Title: The AMP-Foot 2.0 - Control of a Powered TransTibial Prosthesis mimicking intact ankle behaviour in 'real-life' environment.

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The Ankle Mimicking Prosthetic (AMP-) Foot 2.0 is a powered ankle-foot prosthesis, developed within the Robotics & Multibody Mechanics research group. The concept behind the AMP-Foot 2.0 relies on the use of springs, to store energy during early stance while an electric compliant actuator injects even more energy into the system. Due to the use of a locking mechanism, the energy can be delayed, combined and released at push-off to provide the necessary torque and power needed for locomotion. Preliminary experiments with an amputee have been conducted and proved its effectiveness with very basic control algorithms. The goal of this project is to develop a smart high level adaptive controller capable of predicting the users' intentions in a 'real-life' environment (adaptable walking speed, up and downhill, stair climbing, etc). The steps needed to complete the project include:
- Improving Sensorial equipment of the AMP-Foot 2.0
- Implement different control algorithms so the device has different modes of walking.
- Perform walking experiments with the device and analyze the results

http://www.youtube.com/watch?v=tXLQq9a5kyl

Requirements¹: basic knowledge in mechatronics, ICT and control design.

Number of possible students: 1

Assistant/PhD student that will guide the student: Pierre Cherelle

E-mail and tel. contact person(s): pierre.cherelle@vub.ac.be
Title: Development of a motor controller test setup

Promotor(s): Bram Vanderborght - Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

All robotic systems are using some sort of actuation. At R&MM we are currently developing devices for human rehabilitation, most of this systems are using electric actuators. In order to control such systems dedicated electronic hardware was developed that is able to read different sensor data, perform real time control and provide power to the actuators. It is required to design and build a test setup for developing and testing control algorithms for mentioned hardware. The project consist of:

- Design a electromechanical setup for variable loads and easy to change motor system;
- Integrate developed hardware
- Design and tune low level control loops using available sensor data.

Requirements: mechatronics, ICT, control design.

Number of possible students: 1

Assistant/PhD student that will guide the student: Victor Grosu

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Development of Position Smart Sensor unit

Promotor(s): Bram Vanderborgh - Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

To make a robotic system safe many strategies are considered. One of them is making the sensor feedback system redundant. We propose to develop a smart sensor unit that is able to provide redundant position and velocity information of the joint. The main idea is to integrate two different types of sensors in one compact, easy to integrate unit. The project will focus on complete unit development as follows:

- Schematis, PCB design and realisation
- Mechanical design
- Software development and integration

Requirements: mechatronics, ICT, control design.

Number of possible students: 1

Assistant/PhD student that will guide the student: Grosu Victor

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Development and testing of a software architecture for the implementation of different types of gestures for the robot Probo

Promotor(s): Bram Vanderborght - Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The social robot Probo, developed by the R&MM is able to show different facial expressions by the 20 compliant actuators that are situated in the head. The control software consists of different parts such as the Attention System that determines de gaze direction of the robot, and the Emotion System that imposes a certain facial expression. The DOF’s that are required by each of those subsystems are correctly mixed by the Motion Mixer into a fluent and natural motion. For this project, a similar architecture should be developed for the arm movements. A human can perform different kinds of gestures simultaneously, like for example pointing to a direction and expressing a certain emotion. To transfer this to robots, it is necessary to categorize different motions and to mix them correctly into the desired motion, while taking into account the priority of different gestures. This software should be tested on an existing robot platform, such as Probo or the Kuka-robot.

Requirements: mechatronics, ICT, control design.

Number of possible students: 1

Assistant/PhD student that will guide the student: Greet Van de Perre

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be

Figure 1: Probo's system architecture
Title: implementation of a lip sync and text to speech module in the Probo-software

Promotor(s): Bram Vanderborght - Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The social robot Probo, developed by the R&MM is able to show different facial expressions by the 20 compliant actuators that are situated in the head. The control software of the robot includes a Sequence Editor that is used to create motion sequences. The Sequence Editor has a time line that is composed out of a sequence of frames. To make an animation, the position of every DOF can be set for every frame. The lip movements are currently generated by an external program. The goal of this project is to develop an implemented module the create lip movements corresponding to spoken and written text.

