STUDENT *design contests* PROMOTE HANDS-ON *learning* AND *innovation* IN *precision* AGRICULTURE

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Abstract

Student numbers in Agricultural Engineering are decreasing. The high-tech approach of Precision Agriculture with its strong involvement of Information Technology is certain to improve the public image of Agricultural Engineering and to attract the interest of high school students. Hence, Wageningen University and Research Centre (The Netherlands) is organizing a two days field robot event. The combination of a student design contest and a scientific fair generates high academic, agricultural and publicity value.

Keywords: field robot, design contest, education, students

Introduction

As a global trend in Europe and the U.S.A., student numbers in Agricultural Engineering are decreasing in spite of a good job market for graduates. Technically oriented high school students prefer studies that are more related to high-tech disciplines and Information Technology. Precision Agriculture includes both aspects and offers a good opportunity to attract more students. Especially the combination of "serious" and "playful" aspects of robotics are appealing to the upcoming student generation. Therefore, Wageningen University and Research Centre (WageningenUR) is organizing a field robot event, including a student design contest as well as a scientific fair.

The objectives of the WageningenUR Field Robot Event are:

- Improving the public image of Agricultural Engineering
- Attracting interest of high school students for Agricultural Engineering
- Creating a platform for exchange of knowledge on field robots
- Harnessing students creativity to promote the development of field robots
- Promoting off-curriculum skills like communication, teamwork, time management and fundraising

Materials and Methods

The WageningenUR Field Robot Event is composed of various academic, scientific and publicity elements (Figure 1). The pedagogic elements are derived from the design competition of the Massachusetts Institute of Technology (MIT). As design object, field robots have been chosen, i.e. the scientific element is originated in precision agriculture. Publicity elements such as open-air atmosphere and agricultural context are in common with events such as tractor pulling. These elements will be explained in more detail.

MIT 6.270: academic archetype of the WageningenUR Field Robot Event

At the Massachusetts Institute of Technology, design projects based on Papert and Harel's (1991) educational theory of constructionism have a two decade tradition. According to the theory of learning-by-creating, people learn most effectively when they create an external artefact in the world and therefore have to develop new ideas without being obstructed by existing solutions.

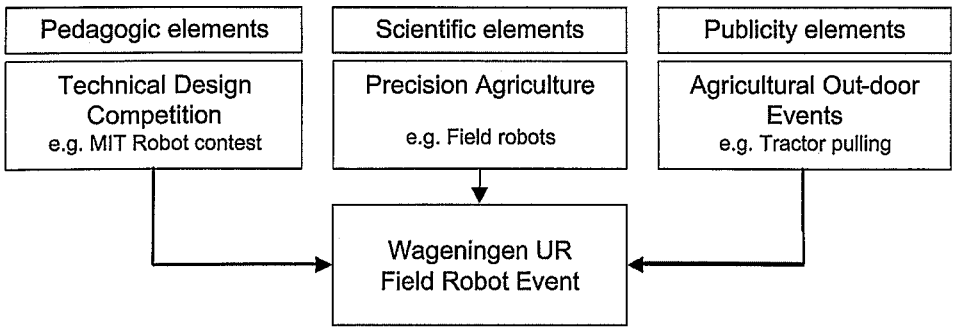


Figure 1. Academic, scientific and publicity elements of the WageningenUR Field Robot Event.

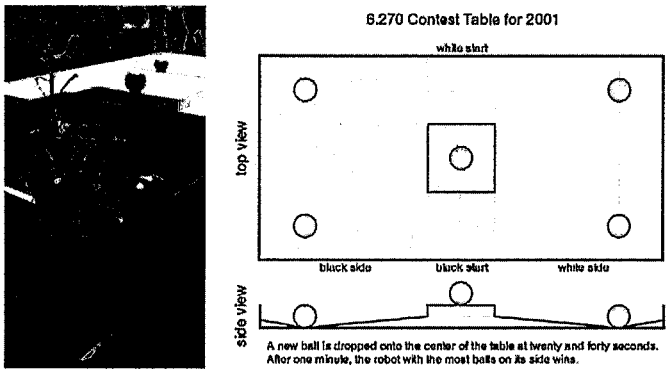


Figure 2: Playground of the 6.270 MIT's Autonomous Robot Design Competition 2001 "Master of the Universe" (Anon, 2003).

