

# TechUnited Team Description

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**Abstract.** TechUnited is the Robocup midsize league team of Eindhoven and Delft Universities of Technology. It is a carrier project for research streams on mechatronics, computer vision, software architecture and engineering, and sensing and planning. In addition, its industrial complexity makes the project a case study for researching processes and practices of integrated high-tech systems development projects. The team is set up mid 2005, with the ambitious goal of competing in the 2006 Robocup World Championships. Reuse of the knowledge of the former Dutch Robocup team Clockwork Orange plays a key role in this strategy.

## 1 Introduction

TechUnited is the Robocup midsize league team of Eindhoven and Delft Universities of Technology. It is a carrier project for research streams on mechatronics, computer vision, software architecture and engineering, and sensing and planning. The project is a cooperation of the Eindhoven departments of Mechanical Engineering, Electrical Engineering, Mathematics & Computer Science, and Applied Sciences from Delft.

Clockwork Orange was the first Dutch RoboSoccer Team, a collaboration of the Delft University of Technology, the Utrecht University and the University of Amsterdam. The team played in the mid-size RoboCup league from 1999 until 2004. The research was continued in Delft, with special focus on the robot vision algorithms and the behavior modules. This was the starting point for TechUnited in 2005.

The team is set up mid 2005, with the ambitious goal of competing in the 2006 Robocup World Championships. This team description is prepared based on the status of TechUnited in January 2006, as part of the Qualification package for the World Championships 2006 in Bremen. As research and developments are ongoing in the team, many individual modules or techniques may change over time.

## 2 Mechatronics: the TURTLE platform

At the start of the project, the team decided to develop its own robotics platform, the so-called TURTLE (short for TechUnited Robocup Team - Limited Edition). Analysis of the requirements for the Robocup mid-size league showed that a design was required with the mixed capabilities of high speed and flexibility as well as robustness. A closed-box, triangular platform with three omniwheels is built. Motion control is based on encoder feedback as well as independent optical tracking sensors.

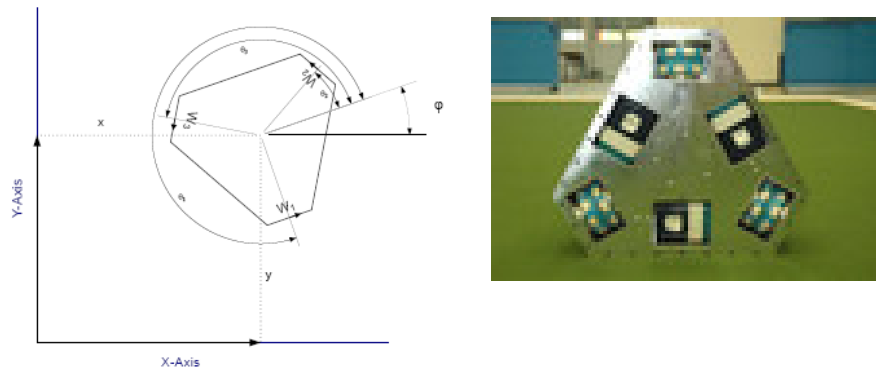


Figure 1. Schematic layout and picture of the TURTLE platform

This TURTLE platform has also been modeled in the Open Dynamics Environment for modeling (ODE) [1], for the purpose of learning more complex behavior in simulation mode and then packaging this into behaviors for use on the real robots.

On top of this platform, a kicking and ball-handling mechanism is mounted. The current kicker is based on a controlled valve-operated air pressure tank. The kicking mechanism is supported by a ball handling set-up that allows catching a ball passed to the robot and keeping a ball close, within the limits as specified in the Robocup rules.

## 3 Vision

In the first version of the robot, the proven concept of omnidirectional vision is incorporated, according to the image pipeline as in figure 2.

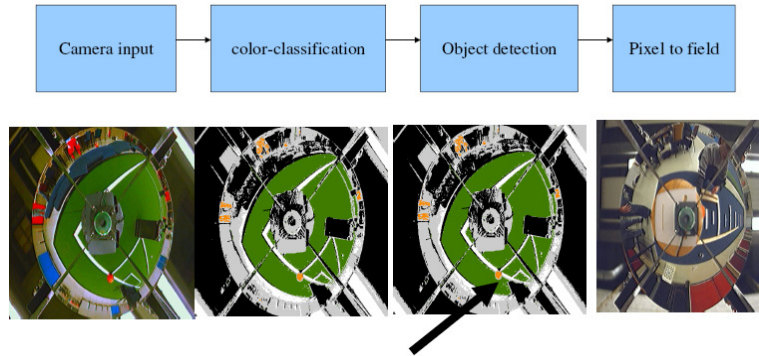


Figure 2. Vision pipeline with image examples.

The color classification is done in the YUV space, based a lookup table, that is filled with dedicated calibration utility. Object detection is then performed with a guided grid search for specific color labels, followed by a blob-growing algorithm to detect object size. In the current set-up, this allows real-time ball-tracking.

For future addition to the omnivision system, a stereo-camera set-up is being researched, with which stereo-images can already be captured. Based on these images, a 3D object detection algorithm can be used to improve the ability of the robots to view forward as humanoids.

