RoboCup X: A proposal for a new league where RoboCup goes real world

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Abstract. To put more emphasis on real-world problems, the authors propose to extend the RoboCup competitions. In order to foster progress in the desired abilities the authors propose to expand the existing challenges by a set of simple tests. The passing of the entire set should lead to robots that are capable of working both autonomously and in cooperation with humans in different realistic scenarios. Robots from all RoboCup leagues but also from outside of RoboCup should be allowed to participate. The new league especially aims at fostering the development of practical solutions and applications for supporting humans in everyday life.

1 Introduction

1.1 The aim of RoboCup

On the first page of the official RoboCup web-site [1] it is stated literally that:

RoboCup is an international joint project to promote AI, robotics, and related field. It is an attempt to foster AI and intelligent robotics research by providing a standard problem where wide range of technologies can be integrated and examined.

Furthermore it says:

The ultimate goal of the RoboCup project is, ***By 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer.***

It ends with:

One of the major application of RoboCup technologies is a search and rescue in large scale disaster. RoboCup initiated RoboCupRescue project to specifically promote research in socially significant issues.

1.2 Achieving the aim

To achieve the RoboCup mission statement the closed environments of present day leagues are not enough. The social interaction between humans and robots

is, due to the 'no human intervention' rules in most leagues, almost non existing. But soccer playing and rescue also include social aspects. For example, robots have to cooperate with humans in rescuing efforts. The authors think that after almost a decade of RoboCup it is about time to take the first steps out of the artificial environment. The rescue league is making a good progress in this direction but the disaster scenario in the Rescue league is for sure not a usual but an exceptional case humans encounter. There is a need for application based progress, for robots cooperating with humans. The RoboCup X-games are more AI based than the other leagues, since social intelligence and interaction with both humans and robots will play a big role.

2 RoboCup eXtends

The RoboCup X-games are a proposal to advance robotic technologies beyond what nowadays is or seems possible. It is also meant to inspire people from different leagues to use and recombine existing technology and work together on new solutions and useful applications. The X in the name of the league stands for eXtended or eXpanded, eXperimental, eXtreme and for the celebration of the $X^{th}/10^{th}$ anniversary of RoboCup. It is not about a single specific topic, but about the building of re-usable real-life robotic solutions. It is extended because it widens the scope of RoboCup beyond rescue and soccer, experimental because new technologies can be applied and extreme because it puts robots in uncertain real-life situations where they have not been before.

To retain the necessary attention and acceptance of society and economy to continue high quality research, we have to prove that the results of our work are useful and promising. Coping with self-explaining real-life tasks seems a good way to do this. The RoboCup initiative has the quality needed, but not all elements are there yet.

2.1 Competition

RoboCup is a versatile set of challenges where the robots compete against each other. The element of competition accelerates the process of research and offers the possibility of benchmarking. A drawback of the competition element is that in some leagues the approaches used in hardware and software seem to converge to a specific set of solutions, pushed by the rules of the competition. In the RoboCup X-games, the real world robot league, this should be avoided, while retaining the competitive elements. The proposal is to have a group of tests that benchmark a robot on its ability to fulfill useful tasks in applied, real-life scenarios with a lot of human intervention. As a consequence, effective human-machine interaction will play a big role in this league.

The tests in this league are rated with points. In the end, the one with the highest amount of points wins. By choosing new tests the community is able to rapidly steer the research in desired directions. The idea to propose a *new* league instead of adjusting an existing one is that it is probably tough to change a league

so dramatically that it includes social human interaction. Many researchers have put a lot of effort in one of the existing leagues and would like to continue with it.

3 The RoboCup X tests

RoboCup X is a benchmark for RoboCup and non-RoboCup robots. If a robot wins the RoboCup X-games this does not mean that it also wins in another competition, but it does suggest that its application-related qualities are better than of others. By actually using the benchmark tests of RoboCup X the RoboCup community is able to set the standards for research groups and the industry.

The areas that are covered by RoboCup X should include, but are not limited to: animal like/intelligent behavior (bio-inspired robotics), adaptivity, appearance, applicability, autonomy, endurance, ergonomy, human-robot interaction, modularity, navigation, out-door abilities, precision work, reliability, reusability, safety, speed and transportation.

The criteria of the tests are the following:

- The scenarios/tests are easy to set up, so that researchers can test at home. They are low cost and available world-wide.
- Tests should preferably not be boring to watch.
- Tests take a finite and not too long amount of time.
- The tests should have definite and easy rules, to avoid long-lasting rule-specific discussions.
- The test should be self-explaining
- The tests should preferably point at applications which are possible with the new abilities.
- The tests should have a strong relation to real-life problems and applications, partly driven by industrial demands.

