Task guided Attention Control and Visual Verification

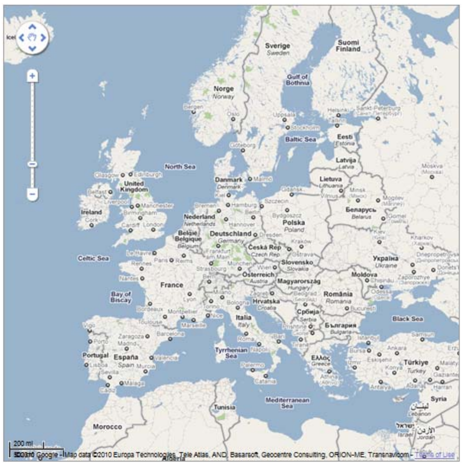
Kei OKADA
JSK Robotics Lab, The University of Tokyo

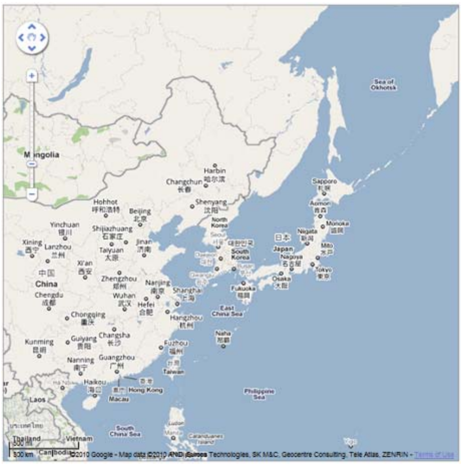
5. November, 2010

Outline

- History of JSK Robotics Lab
- Hardware platform HRP2
- Software platform for intelligent robotics
- Task guided attention control and visual verification
- Connecting high-level reasoning and recognition behavior system
- Conclusions

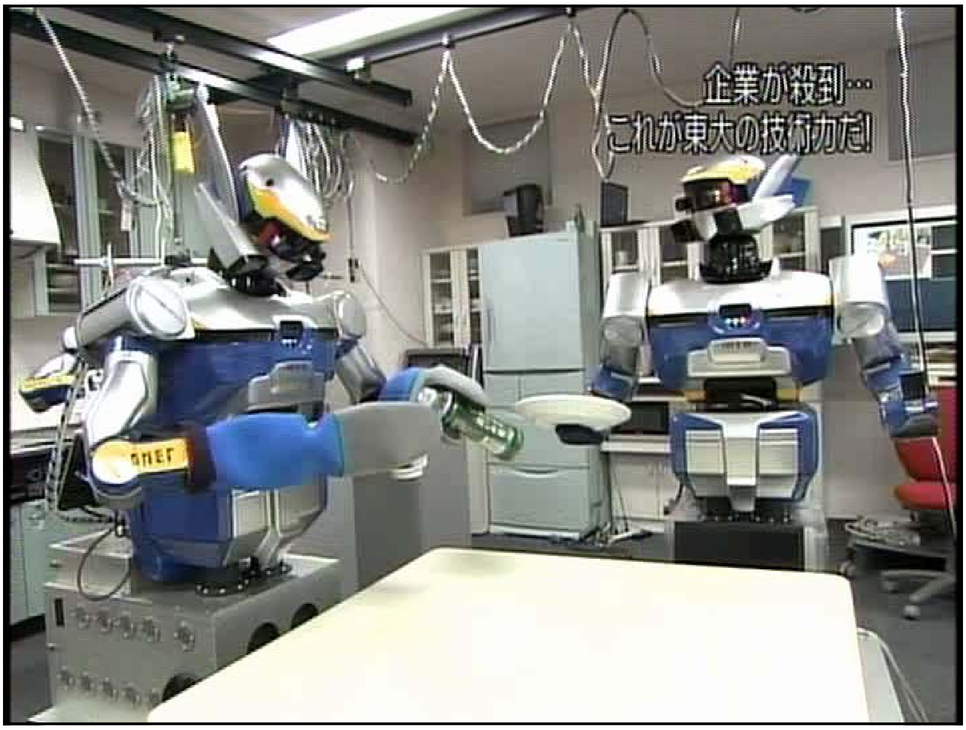
Tokyo, Japan

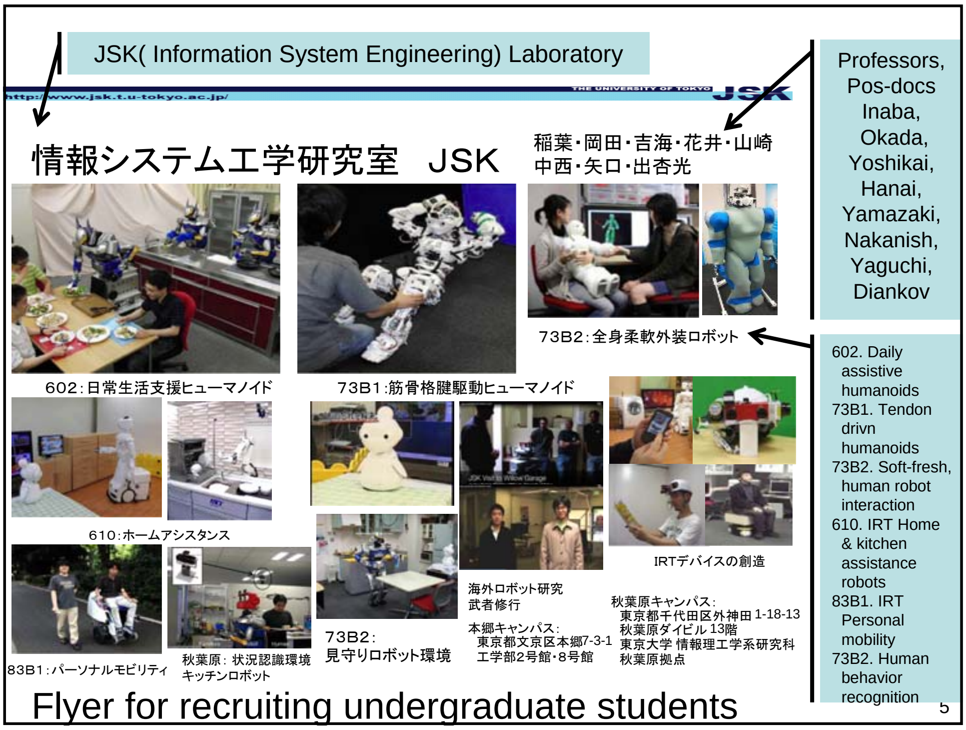


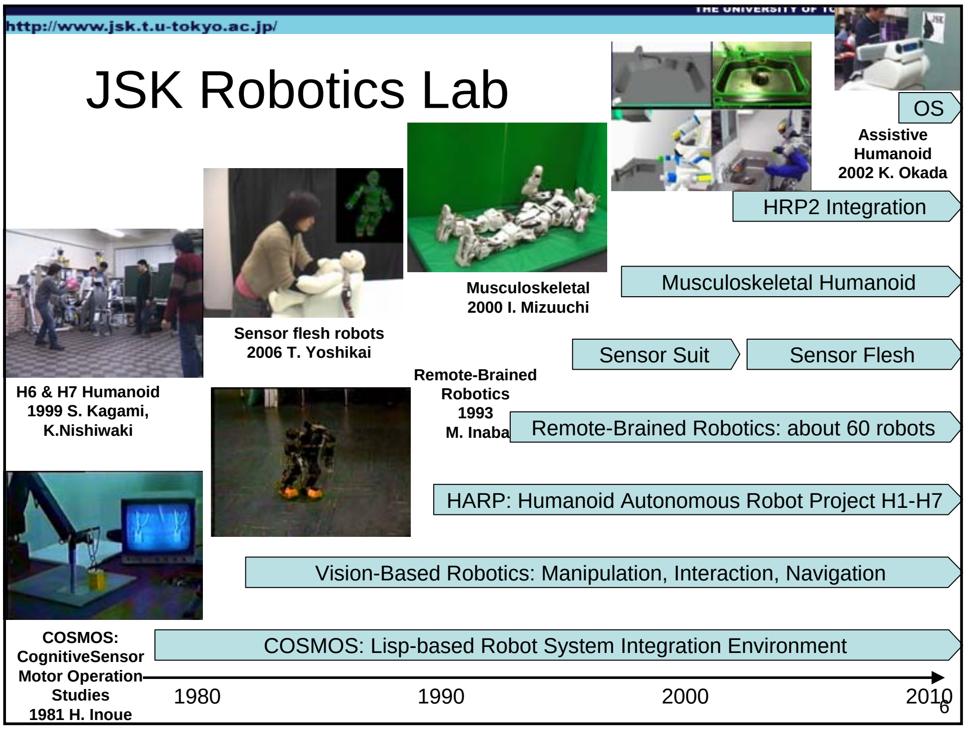


- Germany
- Area : 357,021km²
- Population : 81,750,000

- Japan
- Area: 377,914 km²
- Population : 127,288,419




JSK(Information System Engineering) Laboratory
http://www.jsk.t.u-tokyo.ac.jp/
情報システム工学研究室　JSK
稲葉・岡田・吉海・花井・山崎
中西・矢口・出杏光
Professors, Pos-docs Inaba, Okada, Yoshikai, Hanai, Yamazaki, Nakanish, Yaguchi, Diankov
73B2:全身柔軟外装ロボット
602:日常生活支援ヒューマノイド
73B1:筋骨格腱駆動ヒューマノイド
610:ホームアシスタンス
IRTデバイスの創造
83B1:パーソナルモビリティ
秋葉原: 状況認識環境
キッチンロボット
73B2:
見守りロボット環境
海外ロボット研究
武者修行
本郷キャンパス:
東京都文京区本郷7-3-1
工学部2号館・8号館
秋葉原キャンパス:
東京都千代田区外神田 1-18-13
秋葉原ダイビル 13階
東京大学 情報理工学系研究科
秋葉原拠点
602. Daily assistive humanoids
73B1. Tendon drivn humanoids
73B2. Soft-fresh, human robot interaction
610. IRT Home & kitchen assistance robots
83B1. IRT Personal mobility
73B2. Human behavior recognition
Flyer for recruiting undergraduate students
5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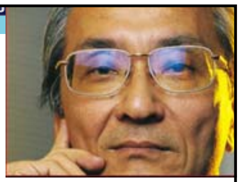
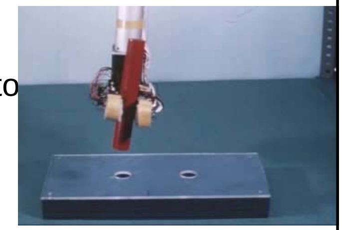
JSK Robotics Lab
OS
Assistive Humanoid
2002 K. Okada
HRP2 Integration
Musculoskeletal
2000 I. Mizuuchi
Musculoskeletal Humanoid
Sensor flesh robots
2006 T. Yoshikai
Sensor Suit
Sensor Flesh
H6 & H7 Humanoid
1999 S. Kagami, K.Nishiwaki
Remote-Brained Robotics
1993
M. Inaba
Remote-Brained Robotics: about 60 robots
HARP: Humanoid Autonomous Robot Project H1-H7
Vision-Based Robotics: Manipulation, Interaction, Navigation
COSMOS: CognitiveSensor Motor Operation Studies
1981 H. Inoue
COSMOS: Lisp-based Robot System Integration Environment
1980
1990
2000
2010
6

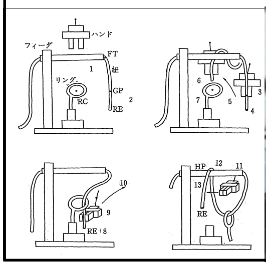
Behavior generation through sensing



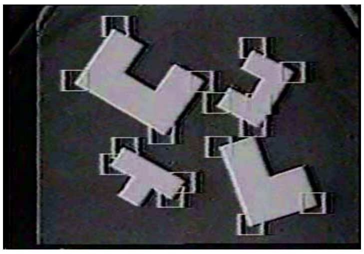
Picture from : Robo sapiens

- 1969 Hirochika Inoue
  Computer Controlled Bilateral Manipulato
- 1983 Masayuki Inaba
  Vision-based Rope Handling

