Interest of Ludic Competitions for Robotic Education and Research*

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ABSTRACT

Playful competitions in robotics have really started to grow important since the middle of the nineties. Competition is a collective behavior, which is well known to help identify and select best practices and experts. Well coached and judged, like in sports for example, competitions may additionally set the attitude of participants towards excellence, mutual respect and peace. The main robotic competitions are probably organized within Eurobot, Robocup and FIRST organizations. Eurobot often foster very sophisticated, totally autonomous, real-world systems. Robocup is very good in the context of academic sharing of scientific elements, and of world-wide coverage. And FIRST is very elaborate and effective in opening the mind of children to the potential interest and fun of science and technology. The interest of robotics appear mainly to stem from its multidisciplinary nature and from its perceived character of novelty; from the possibility to perform hands-on education and for the participants to play many different roles in teams; and finally ludic competitions in robotics are great for research as well, because they allow the validation of some new proposed solutions as well as they make apparent new challenges to meet. Robotics deserve more education and research initiatives nowadays, in particular because it may affect many social fields, beyond science and technology; because the pervasive information systems of today need be interfaced to the physical world; and finally because robots can significantly contribute to transport locally objects and help people in private residences and individual working places.

Keywords:, Robotic competitions, Hands-on Education and Coaching. Experimental and holistic approaches, validation and definition of new areas for research.

1. INTRODUCTION

Ludic competitions are very useful for robotic education and research.

Competition is a collective behavior, which is usually found appropriate to identify and select best practices and experts. Competition is widely spread in our societies, with successes in areas as different as economics, sports, arts (e.g. music) or games (e.g. chess). Games are some kinds of models replicating some aspects of real life and society, and where rules and referees ensure that unwanted risks are kept to acceptable levels. As for games, competitions in robotics allow typically

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to push limits further (re. similar olympic goals: further, higher, faster) in an atmosphere of excellence, mutual respect and peace.

Education and research are classical activities, they have centuries of tradition at a large scale and even millennia of existence for some selected cases [1]. But maybe in the past the complexity considered and somehow manageable apparently was not as intense as what is possible today. Or the applications were segmented in smaller, more technically focused and more locally bounded domains, which made ludic technical and scientific competition of some larger span impossible ? Nevertheless things have changed with a breakthrough in the 90's (this point will be developed below in Part 2, [ref. 2-4]). After about 10 years of (strong) development, the moment has now come to sketch a particularly meaningful assessment of the interest of ludic competitions in robotic education and research; the Eurobot Workshop provides a good opportunity for it. This has already been somewhat done in the past, in a more restricted way [5] or may concern a single organization: in particular, ref. [6] reports on a thorough study, and has assessed the (very good) impact of FIRST robotic competitions on the school success and career selection of the participants. Nevertheless the authors provide here additional views, based on significant direct experience.

The paper is organized as follows: Part 2 presents the main organizations active at world-level in robotic competitions, including a flashback on their early days. Then the paper presents in three successive sections, what looks like the key ingredients for success of robotic competitions, from education and research perspectives. Part 3 discusses the multidisciplinary nature of robotics and the novelty character of associated technologies. In part 4, the benefits of hands-on education, which is central in robotic competitions as well as the diversity of roles that participants may play in teams is discussed. And finally the implication for research activities is addressed in part 5.

2. MAIN ORGANIZATIONS FOR COMPETITIONS IN ROBOTICS

The most relevant robotic competitions in the context of education and research are surely those organized under the three banners Eurobot, Robocup and FIRST. Of course beside these major organizations, many other initiatives have been led or exist in the world, and may have a high specific interest even if possibly less known, or smaller in scope. In fact even the big three organizations are themselves structured in subgroups, in smaller domains where particular constraints apply, typically in terms of nature of application, of age of participants, or of level of required expertise. They are rather diverse and each have some particular merits.

2.1 Eurobot

Eurobot [2] has made its first European, multinational, competition in 1998, in the continuation of a very successful growth in France which had already given annual national competitions since 1993. No active promotion is made outside Europe, however the competition is "Open" and many teams have come from other continents and are most welcome. Last year Eurobot finals were organized in Switzerland (Yverdon-les-Bains) and 23 countries were represented. Globally, hundreds of teams register each year, with about 200 just for France.

