Qualification document: RoboCup 2015 Standard Platform League

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Conference Article

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Abstract—**This is the application for the RoboCup 2015 Standard Platform League from the "LiU Robotics" team. In this document we present ourselves and what we want to achieve by our participation in the conference and competition.**

I. BACKGROUND

Our team ("LiU Robotics") represents the student association FIA Robotics from Linköping University (LiU), Division for Artificial Intelligence and Integrated Computer Systems (AIICS) at the Department of Computer and Information Science (IDA) at LiU and the Computer Vision Laboratory (CVL) department at the Department of Electrical Engineering (ISY) at LiU. The team consists of:

- Fredrik Löfgren – Team Leader, Student 4th year Applied Physics and Electrical Engineering
- Martin Danelljan – PhD student at CVL
- Jon Dybeck – Student 4th year Computer Science and Engineering
- Michael Felsberg – Professor at CVL
- Fredrik Heintz – Associate Professor of Computer Science
- Gustav Häger – Master thesis student at CVL
- Fahad Khan – Assistant professor at CVL
- Daniel de Leng – PhD Student at AIICS
- Mattias Tiger – PhD Student at AIICS

We all have different backgrounds, but we all share a common interest in robotics. We have all been working on humanoids before, all with the NAO and some with both the Nao and the Darwin-OP.

Each fall we organize a project course where the new Computer Science and Computer Engineering students program humanoids to play soccer. In the course the students use a Python API that we have written. We have made the interface to the robots easy to use by using state machines where we provide pre-made states and transitions. During the course the students are also using Webots for simulating their programs before they test them on the real robots. The course is very appreciated by students. The system is currently called RosBots and is hosted here: https://bitbucket.org/jondy276/rosbots.

Some of the team members have experience from previous RoboCup competitions. Such as Fredrik Heintz which participated in the simulation league years 1999 and 2001. Or Fredrik Löfgren which is a member of the technical and organizing committee of the RoboCup Junior Rescue league since 2012. Several of our team members has also been participating in Robocup Junior earlier.

At the university we have a student association called FIA (Swedish abbreviation for the association for intelligent and autonomous systems). The association was founded 2012 to organize RoboCup Junior in Sweden and other activities in the new humanoid laboratory at Linköping University. Since then we also run student projects for our members. The association has over 40 members, access to 4 NAO from Aldebaran, 1 Darwin-OP from Robotis and 5 LEGO EV3 robots.

Last fall we won the Humabot Challenge at 2014 IEEE-RAS International Conference on Humanoid Robots.

"In the HUMABOT Challenge, the robot is an integral part of the house and helps its occupants to live there better. In this edition, the tests will be held in the kitchen of the house." http://www.irs.uji.es/humabot/humabot-challenge

We learned a lot from this competition and looking forward to new challenges!

II. MOTIVATION

We aim to participate in the RoboCup SPL, because we are convinced that the therein required competences are of high relevance for collaborative embodied and autonomous systems. Besides from being challenging, interesting, and highly motivating, working with problems relevant for the competition is thus also of highest relevance to societal and more serious application areas such as autonomous transportation and rescue robotics. The lessons learned during the preparation for the competition will have major impact on future research projects of the involved research labs as well as on future industrial initiatives triggered by the involved students.

The participation in this competition is not done as part of any course at the university. We are spending our free time programming robots because we are truly interested in the topic, you can say we are passionated about robotics! We are committed to participate in the Standard Platform League and we will spend our free time on this project.

We are willing to compete in all 3 SPL competitions: the team competition, the drop-in player competition and the 2-3 technical challenges.

It is our hope that competing in the SPL competition will impact our university in a number of ways. Such as contributing to new areas of research, attracting attention amongst students not already interested in robotics or AI. During the competition we are hoping to establish contact with other researchers and students working with humanoids.

III. RESOURCES

The application is supported by the Division for Artificial Intelligence and Integrated Computer Systems (AIICS) at the Department of Computer and Information Science at Linköping University, and the Computer Vision Laboratory (CVL), part of the Department of Electrical engineer at Linköping University.

