DOF motion sensing



3-DOF VR Spherical Motor



Motivation

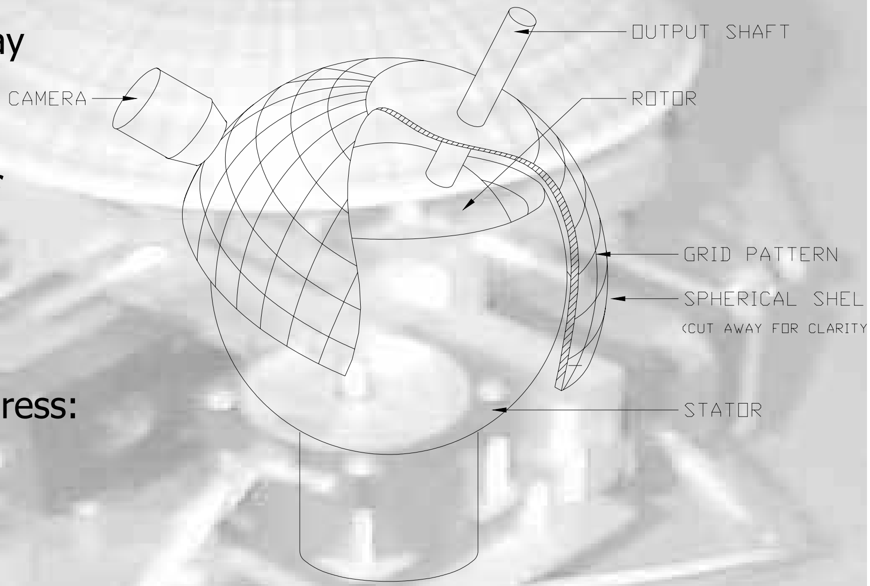
- The development of multi-DOF actuators hinges on good sensing and control.
- Typical single-DOF sensors introduce mechanical complexity and associated problems:
  - guide structures are needed, which add mass and friction to the overall system.
  - encoders require contact with the shafts being measured, which adds friction.
- Need a non-contact, absolute, accurate, multi-DOF sensing method - MACHINE VISION.

Sensor Concept

Vision-based orientation sensor

Position information may be encoded in a grid pattern many ways

- *Spacing between lines*
- Width of lines
- Line color



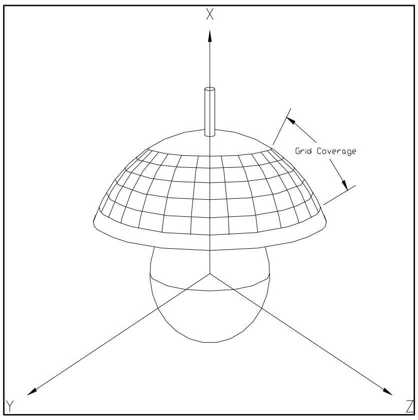
Two main tasks to address:

- Grid preparation
- Orientation sensing

Grid Pattern Design

Circular vs Linear Absolute Position Strings

p=2,m=3, S={0,1}, There are n unique words:
{0,0,0}, {1,0,0}, {0,0,1}, {1,0,1}, {0,1,0}, {1,1,0}, {0,1,1}, {1,1,1}



A linear string using all n words:

0001011100

The overall length is $p^m + m - 1 = 10$ elements.

A circular string using all n words:

1 0 0
1 0
1
1 0

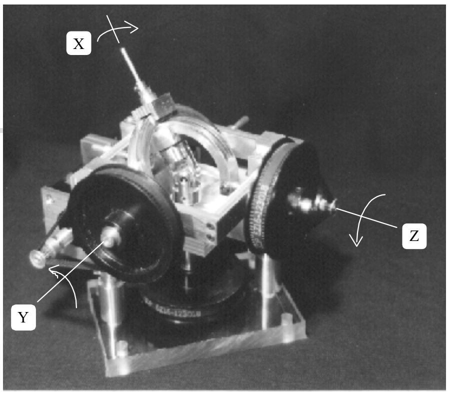
The overall length is $p^m = 8$ elements.

Grid Preparation

Specification

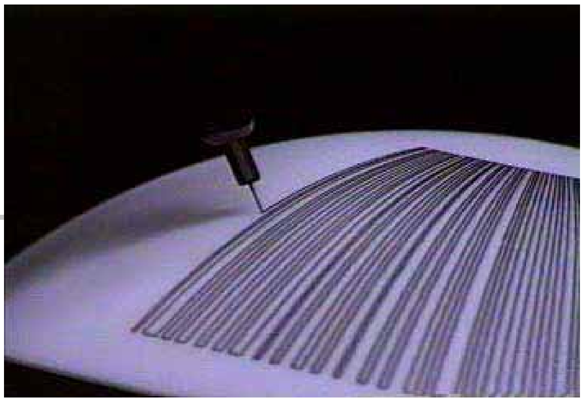
3 DOF Actuator for generating the grid

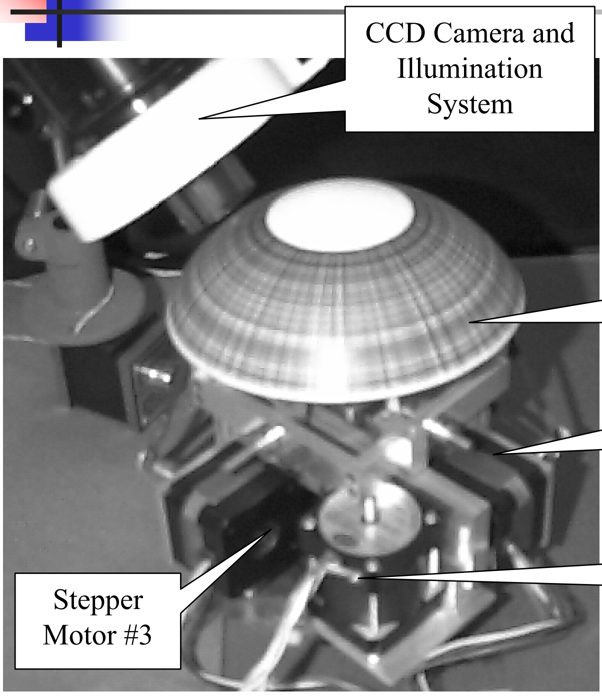
Line thickness: 0.17mm pen
(Koh-I-Noor Rapidograph)



	Longitude	Latitude
Spacings, p	8	5
Word Length, m	4	4
Motor Resolution, steps/rev.	10,000	400
Min. Spacing, mm (unit steps)	0.957 (180)	0.665 (5)
Unit Steps/Spacing, u	60	3
Field of View, mm (unit steps)	6.75 (1268.9)	5.5 (41.4)
Format	Circular	Linear
Length (unit steps)	90,000; 360°	375; 37.5 °

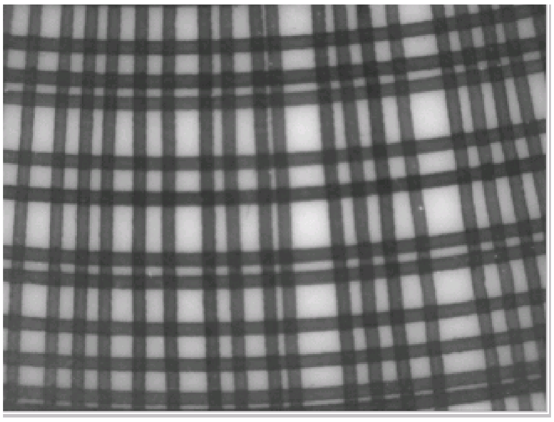
Experimental Setup



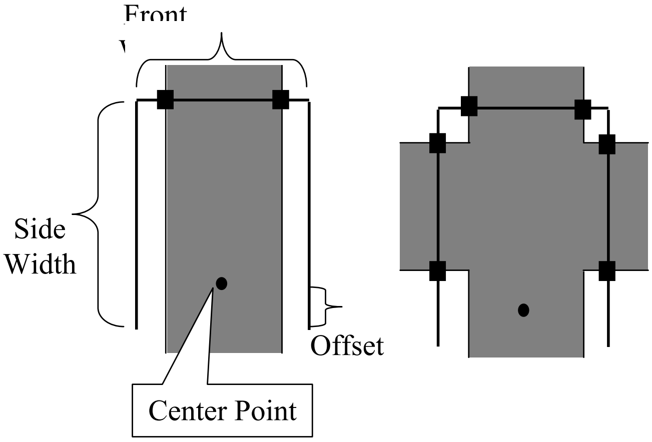


ORIENTATION SENSING

Line tracking algorithm



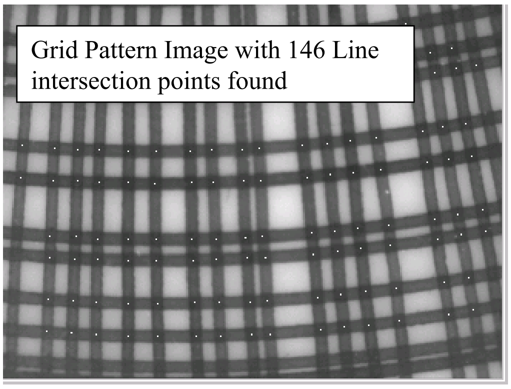
Sample image



(a) Single Line (b) Line Intersection

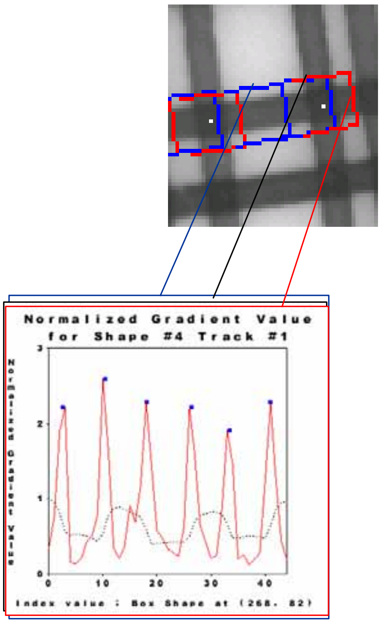
Going beyond position measurement

- a 3-DOF **absolute** orientation sensor

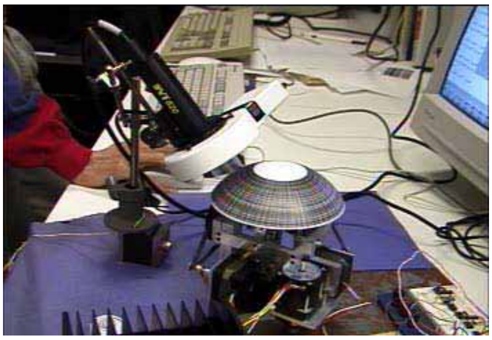


Grid Pattern Image with 146 Line intersection points found

- Pentium III 733 MHz
- Line tracking algorithm
  - 1200-1400 intersection points/second
- Camera calibration performance
  - 5.7μm average distance deviation for 77 points
- Absolute orientation recovery 4.5ms or **~200fps**



Experimental test



Trajectory:

1. Nutate from an initial position by 10° to a starting position.
2. Nutate in the opposite direction by 20 °.
3. Precess by 90 ° while spinning by 90 °, then to nutate by 20°.
4. Precess by 90 degrees while spinning by 90 degrees back to the starting position.

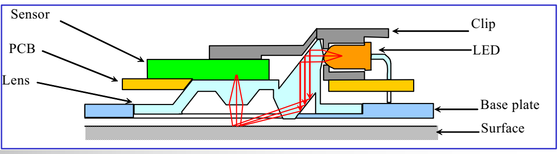
Experimental results

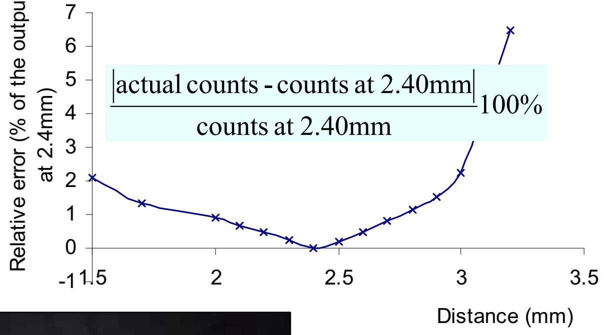
Image	Calculated Rotation Matrix	Actual Rotation Matrix
#1	1.0000 0.0001 -0.0001 -0.0001 1.0000 -0.0007 0.0001 0.0007 1.0000	1 0 0 0 1 0 0 0 1
#2	0.9999 -0.0154 0.0064 0.0162 0.9854 -0.1695 -0.0037 0.1696 0.9855	1.0000 0.0000 0.0000 0.0000 0.9848 -0.1736 0.0000 0.1736 0.9848
#3	0.9996 0.0193 -0.0209 -0.0161 0.9893 0.1448 0.0235 -0.1444 0.9892	1.0000 0.0000 0.0000 0.0000 0.9848 0.1736 0.0000 -0.1736 0.9848
#4	0.9827 0.0543 -0.1770 -0.0540 0.9985 0.0064 0.1771 0.0032 0.9842	0.9848 0.0000 -0.1736 0.0000 1.0000 0.0000 0.1736 0.0000 0.9848
#5	0.9808 -0.0557 0.1869 0.0559 0.9984 0.0041 -0.1868 0.0064 0.9824	0.9848 0.0000 0.1736 0.0000 1.0000 0.0000 -0.1736 0.0000 0.9848
#6	0.9999 -0.0153 0.0056 0.0160 0.9854 -0.1697 -0.0029 0.1698 0.9855	1.0000 0.0000 0.0000 0.0000 0.9848 -0.1736 0.0000 0.1736 0.9848

What have been achieved:

- Theoretical basis of a vision-based 3-DOF Orientation sensing system
- The system eliminates the mechanical structure required for single-axis encoders
- Non-contact, flexible, direct-computation of 3D orientation, frictionless, no added moving mass
- Grid pattern design and algorithm for analyzing grid
- Concept experimentally demonstrated

Micro-feature-based orientation sensor





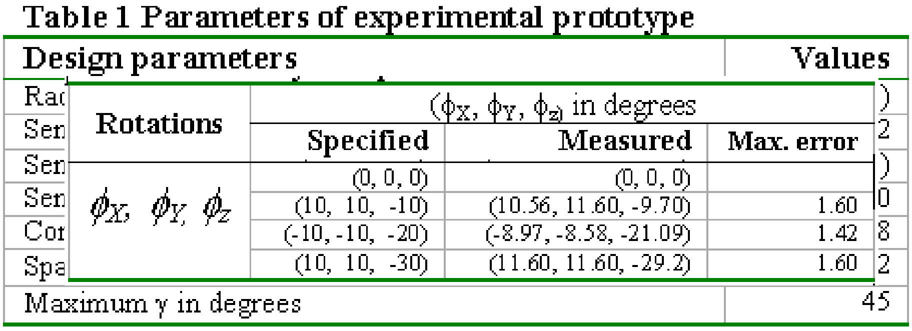
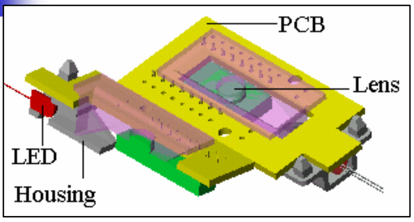


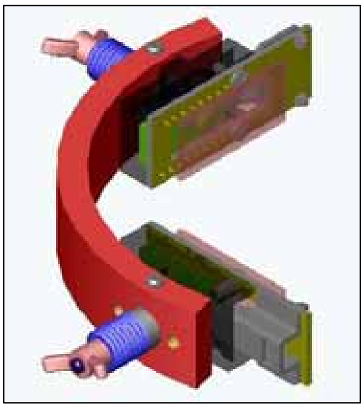
Table 1 Parameters of experimental prototype

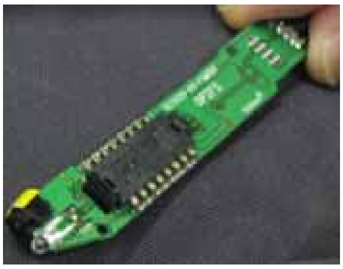
Design parameters	Values
Rad	)
Sen	2
Sen	)
Sen	0
Cor	8
Spa	2
Maximum γ in degrees	45

Rotations	(ϕ_X, ϕ_Y, ϕ_Z) in degrees		
	Specified	Measured	Max. error
ϕ_X, ϕ_Y, ϕ_Z	(0, 0, 0)	(0, 0, 0)	
	(10, 10, -10)	(10.56, 11.60, -9.70)	1.60
	(-10, -10, -20)	(-8.97, -8.58, -21.09)	1.42
	(10, 10, -30)	(11.60, 11.60, -29.2)	1.60

Snap-shots of other alternatives







Snap-shots:
where we go from here?

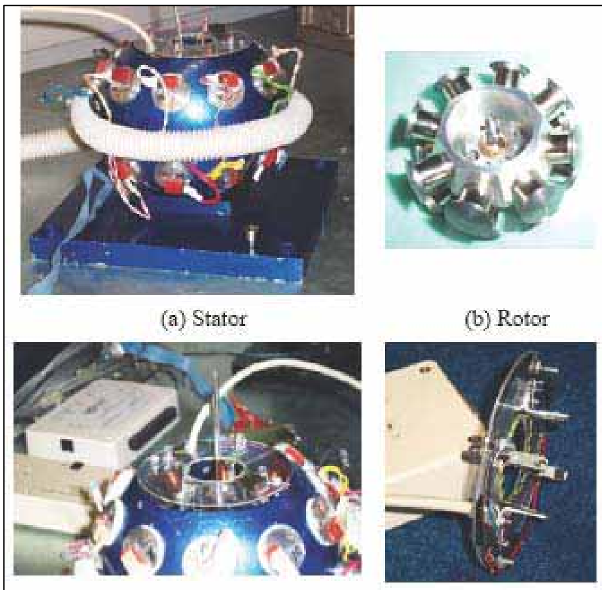
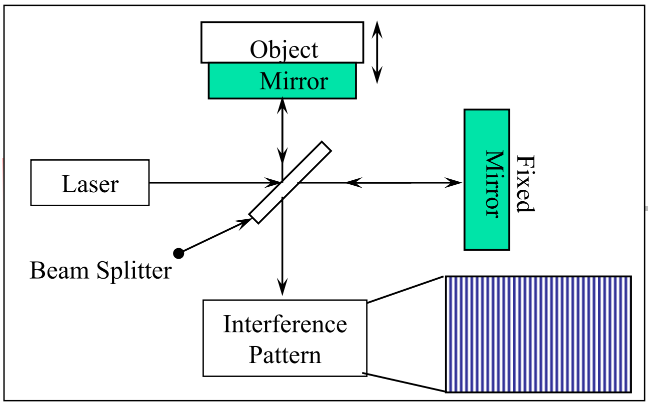

(a) Stator
(b) Rotor

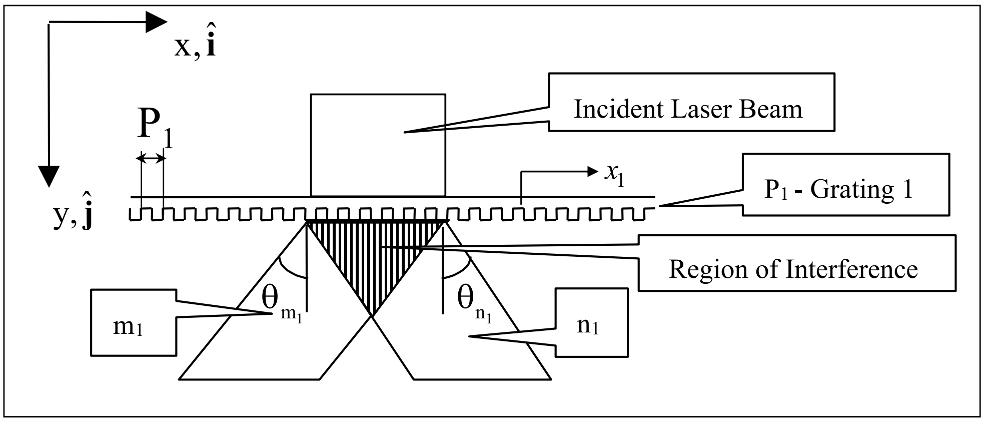
Figure 7: VRSM Prototype

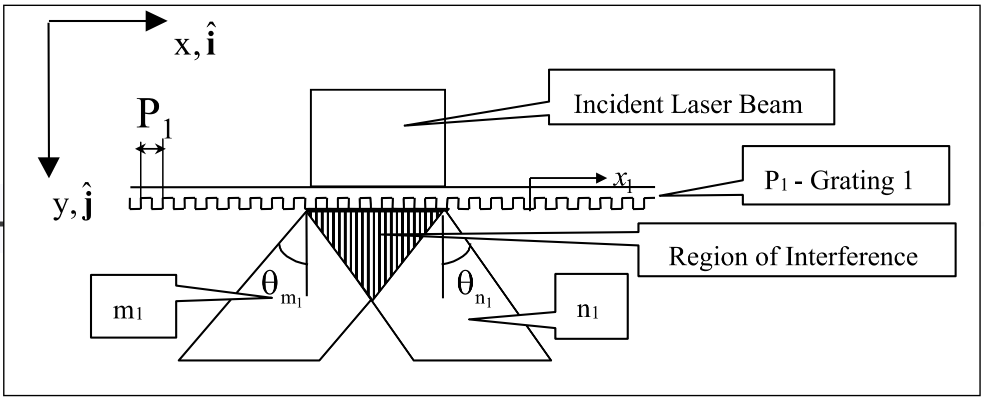


3.2 nano-scale displacement measurement

Conventional Interferometer

Compact Interferometric Technique (CIT)





$$I_{m_1 n_1}(x,y) = \left\|E_{m_1} + E_{n_1}\right\|^2 = 2\left(A_{m_1}\right)^2\left[1+\cos\left(\Delta\phi\right)\right]$$

where

$$\Delta\phi = \frac{2\pi}{P_{D1}}x + \frac{2\pi}{P_{Dy}}y + \frac{2\pi}{P_{S1}}x_1$$

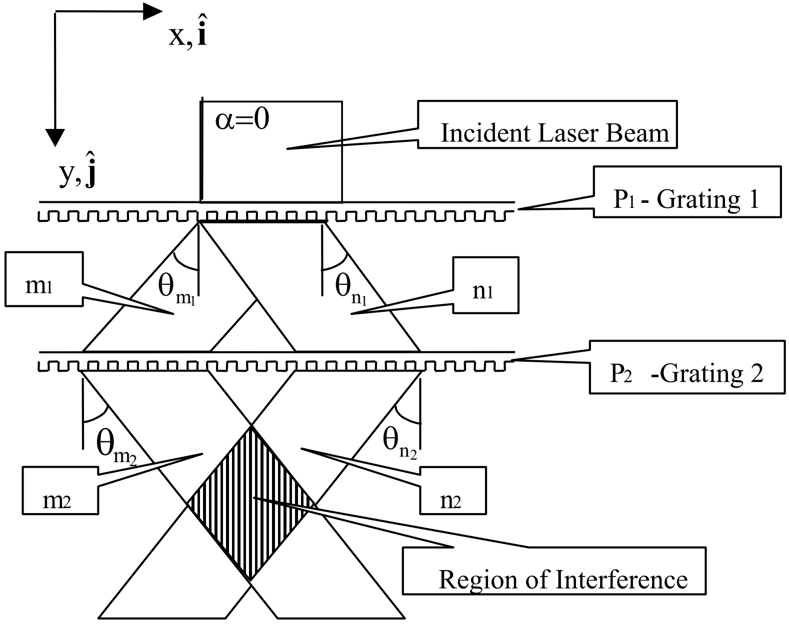
$$P_{D1} = P_{S1} = \frac{P_1}{n_1 - m_1} \quad \text{and} \quad P_{D1y} = \frac{\lambda}{\cos\theta_{n_1} - \cos\theta_{m_1}}$$

$$\boxed{\Delta x_1 = \frac{P_{S1}}{2\pi}\Delta\phi_1}$$

P_{D1} and P_{D1y}: Periods of interference fringes in x and y directions.

