Government
Office for Science

HUMANOIDS

Humanoid robots resemble humans, typically with two arms, a torso, and a head. They can be legged, static, or wheeled. These robots vary in abilities and serve many purposes.

CONTEXT

Humanoid robots have been in development for decades and have seen increasing attention in the 2020s, spurred on by industry activity and the potential impact of advances in AI. The ultimate ambition is a general-purpose humanoid robot that can function in the dynamic and unpredictable environments in which humans excel.

TECHNOLOGY

Humanoid robots require an incredibly complex combination of technologies including high precision and resilient hardware, sensors, and software. Since the 1980s, humanoid robots have developed substantially, becoming more mobile, dexterous, and better able to perceive and respond to their environment. However, there remain significant technical challenges to realising a general-purpose humanoid robot for commercial use.

FUTURE THINKING

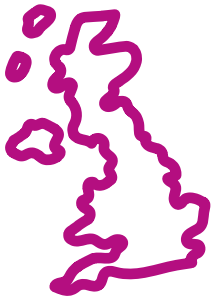
Humanoid robots are already used in some sectors, largely as immobile information points (e.g. as a receptionist) or novelty. The most advanced humanoid robots are being trialed in highly structured environments such as factories or warehouses. In the future, highly capable, mobile, dexterous and autonomous humanoid robots have potential applications across most areas of the economy and society.

UK POSITION

The UK produces a small amount of high-quality research and has some industry activity. Other countries are more active in this area such as China, the USA, Japan, the Republic of Korea, and Canada.

$30-150K
estimated manufacturing cost for a single humanoid robot.

Source: Goldman Sachs Research



1ST
The UK is 1st globally for research quality by FCR.

Source: Dimensions

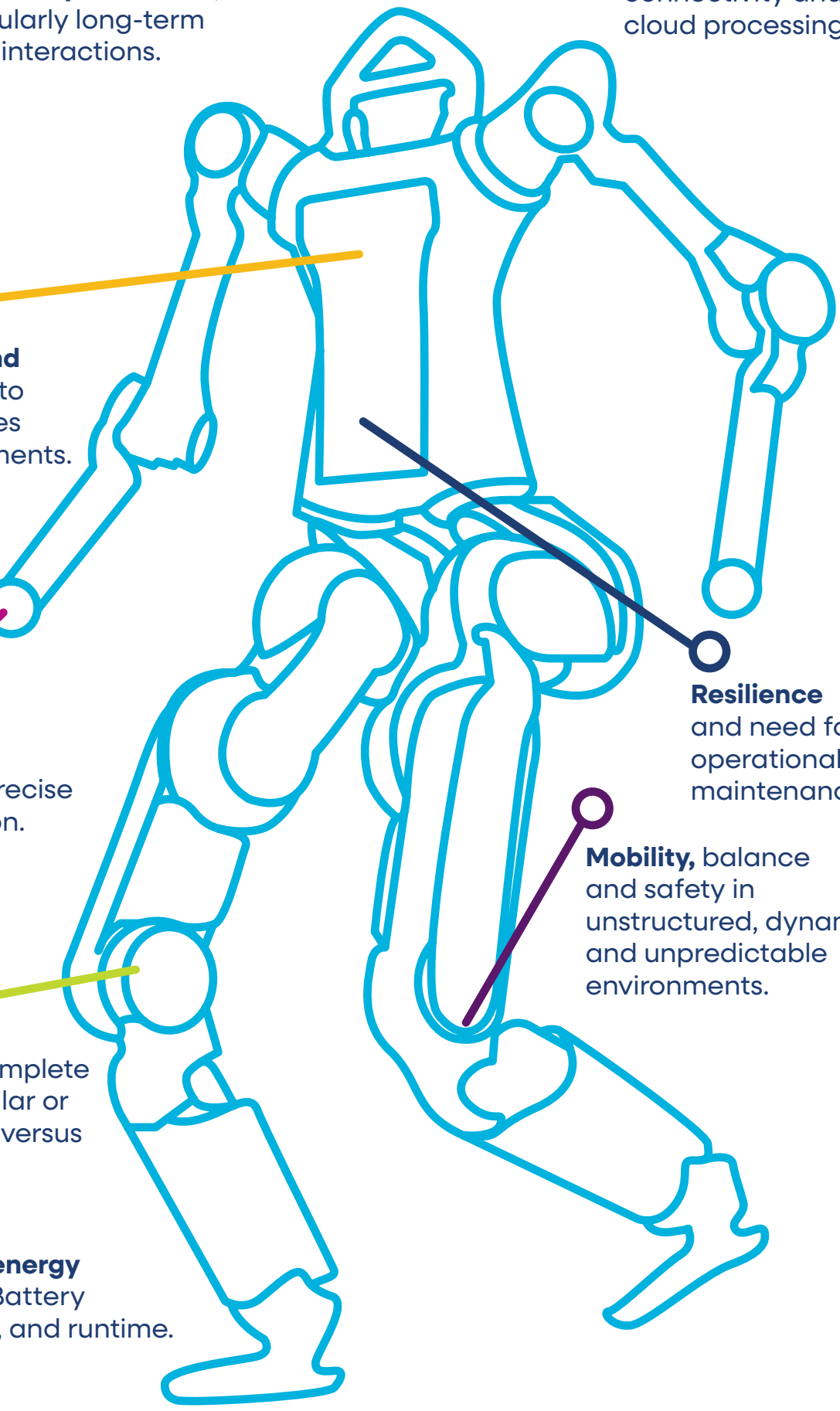
7TH
The UK ranks 7th in overall volume of humanoid publications.

