Fumanoids
The soccer playing humanoid robots of
Freie Universität Berlin
Dear reader,

Robots are in everyone's minds nowadays. In science fiction movies and books they are shown to be powerful machines, capable of extraordinary deeds. Although we're not quite there yet, researchers are working to realize the dream of intelligent machines that will assist us in our lives and make the world a better place. Robots are an inherent part of the technical evolution we will experience in the near future.

In RoboCup, where teams of autonomous robots play soccer against each other, universities all over the world are trying to tackle the core problems at the heart of robotic research. The game of soccer poses an extreme challenge for today's robots: stable walking, perceiving the world visually, interacting with a highly dynamic environment and cooperating with other robots are all problems that have yet to be fully solved. Solutions for these problems are not only necessary to play soccer, but are also essential in many other areas: e.g. household aids for senior citizens, rescue operations in dangerous environments or autonomous vehicles.

With its research, our team is not only making an active contribution to the creation of current and future robot generations, but is helping to solve societal challenges, too.

The FUmanoids team
Who We Are

The FUmanoids are a student-based project at the Freie Universität Berlin, led by professor Dr. Raúl Rojas. Their name is an amalgamation of Freie Universität (FU) and the English word, humanoids. Founded in 2006, the team of bachelor and master students develops humanoid robots and works in the fields of artificial intelligence, robotics, computer vision, electronics and mechanics.

The aim of the project is to develop autonomous, soccer-playing robots. Any work the team members spend on the robots is done voluntarily, as the project is not part of the university curriculum. However, the university supports the team by providing equipment and a work space. The project is a unique opportunity to apply what has been learned and to pursue personal research interests. Creative ideas can be tested and verified on actual robots. Additionally, students gather valuable experience while working with complex software in a professional team.

The team consists of six humanoid robots. On average, the robots were designed and programmed by a dozen bachelor and master students.
The RoboCup Initiative

RoboCup is an international initiative to help facilitate the exchange and comparison of knowledge in the field of robotics. It was founded with the goal to beat the human soccer world champions in a fair match by the middle of the 21st century. This new standard challenge within artificial intelligence (AI) research allows us to compare and experience any progress made in the robotics field. It increases the exchange between scientists from all over the world.

Competitions

Teams from all around the globe compete in national competitions (e.g. RoboCup German Open) and the annual RoboCup world championship. These events cover multiple robot leagues. More than 2,600 participants from 45 countries participated in the 2013 RoboCup competition in Eindhoven. The championship attracted over 40,000 visitors. RoboCup events are covered by both national and international media outlets.

Humanoid League

The FUmanoids participate in the Humanoid League, one of the most popular RoboCup soccer leagues. They play in the kid size category where 24 teams have their robots play in 4 vs 4 matches. These robots are up to 90cm in height and are designed, built and programmed by the teams themselves.
The FUmanoid team currently consists of six robots. The newest model is an improved version of our robots from 2012.

The robots use a web cam to gather visual information about their surroundings. Using three gyroscopes and acceleration sensors they maintain their balance while walking on two legs. They play autonomously and select where to walk and when to kick the ball. If they fall down, they get right back up again and continue playing.

**Design:**
- Height: 65cm
- Weight: 4,5kg
- Degrees of Freedom: 20

**Hardware:**
- CPU: ODROID-X2 mit 4 x 1.7 GHz
- Webcam: Logitech c920 (640 × 480)
- OS: Linaro (based on Ubuntu)
The rules of the Humanoid League dictate many aspects of the robots’ design. They are updated every year to facilitate the development of new designs and to get closer to the 2050 goal of winning a fair match against the FIFA champions. The rules require the robots to roughly have human proportions. They are only allowed to use sensors that resemble human-like senses, e.g. vision, touch or sense of balance. Contrary to human soccer players, they may use WiFi to communicate with each other and with the referee.

