PRESENTATION //

Power Management Challenges in Leg-Based Robotic Systems

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ANYbotics AG

Strictly Confidential

ANYbotics

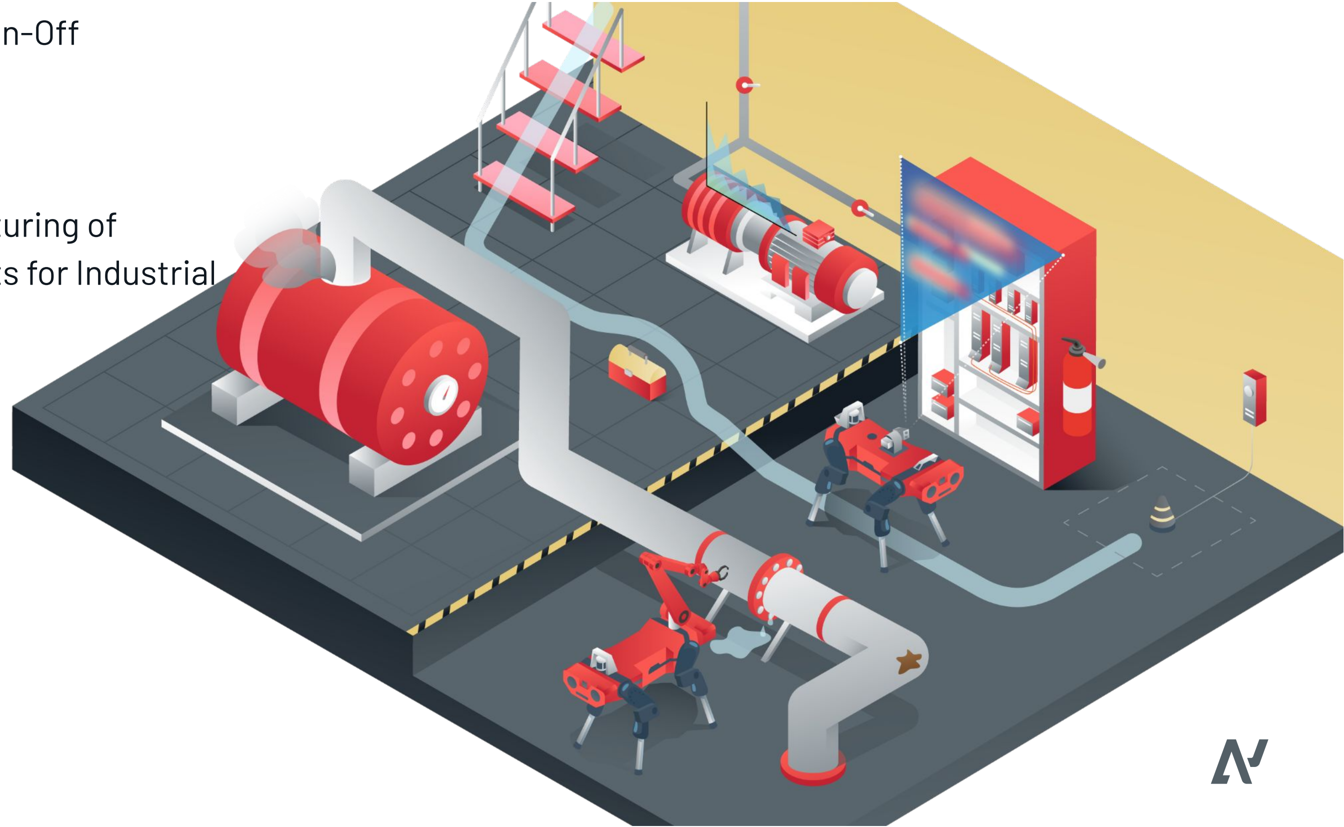
ANYbotics

Company Overview

ANYbotics AG

