Effect of Sensory Augmentation via Skin Stretch Feedback on Quiet Standing Balance

Yitsen Pan, Yoo-Seok Kim and Pilwon Hur

39th Annual Meeting of The American Society of Biomechanics

August 8th , 2015 | Hyatt Regency | Columbus, Ohio

MECHANICAL ENGINEERING
TEXAS A&M UNIVERSITY

HUman
Rehabilitation Group

Outline

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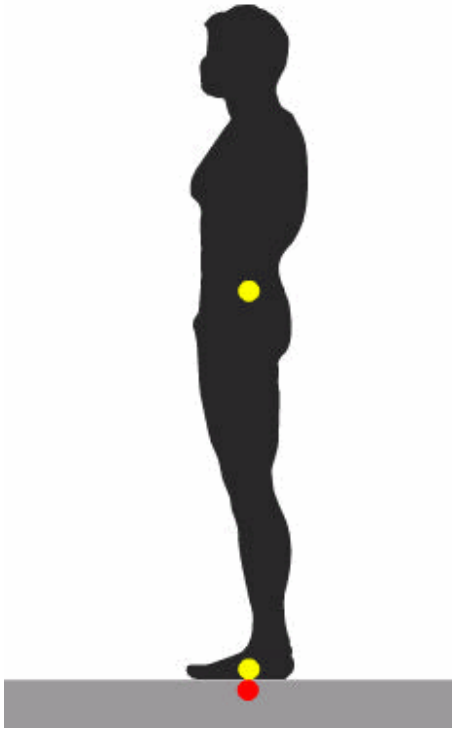
Introduction

- Human bipedal upright stance is achieved primarily by visual, vestibular, and proprioceptive sensory systems [1].
- Dysfunctional sensory systems cause postural sway and increase the risk of falling, which threatens quality of daily life [2].



Schematic diagram of human postural sway.
Center of Mass (COM, yellow dot), Center of Pressure (COP, red dot) .

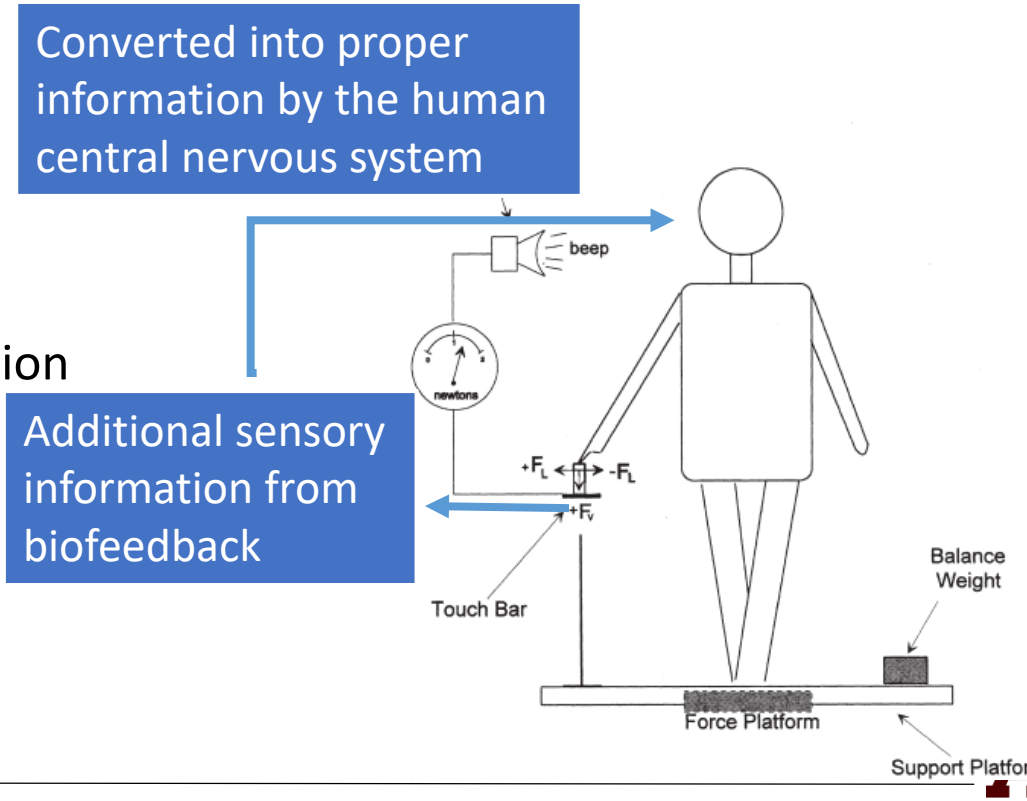
[1] R. J. Peterka, "Sensorimotor integration in human postural control," *J.Neurophysiol.*, vol. 88, no. 3, pp. 1097–1118, 2002.
[2] F. B. Horak, "Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls?," *Age Ageing*, vol. 35 , pp. ii7–ii11, Sep. 2006.

