# ON THE UTILITY OF AN ACTIVE DAMPING LEG FOR SAFE LANDING FROM A FREE FALL

Mechanical Engineering

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## OBJECTIVE

To design & build a new 2D monopod that can:

- withstand high impacts
- land safely from freefalls of heights over 3 m

Demonstrate the use of active damping to:

- Effectively dissipate energy accrued from the free fall

## MOTIVATION

•Emulate humans' ability to land without injuries from **1.5 – 2 m** jumps**,** and exploit this capability to perform extreme maneuvers like in parkour

•Currently, no humanoid robot can perform such extreme jumping motions

•Augment exploration & disaster response performance

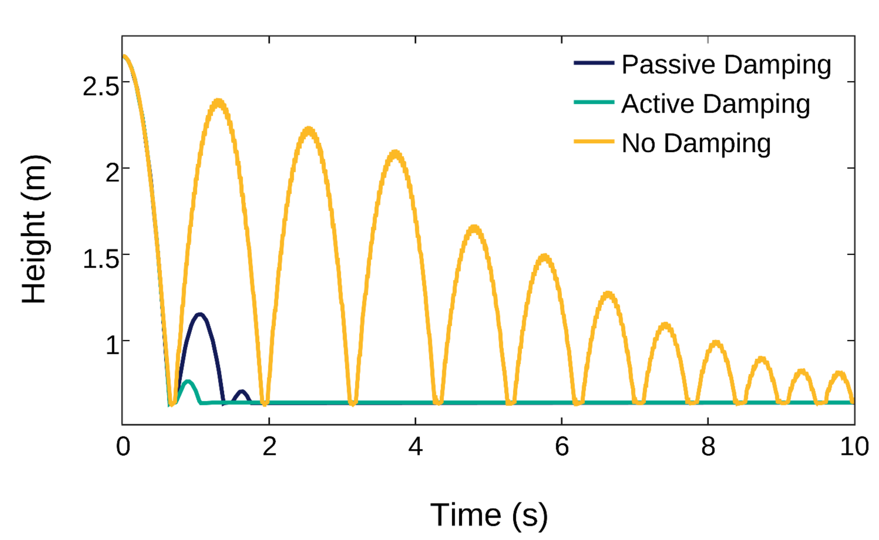
•Technology could lead to the development of newer prosthesis

•Helps safeguard hardware from damage due to high impacts

## WHY ACTIVE DAMPING

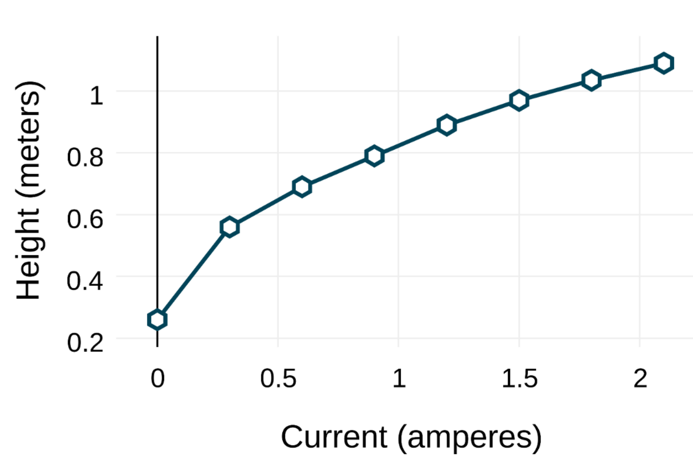
- Passive damping only capable of critically damping small range of jump heights
- Adapt hardware to maximize performance of distinct tasks in real time
- Proven to improve shock absorbing performance in cars

