Melbourne Networked Society Institute

Seed Funding 2017

Project

A real-time virtual reality system for self-directed upper limb rehabilitation

Elevator Pitch (max 30 words)

This proposal will combine stimulating virtual reality environments with real-time biomechanical data from wearable sensors to facilitate highly motivating and personalised rehabilitation for stroke and brain injury patients

Research Team

Chief Investigator	Department	Email	Contribution
David Ackland	Biomedical Engineering, UoM	dackland@unimelb.edu.au	0.2
Researchers	**Department**	**Email**	**Contribution**
Mr Wen Wu	Biomedical Engineering, UoM	wenw1@student.unimelb.edu.au	1.0
Dr Vijay Rajagopal	Biomedical Engineering, UoM	vijay.rajagopal@unimelb.edu.au	0.1
Prof Peter Lee	Biomedical Engineering, UoM	pvlee@unimelb.edu.au	0.05
Prof Mary Galea	Department of Medicine, UoM	m.galea@unimelb.edu.au	0.1
Dr Eduardo Cofre Lizama	Department of Medicine, UoM	eduardo.cofre@unimelb.edu.au	0.1
PhD Students working on project			
Student	**Department**	**Email**	**Contribution**
Shouryadipta Ghosh	Biomedical Engineering, UoM	shouryadipta@student.unimelb.edu.au	0.1
External Collaborators			
Collaborator	**Organisation**	**Email**	**Contribution**
Prof Fary Khan (Director of Rehabilitation, RMH)	Royal Melbourne Hospital	fary.khan@mh.org.au	0.05

Project Impact (max 150 words)

Inpatient rehabilitation of stroke patients is highly time consuming, costly, and associated with poor patient mental health, with a significant burden placed on caregivers and support agencies. The objective of this project is to investigate how low-cost virtual reality platforms such as *HTC Vive* can improve the way personalised upper limb rehabilitation and exercise therapies are prescribed and executed. Musculoskeletal models of the human body have previously been developed to provide quantitative information on muscle and joint function. By integrating musculoskeletal modelling into the virtual reality environment, stimulating and motivating gaming and rehabilitation tasks may be performed to increase user compliance and improve quality of life in patients with neuromuscular disorders.

Project Overview (max 300 words)

Stroke and traumatic brain injury, which represent the leading causes of permanent disability in adult Australians, result in debilitating upper-extremity impairment as a result of weakness and spasticity in up to 80% of survivors. Inpatient rehabilitation is highly time consuming, costly, and associated with poor patient mental health, with a significant burden placed on caregivers and support agencies.

This interdisciplinary project will bring together unique expertise in biomechanics (Department of Biomedical Engineering), clinical stroke management (Department of Medicine) and software development (including VR support at MNSI). The aim is to create a set of low-cost virtual reality tools that that will improve the way personalised upper limb rehabilitation and exercise therapy is executed, and facilitate goal-directed rehabilitation treatment in the home or clinic.

This aim will be achieved by combining stimulating virtual reality environments through a VR-headset with engaging augmented-reality 3D video games to motivate upper limb motion tasks. Low-cost wearable sensors including motion and electromyography (EMG), will be employed to provide real-time biomechanical feedback during therapy, including visualisation of limb motion, muscle loading and task performance. Biomechanical data will be integrated into the video games, displayed in the virtual environment, and used to create a highly motivating and enjoyable therapy. Biomechanical data will be logged for access and use by clinicians to monitor patient performance and compliance.

This highly networked capability will be implemented on healthy subjects (phase 1). Beyond this seed research project (phase 2), the tools will be used to motivate rehabilitation and exercise therapy in stroke and brain injury patients. There are significant social benefits anticipated, through increased exercise motivation, multi-user integration capability (patients connecting with one another), improved mental health and quality of life. The tools can be operated in the home, thus reducing the enormous patient-therapist-carer time-cost burden.

Expected Future Outcomes (max 150 words)

This interdisciplinary project aims to demonstrate proof-of-concept of networked tools and capability that will ultimately improve upper limb rehabilitation and mental health of people affected by stroke and brain injury. The tools may be expanded using the Melbourne School of Engineering CAREN Motek facility, a new full-body human movement and virtual reality environment set to open in 2017 e.g. lower-limb rehabilitation and sports medicine. It is anticipated this will produce spin-off projects with the investigators' research groups and colleagues. Prof Fary Khan, the Head of Rehabilitation at the Royal Melbourne Hospital, will help the team leverage this seed project through translation of the tools and capability to her stroke and traumatic brain injury clinic. This seed funding will produce critical pilot data required for ARC Discovery Grants (e.g., low-cost technology to improve mental health and wellbeing) and NHMRC Project grants (e.g., larger-scale clinical trials on stroke patients at RMH).

Project Phase 1

Deliverables

- A real-time motion analysis system that can be easily setup for any subject
- A robust, real-time biometrics calculation and display system for the upper-limb

Plan

Aim of Phase 1: Build up a real-time biometrics calculation and display system for upper-limb using low-cost sensor data.

