The Energetic Cost of Adaptive Feet in Walking

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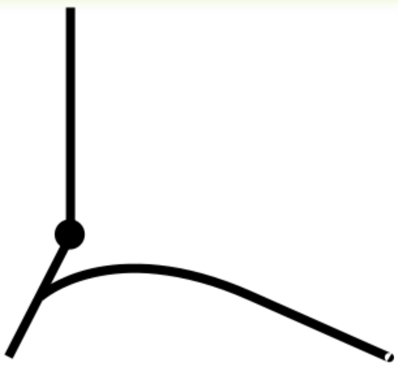
Related Studies

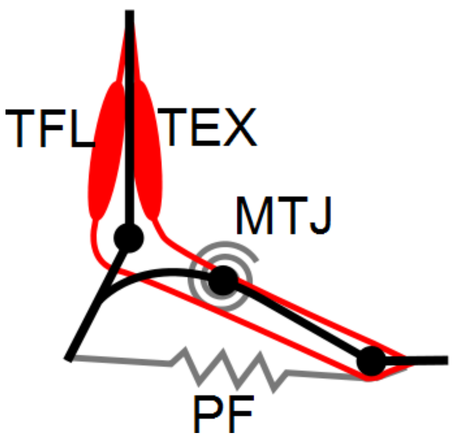
Variable height (Kang et al., 2010)
Variable stiffness (Hashimoto et al., 2010)
Toe (Zhang et al., 2010, Zhu et al., 2011)

Stiffness change (Briggs et al., 2001)
Ball cushion (Bojsen-Moller et al., 1976)
Windlass mechanism (Hicks, 1954)

How Much Do We Pay for Adaptive Feet?



Baseline foot

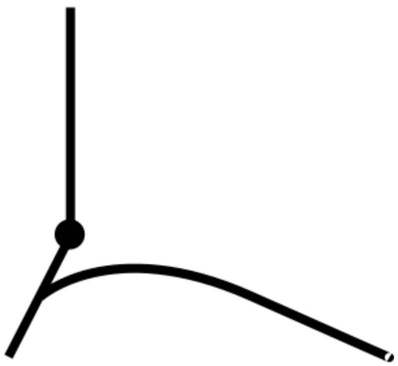


Human foot

Absorbs impacts
Provides secure grip

Requires additional muscles
Provides less power transfer

How Much Do We Pay for Adaptive Feet?



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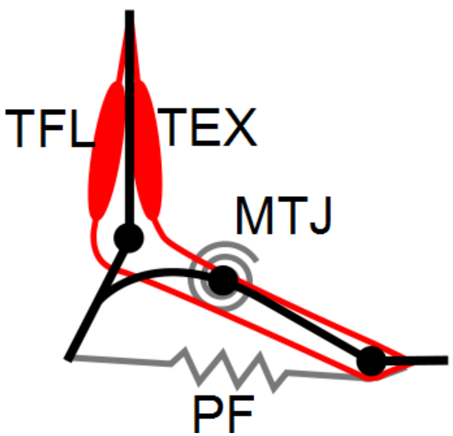

Human foot

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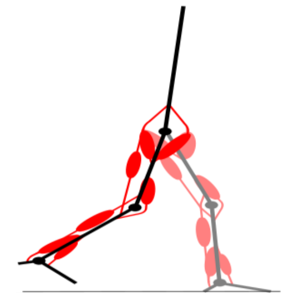
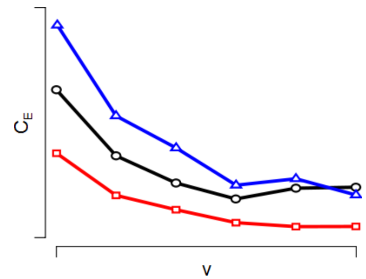
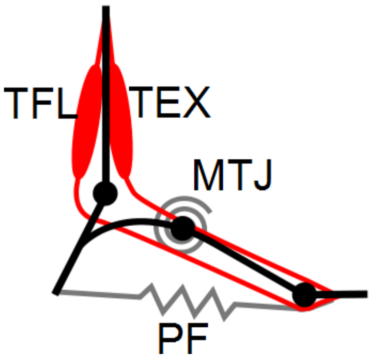


