ANYmal

A unique quadruped robot conquering harsh environments

Inspection and surveillance tasks on industrial sites can be repetitive, dirty and dangerous. The ANYbotics team based in Zurich, Switzerland, have developed a solution to this problem in the form of 'ANYmal'; a unique quadrupedal robot that can perform these roles autonomously, carrying sophisticated sensory equipment to any point of interest. Its unique ANYdrive system provides exceptional mobility and enables the four-legged robot to work in harsh environments.

Mobile machines have always had the potential to support humans in dangerous industrial situations, but only recent advancements in robotics have given them the capacity to do so. The physical layout of industrial sites, comprising of stairs, gaps and other obstacles, adds a layer of complexity, preventing the use of traditionally wheeled or tracked robots. While drones can overcome some of these problems, they cannot operate in bad weather and their payload capacity and energy autonomy can be limiting.

The ANYbotics team has developed an exciting new solution to this problem: ANYmal. It is a highly sophisticated four-legged robot, designed to tackle the challenges of a harsh industrial environment head-on. Resembling a medium-sized dog and weighing in at 30 kg, it teams high-end computer systems with robust hardware. Built specifically to work autonomously in difficult surroundings, it is equipped with sensory systems to perform search and rescue operations, inspections, and other surveillance duties.

ANYmal was developed to support humans in dirty, dangerous and dull work.

MEETING THE CHALLENGE OF DYNAMIC MOBILITY

ANYmal was born from a need for a robot that can move easily over challenging terrain such as found at industrial sites. The ANYbotics team applied a specific focus to enhanced mobility, locomotion and robustness while ensuring the robot was safe to handle and easy to maintain by a single operator.

A quadruped design offers the best advantage in terms of mobility and versatility, but their legs cannot be powered by a classical mechanically geared system, as employed by almost all robotic arms. This type of actuator (a component of a machine responsible for moving and controlling a mechanism or load) can only produce slow and static locomotion (i.e., always balanced) to reduce impulsive forces, which occur when two bodies collide, such as when a leg contacts the floor.

The robotic research community put forward several solutions to get around this problem. One promising approach are Series Elastic Actuators (SEAs). The design of these compliant actuators is inspired by nature; tendons and muscles working together to control force. SEAs can be described as actuators attached to the load via a spring or elastic element. This clever set up allows a force to be controlled precisely; as the spring expands or contracts it supplies information about the force applied. In addition, the spring absorbs impact, having the effect of increasing shock tolerance. It can also store energy temporarily during locomotion, increasing energy efficiency and peak power.

The four-legged design of ANYmal allows the robot to conquer difficult terrain such as gravel, sand, and snow.

Photo credit: ETH Zurich / Andreas Eggenberger

ANYDRIVE – A POWERFUL, TORQUE-CONTROLLABLE ROBOT JOINT

The ANYbotics team have developed with ANYdrive their own SEA unit, a compact, tightly integrated and sealed actuator module containing custom control electronics. ANYdrive can regulate the joint torque, position and impedance directly, without the need for any additional components. Using ANYdrive as a base, a robot will be simple to manufacture, assemble and maintain. In case of failure, an ANYdrive joint can be exchanged quickly and easily.

The ANYdrive units make ANYmal unique. Each leg has three of these joint units, allowing a wide range of movement: hip abduction/adduction, hip flexion and knee flexion/extension. They allow ANYmal to walk, trot and jump, as well as walk and crawl up stairs. These joints can be fully rotated, allowing the legs to turn overhead to prevent collision with the ground or side rails, as well as get up after a fall.

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ANYBOTICS EMERGES FROM RESEARCH

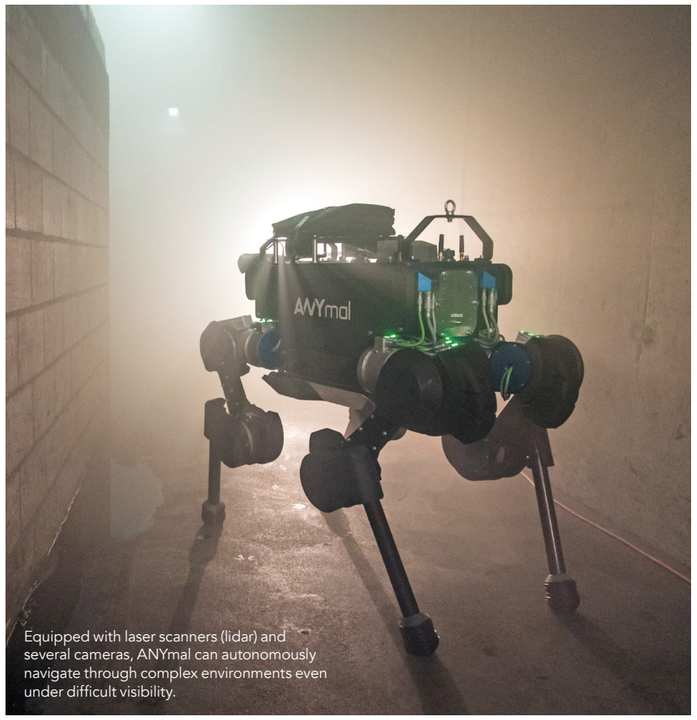
ANYmal's ground-breaking technology began in the legged robotics group at the Autonomous Systems Lab, ETH Zurich and further in their Robotic Systems Lab. Nine years of extensive research went into the development of ANYmal and its component products. The ARGOS (Autonomous Robots for Gas and Oil) challenge, organised by the French Oil & Gas group Total, provided the first platform to demonstrate ANYmal's capability of navigating and moving dynamically in very challenging terrain. Numerous advanced autonomous surveillance and intervention tasks were completed safely on a replica of a multi-floor industrial oil and gas platform in a potentially hazardous offshore environment.

