Workshop on
Domestic Service Robots
in the Real World

Domestic Service Robots in the Real World: the Case of Robots Following Humans

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1. **Introduction**
2. **Taxonomy of human-following capability and associated topics**
3. **The need for path programming - why to follow; whom to follow; and what to follow**
4. **Implementing security measures and functional capabilities**
5. **Conclusion**

Introduction 1 of 2

- **Robotics and AI**: from research to applications
- Required functionalities of robots are varied and complex; standards should help
- Special areas of interest for us:
  - Cooperative robotics
  - Human interaction in domestic environment
  - AI, cognition, cognitics
  - Go quantitative ! Analogy: height of a wall to pass over
- Publications made, re. “MCS”, a book; quantitative; in real world, also re. SCPR’08 about standards.

Introduction 2 of 2

- Goal: cooperative robotics and human interaction for the domestic environment
- “Robocup”, in particular “At-Home” : excellent environment for testing and validating
- More specifically, “following humans”, **basic and necessary capability** of domestic service robots:
  - “Follow and Guide”(2007), “FastFollow”(2008), and “Follow Me” (2009, 2010 with the new concept of “checkpoints”); etc.

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2. Taxonomy of human-following capability and associated topics

2.1 Intelligence is a property exclusively implemented in humans? No; re. MCS.

2.2 Taxonomy:

- **Class 1:** human-following at home is to guide a robot for training it in new grounds
- **Class 2:** with closer interaction, possibly with contact (e.g. arm, or dedicated steering device)
- **Class 3:** pushing people (or robots) in a compliant way
- **Class 4:** following from a larger distance
- **Class 5:** progressing possibly incognito or searching for a person in a crowd

2.3 Other standards related to robotics

- Appropriate distances depend on circumstances (e.g. for a first encounter, according with Hall's proxemics etc.)
- Other aspects :
  - Affordance: awareness is growing of the importance of affordance, i.e. usability and ergonomy
  - Autonomy : for stable and fast behavior, autonomy must sometimes be granted to robots
  - and user's responsibility: for typical cases, the responsibility must remain on user's side (the guide), and therefore the latter must be given the possibility at all time to adjust the degree of control he or she retains, versus granting autonomy to robots.
  - Beyond body trajectory, limb configurations may also be pertinent.

Content

3. The need for path programming

1 of 2

- **Why?**
  - **To bring domestic service robots into the real world to address the most relevant problems: need for path programming**
  - **How to specify a robot the way from the TV set in the living room to the fridge in the kitchen**
  - **Traditional programming: define textually as a set of locations in a script, or click with a mouse on a map. But it is far more convivial just to guide the robot once through the path**
- **Whom?**
  - **Guide or robot ?**
- **What?**
  - **Simultaneously racking fixed properties: walls? Re maze.**

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3. Quantitative cognitics 2 of 2

Examples in Suzhou (China), Robocup 2008...

1. **FastFollow challenge, with RH3-Y following its guide, then crossing another team, and finally successfully finishing first the walk through home;**
2. **RH-Y as an intelligent, cooperating caddie.**

3. ...and OP-Y in WalkAndTalk 2009 (at Graz) re. videos on http://rahe.populus.ch

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4. Implementing security measures and functional capabilities 1 of 3

The experience gained since the beginning of the Robocup-at-Home competitions, in 2006, and related research allows to sketch the most appropriate security measures for the context of robots following humans, and their implementation:

- **4.1- Requirements**
- **4.2- General solution**
- **4.3- Seven key elements; and more**

4.1- Requirements 1 of 3

Requirements for a robot to follow a person and learn a trajectory:
- speed on the order of 1 m/s
-positional accuracy on the order of 1%, e.g., of about 10 cm in a 10 m range
-a trajectory can be viewed as a sequence of locations in a 2-dimensional space
-this information amounts to about 15 bit per second, assuming equiprobability of locations of interest, and is the minimum information that the robot must acquire
-Considering a similar accuracy in the plane (1%, 3 coordinates, e.g. x,y, and orientation) about 21 bit of control must be elaborated. Consequently:
-required amount of knowledge: $K = \log_2\left(n_o \cdot 2^{n_i}\right) = \log_2\left(21 \cdot 2^{15}\right) \cong 20[lin]$