P_{S1}: Period of the fringe phase shift due to grating motion.

Dual Grating Configuration



$$\Delta\phi = \frac{2\pi}{P_{D2}}x + \frac{2\pi}{P_{S1}}x_1 + \frac{2\pi}{P_{S2}}x_2 + \frac{2\pi y}{P_{D2y}}$$

$$P_{D2} = \frac{P_1P_2}{P_1\left(n_1 - m_1\right) + P_2\left(n_2 - m_2\right)}$$

and $P_{si} = \frac{P_i}{n_i - m_i}$

$$\boxed{\Delta x_2 = \frac{P_{S2}}{2\pi}\Delta\Phi_2}$$

Detector Width Compensation (DWC) using dual grating configuration

To recover the phase from the fringe pattern conveniently,

$$P_D = 4\delta$$

where δ the width of the detector element. This means

single grating case, $P_{D1} = P_{S1} = 4\delta$

In practice, the detector element size δ is a fundamental limitation that constrains the resolution of a single grating system.

dual grating case, $\boxed{P_{D2} = \frac{P_1P_2}{2(P_1 - P_2)} = 4\delta}$

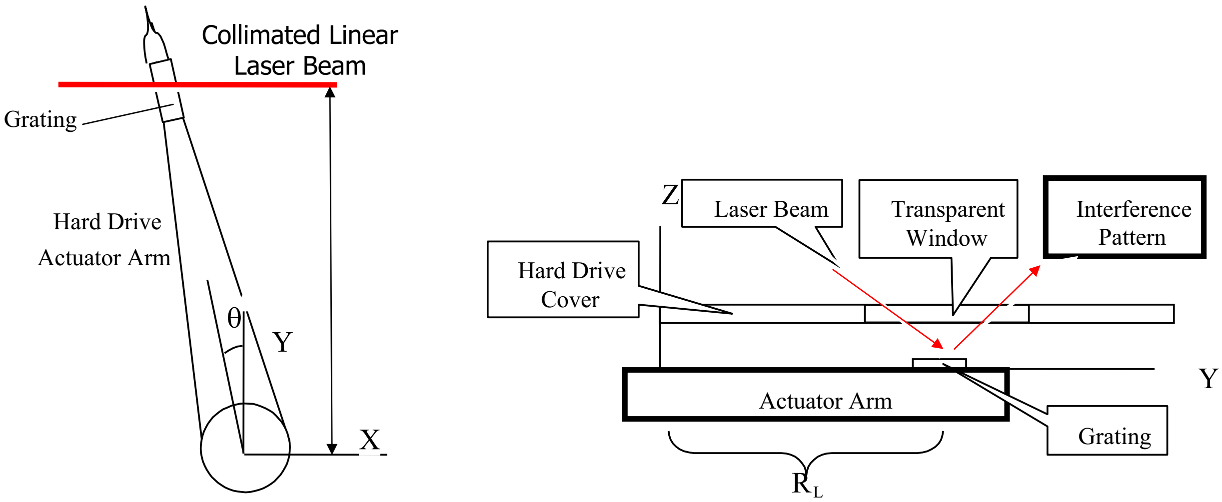
And for the m_2 and n_2 diffracted beams to overlap each other,

$$\boxed{P_2 < P_1}$$

Unlike for the single grating case, the criteria for the dual grating case are in terms of two grating period values.

An CIT application: Servo-Track Writing

special type of track written to hard drive during the final stage of manufacturing process.



(a) Top View

(b) Side View

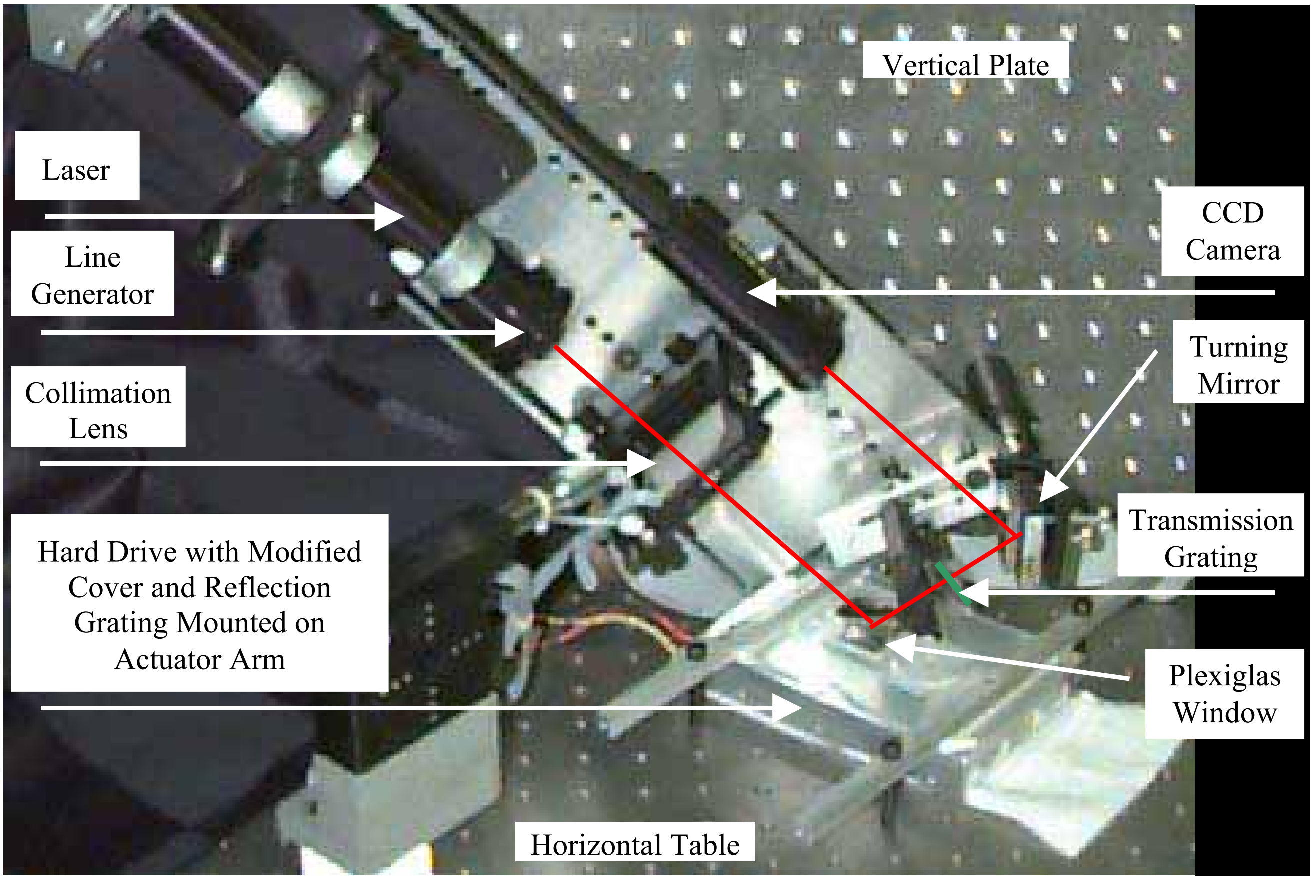
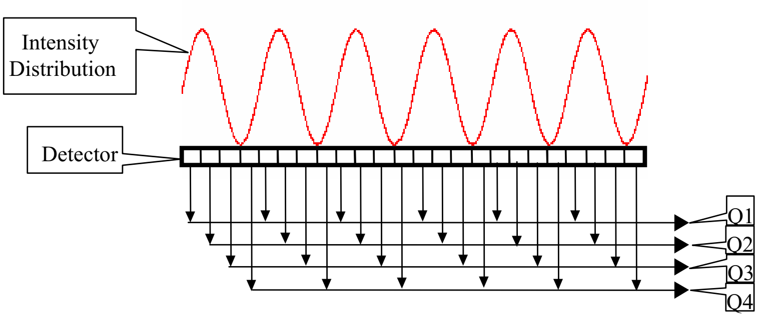
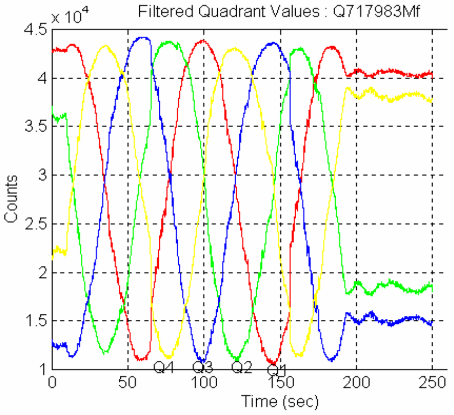


Image of **Hard Disk Drive** Experimental Setup

Rotary Stage (Motion Test)

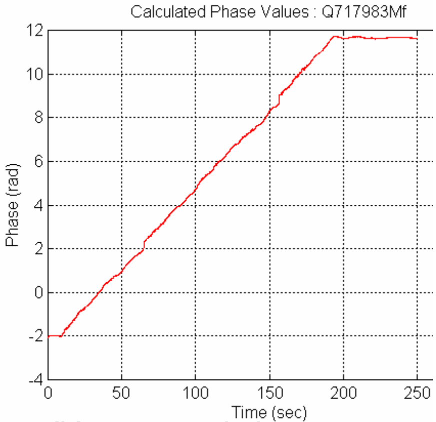




(a) Quadrant Values

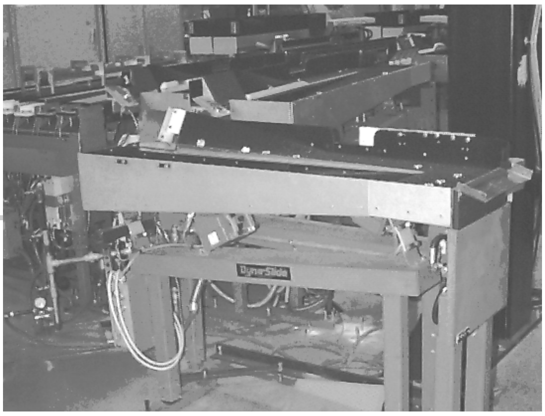
$$\Phi_1 = \tan^{-1}\left(\frac{Q_4 - Q_1}{Q_4 - Q_3}\right) = \tan^{-1}\left(\frac{\Delta Q(4,1)}{\Delta Q(4,3)}\right)$$

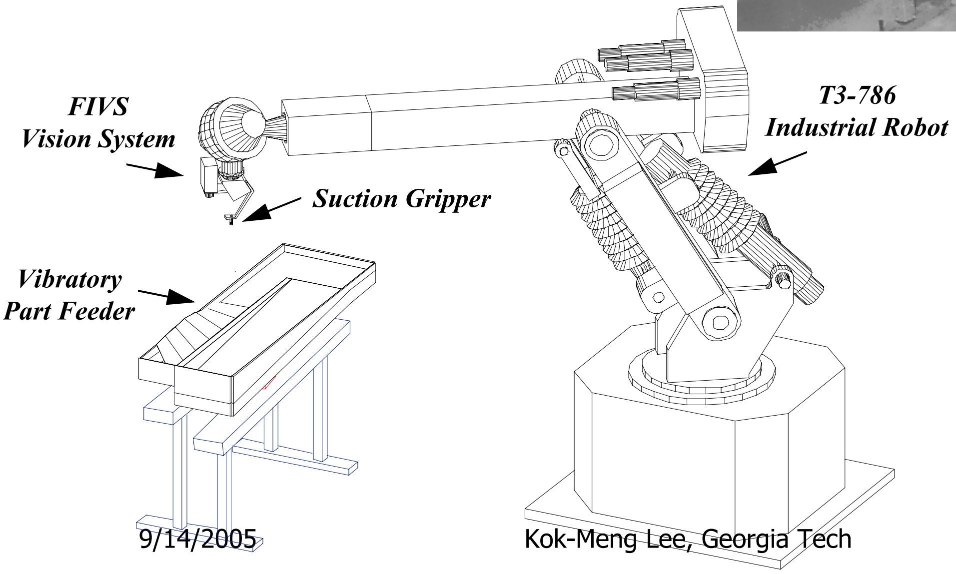
	Unfiltered Data		**Filtered Data**	
Angular displacement	**(tracks)**		**(tracks)**	
Actual	10		10	
Calculated	9.9959		10	
Difference (% Diff)	0.0041(0.0406%)		~0(~0%)	
Radius Value mm(in)	31.31(1.2312)		31.31(1.2312)	
Incr. Disp. Statistics	**(nrad)**	**(tracks)**	**(nrad)**	**(tracks)**
Mean	77.4	0.001109	77.4	0.001109
Standard Deviation	8105.3	0.116070	142.2	0.002037
Tracks per Sample	0.0011065			

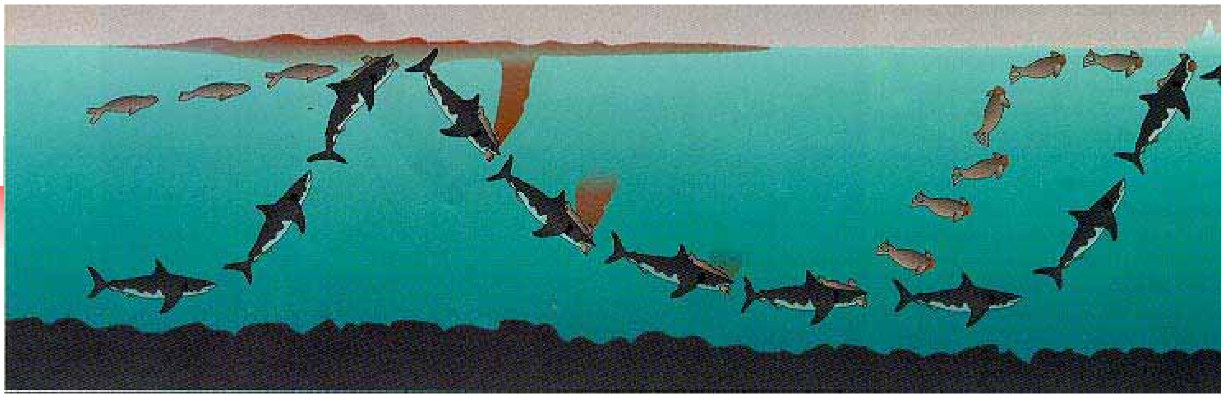


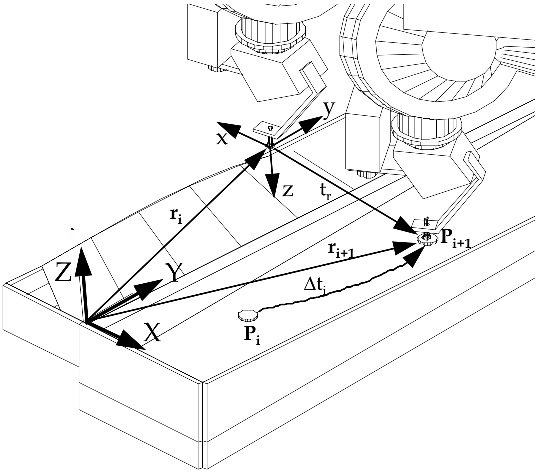
(b) Calculated Phase Values

3.3 Robotics and Automation









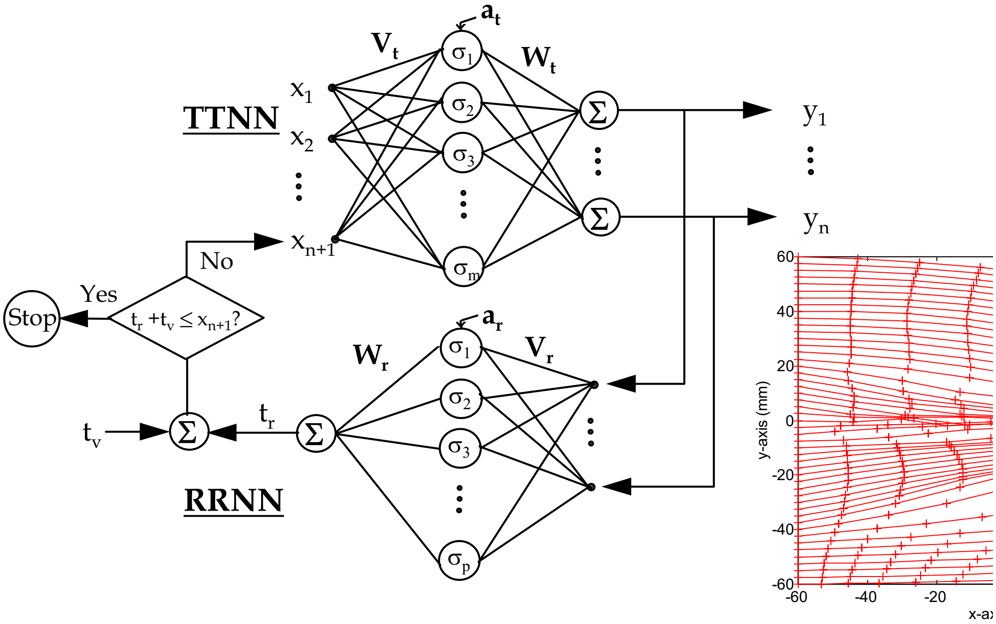
To ensure a successful pick up, the following control objective must be matched:

$$p_{i+1} - r_{i+1} \le \delta$$

where $p_{i+1} = f_1(p_i, \Delta t)$;

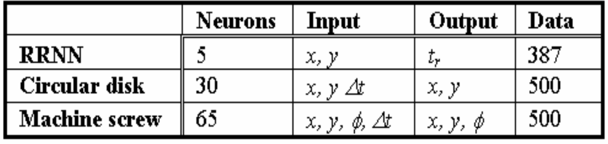
and $r_{i+1} = f_2(r_i, t_r)$

Back-propagation network training algorithm



Experimental results

Table 1 Summary of training configurations



	Neurons	Input	Output	Data
RRNN	5	x, y	t_r	387
Circular disk	30	$x, y\ \Delta t$	x, y	500
Machine screw	65	$x, y, \phi, \Delta t$	x, y, ϕ	500

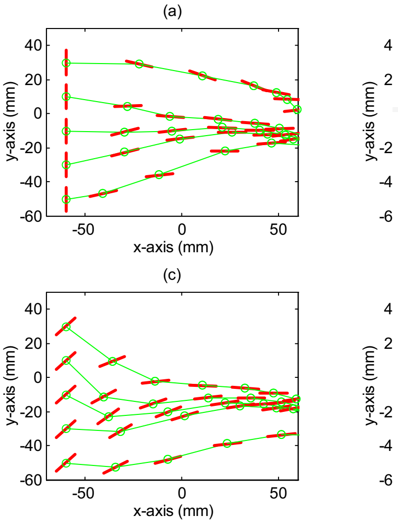
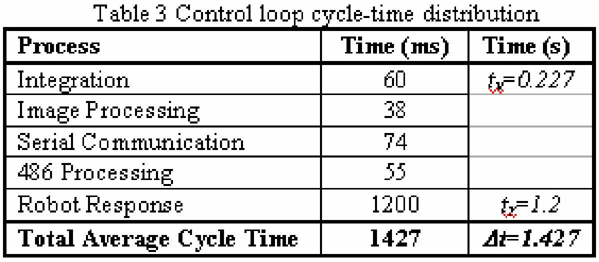
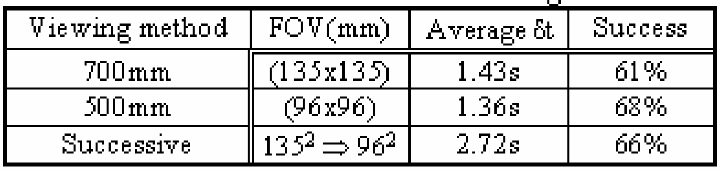


Table 3 Control loop cycle-time distribution



Process	**Time (ms)**	**Time (s)**
Integration	60	t_v=0.227
Image Processing	38	
Serial Communication	74	
486 Processing	55	
Robot Response	1200	t_r=1.2
Total Average Cycle Time	**1427**	**Δt=1.427**

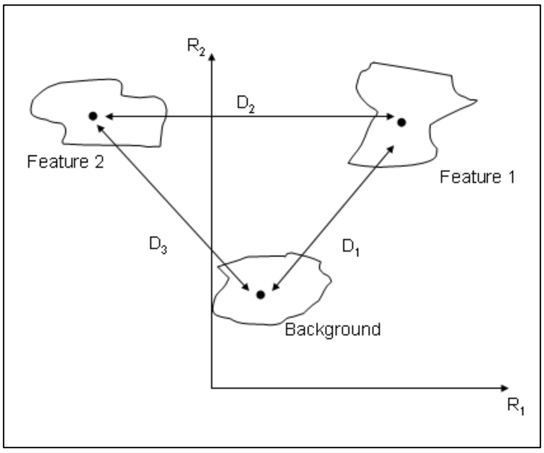
Table 4 Success rate for three different viewing methods

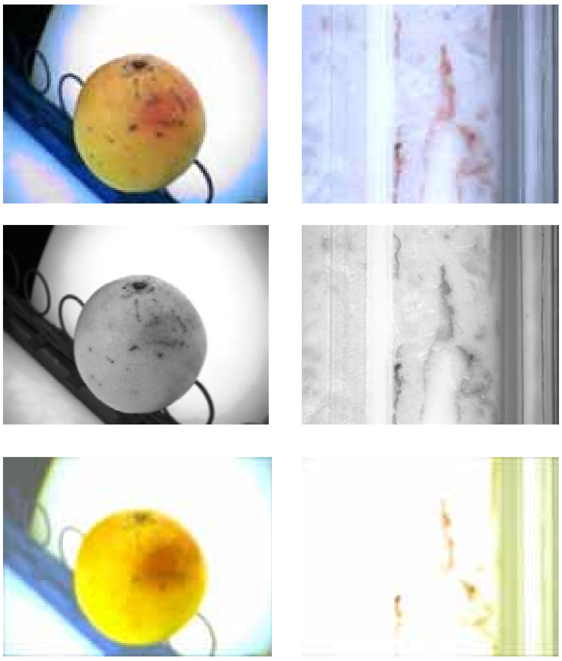


Viewing method	FOV(mm)	Average δt	Success
700mm	(135x135)	1.43s	61%
500mm	(96x96)	1.36s	68%
Successive	$135^2 \Rightarrow 96^2$	2.72s	66%

Color Vision in Food Processing

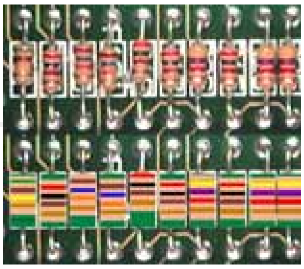
Variability in natural objects renders grayscale-based MV algorithms difficult to work.



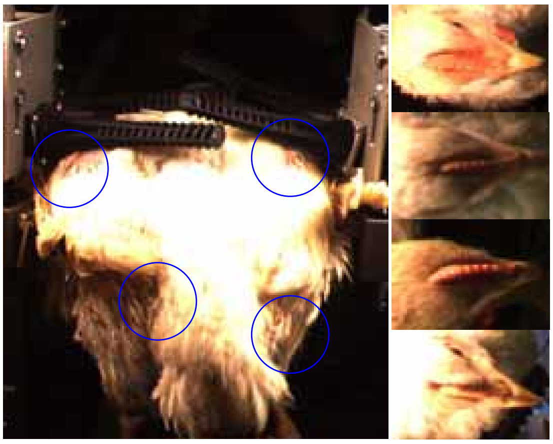


Feature Identification Based on Color

- Advantages
  - Faster than shape algorithms
  - Easy to apply when color difference between the target features and its background is significant.
- Challenges when applied to natural live object in real-time
  - Limited processing time
  - Color noise
  - Color variation and uniformity.