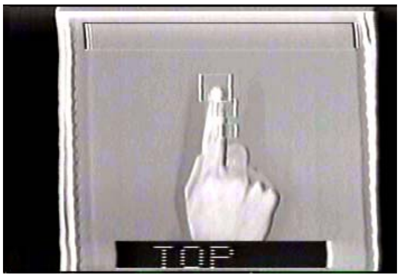




'85-90 Tracking / Multi Window Vision



Multiple tracking windows



deformable shape

Change of flow pattern

Realtime Tracking Hardware

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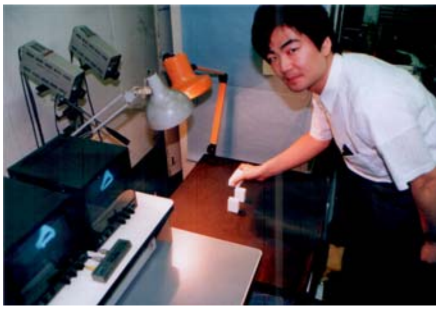
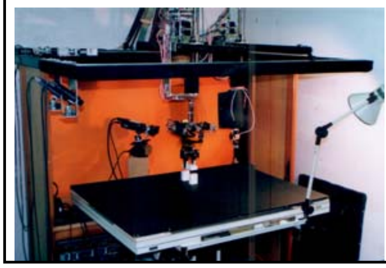
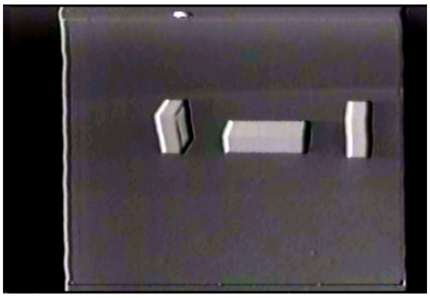
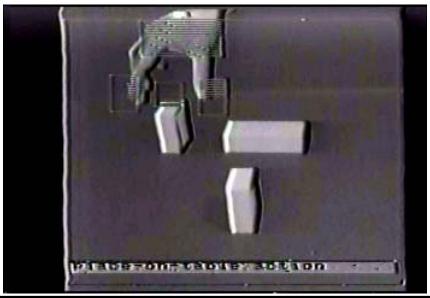
1988 Teaching by Showing



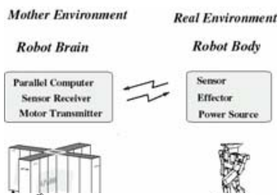


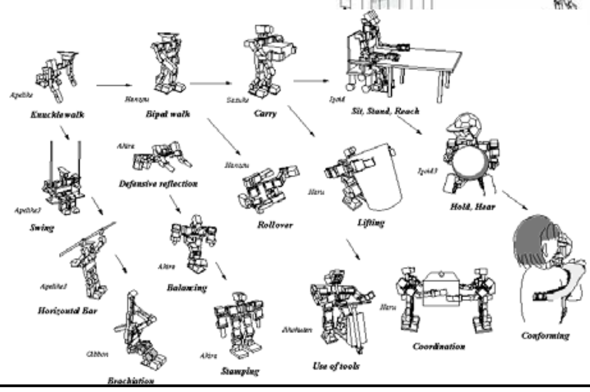




1993 Remote Brained Robotics

Develop software independent from robot body





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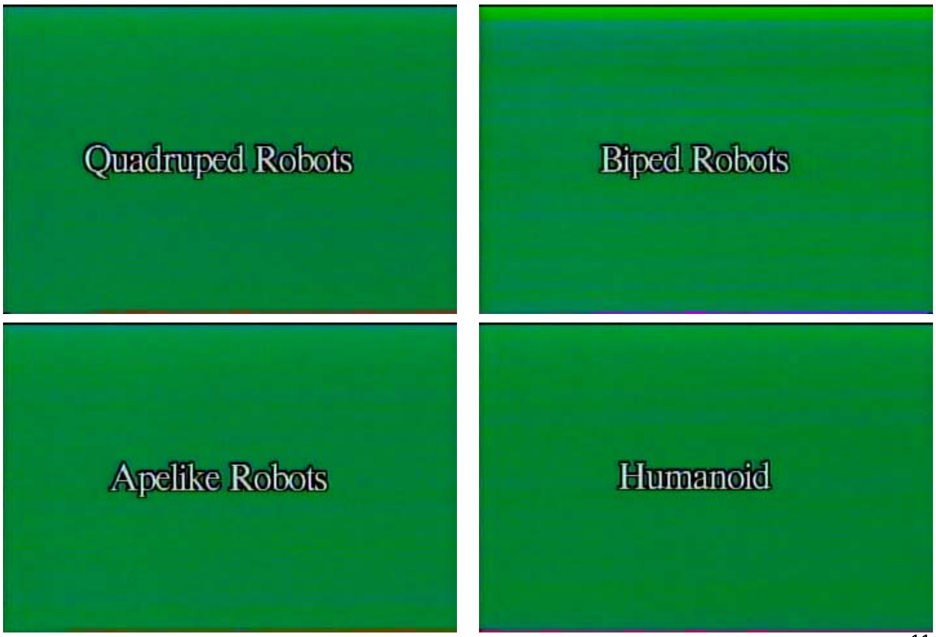

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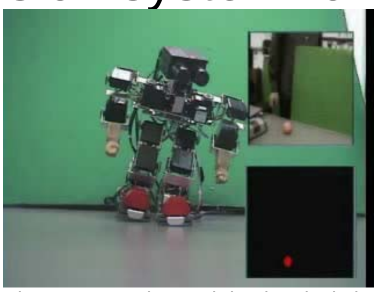
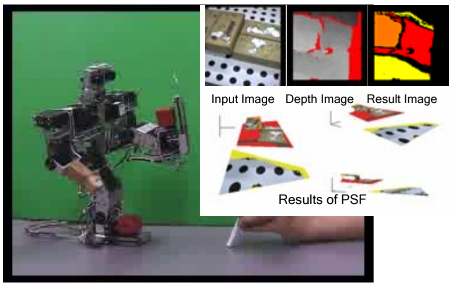
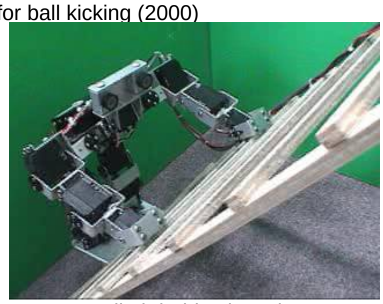
Vision system for remote-brained robots



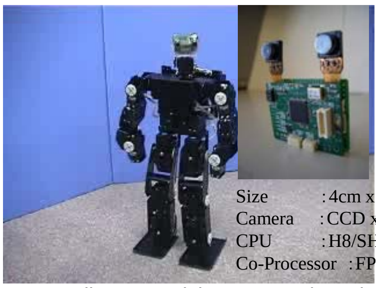
Color segmentation and depth calculation for ball kicking (2000)



Plane detection and climb stairs (2000)



climb ladder (2002)



Small Stereo Vision system (2004)

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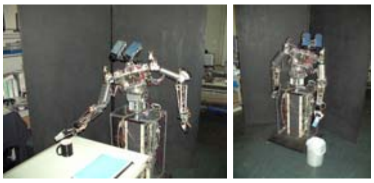


1997 H2 Interactive Humanoid

1998 H4 Mobile Humanoid

1997 H5 Dynamic Humanoid

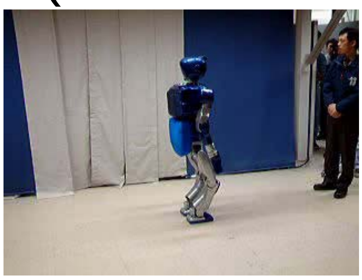
1998 H3 Networked Humanoid

1999,2000 H6,H7 Integrated Humanoid

HARP:
Humanoid Autonomous Robot Project

MITI HRP Project (1998 – 2002)

HRP1 : Honda P3 based robot

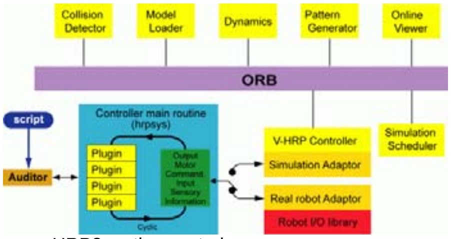


HRP2P : failing down

HRP2: work with human

HRP2 Software system(AIST, GRX)

- OpenHRP
  - Humanoid software platform
  - Dynamics, Collision Detector, Model Loader as CORBA service
- HRP2 motion control system
  - Plugin architecture for Periodic control module
  - Walking pattern generator, stabilizer etc



HRP2 motion control

Name	Function
Kalman filtering	Estimate robot posture from jyro using EKF
ZMP sensor	Calculate zmp from6D force sensor on the foot
Dynamics	Forward and Inverse dynamics calculation
Pattern generator	Online walking pattern generator
Sequence player	Motion sequence player with interpolation
Stabilizer	ZMP based motion stabilizer
Logger	Write to logfile

http://www.generalrobotix.com/product/openhrp/products.htm

HRP humanoids

- HPR2 (2002)
- 30DOF
- 1540mm/58Kg

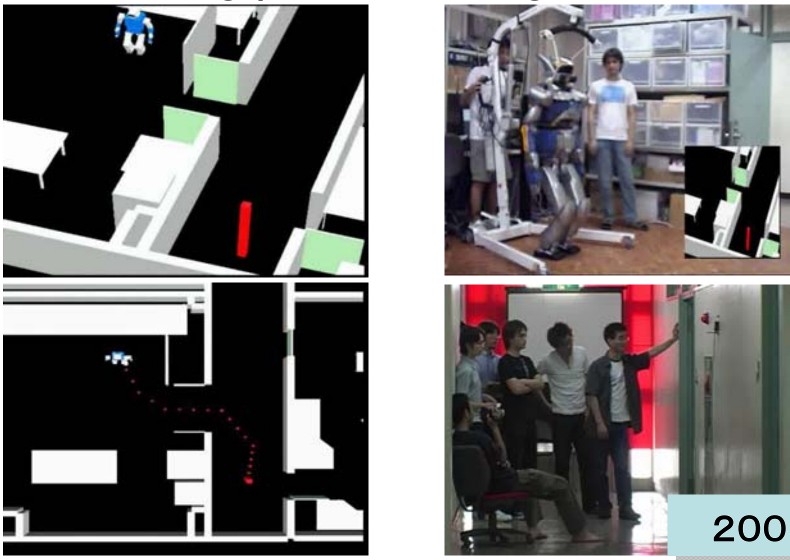
- HPR3 (2007)
- 42DOF
- 1600mm/68Kg
- Water proof
- RT-Ether/BodyLAN

- HPR4-c (2009)
- 42DOF
- 1580mm/48Kg

- HPR4(2010)
- 34DOF
- 1510mm/39Kg

http://www.youtube.com/watch?v=swyWSGc3dI8

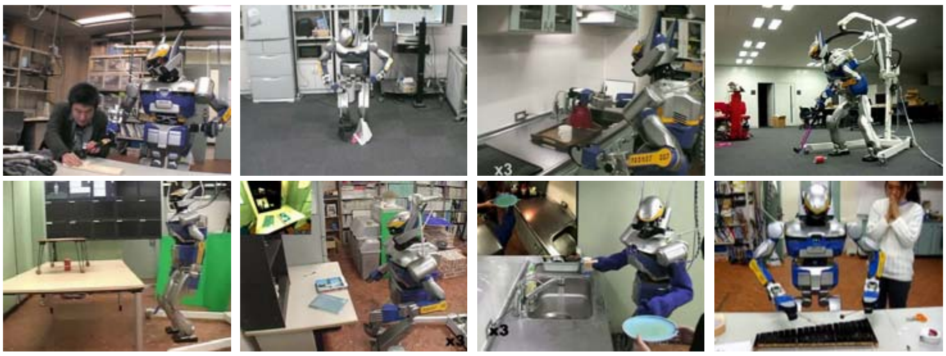
1st experiments using HRP2: Connecting walking planner and generator



2003

Daily assistive tasks of HRP2JSK

HRP2JSK(2002-)
Tasks generated based on humanoid motion planning technology



Tool manipulation | Clean up | In the kitchen | Play ;-)

