Plenary Talks

Plenary Talk I, Wednesday, 11 April 2007

08:20-9:10 (WePP)
Aula Magna (Angelicum University)
Chair: Paolo Dario, Scuola Superiore S. Anna, Pisa, Italy

Simplifying principles for perception, action, locomotion and navigation. A common problem for brains and robots

Prof. Alain Berthoz
Collège de France
Paris, FRANCE

Abstract

The planning, control and memory of arm movement control, locomotion and navigation in animals and humans require extremely complex neural mechanisms which have been elaborated throughout millions years of evolution. The multiplicity of degrees of freedom to be controlled, the multiple possible reference frames, the changing external conditions have challenged living organisms to find solutions in order to perform these tasks rapidly and efficiently. Simplifying principles have been found which I will describe for each of these functions.

They include various anticipatory mechanisms involving a top-down selection for relevant sensory inputs, task specific attention mechanism, and so on. Natural movement is governed by laws such as the 1/3 power law which links curvature and velocity, segmental limb coordination, end point control of gesture, use of composite variables for transforming nonlinear problem into linear problems, and reduction of the number of degrees of freedom by the

anatomical organization of neural projections. In addition, the problem of reference frames has been solved by several clever solutions, e.g., stabilization of the head during complex movements, use of gaze as a reference frame for guiding movement to a goal, or the Listing law for rotation of the eye as a solution to the non-commutativity of rotations.

For navigation, recent findings of Cognitive Neuroscience and modeling have revealed the system that underlay the capacity of the animal or human brain to use several strategies for solving navigation tasks. These include specialized systems for coding place, direction and movement, distinction between egocentric and allocentric strategies, task dependent selection of pertinent sensory inputs, mechanisms for “filling up” incomplete information.

Finally, although nearly all computations for movement or navigation control use a Euclidean geometry framework, it is possible that in fact simplifying mechanisms may come from the use of non-Euclidean geometries.

Up to now, although in robotics many elegant solutions have been found to solve the same problems, some of the solutions found by evolution may be usefully implemented in robots and humanoids in a bio-inspired and a neurobotics approach. I will mention some of these achievements. In addition, modern robotics provides neuroscientists with thoughtful modeling and original principles that may guide the study of brain mechanisms.

Biography

Alain Berthoz is currently Professor at the Collège de France, member of the French Academy of Sciences, the Academia Europae, the American Academy of Arts and Sciences, and other Academies (Belgium, Bulgaria). He is the Director of the Laboratory of Physiology of Perception and Action of CNRS. He is an Engineer, Psychologist, and Neurophysiologist and has done his career at the CNRS as a scientist in the field of Cognitive Neuroscience.

He obtained a first doctoral degree with a thesis in biomechanics on the effect of vibrations of the human body. After a stay in the US, during which he trained in Neuroscience, he received a second doctoral degree with a thesis on vestibular and oculomotor mechanisms and created a multidisciplinary laboratory in which the problems of gaze control, equilibrium, arm movement control, multi-sensory perception, adaptive mechanisms in sensory-motor systems, and spatial memory for navigation were studied with methods including neuronal recording in animals brains, biomechanics, mathematical modeling, and psychophysics in humans. He then used also brain imaging and intracranial methods in humans.

He has been at the origin of the technical development of a number of biomedical equipments, including the testing of equilibrium, haptic force-feedback devices, and eye movement measurement. These themes have been studied both in normal subjects and in patients through cooperation with clinical groups. His group was also a pioneer in the study of adaptation to Microgravity in space stations both in Russia (MIR station) and in USA (Shuttle). He has conducted several projects in cooperation with robotics groups for the study and design of mobile robots and is currently cooperating, within European Projects, with robotics groups for bio-inspired robotics and common research projects on brain mechanisms (NEUROBOTICS, BACS) and brain computer interfaces (NEUROPROBE). He has been the coordinator of many national research programs, is a member of scientific councils at the national and international level, and a referee for the top international journals in Neuroscience.

He received the Dow Award of the Portland Neuroscience Institute, the F. Rossi Award from the University of Pavia, prices from the French Academy of Sciences and the French Academy of Medicine, and the gold medal of the Arts and Literature Society. He is Chevalier de la Légion d’honneur and Officier de l’ordre National du Mérite. He authored more than 250 papers in international journals and several books on these subjects, among the others “The Brain’s Sense of Movement” (Harvard University Press, 2002) and “Emotion and Reason. The Cognitive Foundation of Decision Making” (Oxford University Press, 2006).

Plenary Talk II, Thursday, 12 April 2007

09:40-10:30 (ThPP)

Aula Magna (Angelicum University)

Chair: Bruno Siciliano, Università di Napoli Federico II, Italy

Putting the Turing into Manufacturing: Automation Science and Recent Developments in Feeding and Fixturing

Prof. Ken Goldberg
University of California
Berkeley, USA

Abstract

Automation includes much more than manufacturing: security, laboratory automation, home automation, food processing, and almost any repetitive task that can be machine controlled. I'll review some of these exciting new applications and then focus on manufacturing.