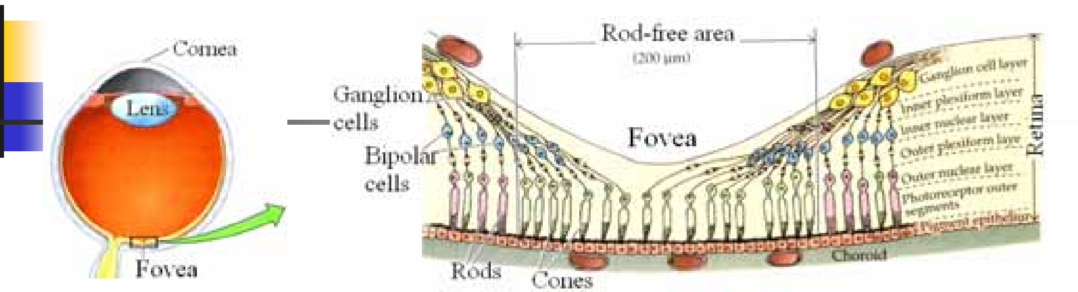


Manufactured object – Color code of resistor

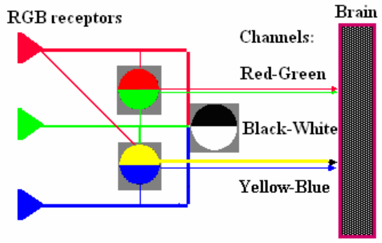


Natural live object – Chicken comb

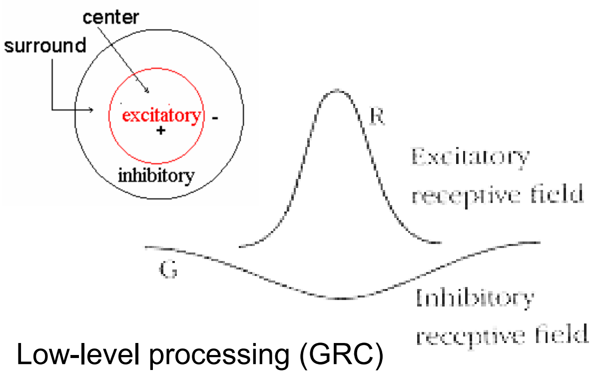
4.1 Human Vision System (HVS)



Retina Neurons: photoreceptors, bipolar and ganglion cells (RGC)

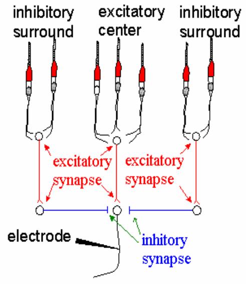


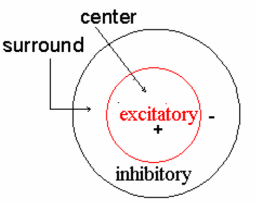
Color Vision Theories:
– Trichromacy (LMS cones)
– Opponent (Herring, 1964)



Low-level processing (GRC)

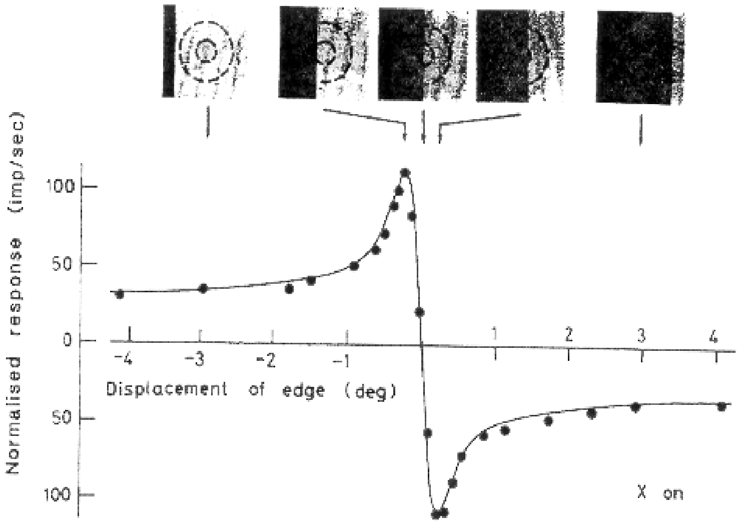
Contrast in HVS





On/Off-center

Kuffler 1953



Cat's RGC response to an edge stimulus and DoG model

Type I and Type II Surround

The Gaussian kernel

$$G_\sigma(x,y)=\frac{1}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$

The difference of two Gaussian-smoothed images

$$\boxed{h_i(x,y)=G_{\sigma c}*f_i(x,y)-G_{\sigma s}*f_j(x,y)}$$

Type I surround $f_i(x,y)=f_j(x,y)=f(x,y)$

➡ $$\boxed{h(x,y)=(G_{\sigma c}-G_{\sigma s})*f(x,y)=DoG*f(x,y)}$$

Type II surround $f_i(x,y)\neq f_j(x,y)$

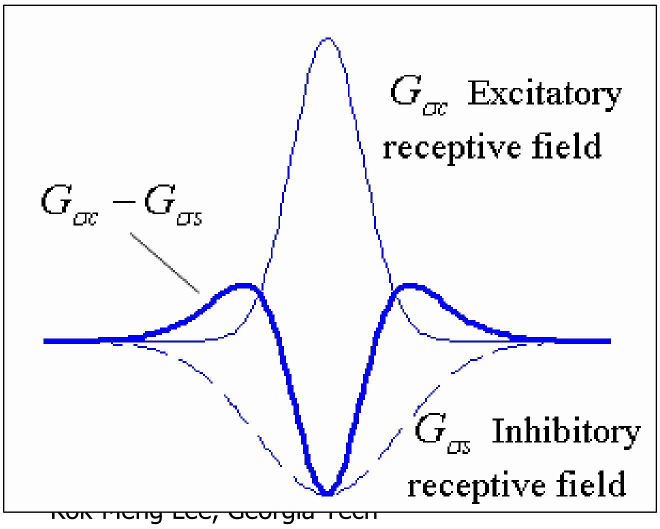
➡ $$\boxed{h_j(x,y)=G_{\sigma c}*f_i(x,y)-G_{\sigma s}*f_j(x,y)}$$

DoG Model of Receptive field

The DoG Model $DoG \triangleq G_{\sigma c} - G_{\sigma s} = \frac{1}{\sqrt{2\pi}}\left[\frac{1}{\sigma_c}e^{-(x^2+y^2)/2\sigma_c^2} - \frac{1}{\sigma_s}e^{-(x^2+y^2)/2\sigma_s^2}\right]$

Type I surround

$h_i(x,y) = DoG * f_i(x,y)$



Type II Surround

$h_j(x,y) = G_{\sigma c} * f_i(x,y) - G_{\sigma s} * f_j(x,y)$

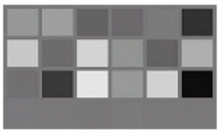

[170,110,108] [169,90,8]

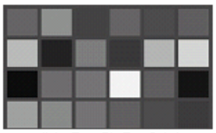
Two possible surrounds (inspired by opponent theory)

$f_{\pm(R-G)}(x,y) = \pm(R-G);$

$f_{\pm(Y-B)}(x,y) = \pm(R+G-B)$


(a) Color checker


(b) R-G of (a)

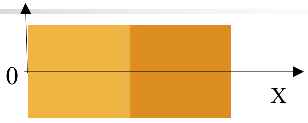

(b) R+G-B of (a)

$$h_{R_c(R-G)_s}(x,y) = DoG * R + G_{\sigma s} * G$$
$$h_{G_c(R-G)_s}(x,y) = DoG * G + G_{\sigma s} * [2G - R]$$
$$h_{B_c(R-G)_s}(x,y) = DoG * B + G_{\sigma s} * [B - (R-G)]$$

$$h_{R_c(Y-B)_s}(x,y) = DoG * R + G_{\sigma s} * [B - G]$$
$$h_{G_c(Y-B)_s}(x,y) = DoG * G + G_{\sigma s} * [B - R]$$
$$h_{B_c(Y-B)_s}(x,y) = DoG * B + G_{\sigma s} * [2B - (R+G)]$$

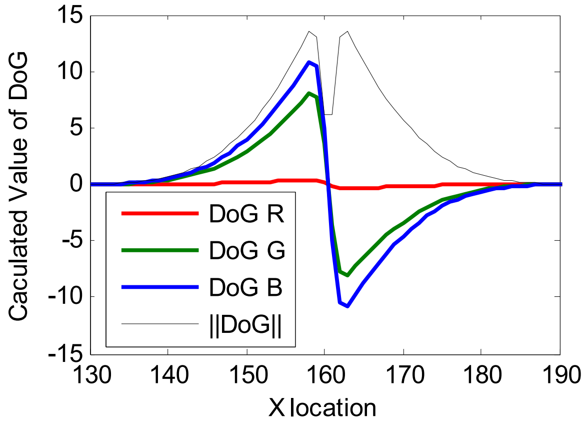
$$h_4(x,y) = h_{R_c(R-G)_s}(x,y) = DoG * R + G_{\sigma j} * G$$
$$h_5(x,y) = h_{G_c(R-G)_s}(x,y) = DoG * G + G_{\sigma s} * [2G - R]$$
$$h_6(x,y) = h_{B_c(Y-B)_s}(x,y) = DoG * B + G_{\sigma s} * [2B - (R+G)]$$

An Illustrative Example of ACC

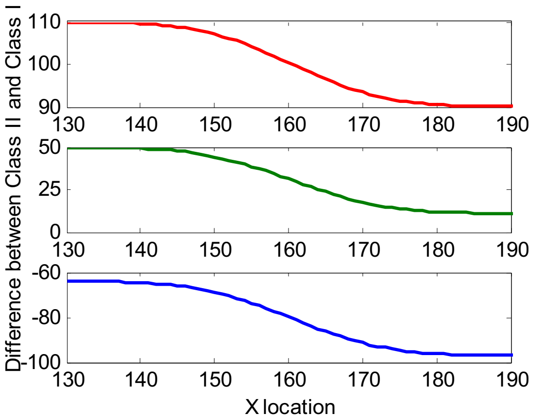


[170,110,108] [169,90,8]

[110,50,-39] [90,11,-93]

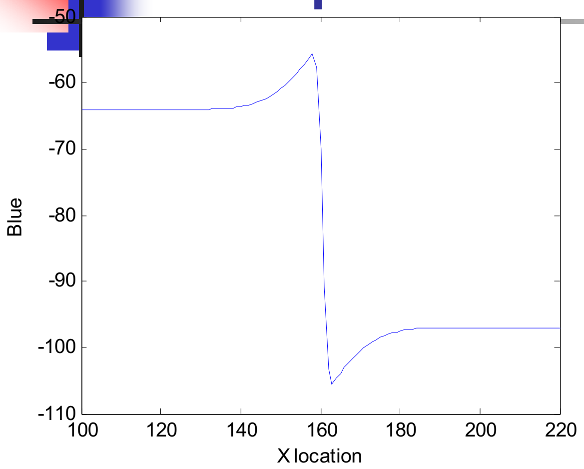


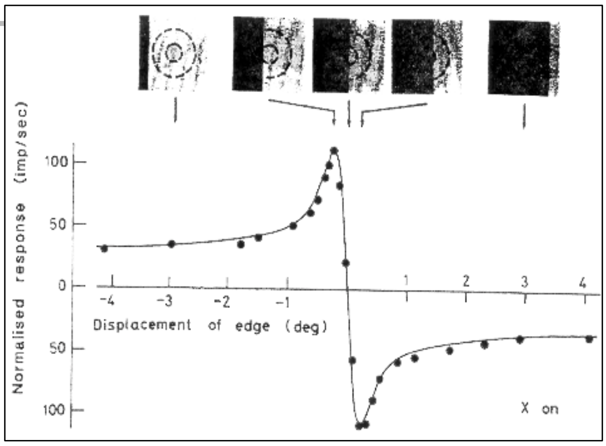
Output of Type I



Output of Type II-Type I

Comparison

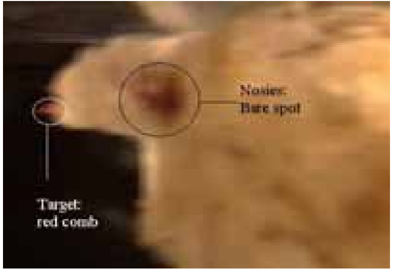


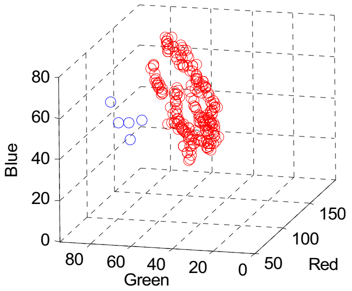


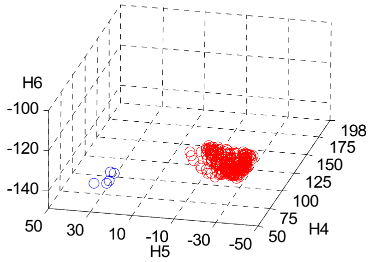
Type II output
(Blue Color)

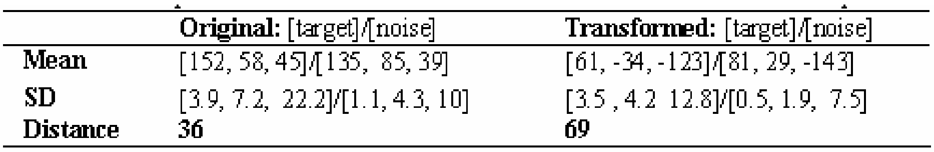
Cat's RGC response to an edge stimulus (Cugell & Robson 1984)

Color Separation with ACC Model



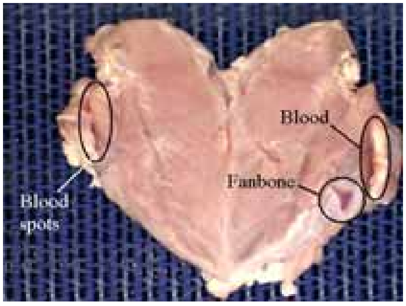


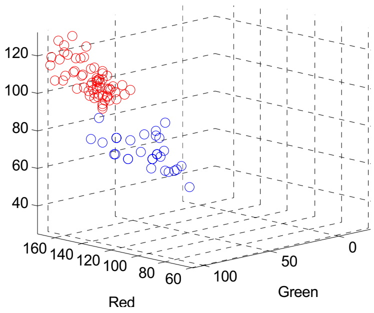




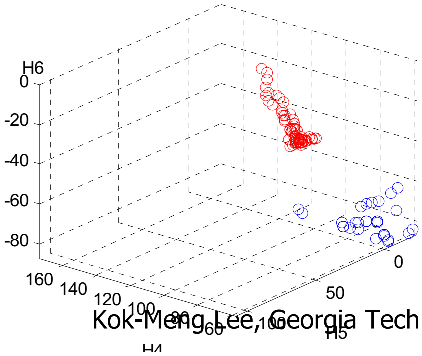
	Original: [target]/[noise]	**Transformed:** [target]/[noise]
Mean	[152, 58, 45]/[135, 85, 39]	[61, -34, -123]/[81, 29, -143]
SD	[3.9, 7.2, 22.2]/[1.1, 4.3, 10]	[3.5 , 4.2 12.8]/[0.5, 1.9, 7.5]
Distance	**36**	**69**

Fanbone Application (3-CCD)



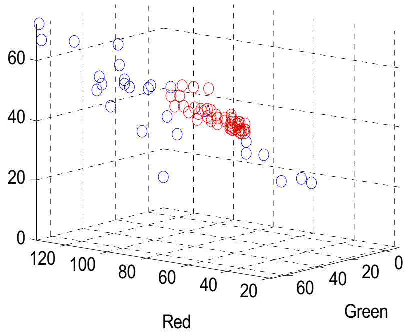


Color in RGB space (3-CCD)
Mean=[150, 92 108] /[138, 62, 67]
SD=[**4.1, 6.6 11.9**] /[5.3, 8.0, 14.0]
Distance= 52

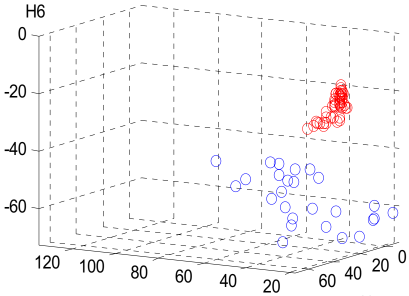


Color in ACC space (3-CCD)
Mean=[88, 30, -24]/ [70, -5 -77]
SD=[1.9, 4.1, 10.9]/ [4.4 7.1 11.9]
Distance= 67

Fanbone Application (single CCD)



Color in RGB space (1-CCD)
Mean=[67, 39, 44]/[93, 45, 45]
SD=[1.2, 2.3, 9.2]/[5.6, 9.9, 31.2]
Distance= 27

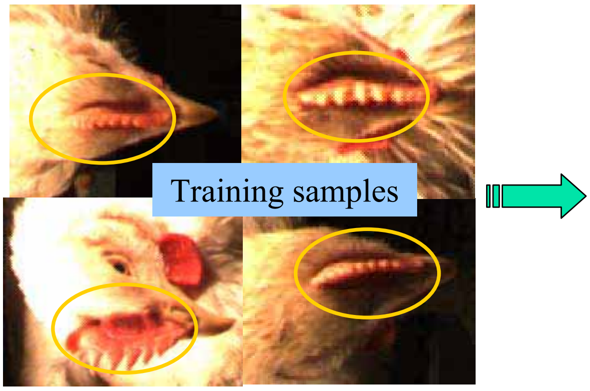


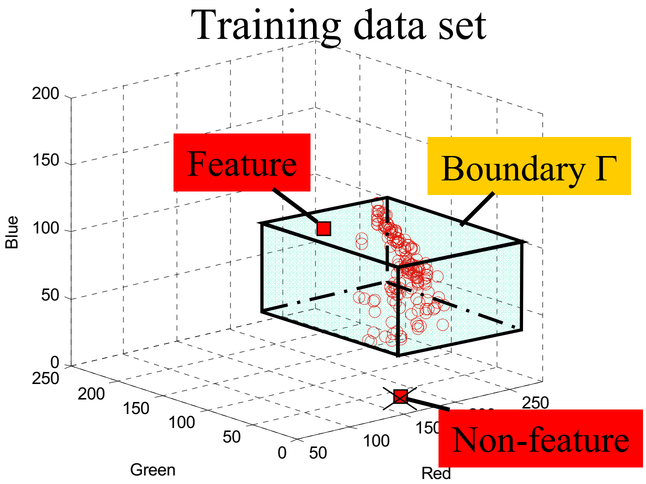
Color in ACC space (1-CCD)
Mean=[36, 9, -24]/[50, 7, 57]
SD=[**0.6, 2.0, 5.9**]/[5.1, 7.8, 18.4]

Distance= 36

Recall 3CCD without ACC
SD=[**4.1, 6.6 11.9**] /[5.3, 8.0, 14.0]

4.2 Color Identification Problem



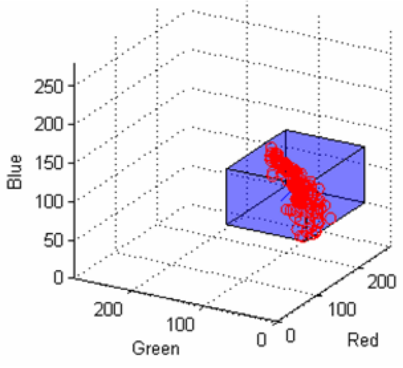


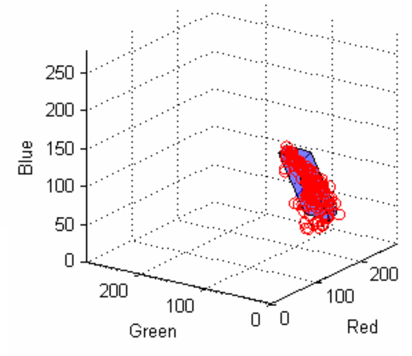
Given: a set of scatter points in target color subspace Ω
Problem: find an "optimal" boundary Γ for the following **classification**
If any C is inside Γ, then C →target feature;
otherwise, it does not belong to the feature.

Statistical, Fast Bounded Box (SFBB)

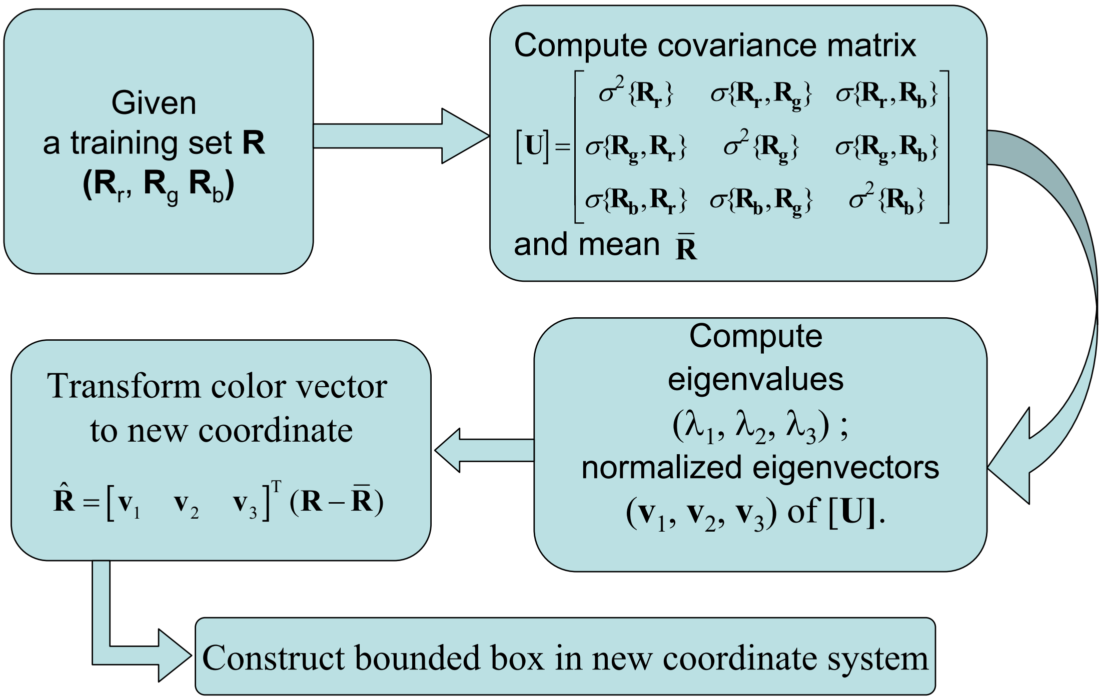
- Assumption
  - 3 color components are independent random variables.
- Problem with Simple Bounded Box
  - Does not take into account the color characteristics of the feature.
  - Not result in a tightest box;

    this larger-than-necessary box would result in introducing unwanted color pixels (as noise).
- Modification Made in SFBB
  - Minimize the correlation about the component vectors by computing the three principal axes of the training set





Training Procedure of SFBB



Given a training set **R** (**R**$_r$, **R**$_g$ **R**$_b$)

Compute covariance matrix

$$[\mathbf{U}] = \begin{bmatrix} \sigma^2\{\mathbf{R}_r\} & \sigma\{\mathbf{R}_r,\mathbf{R}_g\} & \sigma\{\mathbf{R}_r,\mathbf{R}_b\} \\ \sigma\{\mathbf{R}_g,\mathbf{R}_r\} & \sigma^2\{\mathbf{R}_g\} & \sigma\{\mathbf{R}_g,\mathbf{R}_b\} \\ \sigma\{\mathbf{R}_b,\mathbf{R}_r\} & \sigma\{\mathbf{R}_b,\mathbf{R}_g\} & \sigma^2\{\mathbf{R}_b\} \end{bmatrix}$$

and mean $\bar{\mathbf{R}}$

Compute eigenvalues $(\lambda_1, \lambda_2, \lambda_3)$; normalized eigenvectors $(\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3)$ of $[\mathbf{U}]$.

