Training Opportunity for Luxembourgish Trainees

Reference	Title	Duty Station
LU-2020-TEC-MMA	**Automation and Robotics: Human-Robot Interaction**	**ESTEC**

Overview of the unit's mission:

The automation and robotics section located at ESTEC, the technical heart of ESA, has 3 labs with corresponding working groups: Orbital Robotics, Planetary Robotics and Human-Robot Interaction. This position is set in the Human-Robotic Interaction Lab. Here we are developing mechatronics, control algorithms and distributed robotics systems for usage in space and terrestrial environments (analog missions). The focus is on haptic telemanipulation, human robot interfaces, distributed robot software, real-time middleware, mechatronics and simulation as well as designing the operators experience and analysing their performance. In the past we have developed and implemented technology demonstration missions on the International Space Station such as: HAPTICS 1 & 2, INTERACT, SUPVIS Justin and ANALOG-1. These were mainly proof-of-concept demonstration of advanced teleoperation over delayed and lossy data networks through a satellite relay system. The current focus is the continuation of these developments including the development of flight hardware and software demonstrations. We are currently working on the continuation and successors of ANALOG-1 and SUPVIS Justin in collaboration with DLR, where an astronaut from the ISS will operate multiple rovers and robotic assets on earth to do various tasks on an analog site.

The team you will be working in consist of mechanical, electrical, control and software engineers. Our equipment consists of commercial industrial and space qualified components as well as in-house developed ones. Our goal will be to integrate/implement a combined 'shared-autonomous' control of a robotic vehicles that will perform geology, maintenance and constructions tasks remote controlled by an astronaut. To achieve this objective you would support one or more topics below:

Overview of the field of activity proposed:

We are looking for highly motivated, technically strong and competent trainees that are interested in joining the Laboratory. The lab is a research and development environment. Along the project goals and the daily coordination of the activities, individually and in the team, you are given a high degree of freedom and responsibility. The exact task will be tailored to your final qualifications, interests and the needs of the section and the course of the project. However it will be related to one or more from the following:

Autonomous robotic systems

The rover as of now was mainly used for direct teleoperation. With the advancements in autonomy and navigation we want to enable the user to command the rover to travel to selected destinations autonomously. Therefore all technologies required have to be implemented beginning with the scanning of the environment, path planning with the consideration of terrain and manoeuvrability, path following and the proper user interface. This task package includes the integration of the sensors, the development of the algorithms and the testing with the real hardware. Another focal point for increasing the autonomy is the robotic arm with its gripper. This multi-purpose manipulator can be used for geological sampling tasks, handling equipment for maintenance and construction. The major goal in this domain would start with object recognition to the execution of "learned" motion and force control patterns for different purposes. This could be for example the recognition of rocks and the pick-up based on a click in a camera image by the user, or the instruction to manipulate a valve handle. The outcome should be a practical usable system while taking the user friendliness, technical capabilities and execution quality into account.

Enhanced vision systems

A major part of any teleoperation is providing the operator with an optical impression of the scene. This could range from normal cameras to 3D cameras or more advanced systems such as LIDAR. In addition the raw sensor data can be processed, merged and presented to the user with augmentations and will have an impact on the quality of the teleoperation. You would be developing an extension of the laboratory's tool-chain to: improve existing 3D vision, develop methods to process and visualise point clouds and merging these tools and techniques with teleoperation and haptic feedback. This work includes the implementation of appropriate sensor interfaces (LIDAR, structured light cameras) to perceive objects in the scene, compute collision likelihoods, perform localization and mapping, and apply the position estimates and collision estimates to a human-machine interface.

Telerobotics & Haptics

The remote manipulation of robotic arms to perform a certain task is the center of our activities. The focus in the ANALOG-1 mission is mainly to manipulate rocks, from sampling and simple manipulations, to the placement of sensors and tools on these rocks. In addition manipulation tasks on technical equipment ranging from inserting plugs, toggling switches, opening drawers etc. for maintenance and repair scenarios are investigated. The main task is to improve existing algorithms to provide appropriate force feedback. Additionally the measured forces need to be presented to the user via visualisation or sonification. We also want to investigate methods of shared autonomy and haptic guidance. The development and testing of these methods are the core of this work package taking into account that the scenarios often include delays in the range of tens of milliseconds up to hundreds of milliseconds. Thus algorithms and strategies in the domain of model mediation and/or shared control to mitigate the effects have to be considered.

User experience

The quality, performance and experience of the operator are highly dependent on the presentation to the user. This ranges from the basic visuals, somasensory (haptics), audio, user interface design over ergonomics of the layout of the workstation to the total experiment setup. Improving one or multiple elements and the evaluation of the impact on the overall user performance are very important to building systems that improve the teleoperation. In this task package (co)designing and implementing these interfaces are the focus. This will be on a dual approach: one side a research approach where all technologies can be used and implemented, and on the other side a pragmatic approach with the restrictions of on-board space system in mind.

In all these tasks there will be support and coordination with specialist from the lab. In addition to the topic above you will also work on software control system development and support us in integrating new systems in our infrastructure. You are expected to take (co)ownership of the ongoing projects, be responsible for tasks and help with the day-to-day maintenance. Since this is going to be a part of an ESA official traineeship programme, you will also support some other projects of the laboratory, related to industrial developments and potentially interacting with academia and industry.

Required education:

- Master-level degree in electrical, mechanical or software engineering from an accredited institution
- Strong ability to understand and abstract real-world systems including their physical properties and behaviours into the digital domain.
- Good programming skills in C/C++
- Knowledge about Unix/Linux systems or real-time systems are considered an asset
- Knowledge in Matlab/Simulink and also development of S-functions considered an asset
- Machine learning skills are considered an asset
- Embedded programming skills are considered an asset
- Background in control engineering considered an asset
- Knowledge in networking protocols is considered an asset
- (Alternatively, a strong background in mechanical design and mechatronics integration can also be considered an asset, however, will then be directed in another topic)
- Experience with computer vision are considered an asset
- Practical experience of software development challenges like design approaches, prototyping, mocking, testing and build systems are considered an asset
- Excellent communication and organizational skills
- Fluency in English and/or French, the working languages of the Agency