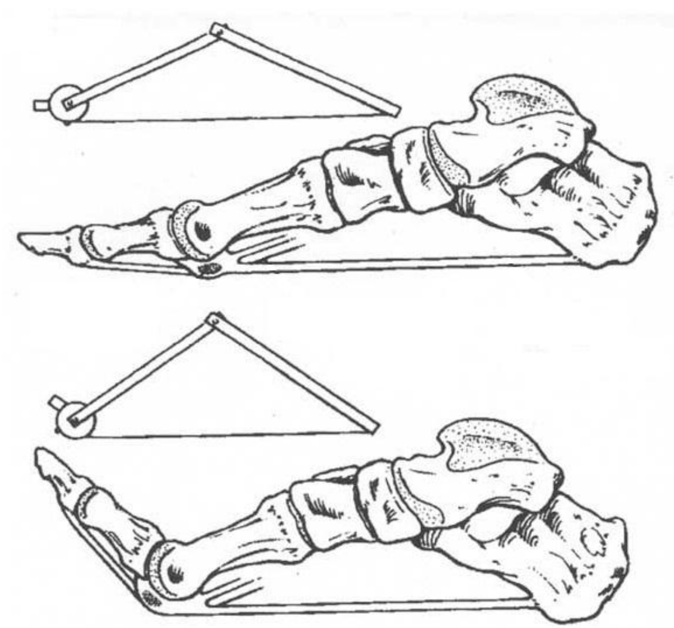
2. Results

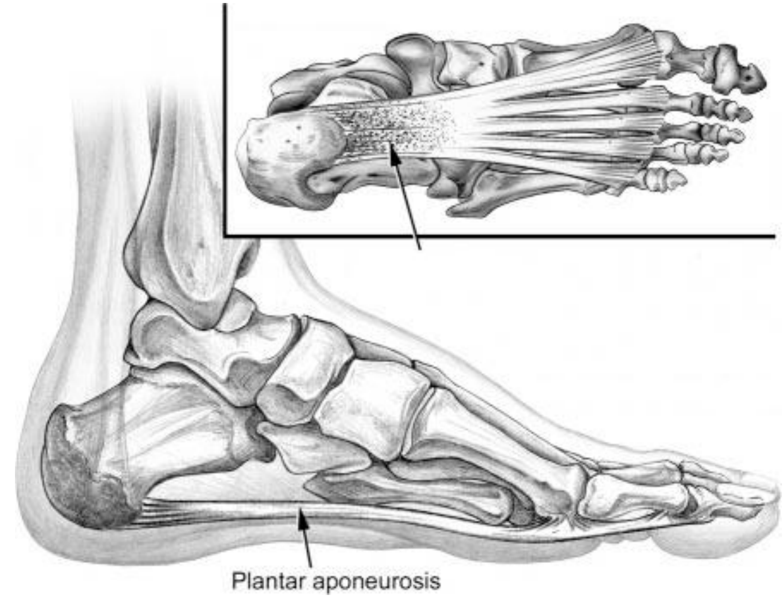


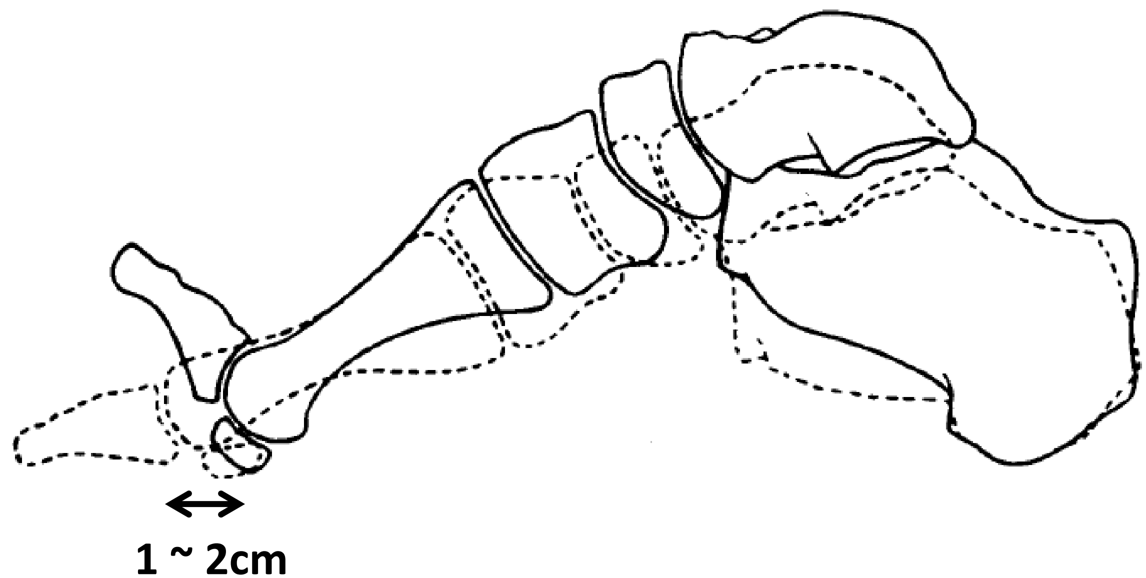
3. Future Direction

The Windlass Mechanism









(Hicks, 1954 II, Bolgla et al., 2004)

