Project proposal template
Graduate School studentships
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Project title	Human-assist wearable exoskeleton robot
First Supervisor	Dr — Yahya Zweiri
Second Supervisor	Necip Sahinkaya
School	Mechanical and Automotive Engineering
Other member of supervisory team (no more than three KU supervisors in total)	Olga Duran
Specific requirements beyond 2:1 degree	

Project summary **(max 4,000 characters)**

Problem statement

Wearable powered-exoskeletons require a combination of a high-energy power source and efficient actuators in order to provide the energy level and frequency response desired for exoskeleton functionality. Pneumatic artificial rubber muscles have demonstrated their ability to enhance load-carrying capabilities of human muscles but a novel control system with force feedback need to be developed to enhance the system speed, capability and comfortably, thus making the system more natural. Wearable exoskeletons robots are currently being used in different areas, such as military, agriculture and medical welfare. More importantly, exoskeleton suits allow patients with partial disability to function fully.

PhD deliverables

The proposed research study shall address the problem of controlling wearable exoskeleton suits. An adaptive force feedback control approach optimizes control model parameters utilizing muscle surface electromyography and strain gauges data will be investigated and developed. Then the adaptive control scheme controls a curved pneumatic rubber muscle, by modulating air pressure of the muscle as a function of the system output requirements. The muscle surface electromyography brings the interaction to the neural level, thus making the system more user-friendly.

Curved artificial muscles will be used, such muscles capable of a curved operation and there is no need for torque conversion mechanisms compared with linear actuators. The curved muscles are also friendly wearable.

The solution delivered by the proposed PhD would be intelligent, incorporating architecture for the adaptive control scheme and air delivery regulation. The study would include extensive development, simulation and validation of the algorithms under a range of human and environmental conditions.

Key PhD stages:

1. Understand existing system architecture
2. Development of online muscle model parameters prediction algorithm
3. Development of estimation algorithm
4. Design and implement an adaptive force feedback control scheme
5. Test and evaluate performance *in silico* utilising offline data
6. Test and evaluate performance, final algorithm tuning and validation of solution benefits

Solution technical overview

The human-assist wearable exoskeleton suit constituting the deliverable of the proposed PhD study will retrieve curved muscle's model parameters in real time. The system would take into account parameter uncertainties and changes in the curved muscle parameters occurring over time.

The relationship between contraction of a curved rubber muscle and the supplied air pressure is non-linear; an experimentally-setup will be developed to estimate the muscle mechanical model parameters. These artificial muscles are expected to behave in a fashion similar to that of human skeletal muscles, which can be modelled as three degrees of freedom spring-damper system.

The human-assist wearable exoskeleton suit will incorporate joints forces and angular position measurements and an online estimation algorithm of the end-effector force (load). The estimation algorithm would relate end effector load to supplied air pressure.

The adaptive force feedback control approach optimizes control model parameters utilizing muscle surface electromyography and the estimator output. Then the exoskeleton could be controlled by the user's motion intention in real time and that it is useful for augmenting arm performance with neurological signal control.