Recycling Human Energy

Managing and Recycling Pneumatic Energy to Actuate a Lower Limb Exoskeleton

Rachel Rieger[1], Jacob Rosen[2]
[1]University of California Davis
[2]Bionics Lab, University of California Santa Cruz

Original LEX Design

New LEX Design

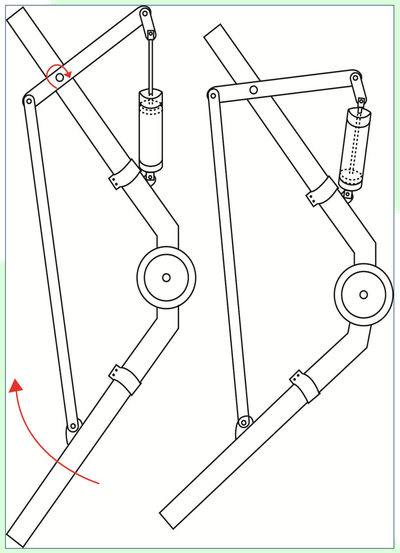


Figure 1.
Mechanical movement of the piston cylinder assembly being fully compressed from a small knee bend.

Objective

- Lower limb exoskeletons allow soldiers to carry heavy loads without enduring the weight.
- Existing lower limb exoskeletons are either gas or battery powered and therefore are impractical for extended periods of time.
- The LEX , UCSC's Lower Limb Exoskeleton, will harvest energy absorbed from the knee and ankle joints and expel it through the hip and ankle joints.
- Research aim: the mechanical redesign of the pneumatic system to recycle energy.

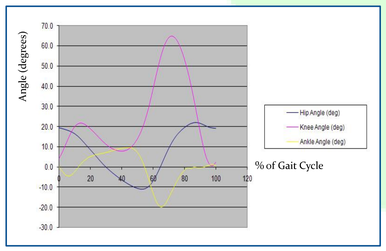


Figure 2.
Flexion (+) and Extension (-) angles of the hip, knee, and ankle joints exhibit during gait cycle.

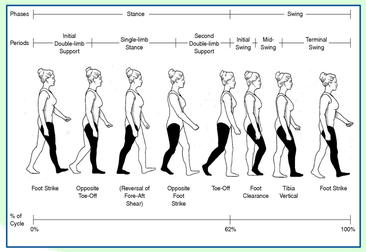


Figure 3.
Phases, periods, and percentages of the gait cycle.
Cite: Journal of American Academy of Orthopedic Surgeons

This work was sponsored by the National Science Foundation, SURF-IT (surf-it.soe.ucsc.edu) Research Experience for Undergraduates Program. NSF grant Award No. CNS-0852099. In addition, thanks to the University of California, Santa Cruz.

Approach

- Energy in the form of pressure is stored in a reservoir tank and released back into the joints by voltage controlled solenoid valves.
- Timing of valve openings is a balance of LEX movement fluidity (longer release) versus the amount of work produced (instantaneous release). (Fig. 4,5)

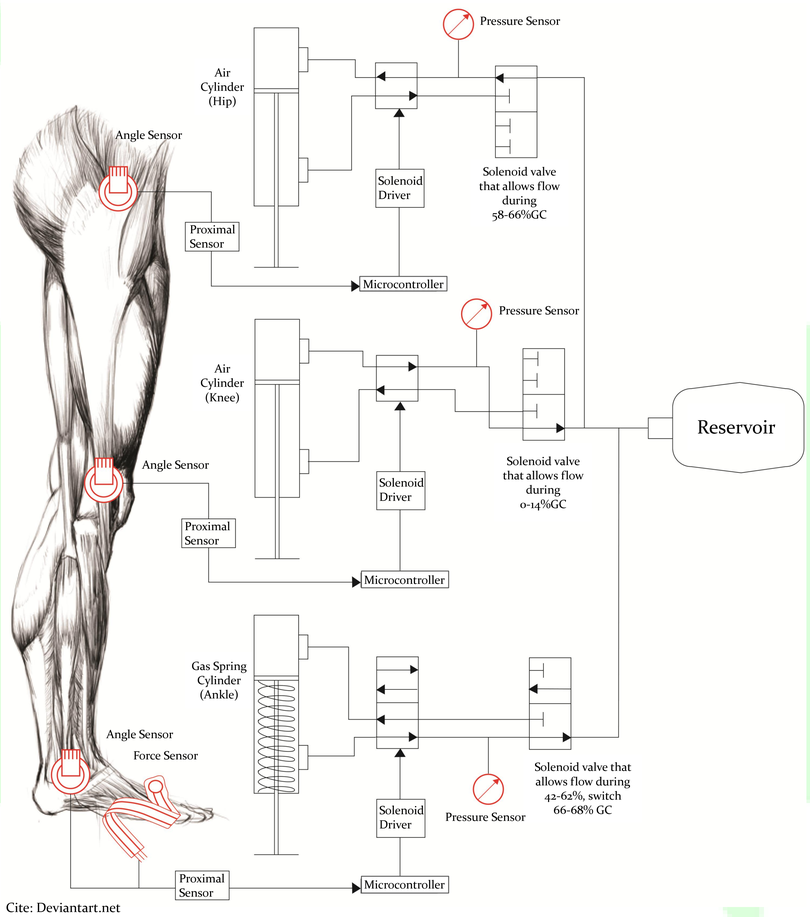
New knee design:

- Lever and fulcrum to turn a 20 degree knee bend into a large displacement on a piston cylinder assembly. (Fig. 1)
- Optimized to the least bulky design while maintaining maximum forces. (Fig. 6)

New ankle design:

- Compresses a gas spring cylinder upon flexion to harvest energy.

Pneumatic Schematic



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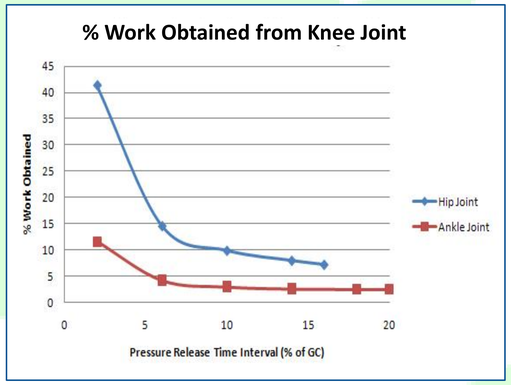
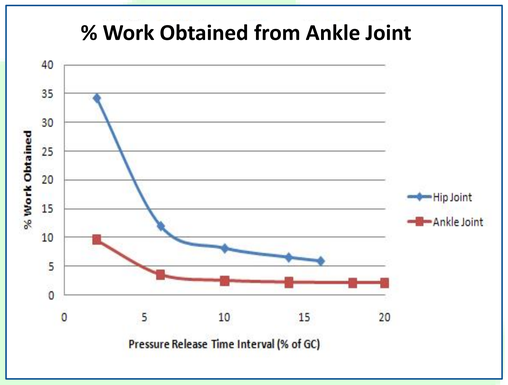


Figure 4.
For a quasi-static process: Percent of work created for normal 1.3 second gait cycle extruded to respective joint by harvested energy from hip joint based on release time.

Figure 5.
For a quasi-static process: Percent of work created for normal 1.3 second gait cycle extruded to respective joint by harvested energy from ankle joint based on release time. Does not include work done by spring.



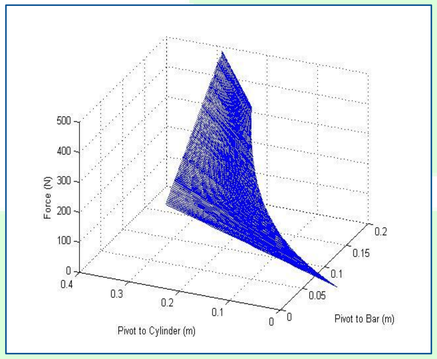


Figure 6.
Optimization of varying positioning of lever fulcrum system and force it produces. Force calculated from peak ground reaction force at 2% of the gait cycle.

Results

- The LEX will be able to support approximately 10% of the wearers load from recycled energy.
- No time restraints or pneumatic power supply required.
- Pressure accumulated from recycled knee energy is released to the hip for .156 seconds.
- Pressure accumulated from recycled ankle energy is released back to the ankle for .026 seconds.
- Allows soldiers in the field, and eventually backpackers, to support heavier loads with less muscle restriction and fatigue.