Fulfilling all soccer-related tasks requires a coherent hardware concept. Additionally, the team has to consider limitations of weight, battery capacity and computational power in their design. Finally, funding sometimes has a limiting factor in how far a desired hardware design can be realized.
Currently, almost all teams in the Humanoid League use a single camera to gather visual data. This approach comes with limitations, as no depth perception is available. Therefore the FUmanoids have started integrating a stereo camera, developed by our research group at Freie Universität. This camera operates in a similar way to the human eyes. It provides the robots with accurate depth information which allows them to identify the distance and location of objects more precisely.

**Power Board**

The power board is a smart power-supply circuit board the team developed in early 2013. It has undergone a process of constant improvement ever since. The board not only provides the whole robot with the correct current, but also detects errors in the electronic system. If a short circuit occurs, the power board protects the electronic components by switching them off in less than two milliseconds. Additionally, the current battery charge level can easily be seen by the human handlers thanks to a colored LED.

**Stereo Vision**

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Software

The robots are only able to work efficiently with powerful software. It prepares and processes sensor data, controls the hardware and makes decisions about the robots' behavior. The FUmanoids show a high degree of creativity and innovation in this area. Their success in competitions is based on the development and implementation of new technology. Currently the focus lies on three main areas:

**Image Processing**  Image processing extracts detailed information from the camera images. With the help of color-classified images and object extractors, the position of the two goals, the field lines, the ball and other robots are determined. Based on this data, the behavior control makes decisions. The software has to overcome difficulties like blurred images as a result of walking, changing lighting conditions or, thanks to the colorfully dressed audience, a highly dynamic background.
Position Data  
After the image-processing has determined the objects on the playing field and calculated their coordinates relative to the robot, the software then creates a global world model based on this data. This allows the player to guess the position of objects very precisely, even if they cannot be seen at that precise moment. Thus, the position of the ball rolling behind another robot can be predicted based on the physical properties of its movement - although the ball is currently hidden.

Localization  
Based on the world model and visual data, the robots will constantly try to locate themselves on the playing field. Knowing where the robot itself and all other objects are, is an important prerequisite for effectively planning the next moves. A particular challenge is the symmetry problem. Both halves of the playing field are absolutely identical and own goals have already been the downfall of many teams. Our current approach combines several types of information to aid this process. On the one hand, the robot uses the position of non-moving objects like goal posts. On the other hand, the positions of team members can provide orientation. In addition, the goalie acts as a corrective function for other players’ estimations, as it is in a well defined and easy-to-verify position throughout the game.
Public Appearances

The FUmanoids have demonstrated their skills at various events. They have participated in tournaments ranging from 2,000 visitors at local competitions to 40,000 visitors at the RoboCup world championship. Aside from students and people interested in technology, families with children make up the bulk of the audience.

The FUmanoids are visited regularly by camera teams from national and international TV stations and are interviewed by print and online media. In doing so, the robots have already reached a broad audience. Additionally, we also publish updates on our homepage, our YouTube channel or on Facebook for those who are interested in our research and progress.

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<tr>
<td>Long Night of Science</td>
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Achievements

1st place RoboCup German Open 2014
1st place RoboCup Iran Open 2014
4th place RoboCup German Open 2013
2nd place RoboCup German Open 2012
4th place Robocup 2011 (Turkey)
2nd place RoboCup 2010 (Singapore)
2nd place RoboCup 2009 (Austria)
2nd place RoboCup German Open 2008
3rd place RoboCup 2007 (USA)

At the 2012 and 2013 RoboCup competitions the FUmanoids reached the quarterfinals. The team did not participate in RoboCup 2014.
Got interested? On the back of this brochure you will find our contact details. We are happy to answer all of your questions.

Are you a student? The FUmanoids offer topics for bachelor and master theses as well as software projects on a regular basis. We are always happy to welcome new team members.

Support us! The development of modern autonomous robots is a costly undertaking. As a student-based project we are grateful for every sponsor and are happy to offer individual sponsoring deals.

Don't hesitate to contact us!
Version: February 2015

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Photos: Fumanoids, Kristina Schippling, Thomas Trutschel, Jakob Weber