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Proposal of Powered Foot Prosthesis Emulating Motion of Healthy Foot (PEHF)



Prof. E. Yoshitoshi Murata,
Faculty of Software and Information Science,
Iwate Prefectural University
y-Murata@iwate-pu.ac.jp

Mr. Haruki Baba,
Prof. Yukihide Nishimura

Short Biography

- Yoshitoshi Murata received his Dr. Engineering from Shizuoka University, Japan. From 1979 to 2006, he was belonging to NTT and NTT DoCoMo. From 2006 to 2020, he was a professor of Iwate Prefectural University. He retired Iwate Prefectural University end of March, 2020. He is a Professor Emeritus of Iwate Prefectural University
- Prof. E. Yoshitoshi Murata is a member of Fellow of IARIA.
- His research interests are IoT in the medical and health industry and the Factory.



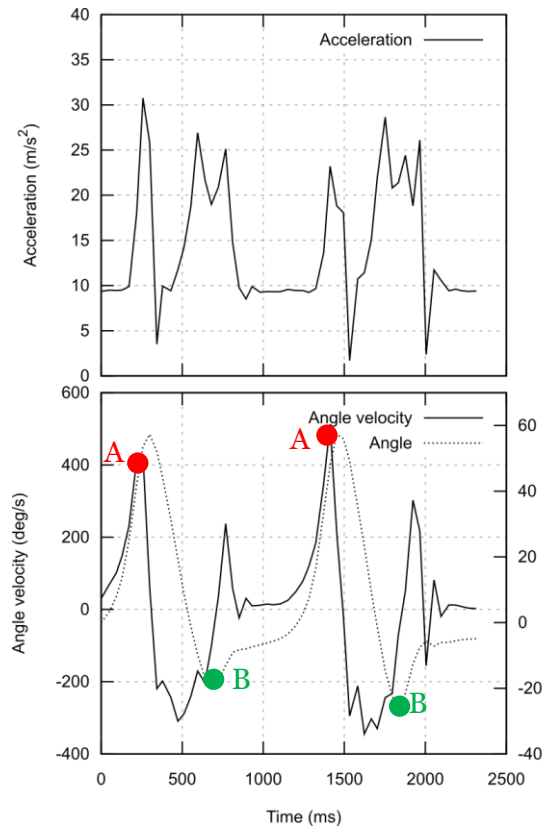
Background

- Several million people around the world live with limb loss.
- Foot prosthesis is useful to improve their quality of life, and powered foot prosthesis enables them to walk naturally.
- However, most are too expensive for most amputees to afford.
 - ◆ The prosthetic market is not open.
 - ◆ Their control systems are complex.

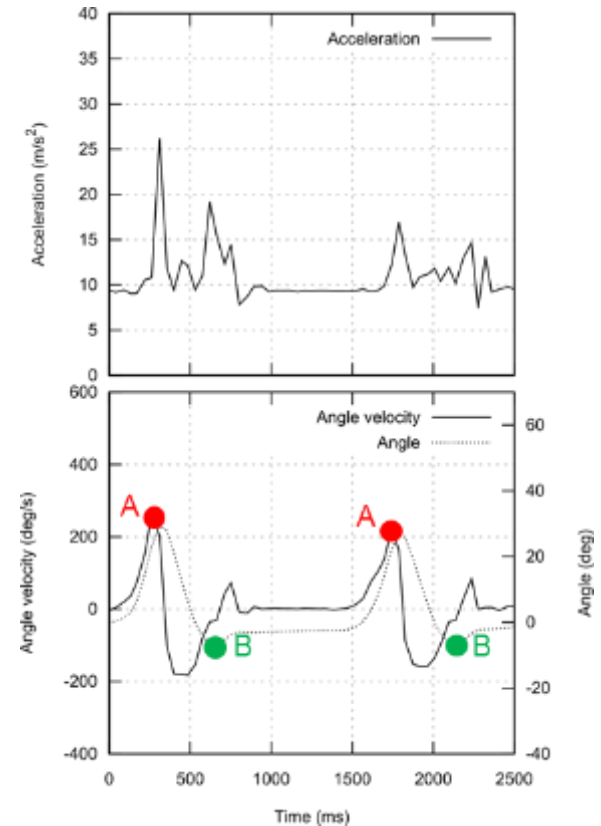
Purpose

- Developing and providing a **low price and high performance** foot prosthetic.
 - ◆ It emulates the motion of a healthy foot with a half cycle delay.
- Introducing changes of angle velocity and angle for both healthy feet during walking.
- Introducing a prototype of proposed foot prosthesis.