Center-of-Mass Trajectory for a 2m Drop Height




*The Good Active Damper*

Max. drop height possible with no bounce




## PROTOTYPE OVERVIEW

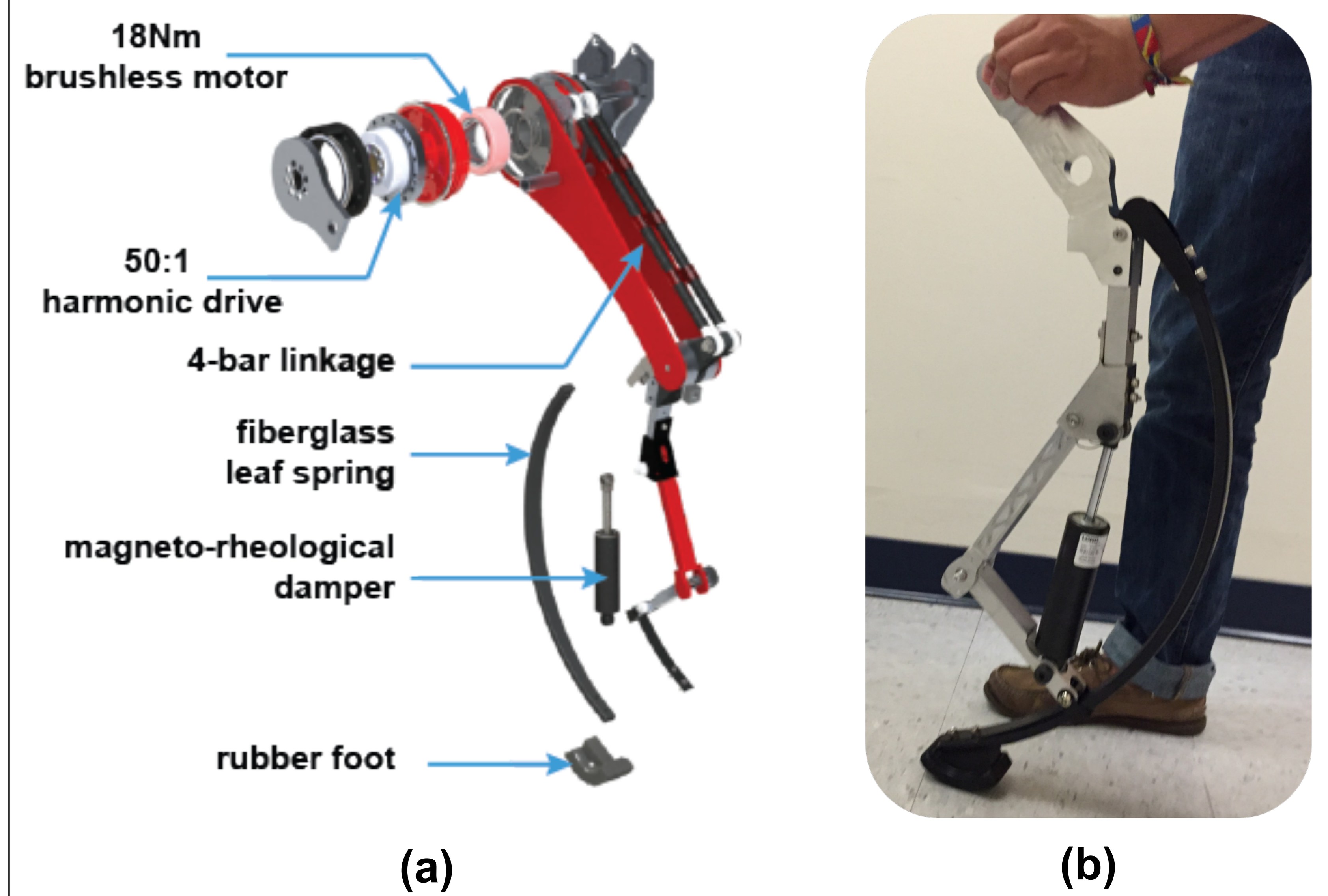



**Figure 1**: (a) Exploded view of leg design CAD, (b) picture of built lower limb

*MR Damper Model*

$$F_d(x,\dot{x},i) = (\alpha_0 + \alpha_1\sqrt{i})\tanh[\beta_0\dot{x} + \gamma_0\,\mathrm{sgn}(x)] + \delta_0 x + \eta_0\dot{x} + \kappa_0$$

