ASML Robo Team
Team Description Paper 2014

ASML RoboCup Team
Alexandrios Mathew, Andani Osuman, Andre Pool, Christiaan Bakker, Dave Trienekens, Evangelos Iliadis, Gerardo Santiago Flores, Giovanna de Simone, Gozde Toral, Herman Marquart, Ivo Matthijssen, Jaap Vos, Jan Feitsma, Jelm Franse, Jeroen Sluijter, Krzysztof Labinowicz, Levente Safrany, Lex Coenen, Ludovico Verducci, Lukasz Sosniak, Mathijs Brands, Mike Hoogstraten, Mojtaba Sabeghi, Naveed Abbasi, Prakash Hireraddi, Raf van Son, Ranadeep Pal, Roel Merry, Ronald van der Weide, Ruben Poorters, Sean Duffy, Simon van den Boom, Stan Mertens, Taiyebi Daghigh, Tim Kouters

February 2014
Table of Contents

Background on ASML..................................................................................................................3
Roadmap and ambition..................................................................................................................3
Motivation for participation in the Mid-Size League..................................................................4
Infrastructure development & cooperation with other teams .....................................................4
Turtle 5k robots ............................................................................................................................5
  Mechanical design.......................................................................................................................5
  Electrical design.........................................................................................................................7
    Battery supply (accu).................................................................................................................7
    Internal Voltage distribution.................................................................................................7
    Drive motors............................................................................................................................7
    Ball handling motors.............................................................................................................7
    PC.............................................................................................................................................8
  I/O Module.................................................................................................................................8
  WLAN..........................................................................................................................................8
  Compass sensor..........................................................................................................................8
Keepers..........................................................................................................................................9
  Kicker..........................................................................................................................................9
  Emergency off............................................................................................................................8
  Software design..........................................................................................................................8
Improvements Turtle 5k for RoboCup 2014 ..............................................................................9
Keeper..........................................................................................................................................9
Conclusion.....................................................................................................................................10
Background on ASML

ASML develops, manufactures and markets Semiconductor Lithography equipment and equipment to evaluate the results of these machines (Metrology equipment). The company will exist 30 years in 2014. It has grown from an internal Philips Electronics department into a publicly listed company with an annual turnover of more than 5 billion euro and more than 12,000 employees worldwide.

The ASML equipment enables the roadmap of the Semiconductor Industry (Moore’s Law) by offering ever more precise and faster equipment, allowing the overlay of layers in semiconductor devices to be stacked to nanometer accuracy and to be produced at high speeds.

To realize this, ASML has built up world class competences in mechatronics, optics, thermal control, vacuum technology, materials science and many other fields of science and engineering, organized in its 3000 FTE development sector.

Roadmap and ambition

The ASML initiative to participate in RoboCup started after the 2013 World Championships in Eindhoven as an initiative of the authors of this paper. The initiative is supported by the ASML top management as it:

1) Stimulates employee development and interaction in a multi-disciplinary and multi-sector environment.
2) Enables interaction and knowledge sharing with top robotics universities and companies.
3) Contributes to technology promotion.
4) Is a thrilling and fun team experience.

The ambition and roadmap of the ASML RoboCup team is depicted in Figure 1 and consists of three phases:

1) Buy “Turtle 5k” robots, start playing and learning and participate in the Middle Size League world championships in Brazil 2014
2) Develop modular improvements on the “Turtle 5k” robots to participate in RoboCup 2015.
3) In parallel, develop an “ASML platform” to participate in RoboCup 2016.

![Figure 1 Roadmap and ambition ASML RoboCup team](image-url)
Motivation for participation in the Mid-Size League

The various leagues were carefully considered, and the mid-size league was preferred in the end for the following reasons.

1) It offers possibilities for both hardware and software development (multi-disciplinary challenge).
2) Competition and team play at a high performance level. The MSL games are very dynamic, which stimulates team spirit and has a large fun component.
3) The basic rules of the game stay nearly the same year on year so platform development using a system engineering approach is possible.

Infrastructure development & cooperation with other teams

ASML is preparing a dedicated location for the RoboCup team where a full size MSL soccer field will be realized (Fig 2).

Figure 2 Venue ASML Robo Team

The intention of ASML is to co-operate with other teams as much as possible on non-competitive aspects (there are 4 existing and starting Dutch MSL RoboCup teams). We are discussing with two teams that are in the startup phase to give them access to the ASML facility to stimulate knowledge exchange and cooperation. ASML will also organize local development and practice events with the teams throughout the year. Already an intensive collaboration between the ASML team, the “Turtle 5k” team and Tech United has started.
Turtle 5k robots

After the 2012 world championship, a consortium of Dutch companies (ACE, VEDS, Frencken) started to work with Tech United to develop a low cost version of the 2012 Tech United robots (target price point was 5 k€). A prototype of this robot was available at the world championship in 2013 and is shown in Fig 3.

Figure 3 Turtle 5k prototype at RoboCup 2013 in Eindhoven

To enable a quick participation in RoboCup ASML has bought 6 “Turtle 5k” robots. In the sections below the mechanical, electronic and software design of the “Turtle 5k” robots is described.

Mechanical design

Figure 4 Overview of all turtle 5k modules
The supporting frame of the robot consists of a 6mm thick steel baseplate on which an aluminum frame is bolted. Sheet metal parts are used to reduce costs and milling time. The covers of the robot are made of 3mm aluminum sheets.

