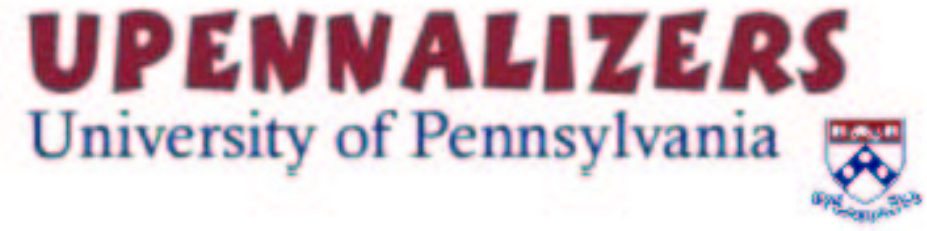
# University of Pennsylvania's RoboCup Legged Soccer Team (the UPennalizers)

D. D. Lee, D. Cohen, P. Srivastava, Y. Ooi
with L. Saul, C. J. Taylor and V. Kumar
GRASP Laboratory




## Introduction

The University of Pennsylvania RoboCup team has participated in the Legged League competition for the past four years, and intends to continue its activities this coming year and in the future. This past year has been a transition year for the team, as Jim Ostrowski who led the team in previous years took a leave of absence from the university. We reformulated the team with a new team leader and a fresh group of students from various departments at the Engineering School. With this new group, we have been very active in creating a new code base for the robots, as well as engaging in several related research thrusts. Details about the new team are provided below.

## Research Interests

The main related research interests of the team involve applying machine learning to the associated problems of programming and coordinating robots to play soccer, as well as other complex sensorimotor tasks. In particular, the goal of the research agenda is to take inspiration from biological information processing systems, and to try to build some of the same fundamental concepts into

artificial robotic systems. In biological organisms, external stimuli such as images, sounds, and smells are transduced into spatiotemporal activations of sensory neurons in the peripheral nervous system. These signals are analyzed by complex neural circuitry where they are transformed into perceptually meaningful representations of the external world. These representations are then used to generate appropriate motor actions that allow biological organisms to adapt to changes in their external environment. The research focus of our group is to discover the relevant computational principles that underlie the signal transformations and adaptations that occur in biological information processing systems, and to use these principles to improve artificial sensorimotor systems.

An example of a particular research question that we have been engaged in is the problem of auditory scene analysis. We would like to construct robots with the ability to respond in real-time to acoustic cues. We hope to enable them to process external stimuli, learn in real-time, and respond with an appropriate motor action. We are currently working on signal processing algorithms that can be used to achieve real-time performance on the Aibo robots using their binaural microphones. It is anticipated that this auditory system would enable the team to have better localization ability, even in the absence of visual stimuli.

As another example, we have also started to incorporate olfactory sensory information into these robots. As a sensory modality, olfaction is quite unique when compared to vision and audition. The very act of smelling requires active drawing or "sniffing" of air across the odor receptors in the olfactory epithelium. The olfactory receptor neurons transduce chemical binding events into electrical signals that are propagated to other regions of the brain. Artificial electronic noses, or "E-noses," mimic this process. They rely upon an array of chemosensitive detectors which absorb different odorants. This absorption is monitored using electrical resistance changes, and these electrical signals are then analyzed to determine its odorant characteristics. As a research project, we have replaced the IR distance sensor on the Aibo robot with a chemical sensor. This endows the robot with the ability to sense alcohol vapors at short distances. We are currently working on the several algorithms that would enable a team of these robots to efficiently locate the source of an odor.

# Principal Investigator

Daniel D. Lee, is the new team leader and principal investigator of the Univ. of Pennsylvania RoboCup team. He is currently an Assistant Professor in the Electrical and Systems Engineering department, with a secondary appointment in the Bioengineering department at the university. He has a PhD in Physics from MIT (graduated in 1995), and has experience as a researcher in the Theoretical Physics and Biological Computation department at Bell Laboratories, Lucent Technologies (1995-2001). His research focuses on trying to understand the general principles that biological systems use to process and organize information. He works on applying that knowledge to building better artificial systems for vision, speech, language, and data communications.

## Team Organization

The students on the team are drawn from several different departments at the Engineering School, including Electrical and Systems Engineering, Mechanical Engineering, Computer and Information Science, and Bioengineering. Currently, most of the team members are advanced undergraduates who have taken relevant robotics and programming courses, and are working on projects related to Aibo robots and RoboCup. There are also a smaller number of graduate students who are conducting research relevant to machine learning in robotics. The GRASP Laboratory at the university is providing the facilities for the team, where the playing field, robots, and associated computational facilities are stored.

## Statement of Commitment

We intend to compete at the 2003 RoboCup tournament this summer in Padova, Italy, and have been raising funds to support our travel as well as registration fees.

## References


[1] L. K. Saul F. Sha and D. D. Lee. Multiplicative updates for nonnegative quadratic programming in support vector machines. In *Advances in Neural and Information Processing Systems*, volume 15, 2003.

[2] C. L. Isbell L. K. Saul, D. D. Lee and Y. LeCun. Real time voice processing with audiovisual feedback: toward autonomous agents with perfect pitch. In *Advances in Neural and Information Processing Systems*, volume 15, 2003.

[3] D. D. Lee and H. S. Seung. Learning in intelligent embedded systems. In *Usenix Workshop on Embedded Systems*, 1999.

[4] D. D. Lee and H. S. Seung. Learning the parts of objects with nonnegative matrix factorization. *Nature*, 401:788–791, 1999.

[5] H. S. Seung and D. D. Lee. The manifold ways of perception. *Science*, 290:2268–2269, 2000.

[6] O. Shriki, H. Sompolinsky, and D. D. Lee. An information maximization approach to overcomplete and recurrent representations. In *Advances in Neural and Information Processing Systems*, volume 13, 2001.