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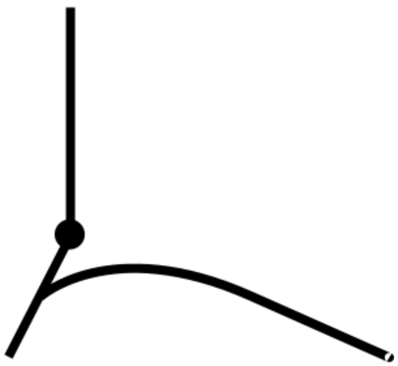

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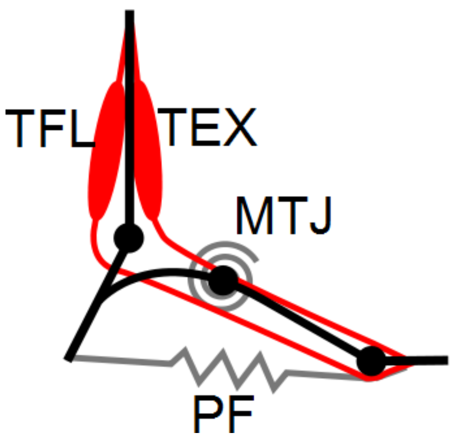
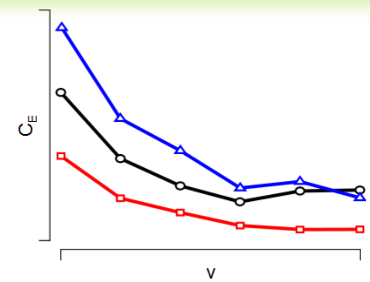