-required amount of expertise: $E = K/\Delta t = 20/0.1 \cong 200[lin/s]$ *
-other requirements: smooth (versus time) and fast motions
** re forthcoming B-Prize*

4.2- General solution 1 of 8

-For the perceptive capacity estimated above, and for the "Follow a person", vision instruments or rangers are adequate; an alternative, albeit slower mode, might rely on compliant motion, i.e. on a kind of force and torque perception. In all cases, a complex hierarchy of functions and devices are necessary
- At lower levels, depending on the considered test phase (following mode or navigation), either the position or speed controls provide the best solutions, either positional accuracy or smooth motions.

4.2- General solution 2 of 8

***General view of RH5-Y*. From top, the yellow arrows successively point at**

1. **a planar laser ranger;**
2. **an ultrasonic distance sensor;**
3. **a color camera; and**
4. **a 2-D time-of-flight ranger, i.e. a 3D camera.**

From the top down, the hierarchy of controls is described here in five steps

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4.2- General solution 3 of 8

1. **the linear and rotational robot motion commands are elaborated as speed targets based on the walker's location relative to the robot. Two parallel controls are in operation.**

   Attention is also given to possible overall mode commands: "sleep", "follow", or "observe and interpret remote gestures".

   Distance discontinuities are monitored for possible path cutting,

   Excessive errors are also monitored to guarantee orderly phasing out.

   Perception is best done with a planar ranger (240 degree aperture, 10 Hz refresh rate, about 700 radii between 0 and 400 cm, with 1 cm accuracy).

   Nevertheless, other modes are feasible (eg.3D), and some have been performed in competition (e.g., color vision or ultrasonic sensors, with much less aperture though, less angular resolution and lower distance reliability). Multi-agent approaches, e.g. with our original Piaget environment [e.g. 6], and vocal channels also act in parallel to help prevent errors and cope with them when they occur

4.2- General solution 4 of 8

2. a MIMO stage performs inverse kinematics, providing the necessary joint commands (wheel 1 and 2) based on the linear and rotational speed targets naturally expressed in world, Cartesian or polar coordinates.

In particular, a parameterized gain matrix is used.

The functions described in points 1 and 2 are implemented on a supervisory computer (typically, an embedded laptop).

4.2- General solution 5 of 8

3. Then, the motion law stage is entered , and parameterized “constant” accelerations are used for interpolating speed target values.

4.2 General solution 6 of 8

4 The wheel velocity control is accomplished with two independent PID closed loop controllers with encoder management.

Coordination is implicitly ensured by simultaneous commands and appropriate respective acceleration and speed targets.

Information between the laptop and servo-controllers is conveyed via Ethernet with the TCP-IP mode

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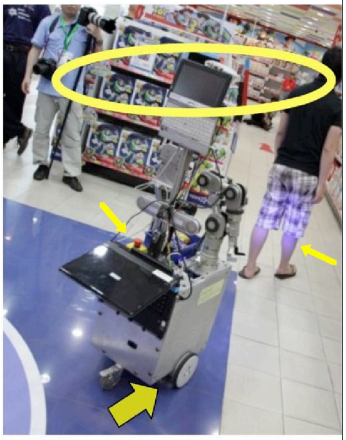
4.2- General solution 7 of 8

5. Finally (level 5), amplifiers manage the motor currents, ensuring that limits are not transgressed (two on/off action, closed-loop controls).