FCR: Field Citation Ratio

KEY TECHNICAL CHALLENGES

Interactivity with users, particularly long-term social interactions.

Compute to reduce reliance on connectivity and cloud processing.



Autonomy and adaptability to new use cases and environments.

Dexterity, precise manipulation.

Speed to complete tasks at similar or faster pace versus a human.

Power and energy efficiency. Battery weight, size, and runtime.

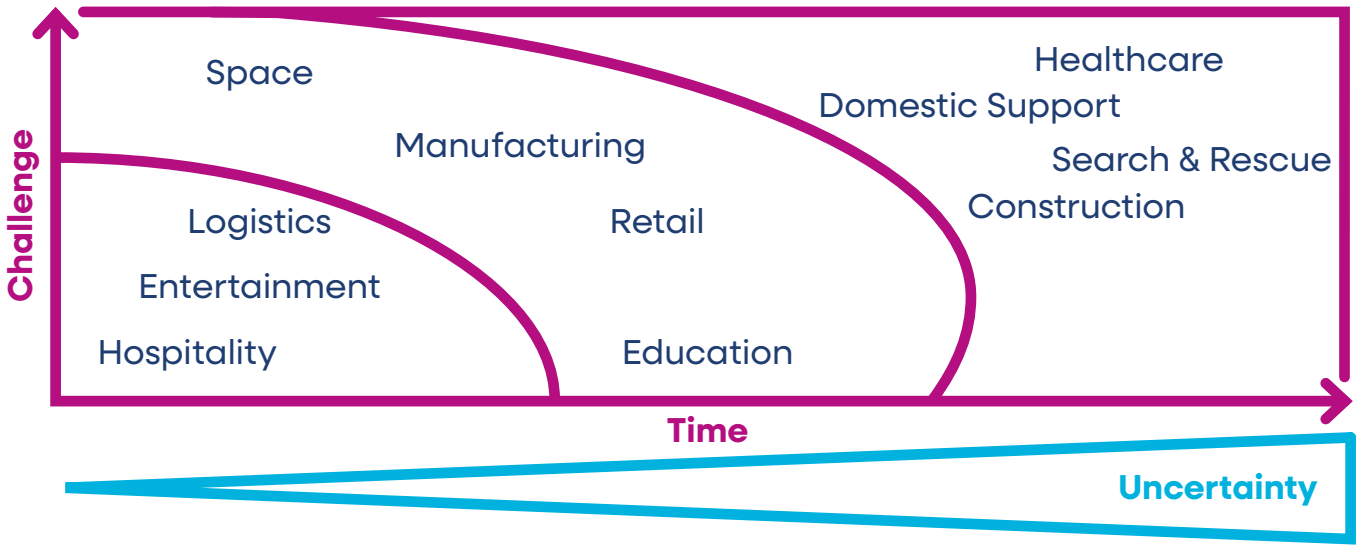
Resilience and need for operational maintenance.

Mobility, balance and safety in unstructured, dynamic and unpredictable environments.

Illustration inspired by Apptronik's Quick Development Humanoid (QDH)

CURRENT AND FUTURE APPLICATIONS

Although some experts believe we will see highly capable and general-purpose humanoid robots in the 2020s, there still remains significant uncertainty and divergent opinions across both industry and academia. Settings and tasks that require greater dexterity, mobility and autonomy are more uncertain.



OPPORTUNITIES

- **Productivity and safety improvements** could be realised from deployment of highly capable humanoid robots, particularly in sectors facing labour or skills shortages. However, there is substantial uncertainty about how businesses and the public would respond to humanoid robots and whether they could offer substantially better value for money than alternative automation solutions.
- **Leveraging UK strengths** in robotics and autonomous systems R&D to develop specialised components or software for design or deployment of humanoid robots.

CHALLENGES

- **High levels of technological uncertainty** remain as to how humanoids will improve, on what timescales, and if they will be cost-effective.
- **Public acceptance** of humanoids is highly uncertain and is expected to vary depending on the robot design, application, and features of the people involved (e.g. previous exposure to robot technology).
- **Safety and standards** are key to ensuring that the use of humanoid robots does not cause harm to humans in public and private settings.
- **Societal implications.** Widespread adoption of humanoid robots could have significant impacts on different parts of society. There are outstanding questions as to how to ensure their use is acceptable to society, ethical, and does not exacerbate inequalities or present privacy challenges.

Please share your views.
Email us at **emtech@go-science.gov.uk**