Requirements: ICT, control design.

Number of possible students: 1

Assistant/PhD student that will guide the student: Greet Van de Perre

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Identifying and validating the use of a bi-articular element in a one-legged hopping robot

Promotor(s): Bram Vanderborght - Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

A one-legged hopping robot is currently (academic year 2012-2013) being designed and build by a student for the master 1 project. This hopper is actuated in both hip and knee by means of common spring MACCEPA actuators. These MACCEPA actuators, compliant actuators developed at the R&MM research group, are linked in a bi-articular way, which allows for energy transfer between hip and knee. However, the use of the bi-articularity in this case is not clear, which yields the main research goal of this thesis, namely identifying it. After identifying the use or potential use of a bi-articular element in the hopping robot, adaptations can be made to the robot in order to validate the findings. Additional elements (e.g. a parallel spring) can also be introduced into the hopper in order to increase its performance. Sensorial equipment will also have to be improved.

Requirements: mechatronics, robotics and multibody mechanics, Matlab

Number of possible students: 1

Assistant/PhD student that will guide the student: Maarten Weckx

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Research on a novel compliant actuator concept (SPEA 2)

Promotor(s): Bram Vanderborght – Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The R&MM developed several compliant actuators as the pleated pneumatic artificial muscles and the maccepa. Normally robotics use stiff actuators, which will try to reach a certain position whatever the external forces are, like e.g. a servomotor. By introducing a compliant element (for example a spring), the actuator has the ability to store and release energy which is beneficial for walking and running robots regarding energy efficiency, shock absorbance and safety characteristics. This type of actuator is now richly studied in robotics to produce the new generation of robots that has to work in close collaboration with humans. We are currently working on a novel concept which we call SPEA. More info on our website (http://mech.vub.ac.be/multibody/topics/spea_sub.htm). Main goal is to increase the torque capabilities and efficiency compared to other compliant actuators. The aim of the thesis is to start the fundamental study on a second SPEA concept (SPEA 2) and prove the preliminary results with a proof of concept set-up. Due to intellectual property conservation, we cannot go deeper into details, students interested in this project need to contact me directly.

Requirements*: matlab, inventor, mechatronics

Number of possible students: 1

Assistant/PhD student that will guide the student: Glenn Mathijssen

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Development of lightweight and energy efficient compliant actuator for badminton robot Jada

Promotor(s): Bram Vanderborght – Dirk Lefeber

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

Flanders' MECHATRONICS Technology Centre (FMTC) has developed a badminton robot called Jada. At the moment stiff servomotors are implemented. The aim of the thesis is to develop novel compliant actuators to reduce the weight of the robot and improve its energy efficiency by storing and releasing energy in an energy buffer (a spring). The performances of the robot may not be reduced. The project aims to study the theoretical framework (by simulations of the motion), designing a prototype and validating the experimental results.

Requirements: matlab, inventor, mechatronics, control

Number of possible students: 1

Assistant/PhD student that will guide the student: Glenn Mathijsen

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be

Contactperson FMTC: Wim Symens (Wim.Symens@fmtc.be)
Title: Study and optimization of socket forces in leg prostheses

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work:

The interface between a leg prosthesis and the amputee stump causes problems for a lot of amputees. Because of the reaction forces and friction between the leg and the prosthesis socket, the amputee develops wounds and is not able to wear the prosthesis at all time. The purpose of this thesis is to investigate what the forces on the socket of (active) prostheses are, which cause the most problems and what possible solutions are. The project will mainly consist of following parts:

- Make a simulation of one of the prostheses developed at the VUB to investigate the forces in the prosthesis socket.
- Measure the forces on the prosthesis and investigate possible ways to reduce the forces and the impact of the forces on the amputee.