Human foot

1. Neuromuscular Model

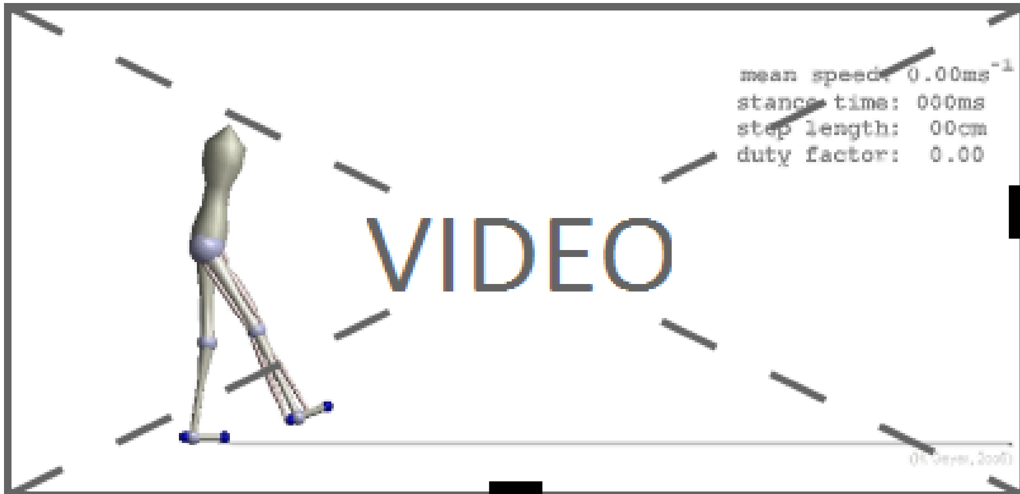
2. Results



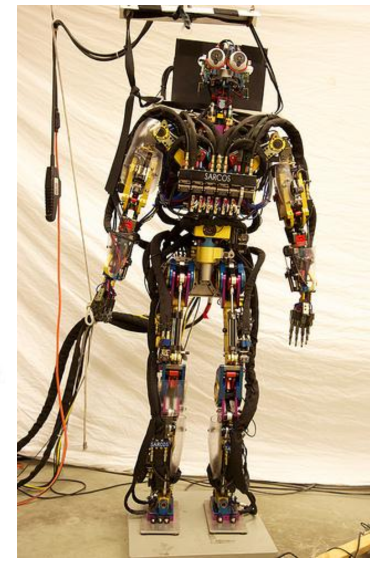
3. Future Direction

TFL, TEX (Yamaguchi et al., 1990), PF (Gunther et al., 2002), MTJ (Hashimoto et. al, 2010)

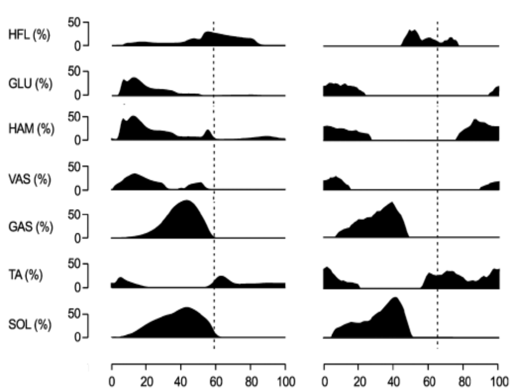
Neuromuscular Model

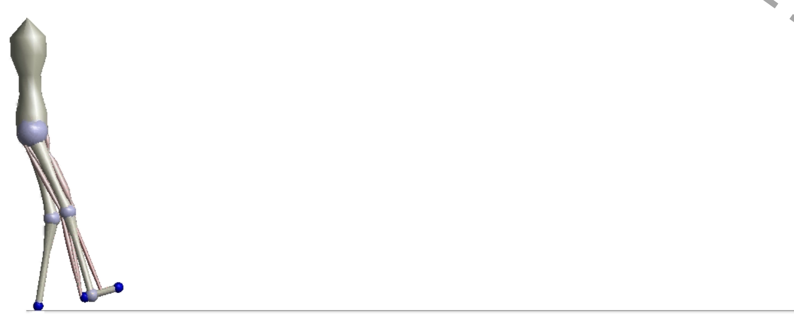


Control algorithm for robotic platforms



Research platform for understanding human



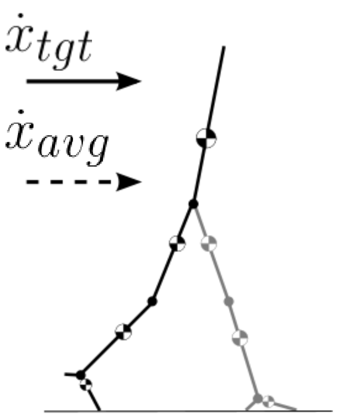


(Geyer et al., 2010)