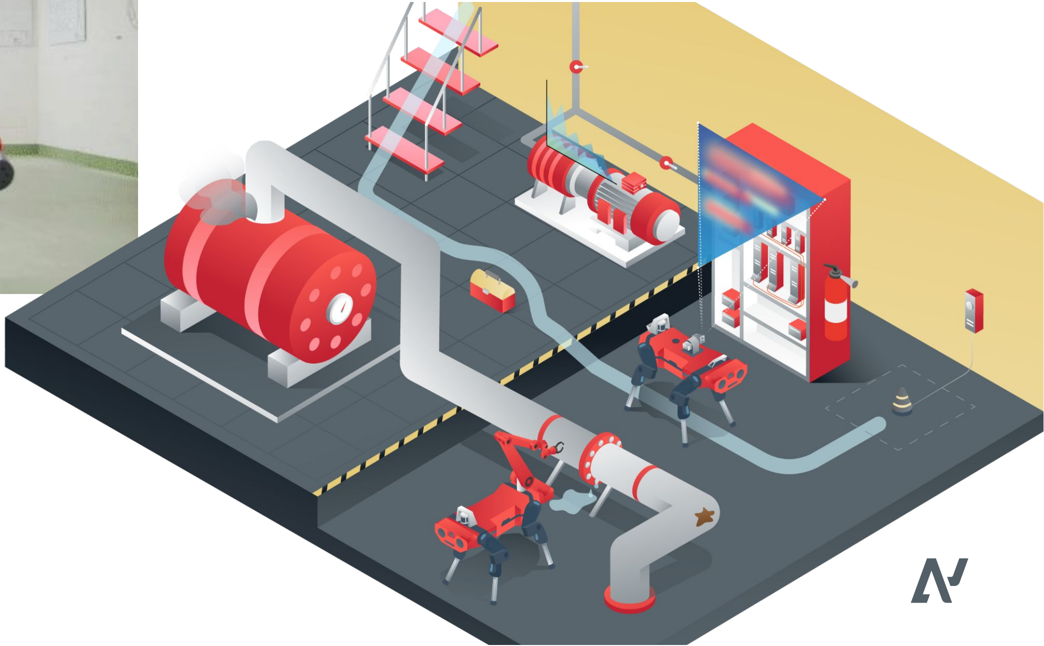
- Founded in 2016 as ETH Spin-Off
- Headcount: 100+
- Headquartered in Oerlikon

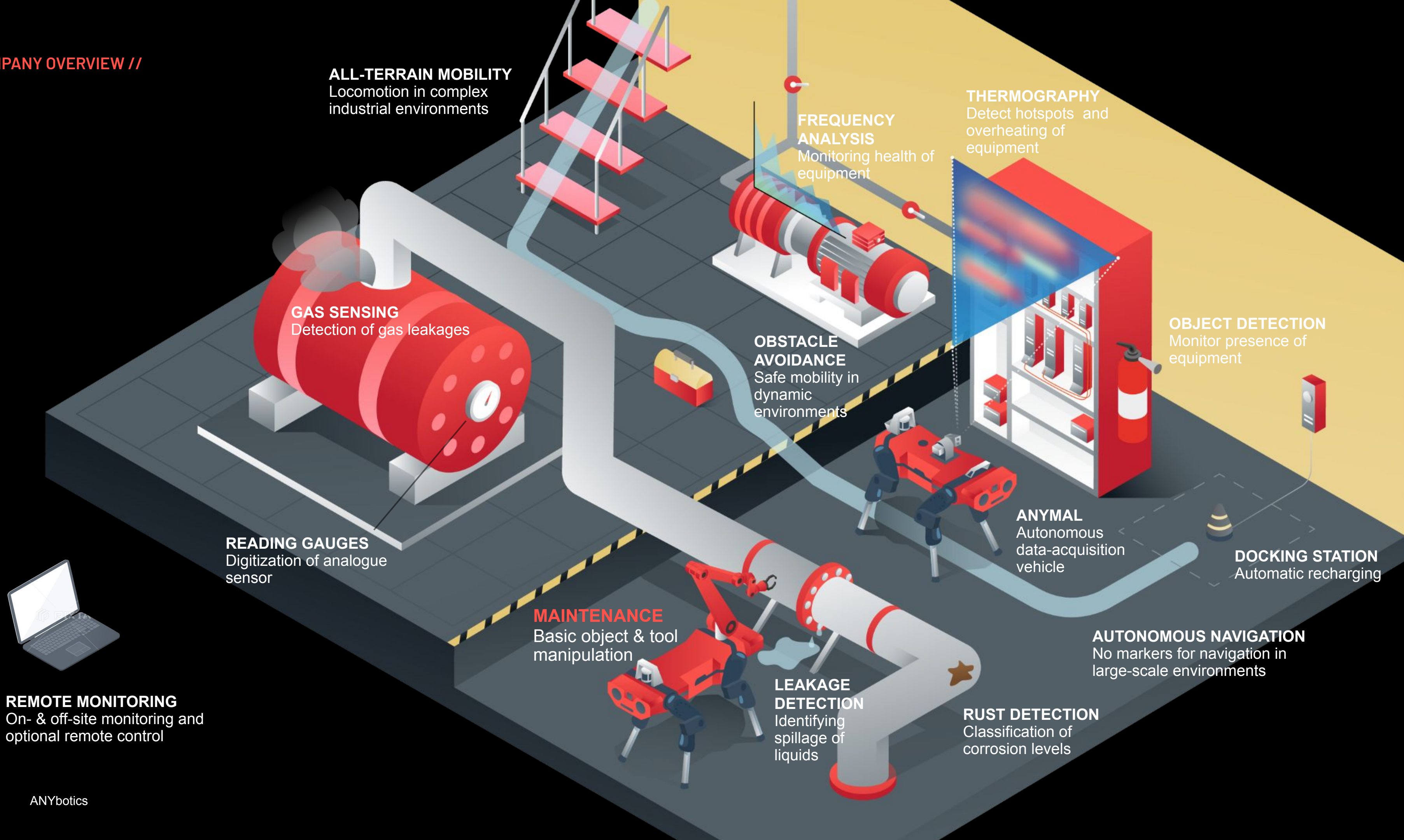
- Development and Manufacturing of Autonomous Legged Robots for Industrial Inspection



