I. Team Objective

Our joint team Kouretes+AUEBo 2008 intends to participate in the Aibo division of the RoboCup Standard Platform League at Robocup 2008. This document is submitted in support of the team’s bid to qualify as a participant in what is going to be the last Aibo competition.

II. Team History

Team Kouretes+AUEBo 2008 is a joint effort of two research groups based in Greece. Even though the two groups started independently, the shortage of Aibo robots in the last two years and the recent change of league rules, brought the two teams together. The decision to join robot-power and man-power not only facilitates the introduction of a brand new RoboCup team (AUEBo) to the RoboCup community, it also enables a somewhat older team (Kouretes) to put its experience and effort on the Aibos to good use.

A. Team Kouretes

Team Kouretes was founded in February 2006 by Michail G. Lagoudakis, a few months after he joined the Technical University of Crete. Team activities at this early stage were restricted to the Four-Legged league. In January 2007, Nikos Vlassis joined the Technical University of Crete. Under his leadership, team activities were extended to the Simulation league. Recently, the team qualified to participate in the first Two-Legged Standard Platform League with the new Nao robots at RoboCup 2008. The team is also active in the development of custom-made humanoid robots for the Humanoid League (kid size) using the Bioloid kit of Robotis.

The team had its first exposure to RoboCup at the RoboCup 2006 event in Bremen, Germany, where it participated in the Technical Challenges of the Four-Legged league. At that time, Aibo programming by the team was done exclusively in an interpreted language, the Universal Real-Time Behavior Interface (URBI), without any use of existing code. The team entries were specialized to the task at hand and emphasis was put on the Passing Challenge\footnote{Video from RoboCup 2006 available at http://www.intelligence.tuc.gr/kouretes/files/ROBOCUP2006/kouretes2006passing.wmv}.

Even though the team scored low, it gained a tremendous amount of experience.

Subsequent work by a group of six undergraduate and one graduate student led to the participation of the team in the Four-Legged league of the RoboCup German Open 2007 competition in Hannover, Germany. The software architecture of the team was developed on the basis of previously released code by GT2004 and SPQRL 2006. The tournament included ten teams from all over the world. Kouretes reached the quarterfinals round, where it was defeated by the 2006 World Champion Nubots. The team ranked in the 7\textsuperscript{th}/8\textsuperscript{th} place in a tournament featuring the team’s first win and first goals\footnote{Video of the best goal available at http://www.intelligence.tuc.gr/kouretes/GO2007/2007-04-19-Kouretes.vs.Impossibles-Goal.wmv}.

In Spring 2007, three undergraduate and two graduate students began working with the newly-released Microsoft Robotics Studio (MSRS). The team’s software was developed from scratch exclusively in C# and included all the required services, as well as the motion configuration files for the simulated RobuDog robot of RoboSoft. The team’s participation in the MSRS Simulation Challenge at RoboCup 2007 in Atlanta led to the placement of the team at the 2\textsuperscript{nd} place worldwide bringing the first trophy home. The tournament involved nine teams from all over the world; Kouretes was the only European participating team.
In September 2007, the team acquired a couple of Bioloid robot kits in order to enter the RoboCup Humanoid league (kid size) in the future. This effort is conducted in collaboration with the University of Osnabruck, Germany, where humanoid robots based on Bioloid kits are currently being developed as well. No concrete results have been produced from this effort yet, as there is ongoing work on sensor integration (camera, accelerometers, etc.) and computing power to the base body of the kit.

In October 2007, Team Kouretes and Team Cerberus (Turkey) were invited to play friendly demonstration games for the public during the international business meeting Hi-Tech Innovators Partenariat 2007 in Thessaloniki, Greece. This two-day event marked the first time full RoboCup games under the official rules were played in Greece.

Further information about the team, including pictures and movies from various events, may be found at the team’s web site at www.intelligence.tuc.gr/kouretes.

![Fig. 1. Kouretes at RoboCup German Open 2007 (left) and RoboCup 2007 (middle). Team AUEBo at the lab (right).](image)

B. Team AUEBo

Team AUEBo was founded in Spring 2007 by Diomidis Spinellis at the Athens University of Economics and Business. An exhaustive search for Aibo robots launched by the team led to four robots which were acquired to equip the Information Systems Laboratory of the Department of Management Science and Technology. Even though the team is just entering the RoboCup community, the four Aibos have been used extensively as an academic and research tool. Several student projects have been completed in various topics ranging from human computer interaction to distributed software architectures and ubiquitous computing. Further information about the Information Systems Laboratory and its range of activities may be found at the lab’s web site at http://istlab.dmst.aueb.gr.

