ECCEROBOT: Embodied Cognition in a Compliantly Engineered Robot

The project

Standard humanoid robots mimic the human form, but the mechanisms used in such robots are very different from those in humans, and the characteristics of the robots reflect this. This places severe limitations on the kinds of interactions such robots can engage in, on the knowledge they can acquire of their environment, and therefore on the nature of their cognitive engagement with their environment.

ECCEROBOT is developing a different kind of humanoid robot – an anthropomimetic robot. Instead of just copying the outward form of a human, it copies the inner structures and mechanisms – bones, joints, muscles, and tendons – and thus has the potential for truly human-like action and interaction in the world. Unfortunately, there are as yet no established methods for controlling such robots, or even for describing their intrinsic movement patterns…

Our goals

#1 Design and build a robot using anthropomimetic principles, and mount it on a powered mobile chassis to permit mobile manipulation.

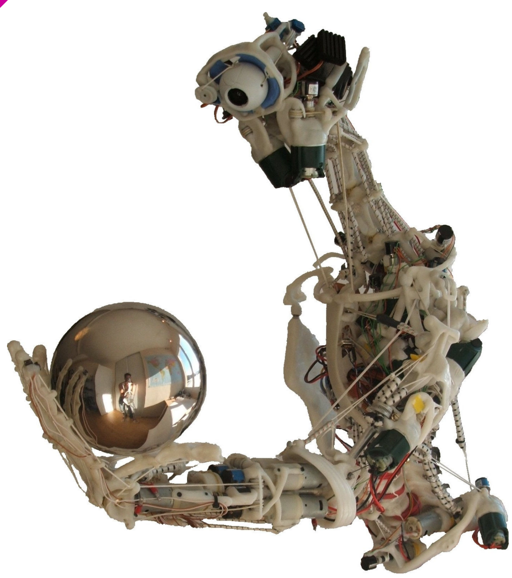
#2 Characterise its dynamics using advanced techniques of motion capture and causal analysis.

#3 Develop appropriate control techniques using classical methods, physics based modelling, and sensory motor strategies.

#4 Exploit the robot's human-like characteristics to produce some human-like cognitive features.

Goal #1

We have successfully developed methods for designing and fabricating analogues of the key components of the human musculoskeletal system: bones, joints, muscles, and tendons, and assembling them into a life-sized anthropomimetic structure. All actuation is through passively compliant elements, providing emergent synergies through cross-coupling and load-sharing. We have now reduced joint friction almost to natural levels, further enhancing the human-like movement qualities.



Goal #2

In order to develop a theoretical basis for causal analysis in systems using compliant antagonistic actuation, we have used Transfer Entropy (TE) to analyse the information flows between antagonistic muscles in a basic 'anthropomimetic' double pendulum simulator. Initial results show that antagonistic muscles yield very similar measurements, that maximising information transfer can serve as a useful guide to controller quality, and that similarly structured body parts may be identified by their similar information transfer.

Goal #3

Taking a classical approach, we have developed a novel approach to the problem of compliant antagonistic actuation by assigning different roles to each actuator. At any time, one actuator will exert force on the actuated element to produce the desired movement – this is the 'puller' - and the other will move to maintain some minimum tension – the 'follower'. The key source of theoretical difficulty lies in switching the roles appropriately. We have solved this problem, developing a single-joint controller that yields excellent performance, and is provably stable.

In order to use physics-based modelling approaches effectively, it will be necessary to capture situations rapidly using distal sensing (vision), and to run multiple copies of the physics-based models faster than real time. The vision problem will be solved using structure-from-motion methods using a variational optical flow algorithm. However, in order for both the vision and the modelling stages to operate with short enough latency, both will be integrated into a single system running on a multi-teraflop GPU computer.

For more information see http://eccerobot.org or contact Owen Holland (O.E.Holland@sussex.ac.uk) Funded by the European Commission FP7 ICT Cognitive Systems and Robotics Programme. Project No. 231864.

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