Introduction

- Light touch (contact force < 1 N) of fingers on fixed surfaces can reduce postural sway during quiet standing and walking [3].

Biofeedback

- Easily recognized.
- compensate for weak or missing sensory information



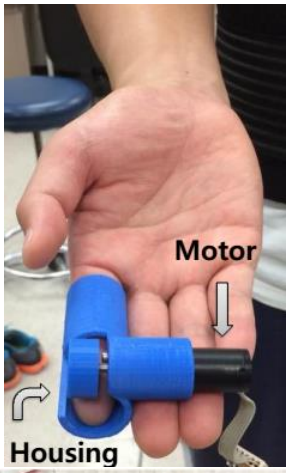
[3] Jeka, J. J. (1997). Light touch contact as a balance aid. *Physical Therapy*, *77*(5), 476–487.

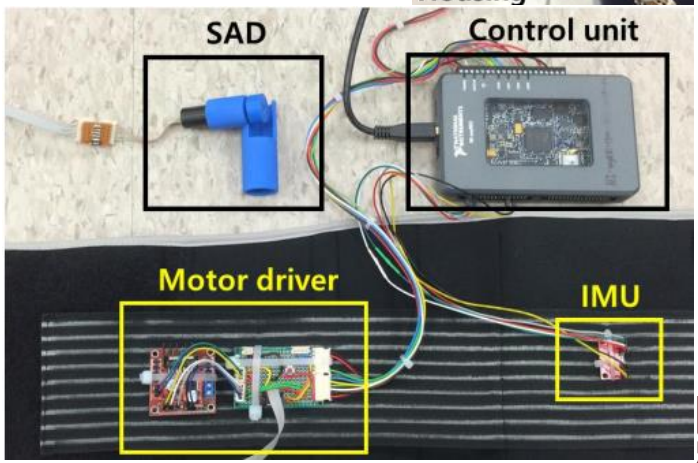
Introduction

- Objectives:
  - Development of a portable sensory augmentation system that can induce skin stretch feedback at fingertip pad.
  - Examine the efficacy of the developed device on quiet standing balance of healthy young adults for various sensory modalities.
- Hypothesis:
  - Augmented sensation via the induced skin stretch feedback enhances quiet standing balance more effectively when more sensory modalities are removed.

