Sabbatical Report

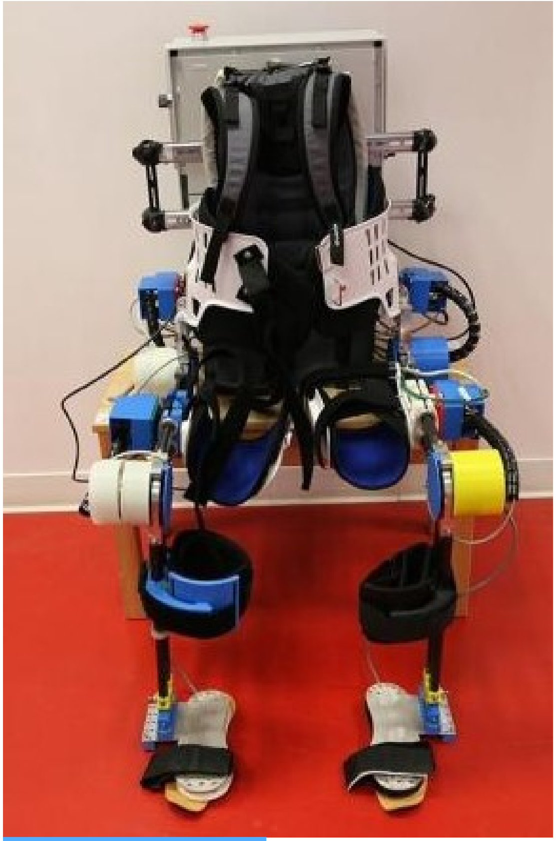
Cerebral Palsy (CP), Spinal Cord Injury (SCI), Spina Bifida (SB), and Traumatic Brain Injury (TBI) are the primary causes of mobility disorder in children. CP is the most common mobility disorder in children [2], [3], with 8,000 to 10,000 children being diagnosed with cerebral palsy worldwide every year. CP results from injury or damage to the brain before birth or in early childhood. Common to most individuals with CP is major trouble controlling movement, posture, and balance. The energy cost of walking for children with CP can be more than two to three times higher in comparison to their unimpaired peers. Unfortunately, there is no cure for CP. Since CP has no cure, CP therapies emphasize how best to support people to enhance their life quality. In this regard, LLEs have shown considerable potential to improve CP children's walking capability. Human gait in interaction with an LLE has extremely unstable dynamics (in the simplest form, similar to the inverted pendulum), and it is susceptible to any input variation. Even a small variation or disturbance in the input can lead to a total failure in the coordination of the complex human-exoskeleton system. Walking assistance requires a strong alignment between human intentions and exoskeleton movement. Hence, a control structure is highly desirable to make stable human walking possible.

The MOTION Project, supported by Interreg 2 Seas, is going to have a massive contribution to this area, addressing two challenges: (i) to advance development, validation and adoption of bionic rehabilitation technology for children with neurological disorders to improve quality of life; (ii) to set up a transregional network to transfer this rehabilitation technology and related knowledge from research to practical application by linking with industry, healthcare professionals and users and to interact with policy makers for the creation of supportive frameworks. If upcoming medical trials prove that rehabilitation with exoskeleton suits leads to a lower total medical costs insurance companies will cover part of the bill and offer the possibility that hundreds of rehabilitation centres open or upgrade their current equipment to include exoskeleton devices which would result in the sale of thousands of units. The 2 Seas area is fortunate in that it houses a complete cluster of experts, competencies, and structures: gait, movement (ALL); Orthosis and prosthesis (MOBILAB); design and manufacturing (KENT); Smart garments (CENTEXBEL); Signal processing(JUNIA-HEI); Biomechanics (MOBILAB); Clinical and Diagnostic centres (GREENWICH); Industrial manufacture and commercialization (AHSN); European Centres of Excellence in research (UPTEX); healthcare education (CCCU).

As a MOTION Project team member, I took a sabbatical in JUNIA-HEI (Hautes Études d'Ingénieur) in Lille, France, closely collaborating with our research partner in the MOTION project to develop a control algorithm for a Lower-Limb Exoskeleton (LLE) for children with CP. In this visiting scholar, we initially started working on the position control of one 150 W Brushless DC Maxon Motor (P/N 662156), using a Real-Time Target Machine (Speedgoat) based on the EtherCAT communication in Simulink/MATLAB. To this end, we configured the EC motor in EPOS Studio and exported the characteristic file to TwinCAT powered by Visual Studio to have further configuration. In TwinCAT, we create the Statusword and Controlword as input and output of the file. After modifying the characteristics of the EPOS4 Driver, we exported an XML file, including motor characteristics, incremental encoder, and Hal Sensor. The exported XML file is imported in the Simulink/MATLAB, using the Real-Time Target Machine (Speedgoat) for the Real-Time Simulink. In this setup, the motor powered by the

EPOS4 Driver is the Slave node, and the Real-Time Target Machine is the Master node. We applied a position-based control strategy to control the motor in a real-time scenario at this level. In Simulink, we utilized a slider to change the target position and dashboard scope to show the result online. Results showed that the motor followed the target position appropriately; however, since the motor was in no load setup, its velocity was very high. In this sabbatical, I had not taken any Gearbox to reduce the motor speed and increase the torque. We designed this TwinCAT XML file for Position Control and then repeated it for Torque Control. Unfortunately, our research team sent the LLE to Paris to receive an Electrical and Magnetic Certificate to apply for the Ethical approvement. Therefore, I had limited time to work with the LLE. The outcome of the first sabbatical was two reports on Electrical and Mechatronic of the one Motor, and some valuable practical findings which will be applied to my fifth chapter of my thesis.

Having returned from France, I started to assemble the exoskeleton fully and developed the prototype at the University of Kent, UK. In this case, I assembled six actuators, fabricated the required items with a 3D printer, and connected them to their drivers. Then, I connect drivers in serial mode as Slave nodes and finally connect to the Real-Time Target Machine as a Master node. In the meantime, I could cut Aluminium tubes and make some holes in the thigh, shank, and waist of the LLE. I assembled the exoskeleton, including six actuators, at the mechanical level. Finally, I sincerely appreciate your Internation travel award in this sabbatical and look forward to receiving further support in the near future. Please find some photos in the following.



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