Figure 1. Eurobot logo

Eurobot competitions address every year a new thematic challenge, a new game with new rules. They typically provide the opportunity for students of technical schools and universities as well as

for clubs and hobbyists to be creative and to meet around a scientific and technical challenge. Restrictions and constraints are minimal in terms of possible approaches, means and strategies; they are mostly set in order to make the games safe, entertaining for participants and public as well, and to ensure an atmosphere of fair-play.

Technically, Eurobot is quite demanding, as all aspects of designing and building relatively complex autonomous systems need to be somehow addressed. About 30% of teams that register cannot pass the "homologation" test, which is meant to garantee total compliance with the rules and a minimum level of efficiency on the D-day (something like effectively scoring one goal in "soccer" game, when there is no opponent). Strict autonomy is required for robots. The rules are made in such a way that more sophisticated robots can have a chance to score well. Nevertheless, special attention is also there to make it possible for robots with moderate level of sophistication to participate. In addition, there is an explicit "random" component which is thrown into the game; this is done in order to make it also clear for occasional observers what insiders know as inevitable: when two robots face each other in real life, chance always plays a significant role in deciding of the outcome; and brute force pre-programmed solutions cannot perform very well.

Beside the main competition league, a league for Juniors ("les Trophées") is also organized, where robotic structures can be remotely controlled by humans.

You find enclosed an URL to access two short Euronews (televisual) reports for the finals 2005 [7], and another one to access a very informative and playful 6-minute video about Eurobot (this link relates to a version in English, but by the time you access to it, more of the 6 existing versions (French, German, etc.) will probably be available online [8].

2.2 Robocup

Robocup is an international initiative which originated from Japan in 1997 [3]. The strong point of Robocup is to provide a long term, motivating Vision of what humans wish to develop, in terms of intelligent artificial servants: robots capable of agile motions, excellent team work, skilled dynamic action and clever individual initiatives. To the point of defeating, by soccer rules, the team of humans who will win the World competition of soccer in 2050.

Figure 2. Robocup logo

Robocup typically involves academic people, mostly active in research. As is typical for research, attention is often focused on some singular (sub-)domains which are explored and where novelty and breakthrough are pursued. Discussions and communications are very central. Numerous leagues include those for simulation, small-sized robot, medium-sized robots, with legged systems, or humanoids. Concepts are very elaborate in some contexts (simulation, humanoid); on the contrary one league used to rely on commercial products for hardware implementation (until recently, Sony Aibo – the famous artificial dogs). Robocup events have grown to very large, and are probably the most widespread in the world.

Some people wish visible, short term benefits from Robocup initiative. To this end, rescue leagues have been created a few years ago, and this year, the Robocup-at-home league has appeared. Here autonomy is somewhat relaxed in order to improve usefulness and cooperation. The goal is to design service robots, reliable and effective, for helping humans as personal assistants.

2.3 FIRST

FIRST, For Inspiration and Recognition of Science and Technology [4], is an organization mostly active in the USA, tracing back its origin to a its first, robotic competition in 1992. Apparently more than thousand teams take part nowadays in these robotic competitions,

FIRST is organized in three leagues, FIRST Robotics Competition (FRC), FIRST Lego League (FLL) and FIRST Vex Challenge (FVC). FIRST has a strong point in education in the broad sense and for children: about 14-16 old (American high school level) for FRC and FVC, and even much younger for FLL.

Figure 3. FIRST logo

Clearly FIRST is very different from Eurobot and Robocup in terms of robotics sophistication : the rules call for mixed human and machine-based actions, teams receive standard kits of parts, the preparation lasts for about 6 weeks, Team participants are younger, have less experience and preparation, but that is OK because goals are different.. Anyway « FIRST isn't about building robots, it's about building life skills." as Steve Sanghi, Pres. & CEO, Microchip Technology tells it. And like for the other organisations, « the competitions combine the practical application of science and technology with the fun, intense energy, and excitement of a championship- sporting event. »

Among the strong points of FIRST, is the fact that occurring at a younger age, these activities have a very broad basis of potential participants, and they may influence the latter early in the choice of their education majors and carreer. The rule book of FLL also encourages the integration into these technical activities of teachers and pupils with major interest in non-technical areas, such as written and oral expression, history, geography, etc. Presentations relating to a yearly theme of competitions (in 2005: oceans and water; in 2006: nanotechnologies) may yield points and help selecting teams to national and international levels. FIRST leagues are very well organized, have a strong support (they declare 8 millions dollars of grants for 2005), and have close ties with some specific economy actors (Lego, National Instruments, etc.). FLL is already well established internationally.