Differences in gait between hemiplegia patients and healthy people

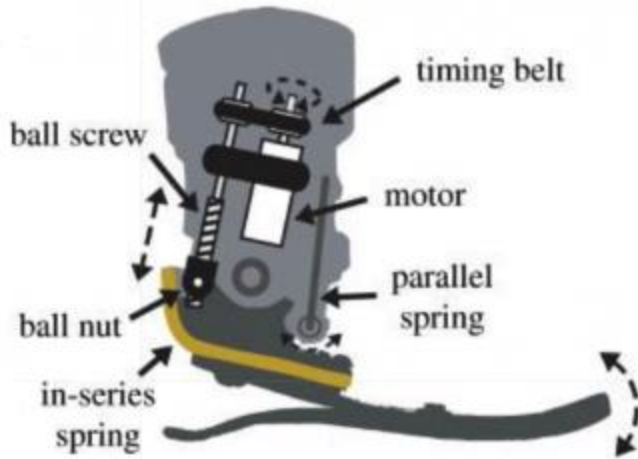


[Unimpaired participant]

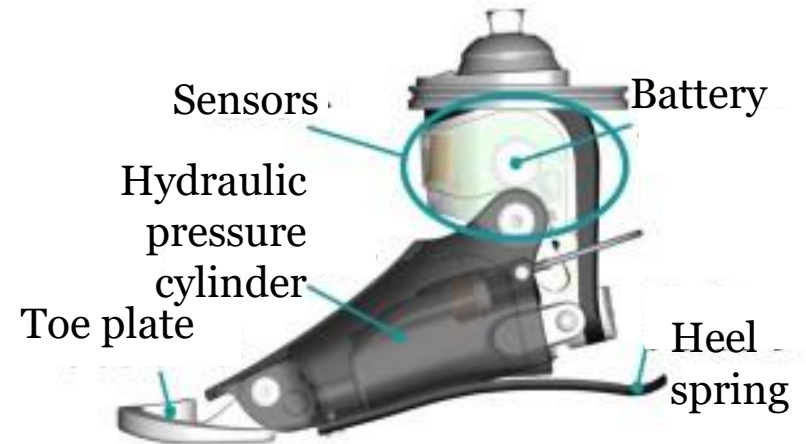


[Participant with walking disability]

EXISTING POWERED FOOT PROSTHETICS



[Biomechatronics Group
of MIT Media Lab.]



[1B1 Meridium,
Ottobock]

