Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

HOCHSCHULE BREMEN
UNIVERSITY OF APPLIED SCIENCES

Proposal for Master-Thesis

Lars Sinda (Matr.-ID.: 169338)

Development of a lightweight force-torque sensor unit for measurement of high loads

The *Robotics Innovation Center (RIC)* of the *DFKI - Deutsches Forschungsinstitut für Künstliche Intelligenz GmbH* in Bremen aims at the development of mobile robotic systems, which are capable of operating in different environments like air, land, under water or space. Locomotion of robots is one of the core fields of research at the *DFKI RIC*. For sophisticated and secure locomotion, a good recognition of a robot's current environment is necessary and is a field to which special attention has to be be paid.

Proper analysis of forces and torques, applied to the legs of a robot will provide it with detailed knowledge about the actual load distribution on single legs and the current surface it is located on. Besides more efficient use of the limited available energy resources, this will also enable a fairly better locomotion of the system, as load-balancing and detection of obstacles can be established.

For gathering the required information, a sensor is needed which is able to measure the forces and torques applied to the robot's legs. As the intended target robotic systems are expected to have a significant mass, the measurement of high loads while being lightweight itself is a core requirement to the sensor. The sensor is meant to integrate directly into the mechanical structure of the robot. Thus no additional fixtures have to be employed and the structure of the robot itself is equipped with sensing functionality.

The design of the sensor shall be carried out in the context of the development of *Sherpa*. *Sherpa* is a hybrid rover with four legs with one wheel attached to each leg. Its targeted field of operation is the transportation of high loads in extraterrestrial planetary environments. The intention of the development for a new sensor system results mainly from the aforementioned demands which could not be fulfilled by currently available sensors.

The measurement of imposed forces to each leg of a robot shall be carried out through analysis of the deformation of steel structures that connect every leg to the torso. The deformation will be observed by the application of strain gauges, which are bonded to this steel structure. Currently, a circuitry equipped with a STM32 microcontroller exists, which is able to sample the raw analog signals from the strain gauges of one particular robot leg.
The central task of the master-thesis is to employ the aforementioned components as a sensor-module for forces and torques which are applied to the attached robot-components. It will be necessary to provide 6 axis measurements which deliver 3 direc-

tions of force and tourque, respectively. To accomplish this task, several steps have to be performed:

- Analysis of the current technologies for force and torque measurements as well as available force and torque sensors
- Analysis and simulation of the existing steel structure in terms of effectivenes for measuring the desired variables. Amongst other analysis, *finite element method (FEM)* simulations shall be carried out to accomplish this. If applicable, the already existing flange for mounting the rover's legs to the body has to be modified.
- Identification of the relationship between the raw values sampled from the strain gauges and the applied forces.
- Development of an algorithm which is able to extract forces and torques from the sensor signals.
- Development of algorithms for conditioning the signals
- Implementation of the developed algorithms into the STM32 microcontroller using the C/C++ programming language.
- Calibration and characterization of the sensor-system by application of real forces
- Creation of communication interface to other systems which are available in the robot

The whole master thesis will be carried out at the *DFKI - Robotics Innocation Center* in Bremen.

The following pages show the proposed outline of the master-thesis and may change during the conduction of the thesis.

Bremen, March 31st, 2011

Contents