4.2- General solution 8 of 8

Overview of some security measures :



1. **The blue warning blinking light reflected on the legs of the guide (arrow on the right).**
2. **If a wheel is blocked, the other wheel gets stopped in a properly coordinated way (lower arrow).**
3. **The unidirectional blocking capability is also active (same lower arrow).**
4. **In principle, the top circle illustrates the concept of the maximal radius of influence; in fact, the effective circle at that very moment is larger than drawn. It must encompass the guide, otherwise all motion would stop.**
5. **Emergency stop mechanism (left arrow).**

Seven key elements; and more 1 of 36

4.3 Close human-robot interaction to prevent crossing
4.4 Blue blinking as a discrete warning signal
4.5 Close interaction for accurate positioning in complex trajectories
4.6 Coordinated blocking
4.7 Unidirectional blocking
4.8 Warning and stopping for a while if people cross the path
4.9 Maximal radius of influence
4.10 Emergency stop procedure

-Mostly, below, the solutions adopted for our RH-Y robot are the ones presented.

-Experimental validation brings a particularly concrete, validated character and does not restrict the scope of applicability of the presented items to only this case.

-In cases where alternatives appear preferable, the latter are explicitly mentioned

Seven key elements; and more 2 of 36

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- 4.10 Emergency stop procedure

4.3 Close human-robot interaction to prevent crossing 1 of 2

- The speed evolves as the distance between guide and robot
- Guides should adapt their walking speed to the circumstances
- In principle path-cutting can be detected as apparent guide location discontinuities
- But the guide is obscured for a while and recovery cannot be guaranteed in all circumstances
- Therefore when the risk associated with third parties possibly cutting the path between guide and robot is perceived as too high, the guide should walk slower,
- When the guide stands still, no significant gap should remain between the robot and the guide
- For other contexts, e.g. distance-keeping for subjective intimacy considerations, the best nominal location of guide relative to robot may be defined differently, made easily adjustable

4.3 Close human-robot interaction to prevent crossing 2 of 2

- In the 2010 @Home competition rules: one meter minimum between the guide and robot, may be useful to practice path-cutting.
- But for security reasons, the minimal value should be as small as physically convenient (10-cm gap, for standing still or at low speeds, e.g., speed≤ 20 cm/s)
- Close interaction to prevent people from crossing the robot-guide path is easily ensured under 2 conditions:
  - First, the guide should walk slowly to reduce the robot-guide gap. Basic behavior : speed varies linearly with guide distance beyond the nominal relative location for standstill
  - Second, the nominal distance for standstill should be minimal, typically calling for a 10 cm gap. Re. step A of Sect.4.2.

Seven key elements; and more 5 of 36

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4.10 Emergency stop procedure

4.4 Blue blinking as a warning signal

- It is usual for vehicles to have some warning signals, especially when visibility is poor or the risk of collisions and consequent casualties is high.
- In our mobile robots, we have a similar blinking signal.

Seven key elements; and more 7 of 36

4.3 Close human-robot interaction to prevent crossing
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4.5 Close interaction for accurate positioning in complex trajectories 1 of 4

- Guides should adapt their walking speed to the circumstances.
- Complicated trajectories may require a lower speed than the average.
- A lower speed decreases the requirements for expertise.
- A complex trajectory has higher requirements in terms of local perception, by definition.

4.5 Close interaction for accurate positioning in complex trajectories 2 of 4

- A lower speed reduces the distance between the guide and the robot and, implicitly, reduce the size of the robot’s environment.
- Perspective considerations: closer guide => details of trajectories and of robot behavior more evident
- Schematically, two alternative approaches can be adopted by robots for learning trajectories while following humans:
    1. Track the robot’s location as the robot follows its guide, and
    2. Store the location of the guide.

4.5 Close interaction for accurate positioning in complex trajectories 3 of 3

- In the early days: a kind of « passive » guide, to frequently save his or her location, and to attempt to replicate the *guide* displacements
- In our mobile robots of the late 1990s: a camera mounted on a specific motor to track targets independently of the robot's orientation.
- Experience has shown that guides should be more active in their leading role, and some freedom in their instantaneous displacements should be granted to them. For security and performance concerns, the task is better split in the following two parts: first, the guide appropriately drives the robots; then, the robots learn the critical semantic content of their *own motions* in these circumstances.