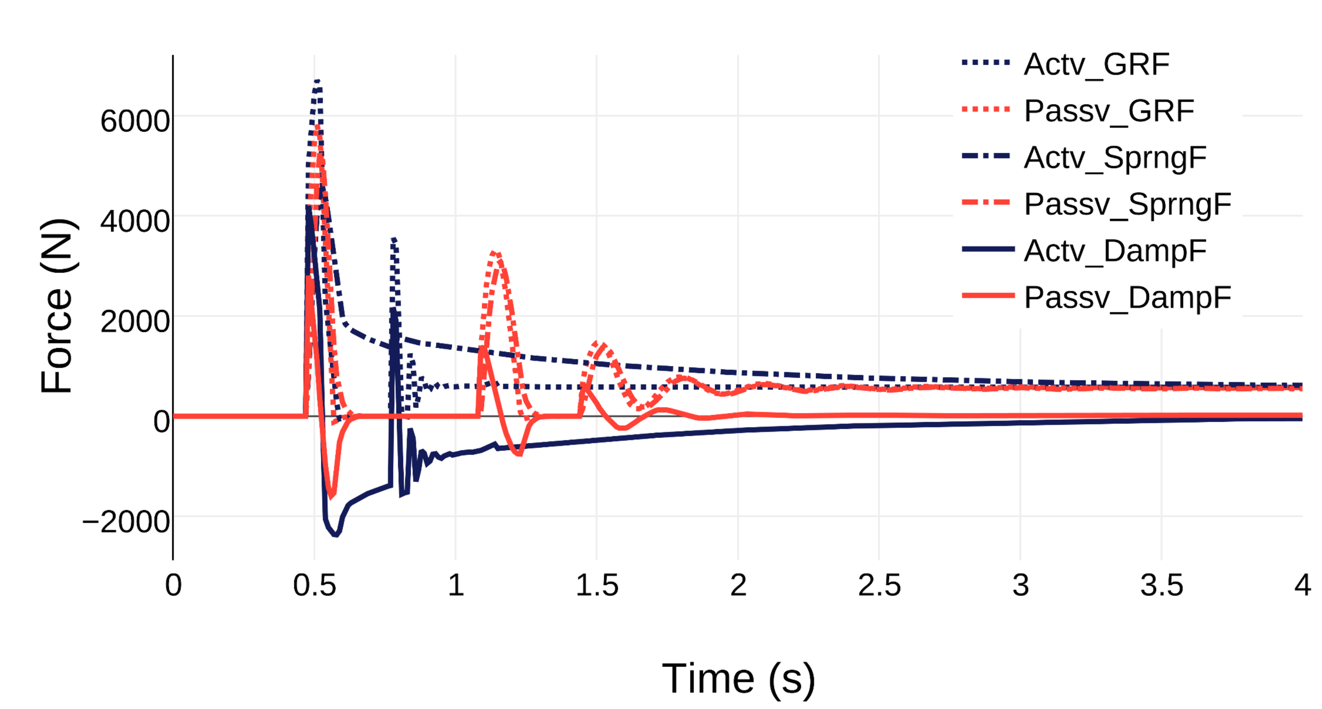
*Leafspring Model*

$$F_s(x) = \frac{-2Ewh^3}{(L-x)^3}x$$

## SIMULATION RESULTS

Developed simulation in SimMechanics based on the CAD model to test the mechanical design and damper performance.

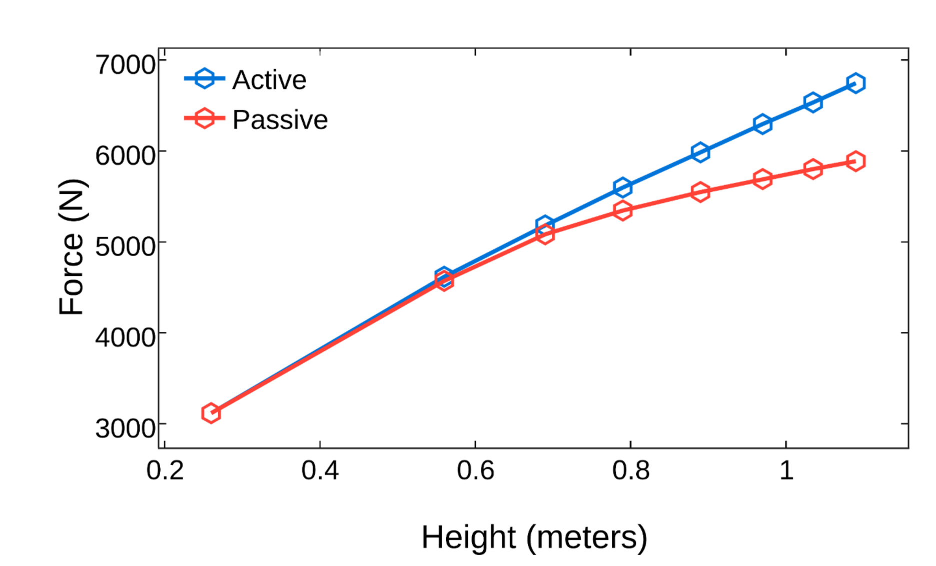
Active & Passive Damping Dynamics for 1.1 m drop height