III. TEAM LEADERSHIP

Michail G. Lagoudakis is an assistant professor with the Division of Computer Science of the Department of Electronic and Computer Engineering at the Technical University of Crete since 2005. He received his Ph.D. degree from Duke University, USA in 2003 and was a postdoctoral researcher at the Georgia Institute of Technology, USA until 2005. His research experience in robotics spans several areas: path planning, motion control, reinforcement learning, coordination.

Nikos Vlassis is an assistant professor with the Division of Production Systems of the Department of Production Engineering and Management at the Technical University of Crete since 2007. He received his Ph.D. degree from the Technical University of Athens, Greece in 1998 and was an assistant professor with the University of Amsterdam, Netherlands until 2006. His current research interests include stochastic optimal control, unsupervised learning, and reinforcement learning. Vlassis has extensive experience with the RoboCup Simulation league and various distinctions with the UvA Trilearn robot soccer team, including the 1st position at the RoboCup world championship (2003), three times 1st position at the German Open tournament (2003, 2004, 2005), and 1st position at the American Open tournament (2003), and the 2nd position in the MSRS Challenge of RoboCup 2007.

Diomidis Spinellis is an Associate Professor in the Department of Management Science and Technology at the Athens University of Economics and Business, Greece. His interest in autonomous robotics stems from his
extensive experience in ubiquitous and distributed software systems. He holds an MEng in Software Engineering and a PhD in Computer Science both from Imperial College London. He is currently the director of the Information Systems Technology Laboratory and the head of the Software Engineering and Security (SENSE) group. Spinellis has published two books in Addison-Wesley’s “Effective Programming Series”: in 2004 Code Reading: the Open Source Perspective, which received a Software Development Productivity Award in 2004 and has been translated into six other languages, and in 2006 Code Quality: the Open Source Perspective, which also received a Software Development Productivity Award in 2007. He is a member of the editorial board of IEEE Software, authoring the regular “Tools of the Trade” column, and Springer’s Journal in Computer Virology. Spinellis is a FreeBSD committer and the author of many open-source software packages, libraries, and tools. He is now leading the EU-funded SQO-OSS cooperative research project, a software quality observatory for open-source software.

IV. TEAM MEMBERS

Team Kouretes+AUEBo 2008 includes five core members from the two institutions. The bracket indicates the main area each member is working on.

1) Chris Lazaris, Technical Laboratory Staff (AUEB) [Modular Software Architecture]
2) Andreas Panakos, Undergraduate Student (TUC) [Color Segmentation and Landmark Recognition]
3) Alexandros Paraschos, Undergraduate Student (TUC) [Coordination and Learning]
4) Georgios Pierris, Undergraduate Student (TUC) [Skills and Localization]
5) Kimon Fountoulakis, Undergraduate Student (AUEB) [Distributed Information Sharing]

The robotic personnel of the team consists of eight ERS-7 SONY AIBOs (four from each institution).

V. TEAM RESEARCH

The team’s research currently focuses on the following areas: team coordination, robust visual recognition, reinforcement learning, distributed information sharing.

A. Team Coordination

Team formations, tactics, and strategies is largely an unexplored area in the four-legged robocup research. In our work, we took a radical step in behavior control and implemented robot soccer strategies, which are based on human soccer strategies used in real soccer games. Considering that the ultimate goal of RoboCup is a game between robots and professional human football players, we believe that our work takes a step towards this goal.

According to our coordination scheme, the strategy of the team is realized using tactics with well-defined roles for each player. So far, we have defined and implemented four tactics: Passive Defence, Pressing Defence, Counter Attack, Passing Attack. There are four roles in each tactic: Attacker, Midfielder, Defender, Goalkeeper. Each role in each tactic is implemented using Petri-Net Plans\(^3\). Figure 2 shows the plan for the Attacker role in the Counter Attack tactic. A finite state machine combined with a broadcast communication scheme is used to decide the team tactic and player roles at each time depending on the current position of the ball in the field and the location of each player. This work led to the following publication

Georgios Kontes and Michail G. Lagoudakis, Coordinated Team Play in the RoboCup Four-Legged League, Proceedings of the IEEE International Conference on Tools with Artificial Intelligence (ICTAI), October 2007, Patras, Greece.

and resulted in improved team play with better field coverage by the players\(^4\).