4.5 Close interaction for accurate positioning in complex trajectories 4 of 4

- Reducing the gap guide-robot reduces the area required for driving motions and expands the angular steering range; therefore, even in intricate areas, accurate training can be performed. Guides should be informed of the paradigm retained.
- As shown on Fig., the planar ranger is mounted at torso level (say, 1.2 m) => reliable and comfortable.
    - Reliability because the probability of detecting (unwanted) objects decreases, as the ranger is higher (1.2 m is relatively high for domestic applications).
    - Reliability is also favored by the comfortable operability: At torso level the hands can replace the body as a mean 1 to control motions, 2 for the easy selection of operation modes and 3 for particularly accurate control in rotation and reverse mode.

Seven key elements; and more 12 of 36

4.3 Close human-robot interaction to prevent crossing

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4.9 Maximal radius of influence

4.10 Emergency stop procedure

4.6 Coordinated blocking 1 of 3

- In the real world, many disturbances occur unavoidably.
- Appropriate failure management procedures must be devised
- Experience has shown that under some circumstances, one of the joints may reach its limit conditions.
- For example in Suzhou (Robocup): ground occasionally extremely uneven, with centimeter-deep holes and similar bumps; => different torques values on the active limbs or wheels.

4.6 Coordinated blocking 2 of 3

- The control strategy must ensure that under all conditions, a minimal coordination of all joints is maintained.
- Failing in this ability typically leads to erratic motions
- A proper solution : if one joint is blocked, all other locomotive actuators should be blocked as well.
- In general, failure management procedures should adapt to robot kinematics and dynamics specificity. The given procedure is adequate for practically all current, wheel-based, robots and platforms

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4.6 Coordinated blocking 3 of 3

- In the RH5-Y, feedback is provided by the low-level units up to the top most element, the supervising computer, in several ways, => allows for coordinated actions
- Upon receiving response to regular requests to low-level units, the Piaget environment does:
    - track elementary joint positions,
    - perform direct kinematic transformations yielding three spatial coordinates (X, Y, and orientation),
    - integrate them into updated maps, and
    - ensure self awareness – conscience

4.6 Coordinated blocking 4 of 4

- It also tracks instantaneous motion errors and decides the appropriate coordinated motions
- Beyond a certain error threshold,
  - a coordinated, soft emergency stop is triggered,
  - attention is kept for possibly changing conditions,
    - allowing a decision reversal to the ordinary operation mode

Seven key elements; and more 17 of 3

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4.7 Unidirectional blocking 1 of 3

- As guides drive robots, errors occur and sometimes robots collide with hard to move obstacles (e.g. heavy pieces of furniture)
- In those circumstances, as developed in the previous paragraph, one joint may reach a torque limit, and, in a coordinated way, the robot should stop the other joint(s) as well. However, the blocking should not be complete; only the motion towards the obstacle, from a joint perspective, should be forbidden.

4.7 Unidirectional blocking 2 of 3

- In the opposite direction, the possibility should remain for the robot under human guidance to actively leave in the reverse direction. From a practical point of view, this capability becomes more important as robots get heavier.
- As described earlier (4.6), being able to stop motions naturally makes the current extension relatively easy to implement for unidirectional blocking

4.7 Unidirectional blocking 3 of 3

- Two aspects of the additional requirements:
  - First, the idea here is not to block all possible motions as mentioned earlier, but only those that face large errors, i.e. in a single direction, e.g. not keeping pushing any longer toward a wall but ready to move away
  - Second, the fact is that in practice limits first occur at the joint level; therefore, inverse kinematics must be performed on current commands, which are normally expressed in space coordinates (typically Cartesian or Euler-typed)

Seven key elements; and more 21 of 36

4.3 Close human-robot interaction to prevent crossing

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4.9 Maximal radius of influence

4.10 Emergency stop procedure

4.8 Warning and stopping for a while if people cross the path 1 of 6

- No one should attempt to cross the path between a robot and a guide.
- However, some people will; therefore, appropriate measures should be devised
- Technically, this is relatively simply done: detect distance discontinuities and so detect when the path is cut.
- Similarly, it is possible to wait for the mirror discontinuity and to proceed as if nothing had occurred; actually, this is what was expected according to @Home rulebook 2010 at the first checkpoint of the “Follow me” test.

