An exoskeleton ‘teacher-student’ gait rehabilitation control system using real-time joint posture acquisition: A feasibility study

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INTRODUCTION

- Gait is central to mobility and enhances community participation [1]
- Interventions for gait include manual therapies, overground walking and robotic exoskeletons
- High manual input of therapies can limit dosage and increase the risk of therapist developing musculoskeletal disorders [2], [3], [4]
- Teacher-student control paradigms for exoskeletons are common for the upper limbs, but are sparsely applied for the lower limbs [5]
- Guiding an exoskeleton using therapist movement may provide manual input otherwise provided by the therapist

AIMS

1 Demonstrate the basic feasibility of a lower limb exoskeleton coupling using a ‘teacher-student’ paradigm

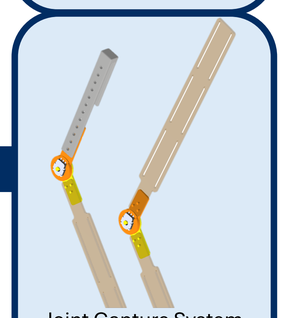
2 Assess the accuracy and phase delay between the kinematics captured from the teacher and their application on the student

METHODS

1 Fourier X2 Exoskeleton with CORC connected to joint capture system

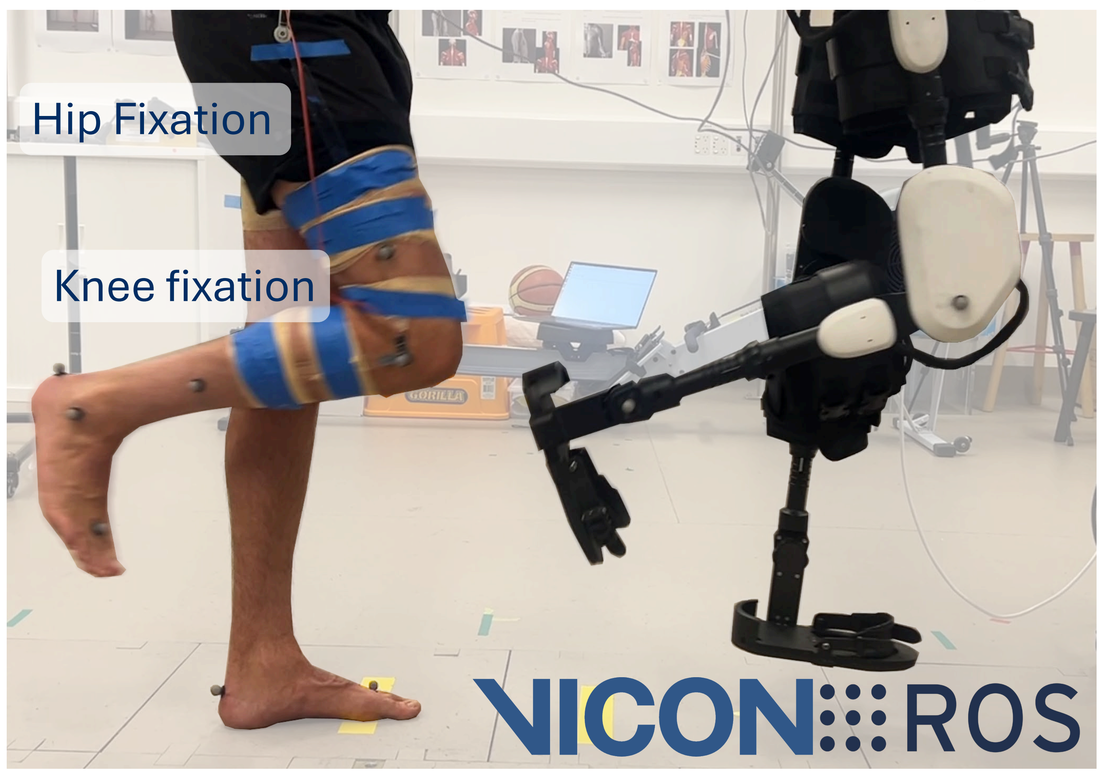


Joint Capture System
- 2 x Rotary Pot
- 1 x Seeduino Xiao
- Sagitally mounted
- Hip and knee joint angle monitoring