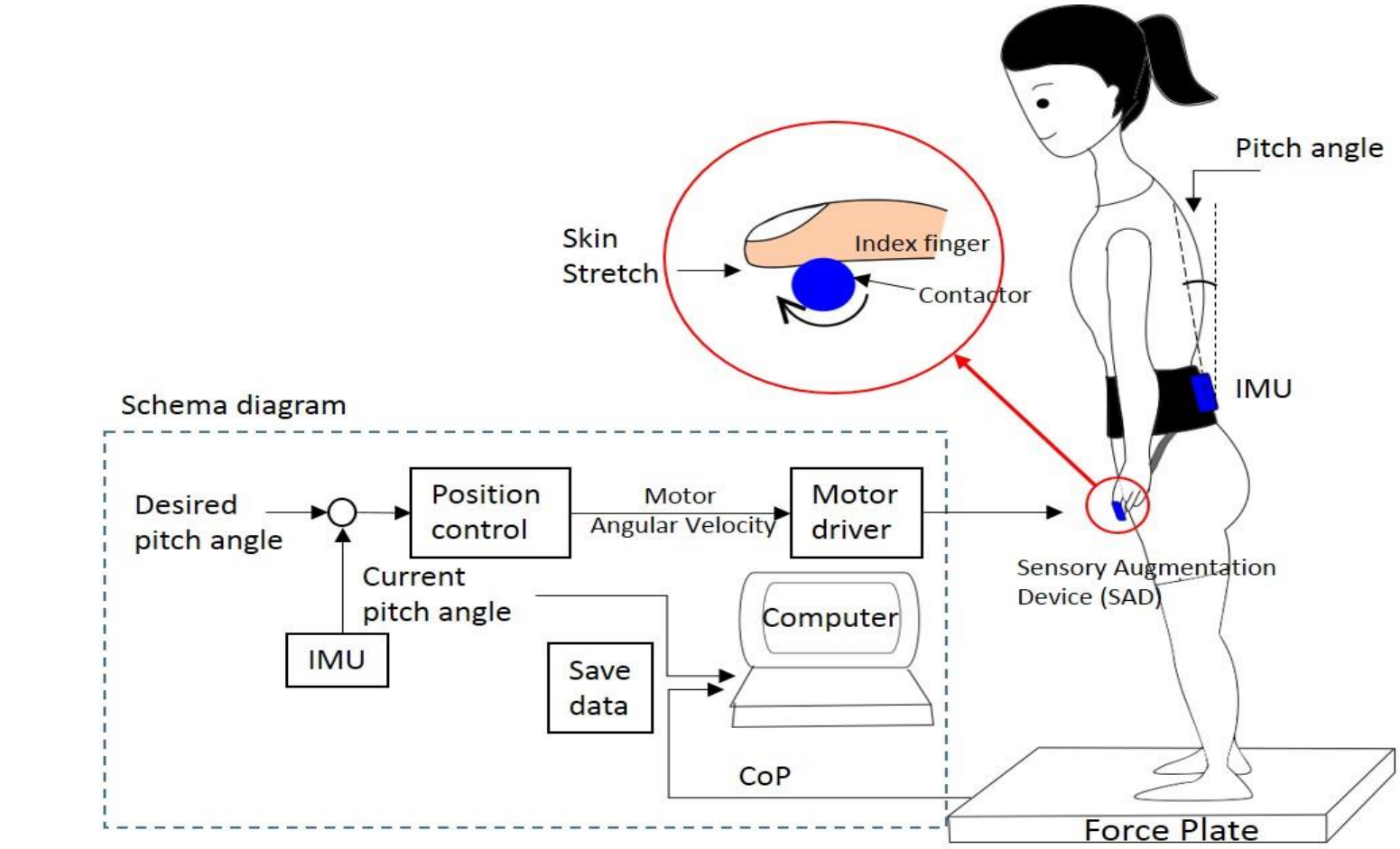
Device Design

- Our designed portable sensory augmentation system consists of
  - Sensory augmentation device (SAD).
  - Embedded control unit (myRIO, National Instruments).
  - A motor driver.
  - Inertia measurement unit (IMU).



