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Four Bar Parallel Actuated Architecture for Exoskeleton Applications Involving the Shoulder, Hip, Wrist, and Ankle

-Background

The field of exoskeleton robotics is dominated by devices that utilize serial actuated architectures. A serial architecture is like a human's limb anatomy, as it represents a series of linkages coupled by actuated joints. This architecture is used by most robotic devices but is not an ideal choice for many exoskeleton applications due to poor dynamic performance.

An alternative to serial actuation is parallel actuation – which uses multiple parallel sets of actuated linkages working in unison to achieve the same motion. Parallel actuation can offer superior dynamic performance over serial actuation but is not widely used in the field due to its architecture being much more complex. There is a need for simple parallel architectures that are still dynamically superior to their serial counterparts.

Invention Description

Researchers at Arizona State University have developed a novel parallel actuated exoskeleton architecture with spherical workspace that can be used to augment human spherical joints, like the ankle, hip, wrist and shoulder. This structure consists of three actuated four-bar mechanisms that are positioned around the human joint and work synergistically to manipulate the joint appendage. The parallel architecture is unique to the field of exoskeleton robotics and offers both kinematic and dynamic advantages over traditional serial actuated architectures commonly used for similar applications.

This novel parallel architecture also offers flexible placement of its actuated substructures. This can be advantageous when integrating the design onto a greater exoskeleton system that may already have features in place that cannot be moved or contacted, such as a power source, controls, and support structures.

This innovation is covered by US Patent Application No. [16/387,152](#).

Video demonstrations of each of the respective joints can be viewed at the following links:

Ankle: https://youtu.be/DpQU1r_L4E

Shoulder: <https://youtu.be/ZCDfTpBZPro>

Hip: <https://youtu.be/D0NffowFy3w>

Wrist: <https://youtu.be/0RL1S33PbU4>

Potential Applications

- Exoskeleton for human spherical joints (e.g., ankle, hip, wrist, and shoulder)

Benefits & Advantages

- Short moment arm (reduces resultant torque applied at joints by external forces)
- Reduced energy cost during operation (low end effector inertia)
- High end effector acceleration
- Minimal positioning error
- High potential mechanical stiffness
- Does not have to occupy center of rotation

Related Publication: [A new parallel actuated architecture for exoskeleton applications involving multiple degree-of-freedom biological joints](#)