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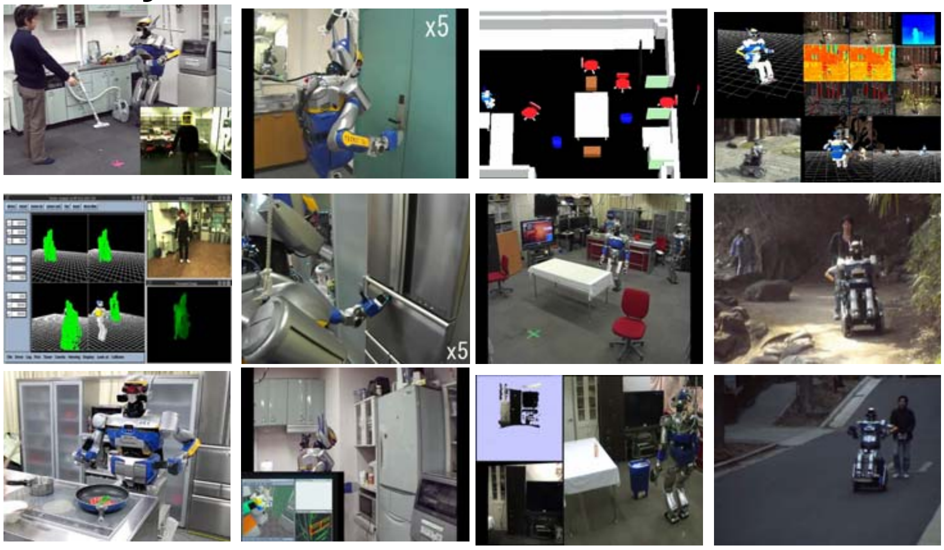
Daily assistive tasks of HRP2JSK



Learning from human | Articulated objects | Environment manipulation | Driving

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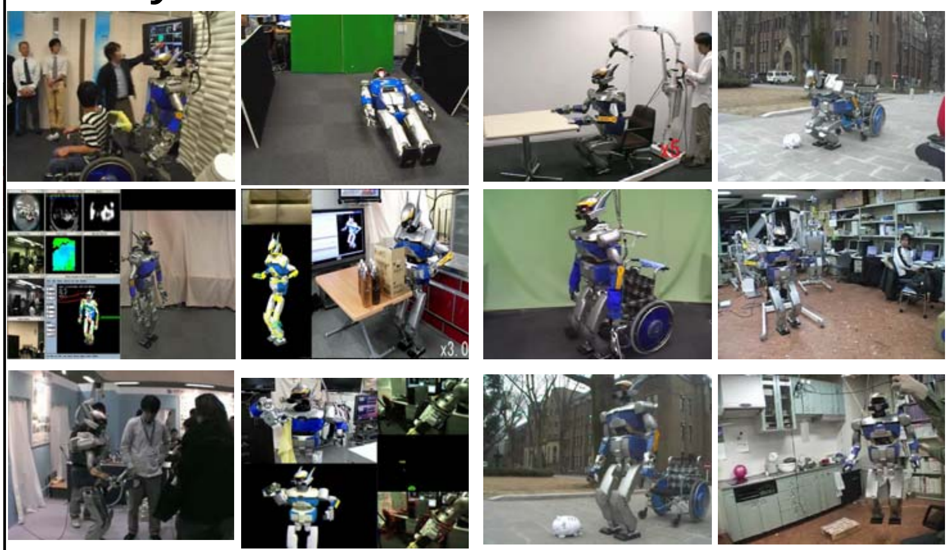
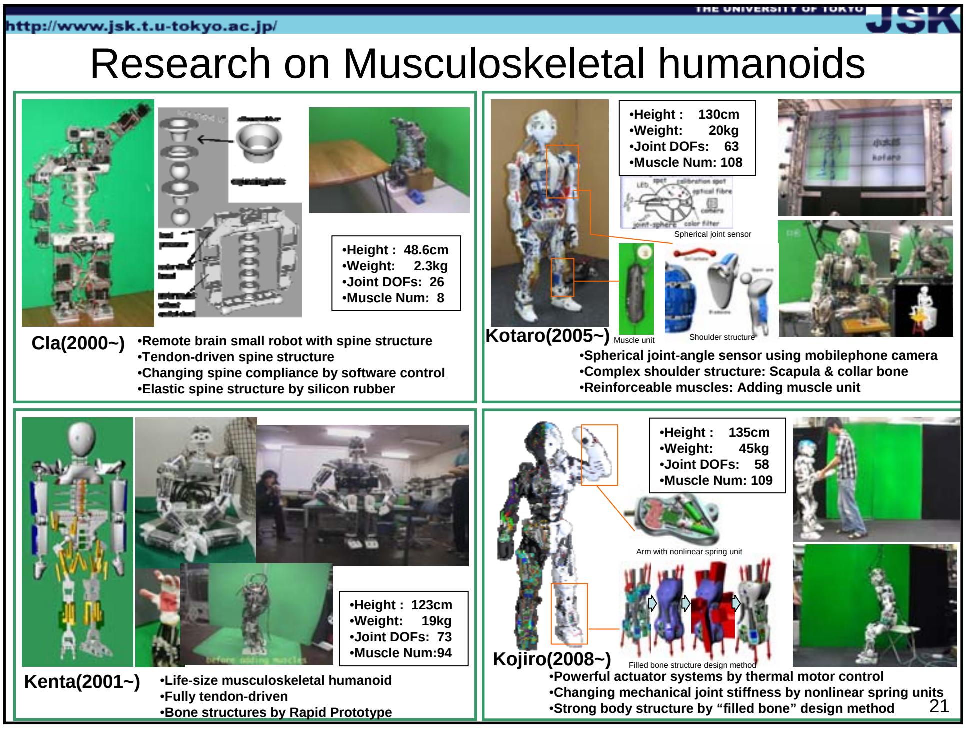
Daily assistive tasks of HRP2JSK



HRI | Torque aware motion | Wholebody motion | Accidnets

20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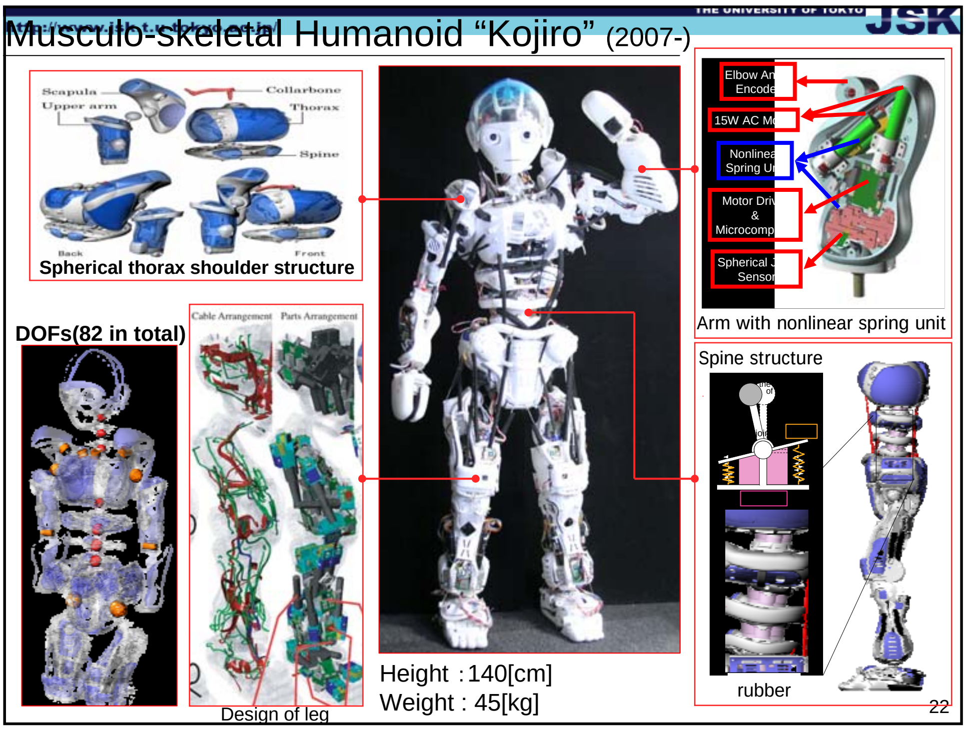
Research on Musculoskeletal humanoids
•Height : 48.6cm
•Weight: 2.3kg
•Joint DOFs: 26
•Muscle Num: 8
Cla(2000~)
•Remote brain small robot with spine structure
•Tendon-driven spine structure
•Changing spine compliance by software control
•Elastic spine structure by silicon rubber
•Height : 130cm
•Weight: 20kg
•Joint DOFs: 63
•Muscle Num: 108
Spherical joint sensor
Muscle unit
Shoulder structure
Kotaro(2005~)
•Spherical joint-angle sensor using mobilephone camera
•Complex shoulder structure: Scapula & collar bone
•Reinforceable muscles: Adding muscle unit
•Height : 123cm
•Weight: 19kg
•Joint DOFs: 73
•Muscle Num:94
Kenta(2001~)
•Life-size musculoskeletal humanoid
•Fully tendon-driven
•Bone structures by Rapid Prototype
•Height : 135cm
•Weight: 45kg
•Joint DOFs: 58
•Muscle Num: 109
Arm with nonlinear spring unit
Filled bone structure design method
Kojiro(2008~)
•Powerful actuator systems by thermal motor control
•Changing mechanical joint stiffness by nonlinear spring units
•Strong body structure by "filled bone" design method
21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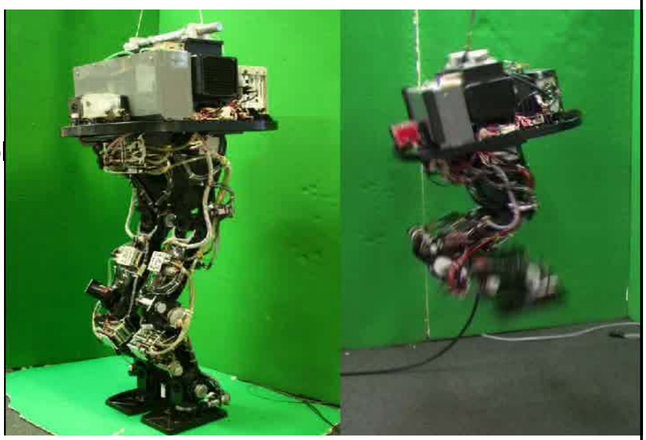
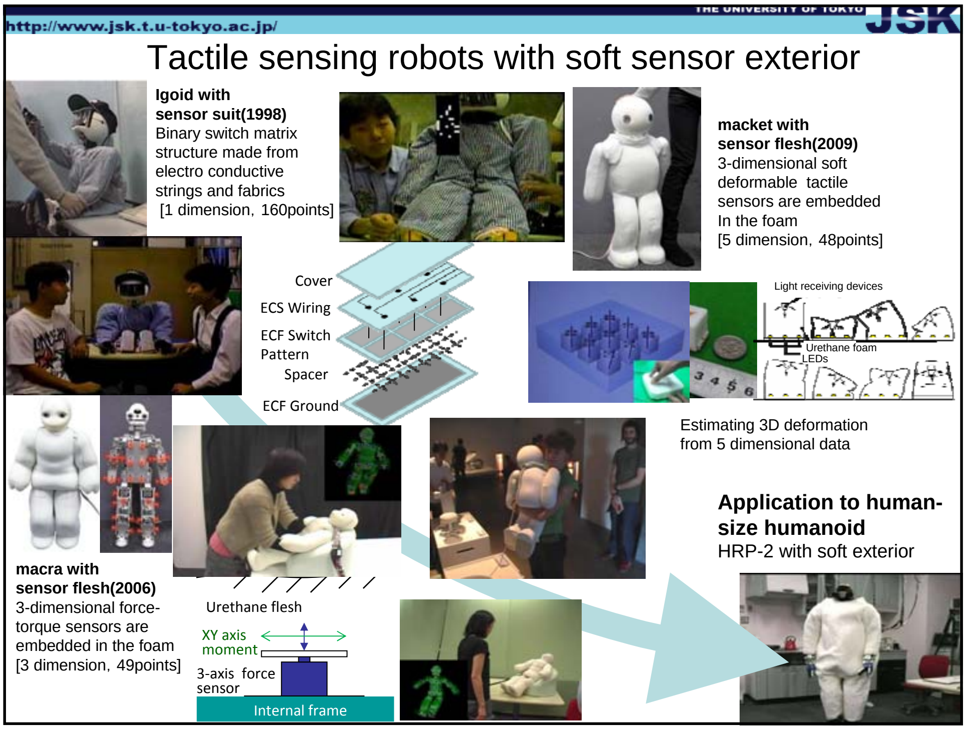
JSK
Musculo-skeletal Humanoid "Kojiro" (2007-)
Scapula
Upper arm
Collarbone
Thorax
Spine
Back
Front
Spherical thorax shoulder structure
DOFs(82 in total)
Cable Arrangement
Parts Arrangement
Design of leg
Height : 140[cm]
Weight : 45[kg]
Arm with nonlinear spring unit
Spine structure
rubber
22