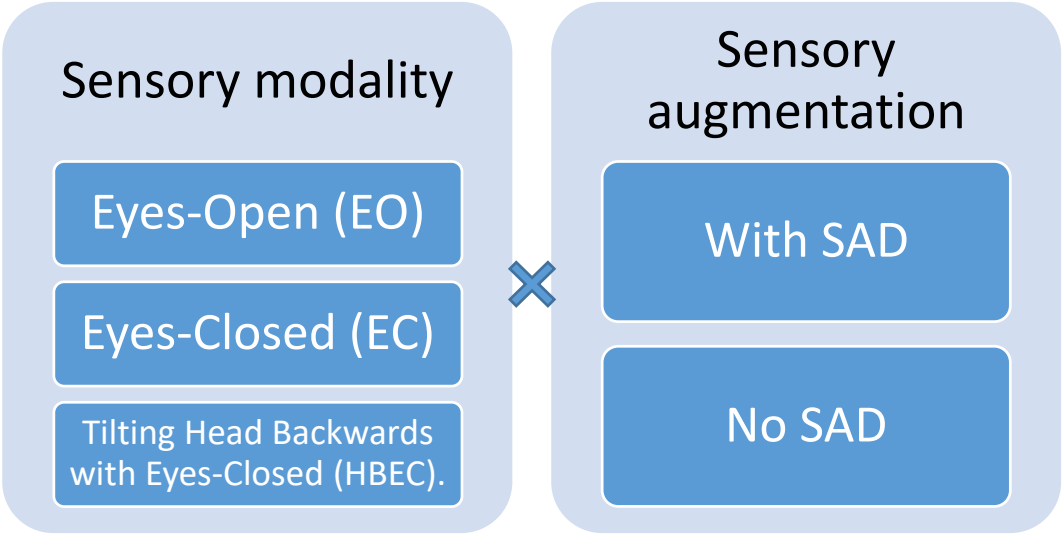


Control Strategy for Postural Sway



Methods

- Experimental Protocol
  - 30s quiet standing balance tests under six conditions were performed among 15 healthy young subjects.



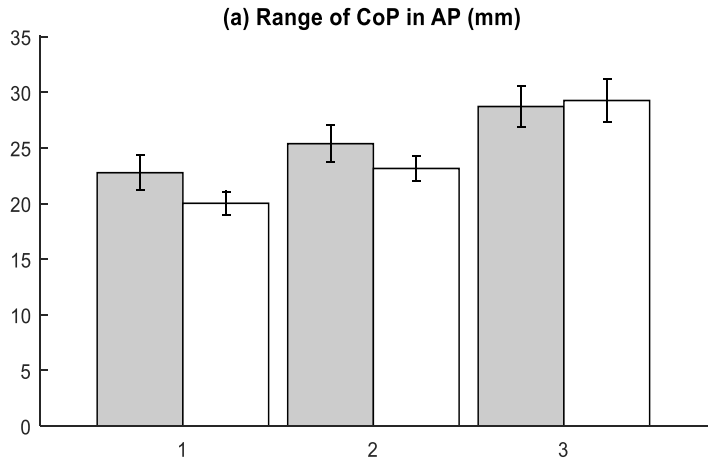
Methods

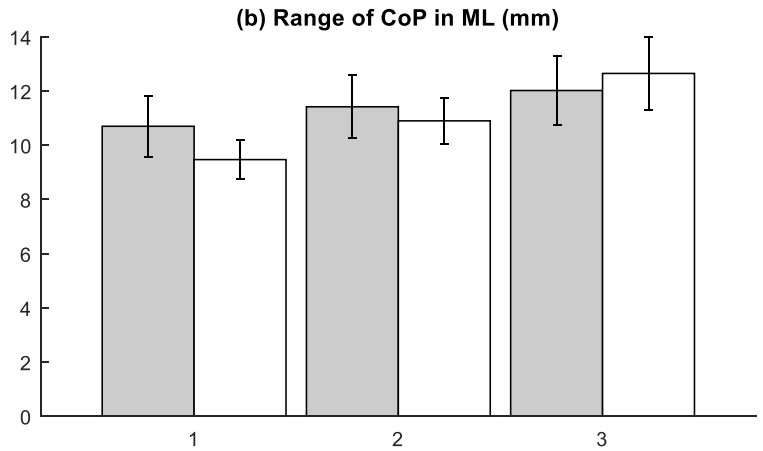
- Postural Sway Measures
  - Center of Pressure (COP) data were collected using a force plate and a data acquisition system, sampled at 1 kHz.
  - Multiple traditional COP-based measures were exanimated in both Anterior-Posterior (AP) and Medio-Lateral (ML) .
    - Range
    - Mean Velocity (*MV*)
    - Mean Frequency (*MF*)
    - Centroidal Frequency (*CF*)

Results

Range are

- ❑Greater when EO and EC with SAD.
- ❑Smaller when HBEC with SAD.