4.8 Warning and stopping for a while if people cross the path 2 of 6

- If people cross the path between the robot and the human guide, stop for a while, as done by the RH5-Y robot, and warn the guide of the situation with a vocal message.
- In short, coping with path-cutters mainly involves three operations that occur in three successive phases:
  - detecting path cutters;
  - stopping and warning the guide and other people; and finally
  - restoring normal operations.

4.8 Warning and stopping for a while if people cross the path 3 of 6

1 In principle, the guide distance needs be estimated permanently.

- In practice, this also means that possible objects and people crossing the path between the guide and the robot must be detected immediately.
- A reliable feature for discrimination between the guide and path-cutters is their distance from the robot, which is expected to vary by at least 20 cm, i.e., much larger than ordinary noise level.

4.8 Warning and stopping for a while if people cross the path 4 of 6

- For distance perception, typically the best method: laser-based planar ranger using a triangulation method.
- In the early years of @Home, vision-based approach has also been shown feasible (even though distance estimation is less reliable and a small risk then exists of slower or sometimes even false detection, namely when a sufficient contrast vanishes between the guide and environment).

2 For highest safety, path-cutting should not occur; small-gap. Nevertheless, if it does => careful stopping procedure, along with a vocal comment (in the Singapore @Home context, for the "follow-me" test, a stop lasting for three seconds was announced and practiced)

4.8 Warning and stopping for a while if people cross the path 5 of 6

- Continuously estimating the current location of the guide may be advisable, e.g., locking on at least the most recently known position, or possibly extrapolating it, if updated measurements are not possible due to temporary occlusion.

3 After stopping for a given time, normal operations can in principle be restored (two classes of situations may schematically occur):

3.1 Wait for a discontinuity in perceived distance to occur, (this time from close to far) and then proceed as if nothing had happened (actually, this is what was expected according to @Home rulebook 2010 at the first checkpoint of the “Follow me” test)

4.8 Warning and stopping for a while if people cross the path 6 of 6

3.2 Alternatively, especially if the perturbation is long or the continuity of the guide location as estimated through the three phases is poor, it may be preferable to return to the scenario adopted at the beginning of the path following operation, e.g., to check guide identity.

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4.10 Emergency stop procedure

4.9 Maximal radius of influence 1 of 6

- **As the distances between the robot and the guide increase, the risk also increases that they miss each other=>define a limit, a maximal radius of influence**
- **If humans lose each other, especially with children, a good practice is to ask people not to move; or to move back to the last common location**
- **Beyond that safety limit, robots should stop, stay still, and be ready to resume operation when the circumstances allow.**

4.9 Maximal radius of influence 2 of 6

- A maximal radius of influence is easy to implement. Similar to basic following operations, the distance between the guide and the robot needs to be estimated.
- A simple comparison with a threshold value, which can possibly and dynamically change as a function of context, allows for the “go on” or “stop” decision.
- For graceful stopping, a constant deceleration parameter can be adjusted (e.g., 2 m/s²).

4.9 Maximal radius of influence 3 of 6

- To restore normal operations after a safety stop, an approach that is similar to the one given in the previous paragraph may apply.
- In the RH-Y implementation, while navigating between tables and teams to reach the contest areas in @Home 2010, the maximum radius was kept below 2 m.
- Depending on the circumstances, the value may change:
  - a smaller radius improves safety and
  - a larger one improves the speed and guidance capabilities

4.9 Maximal radius of influence 4 of 6

Example:* *RH-Y in @Home 2010*, *Singapore. **The robot starts, its light starts blinking, follows the official guide (1), turns and passes the wall, detects a path cutter and consequently announces it will stop for 3 seconds (2); when the time is elapsed, however, the guide has gone beyond limits and the robot stands still, observing the maximum safety radius (3)**

4.9 Maximal radius of influence 5 of 6

For the mentioned “Follow me” test of @Home 2010 competition in Singapore (re. Fig.), the strategy adopted by the RH5-Y robot was of the type advocated here, i.e.:

-if and when people crossed the path between the robot and the guide, to stop for a while,

-to warn the guide with a vocal message of the situation and

-if possible, after the path cutter had gone, to restore normal operations.