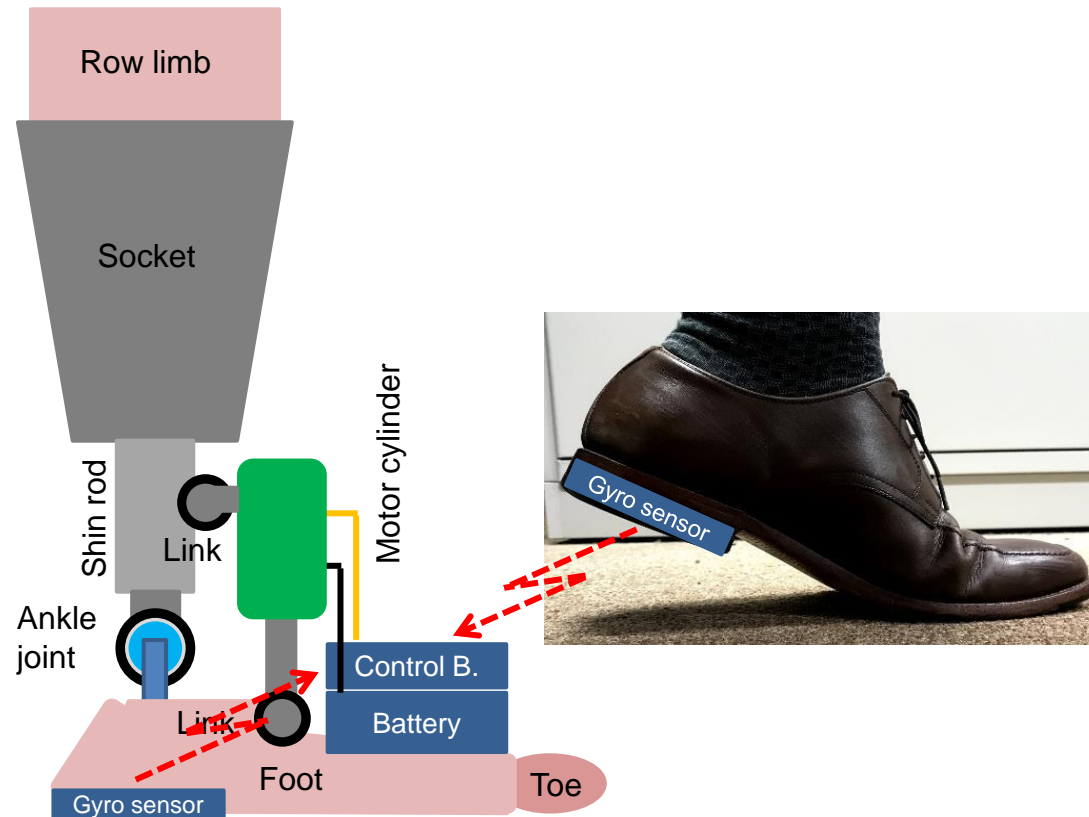


[PROPRIO FOOT®,
Össur]

Basic principle and structure

■ Principle: The motions of both feet are basically the same, with a half cycle difference.

■ Structure



Normal walking gait cycle

(1) Initial entirely contact



(2) Initial heel-up



(+)
Yaw

(3) Terminal heel-up/
Initial swing forward



Yaw (-)

(4) Terminal swing forward



Yaw
(+)

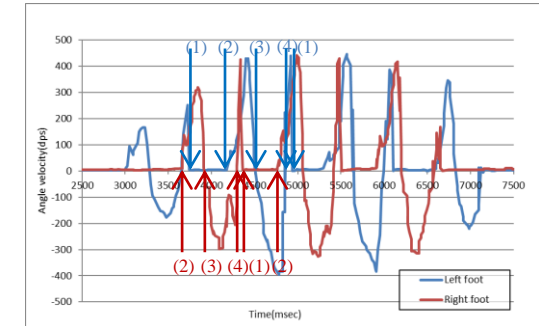
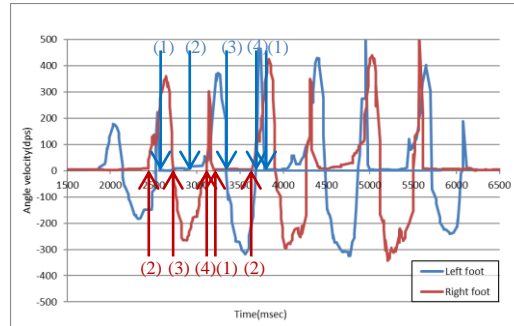
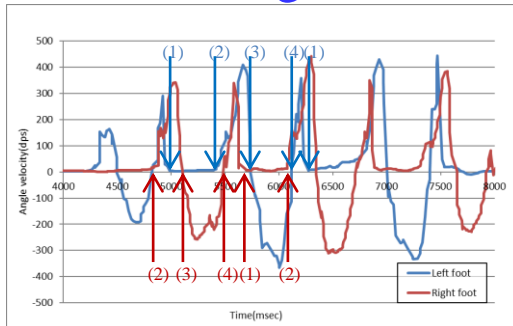
Differences between the right foot and left foot while walking