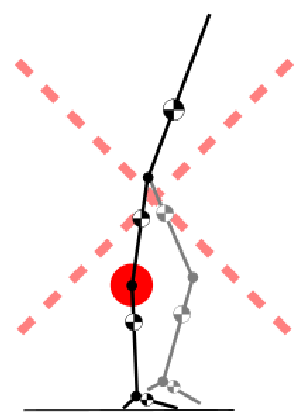
Neuromuscular Model: Optimization (CMA-ES)

$$J = \left| \dot{x}_{avg} - \dot{x}_{tgt} \right| + P + C_E$$

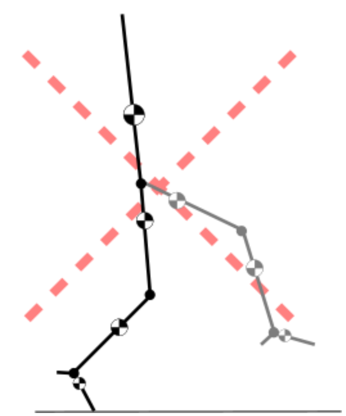
Target speed



Pain



Energy cost



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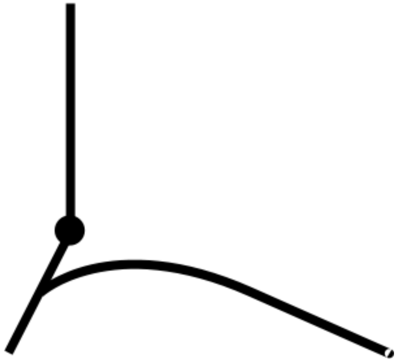
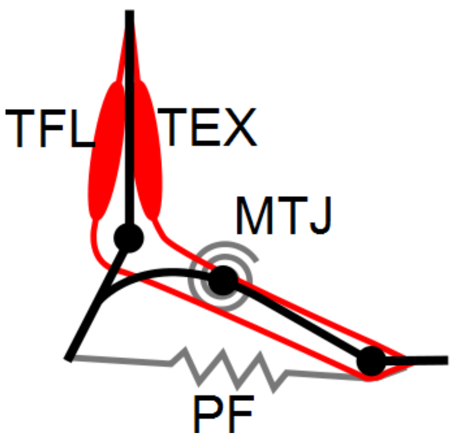


Baseline foot



Human foot

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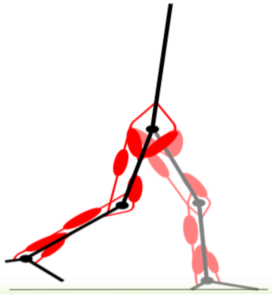

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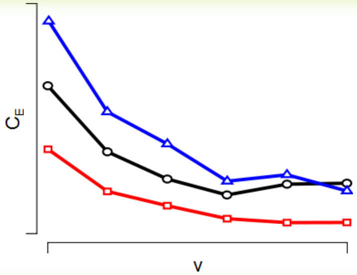