With SAD

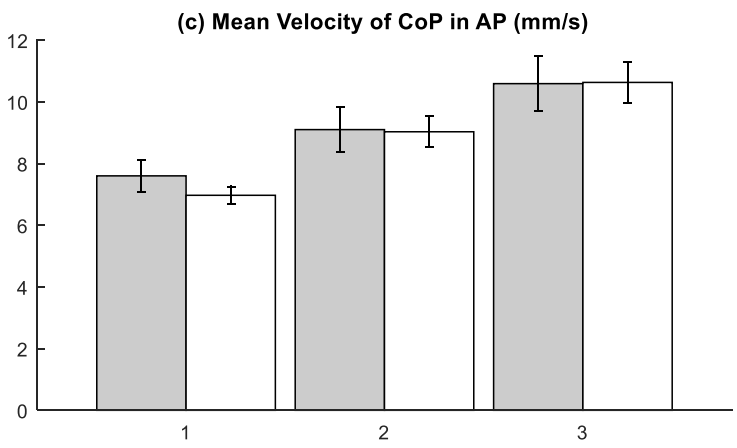
No SAD

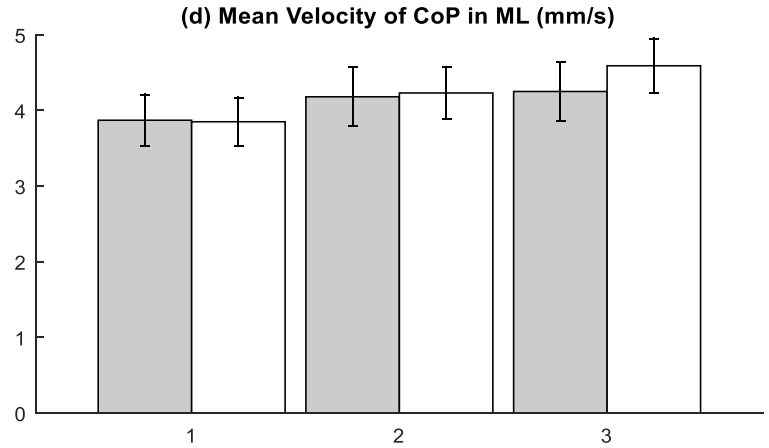
1: EO 2: EC 3:HBEC

Results

Mean Velocity are

- Without significant change or greater when EO and EC with SAD.
- Smaller when HBEC with SAD.





With SAD

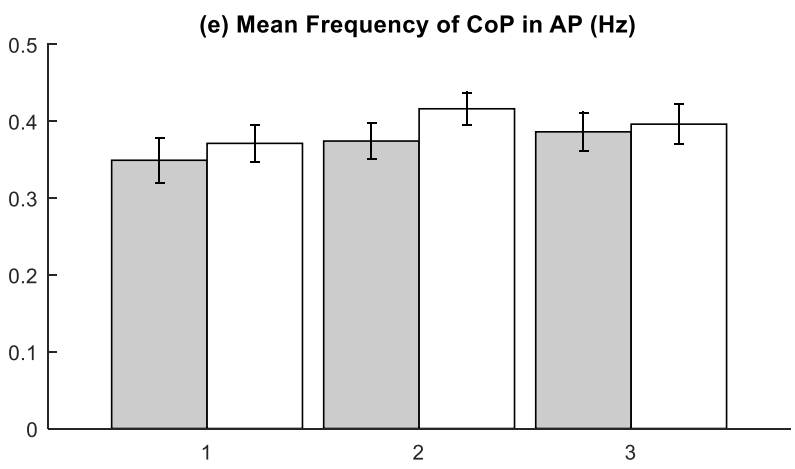
No SAD

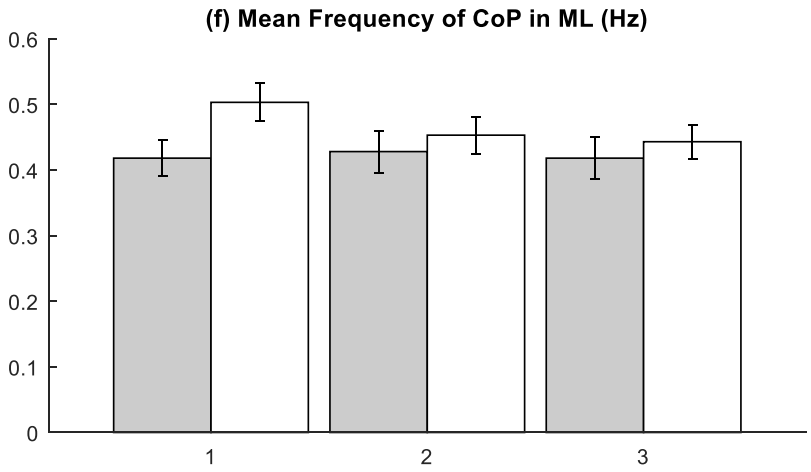
1: EO 2: EC 3:HBEC

Results

MF are

- ❑ All smaller when EO, EC and HBEC with SAD.