3.1 The RoboCup X-games

We expect many of the tests in the RoboCup X-games to have a good show element. Competing and socially interacting robots make a versatile show for both scientists and the public watching. It also attracts the industry by focusing on real-world applications for every day use. The stakes are a bit higher in the RoboCup X contests because real world scenarios are less predictable. Some test might even involve interaction with the public!

The size, weight and other dimensions of the robots are specified in the rules of the other leagues. Any robot that is allowed in another league is allowed in the RoboCup X-games, but also modification or rebuilding a robot within a certain range of size should be possible.

The authors think that the technical committee of the RoboCup X-games should allow *all* technologies, unless it requires a *special external setup* or is harmful to other robots or humans. The RoboCup X-games should encourage

innovative ideas on autonomous systems, even if they are not allowed in the other leagues. This rule should prevent external camera use, special navigational markings, radio waves for local positioning etc. Though it should allow GPS, sonar, laser range finders, vocal communication etc.

3.2 Points

Autonomy: The robots have to work autonomously. The problem is to define autonomously. The authors suggest that a restricted period of time (e.g. 10 minutes) is given, where human-intervention is allowed before the test (e.g. for calibration and set-up) on the test-site. There should be *no* flexibility in these time limits once they are defined. Exceeding this time-limit, or controlling the robot during the test remotely by a human operator is considered a failure. If one cannot comply with the specifications the team faces disqualification for the specific test.

Difficulty multiplier: If less than $\frac{1}{4}$ of the participating teams succeeds in a test it gets a multiplier of 2. If more than $\frac{3}{4}$ of the participants succeed then it gets a multiplier of $\frac{1}{2}$. The last situation indicates that the test could be revised for the next games, either by changing it or not having it.

General applicability: A test consists of 2 parts. First a test is done with settings specified by the robots team to show that the system works. After a successful demonstration of the capabilities the same test is done with generalized and therefore more difficult settings specified by the RoboCup X committee. If the robot also succeeds here the amount of points is doubled.

Human intervention: During a test human intervention (like touching, restarting or helping a robot out of a stuck situation) is not allowed and results in disqualification for the test, unless human interaction is an essential and wanted feature of the test itself (like giving speech or gesture commands).

3.3 Specific tests

The general idea: A list of possible tests with a short description is presented here. The list is a proposal and debatable. Of course for all tests it is obligatory that the robot remains (fully) operational during the entire test. A maximum of 3 robots per team is allowed to participate. Only one of these robots is allowed to participate in a single test. Calibration periods are very restricted, just as repair time. The idea is that the robot goes through as many tests as possible in a very short period of time. In the first years a tame version of the rules and the tests can be used.

The list presented here are proposals for tests. Further in this article a few tests are highlighted to be used in the first edition of the RoboCup X-games

and described in more detail. On request and after consulting the RoboCup community the committee of the RoboCup X-games league can add or change a test.

Bar Can the robot serve drinks in a bar?

Burglar Does it recognize its owner and give an alarm when it detects an unknown intruder?

Elderly Can it aid elderly people, for example support a person while walking?

Falling Does the robot survive a 10 cm drop? And 25 cm? And 50 cm ? And 100 cm?

Guide robot for the blind Lead a blind person from place A to B.

Light The robot should, without manual recalibration, go to an object that it has seen in a dark place, but which is now put outside or the other way around.

Looks Does it look nice to interact with or does it look very technical with sharp edges and wires sticking out?

Open challenge Demonstrate a new and challenging ability not yet covered in another test.

Racing Can the robot go on a (difficult) race track? The early version can consist of a race track with an uneven floor. Touching the border reduces the score. Putting more than one robot on the track gives a very nice racing character to this test.

Rain The robot should be capable of functioning in rainy environments. A shower or watering can should suffice.

Robot agility Similar to competitions with dogs, walk, talk or point a robot through an obstacle parcours.

Stairs Can it climb stairs autonomously? And a stairway?

Supermarket Can it find a certain product in the supermarket (on a shelf)?

Suitcase Carry a suitcase and avoid obstacles while following a human. Sound an alarm if the suitcase gets stolen or lost.

Traffic The robots drive in a miniaturized street where the robots have to follow a certain path (e.g. marked by arrows on the ground) the path consists of one mayor crossing and some streets on the side. The robots have to obey the traffic rules, recognize signs, etc. The robot which does the most rounds in a certain time, without bumping in other robots or going besides the track, wins.