High powered humanoid robot

- Driving a 200W motor
- 80x65x34[mm] 230[g]
- Voltage: 80[V]
- Max. current: 200[A]
- Current Vector Control
  - Id=0 control, flux weakening control
- Liquid-cooling
  - High density implementation

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Tactile sensing robots with soft sensor exterior
Igoid with sensor suit(1998)
Binary switch matrix structure made from electro conductive strings and fabrics
[1 dimension, 160points]
macket with sensor flesh(2009)
3-dimensional soft deformable tactile sensors are embedded In the foam
[5 dimension, 48points]
Cover
ECS Wiring
ECF Switch Pattern
Spacer
ECF Ground
Light receiving devices
Urethane foam
LEDs
Estimating 3D deformation from 5 dimensional data
Application to human-size humanoid
HRP-2 with soft exterior
macra with sensor flesh(2006)
3-dimensional force-torque sensors are embedded in the foam
[3 dimension, 49points]
Urethane flesh
XY axis moment
3-axis force sensor
Internal frame


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COE Project (2007.1.10)
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IRT Assistant Robot (2008.10.24)

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IRT Integration (2008.12.3)

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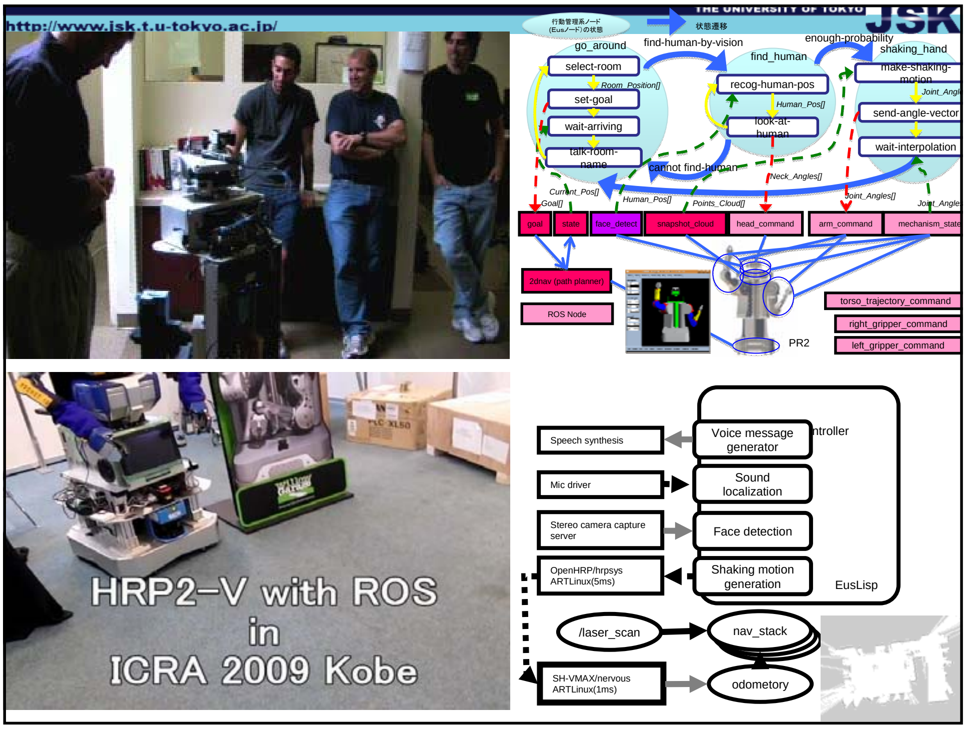
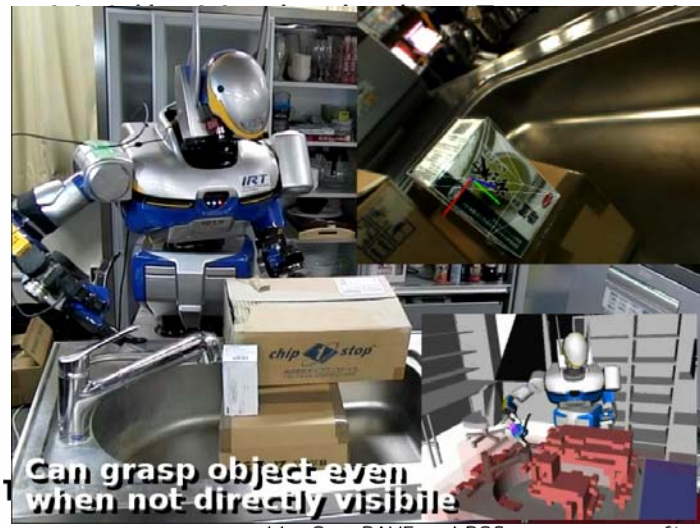
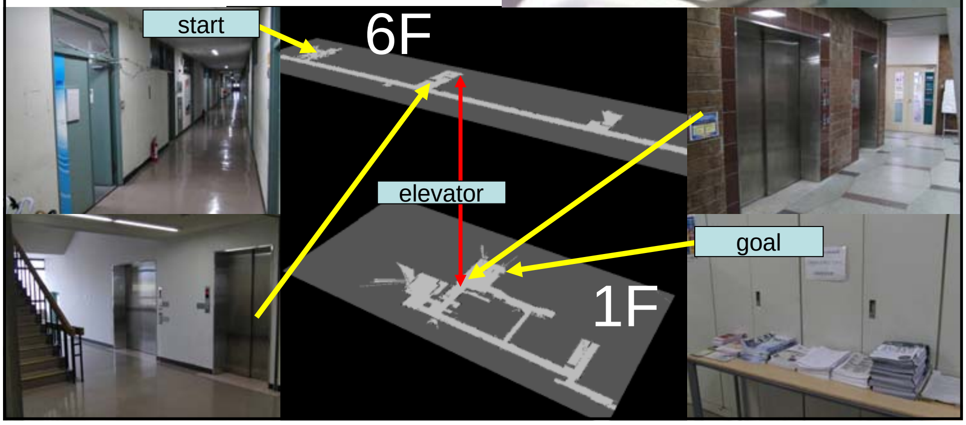


Integration of ROS/EusLisp/OpenRAVE/OpenHRP



powered by OpenRAVE and ROS open source software http://www.jsk.t.u-tokyo.ac.jp/

First experiment: Inter-floor navigation using elevator



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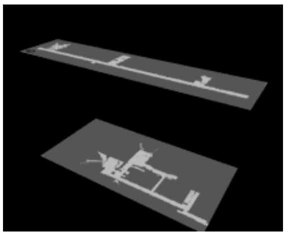
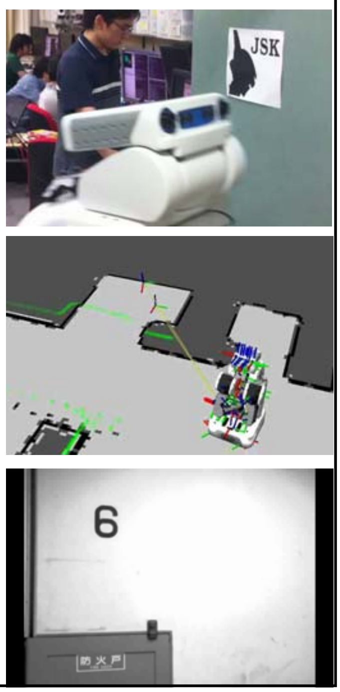
Task knowledge for inter-floor navigation



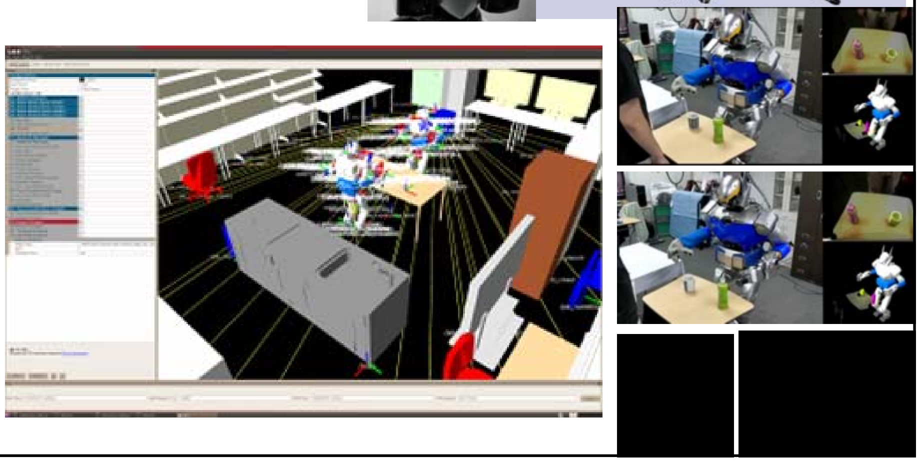
Floor map for laser navigatoin with rough location of panel and elevator

Pr2 kinematic model for push-button motion and visually detected panel locati

Templates to detect precise elevator panel locations Left) outside elevator, Right) inside elevator



HRP2
integration
in ROS



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Software platform for intelligent robotics

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EusLisp

- Light Weight Language
- 3D Solid Modeling
- Foreign Language Function
- Multithread, OpenGL, Object Oriented, CORBA,,,

- 1986 Toshihiro Matsui @ AIST
  - Essence of the robotics research are sensory data processing, visual recognition, motion and task planning, which 3D shape models of robots and environment play crucial roles. A motivation to the development of EusLisp was a demand for an extensible solid modeler that can easily be made use of from higher level symbolic processing system.…

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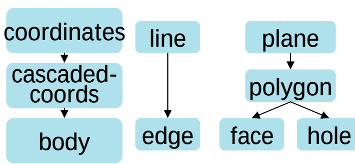
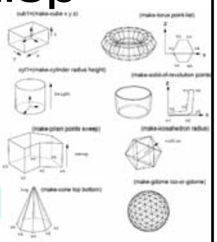
Solid Modeling in Eus Lisp

- coordinates
  - :locate points
  - :rotate theta axis
- Primitive Bodies
  - (make-cube x y z)
  - (make-prism points sweep)
  - (make-cylinder radius height)
- Composition of Bodies
  - (body+ body1 body2)
  - (body- body1 body2)



Class hierarchy of solid modeler



Primitive shapes

```
(setq *viewer* (view))
(setq cube1 (make-cube 50 50 50))
(setq cyl1 (make-cylinder 15 50))
(gldraw *viewer* cube1 cyl1)
(send cyl1 :rotate (deg2rad –50) :x)
(setq cubecyl1 (body+ cube1 cyl1))
(send cubecyl1 :rotate (deg2rad 60) :y)
(setq cubecyl2 (body- cube1 cyl1))
(send cybecyl2 :rotate (deg2rad -45) :z
```

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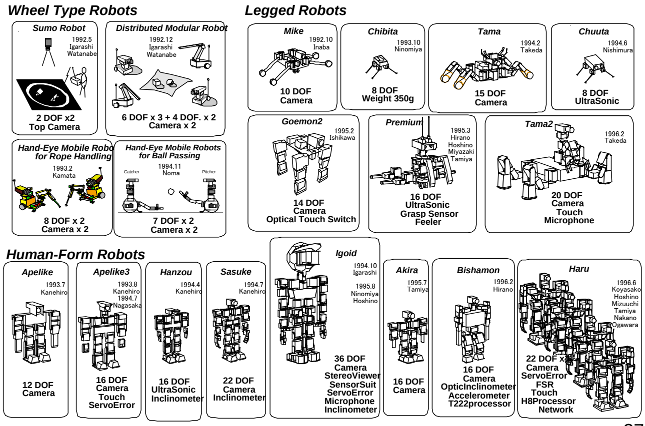
Remote brained robotics (Inaba '92)

- Develop software independent from body
- Connecting body and brain through wireless

Many DOFs, various sensors, vision, solid model, dynamics, image processing, learning,