One of such design projects with course number 6.270 started in 1987 as a programming competition in which students wrote computer games simulating robots that tried to find and destroy other robots. Two years later, the course was developed to a hands-on class where students designed and built a real robot that played in a competition at the end of the course. The students worked in teams of two or three. Each team was given the same kit containing various sensors, electronic components, batteries, motors, and LEGO. The kits were handed out three weeks before the competition. The objective for the students was to design an autonomous machine that would be able to navigate its way around the playground, recognize opponents, and manipulate game objects without human interference. Teachers of 6.270 found, that students *"...can learn everything they need to know by working with each other, being introduced to some material in class and, mostly, by hacking on their robots"* (Anon, 2003).

The game idea and playground are developed afresh every year. Figure 2 shows as example the playground of the contest in 2001 together with a robot in action. Meanwhile, the MIT competition became very popular and similar competitions have been organized worldwide at many technical universities. Winning teams are sent to a final international contest.

Field robots: scientific object of the WageningenUR Field Robot Event

Technologies in Precision Agriculture concerning GPS-navigation and sensor systems have now reached a stage which seems to make autonomous vehicles for open field operations a realistic option. Recently, the number of research groups presenting their field robots at congresses or in scientific journals has been increasing. The field robots can be classified into auto steering tractors, super-canopy robots and sub-canopy robots. Examples are presented in Table 1.

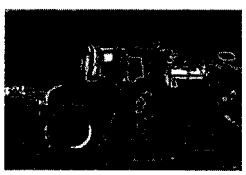
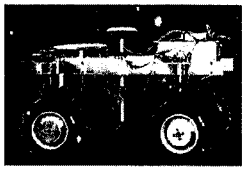
Auto steering tractors are based on conventional tractors that are equipped with high quality GPS-navigation systems and various sensors to keep track on a programmed path without the intervention of a driver. Super-canopy robots are autonomous vehicles without driver cabin. These platforms are smaller than conventional tractors, navigating on a programmed path or along the plant rows with the help of sensors. Super-canopy robots straddle one or more plant rows, riding over the crop canopy. Sub-canopy robots are small enough to move in-between the plant rows, i.e. below the crop canopy. High quality GPS receivers are presently still too heavy for sub-canopy robots; navigation is based on machine vision or other sensor systems.

Results

The Wageningen UR Field Robot Event combines academic, scientific and publicity elements, inviting university teams European-wide to contribute to a two days inter-campus event on autonomous vehicles in agriculture, see Figure 3.

A student design contest comparable to the MIT's Autonomous Robot Design Competition is integral part of

Table 1. Examples for different types of field robots

Auto Steering Tractors		Auto Steering Tractors are based on conventional tractors but equipped with navigation systems and other sensors. Example: Cemagref, LASMEA, France (Thuilot et al., 2002)
Super-Canopy Robots		Super-canopy robots are small platforms, which are straddling one or more rows and surmounting the crop canopy. Example: Technical University of Denmark (Madsen et al., 2002)
Sub-Canopy Robots		Sub-canopy robots are small enough to move in-between the plant rows. Example: Wageningen University, The Netherlands (Claessens et al., 2002)

the event. Instead of developing new robot playgrounds every year, as practiced in the MIT contest, a challenging playground is provided by the natural degree of non-uniformity of a maize field. Navigating in the plant rows, turning at the headland and treating obstacles are program disciplines. Scouting capabilities are performed in freestyle and rated by an expert jury. In contrast to the MIT contest, there is plenty of time to design a robot during spare time and the choice of components is not limited to a standard kit. This allows unhampered creativity of the participants. In return, the jury assesses the hardware costs of the robot, based on the bill of material, admitting economy to an additional selection criterion. By accepting freestyle robots that are built at the home universities, the contribution of non-student resource persons cannot be ruled out. This is not a disadvantage but an increase of value, because identifying and motivating resource persons as well as fund-raising are skills which students are also learning from the project. Furthermore, the system is more promoting the spirit of university competition than individual competition, turning loose additional resources and creative energy. Parallel to the student teams, research teams are also invited to demonstrate the performance of their autonomous agricultural vehicles in the contest, participating in a separate, professional class.