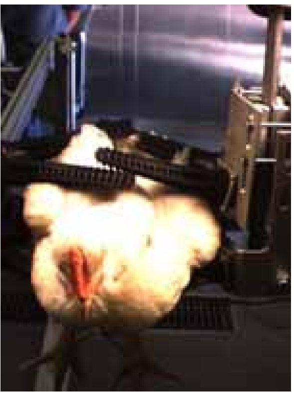
Transform color vector to new coordinate

$$\hat{\mathbf{R}} = [\mathbf{v}_1 \quad \mathbf{v}_2 \quad \mathbf{v}_3]^T (\mathbf{R} - \bar{\mathbf{R}})$$

Construct bounded box in new coordinate system

Live Object Transfer Application

Objective: To detect the orientation of the bird by identifying the comb



Requirement

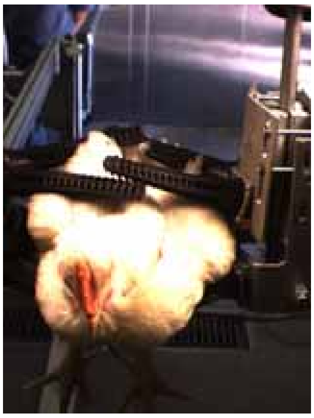
- Cycle time≤1 second.
- 99% detection rate.

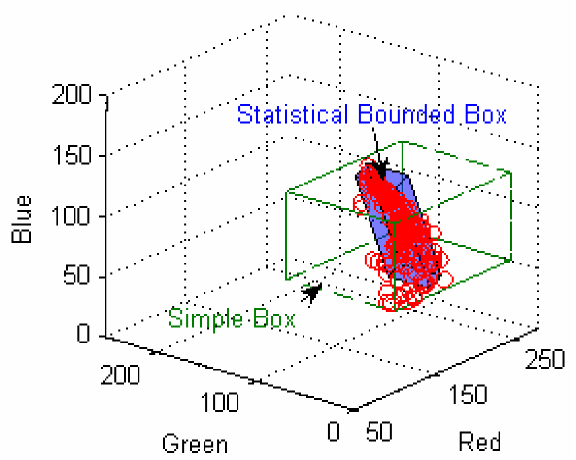
Color noise will cause false detection!

Potential noise

- Bare spots of flesh
- dirt on the feathers
- shadow and reflection of environmental illumination

Live-bird Handling Application





Mean

$$\overline{R} = (242, 112, 69)$$

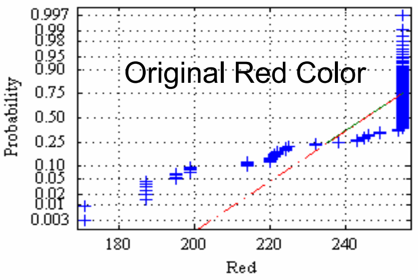
Covariance matrix

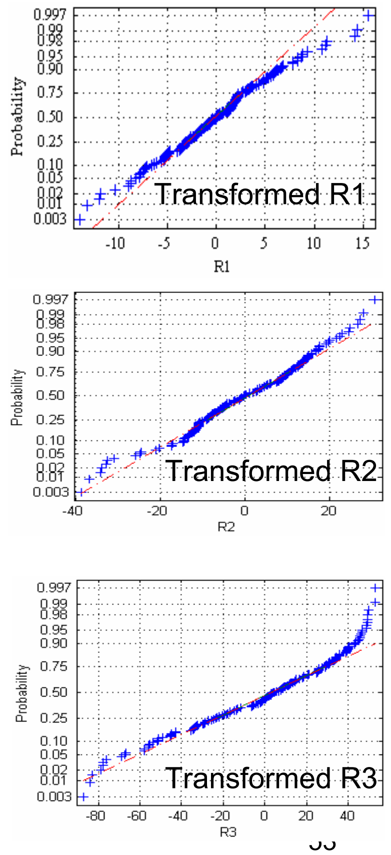
$$[\mathbf{U}] = \begin{bmatrix} 441 & 384 & 226 \\ 384 & 666 & 432 \\ 226 & 432 & 325 \end{bmatrix}$$

Transformation matrix

$$\begin{bmatrix} \mathbf{v}_1^T \\ \mathbf{v}_2^T \\ \mathbf{v}_3^T \end{bmatrix} = \begin{bmatrix} -.14 & .61 & -.78 \\ .86 & -.32 & -.41 \\ .50 & .72 & .48 \end{bmatrix}$$

Validation of Assumption of Independent Variables





If three color components are independent random variables, their distribution should be close to the ideal normal distribution.

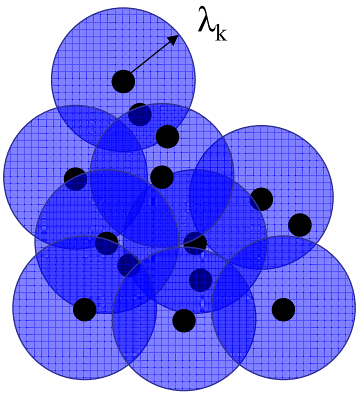
Plot relative cumulative for each point:

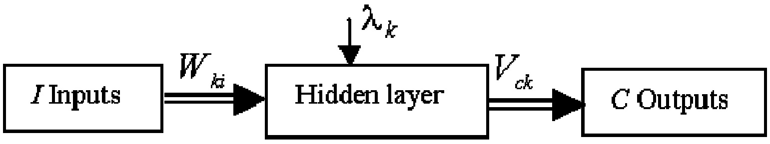
$$p(R_x) = \frac{i}{n+1}$$

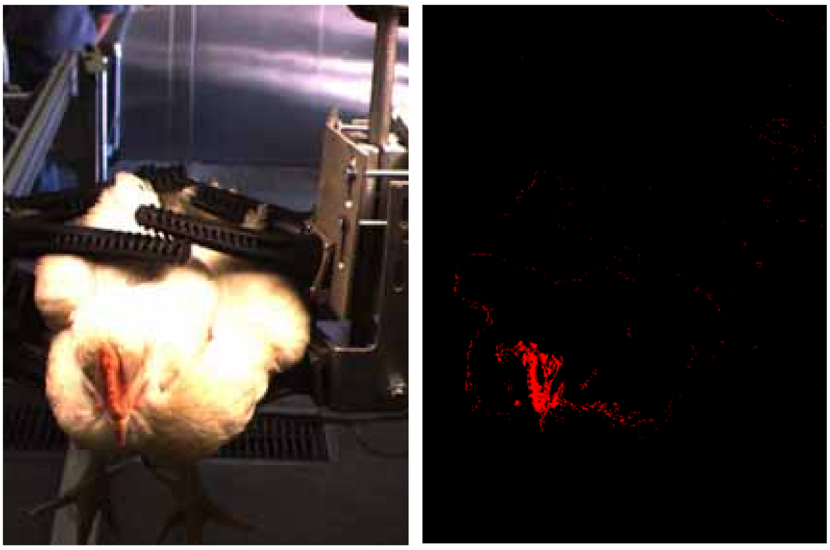
where is the index such that $X_1 < ...< X_i … < X_n$.

The transformed color component is closer to ideal normal distribution, validating our assumption.

RCE Neural Network Reilly, Cooper & Elbaum 1982





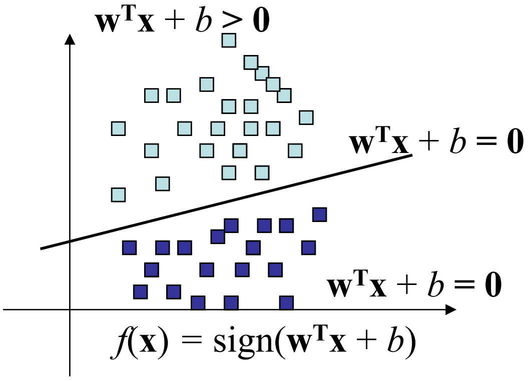


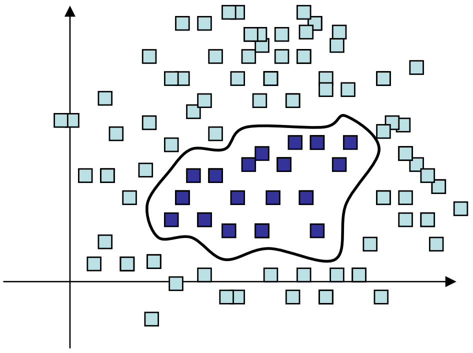
Processed image by RCE

Effect of λ_k :

- Small λ_k will slow down the speed.
- Large λ_k will introduce noise.

Support Vector Machine

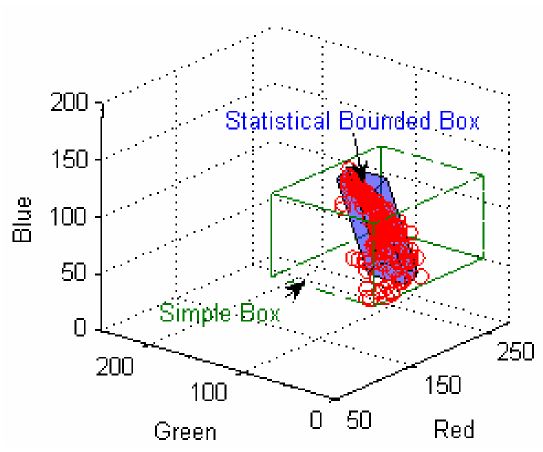


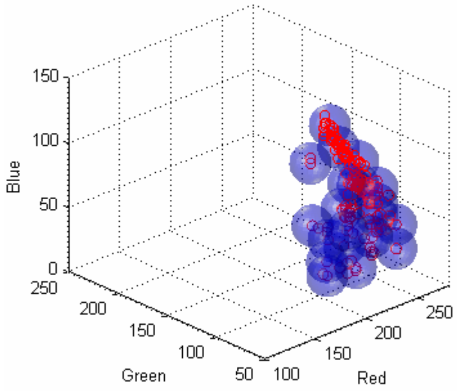


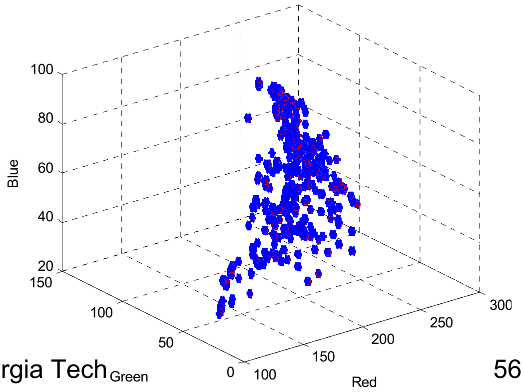
Linear Method (Vapnik, Lerner 1963) Nonlinear – kernel method

- Maximize the margin around the separating plane
- Kernel transformation

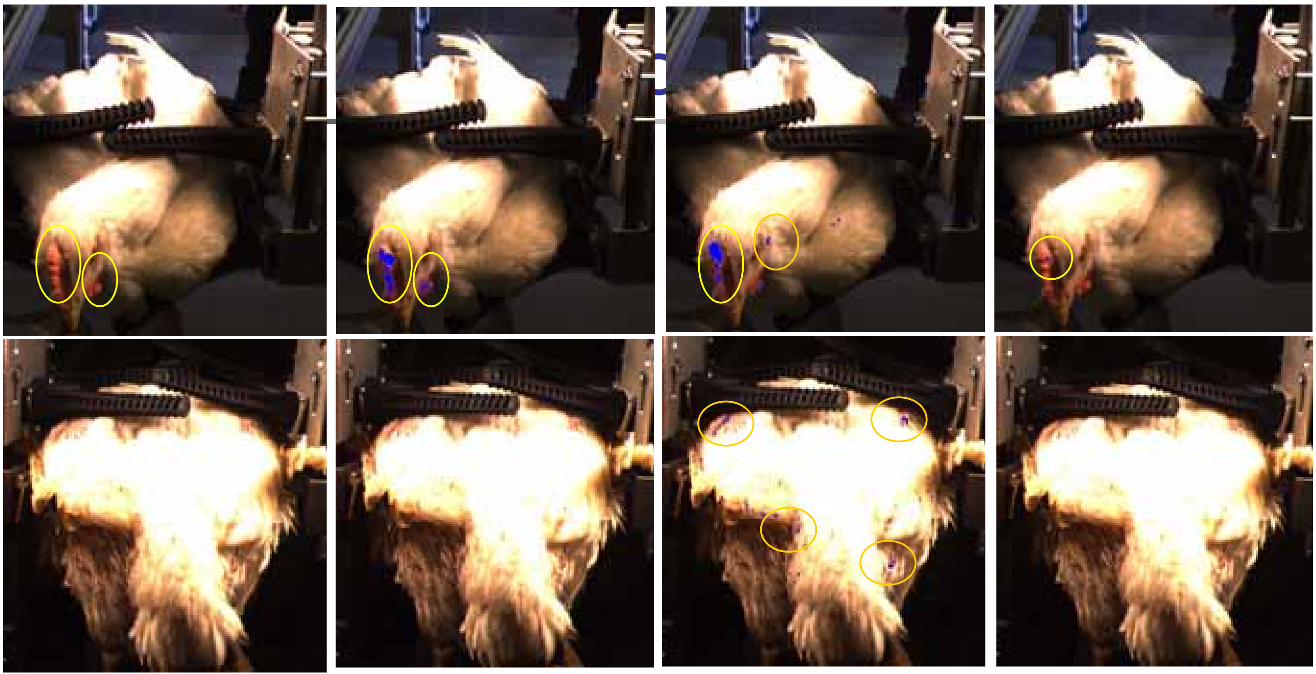
Constructed Boundary Comparison







- SFBB uses box to present boundary of feature class.
- RCE uses hyper-sphere.
- SVM uses hyper-plane (in transformed space).



Original	SFBB	RCE	SVM
Time	T	1.9T	13T
Detection Rate	99%	85%	74%

We have achieved:

- A pre-processing method (ACC) inspired by human visual system to enhance contrast between features in color space has been introduced.
  - reducing the standard deviation of the target pixels, and
  - increasing the separation between feature clusters in color space
- An algorithm (SFBB) for capturing the essential characteristics of natural color
  - SFBB simplicity in training, and fast classification
  - RCE trends to include noise while SVM trends to exclude the feature pixels

A few final words

Questions asked

FIVS developed

Algorithms for RAM applications

1980 *1990* *2000* *2010*

RS170

2. Digital vision

Motivated by mechatronics and robotics

3. Vision gauging

3.1 Multi-DOF

3.2 nano-scale displacement measurement

4. HVS-based color vision

for robotics and Automation

4.1 Artificial Color contrast

4.2 Statistical fast bound box

Needs: Gauging of multi-DOF motion (nano or better resolution)

HVS-based capability for complex RAM applications.

THANK YOU !

Presentation to Robotics DSIG

Sep 05 OMG Technical Meeting

Hung Pham

About the Presentation

- *Slashing development costs with component-based development*
  - Component-based programming
    - Benefits.
    - Software development tools as enabler.
  - *Constellation* software platform
    - Designed specifically to address challenges of component-based development of distributed, complex control systems.
  - Component-based application development in action: Autolog case-study
    - 1/4-scale prototype of heavy-lift crane for at-seas replenishment.

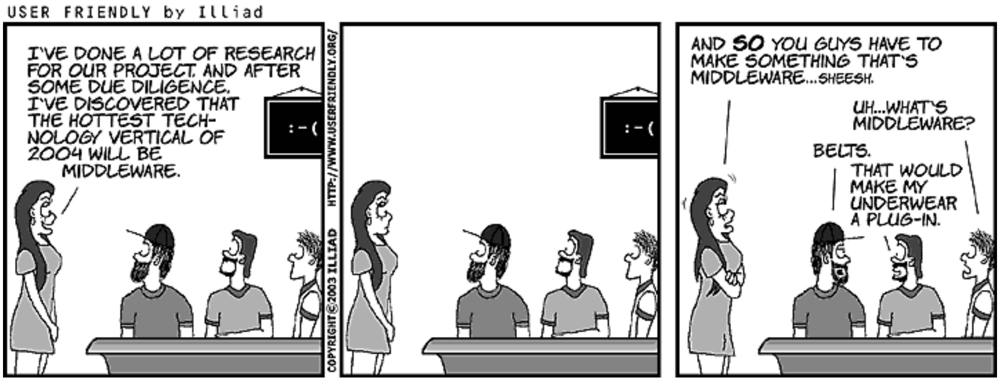
Interesting Fact

- Most elephants weigh less than the tongue of an adult blue whale.

About RTI

- Real-Time Innovations, Inc.
  - Privately-held company, located in heart of Silicon Valley, since 1991.
  - NDDS networking middleware
    - Real-time information networking for data-critical applications.

About Middleware



About RTI

- Real-Time Innovations, Inc.
  - Privately-held company, located in heart of Silicon Valley, since 1991.
  - NDDS networking middleware
    - Real-time information networking for data-critical applications.
  - Constellation software platform
    - Tool for prototype development of controls & robotics systems.
  - Professional services
    - Networked systems, robotics & control systems
      - Design consulting.
      - Specified subsystem implementation.
      - Turnkey development.
    - Training, support.

About Our Clients

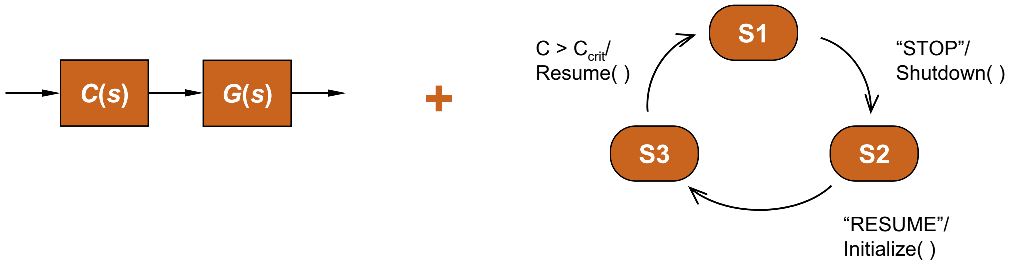
- RTI provides products and services to range of clients
  - Size
    - Small start-ups.
    - Fortune 100.
    - US DoD.
  - Applications
    - Robotics/controls
      - Surgical & humanoid robots.
      - UGV & ROV.
      - Material handling.
      - CNC manufacturing.
      - Radar tracking, *etc.*
    - Networking/communications
      - *etc.*

About Component-Based Development

- To be effective, component-based development needs technology enablers
  - Component creation & management
    - Jumpstart component creation.
    - Catalog, store, and retrieve components.
  - Application modeling & development
    - Specify relationship & causality among components.
  - Application (*i.e.*, runtime) framework
    - 'Glue' components together.
    - Allocate resources.
    - Schedule execution.
  - Testing and integration support
    - Component-level & system-level debugging.

About Complex Control Systems

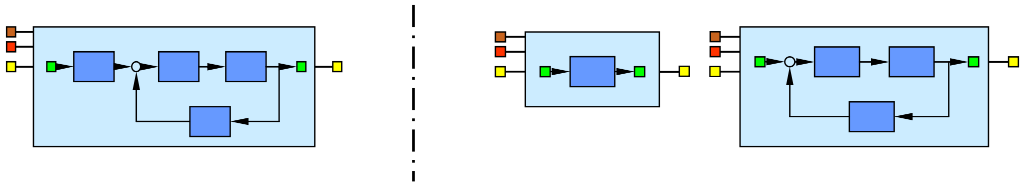
- Development of complex control systems has special set of challenges, *e.g.*,
  - Complex, modal-driven behavior requires combination of ‘periodic’ and ‘event-driven’ semantics
    - Text-based implementation often results in ‘spaghetti’ code.
    - Difficult to decipher, impossible to debug.



  - Stringent scheduling and resource requirements
    - Competing demands ⇒ Unintended consequences.

About Complex Control Systems

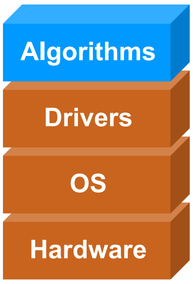
- Development of complex control systems has special set of challenges, *e.g.*,
  - Distributed deployment requires robust networking support.



  - Very high testing & integration costs
    - 1 hr of coding ⇒ 4/8/20/?? hrs of debugging, tuning, *etc.*

About Complex Control Systems

- Development of complex control systems has special set of challenges, *e.g.*,
  - Need to adapt as hardware technologies evolve
    - Devices
      - I/O.
      - Sensors.
      - Servo systems.
    - Platforms
      - VxWorks yesterday…
      - Linux today...
      - VxWorks tomorrow?



  - Multi-disciplinary team ⇒ communications challenge
    - Different vocabulary, mental models.

Summary of Observations

- Component-based application development
  - Has huge potential upside.
  - You can do development without tools…
  - But would you really want to?
- Complex control systems bring special set of challenges
  - Specific to problem domain.
  - Increases level of difficulty of component-based development.

About *Constellation*

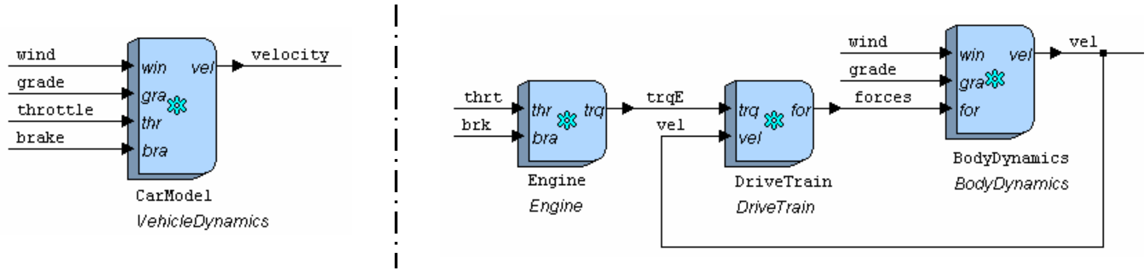
- *Constellation* is a Software Platform

Software Platform = Framework + Tools

  - Designed specifically to address challenges of complex, control systems.
  - Combines
    - Power of top-down design (graphical modeling).
    - Leverage of bottom-up synthesis (C++ construction).

Top-down: Object-Modeling

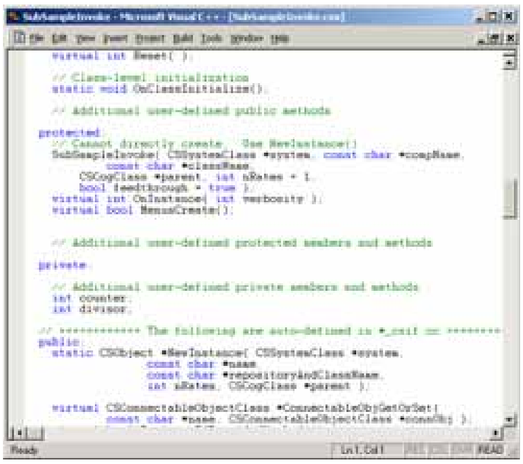
- Top-down provides the design roadmap
  - Intuitive process that divides complex problems into successively smaller parts, *e.g.*,



  - Powerful, general approach that provides the ’10,000 ft perspective’
    - Critical for problem understanding & team communications.