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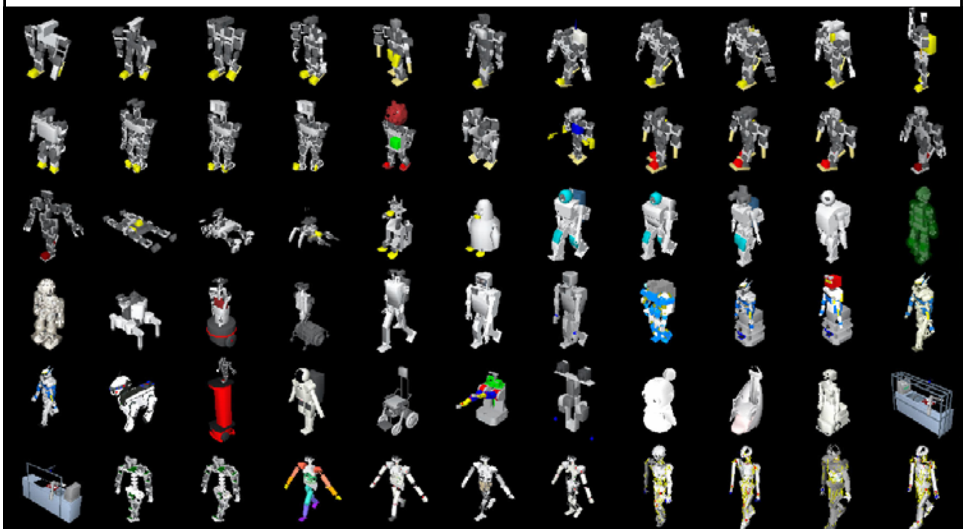
Robots modeled in our system



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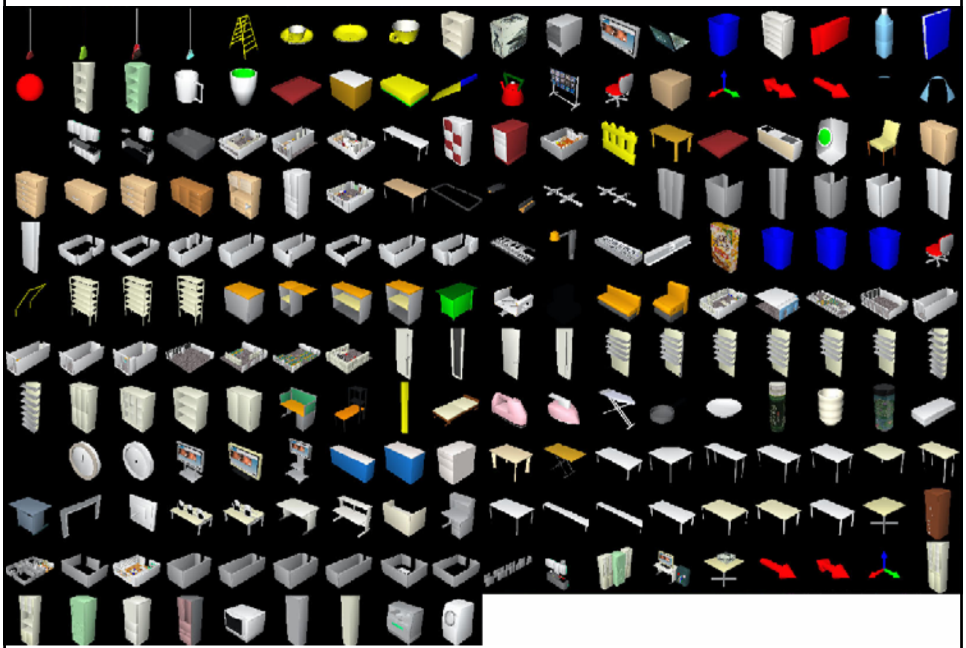

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EusLisp on jsk-ros-pkg

- [euslisp] We have released EusLisp under BSD licence
  - (euslisp.sourceforge.net)
- [euscollada] URDF->EusLisp robot model converter
  - Samples: ./pr2.sh and ./nao.sh scripts in [euscollada] package
  - convert URDF file to EusLisp via COLLADA format
  - [collada_urdf_jsk_patch] for color material and cylinder/box/sphere. Now, we can generate nao COLLADA file from URDF.
- [roseus] ROS Client Library for EusLisp
  - [roseus] roseus/test for sample programs

[pr2eus] ROS/EusLisp/PR2 Sample programs

- `> roslaunch pr2eus pr2-read-state.launch`
  - read joint state from real robot and calculate jacobian

[INFO] [1283850940.934673944]: larm jacobian

0.001	0.077	-0.384	-0.059	-0.154	0.000	0.000	0.000
0.001	-0.078	0.103	0.146	0.426	-0.004	0.180	0.000
0.000	0.177	0.117	-0.365	0.167	-0.093	-0.007	-0.000
0.000	0.535	0.209	-0.790	0.202	0.855	0.000	1.000
0.000	0.834	-0.284	0.515	-0.294	0.519	0.041	0.000
0.000	0.133	0.936	0.333	0.934	-0.021	0.999	0.000

- `> roslaunch pr2eus pr2-send-joints.launch`
  - jsk-way of basic robot programming

```
(setq *pr2* (pr2))
(send *pr2* :arms :elbow-p :joint-angle -90)
(send *ri* :angle-vector (send *pr2* :angle-vector) 3000)
```

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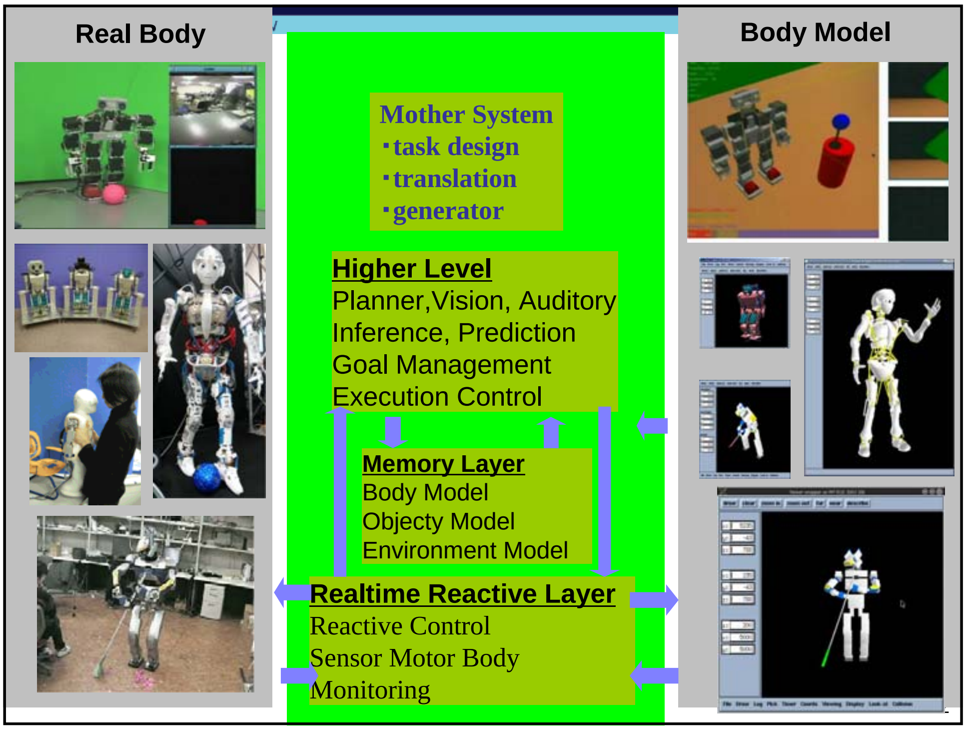
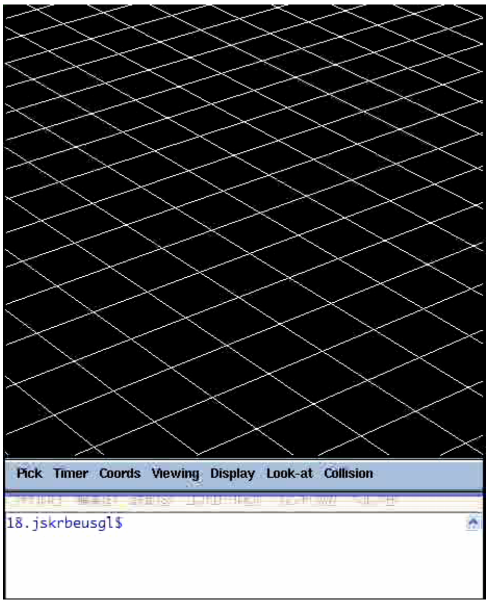
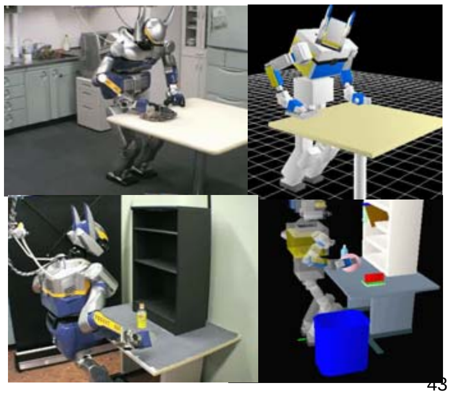


EusLisp powered by dynamics engine

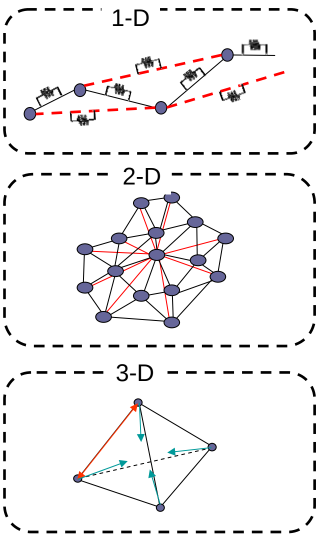


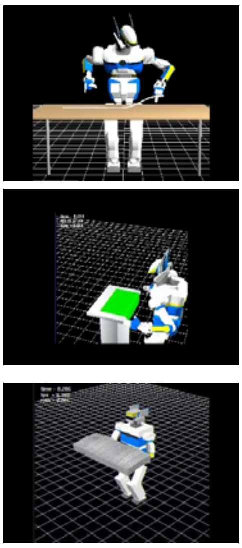
- Add an object
- Translate / rotate objects
- Toggle dynamics
- Control simulation loop



Modeling deformable objects in the simulator engine

[IAS2008]





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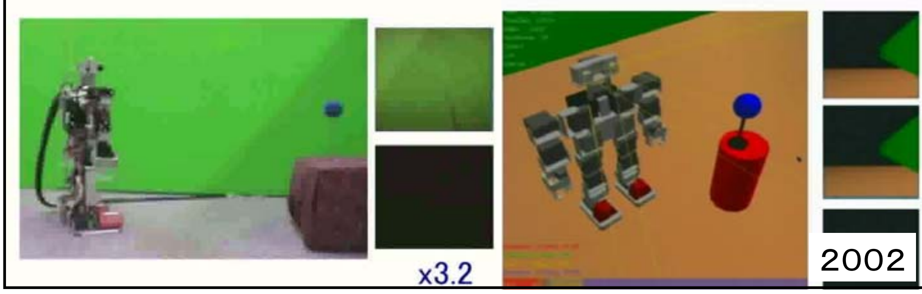
Humanoid behavior simulator

- Humanoid simulation system based on game physics SDK
  - Humanoid behavior simulator (Kanehiro 2001)
- Vision, touch force sensor simulation
- Using same software for simulated and real humanoid



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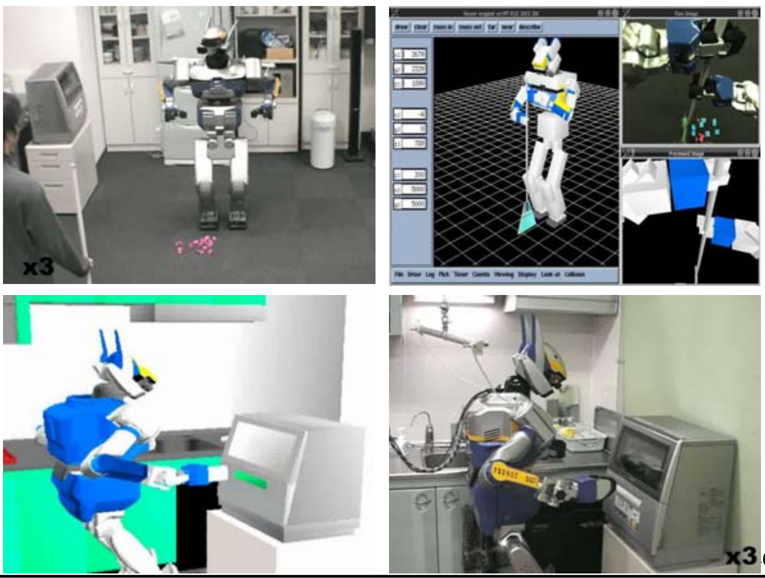
Connecting software environment and real environment

