Past years and next 10 years of RoboCup and RoboCupSoccer Humanoid league

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Invited talk
Workshop on Humanoid Soccer Robots
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Outline of my talk

1. Past 10 years
- SSL, MSL, and Sim.L since 1997, Legged since 1999, Rescue and Junior since 2000, Humanoid since 2002, and RoboCup@home since 2006.
- Focusing on engineering issues on perception, mechanism, and control for real-time responses.

2. Next 10 years
- Current Discussion
- Research issues..
- RT experiments open to public

Yesterday and today (I)

- Someday in September, 1993: discussing on the idea of robot soccer in Japan.
- After that, US and European members have participated in the meeting to form the international committee.

Yesterday and today (II)
The current structure (1)

President
- **Minoru Asada (Osaka University, Japan)**

The Board of Trustees:
- **Manuela Veloso (Carnegie Mellon University, USA) *Vice President**
- **Hans-Dieter Burkhard (Humboldt University, Germany) *Vice President**
- **Hiroaki Kitano (Kitano Symbiotic Systems Project, JST, Japan) *Founding President**
- **Tucker Balch (Georgia Institute of Technology, USA)**
- **Silvia Coradeschi (Orebro University, Sweden)**
- **Gerhard K. Kraetzschmar (Fraunhofer IAIS and University of Applied Sciences Bonn-Rhein-Sieg , Germany)**

Yesterday and today (III)
The current structure (2)

The Board of Trustees: (cntd.)
- **Pedro U. Lima (Instituto Superior Técnico, Portugal)**
- **Daniele Nardi (University of Roma "La Sapienza", Italy)**
- **Itsuki Noda (National Institute of Advanced Industrial Science and Technology, Japan)**
- **Enrico Pagello (University Padova, Italy)**
- **Elizabeth Sklar (Brooklyn College, City University of New York, USA)**
- **Peter Stone (The University of Texas at Austin, U.S.A.)**
- **Satoshi Tadokoro (Tohoku University, Japan)**
- **Ubbo Visser (University of Bremen, Germany)**

Yesterday and today (IV)
The current structure (3)

- **The Executive Committee consists of members of the board of trustee, and representative of each activity area. The terms are three years.**

Simulation League, Small Size Robot (F-180) League, Middle Size Robot (F-2000) League, 4-Legged Robot League, Humanoid League, RoboCupRescue Robot League, RoboCupRescue Simulation League, RoboCup@Home, RoboCupJunior, Web Presentation::

Humanoid League
- **Changjiu Zhou (Singapore Polytechnic, Singapore) 2006-2009**
- **Norbert Mayer (Osaka University, Japan) 2004-2007**

Yesterday and today (V)
The current structure (4)

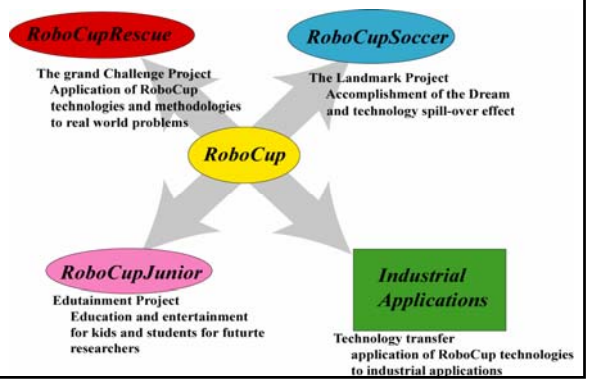
- **The Technical Committee is responsible for technical issues of each league along with the Exec members from above. The TCs consist of the exec members from above and the members.**

Humanoid League
- **Jacky Baltes (Univ. of Manitoba, Canada)**
- **Oskar von Stryk (Germany)**
- **Emanuele Menegatti (Italy)**
- **Li Liu (Singapore)**

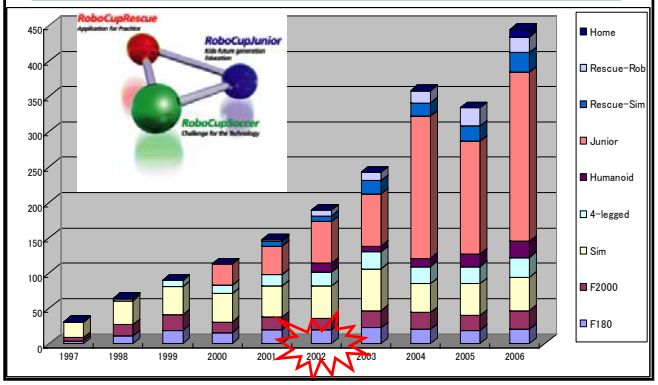
RoboCup vs. RoboCop?