Straight

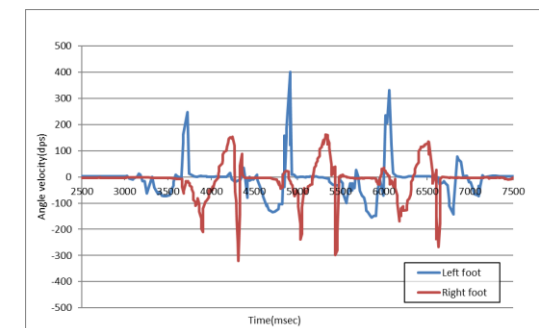
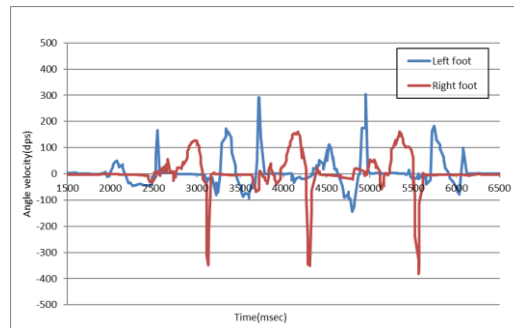
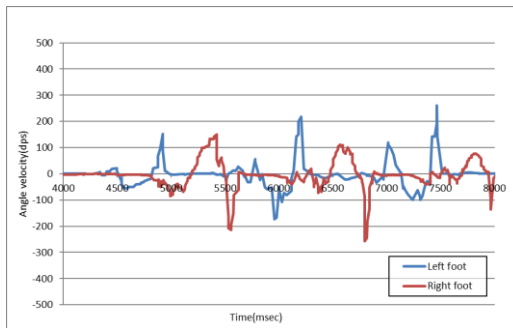
Clockwise

Counter Clockwise

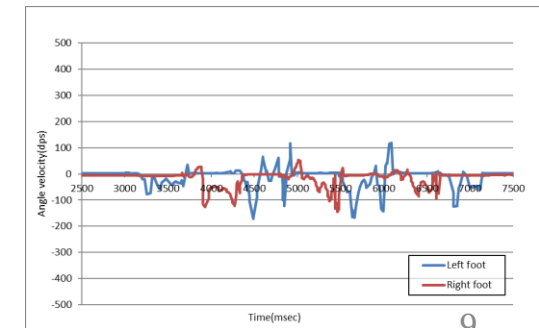
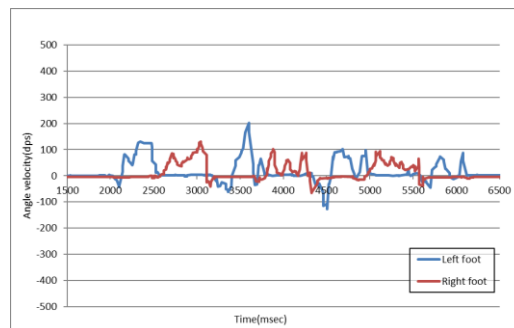
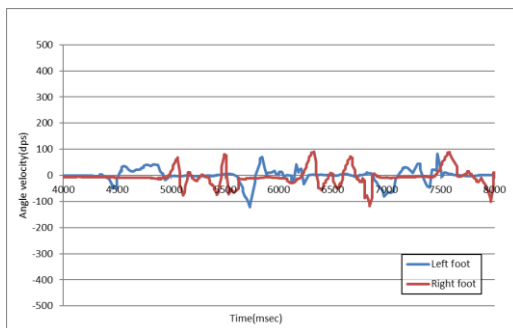
(a) Pitch