From this successful outing came the creation of a commercial spin-off company, ANYbotics, allowing for the commercialisation of both ANYmal and the ANYdrive component that makes ANYmal so unique.

A COLLABORATIVE RESEARCH COMMUNITY

Together with its partners, ANYbotics has founded the collaborative research community 'ANYmal Research' to develop and share software and other information to improve and extend the capabilities of the ANYmal robot. Members include the Toyota Research Institute,

ANYdrive powers the ANYmal as a fully integrated, robust, and torque controllable robot joint.



Equipped with laser scanners (lidar) and several cameras, ANYmal can autonomously navigate through complex environments even under difficult visibility.

With the help of robotic legs, stairs and other obstacles are negotiated with ease.

ANYmal is designed for harsh environments and is fully water- and dust-proof.

the German Aerospace Center (DLR), Nvidia (computer hardware and software) and several prestigious universities. This research community has full access to ANYmal's control software, simulation, documentation, and community support.

ANYMAL FEATURES AND CAPABILITIES

The modular design of the hardware and software of ANYmal simplifies setup and maintenance. Physically, it is constructed of a single carbon-fibre lightweight body, with 12 identical joint units connected by simple mechanical links. Environmental perception is enabled through lidar sensors, stereo and wide-angle cameras; sensors in the rubber feet provide haptic information. The payload can range from simple sensors to complex robotic arms for manipulation, depending on the application. For industrial inspection, ANYmal is equipped with a pan-tilt head with various sensors, including an optical zoom and thermal camera, a gas detection sensor, an ultrasound microphone for gas leak detection, as well as artificial LED lighting.

ANYmal can survive falls from over 0.5m height; sensors are equipped with a fall-protection housing, foam absorbs the impact of side falls and a Kevlar belly protects from sharp objects below. The main body holds the computers, batteries, network devices, power management system and navigational sensors. It is sealed against water and dust ingress, complying to IP-67 standards. ANYmal can work autonomously for two to four hours before recharging and connects to a docking station independently.

Legged robots, such as the ANYmal, will be part of our daily lives in ten years.

The powerful brain of ANYmal, housed in the main body, comprises of several computers for locomotion control, localisation and mapping, and for the specific task it is undertaking. All electronic components are thermally connected to an actively-cooled heat sink to prevent them from overheating. ANYmal's software is built on the open-source Robot Operating System (ROS), allowing for quick integration in an existing framework and the re-use of available software.

REAL-WORLD CAPABILITIES

ANYmal has a proven capability of working in harsh environments with the potential for use in a wide-range of applications. It can operate in rough outdoor locations, crawl through pipes, and access buildings over steps and stairs, making it perfect for use on industrial platforms, in mines, construction sites, or patrolling remote locations. ANYmal's use in the industrial sector will not only increase efficiency and reduce operational costs, but it will also reduce the risk to personnel, installations and the environment. In addition to this, ANYmal can support disaster relief teams with safer search and rescue operations, as well as other activities that may involve human interaction.

ANYmal is also used in the entertainment industry – museums, amusement parks and theatre productions. While it amazes children and adults alike, it can also be used to educate its most important functions.

Behind the Bench

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Bio

ANYbotics was founded by ETH Zurich (Switzerland) researchers and engineers in 2016. Having worked on legged robotics since 2009, the group spun off from the Robotic Systems Lab (RSL) to bring the ANYmal robot and the ANYdrive robot joint to real-world applications.

Research Objectives

ANYbotics is part of the research community 'ANYmal Research' that aims to advance legged robotic systems. With the quadruped robot ANYmal at the core, designed for autonomous operation in challenging environments, they strive to improve and extend its capabilities.

Collaborators

- ETH Zurich, Robotic Systems Lab, Prof Dr Marco Hutter, www.rsl.ethz.ch

References

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www.anybotics.com
www.anymal-research.org

Personal Response

Where do you see ANYmal in ten years' time?

Legged robots, such as the ANYmal, will be part of our daily lives in ten years. Less in directly visible applications, but more in underground, remote and potentially dangerous industrial locations. The robots will work alongside humans to perform maintenance relevant tasks such as inspection and repairs to ensure safe and efficient operation of facilities. One day, the robots might even build complex installations themselves.