The research group at CVL has produced a number of relevant research papers and has won the following robot vision challenges:

- Visual object tracking challenge 2014 (Martin Danelljan, Gustav Häger, Fahad Khan and Michael Felsberg)
- Pascal image segmentation challenge 2010 (Fahad Khan)
- Pascal action classification challenge 2010 (Fahad Khan)
- Semantic robot vision challenge 2007 (Per-Erik Forssn)

As well as scoring well in the following challenges:

- Visual object tracking challenge 2013, third rank (Michael Felsberg)
- Pascal image classification challenge 2012, honourable mention (Fahad Khan)
- Pascal image classification challenge 2009, honourable mention (Fahad Khan)
- Pascal image segmentation runner-up 2009 (Fahad Khan)

At Linköping University we have full access to the AIICS humanoid laboratory, where we have access to four H25 NAO v4s. In preparation for the competition LiU intends to buy at least two more H25 NAO v5s. Since we have already integrated the NAO with ROS we also have access to all the tools and algorithms available through ROS. The laboratory also has six powerful computers with Webots installed. In the lab we have a four by eight meter soccer field, which thus differs from the dimensions of the RoboCup field. Since we are aiming to develop a scalable and adaptive overall approach, absolute size does not matter in our case.

IV. PREVIOUS RESEARCH

AIICS has a long history of research in artificial intelligence and its application to intelligent artifacts. Intelligent artifacts are defined as man-made physical systems containing computational equipment and software that provide them with capabilities for receiving and comprehending sensory data, for reasoning and for rational action in their environment. Examples of such artifacts range from PDAs and software agents to ground and aerial robots. An equally important focus is the development of integrated systems which include hardware, software, sensors and human users.

AIICS has more than 15 years of research experience with developing robotic systems. We have focused mainly on unmanned aerial vehicles but the techniques and technologies developed can also be applied to humanoid robots. Our research includes for example logic-based spatio-temporal reasoning over streaming data, automated task and motion planning, task allocation in multi agent systems, and localization and navigation of robots. These techniques can all be used to achieve the tasks in the Standard Platform League.

For more information on research at AIICS see: http://www.ida.liu.se/divisions/aiics/.

The research at CVL covers a wide range of topics within artificial visual systems (AVS): three-dimensional computer vision, cognitive vision systems, object recognition, image analysis and medical imaging.

Computers are better than humans at playing chess, but even a small child has better generic vision capabilities, as required for robot vision and playing soccer, than any artificial system. CVL aims at improving AVS capabilities substantially, driven by a human visual system inspired approach, as AVS are supposed to coexist with and therefore predict actions of humans.

CVL has more than a decade of research experience on real-time computer vision for robotics and building robotic systems with distributed computations using, e.g. ICE and ROS. CVL's research focuses on systems with layered feedback loops that are formed by online perception-action learning. These systems have been applied on various platforms, such as manipulators, mobile ground vehicles, and unmanned areal vehicles.

For more information on research at CVL see: http://www.cvl.isy.liu.se/research/.

V. SOLUTIONS

In order to compete in the SPL league a number of systems have to be implemented. The most important systems can be divided into the following, the machine vision system, the localization system, the communication system, the robot walk system, and last but not least the decision making system controlling each robot. We have working initial solutions to the vision, localization and decision making system.

The vision system is one of the most challenging parts and in previous work we have spent considerable amount of effort implementing several vision components for the NAO robot. Most important among the challenges is the need for efficient use of CPU time and memory. As well as simple configuration and testing of the system. In order to address the two first challenges we use ROS and Nodelets to allow for direct memory accesses between different components of the vision system. This is very important since the components of the vision system often must exchange images at high frequencies between each other. One might ask why the components are separated at all, the reason is that this addresses the two later challenges. The system must be configurable and testable in order for us to work efficiently with them. By separating the different components each component can be easily configured using ROS and also be debugged and tested individually, which is very useful since it saves time by not always requiring the robot.

Color is one of the important characteristics of materials in the world around us. As such it is one of the important features for computer vision systems in their task to understand visual data. Its description however is complicated due to many scene accidental events such as unknown illuminant, presence of shadows and specularities, unknown acquisition system and image compression.

There exist several methodologies to the color description problem. Ideally, a color descriptor should be robust to photometric variations. However, robustness in photometric variations should not be compensated by reducing the discriminative

power. Typically, achromatic colors such as black, white and gray are in abundance in man-made objects. Robust description of these achromatic colors increase the discriminative power of the color descriptor.