Autonomous Legged Robots for Industrial Inspection

Check our YouTube Channel:
youtube.com/anybotics




ALL-TERRAIN MOBILITY
Locomotion in complex industrial environments
FREQUENCY ANALYSIS
Monitoring health of equipment
THERMOGRAPHY
Detect hotspots and overheating of equipment
GAS SENSING
Detection of gas leakages
OBSTACLE AVOIDANCE
Safe mobility in dynamic environments
OBJECT DETECTION
Monitor presence of equipment
READING GAUGES
Digitization of analogue sensor
ANYMAL
Autonomous data-acquisition vehicle
DOCKING STATION
Automatic recharging
MAINTENANCE
Basic object & tool manipulation
AUTONOMOUS NAVIGATION
No markers for navigation in large-scale environments
LEAKAGE DETECTION
Identifying spillage of liquids
RUST DETECTION
Classification of corrosion levels
REMOTE MONITORING
On- & off-site monitoring and optional remote control

COMPANY OVERVIEW //

Modular platform with custom payload for inspection missions

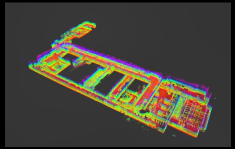
ROBOTIC PLATFORM

STANDARD PAYLOADS

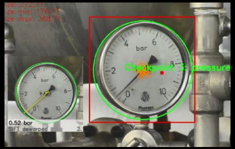
- Optical zoom-camera
- Thermal camera
- Ultrasonic microphone
- High-power LED

Mass: 55 kg
Payload: up to 15 kg
Power: 2-3 h
Ingress protection: IP67
Speed: > 1.0 m/s
Operating temp.: 0–40 °C

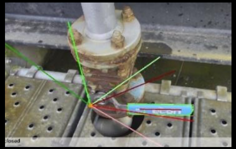
INSPECTION INTELLIGENCE



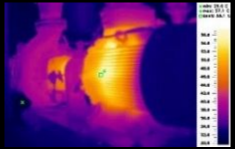
Monitoring environment
Building 3D maps



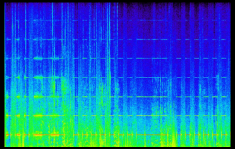
Reading instruments
Gauges



Analyzing operation state
Valves



Checking equipment state
Thermography



Checking equipment health
Acoustic inspection

Detecting events
Gas

Checking material state
Corrosion

Checking equipment health
Leakage

Detecting objects
Fire extinguishers, humans, missing parts

Challenges in Mobile Robotics Power Systems

Wires and joints: Towards a Wireless Leg

Drives' Optimisation Considering Full System and Mission Profile

Wireless Charging Systems

Energy Storage & Peak Power

Towards a Wireless Leg

Cables are a pain

Especially the cables exposed to outdoor conditions are an important challenge.

The leg cables are subject to twisting and general tear/wear from repeated stresses.

In the Ex-certified robot, cumbersome cable potting is needed for maintaining pressurisation.

Let's remove them!

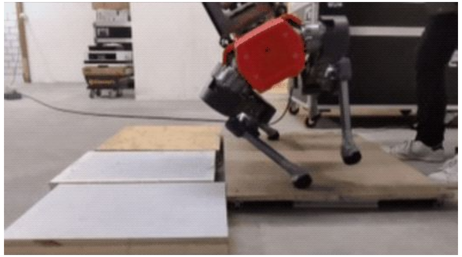
An integrated wireless power transfer + wireless communication interface for the leg joints would minimise/eliminate these pains.

Power Link

Communication link

Challenges

- Reliability, reliability and reliability.
- Space, weight and inertia limitations
- Thermal management
- Strongly pulsating loads (power path)
- Compliance with EMC norms
- Communication loss results in robot collapses



Drives' Comprehensive Optimisation

Drive design approach

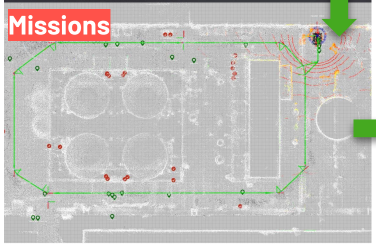
Defined drive requirements:
Torque/speed characteristics, mechanical stresses, electrical parameters (e.g. battery voltage), cooling situation, etc.