Requirements: mechatronics, ICT, control design

Number of possible students: 1

Assistant/PhD student that will guide the student: Joost Geeroms

E-mail and tel. contact person(s): dlefeber@vub.ac.be
Title: Development of a self-healing actuator

Promotor(s): Bram Vanderborght - Guy Van Assche

Research Group: Robotics & MultiBody Mechanics Research Group in collaboration with Materials and Chemistry (MACH)

Description thesis work:

The human body has a remarkable great advantage, the ability to heal itself when certain damages, injuries occur. Almost in every body part a certain healing system is incorporated. The skin is healing continuous, muscles can recover from tears and bones can heal from fractures.

Material sciences is currently developing novel materials with self-healing properties. The aim of the project is to investigate the feasibility of using these materials for robotic actuators and build a prototype to show the capabilities. As such an actuator that is physically damaged by overload, can repair itself.

Requirements*: mechatronics, material sciences

Number of possible students: 1

Assistant/PhD student that will guide the student: Glenn Mathijssen

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be - gvassche@vub.ac.be
Title: Actuator with flexible cable transmission for rehabilitation robotics

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The R&MM develops light-weight robotic devices such as assistive exoskeletons, protheses, etc. In these applications that are often powered by electric motors, the weight and weight distribution of the actuator systems are crucial. Flexible cable transmissions offer the possibility to relocate the electric motor to a more convenient location such as the person’s back.

A prototype test setup is being built to evaluate this actuation system. The torsional compliance of the transmission cable, in combination with the compliant MACCEPA actuator system lead to design and control challenges.

- A feedback controller must cope with the extra dynamics of the flexible cable
- A low-weight design should combine high power, high efficiency, fast response, etc.
- Optimization of a brushless DC motor controller

Requirements:\(^{10}\): Mechatronics, ICT, control design, experimental skills, programming C.

Number of possible students: 1

Assistant/PhD student that will guide the student: Branko Brackx, Victor Grosu

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be

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\(^{10}\) E.g. knowledge of a computer language, software code (matlab, ansys,...), certain experimental skills, mobility of student (e.g. thesis in cooperation with industry) etc.
Title: Control strategy for rehabilitation exoskeleton based on multi-axis force sensors

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & MultiBody Mechanics Research Group

Description thesis work (5 to 10 lines):

The R&MM developed the gait rehabilitation robot ALTACRO. The device is a powered exoskeleton that assists and guides disabled individuals to walk on a treadmill. The aim is to evaluate all 12 powered degrees of freedom together with new control strategies in gait rehabilitation.

The 5 actuators for the pelvis are to be compliantly controlled with an “admittance control” scheme that is based on the force sensing signals of four 3-axis force sensors.

- Calibration of 3-axis force sensors, tensile testing
- Evaluation with existing finite element model
- Real-time calculations on force signals (programming on local and globals CPU’s)
- Design of MIMO controller
- Modeling of actuated system
- Simulation of “compliant” control loops
- Implementation of the control strategy on the ALTACRO robot

Requirements: Mechatronics, ICT, control design, experimental skills, programming Matlab, LabVIEW, C.

Number of possible students: 2 (preferably 1 WE + 1 EIT)

Assistant/PhD student that will guide the student: Branko Brackx, Victor Grosu

E-mail and tel. contact person(s): bram.vanderborght@vub.ac.be
Title: Design and development of an actuated ankle foot orthosis for stroke patients with a drop-foot

Promotor(s): Dirk Lefeber – Bram Vanderborght – Ivanka Veneva (Bulgarian Academy of Science)

Research Group: Robotics & Multibody Mechanics

Description thesis work (5 to 10 lines):

The R&MM group has gained a considerable know-how in wearable prosthetic and orthotic devices. In this master thesis a wearable orthotic ankle-foot orthosis for patients with a drop-foot problem is studied. A drop-foot occurs when a stroke patient is unable to actively dorsiflex his foot. First a compliant actuation module is simulated in matlab. The actuated orthosis is to be designed as a wearable ergonomical device. User acceptance is very important. To reduce the size of the actuator a compliant actuator is used. After construction a controller for the orthosis is written and the whole system is tested with healthy subjects. In case of a successful study a ph-d on this topic is possible.