Importance to RoboCup: Recognition and detection of objects is one of the fundamental objectives in the competition. To this end, a robust color descriptor is crucial for the overall system. Additionally, color descriptor should be efficient to compute due to limited amount of resources. The task will be to build a recognition system that efficiently recognizes objects in context. CVL has previously successfully developed robust color description and fusion methods for many computer vision applications [1], [2], [3], [4]

We aim to improve previously designed primitive vision components that used look-up tables for classifying image pixels into relevant classes (ball, goal, field, etc.) a color-based segmentation step, and sub-sequent detectors and trackers. From a joint research project AIICS-CVL, we have access to state-of-the-art real-time object detectors and trackers that process image streams in a ROS framework. The object detectors are computationally more demanding than the object tracker and a thus only run every few frames, whereas the object tracker are applied to each frame.

Once an object has been identified its coordinates in the image plane is sent to the localization system. The localization system takes observations from the vision system, uses TF (a ROS packet) and the odometry from the robot to calculate the real world 3d coordinates of the objects relative to the robot. Once it has these coordinates it attempts to determine it's position on the field. This is something which we are still working on, amongst other things we need to find more efficient ways to calculating the various transformations, possibly by replacing TF.

One way to greatly improve the accuracy of our localization system is to use multiple robots to provide multiple viewpoints. This is something we have experimented with, both using the NAO robots and other craft, such as UAVs. However to do this (and other things related to AI) we need reliable communications. Or at least systems which can cope with unstable networks. This is where both ROS and NaoQI are somewhat lacking, ROS requiring its master node to coordinate name look-ups. NaoQI, being a RPC framework simply raises errors when the underlying network fails. Our plan is to augment one of these systems to provide a partition tolerant network model so that our robots can re-establish communication in the face of unstable WiFi networks.

However the most challenging system will for us be the walk system. We have noted that in order to compete effectively the robots of a team must be fast. Until now the only system that we have used is the Aldebaran stock walk engine. We realize this will not give us much of a fighting chance, so it will be necessary to implement a better alternative. To do this we have invited more students with control engineering and signal processing background to help us. We well probably look for inspiration in the code of other teams, however we will not directly copy code from other teams.

Finally there is the decision making system which coordinates the actions of one or more robots. Here we have determined that the hardest part is not actually the artificial intelligence or the policy it should follow. But rather the support systems (communication, localization) because if these do not perform adequately our time is quite wasted on designed a advanced AI.

At the time of writing the systems that are in working order (vision and localization) do not use the code from any other team. Only open source ROS packages such as TF and naoqi_bridge and naoqi_nao_robot. We do not intend to copy any other teams code directly, but use other teams as inspiration for our own implementations.

VI. Future work

We want to continue working with humanoids. This year we will learn a lot during the project time and the main goal is to gain capabilities to be able to compete for a top position in the coming years.

We are also interested in human-robot-interaction and think that the capabilities we will learn during RoboCup Soccer can be applied on other fields such as the kitchen in Humabot Challenge.

VII. Conclusion

The LiU Robotics team is committed to work with RoboCup SPL and to build up a competitive team. We have been working with the NAO for over 2 years and have built up a laboratory facility with 4 NAOs, 6 workstations and a soccer field that have mainly been used for teaching so far, but always with RoboCup in mind.

The team consists of both students, PhD students and researchers covering all the important skills from computer science, computer vision, artificial intelligence, control theory and robotics. We hope that we will have the possibility to participate in the Standard Platform League 2015 as it will give us the possibility to learn more about programming, robotics and especially humanoids to be able to compete for a top position in the coming years.

We really looking forward to participate in the competition and the Standard Platform League!

References

[1] Martin Danelljan, Fahad Shahbaz Khan, Michael Felsberg, Joost van de Weijer: *Adaptive Color Attributes for Real-Time Visual Tracking. CVPR 2014.*

[2] Fahad Shahbaz Khan, Rao Muhammad Anwer, Joost van de Weijer, Andrew D. Bagdanov, Antonio M. Lpez, Michael Felsberg: *Coloring Action Recognition in Still Images. International Journal of Computer Vision 105(3): 205-221 (2013)*

[3] Rahat Khan, Joost van de Weijer, Fahad Shahbaz Khan, Damien Muselet, Christophe Ducottet, Ccile Barat: *Discriminative Color Descriptors. CVPR 2013.*

[4] Fahad Shahbaz Khan, Rao Muhammad Anwer, Joost van de Weijer, Andrew D. Bagdanov, Maria Vanrell, Antonio M. Lpez: *Color attributes for object detection. CVPR 2012.*