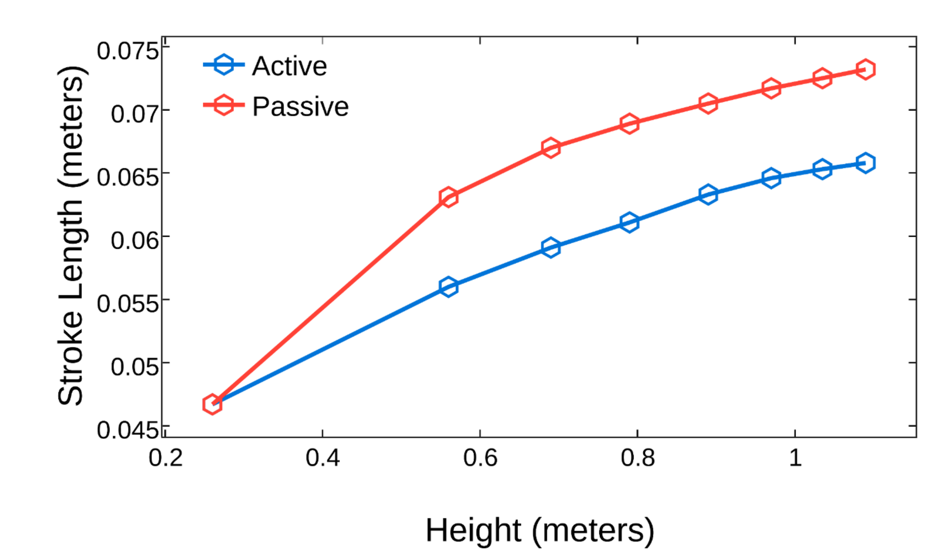

*Energy Dissipated by Active Damper >> Passive Damper*

## SIMULATION RESULTS CONT.

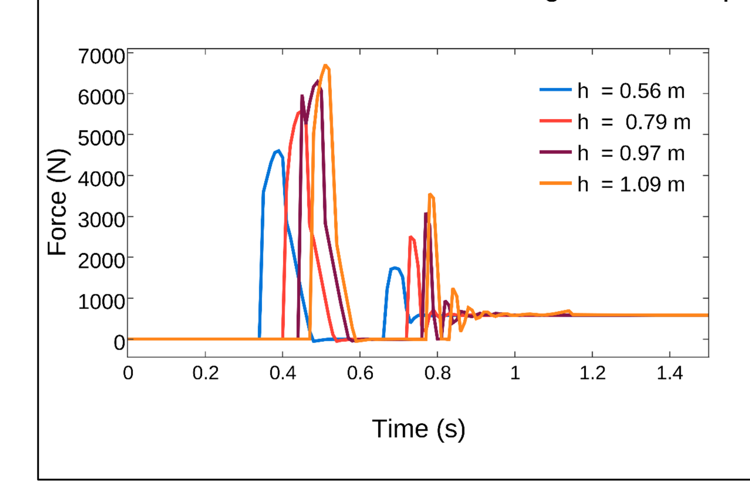
Max Impact Force v/s Drop Height



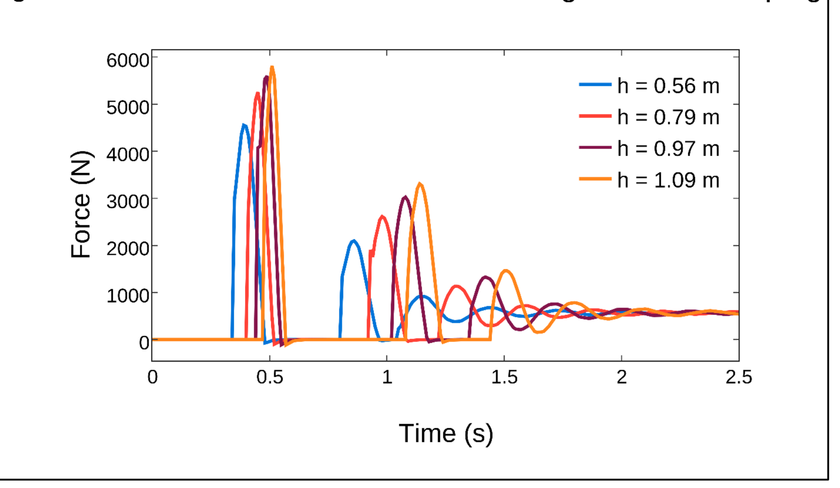

Max Stroke v/s Drop Height




Ground Reaction Force Profiles using Active Damping




Ground Reaction Force Profiles using Passive Damping




## CONCLUSION

- Upon impact, stationarity is achieved in fewer bounces (and about 2 times faster) using active damping.
- Energy dissipated by the active damper is greater than that of the passive damper.
- Having a non-constant current input through out the motion lead to lower impact forces but longer settling times
- Results look promising but still far from optimum

## OPEN QUESTIONS

- How to increase energy dissipated by the damper?
- How to minimize peak impact force?
- How to cancel MR Damper's high passive damping?