2.4 Other competitions

Before closing this section, let us notice once more that beside the three mainly mentioned organizations, many other initiatives exist, which have also a lot of interest, even if they are somewhat smaller or different in scope.

For example in Japan several other organizations are active in robotic competitions (re. NHK robotic competitions, Robot-One…). In the USA, DARPA sponsored competitions for unmanned vehicles rushing for 100 miles and more on road and in the desert is another significant example. Many Universities or schools for children organize more or less formal, internal competitions (e. g. in Switzerland: Robopoly at EPFL, Lausanne, or the "Coupe des Ecoles, at Yverdon-les-Bains, Switzerland) or even some international events (e. g. Per'Ac –from Perception to Action – an international contest once held at EPFL), Other competitions stress more classical academic aspects (scientific papers, oral presentations) rather than concrete hands-on competitions; an interesting example is the Student Competition of IAF (International Astronautical Federation, [9]), currently chaired by Bénédicte Escudier, which each year at world level delivers Students awards to the best of some students often already pre-screened on a national basis (undergraduate and graduate levels).

3. MULTIDISCIPLINARITY AND NOVELTY OF ROBOTICS

Ludic competitions in robotics are interesting because robotics is a multidisciplinary field, where contributions from very different people and topics may prove useful. They also benefit from fast and visible progress in technologies and from novel methodologies.

Robotics is a multidisciplinary field. It is a wide domain including elementary components sensors, actuators, lines, connectors and skeletal structures such as plates, bolts and screws ; including also often much more general facets, such as, non-exhaustively, programming, machine vision, strategies, real-time management, "legal" negotiations, budget questions, team organization and human relationship issues. Even in its kinematic focus, multiple joints and degrees of freedom are the rule, often with non-holonomic or redundant qualities. Coordinate conversions, motion laws and dynamic considerations usually cannot be ignored.

Another key feature of robotics is also its strong novelty. Unlike classical games, such as chess or soccer, robotics have only recently reached a level allowing for effective and entertaining behavior. And with the ambitious goal to reach close-to-human skills, progress will go on, with visible increments, for years. In parallel, the world of arts (re. theater, movies, cartoons, mangas…) provides exciting scenarios on how things may develop.

4. HANDS-ON EDUCATION AND MULIPLICITY OF ROLES IN TEAMS

Ludic competitions in robotics are also interesting because they provide to the participants an opportunity to gain skills by hands-on experience. Besides, participants may play many different roles, depending on their taste and competences.

Education is found necessary for everyone in our societies and is traditionally performed during the young years by public institutions - schools. Because of the multidisciplinary nature of robotics however, and also of its rapidly changing nature, the traditional approach, in robotic education, gains a lot to be complemented with competitions. Hands-on experience adds-up to theoretical knowledge and motivates to learn more. Hands-on activities confront people to the complexity of real world, and allows them to acquire capacities to better focus on critical aspects, in technical and scientific challenges. Concrete prototypes are effective means to synchronize and coordinate the activities of multiple team members, and facilitate mutual exchanges of advices.

The scope of competition-related projects may be different, depending on participants and contexts. To name a few : role in team (specialist, coordinator, support resources , coach, etc.), implementation of new or known ideas, acquisition of knowledge, development of know-how. Usually, partners do not individually invest the same amount of time and efforts, yet so many things can be done that they each have the opportunity to contribute with their own available resources to the success of all.

5. RELEVANCE FOR RESEARCH

Finally, even though the "ludic", playful character of competitions in robotics might look to be at the opposite of serious work and scientific research, this is not the case. Like is well known for radio amateurs, the strong enthusiasm and thrust of volunteers' contributions into robotic competitions contribute to advances in research fields.

For research purpose, in all domains, exploration and experimental validation are critical operations. This helps discovering significant problems, and assessing novel proposed solutions. Robotic competitions naturally foster frontier research, where the cooperation of partners with long-term horizon, appropriate for basic research and visionary goals, meet with contributions of partners with short term interests, aware of current market-mature elements and/or of classically known problems and solutions. The specific nature of considered applications (e.g. playing golf on a 2m by 3m table, etc.) is useful, as it restricts the field of possibilities to a tractable complexity level. Usually research is performed in a very singular manner, where efforts bear on a few parameters or phenomena judged as being critical. Making the test in a robotic competition provides a useful perspective where the relevance and effectiveness of new research results can be clearly demonstrated. Very often also, new shortcomings show up, which point at meaningful new areas to explore, featuring good opportunities for further research and development.