B. Robust Visual Recognition

The main sensor used by the Aibo robots is the CCD camera. The robots rely on visual information to isolate particular colors, identify objects of certain shape in the field, and estimate their distance. Our work focuses on adding robustness to visual recognition against object occlusion and faulty color segmentation. In particular, we use histograms to represent the distribution of the target color along the various scanlines over the image. Identification


\(^4\) Videos of roles and tactics in action available at http://www.intelligence.tuc.gr/kouretes/publications.html
of the histogram modes leads to correct recognition of the field landmarks. We are also developing a classification-based color segmentation scheme which is insensitive to illumination variability, the main problem we faced during games in 2007. Figure 3 shows an example of recognizing the ball, a beacon, and a goal in the same camera frame.

C. Reinforcement Learning

Reinforcement learning has been used widely in many robotic applications, mostly in a single-agent form. The multi-agent versions have not been adopted widely due to difficulties associated with efficiency and scaling to realistic domains. Recent independent research work by our team leaders has led to extensions of classic planning and reinforcement learning algorithms to collaborative multi-agent learning (where many agents learn to collaborate...
as a team)\textsuperscript{5}\textsuperscript{6}\textsuperscript{7} and competitive multi-agent learning (where two teams learn to compete against each other, but collaborate within the team)\textsuperscript{8}.

The scaling properties of these algorithms through exploitation of domain knowledge make them attractive for the RoboCup domain. Factorization of the representation can be done on the basis of the proximity between players during a game. In addition, these techniques will be particularly useful for learning sophisticated motion skills for the Aibo robot. The large number of degrees of freedom on the Aibo imply a huge joint action space. This obstacle could be overcome again by appropriate factorization of the representation on the basis of joint proximity on the robot body. Kouretes is our venue for adapting these algorithms and testing their potential in a difficult task with real-time constraints.

\textbf{D. Distributed Information Sharing}

Sharing of information is an important aspect of collaborative teams. Most current robot players commonly seek to address a variety of difficult problems, such as world perception and localization, individually. It is clear that individual efforts are subject to failures given the limited and unstable optical field available to the robot at each time. We believe that such problems can be addressed more effectively by a robot player that fuses information provided by the teammates. Towards this end, we are developing methods for filtering, compressing, and transmitting data between teammates using radio, auditory, and visual signals. We expect that perception and localization abilities of the team will be greatly improved under such distributed information exchange schemes.

In order to produce a functional and efficient information exchange system, we need to overcome a number of challenges. The computational ability of the robots is limited and so is their communication ability through the network or through the physical world. Robot proximity will certainly play an important role. The recently posted constraints on network communication make the task even more complicated; robots cannot communicate directly and all network traffic must be routed through a central access point to verify that it stays within the allowed bandwidth. Finally, the trend to gradually move to larger and larger robot teams with more players implies that the proposed algorithms must scale smoothly without degrading for reasonable team sizes.

\textbf{VI. TEAM SOFTWARE}

The team’s software architecture is an offspring of the software architecture released by team SPQR-Legged 2006 (Italy), which in turn is an offspring of the software architecture of the German Team 2004 (Germany). This architecture was brought to its current form last year by Team Kouretes. The architecture inherits the structural modularity designed by GT2004, however it is written entirely in C++ and is Linux-oriented. The following table shows the origin of the modules we currently use and their current status (the brackets indicate work in progress).

<table>
<thead>
<tr>
<th>Module</th>
<th>Original Code</th>
<th>Kouretes+AUEBo 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>ColorTable</td>
<td>SPQR2006</td>
<td>[Kouretes+AUEBo2008]</td>
</tr>
<tr>
<td>ImageProcessor</td>
<td>SPQR2006</td>
<td>Kouretes2007</td>
</tr>
<tr>
<td>BallLocator</td>
<td>GT2004</td>
<td>GT2004</td>
</tr>
<tr>
<td>BehaviorControl</td>
<td>spqr2005PNExec</td>
<td>Kouretes2007</td>
</tr>
<tr>
<td>WalkEngine</td>
<td>SPQR2006</td>
<td>GT2005 + [Kouretes+AUEBo2008]</td>
</tr>
<tr>
<td>HeadControl</td>
<td>SPQR2006</td>
<td>SPQR2006 + [Kouretes+AUEBo2008]</td>
</tr>
<tr>
<td>Communication</td>
<td>-</td>
<td>[Kouretes+AUEBo2008]</td>
</tr>
<tr>
<td>Tools</td>
<td>SPQR2006</td>
<td>SPQR2006 + Kouretes2007</td>
</tr>
</tbody>
</table>