4.9 Maximal radius of influence 6 of 6

- Because the guide did not listen to the robot, successfully reacting to path-cutter, and asking for a temporary stop,
- and the rules did not allow for guides to walk back towards the robot,
- the robot was stalled in safe mode, waiting for the guide to return;
  - this may look not effective; of course the RH-Y security measures could have been relaxed as they were not required by the rules
  - Nevertheless, for best security conditions, a good solution in practice consists indeed in having the guide to stop for a while when advised so, or to come back for “connecting” to the robot again, if necessary.

Seven key elements; and more 35 of 36

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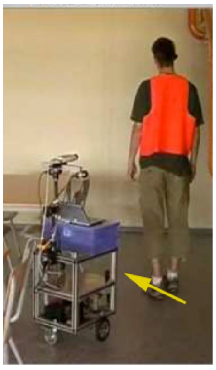
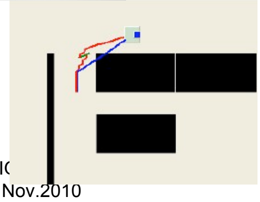
4.10 Emergency stop procedure etc.

4.10 Emergency stop procedure etc.

Other possible safety measures:

- Emergency stop button
- vision-based, following techniques with “one of nine” optimized colors (@Home 2006);
- using high-visibility guide attire (right);
- with lateral ultrasonic sensors (same image, arrow in the middle); and map-registered environment properties (bottom).





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5. Conclusion 1 of 3

- **The international initiative "Robocup" provides an excellent environment for focusing research in robotics and AI**
- **More specifically, the "At-Home" league allows for testing the abilities of cooperating, domestic service robots**
- **Following humans has long been recognized as a basic capability in this context: it allows for convenient path programming, and although the cognitive requirements are quite high, all humans usually proceed in the same way.**

5. Conclusion 2 of 3

- **The environment is dynamic; disturbances and errors may occur; therefore, safety measures must be devised, in particular:**
  - **close human-robot interaction to prevent crossing;**
  - **light signals as discrete warnings;**
  - **close interaction for accurate control of locations in complex trajectories;**
  - **coordinated, unidirectional blocking;**
  - **vocal warnings and the ability to stop while people cross the path;**
  - **the definition of a maximal radius of influence beyond which stopping is triggered;**
  - **emergency stopping capabilities etc.: robust vision-methods; ultrasonic sensors and map-based obstacle avoidance.**

5. Conclusion 3 of 3

- At the most abstract, semantic level, about 15 bits per second of information must be acquired; for this purpose, a variety of sensors are considered, each with specific advantages, including a color camera, a planar laser range scanner, a 3D-ranger, ultrasonic sensors, and joint sensors.
- Smooth and stable real-time behavior is ensured by a 5-level hierarchical control structure and agents implemented in a mix of technologies (computers, PLC, servo controllers, etc.)
- The authors wish to acknowledge the useful suggestions of referees, numerous contributions of past RH-Y team members, as well as HESSO and HEIG-VD for their support to this research.

Thanks for your attention!

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More information... 4 of 4

12 Jean-Daniel Dessimoz and P.-F. Gauthey, "Contributions to Standards and Common Platforms in Robotics; The Role of Color and Recommended Modalities", Standards and Common Platform Workshop, SIMPAR-2010 2nd Internat. Conf. on Simulation, Modeling and Programming for Autonomous Robots, November 15-18, 2010, Darmstadt, Germany.