- Discuss with all investigators the biometrics to output and what the VR environment should ideally look like
- Purchase and test the motion and EMG sensors
  - MPU6050-based motion sensor (BWT61PCL, Wit-motion, $100), MPU9250-based motion sensor (BWT901CL, Wit-motion, $200), and EMG sensor (Muscle Sensor Development Kit, MyoWare, $140), as well as Myoband combined inertial and EMG sensor (2 x $450)
- Test and determine the best motion sensor to use.
  - Potential options: (i) MPU6050 sensor, six channels (ii) MPU9250 sensor, nine channels
- Design and configure the low-cost motion and EMG sensors to obtain wireless real-time data in Matlab.
  - Synchronise the data from different sensors.
  - How to deal with frame drop
- Convert the global sensor coordinate to local joint data.
  - How to align the sensor coordinates with anatomical coordinates
  - How to estimate the 3D kinematics of the clavicle and scapula only using the sensors on thorax and humerus.
- Design easy yet repeatable sensor attachment method and calibration protocol.
  - Potentially sew the sensors to stretchable hook-and-loop straps (Velcro, $40), making them easily attached to subjects.
  - Calibration needs to simultaneously address sensor alignment and EMG magnitude (if applicable).
- Develop an animated demonstration interface.
  - Develop a GUI similar to OpenDay demonstration, with additional functions including calibration, record, etc.
  - Easily expandable to fit in further function (e.g. muscle and joint loading display)
- Develop a real-time inverse dynamic program that computes each joint moment for given real-time captured kinematics.
  - Look into OpenSim C++ API to achieve real-time computing.
- Develop an algorithm for a fast simulation of the glenohumeral joint muscle co-contraction.
  - The current method is rather computationally expensive, making it unfeasible for real-time simulation.
  - The aiming processing frequency is 10Hz with a delay within 0.2s
- Integration the EMG signal with the force computation.
  - The EMG data can be used to adjust muscle and joint loading level, as it is unfeasible to directly measure the external loading.
- Update the demonstration interface with the muscle and joint force display and test the reliability of the system.

Phase 1 Budget

Please complete the following table, including estimates of in-kind contributions from investigators.

Resources			
Researchers	**In-kind (EFT) and Level**	**Cash (from grant)**	**Cash (other)**
Wen Wu (8 weeks at 1.0 FTE)		$13,078.4	
Wen Wu (11 weeks at 1.0 FTE)		$17,982.8	
David Ackland	0.2 EFT, Level C3		
Dr Vijay Rajagopal	0.1 EFT, Level C3		
Prof Peter Lee	0.05 EFT, Level E		
Prof Mary Galea	0.05 EFT, Level E		
Dr Eduardo Cofre Lizama	0.1 EFT, Level B3		
Services & Equipment	**In-kind**	**Cash (from grant)**	**Cash (other)**
Stretchable hook-and-loop straps		$40	
Bluetooth module		$100	
Misc. consumables (EMG electrodes, batteries, cables etc)		$300	
BWT901CL, Wit-motion		$200	
BWT61PCL, Wit-motion		$100	
EMG Sensor, Myoware		$140	
Myoband (x2)		$900	

Project Phase 2

Deliverables

- Migration of biometrics calculations and display system into the VR environment
- Basic computer game developed integrating biometrics in the VR environment
- Analysis of pilot trial data on 8 subjects

Plan

Aim of Phase 2: Integrate real-time biometrics system developed in Phase 1 with VR environment, and test the system with healthy subjects. A secondary aim is to develop a basic VR computer game integrating biometrics

- Develop an interface between the musculoskeletal model and VR system.
  - Enable data communications between the modelling engine and VR.
  - Display the biometrics in VR environment.
- Develop computer game back-end in VR system, integrating biometrics data.
  - Consult with physiotherapist and VR developer to determine the optimal game structure for patient rehabilitation.
- Implement computer game with biometrics into VR environment
- Pilot trial of 8 healthy subjects, and documentation of biometric output data for activities of daily living, and computer game performance
  - Recruit friends and colleagues as participants.
  - Tasks to include pure abduction, flexion, horizontal abduction and flexion
  - Comparison of biometrics with those from gold-standard Vicon motion analysis system
  - Tune system and debug according to pilot results

Phase 2 Budget

Please complete the following table, including estimates of in-kind contributions from investigators.

Resources			
Researchers	**In-kind (EFT) and Level**	**Cash (from grant)**	**Cash (other)**
Research Assistant 1	Masters or Ugrad intern ($4,904)		
Research Assistant 2	Masters or Ugrad intern ($4,904)		
MNSI VR expert	Masters/PhD student ($4,904)		
MSE VR user Shouryadipta Ghosh	PhD student ($8,174)		

David Ackland	0.2 EFT, Level C3		
Dr Vijay Rajagopal	0.1 EFT, Level C3		
Prof Peter Lee	0.05 EFT, Level E		
Prof Mary Galea	0.05 EFT, Level E		
Dr Eduardo Cofre Lizama	0.1 EFT, Level B3		
Services & Equipment	**In-kind**	**Cash (from grant)**	**Cash (other)**
Vicon Optical Motion analysis System, used for validation	$5,000		

Seed Funding Acceptance

Project

A real-time virtual reality system for self-directed upper limb rehabilitation

Seed Funding Allocation Agreement

	Item	Date
	Project Start:	11/9/17
	Phase 1 End:	23/1/18
	Phase 2 End:	31/12/18
	Funding	**Amount**
	Project Development:	$0
	Phase 1:	$32,841.20
	Phase 2:	$0
	Reporting	**Date**
	Phase 1 Report:	
	Institute Publication & Presentation:	
	Final Report:	

This project is funded in accordance with this document and Melbourne Networked Society Institute's Seed Funding Terms and Conditions.

Finance

Departments are required to establish a new and specific Local Purpose Code (LPC) within their 000080 account to ensure all income and expenditure is properly accounted for given that it forms part of the MNSI reporting to the funding body. The nominated Account string for the transfer of funds is:

Co.	Dept	Cost Centre	Account	Project	LPC	Activity	Loc

The nominated **Agreement Administrator** for the Department is:

Name	

Email	

Signatures

Chief Investigator

Department:
Signed:

HoD/ Director

Melbourne Networked Society Institute
Signed:

Prof Thas Nirmalathas
Director