Joint Capture System (Hip, left, Knee, right)

2 Exoskeleton and participant (n=1) marked up using Plug-in-gait



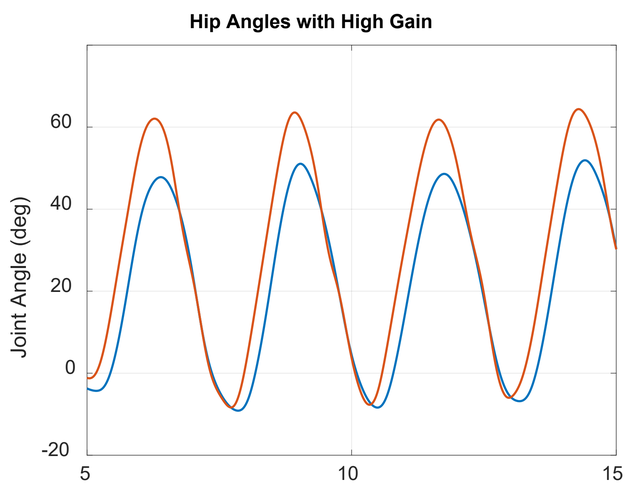
3 Teacher performs static cyclic gait activities with three different gains captured using Vicon Nexus and ROS:*rosbag*

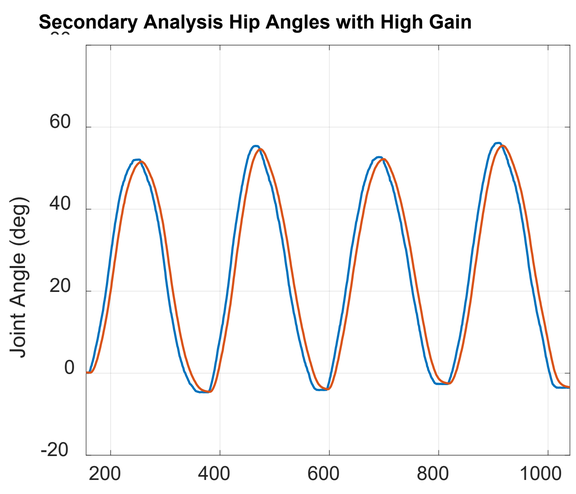
4 Tracking error (mean absolute joint angle difference) and phase delay (peak to peak) were measured

Secondary analysis comparing joint capture system and exoskeleton for tracking error

Demonstration of Teacher-Student

RESULTS





Aim 2	Phase delay (cs, peak to peak)			Mean Absolute Joint Error (degrees, °)		
Gain	Low	Medium	High	Low	Medium	High
Hip (Mean, (sd))	32 (3.4)	19.3 (0.9)	11.1 (0.7)	12.7 (9.6)	9.4 (6.5)	7.7 (6.1)
Knee (Mean (sd))	27.1 (6.3)	17.1 (5.1)	8.4 (4.9)	17.4 (11.9)	13.2 (10.2)	7.6 (5.4)

*Please note that we reported ms accidentally in our manuscript, and this should be cs

DISCUSSION AND CONCLUSION

The error between the teacher and student posture measured using Vicon was 7.7° at the hip and 7.6 ° at the knee (high gain condition)

Other systems calculate error as the different between sensor systems, not the physical interfaces of those systems to report error of 3° for the hip and knee, respectively

The secondary analysis that is comparable to others shows an error of 4.1° and 6.8° for the hip and knee, respectively

Future work will focus on:

- Fixation that doesn’t rely on expert positioning of the joint capture system that is more permanent
- We intend on replicating this work with the exoskeleton worn on healthy participants as the student, and the teacher system applied to both lateralities of the teacher to control both exoskeleton limbs

Conclusion: This feasibility study has demonstrated a low-cost teacher-student control system for clinically relevant exoskeleton rehabilitation

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