13 J.-D. Dessimoz and RH5-Y Team, « Humanoids as cultural mediators; and Tracking Safety », Open Challenge Contest, Robocup-at-Home League, 22 June 2010, Singapore

14 D. Nardi et al. , Rulebook, Draft edition, 13 June 2010, http://www.ai.rug.nl/robocupathome/documents/rulebook2010_FINAL_VERSION.pdf

15 Appendix of this paper, re. http://lara.populus.ch/rub/3 .

9.00 Welcome

9.10 *L. Iocchi, T. van der Zant.* RoboCup@Home: Adaptive Benchmarking of Robot Bodies and Minds
9.30 *S. Schiffer, A. Ferrein, G. Lakemeyer.* Fuzzy Representations and Control for Domestic Service Robots in Golog
9.50 *C. A. Mueller, P. G. Ploeger.* Towards Robust Object Categorization on a Mobile Robot
10.10 *J. A. Alvarez Ruiz.* Text Information Extraction for a Domestic Service Robot

10.30-11.00 Coffee break

11.00 *J.D. Dessimoz, P.F. Gauthey.* Domestic Service Robots in the Real World: the Case of Robots Following Humans
11.20 *T. Breuer, P. G. Ploeger, G. K. Kraetzschmar.* Precise Pointing Target Recognition for Human-Robot Interaction
11.40 *L. Ziegler, F. Siepmann, M. Kortkamp, S. Wachsmuth.* Towards an Informed Search Behavior for Domestic Robots
12.00 *G. Giorgana.* Facial Expression Recognition for Domestic Service Robots
12.20 *Z. Jin.* An Optimized GBNR Sound Localization Algorithm with 4 elements Microphone Array


November 15-18, 2010 - Darmstadt, Germany

2nd International Conference on
SIMULATION, MODELING, and PROGRAMMING
for AUTONOMOUS ROBOTS

SIMPAR
2010

Novel robotics applications driven by research, industry and society call for the development of systems of ever increasing complexity: systems with sliding autonomy; humanoid robots; distributed robots; mobile sensor networks, and so on. But unfortunately, steady improvements in robot hardware have not been matched by corresponding advancements in robot software. Besides fundamental open problems still waiting for sound answers, the development of new robotics applications still suffers from the lack of widely used tools, libraries, and algorithms ready to be incorporated into new projects. Simulation environments are playing a main role in reducing development time and cost of large scale systems. But their use is still regarded by many with skepticism. Seamless migration of code from general purpose simulators to real world systems is still a rare circumstance, due to the complexity of robot, world, sensors, and actuators modeling.

These challenges drive the quest for next generation of methodologies and tools for robot development. The objective of the International Conference on Simulation, Modeling, and Programming for Autonomous Robots (SIMPAR) is to offer a unique forum for these topics and to bring together researchers from academia and industry to identify and solve the key issues necessary to ease the development of increasingly complex robot software, and to boost a smooth shifting of results from simulated to real applications.

Topics of interest include, but are not limited to:

- 3D robot simulation and mathematical modeling of robots
- Reliability, scalability and validation of robot simulation
- Simulated sensors and actuators
- Offline simulation of robot design
- Online simulation with realtime constraints
- Simulation with software/hardware in the loop
- Middleware for robotics
- Modeling framework for robots and environments
- Testing and validation of robot software
- Standardization for robotic services
- Communication infrastructures in distributed robotics
- Interaction between sensor networks and robots
- Human robot interaction and collaboration
- Multirobot systems

News

Wednesday, November 03, 2010
Detailed program of the oral presentations is online!

Wednesday, November 03, 2010
Workshop schedules available on workshop websites.

Tuesday, October 07, 2010
Hotel reservation deadlines are approaching!

E-Mail Forward

General Chair	gc@simpar.org
Local Chair	lc@simpar.org
Program Chairs	pc@simpar.org
Exhibition Chair	ec@simpar.org
Tutorial Chair	tu@simpar.org
Workshop Chair	wo@simpar.org

