The robot "Athena" carries new impulses for robotics research in its luggage

December 17 2014

As the first humanoid robot to pay for a seat on a commercial flight, Athena travelled in style, dressed in a white T-shirt and fetching red shoes. Credit: MPI for Intelligent Systems, Tübingen

Travelling from Los Angeles to Frankfurt onboard of Lufthansa flight LH 457, the passenger arrived on December 16, at 11.05 a.m. with no signs of jet lag: this was no ordinary holidaymaker, after all, but the first

humanoid robot to take up a seat on a commercial flight. And despite causing quite a stir when boarding the plane in Los Angeles, Athena, dressed in a T-shirt and fetching red shoes, received no special treatment: like most of us, she flew economy class. During the nine-hour flight, the robotic creation was accompanied by scientists from the Max Planck Institute for Intelligent Systems. Athena made her way from Los Angeles to Tübingen in order to acquire many new skills: standing, balancing, walking - and various other meaningful activities, which she can use to assist people in daily life.

The Fukushima disaster has demonstrated how far away robotics research still is from creating useful systems for our daily life. There remains a lack of understanding of autonomous systems that can reliably perform useful activities, like opening doors, closing valves or operating a pump, – such tasks were important in Fukushima. Worldwide, researchers and engineers are working on the development of novel robots that can act rationally and independently depending on the situation - as in destroyed power plant buildings or in earthquake zones. This is a formidable task.

Flying Athena home

And this is where Athena comes into play. The humanoid robot, measuring 1.88 m in height and weighing only 48kg, stands on two legs and has feet. Together with his team, Stefan Schaal, director of the "Autonomous Motion" department at the MPI for Intelligent Systems in Tübingen, has formulated ideas and specifications, which guided the development by the US robotics company Sarcos. Athena's development at Sarcos was initiated by a US funding program for Robotics in Disaster Response (DARPA Robotics Challenge), in collaboration with the Californian partner laboratory of Schaal at the University of Southern California, where he holds a professorship for Computer Science, Neuroscience, & Biomedical Engineering.

While the DARPA program focuses largely on teleoperated robots, the aim of the Max Planck Institute's research goes far beyond this: it would like to develop truly autonomous robots, or even ones that are able to learn themselves.

Athena was designed as a humanoid (human-like) robot in order to be able to work with tools for humans in man-built environments. Unlike four-legged or wheeled creatures, bipeds have the advantage that they can pass more easily through narrow passages, can perform activities that are on the floor or high up (e.g., shift levers or fix a light bulb), climb ladders, or even operate a car. Of course, research is just beginning to bring robots into such domains.

On December 16, 2014, at 11:05 am, Athena arrived in Frankfurt on Lufthansa flight LH 457, onboard of a Boeing 747-8. Accompanied by scientists Jeannette Bohg and Alexander Herzog, she spent the flight almost like a normal passenger in the cabin. But of course she didn't have a meal, or a drink – and she never needed to make a trip to the restroom. Athena traveled completely passively, i.e. without any energy source. Her travel companions brought her to the plane in a wheelchair. In the same way, the robot left the plane in Frankfurt, got on board of a minibus and travelled "home" - to the department of "Autonomous Motion" at the MPI for Intelligent Systems in Tübingen. There, the scientists will teach her walking over uneven terrain as one of the first skills in the coming months.

Not your ordinary holidaymaker: humanoid robot Athena turned quite a few heads at the airport. Credit: MPI for Intelligent Systems, Tübingen

A new humanoid robot - rather a helper for disasters than a nurse

The robot is full of technical finesse. Its head is equipped with sensors enabling to detect its environment. A stereo camera system works quite similar to our eyes. From two images it calculates three-dimensional depth images. Thus Athena can determine, for example, the position of objects to grasp in the vicinity. Responsible for long range vision is a Velodyne laser scanner, which resembles a small lighthouse on the head. This sensor sends out 32 fan-like laser beams and, from the reflected light, it calculates the distance from surfaces. With a range of 80 m, the laser scanner rotates 10 times per second around the vertical axis and thus scans the entire environment around the robot.

In Tübingen, Athena will get an inertial sensor for balance control mounted on the upper body—similar sensors are found in the human inner ear. It will detect the orientation of the robot and its accelerations, which are important to understand what is up or down, i.e., the direction of gravity. Athena still has to wait a few more weeks for her real arms, because they are still in production. Currently, she is wearing prototype plastic arms that were printed with a 3D printer in Tübingen. These arms can be moved by hand only and have no sensors, but they allow researchers to evaluate the design.

Athena's legs are very mobile. Her hip and knee joints move hydraulically, with oil at high pressure (200 bar). Sensors at all joints measure the position and torques of each joint and transmit the data to the software, which in turn controls the movement of the joints by hydraulic valves. Athena stands on foot prostheses developed by Otto Bock for humans. The carbon fibre material of the prosthesis allows suitable spring behaviour for running on two legs and makes the legs very light. The Max Planck robot is the first humanoid robot to use such prosthetic feet.

The movement of the joints under its own weight takes the most energy. A large laboratory pump generates a high-pressure oil flow that is directed to the robot with hoses to move the joints. That means, the robot is energetically not autonomous, and currently needs an external hydraulic supply. In the future, this will be directly integrated into Athena. In contrast, the electronics and the sensors need relatively little energy, which is provided by an external electric power supply.

Athena is a machine - and it looks like one. It is not the prototype assistive robot that will help in the hospital or will support the elderly in coping with their everyday lives.

Stefan Schaal explains: "Athena is the robot who saves people from the

collapsed house or that is sent into the woods to look for a six-year-old child, who has lost its way. Athena is intended for physical work in complicated terrain, which is possibly inaccessible or too dangerous for humans."

Athena has a lot to learn

The robot is brand new and, so far, can only perform rudimentary movements. It will take a few more months until it will be able to walk and balance autonomously. The mid-term objective of the Tübingen scientists is to run the robot over rough terrain or obstacles.

Longer-term goals include, amongst others, whole body coordination to grasp and manipulate objects, moving through tight spaces. For these tasks, Athena must be able to maintain balance, to stretch and reach for something, or possibly to independently get up again after falling over. A prerequisite for this is the correct perception of the environment.

To achieve these goals, researchers have to invest a lot of time in basic research and development. The fundamental principles that lie behind the human ability to perform these seemingly simple tasks are still largely unknown today.

"It is important that in the future the robot can safely move even in difficult terrain," says Stefan Schaal. "Our research is specifically concerned with autonomous perception, control and learning in such futuristic systems. We hope that one day the robot can really help in complex outdoor tasks, for example, in an emergency, in space, for assistance during epidemics, or other situations, like fire, search missions, weather catastrophes, etc. – i. e., pretty much anything where systems on wheels cannot be used. Of course, these are all visions for the future, and to achieve that, we have a lot of research ahead of us."

Provided by Max Planck Society