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REACHING, GRASPING AND MANIPULATION IN ANTHROPOMORPHIC ROBOT SYSTEMS

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Robots are becoming more and more a part of our daily life. Therefore, there has been an increasing interest in developing robots that are able to interact with humans in tasks where human-robot collaboration is essential. Anthropomorphic shape and human-like movements have been pointed out as key characteristics of a robot in such human-robot collaboration environments (Duffy 2003, Fukuda Et Al 2000, Fong Et Al 2003), allowing the human user to more easily interpret movements of the robot in terms of goals. Sebanz, Bekkering and Knoblich (2006) support the idea that predicting the motor intentions of others while watching their actions is in general considered a fundamental building block for successful human joint action. The prediction of action outcomes may be used by the observer to timely select an adequate complementary behavior (Bicho Et Al 2009, 2010a, 2010b), contributing to an efficient coordination of actions and decisions between the co-actors in a shared task.

The aim of this PhD project is to endow an Anthropomorphic Robot System (**ARoS**) with human-like reaching, grasping and manipulation, by combining diverse skills in engineering, mathematics and human motor control. The robotic platform used in the human-robot collaboration tasks has been designed and built at Department of Industrial Electronics, University of Minho, and consists of a static torso, equipped with a seven degrees of freedom (DOF) anthropomorphic robotic arm (shoulder - 3 DOF, elbow - 1 DOF, wrist - 3 DOF), a three fingers robotic hand and a stereo vision system mounted on a pan-tilt unit (for details see Silva Et Al 2008). Its design and construction, as well as the equipments mounted on it, were supported by two research projects:

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- *Anthropomorphic robotic systems: control based on the processing principles of the human and other primates' motor system and potential applications in service robotics and biomedical engineering*, Portuguese project financed by FCT (Fundação para a Ciência e a Tecnologia) and University of Minho (ref. CON-CREEQ/17/2001).

Using knowledge from experimental work and functional models of human upper limb we are developing a model for movement planning and control of **ARoS** robotic arm and hand for reaching and grasping objects in 3D for different objects and grip types. Our aim is to generate smooth, fluent and collision-free arm and hand movements that qualitatively explain the main characteristics of hand and arm trajectories observed in experiments with humans (Lommertzen Et Al 2008). We are particularly interested in exploiting the obstacle avoidance mechanism proposed by our colleagues from human motor control (Meulenbroek Et Al 2001; Rosenbaum Et Al 2001, 2006, 2009; Vaughan Et Al 2006) for the robotics domain.

The movement planning and control model is used as part of the robot control architecture to generate the overt motor behavior in different shared tasks. The results show that our strategy to borrow principles from human motor control is a feasible approach towards more human-like movements of an anthropomorphic robotic arm and hand.

The field of anthropomorphic robotics is widely recognized as the current "Grand Challenge" for robotics research. The main motivation is that these robots once viable will find a great number of applications in service tasks requiring the robots to display abilities and skills that are compatible with those of human, and will permit to advance towards better rehabilitation of movement in amputees (e.g. intelligent and more human like prostheses).

REFERENCES

Bicho, E.; Louro, L.; Hipólito, N.; and Erlhagen, W. 2009 "A dynamic field approach to goal inference and error monitoring for human-robot interaction." *New Frontiers in Human-Robot Interaction.*

Bicho, E.; Erlhagen, W.; Louro, L.; and Costa e Silva, E. 2010 "Neuro-cognitive mechanisms of decision making in joint action: a human-robot interaction study." (accepted).

Bicho, E.; Erlhagen, W.; Louro, L.; Costa e Silva, E.; Silva, R; and Hipólito, N, 2010 "A dynamic field approach to goal inference, error detection and anticipatory action selection in human-robot collaboration." book chapter in *New Frontiers in Human-Robot Interaction.*

Duffy, B.R. 2003 "Anthropomorphism and the social robot." *Robotics and Autonomous Systems* 42(3-4):177-190.

Fong, T.; Nourbakhsh, I.; and Dautenhahn, K. 2003 "A survey of socially interactive robots: concepts, design." *Robotics and Autonomous Systems* 42(3-4):143-166..

Fukuda, T.; Michelini, R.; Potkonjak, V.; Tzafestas, S.; Valavanis, K.; and Vukobratovic, M. 2001 "How far away is artificial man?" *Robotics & Automation Magazine*, IEEE 8(1):66-73.

Lommertzen, J.; Costa e Silva, E.; Cuijpers, R.H.; and Meulenbroek, R.G.J. 2008 "Collision avoidance characteristics of grasping: Early signs in hand and arm kinematics." In: *Anticipatory Behavior in Adaptive Learning Systems (ABiALS 2008)* post-conference proceedings, Munich, Germany, pp 188-208.

Meulenbroek, R.G.J.; Rosenbaum, D.A; Jansen, C.; Vaughan J.; and Vogt, S. 2001 "Multijoint grasping movements: Simulated and observed effects of object location, object size and initial aperture." *Experimental Brain Research* 138(2):219-234.

Rosenbaum, D.A.; Meulenbroek, R.G.J. Vaugham, J.; and Jansen, C. 2001 "Posture-based motion planning: Applications to grasping." *Psychological Review* 108(4):709-734.

Rosenbaum, D.A.; Cohen, R.G.; Meulenbroek, R.G.J.; and Vaughan, J. 2006 *Motor Control and Learning*. Springer US, chapter "Plans for Grasping Objects", pp 9-25.

Rosenbaum, D.A.; Cohen, R.G.; Dawson A.M.; Jax, S.A.; Meulenbroek, R.G.J.; van der Wel, R; and Vaughan, J. 2009 *Progress in Motor Control: A Multidisciplinary Perspective*, vol 629, Springer US, chap The Posture-Based Motion Planning Framework: New Findings Related to Object Manipulation, Moving Around Obstacles, Moving in Three Spatial Dimensions, and Haptic Tracking, pp 485-497.

Sebanz, N.; Bekkering, H.; and Knoblich, G. 2006 "Joint action: bodies and minds moving together." *Trends in Cognitive Sciences,*10 (2):70-76.

Vaughan, J.; Rosenbaum, D.A.; and Meulenbroek, R.G.J. 2006 "Modeling reaching and manipulating in 2- and 3-d workspaces: The posture-based model." In: *Proceedings of the ICDL 2006.*

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