Representing world situation through visual recognition

Motion planning on simulated environment and execution through real hardware



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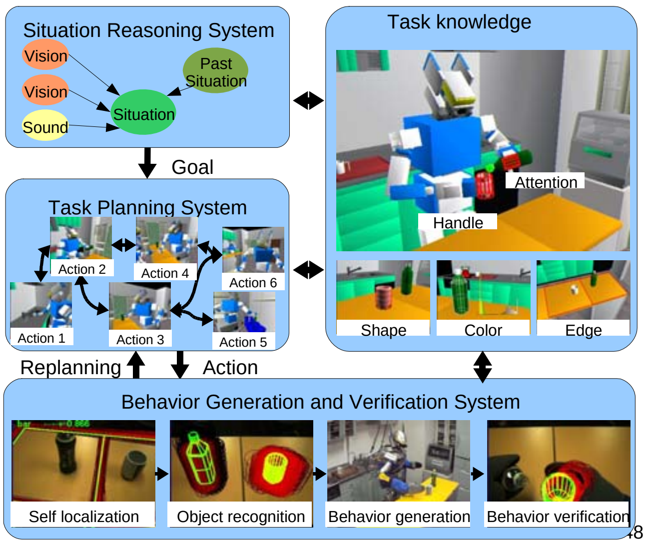
Task guided attention control and visual verification

Integrated humanoid system overview

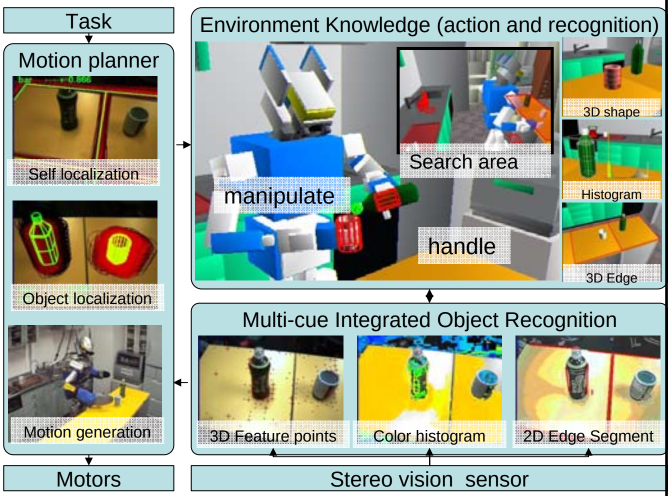
- Task-related knowledge
- Situation reasoning system
- Task planning system
- Vision based behavior generation system



Vision based behavior Generation and Verification System

Manipulation knowledge
- Spot
  - Standing location for executing tasks
- Handle
  - Coordinates and constraints on an object for reaching
- Manipulate
  - A reference coordinate for manipulating an object

Recognition knowledge
- Visual features
  - 3D shape
  - Color Histogram
  - 3D visible edge
- Search area



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Whole Body Motion Generation using Handle knowledge

- Input: Motion of a target object (Washing Machine) and handles.
- Output: Whole body motion sequence

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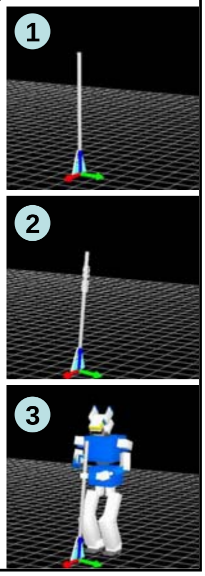
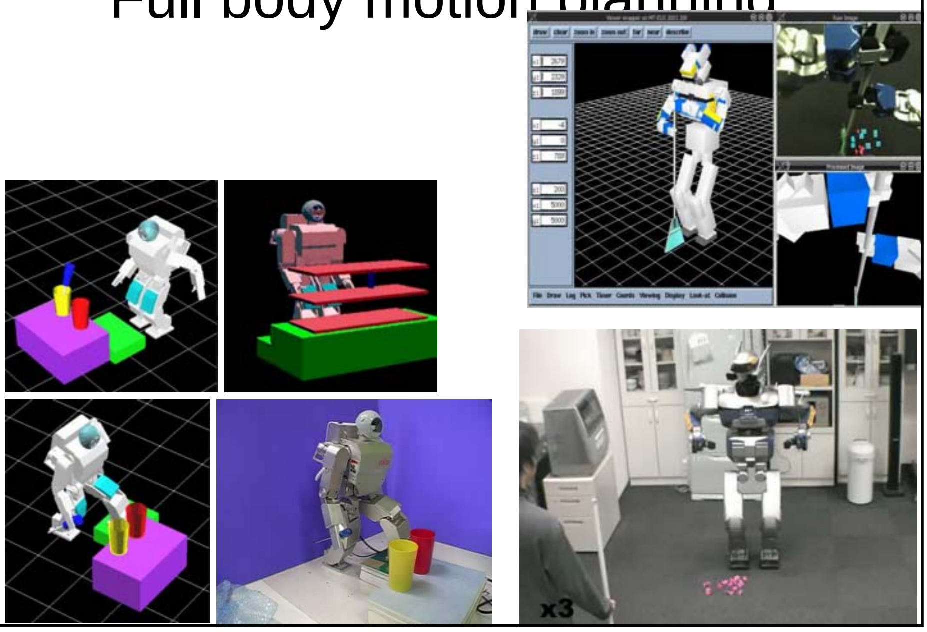
Tool Manipulation Motion Generation using Attention Knowledge

- Input: Attention trajectory
- Output : Motion sequence

1. Move the attention point to determine the position and rotation of the object
2. Update handle locations from the object position and rotation
3. Generate whole body motion from the handle positions



Full body motion planning



Model-based object recognition based on multi-cue integration

(IROS'07)

- Particle filter based multi visual cue integration
- Compute the weight of each particle based on visual feature matching

$$p(\mathbf{x}_t \mid \mathbf{Z}_t) \approx \sum_{i=1}^{N} \mathbf{s}_t^{(i)} \mathbf{w}_t^{(i)}$$

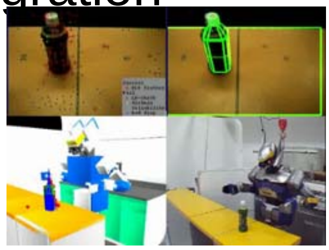
Position — Observation — Particle

$$\mathbf{w}_t \approx \mathbf{w}_{t-1} p(\mathbf{z}_t \mid \mathbf{x}_t)$$

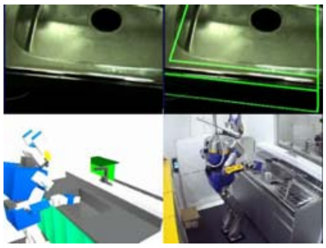
Weight — Likelihood

$$p(\mathbf{z}_t \mid \mathbf{x}_t) = \sum_{j=1}^{M} w_j \, p_j(\mathbf{z}_t^j \mid \mathbf{x}_t)$$

Likelihood of each visual feature



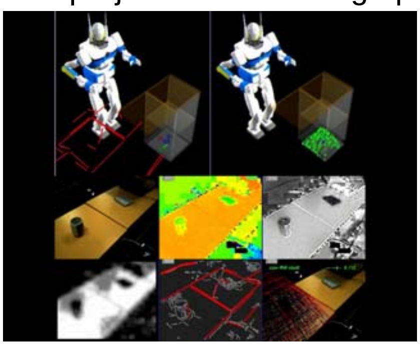
3D feature points based object recognition for manipulation

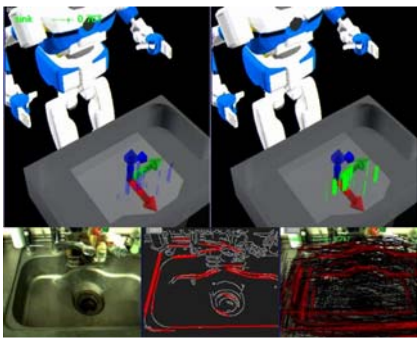


Edge based visual self localization

2D-2D edge matching strategy

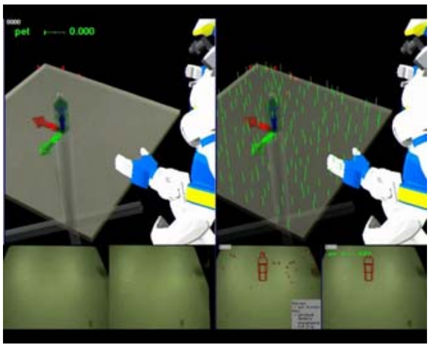
- Calculating 3D edge is difficult for stereo vision, especially the target beyond the view area.
  - 2D edges of visual information : Edge operator
  - 2D edges of visual cue knowledge : 3D edge knowledge projected to the image plane



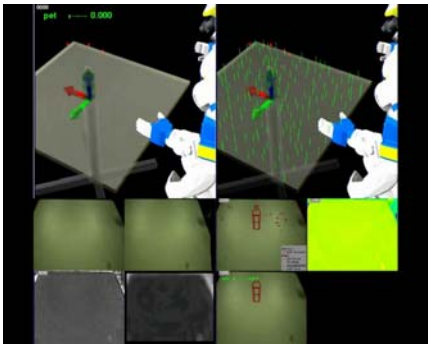


Advantage of multi-cue recognition

- Combination of 3D points and color histogram distinguish same shape but different texture



Plastic bottle recognition using only 3D feature points



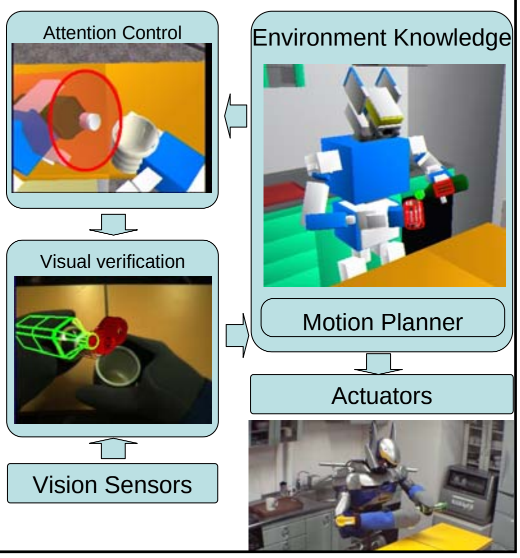
Plastic bottle recognition using both 3D feature points and color histogram

Vision based Behavior Verification

- Environment knowledge based visual processing
  - 3D model based object detection

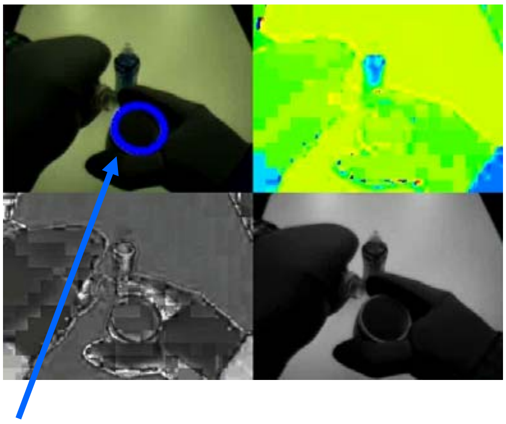
    +

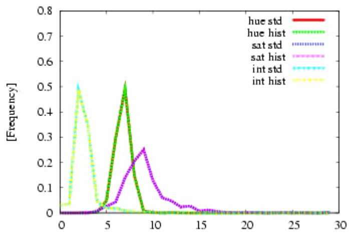
  - Attention knowledge based visual attention control for event detection



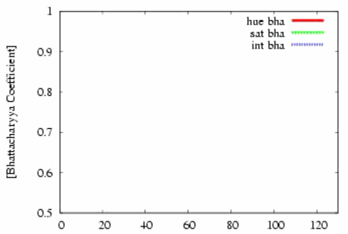
Attention based event detection(1)

- Detecting “green tea” in the cup
- Using Color histogram changes





Color histograms (hue, sat, int)