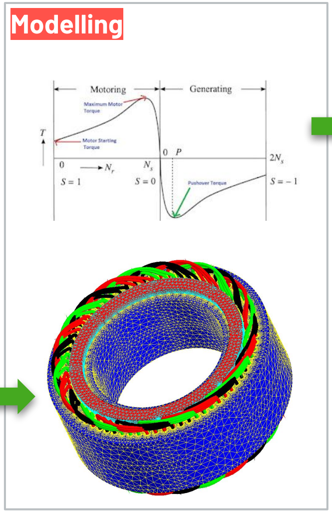
Apply well-known design approaches:

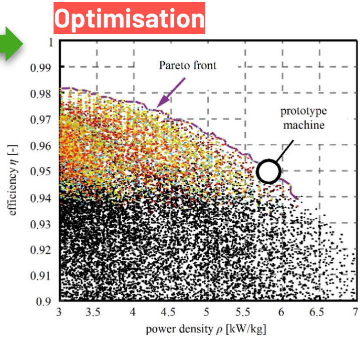
Select off-the-shelf components, design motor geometry and parameters, FEM simulations, etc.

Comprehensive drive optimization

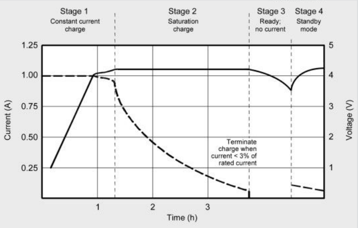
From high-level customer use cases through mission profiles and down to thermo-electro-mechanical modeling and optimized designs







Charging System



Current solution

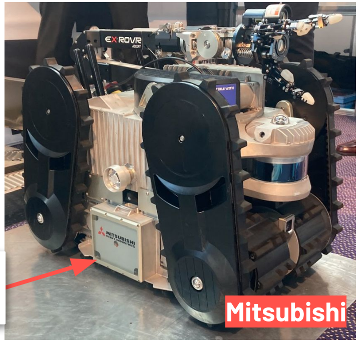
Docking station with mechanical contacts

- Subject to wear & tear
- Exposed to the elements
- Prevents charging in IECEx-Zone

Robot positioning accuracy: cm-range

- Mechanical compliance of the docking station/system

Wireless power charging



Pros / Cons

Pros ✅

- IECEx-Capability
- No exposed contacts: No wear/fatigue
- Good positioning accuracy, small air gap

Cons ❌

- Reliability and overall system complexity
- On-board charger & thermal management ⇒ Mass and costs
- Radiated emissions & field strengths/IECEx

Energy Storage

Peak power

Robots demand high peak powers

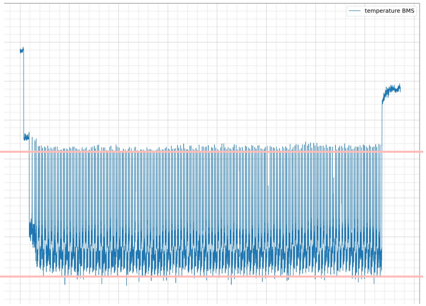
- Rotational inertia in significant number of actuators (12x locomotion drives in ANYmal).
  - Several J per drive when at full speed stored in motor-rotor.
- Fast & frequent movements

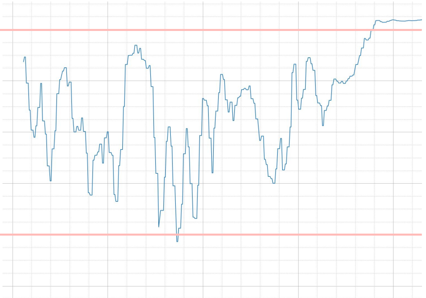
Robots demand high average powers

- Battery management system/safety electronics must be able to turn off peak currents >400A with sufficient safety margins.

Battery cells must be able to provide high peak currents.

- Chemistry trade-off: Energy vs. Power density

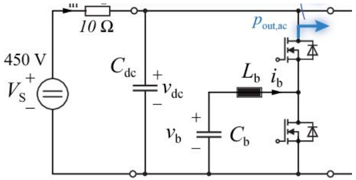




Optimization approaches

Power pulsation buffer

- Battery cells with high energy density (but high internal resistance).
- Peak currents supplied by "power pulsation buffer"



Hybrid battery

- Mix between energy-dense and power-dense cells, with DC/DC in-between

CAREERS //

We are Hiring!

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We frequently look for motivated electrical and mechanical engineers!

Full-Time, Part-Time, Internships

Thank you!

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