For our case, we were surprised during the first edition of Eurobot, to see how many gaps remained in published research works, when a totally autonomous, effective robot is to be made. In particular experience of the first year led us to put in first priority the development of a good environment for efficient real-time control and fast definition of tasks and strategies by humans. This in particular has led us to the design of our "Piaget" environment, where among other aspects an old approach of Texas Instrument, for very fast multi-task implementation (memory-based context switching), is revisited, with the current benefits of pipeline processor architectures and multilevel cache memory mechanisms.

As mentioned, robotic competitions allow for a very broad assessment of state of the art and of necessary developments. To make this point more concrete, two cases will be discussed here. The first one is based on an extreme case which refers to a robotic contest held about a decade ago, and which, in large part, as already been presented [10]; nevertheless it is still very much representative; and it is commented here under new aspects for the first time in a publication. The second case relates to a competition the authors are engaged in very soon, in the context of Robocup-at-home league which is being created this year and which will hold its first, world-wide competition in June.

5.1 Three views on stacking film cans

In Per'Ac contest, the problem was to pick film cans and to store them in stacks, within one minute time. From a research perspective, two points were of strong interest for us beyond, obviously, robotic engineering: how to define an approach valid for assembly tasks in general; and how to be rigorous in cognitive domain [10].

In terms of cognition, the first move that appears necessary in such cases, is to *quantitatively* assess task requirements e. g. complexity, knowledge or expertise [e.g. 11]; independently of solution strategies. This was done and yielded some surprising results: for example even if accepting a large uncertainty of 1 mm on can position coordinates, the task featured on the order of 10 power 60 possible configurations (10 power 60 is a huge number; for comparison: 10 power 17 is the number of seconds elapsed since the so-called "big bang")!

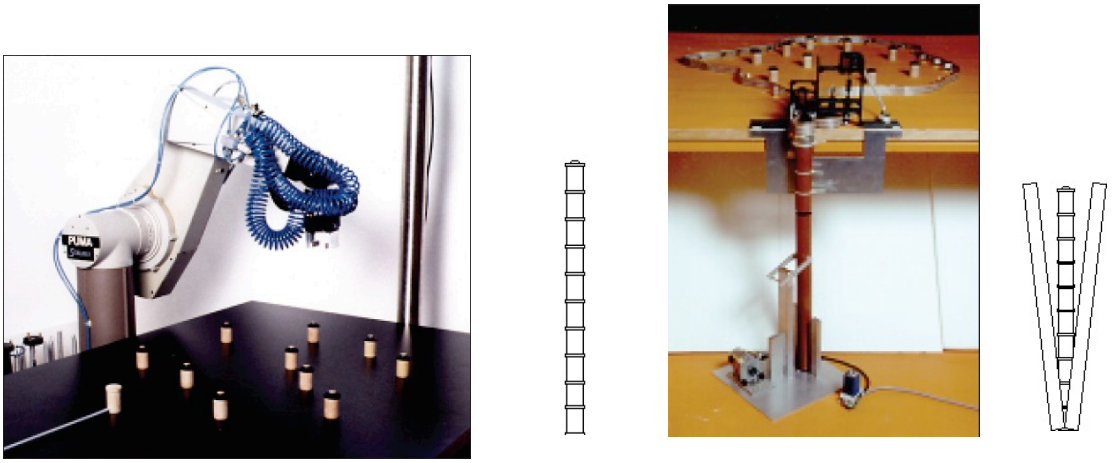

Figure 4. Two very different approaches for gathering film cans and piling them on stacks with success

Then, second move for cognition, if inherent task complexity is meaningful, then a proven solution by any system (e.g. a system of type A) should also be a strong index of feasibility for another system (e. g. a system of type B). We had chosen an industrial robot with vision as system A, and, provocatively, a system without sensor nor computer(!), as system B (notice that these two systems also represent two classes of solutions often considered opposite in industry: robotized, "flexible" solutions versus "hard" automation systems) System A was in (successful) demonstration on videos during the competition, and the system of type B was successful on the spot, and actually won the contest! (In fact the two approaches have more in common than in differences; in particular the robotic system features also some blind constraints, for example in gripper jaws, and both were implemented bottom-up, by assembling standard primitives and functions of incremental complexity: keywords of a language set, then procedures for case A; nuts, bolts and, for a large fraction, standard structures of a universal assembly kit of parts, then subgroups, in case B. Time and resources allocated were similar, as well as numerous "high-tech" aspects, in both cases.)

