

Introduction to the special issue on humanoid multi-event robot athletes

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1 Introduction

It is with great pleasure that I present this special issue on humanoid multi-event robot athletes.

Challenge problems involving sporting events have been an important part of evaluating performance in robotics and AI (artificial intelligence) for more than 20 years. More recently in this period it has become a major focus for humanoid robotics, since advances in hardware and software, decreases in cost, and the goal of having robots function in domains intended to be inhabited by humans have made humanoids a more approachable tool for researchers. Consequently a variety of humanoid robot competitions have become prominent. The highest profile of these are soccer playing robots (e.g. RoboCup and AndroSot).

Multi-events are popular for human athletes. Human decathletes are widely admired for their versatility and are refereed to as the king of athletes. Modern pentathlon (running, swimming, riding, fencing, shooting) is an Olympic event modeled on the necessary skills of a military scout. Olympic Triathlon (swimming, cycling, running), biathlon (cross-country skiing and shooting), and Nordic combine (ski jumping and cross-country skiing) are multi-events with fewer events. There are also human multi-events where multiple and sometimes very distinct skill sets must be applied at different times (e.g. many human extreme endurance challenges).

While sports provide benchmarks and an important context for the public to understand work in these areas, there is also benefit in focusing on multi-events in a competition. Adaptability, flexibility, and versatility are cornerstones of human intelligence. Multi-event competitions also solve the problem of highly specialized special purpose solutions. It has been my observation that as the rules of the game become ever more complex, teams often develop special hacks (i.e. special features that work well in this but no other environment) to win. This greatly reduces the applicability of the developed solutions and leads to teams focusing on fine tuning rather than solving general issues in intelligent robotics and AI. The most obvious example is the micro-mouse competition, which was initially setup as a challenge problem for robot navigation in a maze. The maze solving algorithms have been solved years ago and nowadays the competition focuses on finding the right rubber mixture to increase the maximum acceleration and breaking of the mouse. For example, in 1998, at 2:00 am, I helped repaint all the playing fields of the RoboCup Small Sized League fields because the center-line was 1-mm wider than specified in the rules and a team complained that their vision system was unable to deal with this. This experience also taught me to never use dimensions (5 cm), but only ranges (3–7 cm) in competition rules.

Multi-events also emphasize the versatility inherent in the humanoid form: it has thus far received little attention in the research literature that across the animal kingdom, the humanoid form is not particularly suited to excellence at a single task. Humans are not the fastest runners (cheetahs), best swimmers (dolphins), or most agile climbers (monkeys). However, the humanoid form is unique in that it is near the top in a broad range of activities.

The first paper in the special issue *HuroCup – Competition for Multi-Event Humanoid Robot Athletes* by Baltes *et al.* introduce the philosophy and history behind the HuroCup competition, a nine-event multi-event, where a single robot competes in sprint, obstacle run, lift and carry, basket ball, long jump, marathon, weight-lifting, wall climbing, and united soccer. The paper also describes the progress made by

teams participating in the competition as is evidenced by improved world records. For example, the best time for the 3 m backward and forward sprint was reduced from 1 minute 07.50 seconds to 21.50 seconds and how in turn the organizers adapted the competition to maintain a focus on state of art research. The papers *Stability Margin for Robust Walking Gaits Constructed by Center of Pressure* by Tu et al. and *Parameterized Gait Pattern Generator Based on LIPM With Natural ZMP References* by Ho et al. focus on walking gaits for humanoid robots. The main contribution in the first is a more robust walking gait algorithm. The second paper uses an extended model of the dynamics of the legs of the robot to improve performance in walking and in kicking. *Active Balancing and Turning for Alpine Skiing Robots* by Iverach-Brereton et al. describes the balancing algorithm of the first skiing humanoid robot. Skiing is an interesting domain because skis provide good stability in the lateral direction, but poor stability in the frontal plane. As researchers move from single robots to teams of collaborating robots, the ability to recognize other robots and to identify their pose becomes ever more important. This problem is addressed in *Inter-Humanoid Robot Interaction with Emphasis on Detection: A Comparison Study* by Shangari et al. Locomotion, especially over uneven terrain or with varying loads, is a challenging problem for humanoid robots. But navigation, that is the ability to localize the robot in the environment and to reach a target location without collisions, is also a crucial problem. *Vision-Based Obstacle Avoidance System With Fuzzy Logic for Humanoid Robots* by Shu et al. describe a solution for the obstacle run domain. The robot navigates through a color coded environment using a fuzzy logic controller.

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