## 4 Software

The software architecture for all robots is the same (see figure 3).

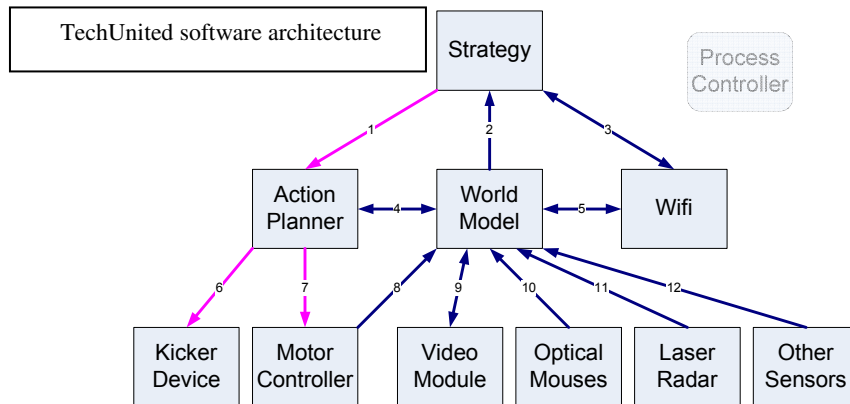


Figure 3: Overview of the main TechUnited building blocks

The Strategy Module decides about the role of the current robot in the game. Although the global role of a robot can be fixed in the beginning of the game, this role should be locally and temporarily changed depending on the game situation (e.g. if the goal keeper fails another team member should take its position). The new role is negotiated via a specific protocol. The World Model module maintains the information collected and interpreted by the sensors from the real world (position of objects, speed/direction of objects). This is separated into a local world view per robot and a global world view (synchronizing the robots local world views across the Wifi network).

The Action Planner module implements specific actions of the robot, based on strategic input. These Actions (such as Throw-in Ball, Dribble to Goal, Pass to Player  $x$ ) are programmed either explicitly through an algorithm or a finite-state machine, or are learnt in the ODE simulation environment.

A key component inside the Action Planner is concerned with path planning, in which smooth trajectory planning with moving obstacle avoidance has been implemented. We use an algorithm which is computationally cheap and generates a sub-optimal smooth path with bounds on the allowed velocity, acceleration and jerk. It outperforms potential field algorithms regarding convergence and optimality. Furthermore, it is able to adapt fast in a changing environment in contrast with computational expensive methods, such as wavefront algorithms and global optimization methods, which target at finding an optimal path in some sense.

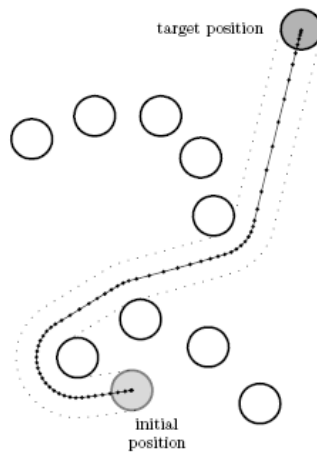


Figure 4. Smooth trajectory planning algorithm example: 9 obstacles in 2 groups.

The video, optical mouse, laser, and other sensors modules implement the interface logic to the specific sensors. The kicker device and motor controller interface do the same for the actuators.

The Process Controller is an orthogonal and independent software module, responsible for correctly implementing the software execution model. It monitors the process and thread structure in which all other modules operate, based on a heartbeat protocol. In addition, it implements the software startup, shutdown, and graceful degradation behavior. The software runs on a Real-time Linux distribution on a standard small-size notebook, and communicates with the sensors and actuators through standard PC interfaces (USB, IEEE1394). Own developments in software infrastructure include improved real-time components for USB as well as the architectural framework for the Process Controller.

As parts of the software have been implemented in a high-level modeling environment (Matlab), other parts are existing software in C and C++, and some behaviors are learnt in a simulation environment, the software architecture integrates these different technologies reliably without system performance impact.

## 5 Integrated development

A key research theme in the project relates to the organizational and process aspects of complex multidisciplinary systems, such as a team of autonomous robots. A project approach has been chosen in which a relatively large and mixed team of specialists cooperates across discipline boundaries such as mechanics, electronics, software, mathematics, and management, across multiple geographical locations.

The process approach to communication of technical and non-technical information is based on internet techniques combined with shared meetings and locations. Much attention has been spend on goal alignment and on balancing system design choices. Regarding these choices, a proper balance between gathering more options and gathering more details per option was needed to prevent project speed requirements to compromise the results. Further research on the applicability of system design methods is currently planned.

## 6 Conclusion

As a new entrant in the Robocup community, TechUnited will have to proof the success of its approach to robot soccer. Promising intermediate results show that the proper mix of reusing existing experience and software, off-the-shelf components, and new developments can lead to competitive advantage.

Technological research streams embedded in this project include stereovision, learning, software architecture and technology, embedded motion control, and localization, planning, and sensor fusion. Further, the project is an excellent case study for researching processes and practices of integrated high-tech systems development projects.

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