- It had not been a joke!
- We were sued by Orion Pictures.
- Hiroaki Kitano and Shu Ishiguro had solved the issue.

What's RoboCup?



Number of Teams



Old Days: from the first RoboCup (1)

- The First Robot World Cup Soccer Games and Conferences (RoboCup-97) was held in conjunction with IJCAI-97 (International Joint Conference on Artificial Intelligence) at Nagoya, Japan from August 23 - 29, 1997.
- 42 teams from 10 nations around the world: Germany, Japan, USA, France, Italy, Spain, Australia, Finland, Canada, and Sweden.
- 5 teams in MSL, 4 teams in SSL, and 38 teams in Simulation league.

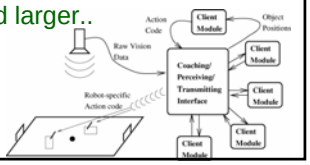
Old Days: from the first RoboCup (2)

Photo in VSD Magazine

First RoboCup in conjunction with IJCAI-97

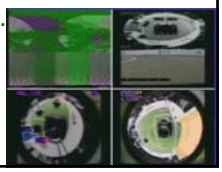
SSL

- Single remote camera → multiple remore cameras
- Non-holonomic vehicle → Holonomic (omnidoirectional) vehicle
- Shooting by dribblling or pushing → kicking device
- Individual play → high level team play
- Wall to keep the ball inside of the field → removed!
- Field has bevome larger and larger..



MSL

- Normal camera → omnidirectional camera
- Non-holonomic vehicle → Holonomic (omnidoirectional) vehicle
- Shooting by dribblling or pushing → kicking device
- Individual play → high level team play
- Wall to keep the ball inside of the field → removed!
- Field has become larger and larger..



Simulation L.

- RC06 report says, “The 2D simulator still provides better soccer competitions than the 3D simulator. Better in this sense that games are faster and team behaviors and cooperation are more advanced. The 3D simulator, although still young in its third year, has improved in small increments since its commencement and now exhibits the first humanoid simulation prototypes.”

First Legged League in 1999

- Actually, the exhibition was held in RoboCup 1998 with prototype of AIBO.
- Simple Individual behaviors → very complex ones and also team plays with communication.
- The field become larger and larger

RoboCupJunior since 2000

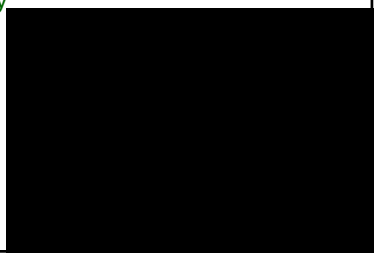
RCJ 2005!

RoboCupRecue Real Robots

RoboCupRescue Simulation

Humanoid League since 2002

- Remote brain and external power → self contained!
- No walls from the beginning.
- Individual play → 2 on 2 game.
- Still lack of the stability



Video clips from RC 2006

- SSL Ch3: 11:31-12:27
- MSL Ch2: 09:42-10:35
- 4LL Ch8: 16:35-18:16
- HL Ch6: 21:15-21:31

What's happened in 2002-2004

- The robots were quite variant in many respects and had to be sorted into three sub-leagues in order to cope with the variety of heights between 10cm to over 2m. The competitions consisted of walking challenges, a free style competition, and penalty kick competition for all size classes. At this time external processing – even remote control was allowed. In order to make results of the competitions comparable between the very different robots performance factors had been introduced. These performance factors had to be applied to commercial platforms, remote control and external processing.

After 2004...

- The emergence of **Team Osaka** in 2004 in Lisbon showed an un-precedented performance with regard to technical compactness and general perfection in this size class and in relation to the manufacturing costs. They got the Best Humanoid Award in that year. At that time their robot arose some hope that regular soccer games were indeed possible with robots of a size of roughly 40-60 cm and certain design features. These features have hitherto been adapted by most teams of the later established KidSize class.

