Humans vs. robots: Study compares 27 humanoid robots with humans to see who is superior

November 7 2023, by Franziska Schmid

ANYmal is a four-legged robot for the inspection and maintenance of technical systems. Credit: Robotic Systems Lab / ETH Zurich

Science fiction films portray the idea relatively simply: the terminator—who either tries to destroy or rescue humanity—is such a perfect humanoid robot that in most cases it is superior to humans. But how well do humanoid robots perform nowadays away from the cinema screen?

This question is addressed by a new study by lead author Robert Riener, professor of sensory-motor systems at ETH Zurich and founder of the Cybathlon, published in the journal *Frontiers in Robotics and AI*.

Comparing apples with apples

The first scientific challenge was to develop criteria that permit a meaningful comparison between humans and machines. An industrial robot painting car bodies on a production line does this faster, for longer and more precisely than a human. It is especially developed for this but also does not have any other abilities.

Riener therefore excluded such robots from the study. "We humans shape our environment according to our criteria and needs. If robots are to support us in a meaningful way, they need to work in this manmade environment. We therefore quickly arrived at robots that are similar to humans, at least anatomically." It is for this reason that Riener exclusively examined humanoid robots for the study and integrated 27 relevant specimens into his research.

Yet the researchers also defined certain selection criteria within this robot type. "For example, for a robot that has rollers rather than legs it would be fairly easy to roll faster than a human can run—but we didn't want to compare apples with pears," explains Riener.

Only those robots were therefore selected that had two or four legs so that they were also able to climb steps. They also need to have a slim

figure in order to pass through doors, and a certain height (at least 50 cm) with arms and hands (or extendable by arms and hands) so that they can also pick up objects on a tray or shelf. In order to be able to work with and support humans, they should also be quiet and not give off any exhaust emissions.

Robots clearly better—in terms of components

The initial result surprised even the researcher: if one compares the individual components of machines and humans such as microphones with ears, cameras with eyes or drive systems with muscles, the technical components always fare better in terms of key sensory-motor properties.

These days, for instance, carbon fibers are used, which are harder than bones. If we disregard other properties of the human bone, such as the fact that it is self-healing, the technical solution is clearly superior in terms of mechanical features. The baffling thing, as the ETH professor explains, is as follows, "The question that arises is why we are not able today to construct a robot from these high-quality components that has better powers of movement and perception than humans."

Which brings us to the second result of this comprehensive study: if we consider the activities that humans and machines are asked to carry out, humans are generally superior to robots. Although humanoid robots are also able to walk and run, if we set walking or running speed in relation to body dimensions, weight or energy consumption, most robots are no longer able to keep pace.

At 6.1 meters per second, robot MIT-Cheetah runs faster than a jogging human and accordingly lives up to its name. However, the four-legged robot has a high energy consumption (973 watts) and is also only deployed under laboratory conditions. Humans also significantly outperform robots in terms of endurance versus operating time.

Karate Kid with stiff joints

Robots benefit for certain functions from their precision. "For example, when balancing on one leg, robots can easily stiffen their joints, while humans tend to wobble a bit—which costs considerably more energy. Robots can also precisely recognize their joint angles and repeat movements very accurately, which is pretty impressive and somewhat reminiscent of Karate Kid," says Robert Riener.

The results are more mixed for another movement function—picking up objects: while robots can pick up objects extremely quickly, they are not yet able to outdo us regarding our many different hand movements and the manipulative skills of our fingers. And another weakness of robots emerges with regard to various movements such as swimming, crawling and jumping as they are only able to perform some of these movements.

By contrast, most humans are easily capable of performing and combining several of these movements. Playing football is cited in the new study as an example of this: machines are still a long way from dribbling, heading or analyze and interpret the strategy of the other players.

Robots can support us in the future

Are humanoid robots today therefore still just a gimmick?

"No, the progress made by robotics in recent years is incredible. We wish to have robots around us so that they can help us with difficult or dangerous tasks. However, our man-made environments are very complex, and it's therefore not so easy for robots to function here autonomously and without error. Nevertheless, I'm confident that with the powerful technical components that are available we will soon be

able to construct more intelligent robots that are capable of interacting with us humans better," says Riener.

An important next step according to Riener is to go to greater lengths in terms of system engineering and automatic control technology in order to combine the existing powerful components better.

Deployment would then be conceivable, for example, in nursing and home care, the construction industry or in the household—i.e. wherever support is urgently needed in order to relieve staff and to support people with limited mobility, for instance.

More information: Robert Riener et al, Do robots outperform humans in human-centered domains?, *Frontiers in Robotics and AI* (2023). DOI: 10.3389/frobt.2023.1223946

Provided by ETH Zurich