All student and researcher robots are presented together with posters and additional information material in a Field Robot fair that fills half a day of the program. The fair is forming the scientific platform of the event, showing the state of the art in agricultural field robotics and promoting the exchange of knowledge amongst researchers and students. Taking into consideration the creativity, curiosity and IT-skills of the e-generation, the flow of knowledge between scientists and students is not limited to a one-way direction, inspiring the idea of the university as *universitas magistrorum et scholarium*.
The Field Robot fair is not only a scientific platform but also a market place for innovative companies in agrotechnology, to demonstrate advances in mechatronics and to recruit high-potential students for their R&D-departments. As the invitations for the event are sent to all relevant university departments in Europe, company sponsoring is expected to pay off well.

Finally, using a maize field as playground offers not only a real-world scenario in terms of weather, plant and soil condition but also creates an agricultural open-air atmosphere, attracting additional visitors from the surrounding. Media reports about the event are reflecting an innovative high-tech image of education in Agricultural Engineering and attract potential first-year students.

Discussion

In Figure 4 the WageningenUR Field Robot Event is ranked according to its academic, agricultural and publicity value in comparison to tractor pulling, scientific congresses on field robots and the MIT's Autonomous Robot Design Competition.

The MIT's Autonomous Robot Design Competition as prime example of constructionism is of high academic value. Also the publicity value is high due to the standard rules and the high worldwide popularity. However, the MIT's Autonomous Robot Design Competition is an indoor event, focused on mechanical engineering and therefore the agricultural value is low. Tractor pulling events have developed to sport-spectacles with high publicity and professional teams. The reference to its agricultural origin is decreasing. Apart from special tractor pullings like the ASAE Quarter Scale Tractor Competition for students, the academic value of typical tractor pulling events is low. Field robot sections in scientific congresses are innovation motors for Precision Agriculture and hence of high agricultural value. There is a medium academic value for students who are visiting such