After 2004...

- Starting from these experiences many changes have been introduced into the competition making the technical constraints more specific. Performance factors were abandoned, and external processing as well as remote control were banned from the competition. A maximum ratio between foot size and height of the center of mass had been introduced in order to encourage dynamic walking. The number of size classes was reduced from 3 to 2, of which the smaller class was called Kidsize (< 60cm) and the bigger class TeenSize. The total number of competitions remained the same, however, the Freestyle competition was replaced by the above mentioned regular 2-2 games in the KidSize League.

After 2004...

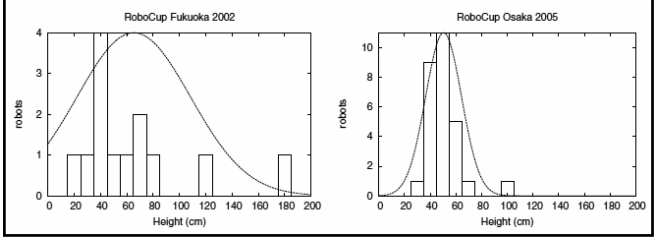
- In the TeenSize league the conductance of 1-1 games was discussed, but could not be carried out. One aim of the technical committee was and still is to lead the development towards current research problems. Dynamic walking and stability have been the most important issues then and still are up to now, which have been enforced by the technical challenges between in the years 2005 and 2006. In the year 2005 and 2006 a rough terrain challenge has been conducted where the robots have to cross over a field of hexagonal tiles, which are of a random height. The technical challenges are changing every year.

After 2004...

- The competitions have been farther refined for the competition in 2006 in many aspects, in particular with respect to the conductance of the 2-2 games. Also the footrace competition had been introduced to the TeenSize class in order to have an equal number of competitions in Teen- and KidSize.
- The rules of 2005 and 2006 and the example of relatively cheap and powerful robots gave a new perspective to many interested people in the RoboCup community and also people from outside who were interested in setting up a team.

Change of the size of the robots

- Histograms of the heights of the robots that participated during the competitions in 2002 (left) and 2005 (right):



After 2004...

- In 2005 a total of 20 teams from 9 countries participated. This is about twice the number of the year 2004. For the first time a real qualification process had to be introduced. Several teams had some background from other leagues and took the advantage to customize relatively successfully their software within the new league. Team Osaka got the Best Humanoid Award again, as well as in 2006, after a very exciting final against Team Nimbro (Germany).

Typical Design Concept of the Robots' Hardware (1)

- Servo motors (initially designed for RC toys). In particular many teams switched to RC servos that can be linked together in the RS 485 bus (similar to the well known RS 232; one example are Dynamixel DX 117 and AX 12 actuators).
- Small reliable mini PCs (e.g. handhelds, industry one board mini PCs, like PINON PNM SG3F. In order to process the vision sensors ca. 15 frames at a resolution of 640x480) and 600 MHz processors are necessary.

Typical Design Concept of the Robots' Hardware (2)

- Microcontroller, in order to guarantee the real time control of the servos.
- As sensors: camera (connected via USB or Firewire to the PC) and attitude sensors (gyro, acceleration sensors). Except for the feedback from the joint angles most robots do not use additional sensors.
- Wireless network (IEEE 802.11) is permitted, and can be used for the communication between the robots and in order to send start and stop signals to the robots. However, wireless networks are not reliable during the RoboCup. A fallback solution is highly recommended. The rules state that the robot has to be able to perform even if the wireless network is not working.

KidSize v.s. TeenSize

- Whereas the KidSize robots evolved rapidly during the past 2-3 years, we expect the same development in the TeenSize yet to come. Typically, TeenSize robots are either derived from KidSize models (typically just on the lower limit of the permitted size of the TeenSize class) or we see that robots participate from initially unrelated fields of research. It is very much to hope that in the near future a TeenSize class with its own profile and own technology evolves.