Requirements2: mechatronic know-how; mechanical design

Number of possible students: 1 (eventually 2)

Assistant/PhD student that will guide the student: Pierre Cherelle

E-mail and tel. contact person(s): dlefeber@vub.ac.be

1 Please note that the description should be in English, max. 1 page including possible figures

2 E.g. knowledge of a computer language, software code (matlab, ansys,..), certain experimental skills, mobility of student (e.g. thesis in cooperation with industry) etc.
Title: Design and development of intermittent locking and unlocking mechanisms under high loads

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & Multibody Mechanics

Description thesis work (5 to 10 lines):

The R&MM group has gained a considerable know-how in wearable prosthetic and orthotic devices. To design more efficient, lighter and more wearable prosthetic and orthotic devices, a breakthrough in the research is possible provided one can lock and unlock energy storing devices, such as springs, under high load. This master thesis builds on the master thesis of ..., new designs can be proposed and worked out, existing designs can be further improved and miniaturized. The student will design, control, test and qualify the proposed locking/unlocking systems.

Requirements³: mechatronic know-how; mechanical design

Number of possible students: 1

Assistant/PhD student that will guide the student: Pierre Cherelle

E-mail and tel. contact person(s): dlefeber@vub.ac.be

³ E.g. knowledge of a computer language, software code (matlab, ansys,..), certain experimental skills, mobility of student (e.g. thesis in cooperation with industry) etc.
Title: Design and development of a transmission with variable gear-ratio with 2 motors for efficient actuation.

Promotor(s): Dirk Lefeber – Bram Vanderborght

Research Group: Robotics & Multibody Mechanics

Description thesis work (5 to 10 lines):

In recent papers the use of gears with variable gear-ratio having 2 motors at the input is published. The goal of this master thesis is to study and improve such systems in view of efficient actuators for robotic applications. Since robots require high torques over a wide range of speeds, often the motors are used very inefficiently, resulting in an over-dimensioning of the motor and an excessive energy losses. The research question is to find out that such a dual-input motor system can be used to provide a more efficient actuation over a wide range of speeds and torques. (A follow-up ph-d is possible)

Requirements*: mechatronic know-how; mechanical design

Number of possible students: 1

Assistant/PhD student that will guide the student: Glenn Matthysen

E-mail and tel. contact person(s): dlefeber@vub.ac.be

*E.g. knowledge of a computer language, software code (matlab, ansys,..), certain experimental skills, mobility of student (e.g. thesis in cooperation with industry) etc.
Title: Theoretical and experimental study of the characteristics of outrunner motors and comparison with the classical innerrunner motors.

Promotor(s): Dirk Lefeber – Bram Vanderborght –

Research Group: Robotics & Multibody Mechanics

Description thesis work (5 to 10 lines):

In an outer rotor design, the windings are located in the core of the motor. The rotor magnets surround the stator windings as shown here. The rotor magnets act as an insulator, thereby reducing the rate of heat dissipation from the motor. Due to the location of the stator windings, outer rotor designs typically operate at lower duty cycles or at a lower rated current. The primary advantage of an outer rotor BLDC motor is relatively low cogging torque.

These motors prove to produce high torques at low velocities and are potential candidates as actuator for robotic wearable systems. In this master thesis a test setup should be build to evaluate the characteristics of 100 to 400 Watt motors. With this setup outer motors should be tested and evaluated with respect to efficiency, controllability,…

Requirements:\footnote{E.g. knowledge of a computer language, software code (matlab, ansys,…), certain experimental skills, mobility of student (e.g. thesis in cooperation with industry) etc.}: mechatronic know-how; electrical design

Number of possible students: 1

Assistant/PhD student that will guide the student: Louis Flynn

E-mail and tel. contact person(s): dlefeber@vub.ac.be