3. Future Direction

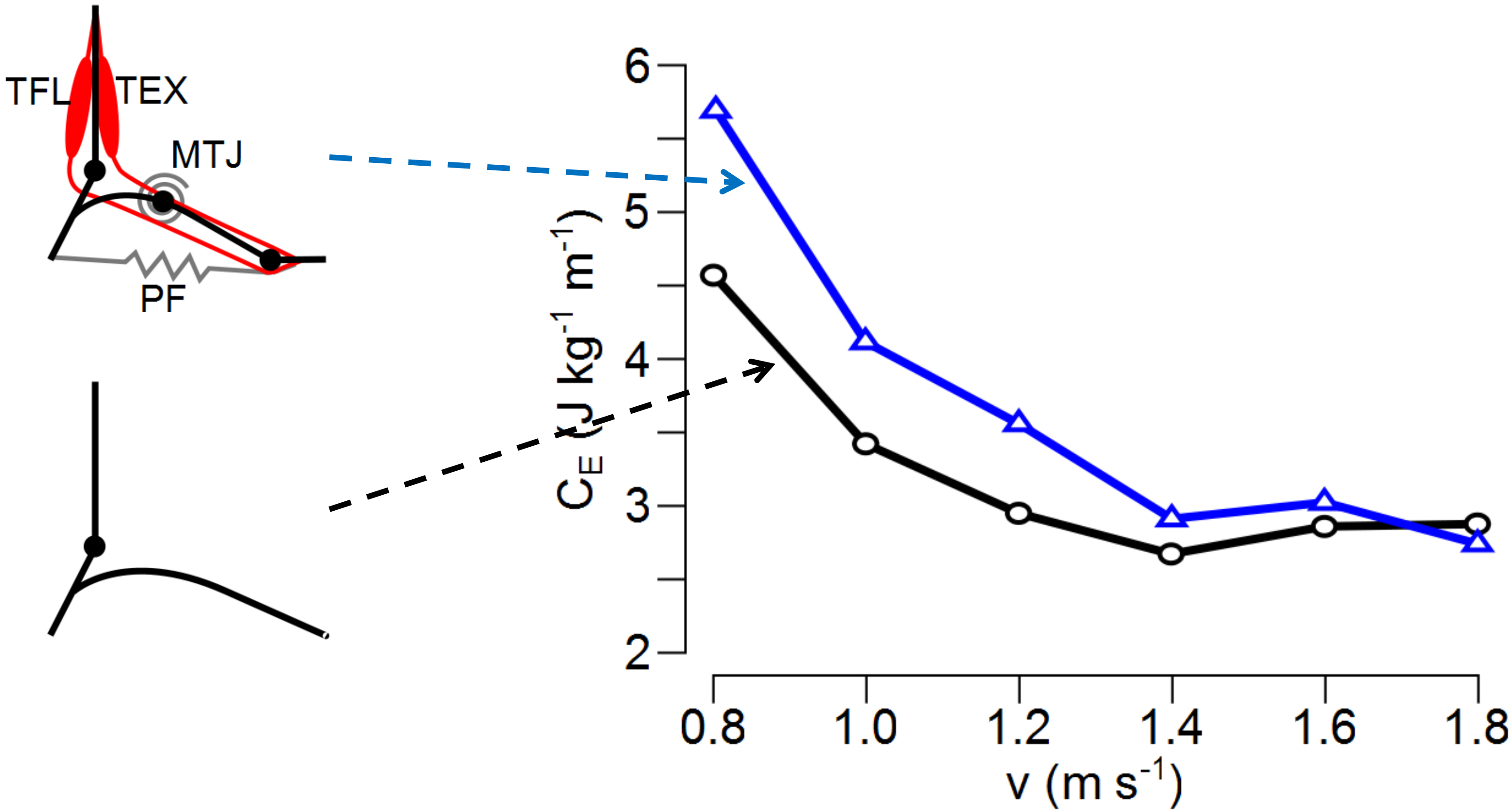
Neuromuscular Model: Simulation

Baseline, $0.8 ms^{-1}$

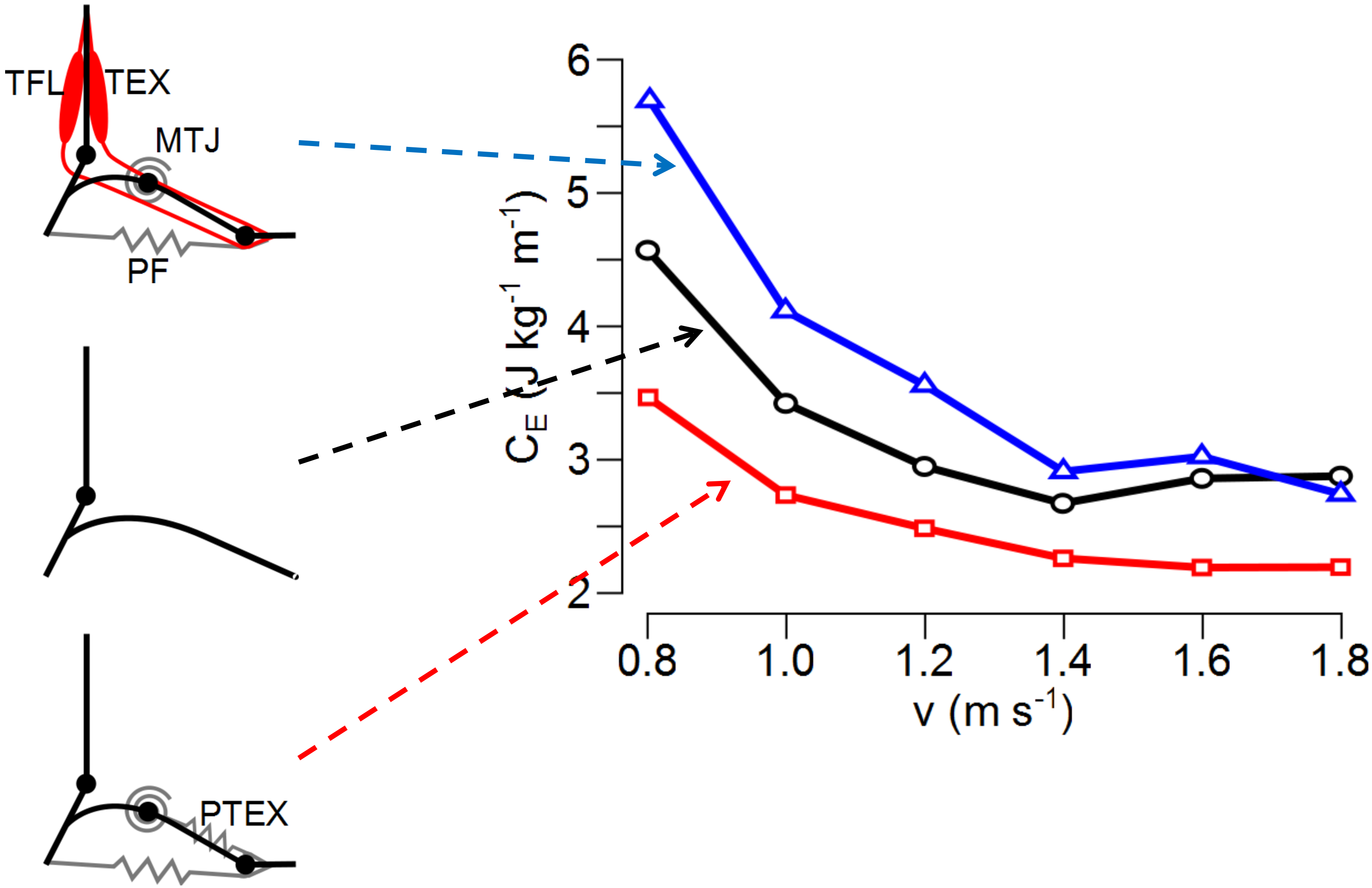
Human, $1.8 ms^{-1}$

Human walking speed (Murray et al., 1984)

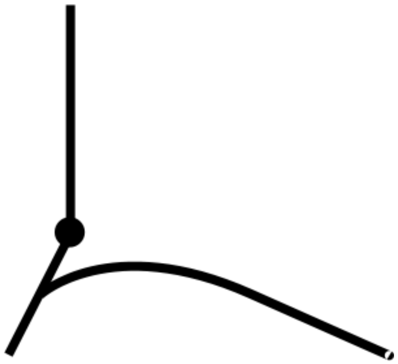
Result I: Human Feet Incur About 20% More Energetic Cost up to 1.2ms^{-1}



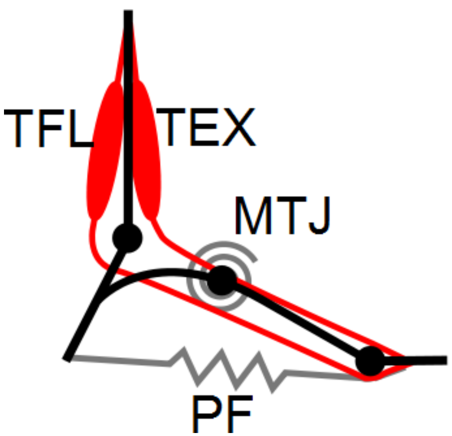
Result II: Passive Feet Reduces the Energetic Cost by 15% or More



How Much Do We Pay for Adaptive Feet?