3.4 Tests for the first time

Out of the list presented in the previous paragraph we have chosen the following for consideration, due to the ease of set-up and possible success of the robots.

Terminology for the remainder of the article: The terminology in the rest of the article is as follows: 'Ranking' means three points for the first place, two for the second and one for the other succeeding robots. 'Boolean' means that every robot that succeeds gets one point, no success is no points.

Elderly Can it aid elderly people, for example support a person while walking? The elderly person must be able to steer the robot, while leaning on it, by simple commands such as voice commands. The test is boolean.

Guide robot for the blind Lead a blind person from place A to B in the RoboCup area. The test is boolean.

Humans Can the robot recognize different humans (bodies and/or faces) and express this in some way, preferably with sound (speech). To pass the robot has to recognize five different humans and has to be trained on the spot in unknown light conditions. The test is boolean.

Light An object (unknown in advance) is shown inside the building on a random spot. The robot is taken outside and may not be re-calibrated. The object is put within within a 15 meter radius of the robot three times. If the robot touches the object all three times then the robot passes the test. The test is boolean.

Looks The appearance of the robot is rated by a jury. Among the criteria can be: smoothness of movements, integration of components (no wires), easiness of charging, attractiveness of shape, safeness of shape, human-machine interaction, type of applications,... The test is ranking based.

Open challenge Demonstrate a new and challenging ability not yet covered in another test. A jury decides on the ranking. It can act as a test generator for the years to come.

Rain The robot has to keep driving around (slowly) for one minute avoiding black objects while cold water out of a shower or watering can is sprayed on top of it. The test is boolean.

Race A circular race track with white borders is used to race on. Several robots race at the same time. Bumping can lead to disqualification. The race lasts 10 minutes and the robot that has traversed the biggest distance wins. The test is ranking based.

Stairs The robot has to climb stairs somewhere in the RoboCup building. The test is boolean.

Suitcase Carry a suitcase and avoid obstacles while following a human through the RoboCup area. Sound an alarm if the suitcase gets stolen or lost. A bit more difficult would be to take a walk from the inside to the outside of the building and back. This is a boolean test.

3.5 The final scenario

At the end of the test round the teams are ranked according to their points they have scored. The teams with the highest points go to the finale which consists of a scenario with an open challenge. An example could be a living room with a person watching television. Here the best robots have ten minutes (five for the setting up, five for the application) to show some capabilities. The ranking of this final show, combined with the ranking from the tests (and maybe even from the audience!), determines the final ranking. The jury should not only consists of roboticists, but also others such as journalists, famous persons from television, government officials, people from the industry, ...

The idea behind this is to promote the open challenge and stimulate the creativity of researchers. The entire finale lasts about an hour and is a nice show for spectators, journalists and participants. A professional host who can entertain the audience could present the entire show, have some interviews, talk to the jury etc. This should preferably be arranged professionally (maybe even by a network station) so it can be broad casted as a nice robot show.

In a previous email discussion (initiated by one of the authors) on the mid-size league list a few years ago, there were roughly two opinions on this issue. One opinion was that we are doing science and should not bother about this, also because it might degrade the work. The other opinion was that such a show does not diminish the importance of the scientific work, but focuses on the fun side for the layman audience watching. The professional will recognize the scientific qualities and/or can read about the work in articles. We think it is worth a try.

4 Discussion

We all know that the RoboCup has to go real world, in order to remain interesting. Playing soccer and winning from humans will probably not bring us all the problems we would like solve in order to have robots capable of functioning autonomously in the real world, which consists of human societies and rough nature.

RoboCup X provides a natural way of extending the current competitions. The tests are not all or nothing but build up in complexity. Also a team does not have to bring several robots to the competition so the overall costs for participation can remain relatively low.

Besides the test cases, which are interesting by themselves, RoboCup X also provides a show for the layman, who is not interested usually in the technical details of the system. By covering a broad area (from science and technology to entertainment and fun) we should be able to get more attention from the media, which increases the chance of more funding by governments and increased interest from the industry. Hopefully the new league can bring some of the excitement that participants feel over to the layman.

In 2006 in Germany the tenth RoboCup world championships will be held. To celebrate this, we should show that we, as a community, are dedicated to improve the lives of human beings; that we work toward a bigger goal that transcends economic pressure and short term visions. With RoboCup X we can show that the community is working toward applicable robots for general use. Hopefully the community can demonstrate, as a gift for the 10^{th} anniversary of RoboCup and to honor the people who have so dedicatedly devoted their careers to this magnificent world-wide event, that we are truly caring for society at large.

References

1. http://www.robocup.org
2. http://www.Xprogramming.com