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   - Current Discussion
   - Research issues..
   - RT experiments open to public

Future of HL: Discussion (1)

- Increase the number of players. This has been a very emotional discussion in the past years, because the costs increase significantly with each additional player. Various test games of mixed teams have been conducted during the previous RoboCup competitions. At the moment, we are planning to increase the number of players. The most probable number at the moment is 3 players in the KidsSize in the year 2008, and further increasing numbers in the following years..

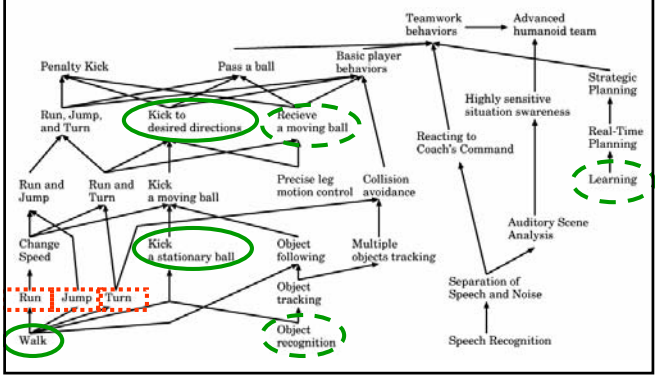
Future of HL: Discussion (2)

- Human-like sensors. In particular the plan is for the later future to ban the omnivision camera. Vision sensors in other places than the head are already banned by the current rules.
- Foot size. The maximal allowed foot size in the current robots is defined as follows. The smallest rectangle covering one foot should not exceed $H^2/22$. This number has been decreased continuously between 2004 when this ratio was $H^2/18$

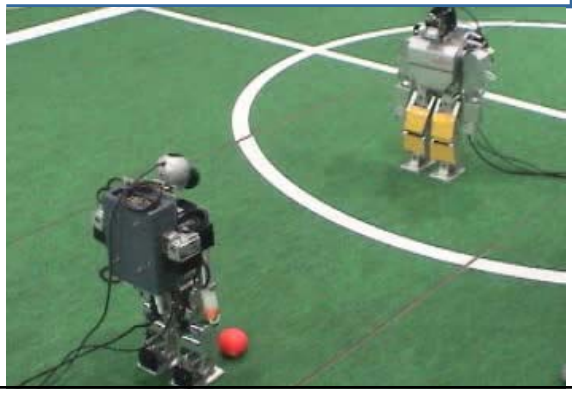
So many research issues...

- Material and mechanism
- Perception: vision (omnidirectional vision? Attention by single camera or stereo camera), touch (avoidance, body representation), force.
- Action: actuator (electric motor → artificial muscle), control.
- Cognition: learning and development, processor architecture.

Benchmark for the humanoid league [Kitano and Asada98]



Face to face pass [Ogino, Kikuchi, and Asada03]



PMA for dynamic motions (1) walking

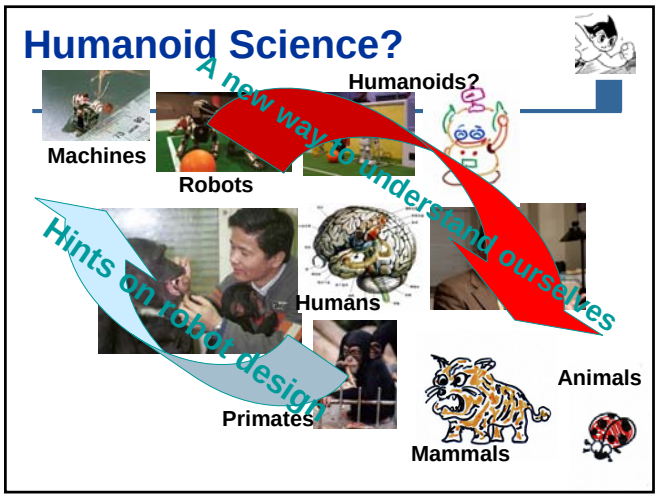
- **Prof. Koh Hosoda's group (Osaka University). He is also a group leader of Physio-SI of JST ERATO Asada Synergistic Intelligence Project (to be explained later).**