VII. TEAM EDUCATION

Student members of the team have the opportunity to receive formal training on RoboCup-related topics through a number of courses offered by the team leaders: Artificial Intelligence (undergraduate) and Autonomous Agents (undergraduate/graduate) taught by M. G. Lagoudakis, Robotics (undergraduate) and Algorithms for Robotic Problems (graduate) taught by N. Vlassis, as well as Advanced Topics in Software Engineering and Advanced Java Programming taught by D. Spinellis. Most of these courses include semester-long hands-on laboratory sessions with Aibo robots, robot arms, and the robot simulators, where the students learn how to use various programming tools (URBI, R-Code, Open-R, Tekkotsu, Pyro) and high-level languages (C#, C++, C, matlab) to program robots to perform various tasks. These courses are complemented by a biweekly reading group, which studies papers and technical reports written by other RoboCup teams in order to keep up with the latest developments.

In addition, our RoboCup teams provide a venue for students to complete their diploma or M.Sc. thesis while being members of the team. One diploma thesis has been completed (Coordinated Team Play in the RoboCup Four-Legged League by Georgios Kontes), another is close to completion (Histogram-Based Robust Landmark Recognition by Suzanna Volioti), and three more (by Alexandros Paraschos, Georgios Pierris, and Andreas Panakos) have just started. Another diploma thesis (by Daisy Chroni) and a master’s thesis (by Elias Kourtoudis) are currently in progress. Finally, Kimon Fountoulakis is currently performing research on location-finding algorithms that utilize GPS training to use with cell-phone tower information data.

VIII. TEAM INFRASTRUCTURE

Team Kouretes is a joint effort of the Intelligent Systems Laboratory (Department of Electronic and Computer Engineering) and the Intelligent Systems and Robotics Laboratory (Department of Production Engineering and Management) at the Technical University of Crete. Both laboratories have a 15-year history of research efforts in various topics related to Artificial Intelligence, Machine Learning, and Robotics. Team Kouretes currently has its own dedicated 40 m² space for a test field. In Spring 2008, the Department of Electronic and Computer Engineering will move to a new 16,000 m² building and the team will be able to use a much larger space than the current one. This development is important in view of the increase in field dimensions for the Aibo and eventually for the Nao leagues.

Team AUEBo is housed within the Information Systems Technology Laboratory. Although hardware advances over the last decade have brought powerful computing infrastructures within reach of even small research groups, the istlab/SENSE server cluster offers top-of-the-line facilities that simplify many resource-intensive research projects. The most important elements of the cluster are the following:

- Sun Fire T2000: 4×core, 4×thread UltraSPARC T1 CPU running at 1.0 GHz; 8 GB of RAM
- Tyan Pepper: 4 × dual core Opteron CPU running at 2.4 GHz; 16 GB of RAM
- Dell PowerEdge 1950: Dual core Xeon CPU running at 2 GHz; 2 GB of RAM
- Tyan Dual Opteron: Dual core Opteron CPU running at 2.2 GHz; 8 GB of RAM

These computational resources will be invaluable for conducting large scale learning experiments in simulation.

IX. TEAM FUNDING

Team participation (registration, travel, accommodation) in various RoboCup events has been supported in the past by the Technical University of Crete. Team Kouretes has received verbal commitment from the university administration that its efforts will continue to be supported. Team AUEBo’s equipment is funded through istlab/SENSE. Kouretes’ research efforts are also supported by a European Marie Curie International Reintegration Grant (MIRG-CT-2006-044980) awarded to Michail G. Lagoudakis and a New Faculty Start-Up Grant awarded to Nikos Vlassis.

X. SUMMARY

There are several reasons to believe that Kouretes+AUEBo 2008 will be a competitive participant:

- It is a relatively new, enthusiastic, and energetic joint team.
- It represents all RoboCup efforts in Greece, a country which is under-represented at RoboCup.
- Its members have participated in three official RoboCup events in less than two years.
- Its members received a distinction at RoboCup 2007 (2nd place in MSRS Simulation Challenge).
• It is led by experienced researchers, faculty members of two leading universities in Greece.
• It studies team coordination, visual recognition, reinforcement learning, and distributed communication.
• It has its own dedicated space and facilities for testing and development.
• Some of its members will travel to RoboCup 2008 for the Nao league anyway.
• It has secured a sufficient number of Aibo robots for this year’s games.
• It has secured sufficient funding for registration and funding.

We hope that the committee will give our team an opportunity to compete in the last Aibo league.