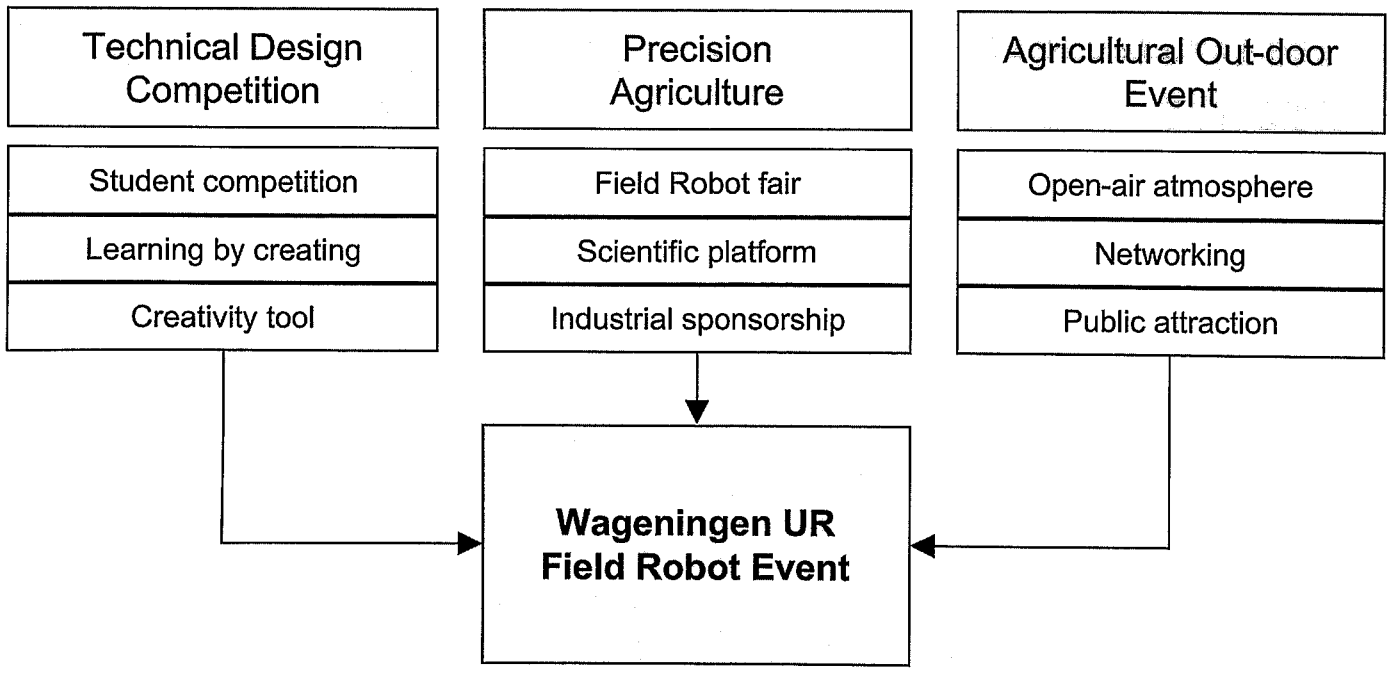


Figure 3: Composition of the WageningenUR Field Robot Event

congresses. The pedagogic value increases if students are enabled to contribute to the program. Field robot sections are focusing on circles of experts; therefore the publicity value is low. Combining elements of the events mentioned, the WageningenUR Field Robot Event is ranking high in the three chosen scales: letting the students create own field robots is of high academic value that is increased by meeting leading researchers during the event. As the WageningenUR Field Robot Event is focusing on field robots and includes also a Field Robot fair the agricultural value is also scoring high. Being the first event of this kind, the publicity value of the WageningenUR Field Robot Event is still medium, but could increase if expanded into an annual or biannual event.

Conclusions

Due to the quickly growing knowledge in navigation and machine vision, various groups of scientists are working on the development of autonomous vehicles for precision agriculture. Most of these activities are based on national research projects that are not linked on an international level. A competition of such field robots is a welcome occasion for the researchers to get together in a sportsmanlike atmosphere for personal exchange of knowledge and a unique opportunity for the audience to see a variety of autonomous vehicles at work. Opening the competition for student teams gives a fresh impulse of creativity in Agricultural Engineering. Furthermore, hands-on learning by designing own field robots is a strong motivation for students, also addressing off-curriculum skills like communication, leadership, teamwork and fundraising. The publicity effect of such contests might increase the interest of high school students to get involved into the subject. Like the MIT's Autonomous Robot Design Competition, the WageningenUR Field Robot Event should become an annual or biennial event and the design process should be embedded in the curriculum according to the educational theory of constructionism. Due to the high costs of the required components, periodical sponsorship will be required in the long run. With respect to the growing mechatronic market and its need of skilled and innovative employees, companies would benefit from sponsoring such student design contests.

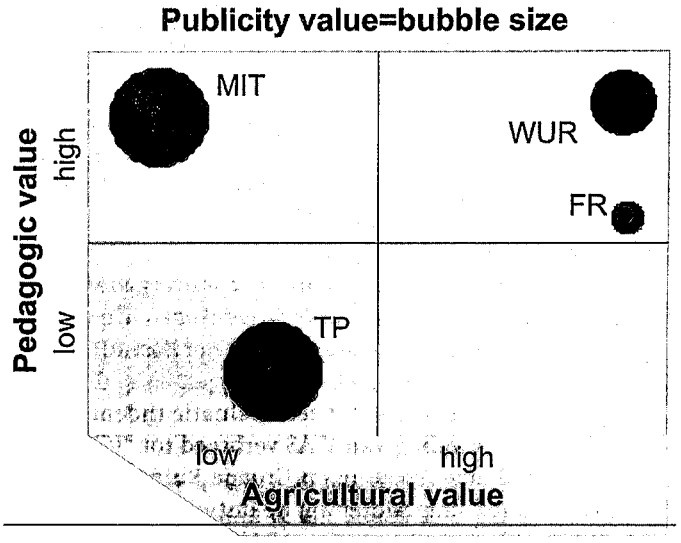


Figure 4. Portfolio of agricultural, academic and publicity value of events such as tractor pulling (TP), scientific congresses on field robots (FR), MIT's Autonomous Robot Design Competition (MIT) and WageningenUR Field Robot Event (WUR)

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