Bottom-up: Component-Based Synthesis

- Bottom-up provides the implementation
  - At primitive level, *Constellation* components are implemented in C++
    - Can be simple (*e.g.*, ‘x+y=z’).
    - Or complex (*e.g.*, neural net).
  - Can group components
    - Can be hierarchical.
    - Parsed at run-time.
  - Maximizes reuse.



```
    virtual int Reset( );

    // Class-level initialization
    static void OnClassInitialize();

    // Additional user-defined public methods

protected:
    // Cannot directly create.  Use NewInstance()
    SubSampleInvoke( CSSystemClass *system, const char *compName,
             const char *className,
         CSCogClass *parent, int nRates = 1,
         bool feedthrough = true );
    virtual int OnInstance( int verbosity );
    virtual bool MenusCreate();


    // Additional user-defined protected members and methods

private:

    // Additional user-defined private members and methods
    int counter;
    int divisor;

// ************ The following are auto-defined in *_csif == ********
public:
    static CSObject *NewInstance( CSSystemClass *system,
                    const char *name,
                    const char *repositoryAndClassName,
                    int nRates, CSCogClass *parent );

    virtual CSConnectableObjectClass *ConnectableObjGetOrSet(
             const char *name, CSConnectableObjectClass *connObj );
```

Case Study: Autolog System

- Develop 1/4-scale prototype of robotic crane
  - Very compressed schedule
    - Code reuse.
  - HW developed concurrently with SW
    - Role of simulations.
  - Large ‘research’ dimension
    - Extensible design.
    - Spiral development.
  - Complex control system
    - Modal-driven behavior.
    - Distributed deployment.
    - High testing & integration costs.

Autolog Background

- Mission
  - Support at-sea replenishment ops during high seas.

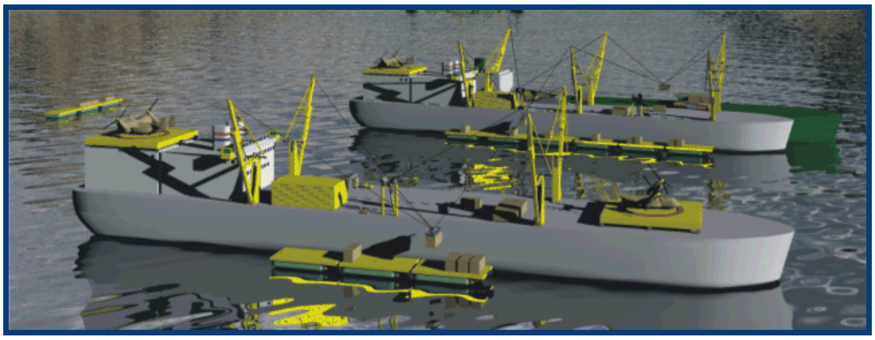
Office of Naval Research

Office of Naval Research

SEICOR CHARLESTON

More Background

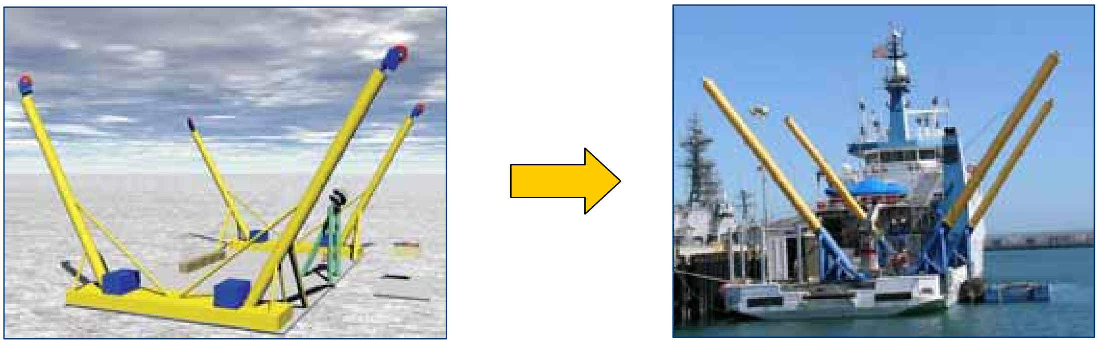
- Technology
  - Kinematically-redundant crane array
    - Motion is constrained in horizontal plane, *i.e.*, no swaying.
  - Sophisticated control system needed to coordinate motion of winches.



Existing State-of-the-Art

- Video clip

To Summarize



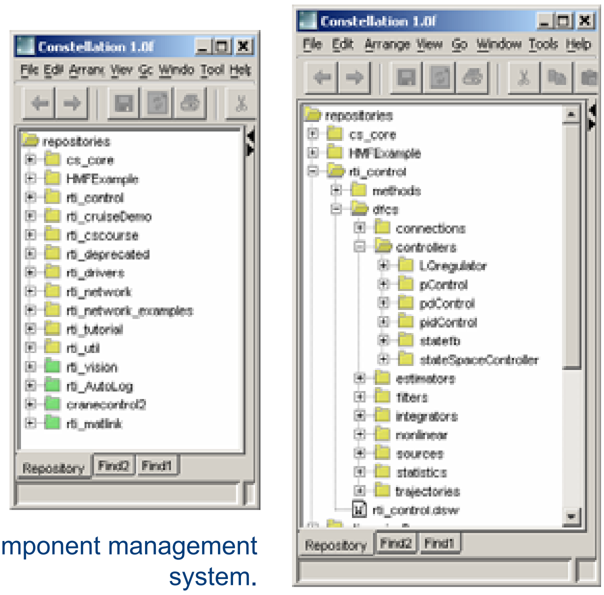
…in less than 8 months?

Challenge: Compressed Schedule

- Extreme schedule ⇒ reuse code as much as possible
  - Used standard *Constellation* components when possible.
  - Scavenged code from 1/6-scale prototype developed at Penn State, circa 1999
    - Application design pattern
    - Components
      - Provided starting point.
      - Most were eventually modified, or eliminated.
    - **KEY:**
      - Self-documenting diagrams.
      - Multiple levels of documentation at component-level.
      - Enabled naïve engineer to quickly grasp legacy system within days.
  - System initially up and running in weeks, not months.

Component Repositories

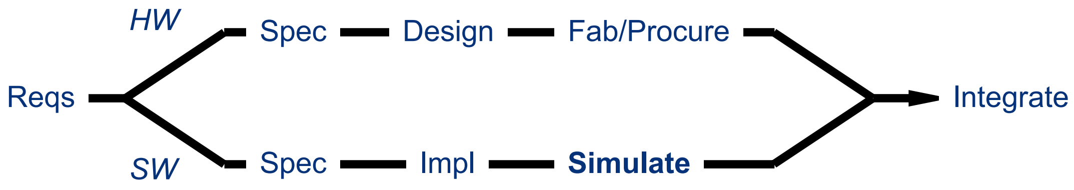
- Repository management system helps with
  - Storing.
  - Sorting.
  - Searching.
  - Documenting.
  - Sharing.



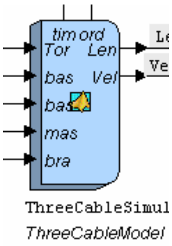
Component management system.

Challenge: Concurrent Development

- HW system developed alongside SW system



  - Long lead times on HW, but cannot pause SW development
    - Needed ability to swap-out ‘simulated HW’ components whenever real HW components became available.
    - **KEY:**
      - Well-defined component interfaces.
      - Seamless integration with Simulink.



Challenge: Technological Risks

- Project had very large research dimension
  - Autolog requirements included many features that were
    - Risky.
    - Technologically unproven with 1/4-scale system, *e.g.*,
      - Sufficient actuator BW?
      - Un-modeled dynamics?
  - Adopted strategy of adding incremental capability
    - Failure to solve a specific technological challenge does not ⇒ overall mission jeopardized*, e.g.,*
      - Point-to-point control.
      - Path-planning.
      - Scheduling, sequencing.
    - **KEY:**
      - Component-based architecture.
      - Ability to easily reconfigure system by modifying diagrams.

Challenge: Modal-Driven Behavior

- In *Constellation*, modal-driven behavior is modeled graphically ⇒ increased clarity.

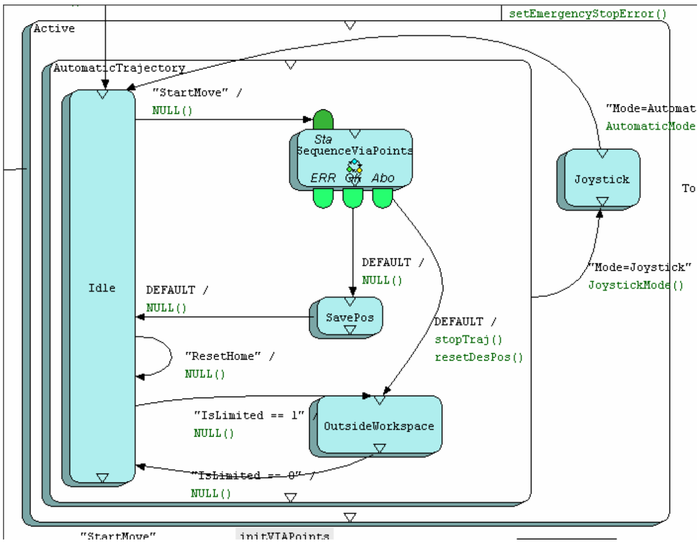
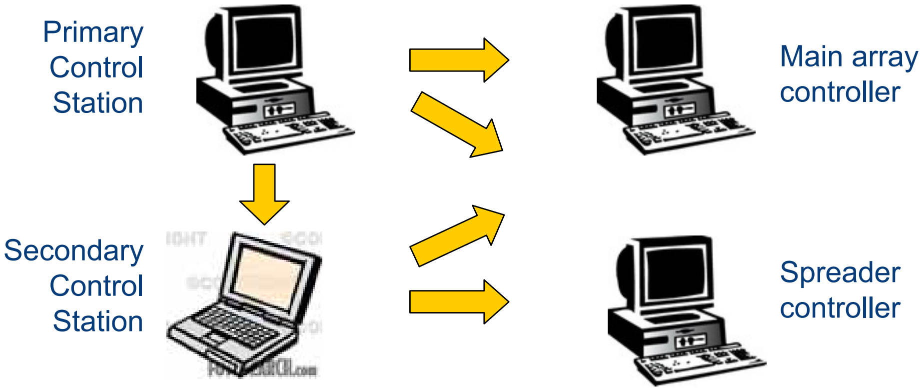


Diagram describes transition between ‘automatic’ & ‘teleoperated’ modes of operation.

Challenge: Distributed Deployment

- System can be deployed on between 2-4 nodes
  - Need to move seamlessly among different configurations.



Primary Control Station

Secondary Control Station

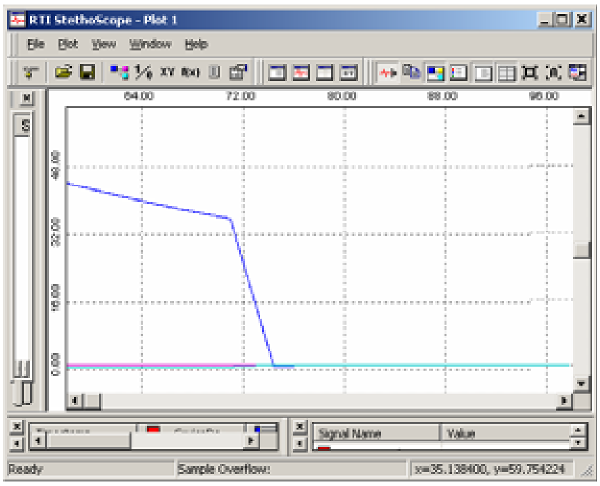
Main array controller

Spreader controller

- **KEY:**
  - ‘Anonymous’ pub-sub eliminated need to specify address of sender or receiver.

Challenge: Testing & Integration Costs

- Plot signals in real-time
  - Capture events.
  - Verify parameters.
  - View disturbances.
  - Check computation.
  - Especially useful for catching hard-to-repeat bugs
    - *i.e.*, when have to run system for long time catch bug.



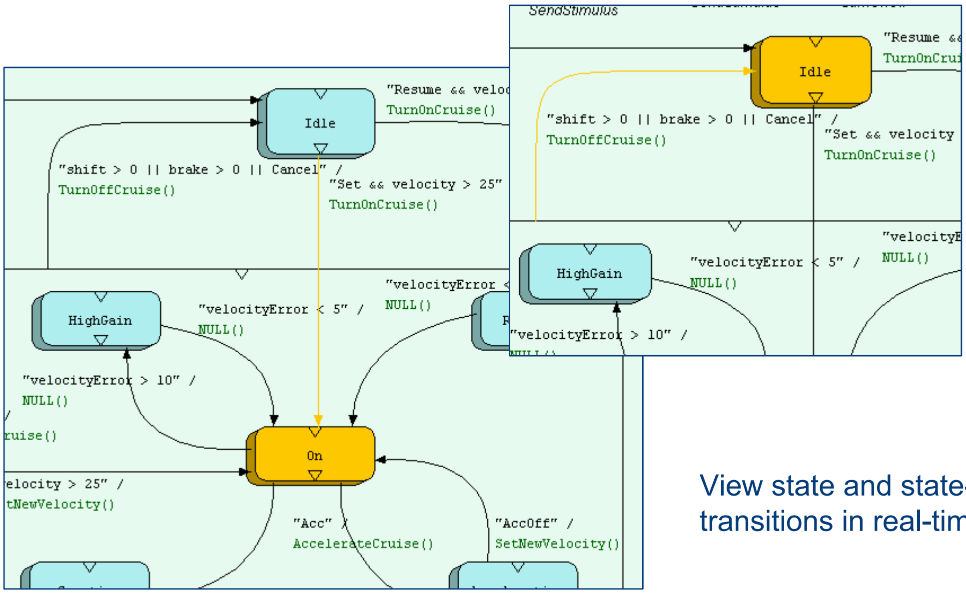
Ready

Sample Overflow:

x=35.138400, y=59.754224

Challenge: Testing & Integration Costs

- Trace execution to understand how system responds to stimuli



View state and state-transitions in real-time

Challenge: Testing & Integration Costs

- Trace execution to understand how system responds to stimuli
  - Especially useful for verifying
    - Startup and shutdown sequences.
    - Fault-detection and fault-handling implementation.
    - Transition between different operating regimes, *i.e.*,
      - Tele-operated or manual control *vs.*
      - Closed-loop control.

Challenge: Testing & Integration Costs

- Interact with application through command-line (shell)
  - Start/pause execution of individual threads of execution
    - Key uses:
      - Debugging individual threads of execution.
      - Avoids having to shutdown entire system unnecessarily if only need to pause, *e.g.*, when someone wanders into the workspace.
  - Change sampling rate(s)
    - Key uses:
      - Tune control system performance.
  - Insert/remove components from execution list
    - Individual components, or entire hierarchical groupings.
    - Key uses:
      - Check whether bug is being introduced by a particular component.

Challenge: Testing & Integration Costs

- Interact with application through command-line (shell)
  - Modify/view signal values
    - Key uses:
      - Verify computation.
      - Tune control parameters.
  - Invoke ‘menu’ methods.
    - Key uses:
      - Execute user-code on demand.
  - FSM interaction
    - Inject stimulus.
    - Force state transitions.
    - Key uses:
      - Verification of system implementation.

To Summarize

- Summary
  - To be effective, component-based development needs technology enablers
    - Demonstrated this point with proto-type development of the Autolog prototype.
  - To be truly successful, needs STANDARDS
    - From software tools perspective, this point is critical because
      - Customers do not want to be locked into someone else’s proprietary solution.
      - Standards will increase development component development activity.

Korean intelligent robot standardization status

September 14, 2005.

Yun Koo Chung

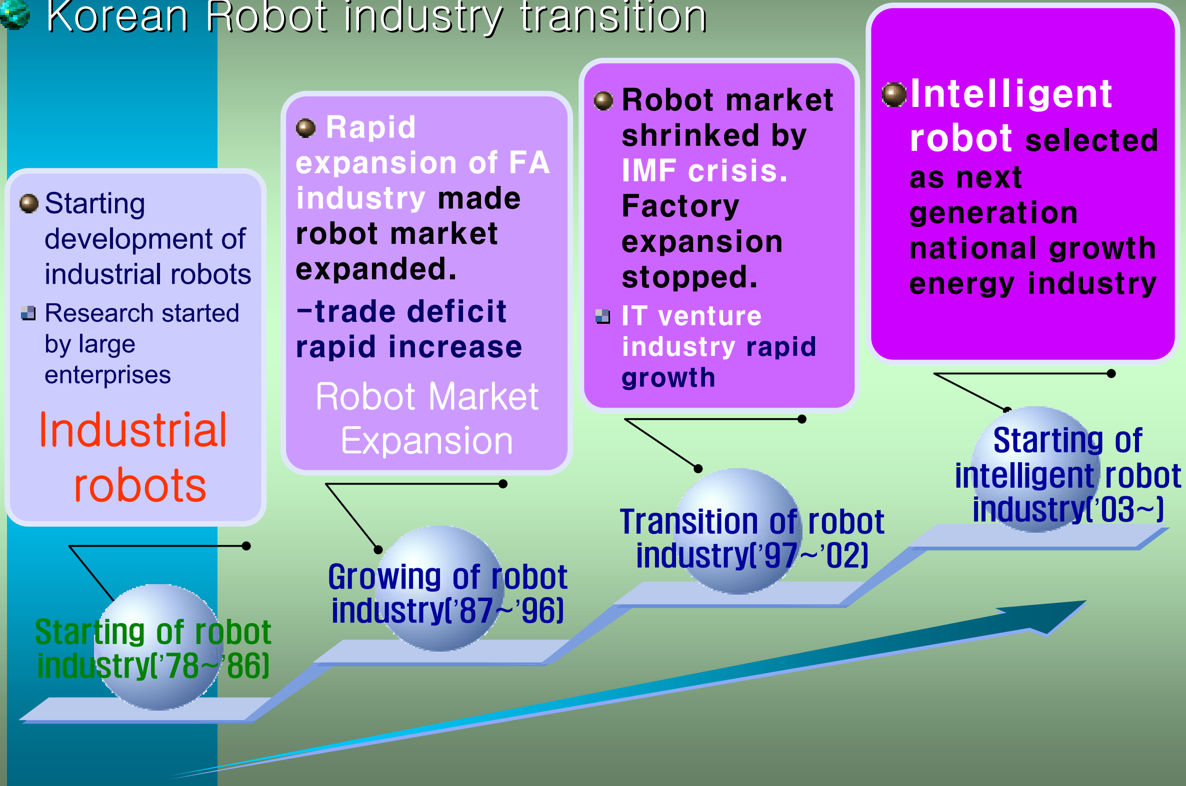
Intelligent Robot Research Division

Electronics and Telecommunications Research Institute

Contents

I. Backgrounds

Korean Robot industry transition



- Starting development of industrial robots
  - Research started by large enterprises

Industrial robots

Starting of robot industry('78~'86)

- **Rapid expansion of FA industry made robot market expanded.**

-trade deficit rapid increase

Robot Market Expansion

Growing of robot industry('87~'96)

- **Robot market shrinked by IMF crisis. Factory expansion stopped.**
  - **IT venture industry rapid growth**

Transition of robot industry('97~'02)

- **Intelligent robot selected as next generation national growth energy industry**

Starting of intelligent robot industry('03~)

Paradigm Change

Industrial soceity → Information & Intelligence society

Industrial robot

Productivity increase

Repetitive task

- Tech. Innovation (Aibo, Asimo)
- Social needs change

Intelligent Robot

Improving living quality

Intelligence / Autonomous action

Definition & Classification of Intelligent Robot

- To **perceive** external environment
- To **make a decision** to the situation by himself
- TO **act and manipulate** autonomously

Intelligence robot includes function distribution and activation in the virtual space

Ex) network based service robot, software robot

classification	**Service Robot**		**Industrial Robot**
	Service Robot for Personal Use	Service Robot for Professional Use	

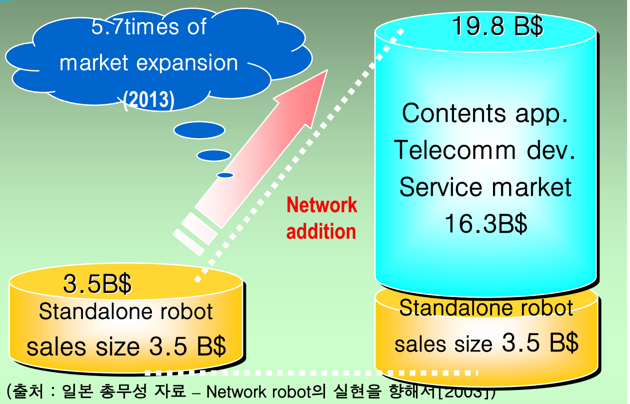
source : IFR (International Federation of Robot]

II. Market states

	Forcasted market amounts	
	2010	2020
World market(USD B$))	150	500

Korean market size (USD B$)		2010	2020
Korean market size (USD B$)	Indus. robot	4	40
	Service robot	6	60
	total	10	100

(source: IFR World Robotics 2002, 21C FA Vision, 2002, KIID, 2003)



5.7times of market expansion (2013)

3.5B$ Standalone robot sales size 3.5 B$

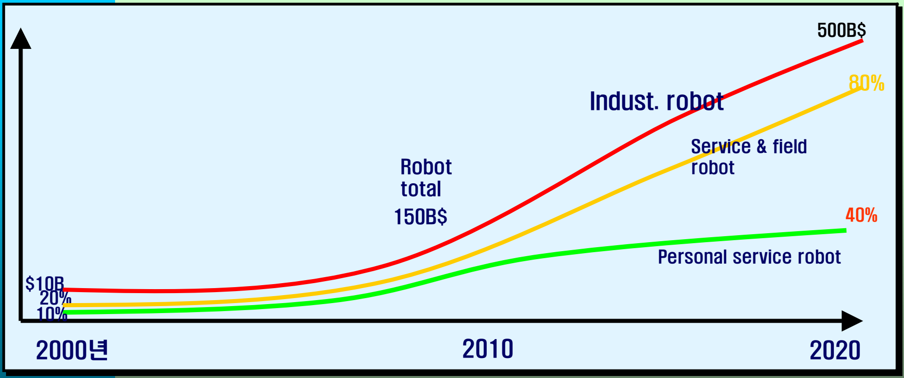
Network addition

19.8 B$

Contents app.
Telecomm dev.
Service market
16.3B$

Standalone robot sales size 3.5 B$

(출처 : 일본 총무성 자료 – Network robot의 실현을 향해서[2003])



(Source: IFR UN-ECE, World Robotics 2000, Litsubishi Lab, 21C Tech.& Ind.(1999. 4))

Korean Market status

- ❑ Korean domestic market size 1.8B$
  - ➢ Korean robot market, 1.4B$ (including industrial robots of semiconductor industry and CNC ind.)
  - ➢ mid,small & venture business: total sales amount of 98 companies in 2004, 300M$
    - – 90% is for manufacturing robots (source:2005 robot industry state survey, MOC,'05.4)
  - ➢ Korean robot market ranked in 6th, Korean robot unit size: 5th (IFR report)
  - ➢ Large enterprises: 13, Mid&small companies: **120**
- ❑ Korean robots: export- 200M$, import: 110M$

(2004 IFR report)

Overseas states

Japan

- Leading the world market of intel. robots with manufacturing robots
- Robot industry is selected as one of Japan's 7 growth industry fields ('04)
- '21C robot challenge program ['04]
- Development of network robot tech. started['04]

USA

- Leading the most advanced robot system and A.I. Research
- Robot production is ranked in 2nd in worldwide
- Research & development in military, space and security area are strong
- medium/small companies have key role (iRobot, Evolution Robotics)

German

- Leading development of robot tech. In EU
- 3rd robot production, 2nd robot use in the world
- Research of visual based robots is very active

Etc.