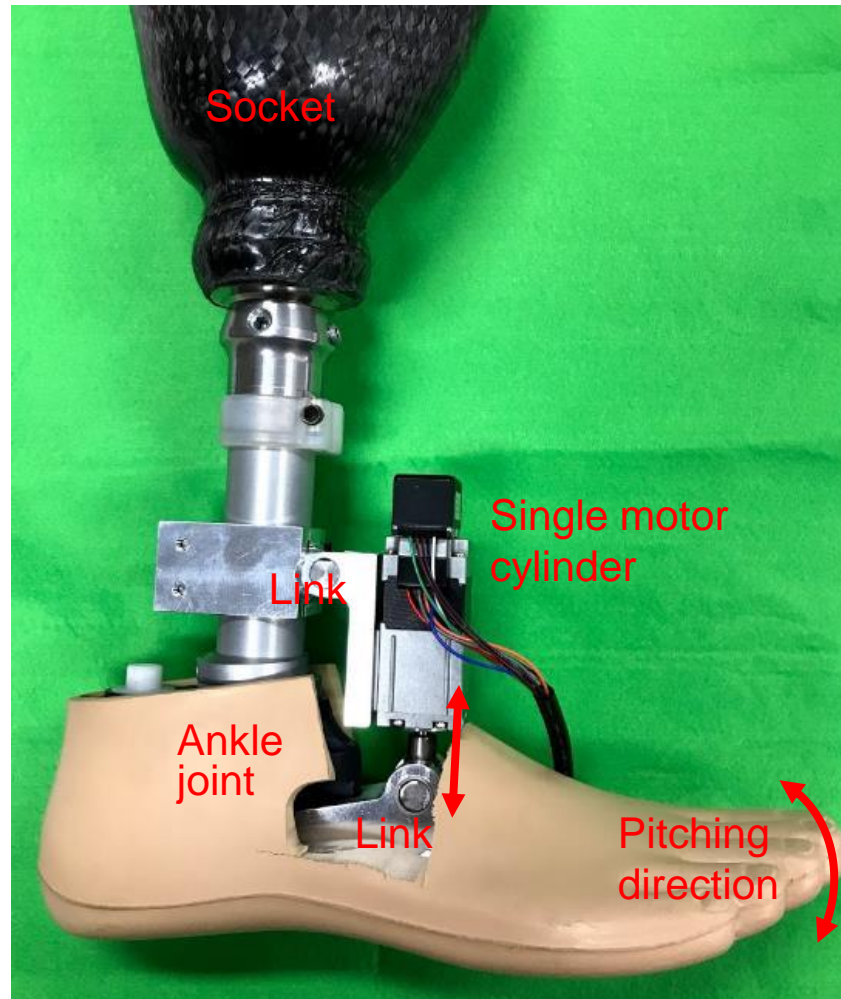
(b) Roll



(c) Yaw

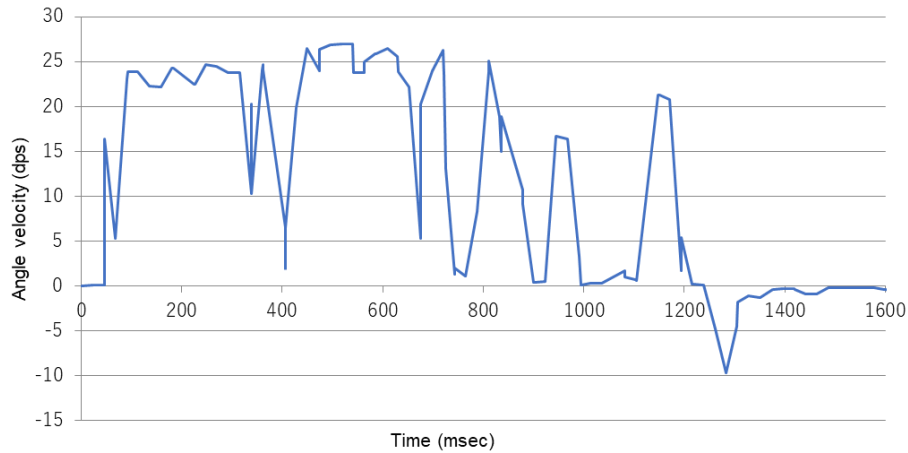


Prototype of PEHF

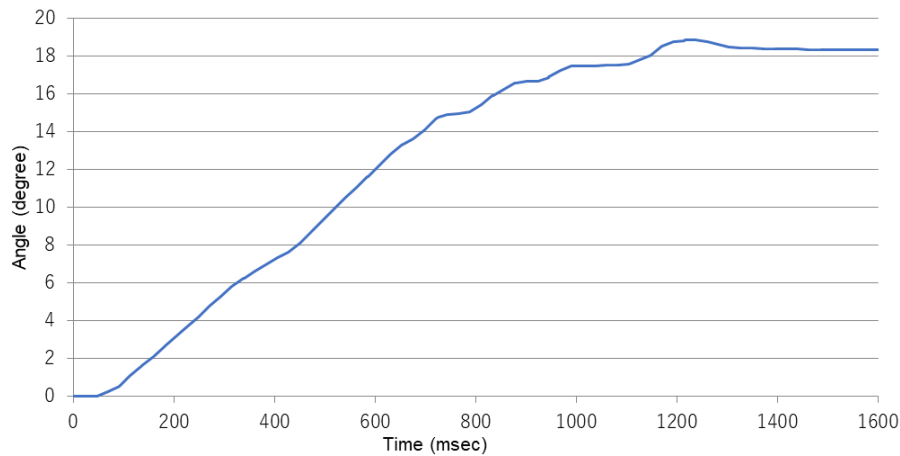


Measured angle velocity and angle in 30/60 KHz pulse

[30 Kpps]