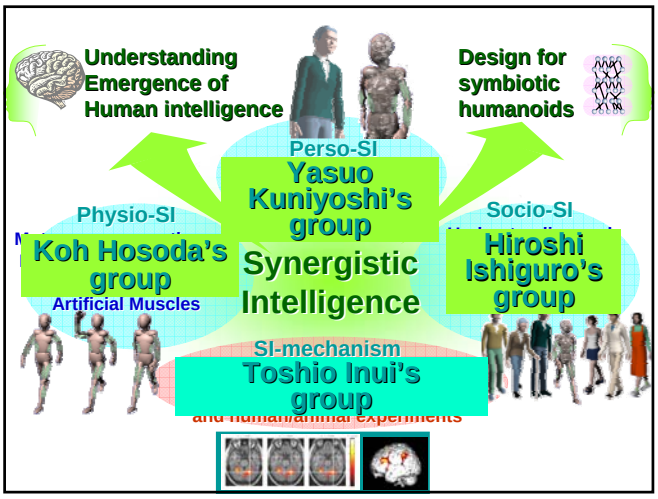
PMA for dynamic motions (2) Jumping

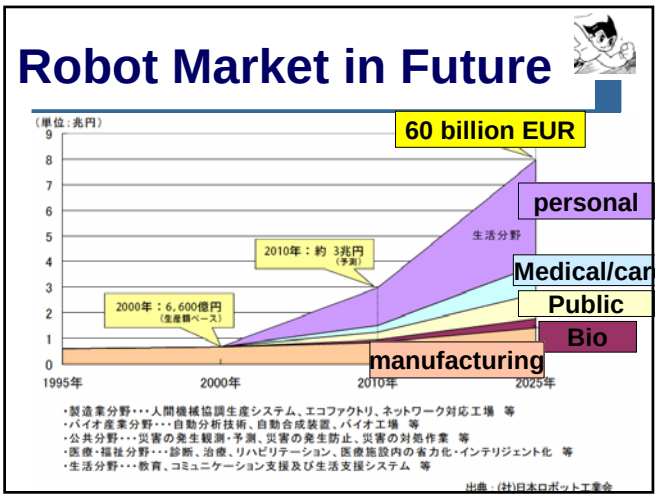
- **Prof. Koh Hosoda's group (Osaka University). He is also a group leader of Physio-SI of JST ERATO Asada Synergistic Intelligence Project (to be explained later).**

PMA for dynamic motions (3) running ?

- **Prof. Koh Hosoda's group (Osaka University). He is also a group leader of Physio-SI of JST ERATO Asada Synergistic Intelligence Project (to be explained later).**

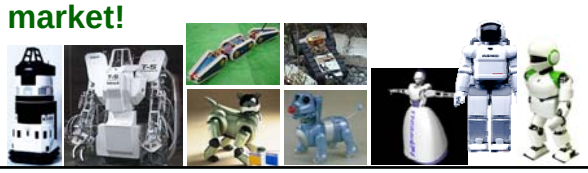






New Robotics

- **New definition**
  → **artifacts that live together, coexist, and collaborate with human beings.**
- **Science, Education, and Industrialization → generation of new market!**



RoboCity CoRE: A Downtown RT Base

- The basic concept of RoboCup
  - International joint research
  - A landmark project: sharing the dream
  - Open to different fields, open to the public
- Currently, once a year.
- A natural extension of RoboCup is to have a permanent place to deploy our activities!

→ **RoboCity CoRE: Center of RT Experiments**

RoboCity CoRE: A Downtown RT Base

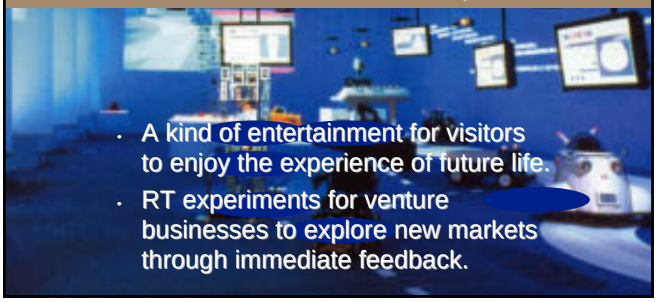
- Downtown labs for symbiotic experiments with robots, partners for our future.
- A single global RT base dedicated to progress in robotics research, industrialization, and education.

What Is RoboCity CoRE?

- Open to the public: researchers, artists, companies, and ordinary citizens interact with each other to forge new ideas. → developing science, technology, and culture
- CoRE: a new cultural icon for the future: a high-tech, ecological city.