The Turtle 5k uses 3 separate motors that drive 3 omni-wheels which allow the robot to move freely in any direction.

The ball handling mechanism consists of 2 rotating aluminum arms; each of them has one actively driven wheel. They are driven by 2 Maxon motors via a gearbox. Two springs will make sure the wheels keep in touch with the ball.

Working principle:
1. The Turtle 5k moves towards the ball while the active wheels are spinning.
2. The Ball makes contact with at least 1 active wheel.
3. The wheel spins the ball in such a way that moves to the center of the robot and makes contact with the 2nd wheel.
4. Now the ball gets pulled inside the Turtle 5k until it touches the passive wheels.
5. While the robot is moving, the active wheels spin the ball in a certain way so it follows the robots movement.

The shooting mechanism is powered by a solenoid. It pushes a kicker with a high speed against the ball. The kicker is adjustable in height to shoot lob shots. This is done by a stepper motor which drives the arm to lift the kicker.
Electrical design

The Turtle 5k robot design contains the following components

**Battery supply (accu)**
2x Makita Ni-MH (BH2433) batteries
- Type: Ni-MH
- Weight: 1.473 kg (per battery)
- Capacity: 3.3 Ah
- Voltage: 24 V

**Internal Voltage distribution**
Internal voltage distribution will be done using DC-DC converters. These converters will make the necessary 24 Vdc, 5 Vdc for onboard clients and a high voltage >450 Vdc used for the kicker.
All power circuits are over-current protected by the fuse box.

**Motor Specifications**

**Drive motors**
3x Maxon DCX35L GB KL 12V with planetary gear. Driving Omni Directional wheels. Powered by 3x custom 5K_DC_drive power motor drivers. Communication with other boards by RS422 Interface.

**Ball handling motors**

*Ball receivers*
2x Maxon RE 25 24 V 20 W with 5:1 wormbox and Encoder: DC-Tacho DCT 22. Powered by 3x 5K_DC_drive power motor drivers

*Ball kicking hinge* (used for kick height adjustment)
Stepper motor with stepper motor driver.
Computer and communication

PC
Mini ITX Socket 1155 pc. I5-3570 Processor.
4GB DDR Memory
With additional serial card.

I/O Module
Custom I/O Module boards. 8x Analog input, 8x Digital input, 13x Digital output.
Communication with other boards by RS422 Interface.

WLAN
Usb wifi dongle @ 2.4Ghz

Vision
The robot will use an Omni vision system. Therefor a HD webcam will point into a nail mirror. This gives the possibility to have 360° vision.

Compass sensor
The robot contains an electronic compass that helps giving information on field location. This will be primarily used to keep friendly goal side from opponent’s goal side.
The compass is communicating with the PC via USB interface.

Kicker
The kicker is powered by a 500 V; 4700 µF Electrolytic capacitor. This capacitor has a low ESR. Therefore it can be discharged very fast into the kicker solenoid.
The capacitor will be charged over 450 Vdc, this is done by the shoot driver board.
The switching is provided by a Power IGBT that is capable driving the high current.

Emergency off
The robot contains an emergency stop circuit. This will disable all motor drivers and discharge the shooting capacitor.

Software design
As mentioned before, the ASML robot is developed from the commercially Turtle5k, which is based on the 2012 world champion TURTLE of Tech United Eindhoven. To cut down costs and to make the project Open-Source, it has been decided to make use of the Robot Operating System (ROS) software. This resulted in a complete reconstruction of the software. The software architecture overview is represented in Figure 7.

![Figure 7: Software architecture](image)
The software architecture can roughly be divided into Vision, World Model, Strategy and Motion. The vision package of the software comprises of two main nodes that perform ball/obstacle detection and localization. The vision package communicates with the Robot to receive input from the camera and motor controllers. With the information gathered in the vision package, a world model is created.

In the strategy package information from the world model is used to determine an action plan. This action plan is communicated to nodes that define motion: path planning, driving, shooting and ball handling. Together these nodes perform the predefined action plan.

**Improvements Turtle 5k for RoboCup 2014**

ASML development and engineering has world class competences in areas highly relevant for the development of soccer robots toward the ultimate RoboCup goals:

- Mechanics
- Mechatronics
- Power and signal Electronics
- Sensors & Optical systems
- Software for functional and diagnostics development

The ASML team will use these technical competences and also the specific ASML way of working (concurrent engineering, functional decomposition and requirements engineering) to develop improvements for the “Turtle 5k” robots.

**Keeper**

For the keeper we designed a frame that will hold all the keeper functionality, including the actuators and controlling components for the moving frame. In this way we only need a few mechanical and one electrical interface on a regular field player. This will allow us to quickly convert a field player to a fully functional keeper if it’s needed. The assembly consists of 1 static frame and 3 moving sections which all can be actuated separately. The actuation will be done via 3 separate solenoids.

Figure 8 Keeper frame
Conclusion

With the “Turtle 5k” robots and the improvements as described in this paper, the ASML RoboCup team is working hard to participate in RoboCup 2014 in less than a year after the team formation.

Towards the future, modular improvements and the development of a new platform are foreseen to further stimulate the multi-disciplinary robotics development and the interaction with the RoboCup community.