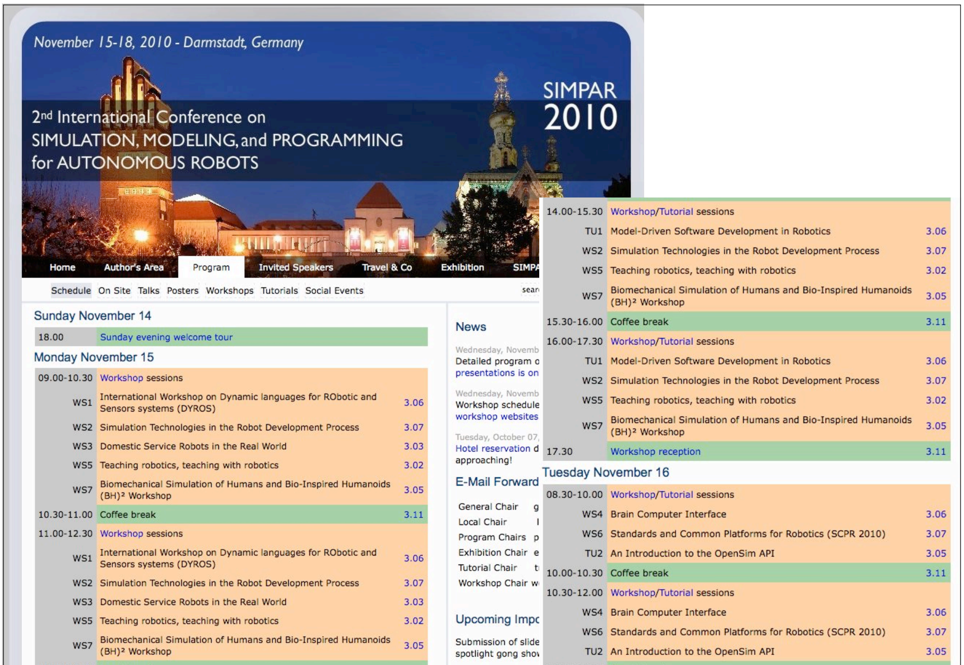
Upcoming Important Dates

Submission of slides for the poster spotlight gong show

- November 10

Download complete **iCalendar**

Exhibition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SIMPAR
2010

Sunday November 14

18.00	Sunday evening welcome tour	

Monday November 15

09.00-10.30	Workshop sessions	
WS1	International Workshop on Dynamic languages for RObotic and Sensors systems (DYROS)	3.06
WS2	Simulation Technologies in the Robot Development Process	3.07
WS3	Domestic Service Robots in the Real World	3.03
WS5	Teaching robotics, teaching with robotics	3.02
WS7	Biomechanical Simulation of Humans and Bio-Inspired Humanoids (BH)² Workshop	3.05
10.30-11.00	Coffee break	3.11
11.00-12.30	Workshop sessions	
WS1	International Workshop on Dynamic languages for RObotic and Sensors systems (DYROS)	3.06
WS2	Simulation Technologies in the Robot Development Process	3.07
WS3	Domestic Service Robots in the Real World	3.03
WS5	Teaching robotics, teaching with robotics	3.02
WS7	Biomechanical Simulation of Humans and Bio-Inspired Humanoids (BH)² Workshop	3.05
12.30-14.00	Lunch break	
14.00-15.30	Workshop/Tutorial sessions	
TU1	Model-Driven Software Development in Robotics	3.06
WS2	Simulation Technologies in the Robot Development Process	3.07
WS5	Teaching robotics, teaching with robotics	3.02
WS7	Biomechanical Simulation of Humans and Bio-Inspired Humanoids (BH)² Workshop	3.05
15.30-16.00	Coffee break	3.11
16.00-17.30	Workshop/Tutorial sessions	
TU1	Model-Driven Software Development in Robotics	3.06
WS2	Simulation Technologies in the Robot Development Process	3.07
WS5	Teaching robotics, teaching with robotics	3.02
WS7	Biomechanical Simulation of Humans and Bio-Inspired Humanoids (BH)² Workshop	3.05
17.30	Workshop reception	3.11

Tuesday November 16

08.30-10.00	Workshop/Tutorial sessions	
WS4	Brain Computer Interface	3.06
WS6	Standards and Common Platforms for Robotics (SCPR 2010)	3.07
TU2	An Introduction to the OpenSim API	3.05
10.00-10.30	Coffee break	3.11
10.30-12.00	Workshop/Tutorial sessions	
WS4	Brain Computer Interface	3.06
WS6	Standards and Common Platforms for Robotics (SCPR 2010)	3.07
TU2	An Introduction to the OpenSim API	3.05
12.00-13.30	Lunch break	

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Tutorial Chair t
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- Novembe