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Basketball Robot: Ball-on-Plate System without Visual Information

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VIDEO ABSTRACT

Building a basketball robot is a recently launched project at the Institute of Automatic Control Engineering (LSR) for investigating fast manipulation with non-negligible dynamics and changing contact situation. This video presents some preliminary results of the project which is balancing a basketball on a plate. An aluminium plate of which the size is 25 × 40 cm is mounted on the end-effector of a six degree of freedom (DoF) serial industrial robot Stäubli RX90. In order to update the current state of a basketball on the plate the robot is equipped with a 6 DoF force-torque sensor between the plate and the end-effector. The mass of the basketball is 0.6 kg.

Standard control of industrial robots is inappropriate for testing complex control algorithms. A possible solution to create a rapid prototyping test environment is to run the system with Matlab/Simulink, see Wollherr et al. (2003). Fig. 1 describes the hardware configuration used in this experiment with an additional PC, on which Matlab/Simulink is executed under realtime Linux (RTAI) environment. It is integrated with sensoray cards and a force-torque sensor receiver. Advantages of using this hardware configuration are that new control algorithms can be designed easily in Matlab/Simulink and executed in the realtime Linux environment while keeping significant safety measures such as motor brakes, supervising joint limits and speeds as well as emergency brake from the original system.

The overall control scheme for the balancing a basketball consists of three parts including balancing control, impedance control, and inner position control. When the basketball loses its equilibrium on the plate and starts moving, velocity and position of the basketball are estimated by force-torque sensor data and the corresponding desired trajectory for stabilizing the ball is generated in the balancing control. The inner impedance control is supposed to take out the kinetic energy from the ball and modify the desired trajectory to avoid significant contact forces. The inner most position control loop generates motor torque commands for the robot to track the desired trajectory.

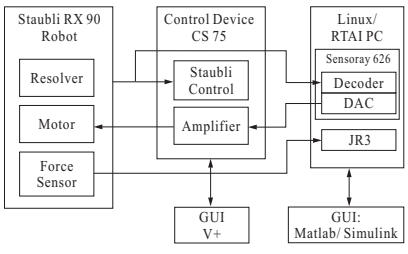

Fig. 1. Hardware configuration with an additional PC

The following features can be found in this video:

- Position-based impedance control,
- Ball dropping, catching, and throwing by an open loop control,
- Ball balancing on a plate against to external disturbance forces,
- Ball balancing on a moving plate, and
- Balancing a falling ball.

As an example, a sequence of snapshots for a stabilizing process against an external disturbance force is shown in Fig. 2. Further information can be referred to Lee et al. (2008).

REFERENCES

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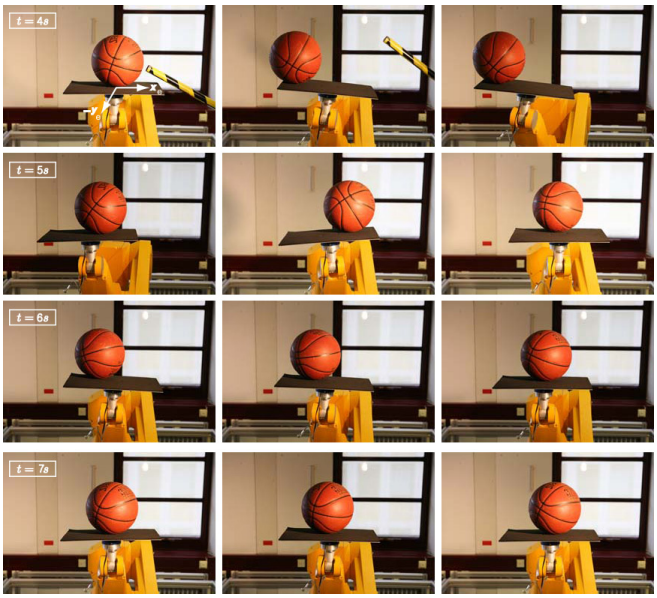

Fig. 2. Sequential snapshots of stabilizing a basketball against an external impact force at $t = 4$ s.