Furthermore, we can now be reasonably confident that the theory holds, and that if we had adopted yet a third technology, e. g. namely mobile robotics a solution would also have been found, with similar investment and success. In fact another team participating in the competition could pile more or less successfully 3 or 4 cans, with a group of three quasi-autonomous mobile robots.

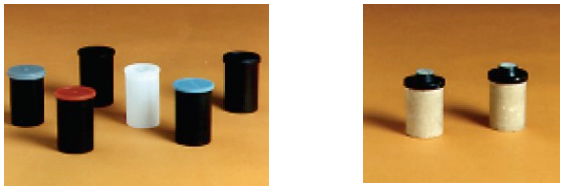

Figure 5. What is a film can? Re. real film cans (left) and "typical" can for competition purpose (right)

Another result of our work in cognition theory had pointed to the fact that reality is always infinitely complex and that in facts and practice we can only cope with very incomplete models. That contest could provide a very striking example of how true the general assertion can be. Here as well: in order to prepare the competition teams had to be told very specifically what is a film can: is it, in particular, a box made of black plastic, or of aluminiun, with cover of size S, etc.? On the

market there exists a huge variety of can types and for assembly purpose many parameters may turn out to be critical depending on strategies… Finally THE can definition was provided by the organizing committee as a sample; it was in wood, with a truncated cone on top, a ring painted in black; and, in the base, a hole matching the shape of the cone had been bored… It was not hollow however, and could not actually contain a film!!!

5.2 Follow a human

"Follow a Human" is one of the three main tests defined for the first Robocup-at-Home competition, to be organized next June in Bremen (i.e. in 2006) [12,13]. Here again, a concrete example is shown of how competition and research may interact, in the context of robotics.

In fact the test is not isolated, and beside predefined tests an "open challenge" is also on the program. Moreover for the test itself, two points of view which may be quite different can/must be adopted: proof of concept, and applicability. Thus invitation is made to consider issues possibly broader than just directly required by the official, specific test.

The main point of the test is to have a robot follow a human walking in a domestic environment, at a distance of at most 2 meters, with a "reasonable " speed (not less than about 1 m per 10 second).

