Active Knee Assistance For Prevention of Slip-Induced Falls During Human Walking

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Abstract

Slip and fall is a major cause of injury in the elderly and outdoor workers. Slip often leads to a fall, when a subject steps on a slippery surface and does not realize that the front foot is slipping, while continues to swing the trailing foot forward. This leads to the subject's center of mass being positioned posterior to the base of support formed by both legs and backward fall occurs. This paper presents the development of a wearable knee device aiming to assist and prevent slip-and-falls.

Introduction

- Foot slip is one of the major causes for falls especially among adults over 65 years [1].
- Preventing slip-induced falls and associated injuries would reduce economic and societal costs.

In our previous works :

- slip detection system and slip-and-fall prevention assistive device (ROKAD) [2,3].

The working principle in our device:

- providing assistive torque to the knee of the swing leg instead of the stance leg.

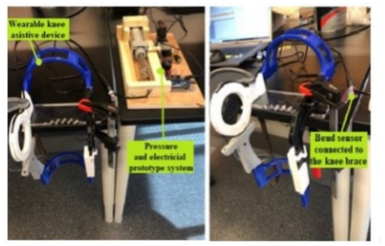
The goal of this study:

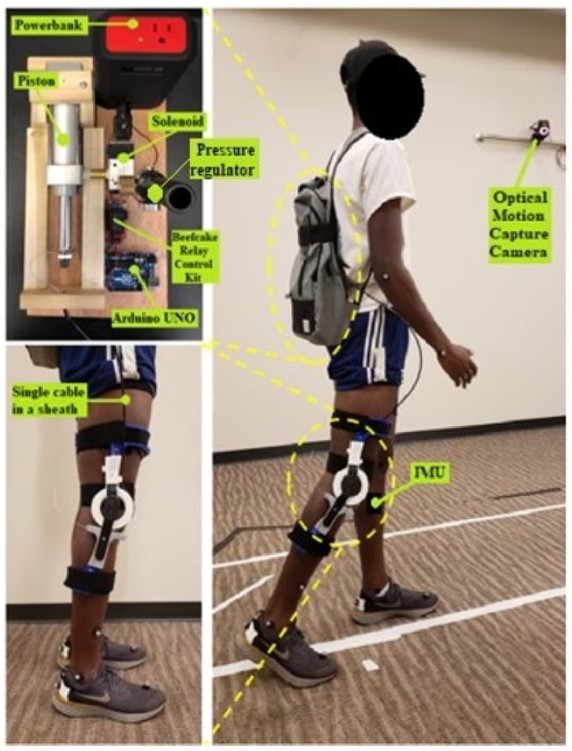
- design a lightweight knee exoskeleton device to assist the elderly and certain high-risk outdoor workers to prevent falls during slip occurrence.

KNEE ASISTIVE EXOSKELETON DESIGN

The wearable device consists:

- a lightweight knee brace driven by Bowden cable **(0.49 kg) ,**
- compressed gas actuation electro-mechanical system **(2.17 kg).**

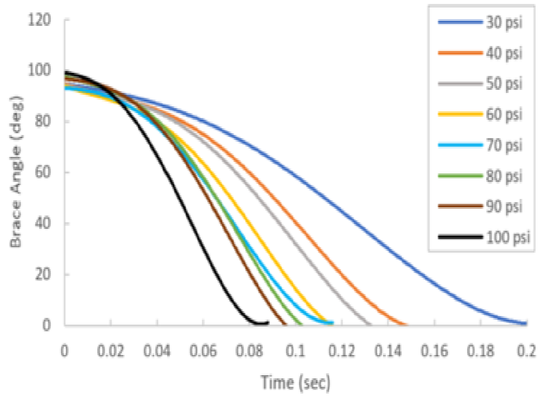


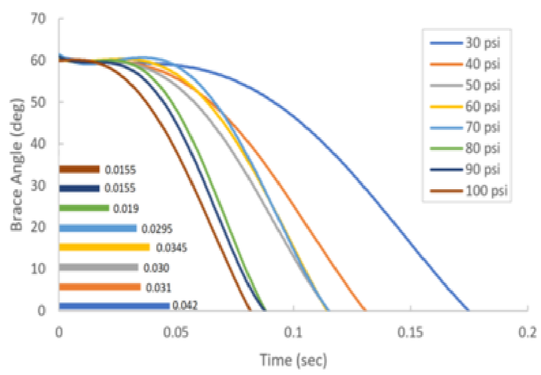


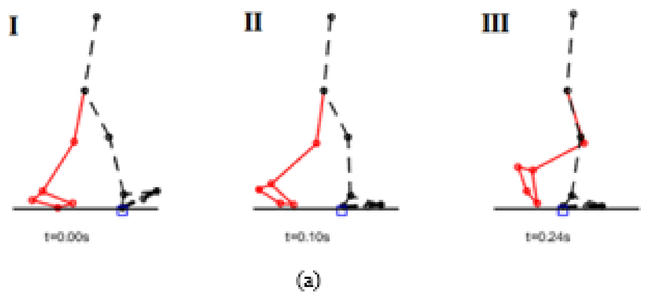
Results

Bench testing of the device showed:

- the device can provide assistive torque and extend knee for 60 deg (~max knee angle) in less than **0.14 sec**.
- The shortest average actuation time for device extension from 90 to 0 degrees is only **0.082 seconds.**







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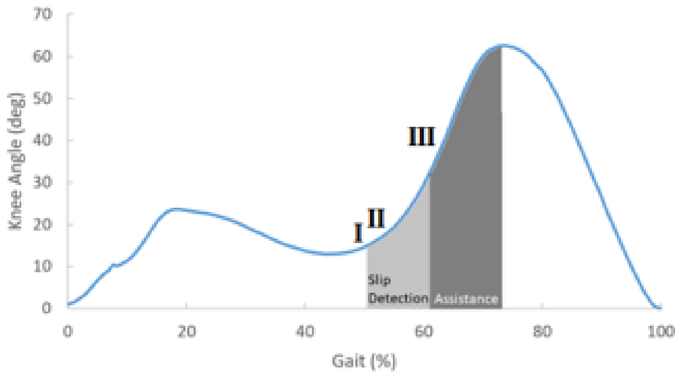

Conclusion

- We proposed a novel active slip recovery control strategy by using an assistive device to extend the trailing leg during the swing phase of a slip.
- The device was specifically designed to avoid bulky stored energy sources.

The importance of the presented strategy:

- this design approach can be extended to other exoskeleton devices designed for other applications.

Future work:

- include improvements of the device design
- human subject testing to test various assistive control strategies and validate efficacy of the proposed slip recovery control strategy.

References

[1] https://nfsi.org/nfsi-research/quick-facts/
[2] M. Trkov, K. Chen, J. Yi, and T. Liu,"Inertial Sensor-Based Slip Detection in Human Walking", IEEE Transactions on Automation Science and Engineering,vol. 16, no. 3, July 2019.
[3] M. Trkov, S. Wu, K. Chen, J. Yi, T. Liu, and Q. Zhao, "Design and characterization of a robotic knee assistive device (ROKAD) for slip induced fall prevention during walking," in Proc. 20th IFAC World Congr., France, 2017.