- EU: 40% of worldwide industrial robot production, Collaborative research such as EUREKA, ESPRIT, BRITE, TELEMAN, etc.
- China: Pursuing 10 national projects of robot development as 10th 5year plan

III. URC project introduction : IT-based ISR Project

Vision

Ubiquitous Robotic Companion(URC)

Objectives

Top 3 ISR production country by 2007 (Market share 20%)
Development of Core Technologies for IT based ISR

Initial Market Creation

Market Enlarge-ment

Market Lead

Strategies

1st Step (~'07)

- Set up a strong TFT (PM)
- Design a new concept of IT-based ISR (Cost/ performance(benefit))
- Create a initial market applicable to Digital Home Program (Test bed)

2nd Step ('08~'11)

- Standardize & open platform
- Develop various core technologies
- Find various Killer-applications

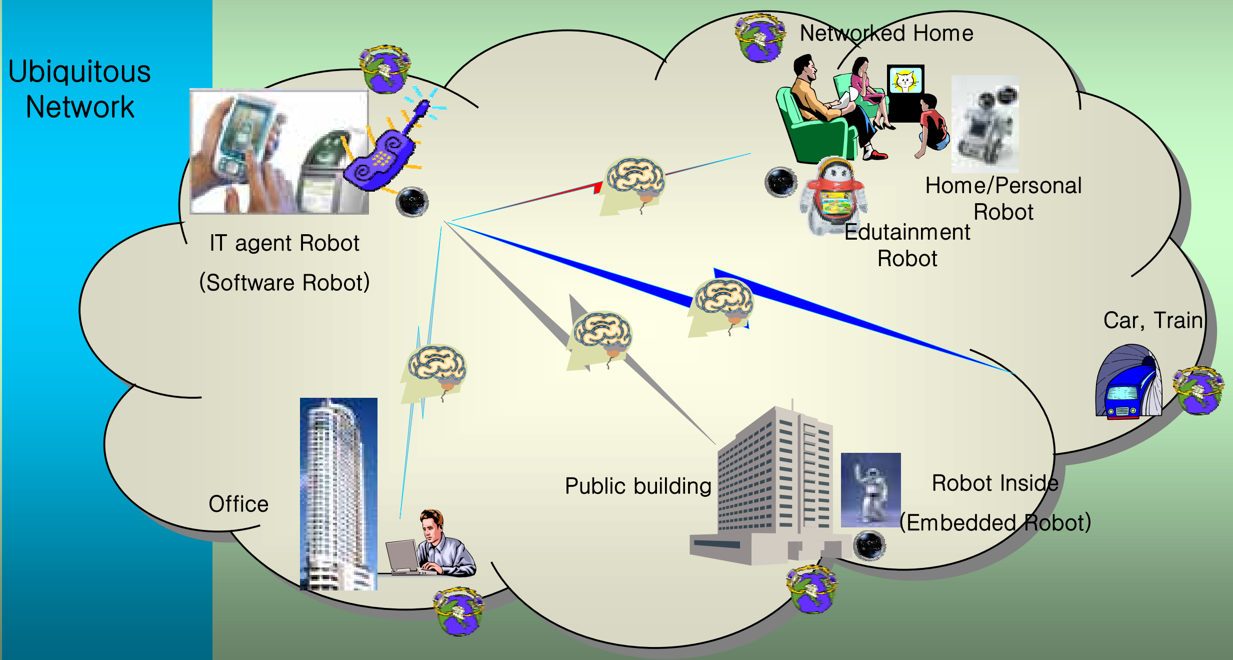
3rd Step ('12~'15)

- Level up technologies and products
- Application to other industries

The Concept of URC

A Robot which provides various required services "whenever" and "wherever"

→ Robot Tech. + Information Telecommunication Tech. (Worldwide best IT infra systems)



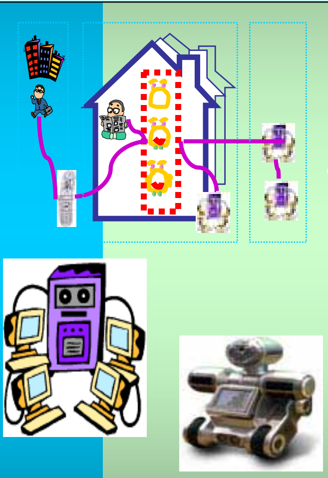
R&D Participants of URC Grand Project

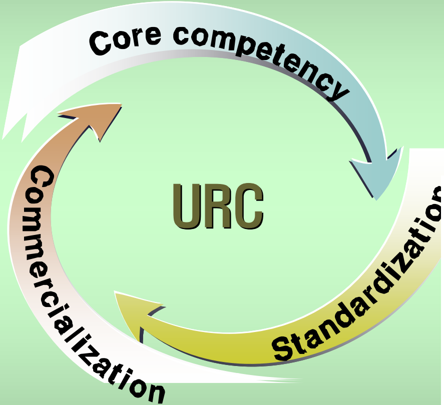
① URC Infra System Technology

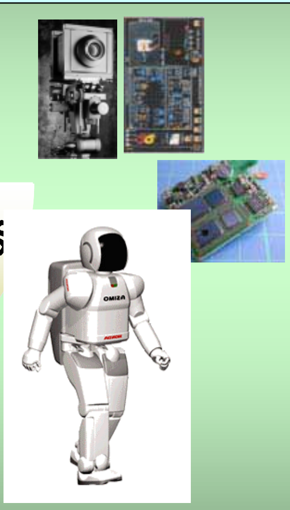
ETRI /
3 companies

② Embedded Component Technology

ETRI / 8 Universities /
10 companies







③ Information Service Robots

5 Industry Consortiums(16 companies)

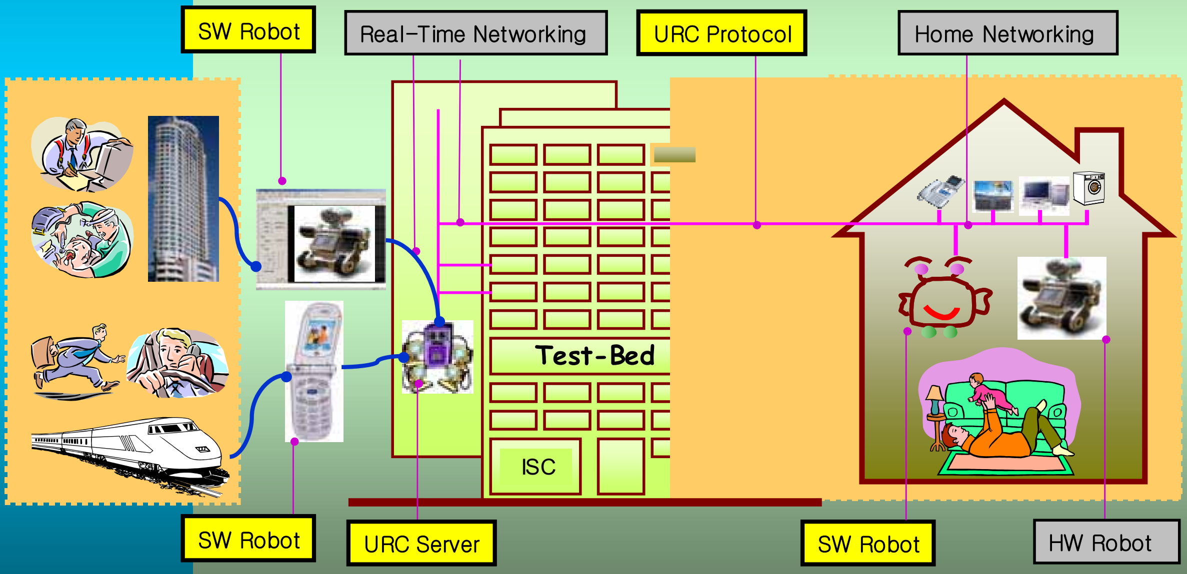
④ Humanoid Technology

KIST / 4 Universities /
2 companies

URC Infra System Research Introduction

IT Infra System supports robots providing all necessary services at anytime and any places

- Software robot tech.: movement and transition to various devices (whenever, wherever)
- URC protocol techn.: real-time service and security protocol (through the Network)
- URC server based service tech. :high usability server and URC various services



Research Objective of URC Infra System

To develop the URC infra system that provides necessary services whenever and wherever, to implement practical URC services in test-beds, and to innovative robot technology through supporting the URC commercialization

URC S/W Robot	Development of context-aware software robot that moves into portable devices and provides seamless services while interacting with human
URC Network System	Design and implementation of wired/wireless networking technology supporting QoS
URC Protocol	Development of secure protocol and API between robot and Server
URC Server	Development of a URC clustering server system with high availability supporting real-time performance for 400 simultaneously connected users

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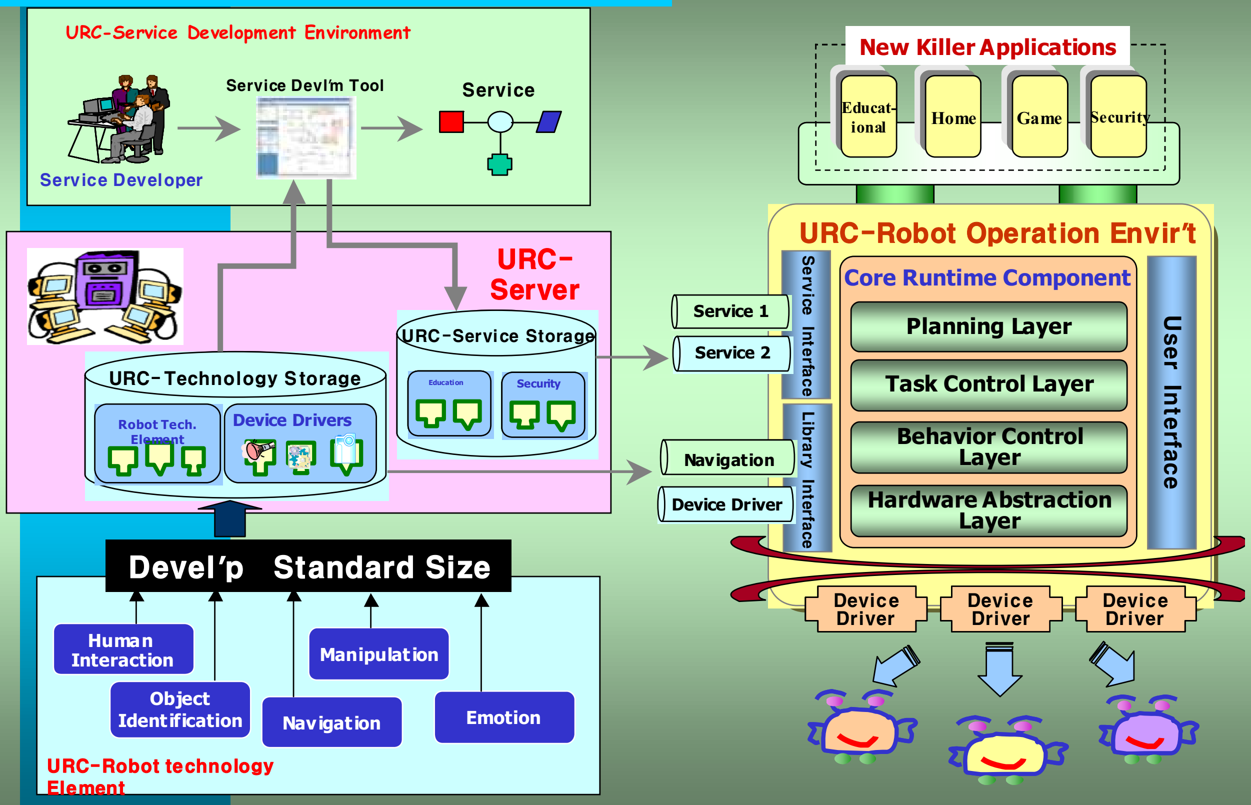
URC Embedded Component Technology Research Introduction



Research Objectives of URC Embedded Component Technology

To develop core H/W or S/W components constructing URC, focusing on enabling technologies that maximize the commercial value of IT-based networked robots

Intelligent Task Control Tech.	Development of S/W components for navigation, localization and task control
Human Robot Interaction Tech.	Development of S/W components for natural human-robot interaction based on vision and voice
Robot S/W Architecture Tech.	Development of robot software architecture simplifying the URC application programming
Robot H/W Component Tech.	Development of core hardware modules and SoC IP for networked robot hardware platforms

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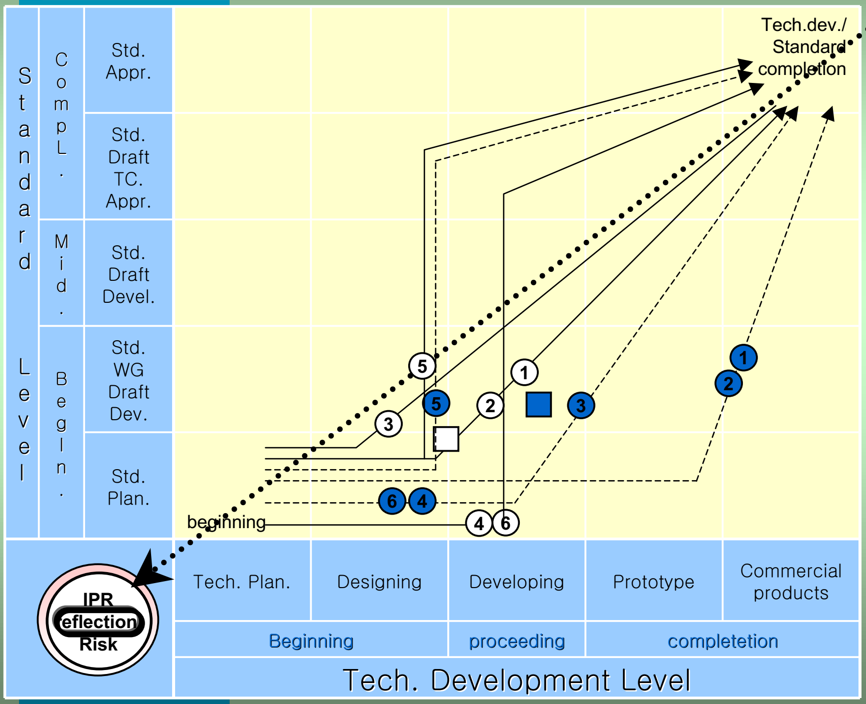
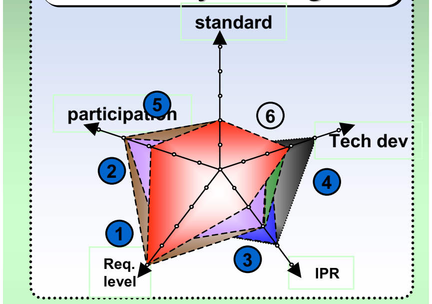
IV. Robot standard state in Korea with roadmap

Current Standard State Analysis of Intelligent Robot Core Items in Korea vs overseas



Core item standard state anaysis diagram



description

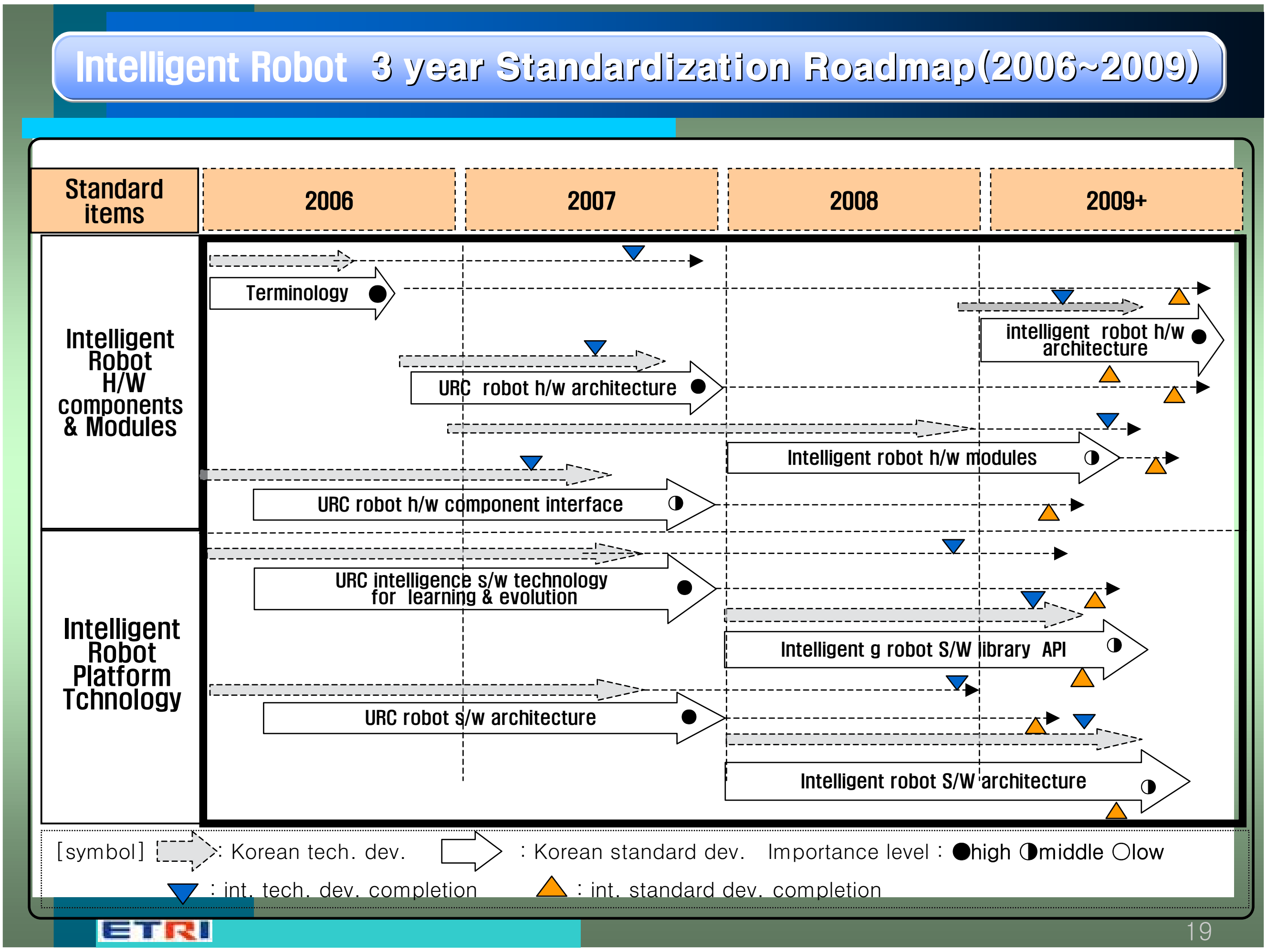
- ⓪ : std.core item state in Korea
- ⓿ : std.core item state in overseas
- ☐ : tech.core item state in Korea(avr)
- ■ : tech.core item state in overseas(avr.)
- → : std.core item transition state in Korea
- ⇢ : std.core item transition state in overseas

States of ISR Standardization in korea

- Beginning stage:
  - Planning, meetings, events
  - RFP activities for domestic robot standardization
- Active development of Technologies
  - Many robot projects are going on
  - Intelligent robot technology forum activities
- Active standardization of robots
  - Korea Intelligent Robot Standard Forum (KIRSF)
  - Close relationship with member institutes(KATS, TTA, KIRA)
  - Exchanging standardization information & technology with international meeting (OMG, ISO, IEEE, ITU …)

Business modeling

- **Testing business project of Int. service robots**
  - project term: 2003.11. ~ 2005.12.
  - Targets:
    - Building home-network in 400 apartments.
    - URC home robots are distributed and tested in each home of the apartments for one year.
    - URC public service robot is distributed and tested in the post office in the apartments.
- **Supplying target of intelligent robots**
  - one million robots are supplied into homes and public institutes through projects and business until 2007.
- Development of standard items
  - Various kinds of standards are expected to develop and import such as middleware, protocols, interfaces, application service description, and so on.