Today, automation for manufacturing is where computer technology was in the early 1960's, a patchwork of ad-hoc solutions lacking a rigorous scientific methodology. CAD has progressed a long way toward elegant modeling of mechanical parts and behavior. Still needed is an associated “science” of automation: rigorous abstractions for the required handling, assembly, inspection, and storage of parts.

Over the past decade, researchers have made progress, developing a variety of algorithmic models and results for part feeding and fixturing. I'll review selected results including a new framework for fixturing deformable parts and new geometric primitives for vibratory bowl feeders, and propose several open problems for future research.

Biography

Ken Goldberg is an artist and professor at UC Berkeley. He is Professor of Industrial Engineering and Operations Research, with an appointment in Electrical Engineering and Computer Science. He received his PhD in Computer Science from CMU in 1990 and studied at the University of Pennsylvania, Edinburgh University, and the Technion. From 1991-95 he taught at the University of Southern California, and in Fall 2000 was visiting faculty at MIT Media Lab.

Goldberg and his students work in two areas: Geometric Algorithms for Automation, and Networked Robots. In the first category, he develops algorithms for feeding, sorting, and fixturing industrial parts, with an emphasis on mathematically rigorous solutions that require a minimum of sensing and actuation so as to reduce costs and increase reliability. In the area of Networked Robots, Goldberg and colleagues developed the first robot publicly operable via the Internet (in 1994). He has published over 100 research papers and edited four books.

In 2004, Goldberg co-founded the IEEE Transactions on Automation Science and Engineering and is Founding Chair of its Advisory Board. Goldberg was named National Science Foundation Young Investigator in 1994 and NSF Presidential Faculty Fellow in 1995. He is the recipient of the Joseph Engelberger Award (2000), the IEEE Major Educational Innovation Award (2001) and was elected IEEE Fellow in 2005. He is the Vice-President for Technical Activities of the IEEE RAS.

Goldberg lives in San Francisco with his wife, filmmaker and Webby Awards founder Tiffany Shlain.

More information on his research and teaching: http://goldberg.berkeley.edu.

More information on his artwork: http://www.ken.goldberg.net.

Plenary Talk III, Friday, 13 April 2007

09:40-10:30 (FrPP)

Aula Magna (Angelicum University)

Chair: Alessandro De Luca, Università di Roma "La Sapienza", Italy

Programming-by-demonstration: From assembly-plan through dancing humanoid

Prof. Katsushi Ikeuchi
University of Tokyo
Tokyo, JAPAN

Abstract

We have been developing the paradigm referred to as programming-by-demonstration. The method simply observes what a human is doing and generates robot programs to mimic the same operations. First half of this talk presents the history of what we have done so far under this paradigm. Then, the second half focuses our newest effort to make a humanoid robot to dance Japanese folk dances using this paradigm. Human dance motions are recorded using optical or magnetic motion-capture systems. These captured motions are segmented into motion primitives using motion analysis and music information. We can characterize personal differences of dance using task-and-skill models defined in the paradigm. Then, we can map these motion models onto robot motion by considering dynamic and structural difference between human and robot bodies. As a demonstration of our system, I will show a video in which a humanoid robot performs a Japanese folk dance, Jongara-bushi, and Aizu-bandaisan-odori.

Biography

Katsushi Ikeuchi received the B.E. degree in Mechanical Engineering from Kyoto University in 1973 and the Ph.D. in Information Engineering from the University of Tokyo in 1978. After working at the Artificial Intelligence Laboratory, Massachusetts Institute of Technology, for three years, the Electrotechnical Laboratory, Japanese Ministry of International Trade and Industry, for five years, and the School of Computer Science, Carnegie Mellon University, for ten years, he joined the University of Tokyo in 1996 as a Professor in the Institute of Industrial Science. Since 1999, he is also a Professor of a newly created graduate program, Interfaculty Initiative in Information Studies.

His research interest spans computer vision, robotics, and computer graphics. In these research fields, he has received several awards, including the David Marr Prize in computational vision for the paper “Shape from Interreflection”, and the IEEE Robotics and Automation King-Sun Fu Memorial Best Transactions Paper Award for the paper “Toward Automatic Robot Instruction from Perception”. In addition, in 1992, his paper, "Numerical Shape from Shading and Occluding Boundaries," was selected as one of the most influential papers to have appeared in Artificial Intelligence Journal within the past ten years.

He has served as the program/general chairman of several international conferences, including 1995 IEEE/RSJ IROS, 1996 IEEE CVPR, 1999 IEEE ITSC, 2003 IEEE ICCV. He is the Editor-in-Chief of the International Journal of Computer Vision. He is/was on the editorial board of several major vision/robotics journals, including the IEEE Transactions on Pattern Analysis and Machine Intelligence, the IEEE Transactions on Robotics and Automation, and the Journal of the Optical Society of America. He is a Fellow of IEEE (1998), IPSJ (2006), and IEICE (2007). He has been selected as a distinguished lecturer of the IEEE Signal Processing Society (2000-2001), and of the IEEE Computer Society (2004-2006).