Baseline foot



Human foot

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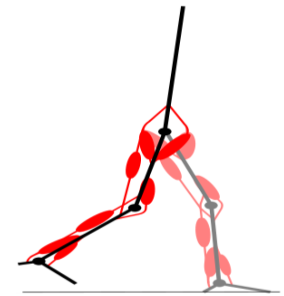
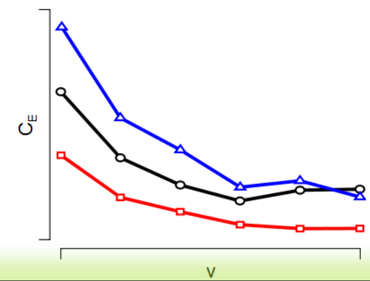


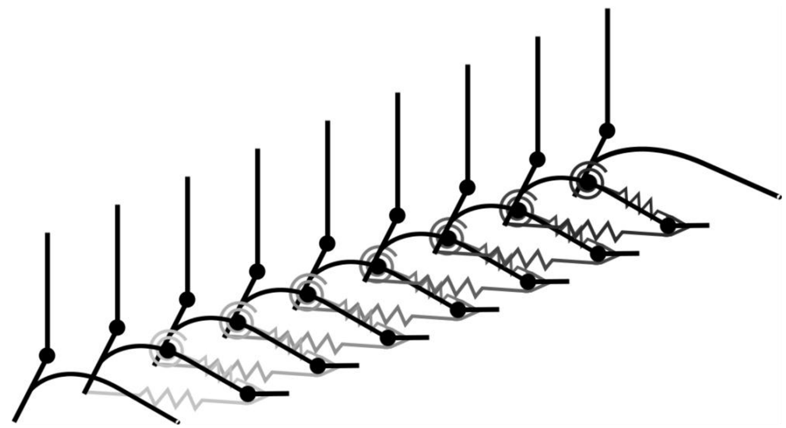
2. Results



3. Future Direction

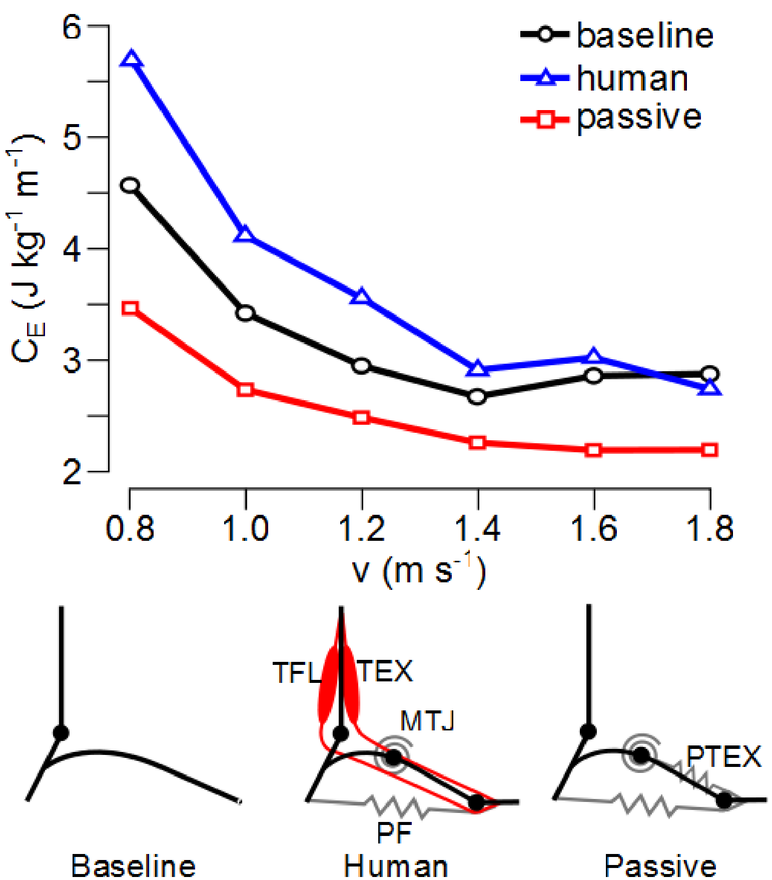
Current and Future Directions

Simulation studies to interpret the result



Development of a robotic foot

Conclusion



1. Human Feet Incur About 20% More Energetic Cost up to 1.2ms^{-1}

2. Passive Feet Reduces the Energetic Cost by 15% or more