1. Introduction

Obstacle avoidance is an important problem in service and mobile robotics. Obstacles on the floor of a room include various objects such as stairs, doorsteps, chairs, tables and even the edges of carpets. Hence, floor based domestic robots need to have strategies to evade randomly placed objects. A new direction in the development of indoor service robots is the use of robotic structures that can move on the, almost obstacle free, ceiling of a room [1], [2].

The present paper describes a new indoor service robot platform developed within the ACROBOTER IST-2006-045530 project [3]. The robot (see Fig.1) consists of an RRT structured climber unit (CU) and a cable suspended swinging unit (SU) that forms a parallel kinematic chain, which is modelled by natural coordinate approach [4]. The SU is actuated by a woundable main cable and 3 secondary cables. Ducted fan actuators are also help to control the orientation of the SU, but despite of the large number of actuators the system is still under-actuated.

2. Motion control approach

The SU is able to move along a prescribed spatial trajectory while it performs various tasks like pick-and-place of objects and manipulating other service robots. The interaction with other objects requires 5-10mm accuracy, which is difficult to satisfy because the system has significant modelling error, and the calculation of the desired trajectory of the under-actuated set of descriptor coordinates is quite complex and computationally expensive. Hence we use impedance control, which handle these uncertainties and unmodeled dynamics of the under-actuated set of coordinates as a perturbation applied on the system.

Commonly impedance control is applied when a manipulator interacts with its environment and the interaction forces have to be accommodated [5], but impedance control is also applied as a robust control method that efficiently handles parametric uncertainties and external disturbances [6]. In the case of a 1DoF linear model the control force $F_{i+1}$ can be computed based on the desired trajectory $x^d$, the measured position $x$, velocity $\dot{x}$ and acceleration $\ddot{x}$ and the last value of the computed actuator force $F_i$:

$$F_{i+1} = \tilde{m}(\ddot{x}^d - \ddot{x} + k_p(\dot{x}^d - \dot{x}) + k_v(x^d - x)) + F_i,$$ (1)

where $\tilde{m}$ is the estimated value of the mass.

3. Numerical simulation and experiment

Fig. 2 shows the simulation results of the vertical trajectory of the SU. The 100mm initial error is eliminated efficiently by a simple PD controller and the impedance control as well. At $t = 2s$ the 9.3kg bare weight of the SU was
increased by a 3kg payload abruptly. Fig. 2 shows that the impedance control can hold the SU on the desired position exactly, while the PD controller generates a constant error.

![Fig. 2: Simulation of vertical motion](image)

The ACROBOTER prototype can be seen in Fig. 3. The position and orientation of the SU are measured by the pose estimating system integrated by an inertial measurement unit and a vision system. The measured data integration and the control algorithm run on the on-board PC of the CU and the SU distributively.

![Fig. 3: ACROBOTER prototype](image)

4. Conclusions

The impedance control as an adaptive method was applied for an under-actuated robot considering the parametric uncertainties. A numerical simulation demonstrates the applicability of the presented control concept. The ACROBOTER prototype provides the possibility to obtain experimental results.

5. Acknowledgements

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6. Patents pending

Application No.: HU-P0900466. Application date: July 28, 2009. Title: "Payload suspension system". Application No.: HU-P0900467. Application date: July 28, 2009. Title: "Suspended payload platform thrusted by fluid mass flow generators".

7. References