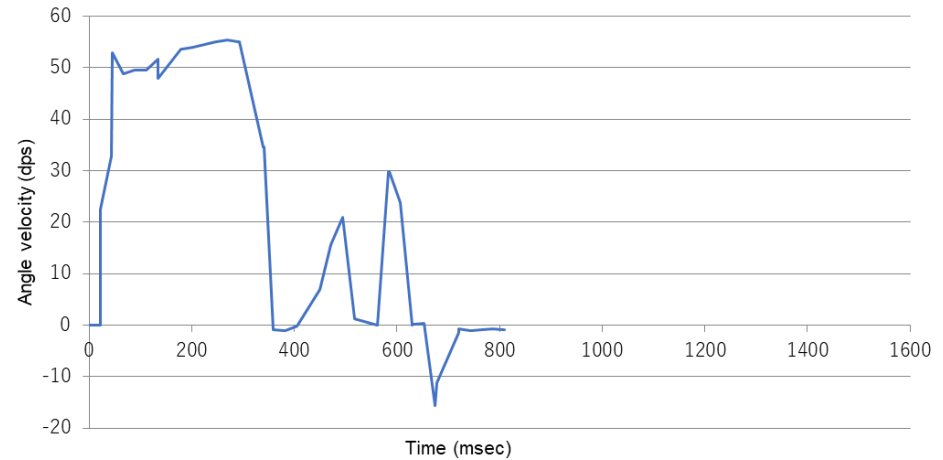


Angle velocity

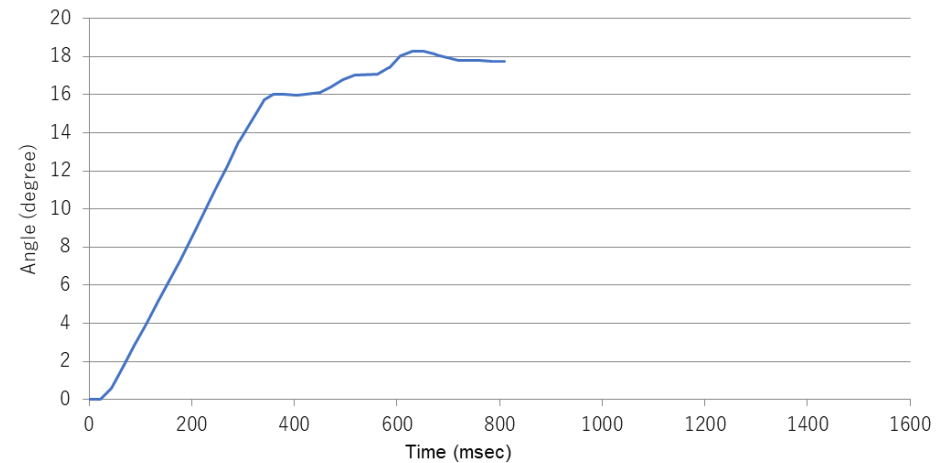


Angle

[60 Kpps]



Angle velocity



Angle

Conclusion

- A foot prosthesis that emulates the gait motion of a healthy foot was proposed.
- There were no differences between both feet except for the half cycle delay. The shape of the curve of angle velocity and the cycle period of the right foot was very similar to those of the left foot.
- It is possible to emulate the motion of a powered foot prosthesis with the gait motion of a healthy foot.

Future works

- The introduced single motor cylinder could not drive a foot part well. We have to look for a suitable cylinder motor.
- Establishing a method for controlling cylinder motors on the basis of the angle velocity of the gyro sensor mounted into the heel part of the shoe worn on the healthy foot.
- Examining a prototype with a real limb amputee.
- Since the proposed foot prosthesis emulates motion of a healthy foot, leg amputees who use this prosthesis and have healthy foot; must start a walk with their healthy foot. We must investigate whether they could accept this limitation.¹³