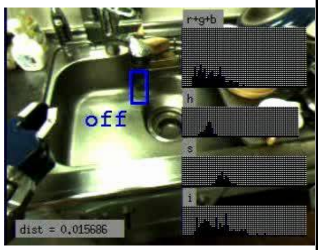


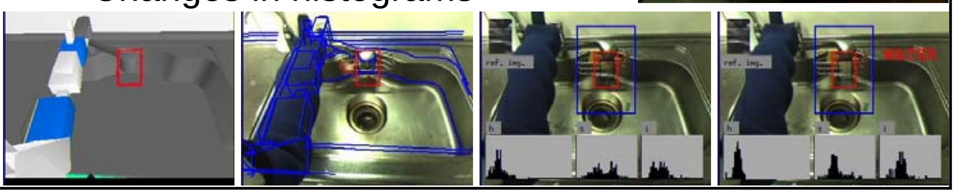
Attention area

Histogram difference from the initial frame

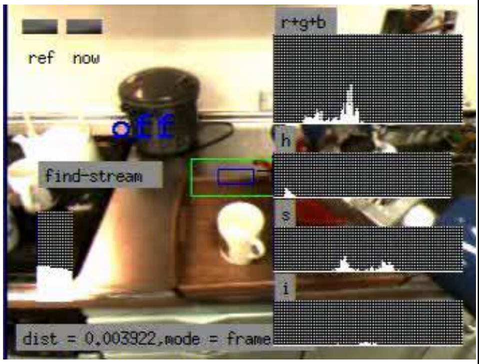
Attention based Event Detection(2)

- Calculate attention area on image coordinates from attention knowledge on the task knowledge
- Detection of the starting / stopping of water flow
  - Background/frame difference
  - Changes in histograms





Attention based Event Detection(3)



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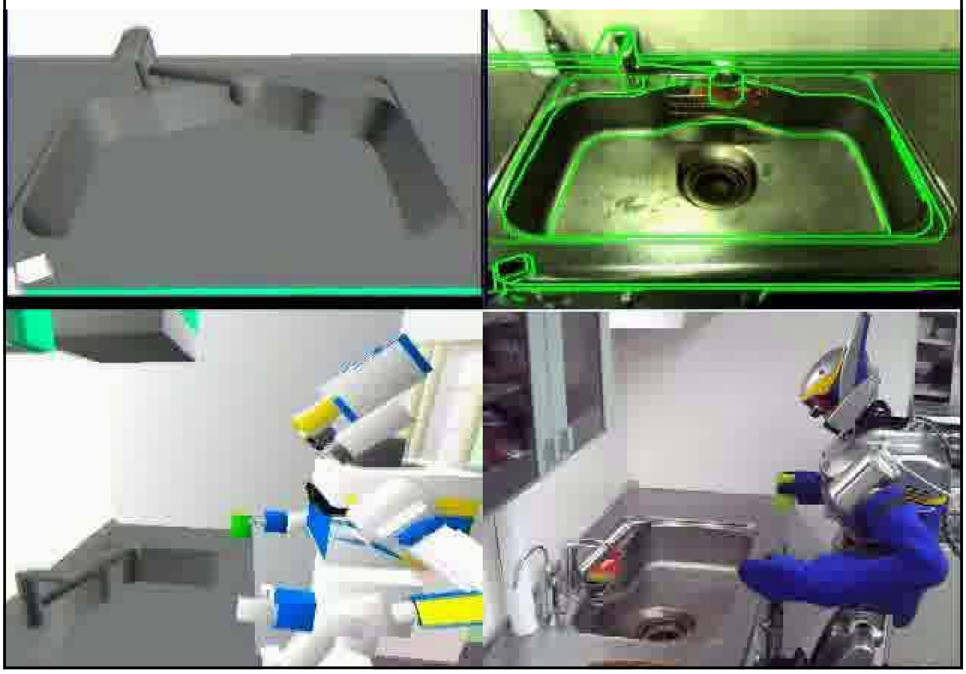
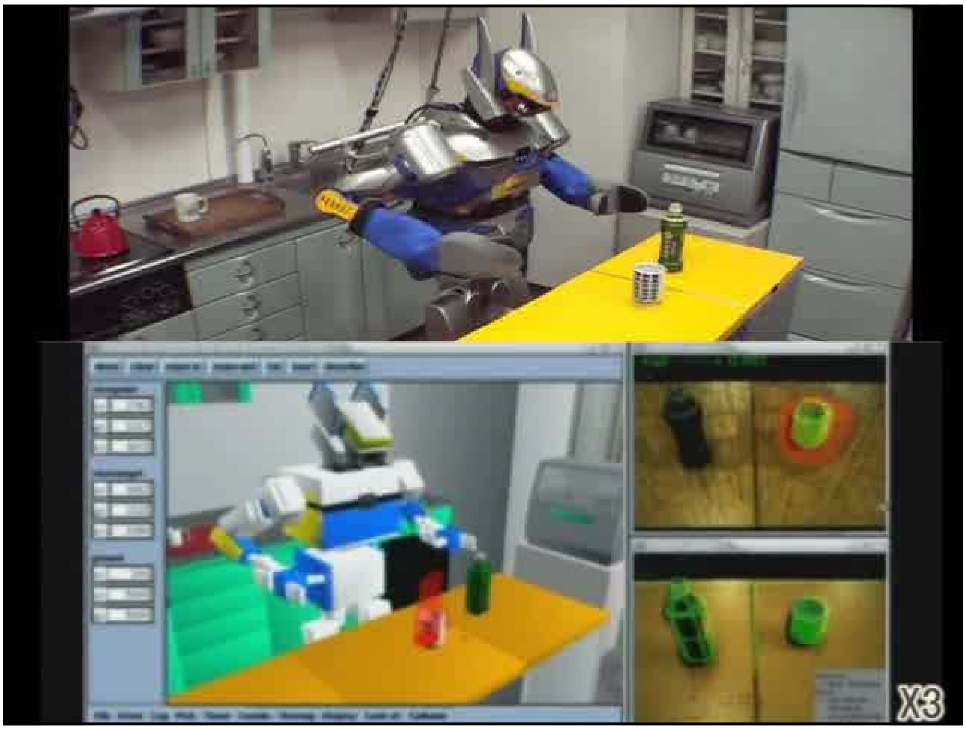


Connecting high-level reasoning and recognition behavior system



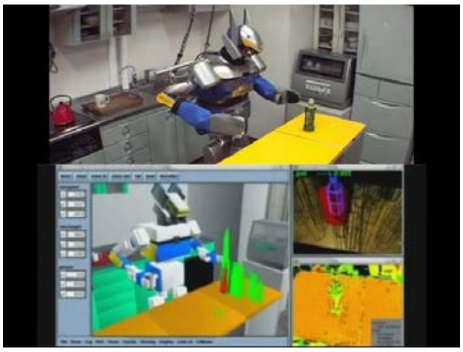
Manipulation and recognition know ledges

Actions	Visual controls
Actions with self localization	
Move to counter	Recog. counter
Move to kitchen	Recog. sink
Actions with object localization	
Hold a cup	Recog. cup
Hold a bottle	Recog. bottle
Place a cup	Recog. cup
Place a bottle	Recog. bottle
Actionss with visual verification	
Pour tea	Recog. tea
Open tap	Recog. water
Close tap	Recog. water
Wash cup	—

Object	Knowledge
Cup	Shape
Bottle	Histogram, Shape
Counter	Edge
Sink	Edge
Search area	**Ttarget**
On counter	Cup, Bottle
Counter foot	Counter
Sink foot	Sink
Under tap	water flow
Event	**Knowledge**
Recog. tea	Color histogram
Recog. water	Water flow model

Table 1. Knowledge description in the kitchen experiment.

Vision based humanoid tasks



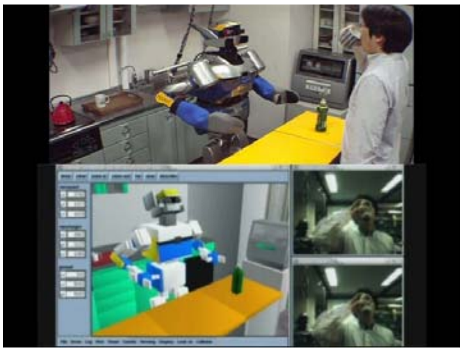
1）**Recognize location of the bottle**

2）Grasp the bottle

3）**Recognize the cup and the bottle to verify grasping motion**

4） pour tea, place the cup.

5）**Verify placing motion by the cup recognition**



6）**Recognize the cup location, update the cup position in the knowledge environment**

7）Grasp the cup

8）Walk to the sink

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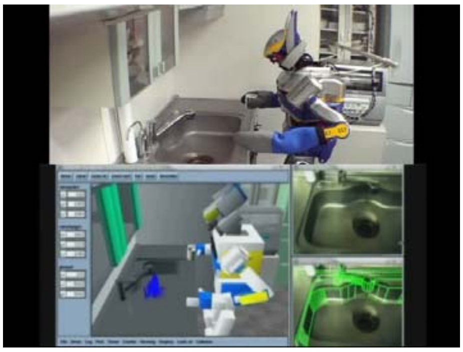
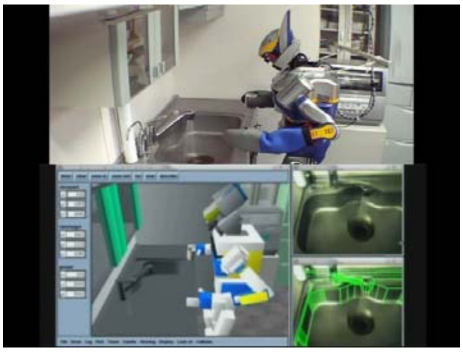
Vision based humanoid tasks (con't)





9) Walk to the sink

10) Recognize the sink, update the robot model, walk for adjust

11) Open the water tap

12) Recognize water flow

13) Wash the cup and place it.

14) Recognize the cup to verify placing motion

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Task planning system

- STRIPS like planner to control the execution of vision based behaviors
- Design operators based on behavior system

HOLD:

preconditions : (ON ?OBJECT ?SPOT) (AT ?SPOT)

Object recognition — Self localization

action : (HOLD ?OBJECT ?ARM)

effects : (HOLD ?OBJECT ?ARM) ~(ON ?OBJECT ?SPOT)

- Verify motion by observing the "effects"

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STRIPS operators based on the behavior system

HOLD:
preconditions : (ON ?OBJECT ?SPOT)
(AT ?SPOT)
action : (HOLD ?OBJECT ?ARM)
effects : (HOLD ?OBJECT ?ARM)
~(ON ?OBJECT ?SPOT)

PLACE:
preconditions : (HOLD ?OBJECT ?SPOT)
(AT ?SPOT)
action : (PLACE ?OBJECT ?ARM)
effects : ~(HOLD ?OBJECT)
(ON ?OBJECT ?SPOT)

MOVE-TO:
preconditions : (AT ?FROM)
action : (MOVE-TO ?FROM ?TO)
effects : (AT ?TO) ~(AT ?FROM)

OPEN-TAP:
preconditions : (AT ?SPOT) ~(WATER-FLOW)
action : (OPEN-TAP)
effects : (WATER-FLOW)

CLOSE-TAP:
preconditions : (AT ?SPOT) (WATER-FLOW)
action : (CLOSE-TAP)
effects : ~(WATER-FLOW)

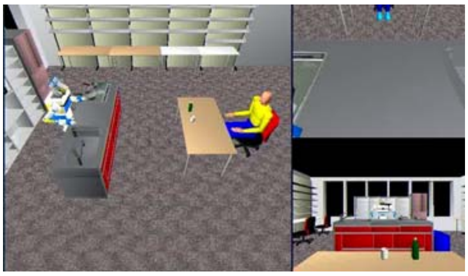
WASH-CUP:
preconditions : (HOLD CUP LARM) (AT SINK)
(WATER-FLOW)
action : (WASH-CUP)
effects : (WASHED CUP)

POUR-TEA:
preconditions : (HOLD CUP LARM)
(HOLD BOTTLE RARM)
action : (POUR-TEA)
effects : (POURED CUP)

Task Planner based behavior sequence generation

- Initial state : a cup and bottle on the table
  (AT KITCHEN) (ON CUP TABLE) (ON BOTTLE TABLE)
- Goal state : a cup is poured
  (POURED CUP) (ON CUP TABLE)
- Planned behavior sequence

1. (moveto kitchen table)
2. (hold bottle larm)
3. (hold cup rarm)
4. (pourtea)
5. (place bottle rarm)



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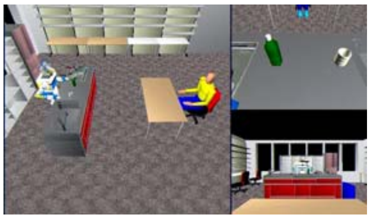
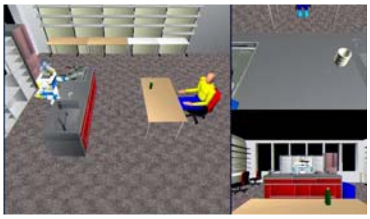
- From different initial state