Future Life Showroom

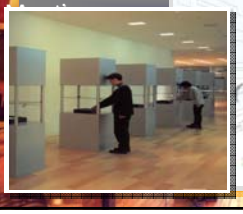
- Life space with the most advanced RT prototypes open to all visitors.
- Offices, residences, and shops

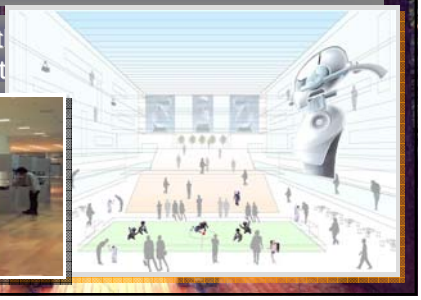


- A kind of entertainment for visitors to enjoy the experience of future life.
- RT experiments for venture businesses to explore new markets through immediate feedback.

Robot Design Factory

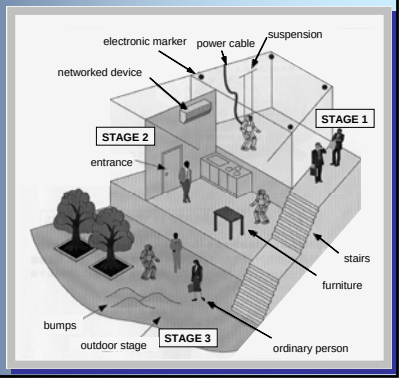
- A new physical site where all kinds of RT content are collected to stimulate dialogue among visitors and researchers of different fields.
- A core space t
of new content

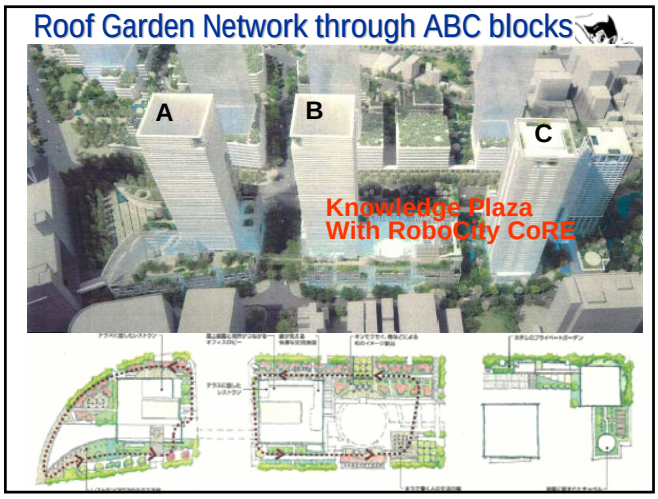




RT experiment field for safety certification

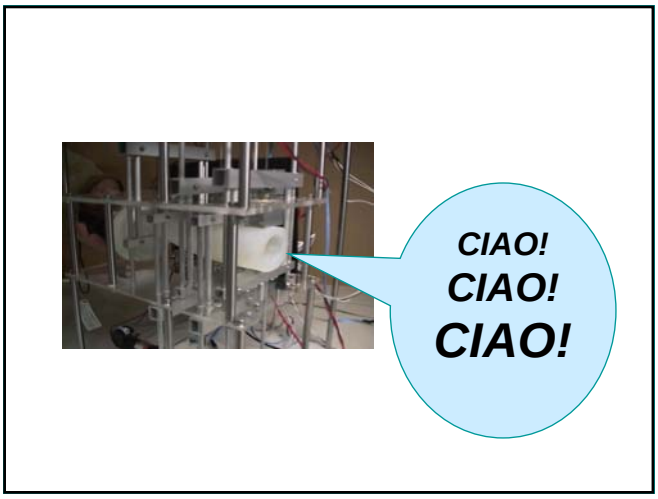
- RT experiment field for safety certification.
- Carrying out necessary safety checks for RT products to be introduced to the market.




Roof Garden Network through ABC blocks
A
B
C
Knowledge Plaza
With RoboCity CoRE


RoboCup @ RoboCity CoRE
2012 OSAKA
ROBOT SOCCER WORLD C


Thank you for your attention!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