With SAD

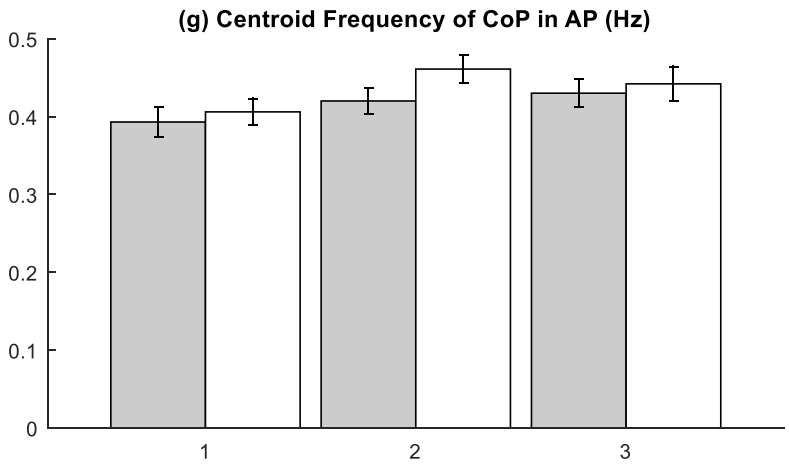
No SAD

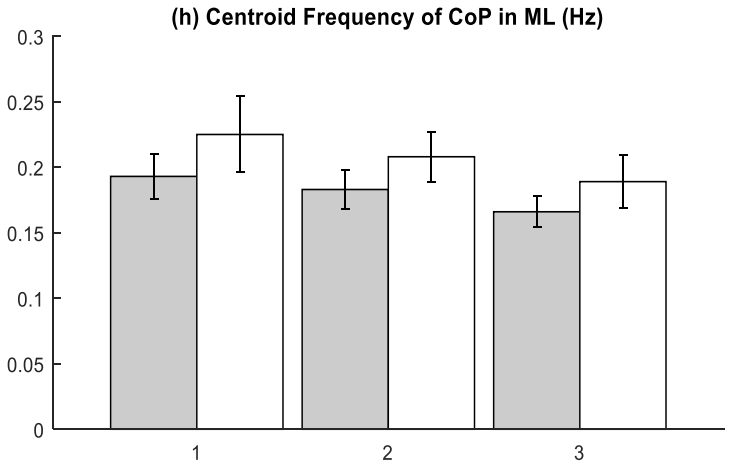
1: EO 2: EC 3:HBEC

Results

CF are

- All smaller when EO, EC and HBEC with SAD.





With SAD

No SAD

1: EO 2: EC 3:HBEC

Discussion

- Availability of sensory systems affects balance during quiet standing.
  - All the sensory systems are functional → better balance control.
  - Deprivation in visual and vestibular system lead to poorer balance control when compared to visual-impaired only people.

- Developed SAD improves postural stability more effectively as the sensory deficit level increased.
  - Range and MV decreased when sensory augmentation was provided only in the most sensory deficits condition.
  - MF and CF significantly decreased when sensory augmentation was provided in all conditions → oscillatory movements of COM was reduced.

Conclusion

- A sensory augmentation system for postural control rehabilitation has been developed using skin stretch feedback.
- The sensory augmentation due to SAD significantly improves balance.
  - Great potential in balance rehabilitation.
  - Portable device is convenient for self-monitoring and home rehabilitation.
- Future works include
  - Development of different type of controllers (e.g. velocity-based control).
  - Recruit patients with impaired sensory systems.

Thank you!

Q&A