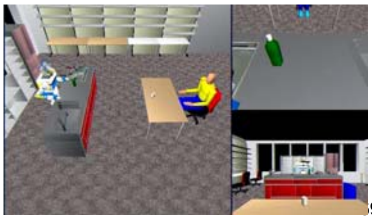
1) a cup and bottle on the kitchen
   - (AT KITCHEN)
   - (ON CUP KITCHEN)
   - (ON BOTTLE KITCHEN)



2) a cup on the kitchen and bottle on the table
   - (AT KITCHEN)
   - (ON CUP KITCHEN)
   - (ON BOTTLE TABLE)



3) a cup on the table and bottle on the kitchen
   - (AT KITCHEN)
   - (ON CUP TABLE)
   - (ON BOTTLE KITCHEN)



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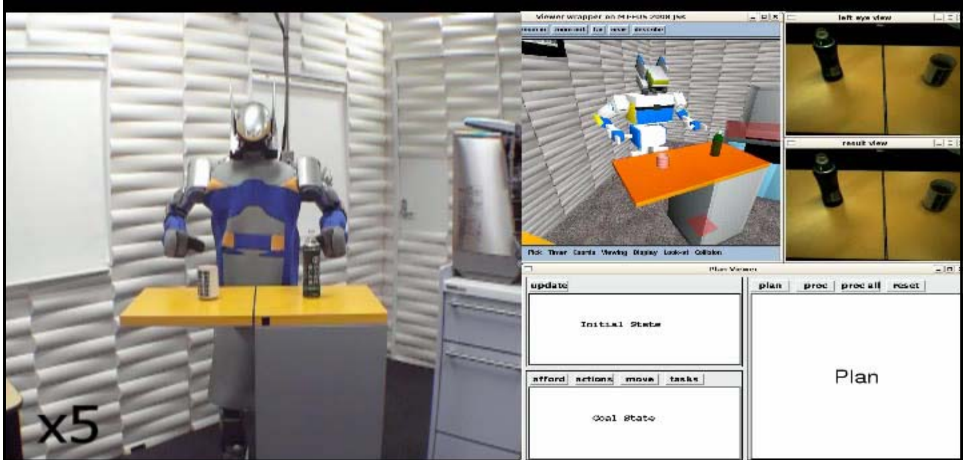
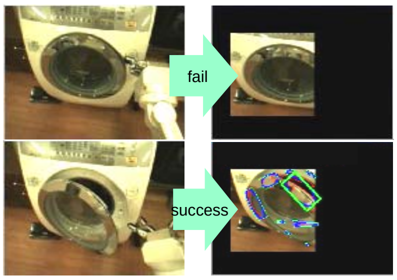
Failure detection and re-planning



Classification of failures

- A. Failures detected before manipulation
- B. Failures detected after manipulation, but the condition of target object is not changed so much
- C. Failures detected after manipulation, and the condition of target object is significantly changed

Ex. Push the button of washer machine



Motion re-planning（x4）

Experiments of failure detection

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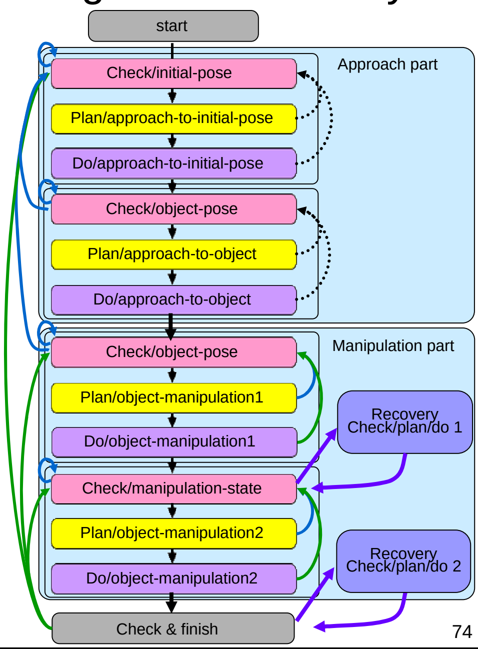
TABLE I

FAILURES AND COUNTERMEASURES ON DAILY TASKS EXECUTION

Target	Target detection and approach	example of failure	failure detectio and recovery
Tray	Verification by vision	Fail to grasp or release of the tray	Check by force sensor and grasp state
Clothes	- recognize the chair by using vision and LRF - recognize the cloth by vision	- approach error depending on wheelbase motion - fail to pick up the cloth - drop the cloth on a floor	- recognize and move wheelbase again - check hand pose after picking up - verify the grasped cloth by vision - pick up the cloth from the floor
Washer	- recognize by using LRF - recognize the button by using vision	- approach error depending on wheelbase motion - miss in pusing the button - the cloth hang out from the washer tab - overload to arm joints while manipulation	- recognize and move wheelbase - verify by vision after pushing the button - recognize the hung cloth just after putting cloth in the washer - put the cloth in a washer again
Chair	- recognize by using vision and LRF	- approach error depending on wheelbase motion - the hand is released from the chair while handling - overload to arm and finger joints	- recognize and move wheelbase again - observe the grasping state of the chair by using force sensors - automatically servo off and recover when overload to joints are obeserved
Broom	- recognize the relative pose of the washer - self localization by using LRF	- the head of broom slants - drop the sweeper while handling - overload to finger joints while handling	- recognize the sweep head and rotate it - pick up the broom on the floor - automatically servo off and recover when overload to joints are observerd

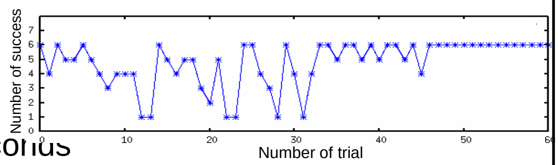
Task description including failure recovery

- A manipulation task
  - Approach + manipulation
- Behavior unit
  - check/plan/do
- Check
  - Pose/position estimation
  - Reflect the result to simulator
- Plan
  - Generate pose streams obeying on the state of the simulator
- Do
  - Perform motion from the poses
  - Observe the motion



AR demo

- Task
  1. Carry a tray
  2. Gather clothes
  3. Handle a washer machine
  4. Handle a bloom
  5. Pull out a chair
  6. Sweep under a table
  7. Align the chair
  8. Sweep around the room

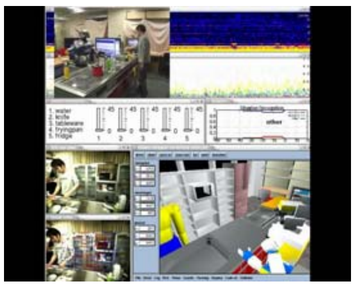


The transition of number of tasks success
(We succeeded to raise the rate by modifying task description and by adding failure recovery functions)

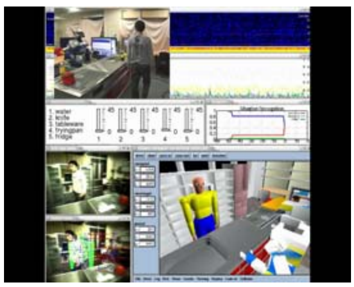
- Execution time
  - 8 minutes and 20 seconds
    (the fastest time without failure recovery)

Situation reasoning system

- Visual-auditory integrated Distributed Bayesian Network to estimate situation.
- Outputs current situation
  - Dish washing
  - Cooking
- Dish washing
  - Goal : (WASHED DISH)
- Cooking
  - Goal : (ON DISH TABLE)



Dish washing situation



Cooking situation

Programming course using life-sized humanoid robots

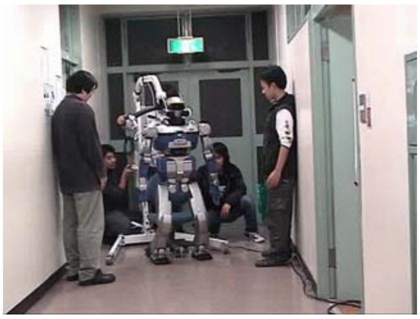
Programming course using humanoid robot

- Undergraduate : Mechano-informatics seminar (機械情報工学ゼミナール)
  - 4-6 student, 3 hours/week for 2.5 month
  - 2003 : Humanoid robot programming
    - 「ヒューマノイドの行動プログラミング」
  - 2005 : Making tools and smart humanoid that can manipulate it
    - 「道具を創り，それを扱える器用で賢いヒューマノイドをつくろう」
- Graduates : Mechano-informatics exercise course (知能機械情報学演習)
  - Since 2004
    - Perception action programming for humanoid robot
    - Action control and learning of robot
    - 「等身大ヒューマノイドの認識行動プログラミング」
    - 「ロボットの行動制御と学習」

2003 Mechano-informatics seminar

- Making motion sequence using geometrical model of humanoid robot
  - Basics of lisp
  - How to control joint on the lisp model
  - Write motion program
  - Convert to motion sequence pattern file
  - Using simulator to check sequence.
  - Apply to the real humanoid robot

Volley ball



Sit on the chair

Do squats

Catch and through ball

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H17年度 機械工学ゼミナール 稲葉

道具を創り，それを扱える器用で賢いヒューマノイドをつくろう

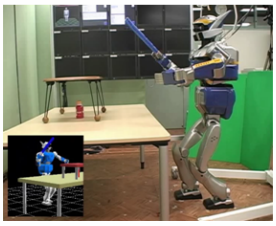
人は，問題に適した道具を創りだし，それを使いこなして問題を解決する能力をもつ．

右のヒューマノイドは，手が届かないところにある缶を，棒を曲げて引き出して使えるようにして，缶を引き寄せている．

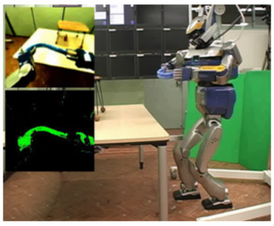
ゼミでは，右のような等身大ヒューマノイドHRP2が，それだけではできない作業のために必要となる道具を考え，その道具をロボットが作ることと扱うことを考えながら，自分でまずそれを作り，その道具をロボットに使わせて作業を達成させることを試みる．

各自の自由な発想で課題となる作業とそのための道具を考え，その道具のモデリングを各自行い，それを使うヒューマノイドの行動実験を行う．

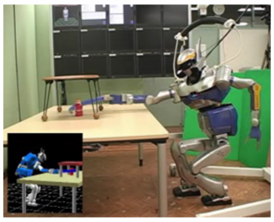
連絡先: inaba@jsk.t.u-tokyo.ac.jp
教授室:８号館707室稲葉



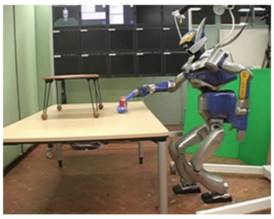
テーブルの下の缶を取りたいが手が届きそうにないので棒をもつ



棒を適当に折り曲げて，目で折り曲がり具合を確認して



机にぶつから無いように，Ｌ棒の曲がり具合にあわせて手を伸ばし



缶が棒からはずれないように棒を操って缶を引き寄せる

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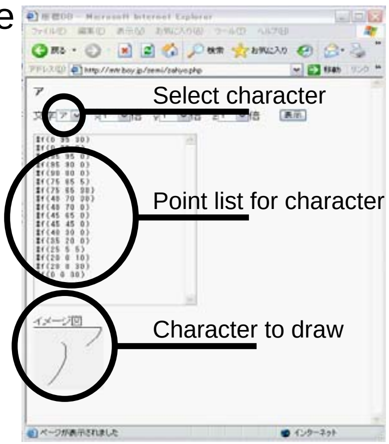
2005 Mechano-informatics seminar

- End effecter position sequence
  - Draw character using pen
  - Play xylophone (木琴)
  - Nailing
  - Cut vegetables



Character to end effecter point list conversion system

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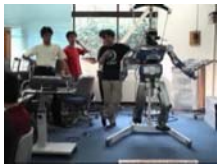
2004 Mechano-informatics course

- Programming exercise course using HRP2 humanoid robot
- Using OpenHRP platform
  - write motion control using plugin architecture
  - Behavior control based on visual processing
  - Apply to real humanoid

preparation



setup

teaching

presentation

experiment

cleanup

2006 Mechano-informatics course

Accidents in 2004

- Need to protect humanoid body from self collisions
- Development “practical” self collision detection system

Conclusions

- JSK :Behavior generation through sensing
- Humanoid platform HRP2
- Rapid development environment with geometry manipulation and symbolic reasoning
- Task guided attention control and visual verification
- Connecting high-level reasoning and recognition behavior system