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A Spherical Parallel Manipulator Architecture for Shoulder Robotic Exoskeleton

In robotic mechanisms, a parallel manipulator uses multiple actuated parallel linkages to synergistically control the motion of the end-effector. In comparison to the more common serial chain manipulator, parallel manipulators typically offer better end-effector performance in terms of precision, stiffness, velocity, and torque generation. Parallel manipulators also exhibit lower effective inertia than serial chain manipulators. This results in lower energy costs associated with the manipulation of the end-effector. Furthermore, it is possible to design a parallel manipulator such that it does not occupy its own center of rotation. This is particularly important for the growing industry of wearable robotics, where many devices must operate in conjunction with the user joint kinematics. However, complex human joints, such as the wrist, shoulder, hip and ankle, operate with multiple intersecting rotational degrees of freedom. Therefore, there is a need for a parallel manipulator that can increase the degrees of freedom in robotic limbs and mimic complex human joints.

Researchers at Arizona State University have developed a new spherical parallel manipulator (SPM) for human-robot interfaces that features modular motion coupling. It uses three linear actuators, with each actuator capable of three degrees of freedom - two rotational (roll and pitch) and one translational (stroke). The device mechanically couples these actuators to create modular motion coupling, such that pitch and linear stroke are made to be dependent. The roll of each actuator is not directly constrained, but rather set by the synergistic movement of all three actuators. This unique coupling of motion allows for the kinematics to be constrained to a single solution. The result is a device that provides low inertia, low energy cost, high velocity, and precise spherical motion.

Potential Applications

- Prosthetics
- Human-robot interfaces
- Artificial limbs
- Robotics

Benefits and Advantages

- Novel Architecture –
  - The use of motion coupling in a parallel actuated system mimics a shoulder joint.
  - The motion coupling effect allows for spherical joints to be used at the end-effector rather than universal joints.
- Increased Efficiency - Improved range of motion with lower energy requirement.

- Proven Results – A working prototype has proven to be effective in trials.

For more information about the inventor(s) and their research, please see

Dr. Panagiotis Artemiadis's directory webpage

Dr. Hyunglae Lee's directory webpage