Intelligent Robot 3 year Standardization Roadmap(2006~2009)

Standard items | 2006 | 2007 | 2008 | 2009+

Intelligent Robot H/W components & Modules

Terminology ●

intelligent robot h/w architecture ●

URC robot h/w architecture ●

Intelligent robot h/w modules ◑

URC robot h/w component interface ◑

Intelligent Robot Platform Tchnology

URC intelligence s/w technology for learning & evolution ●

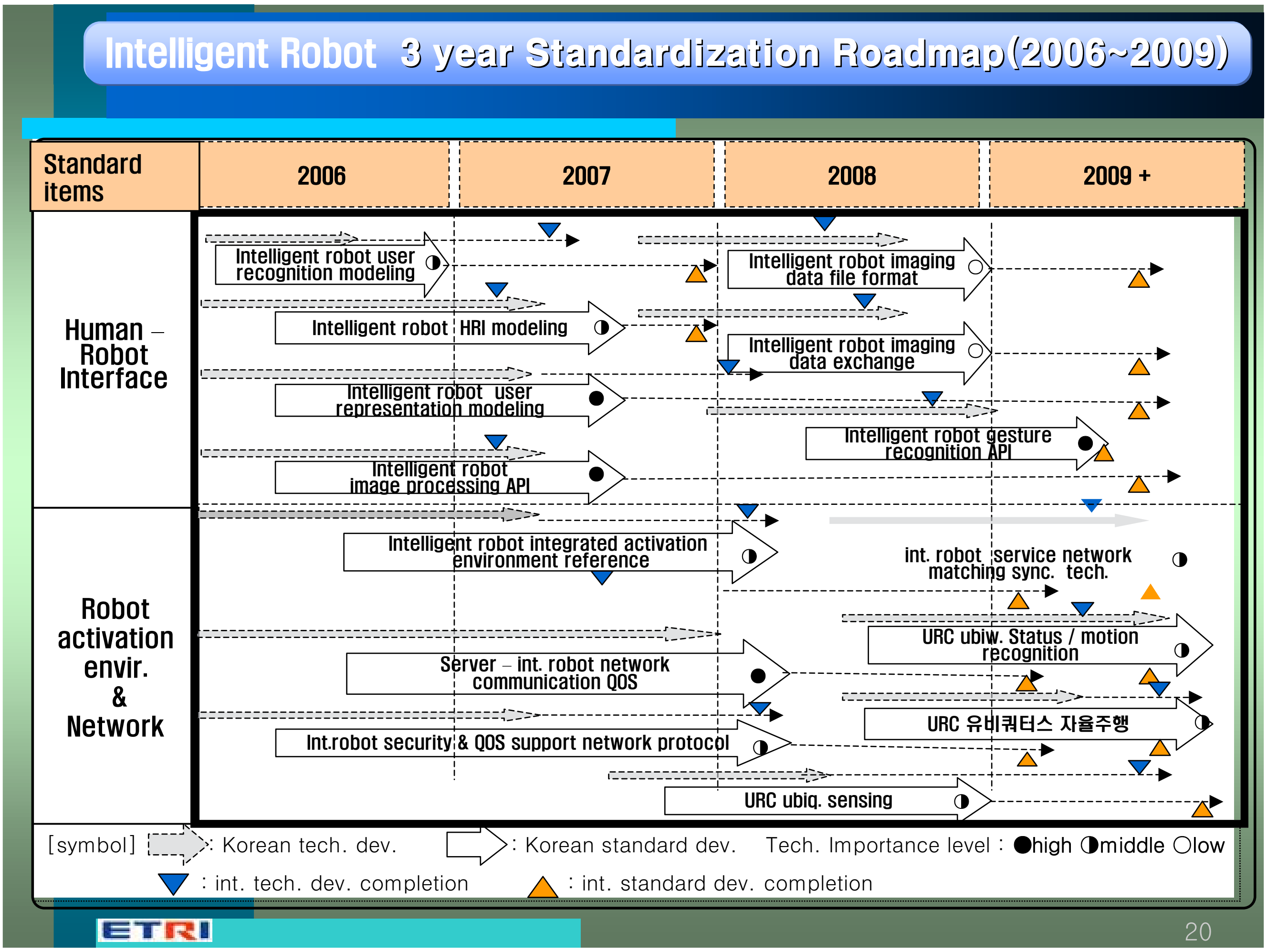
Intelligent g robot S/W library API ◑

URC robot s/w architecture ●

Intelligent robot S/W architecture ◑

[symbol] : Korean tech. dev. : Korean standard dev. Importance level : ●high ◑middle ○low

▼ : int. tech. dev. completion ▲ : int. standard dev. completion



Intelligent Robot 3 year Standardization Roadmap(2006~2009)

Standard items | 2006 | 2007 | 2008 | 2009 +

Human – Robot Interface

Intelligent robot user recognition modeling ◑

Intelligent robot imaging data file format ○

Intelligent robot HRI modeling ◑

Intelligent robot imaging data exchange ○

Intelligent robot user representation modeling ●

Intelligent robot gesture recognition API ●

Intelligent robot image processing API ●

Robot activation envir. & Network

Intelligent robot integrated activation environment reference ◑

int. robot service network matching sync. tech. ◑

URC ubiw. Status / motion recognition ◑

Server – int. robot network communication QOS ●

URC 유비쿼터스 자율주행 ◑

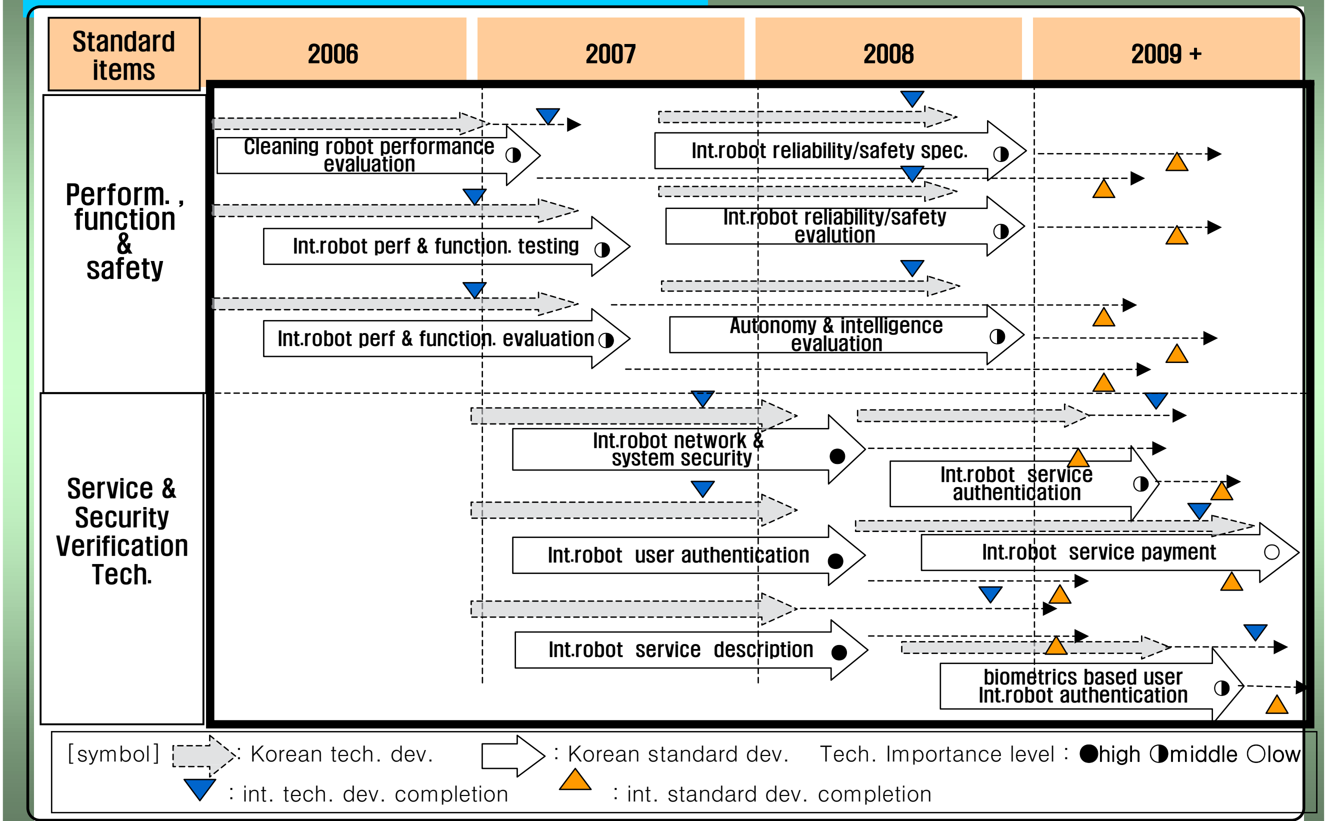
Int.robot security & QOS support network protocol ◑

URC ubiq. sensing ◑

[symbol] : Korean tech. dev. : Korean standard dev. Tech. Importance level : ●high ◑middle ○low

▼ : int. tech. dev. completion ▲ : int. standard dev. completion

Intelligent Robot 3 year Standardization Roadmap(2006~2009)



[symbol] : Korean tech. dev. : Korean standard dev. Tech. Importance level : ●high ◑middle ○low

▼ : int. tech. dev. completion ▲ : int. standard dev. completion

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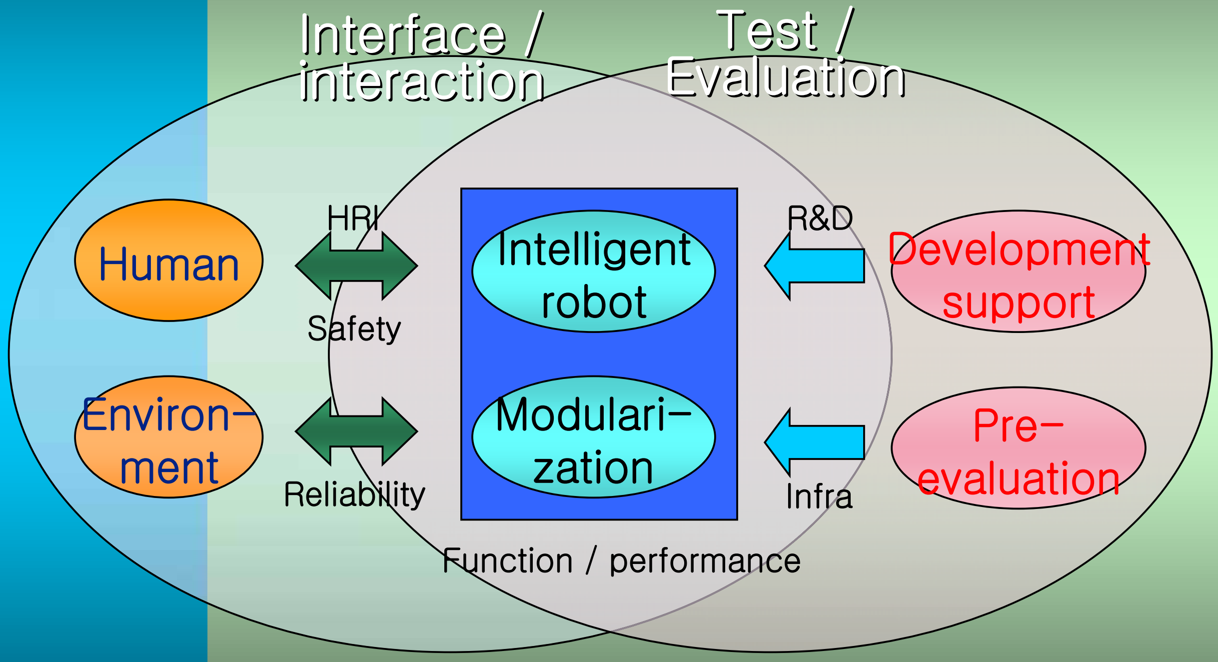
Aspects of Standardization



V. Standards items and examples

Core tech. items	Details of tech. items
Performance & Safety	Performance evaluation / Safety Reliability/Safety evaluation Evaluation of autonomy & intelligence
Service & security authentification	Service description Network / system security User / Service authetification
Platform & components	Robot s/w architecture, Middleware, component interfaces,Robot S/W library, Intelligent agent
Human-robot communication	Human-robot interface, dialogue Five sense recognition for HRI
Network system	Network communication protocol, Network QoS Communication interface
Ubiquitous robot agent	Ubiquitous sensing, Location detection, Situation recognition

---

Test methods of Performance evaluation

- Need of performance evaluation method for robot and its modules
  - In addition to the existing evaluation method of the industrial robot, we need ones for service robots and its modules.

- precision of posture
- deviation of precision in omni-directional posture
- precision of position
- position settling time
- position overshoot
- characteristic posture drift
- precision in trajectory
- deviation during cornering
- trajectory velocity characteristics
- minimum pose time
- static compliance
- weaving error

Terminology and robotic DB

Large grouping	Middle grouping	Small grouping	Detail	Subdetail
General	7 including robot name			
Spec.	7 including size	5 including width	5 including type	
Structure	4 including method for moving	11 including wheel	19 including # of wheels	12 including maker
Controller	4 including CPU	9 including maker	7 including RAM	
HRI	3 including input	6 including contact	19 including force	37 including Screen
etc				
6 items	25 items	31 items	50 items	49 items

total 161 items

VI. Q&A

Thank you.

ETRI
Yun Koo Chung
Ykchung@etri.re.kr

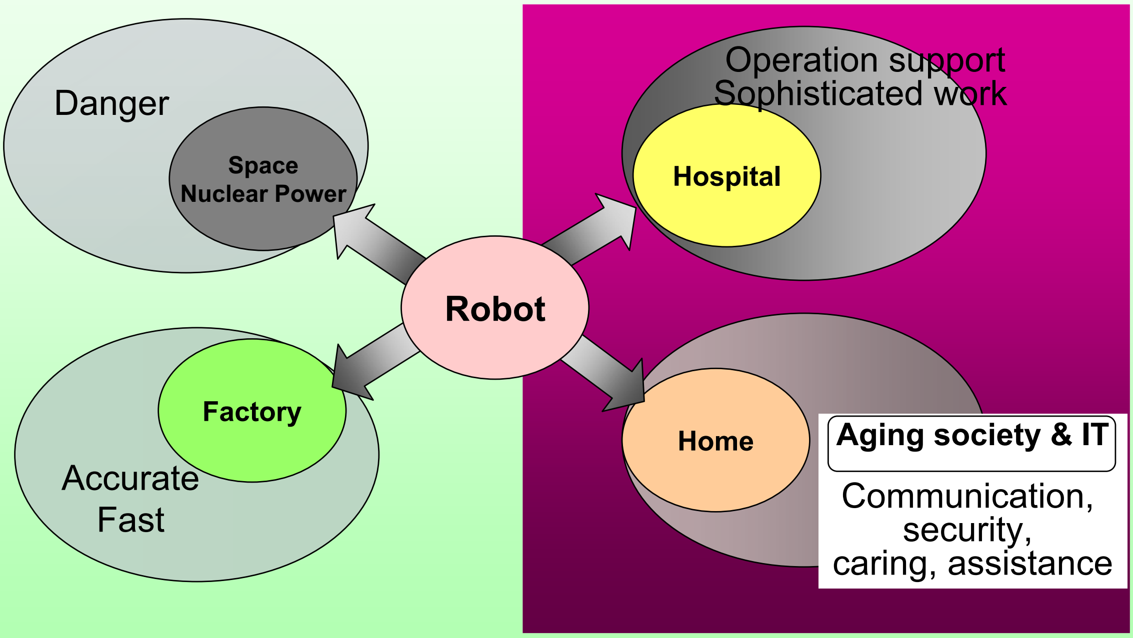
Toshiba Home Robots & Our Approach to RT Standardization

OZAKI, Fumio Toshiba Corporation

- Toshiba Robots
  - ApriAlpha
  - ApriAttenda
- Open Robot Controller Architecture
- RT Standardization

Some of the above robot images are courtesy of TEPCO, JAERI, AIST, and NEDO.

Robot Technology: Specialized use as a life-support partner



Accumulating fundamental technologies ⇒ Human capabilities, expansion of knowledge. A safe, secure society

Technologies in Newly Developed Robot

※Apri: **A**dvanced
personal
robot with
intelligence

ApriAlpha_v3
--Apri, the sharp ear--

ApriAttenda
--Apri, the go-with-you robot--

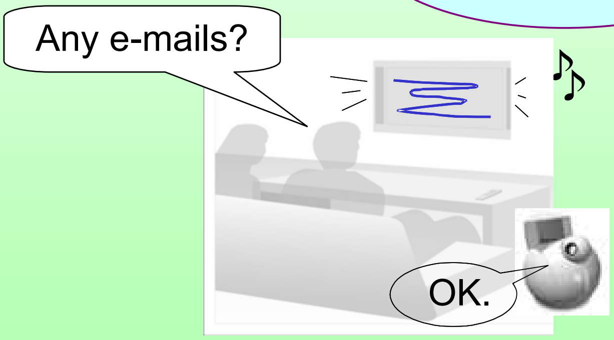
* The new robots were developed as part of the New Energy and Industrial Technology Development Organization's (NEDO) "Next-Generation Robot Commercialization Project (Prototype Development Support Enterprise)" Some of the image processing technologies used for the robot that can follow a person were jointly developed with the Tokyo University of Science.

* These robots were demonstrated at AICHI EXPO's "Prototype Robot Exhibition," at the Morizo and Kiccoro Exhibition Center from June 9 to June 19, 2005.

ApriAlpha_v3

Distinguishes and recognizes voices from any direction

Potential Uses



Give orders while watching TV

Asked for services from many people simultaneously

ApriAlpha – Apri, the sharp ear -

■Detects sound sources of voices

- Six microphones achieve omnidirectional voice recognition
- Analysis of small changes in voice wave patterns (phase-difference analysis) to identify direction of voice origin
- Selects and uses most effective pair of microphones depending on source direction of voice

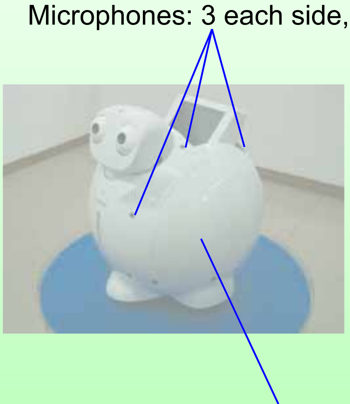
■ Ability to understand speech

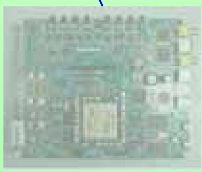
- Analyzes content by applying proprietary voice signal processing technology to extracted voices.

■ New multi-input signal processing PCB

- Miniaturized board allows voice signal processing unit to be installed in the robot
  → No need to connect to PC for analysis

Microphones: 3 each side, 6 in total





Diameter: approx. 380mm
Height: approx. 450mm
Weight: approx. 10kg

Voice signal processing board

Omnidirectional voice recognition in a small robot, a challenging achievement was realized by developing specialized hardware and an algorithm based on voice recognition and microphone-array technology

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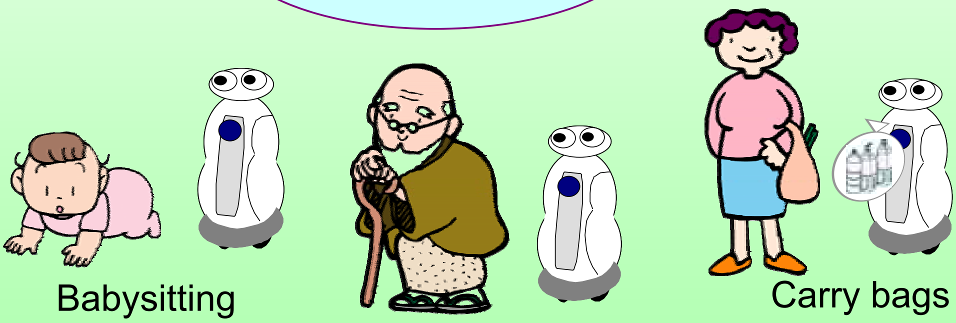
ApriAttenda

ApriAttenda can accompany people

Potential Uses



Babysitting

Watch over the elderly

Carry bags

AppriAttenda—the Go-With-You Robot

Outer diameter: approx. 450mm
Height: approx. 900mm
Weight: approx. 30kg

■ Recognizes a particular person

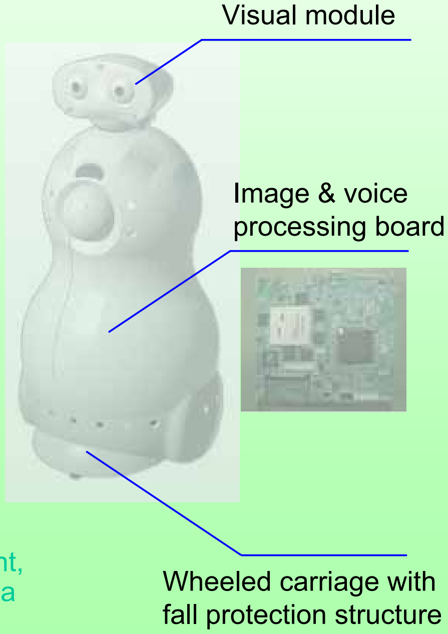
- Proprietary image processing algorithm can extract individuals from cluttered backgrounds
- Registration of the color and texture of clothes enables identification of a particular person

■ Can follow a person

- Follows a particular person at the speed of the target, using a compound eye to calculate distance to the person
- Stable structure that does not fall over easily, even when the robot has to move quickly

■ Finds the target person if contact is lost

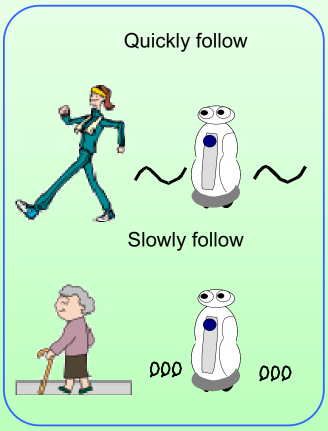
- if the robot loses sight of its target, it will search for the person or call out to re-establish contact



Tracking people with stereo vision, a challenging achievement, was realized by systematizing visual and motion control with a robust algorithm that utilizes multi-layer image data.

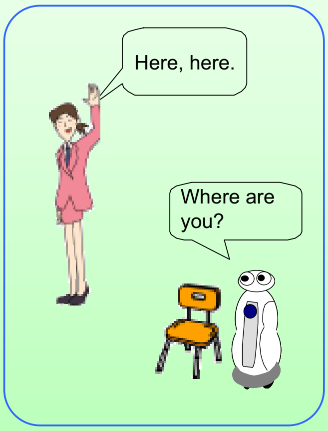
Function to Follow Particular Individual

Moves as the person does



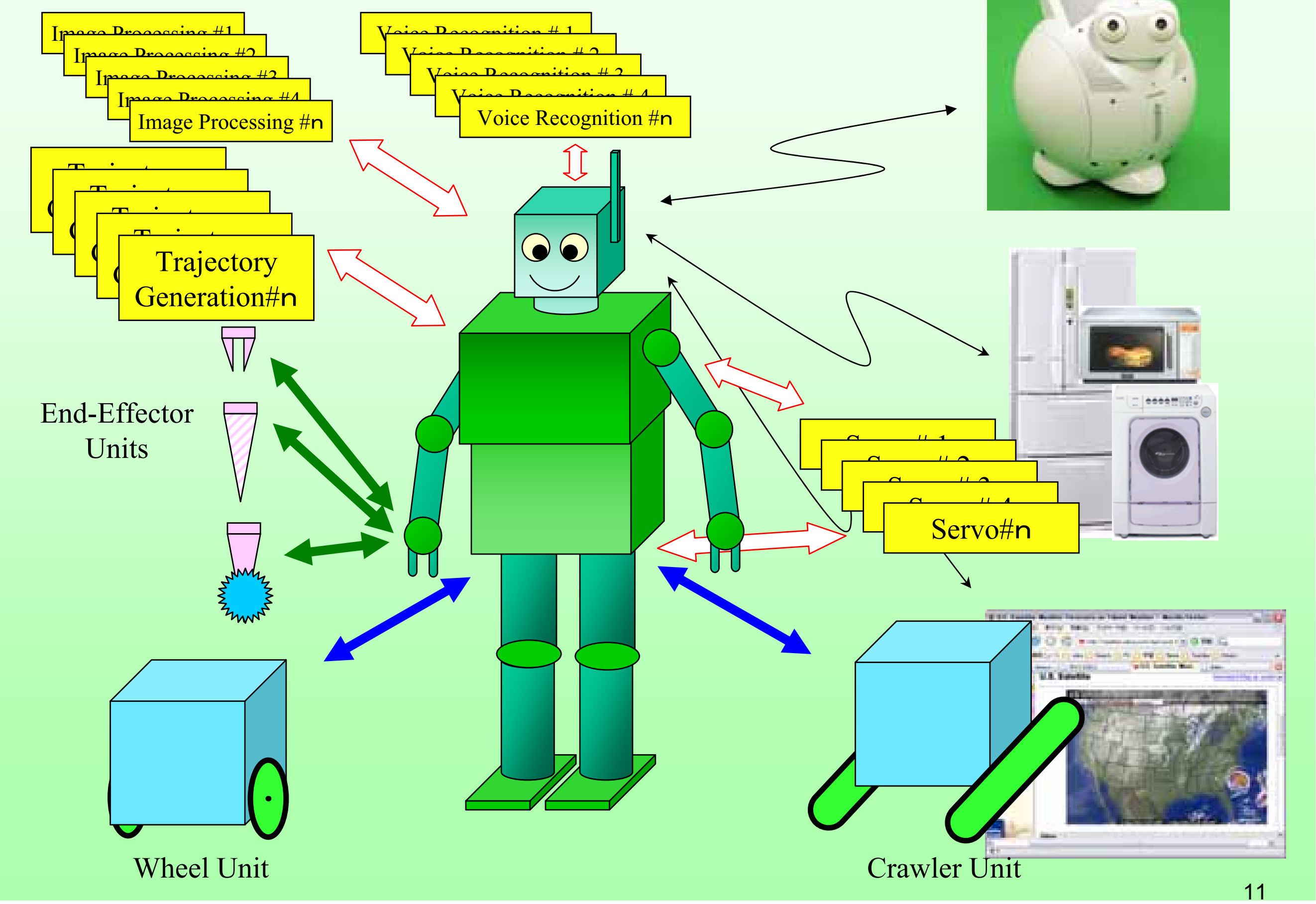
Automatically calculates distances to the target, using visual sensor and image processing technology, and adjusts speed to the optimum level

Reconnect with the person if it loses him/her

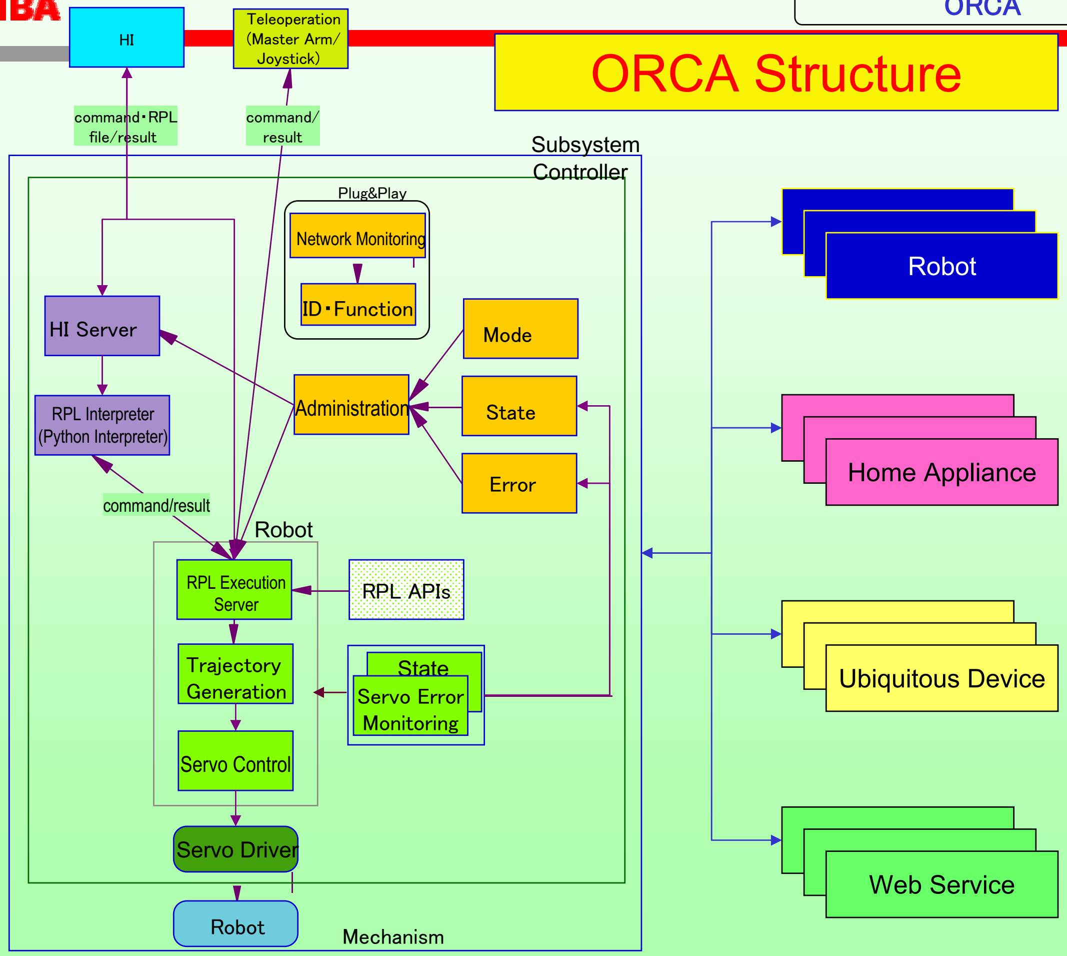


If the robot loses contact with the target, it calls to the person and responds to the reply by turning to the direction of the person and reconnecting

Where standards are needed.