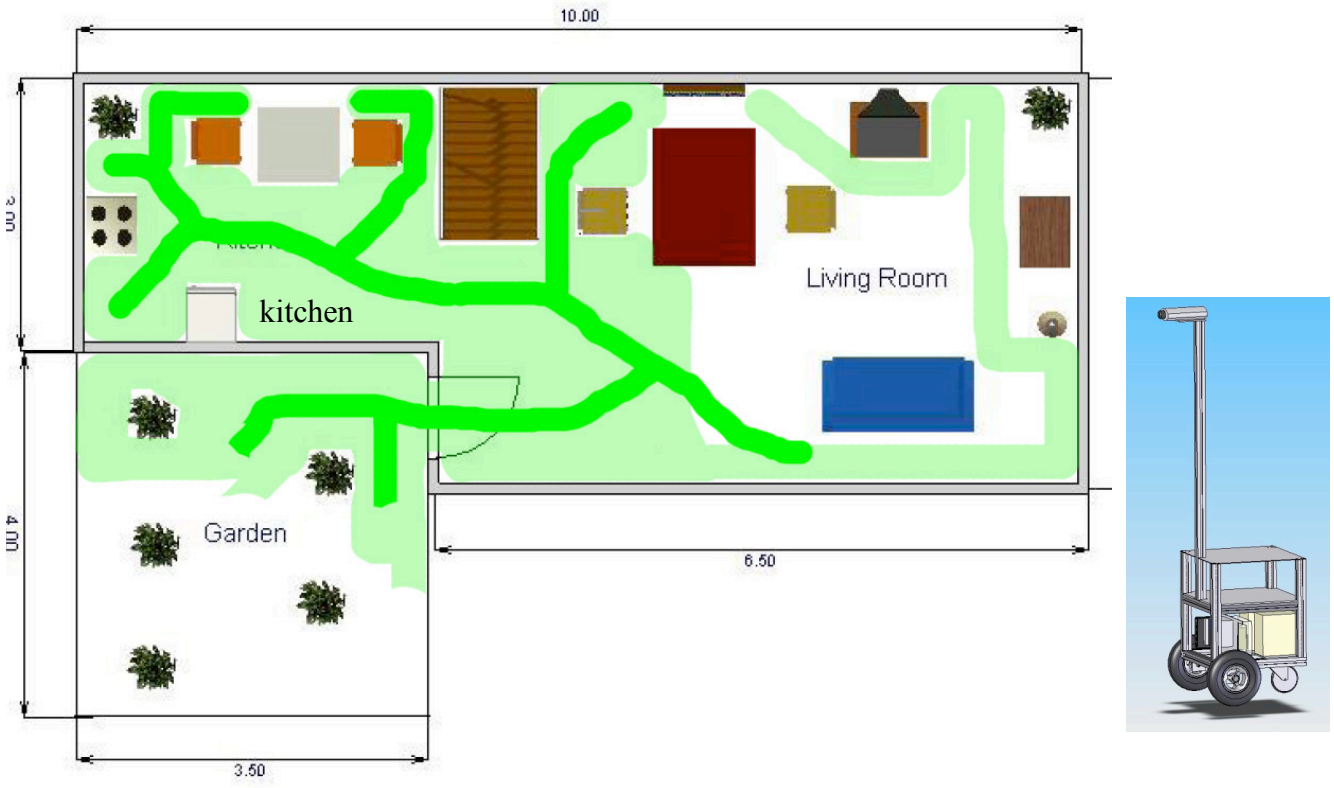

Figure 6. Map of home with visited areas and "skeletal" paths (left) and early view of RH1-Y robot

While autonomous robots have already been developed in various other contexts, the specific elements of the rules make some new territories appear, very meaningful for research. Path management has to be revisited, this time as defined in real time by a moving target, along a path avoiding obstacles[14]. Keeping track of robot motions on a map make areas frequently visited look

like “thick” and irregularly shaped contours, similar to what edge-extraction yields in non-boolean images. Thus it would be most interesting to explore how image processing methods developed for getting the skeletons of contours could be applied on the map in order to yield the “best path”, well centered between obstacles; this looks like a robust and simple way of learning good paths in rooms and homes, resulting from experience [15].

Another area which would be attractive is the assessment of very novel 3D cameras, which directly deliver a depth picture rather than light intensities [16]. Another direction worth to explore, that Robocup-at-home unveils, is now, beyond world-level vocal interaction, how to behave in a “correct”, socially well-accepted fashion (how to call people attention, respond to it, present oneself and one’s references to some one else, and reciprocally). For a robot, research work tends to require to make all this explicit, and in return offers the possibility to make models operational: robots will be able to mimick and implement various social behaviors which in turn may lead to conclusions useful for some behaviors among humans…

6. CONCLUSION

Robotic contests, in friendly and playful atmosphere, have taken a real importance during the last decade. Evidence is made, in this context, of the best performing solutions. Rules of life may be mapped in the game, but this is done with a certain care in order to prevent anyone one from getting seriously injured. At world level, three institutions deserve a special attention, when we consider ludic, robotic competitions. FIRST is an important organization, mostly American, with several leagues, aiming at letting children and young teenagers discover with fun the nice aspects of technology and sciences. One of the leagues makes a big use of Lego bricks and computerized elements and is more international. Robocup is another organization active worldwide, providing a powerful vision over the next decades, in the field of intelligent, agile, cooperating and dynamic robots; in the fashion of a human playing soccer. It is more focused on academic world and research, even though some leagues, like Rescue and especially “robocup-at-home” have more pragmatic, short-term applicability concerns as well. Eurobot overlaps with both worlds, with a league for Juniors, and besides, the main league, dealing with very effective robots, fully autonomous. Within Eurobot, expertise among participants vary on a broad spectrum, yet the rating of the players is very much factual, objective, as is the case for most sports, which clearly favors applicability features,

Robotics is good domain for “large-scale” technical and scientific competitions, for several reasons developed above: multidisciplinary content, character of novelty widely recognized, ease and fun of related hands-on experiments, large variety of possible contributions and charges to assume in teams, and finally, relating to research, for the validation of novel approaches and the identification of neighboring technical and scientific areas to explore.

In conclusion, let us stress that robotics deserve more education and research initiatives nowadays, in particular for the following reasons: the field has far reaching effects on numerous segments of society (re. beside technology and science, the worlds of toys, arts and generally speaking, entertainment); information world is ubiquitous but immaterial and robotics interconnects it with the physical world; finally let us mention that robotics should provide more personal assistance such as local transportation possibilities and help for handling in private environments.

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