ORCA Structure



ORCA Philosophy

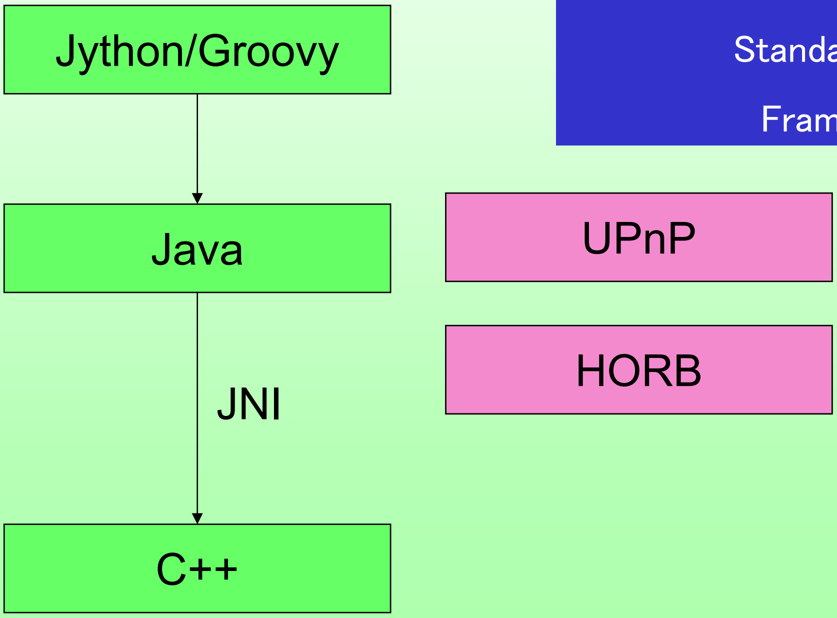
Using Standard IT

Concentrating on Robot Control

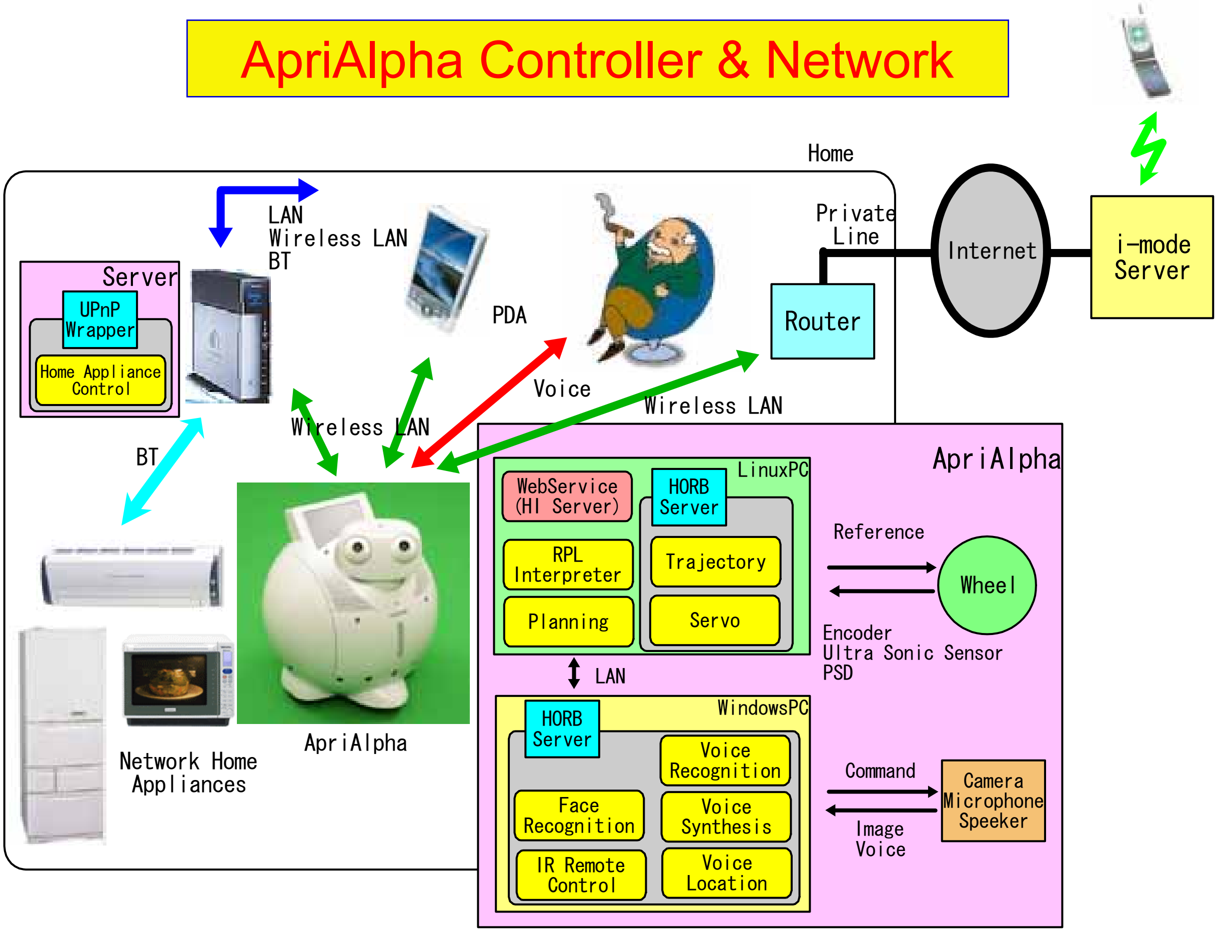
↓

Standard APIs

Framework



ApriAlpha Controller & Network



Issues needed to be discussed

- API standardization
  Classification of API levels

- Framework standardization

Issues needed to be discussed

Performance vs. Standardization
poor resources
for commercial robots, we cannot use rich resource such as high-end CPUs
poor latest software knowledge of developers in embedded world

-> What is the target of RT standardization?
The target robots? -> Service robots/Industrial robots/Robots in hazardous environment
The target developer
researchers, industry developers
Make it scalable?

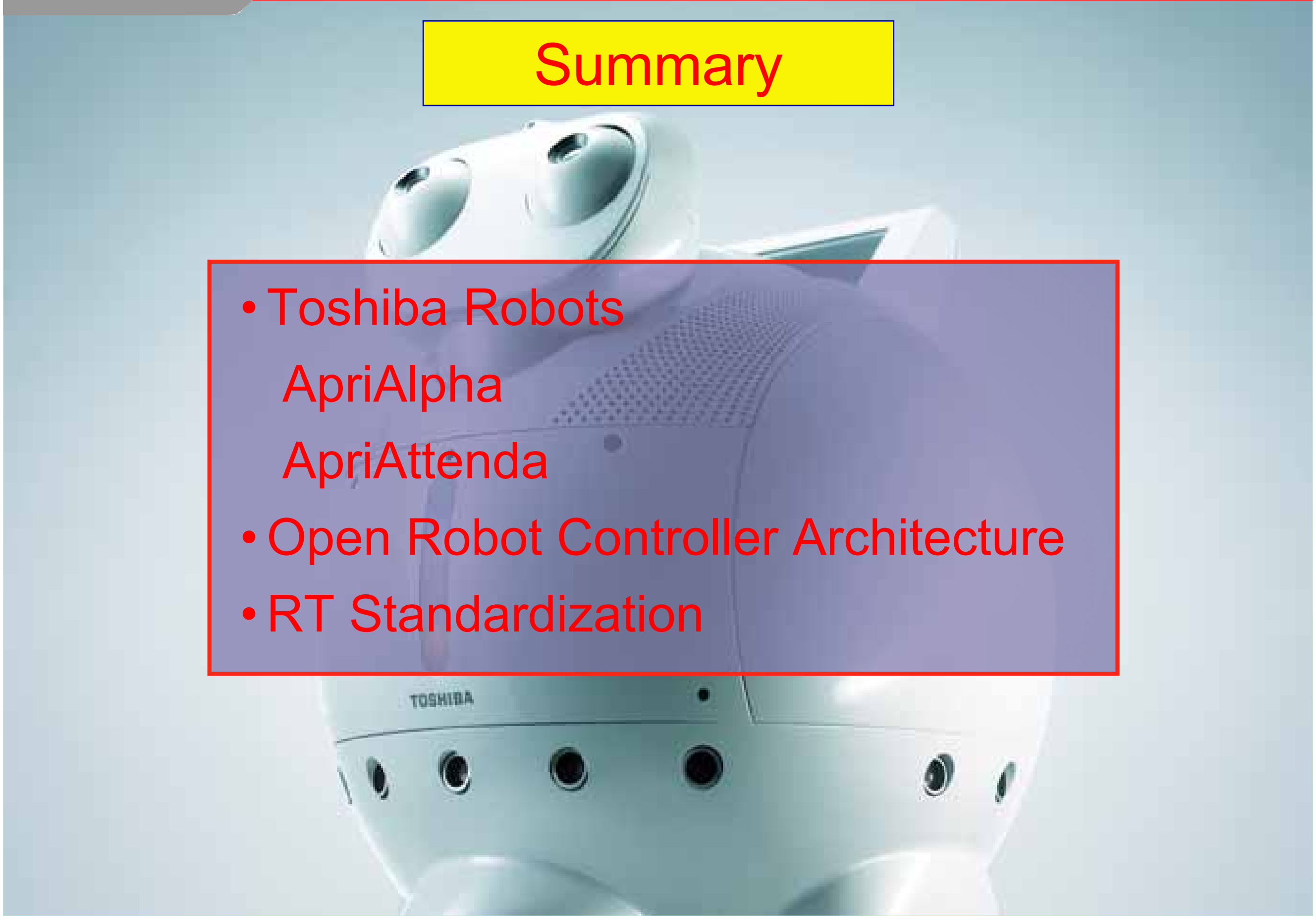
Issues needed to be discussed

RT includes
- Robot Control
- Image Processing
- Sound Processing
- Home Appliance Connection
- and many others

Issues needed to be discussed

Integrated system behavior
- arm with hand
- mobile robot with arm

Summary



- Toshiba Robots
  - ApriAlpha
  - ApriAttenda
- Open Robot Controller Architecture
- RT Standardization

robotics/2005-09-12

Robotics

Date: Friday, 16th September, 2005
Reporting: Tetsuo Kotoku
Group URL: http://robotics.omg.org/
Group email: robotics@omg.org

➢Highlights from this Meeting:

Plenary Meeting (Wed.):

- Prof. Kok-Meng Lee (Georgia Inst. of Tech.) [robotics/05-09-08]
- 6 Participant's Talk
  - **Bruce Boyes** (systronix) [robotics/2005-09-05]
  - **Seung-Ik Lee** (ETRI) [robotics/2005-09-06]
  - **Masayoshi Yokomachi** (NEDO)[robotics/2005-09-07]
  - **Hung Pham** (RTI) [robotics/2005-09-09]
  - **Yun Koo Chung** (ETRI) [robotics/2005-09-10]
  - **Fumio Ozaki** (Toshiba) [robotics/2005-09-11]

Robotics

Date: Friday, 16th September, 2005
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➢Deliverables from this Meeting:

➢Future deliverables (In-Process):

- **RFI responses**

➢Next Meeting (Burlingame, CA, USA):

- **RFI response presentation**

Robotics-DSIG Atlanta Meeting Minutes – DRAFT
(robotics/2005-09-13)

Overview and votes

As the Robotics-DSIG is still waiting for responses to the RFI that was issued during the Boston Meeting (June 2005) and due to November 2005, no particular issue has been addressed. The Atlanta meeting consisted mainly in presentations. A call has been made for electing the co-chairs of the Robotics-DSIG.

OMG Documents Generated

robotics/2005-09-01 Final Agenda (Tetsuo Kotoku)
robotics/2005-09-02 Robotics DSIG approved Boston Meeting Minutes (Tetsuo Kotoku)
robotics/2005-09-03 Opening Presentation (Tetsuo Kotoku)
robotics/2005-09-04 Robotics DSIG Roadmap (Tetsuo Kotoku)
robotics/2005-09-05 Presentation : "Implementing and Teaching Emerging Robotics Standards at the University Level" (Bruce Boyes)
robotics/2005-09-06 Presentation : "Common Robot Interface Framework for Device Abstraction" (Seung-Ik Lee)
robotics/2005-09-07 Presentation : "Standards in Action: Prototype Robots at Aichi International Exposition 2005" (Masayoshi Yokomachi)
robotics/2005-09-08 Presentation : "Machine vision and actuators for robotics and automation" (Kok-Meng Lee)
robotics/2005-09-09 Presentation : "Slashing development time with component-based programming" (Hung Pham)
robotics/2005-09-10 Presentation : "Korean intelligent robot standardization status" (Yun Koo Chung)
robotics/2005-09-11 Presentation : "Introduction to Toshiba Home Robots and Our Approach to RT Standardization" (Fumio Ozaki)
robotics/2005-09-12: Atlanta Robotics DSIG DTC Report Presentation (Tetsuo Kotoku)
robotics/2005-09-13 Meeting Minutes – Draft (Olivier Lemaire and Fumio Ozaki)

Agenda

09:00- 09:20 Welcome and Review Agenda Meeting Kick-off
09:20-10:50 "Implementing and Teaching Emerging Robotics Standards at the University Level" - Bruce Boyes (Systronix)
10:50-10:20 "Common Robot Interface Framework for Device Abstraction" - Seung-Ik Lee (ETRI)
10:40-11:10 "Standards in Action: Prototype Robots at Aichi International Exposition 2005" - Masayoshi Yokomachi (NEDO)
11:10-12:00 "Machine vision and actuators for robotics and automation"- Kok-Meng Lee (Georgia Institute of Technology)
14:00-14:50 "Slashing development time with component-based programming" - Hung Pham (RTI)
15:10-15:40 "Korean intelligent robot standardization status" - Yun Koo Chung (ETRI)
15:40-16:10 "Introduction to Toshiba Home Robots and Our Approach to RT Standardization" - Fumio Ozaki (Toshiba)
16:10-16:40 Robotic Systems RFI (mars/2005-06-12) promotion
16:40-17:00 Next Meeting Agenda Discussion, etc Robotics Closing
17:00 Adjourn

Minutes

14 September, Wednesday
Tetsuo Kotoku, presiding co-chair
Robotics DSIG Plenary
Meeting Week – Kick-off

Meeting was called to order at 09:00
Tetsuo Kotoku provided a brief overview of the Boston Minutes.
Action:
With some minor correction, the minutes were approved.
- Robotics DSIG Boston Meeting Minutes (robotics/2005-09-02)

Tetsuo Kotoku reviewed the roadmap and today's agenda.
- Opening Presentation (robotics/2005-09-03)

Presentation: "Implementing and Teaching Emerging Robotics Standards at the University Level"
Bruce Boyes introduced the educational activity using Embedded Hard Real-time Java for LEGO at Univ. of Utah., introducing his home developed control board which provides a very high level of functionalities while keeping its price as low as 100$ and could be a breakthrough for the development of large scale distributed robotic systems.

Presentation: "Common Robot Interface Framework for Device Abstraction"
Seung-Ik Lee talked about CRIF(Common Robot IF) and his attempt to define standardized interface to achieve the device abstraction necessary to achieve reusability and connectivity in the multiple robotic systems that are developed at ETRI in Korea.

Presentation: "Standards in Action: Prototype Robots at Aichi International Exposition 2005"
Masayoshi Yokomachi introduced the robotic systems that have been developed and displayed at the Aichi International Exhibition with the sponsorship of NEDO, and their applications.

Special Talk: "Machine vision and actuators for robotics and automation"
Kok-Meng Lee presented his present research activities at Georgia Tech. This included the necessity, possibility and achievement to develop a vision system that would be cheaper and more efficient than traditional Machine Vision Systems. This was followed by an argumentation on the advantage of the ACC(Artifitial Color Contrast) space versus the RGB space for image processing in environment incurring a large amount of noise and uncertainty in images like a chicken meat processing line.

Presentation: "Slashing development time with component-based programming"
Hung Pham's main point is that component-based development requires some technology to support the following aspects:

- component creation and management
- application modeling and development
- testing and integration support
- a run-time execution framework

... but that complex control systems have additional complexity ("periodic" and "event-driven" semantics, parallelism, distributed deployment over networks of varying topology, high testing and integration costs, etc.).

The speaker described a specific application that was developed for the Office of Naval Research to perform real-time control of crate loading equipment on ships while at sea.

Presentation: "Korean intelligent robot standardization status"
Korea went through the following stages in terms of robotics:

- Rapid expansion of industrial robots for factory automation in 1987-96

- The IMF crisis halted factory automation in 1997-2002
- A new focus, starting in 2003, is intelligent robots that can improve quality of life.

The world market for robots should increase from $150 billion in 2010 to $500B in 2020, but just in Korea it should grow from $10B (6%) to $100B (20%). The current market size is $1.4B, with $200M in robot exports and $110M in robot imports.

After this preamble, the speaker reviewed some of the architectural and standardization efforts taking place in Korea in this area. There is a Korea Intelligent Robot Standard Forum (KIRSF), but this poses the question on how this can be harmonized with standards from OMG, ISO, IEEE, or even ITU.

Presentation: "Introduction to Toshiba Home Robots and Our Approach to RT Standardization"
Fumio Ozaki showed a video demonstration of the ApriAlpha and AppriAttenda home assistant robots. ApriAlpha uses voice recognition (as well as the direction from which the voice comes) to interact with up to 6 users and perform tasks such as turning on and off Bluetooth-equipped appliances, reading the news, voicing alerts, etc. ApriAttenda recognizes a person and accompanies him/her in the middle of a potentially complex scene and potential obstacles. See:
http://www.toshiba.co.jp/about/press/2005_05/pr2001.htm

Toshiba's work is based on the ORCA (Open Robot Controller Architecture) framework, which uses the following technologies:
- Jython/Groovy
- Java
- JNI
- C++
- HORB, an Object Request Broker from AIST

The speaker said that robotic technology standardization faces several obstacles, one of which is that most embedded software developers do not seem to care, and even resist, advanced development technologies like Java.

Robotics-DSIG / Robotic Systems RFI promotion
- RoboNexus will be held on October 06-09

The Robotics SIG will hold BoF meeting at RoboNexus on Thursday from 6PM to 7:30PM
Other robotics related events will take place in Santa-Clara from the day before:
Arm Developers Conference www.arm.com/developersconference/
WiFi Conference www.wifiamericas.com/2005/

- Announcements

The Robotics-DSIG homepage has been updated and all presentation made during the meetings are available for download. Its URL is http://robotics.omg.org/.

- Development of Mediator (Liaisons)

Bruce Boyes offered to be the liaison with Java.net (which also deal with Sensor Networks)
Yun Koo Chung offered to be the liaison with KRISF

Jon Siegel announced that OMG have official liaisons and they will have a privilege of OMG resource access.

- Advertisement of the RFI

Bruce Boyes offered to put a link to the RFI on his blog
Rely in JARA to dispatch the RFI to the Japanese companies
Should contact IEEE for collaboration

RTI will contact American companies (especially during RoboNexus)
Olivier Lemaire proposes to write a formal introduction letter that should be emailed to organizations involved in the robotics field.

Next Meeting in Burlingame
Monday : Steering Committee
Tuesday : Robotics DSIG plenary (during which the co-chairs will be elected)

ADJOURNED @ 17:00PM

Participants (Sign-in)

- Seung-Ik Lee (ETRI)
- Makoto Mizukawa (Shibaura Institute of Technology)
- Charles Rush (Objective Interface)
- Roy Bell (Raytheon)
- Claude Baudoin (Schlumberger)
- Bruce Boyes (Systronix)
- Fumio Ozaki (Toshiba)
- Seiichi Shin (University of Tokyo)
- Takashi Suehiro (AIST)
- Masayoshi Yokomachi (NEDO)
- Yun Koo Chung (ETRI)
- Jan Popkin (Telelogic)
- Olivier Lemaire (JARA)
- Tetsuo Kotoku (AIST)
- Hung Pham (RTI)
- Shihobu Koizumi (Hitachi)
- Kok-Meng Lee (Georgia Tech.)
- Victor Giddings (Objective Interface)
- Gerardo Pardo (RTI)
- Carlo Cloet (RTI)

Prepared and submitted by **Olivier Lemaire** (JARA) and **Fumio Ozaki** (Toshiba)