Autonomous underactuated vehicle prototype

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1. Overview

An underactuated system is a system controlled by a less number of inputs than the number of degrees of freedom. There are many typical systems of that type e.g. hovercrafts, underwater vehicles, rockets. Underactuation causes problems with system control, especially we observe stability problems in tracking or path following tasks. A vision based control algorithms for autonomous vehicles have issues when object is underactuated.

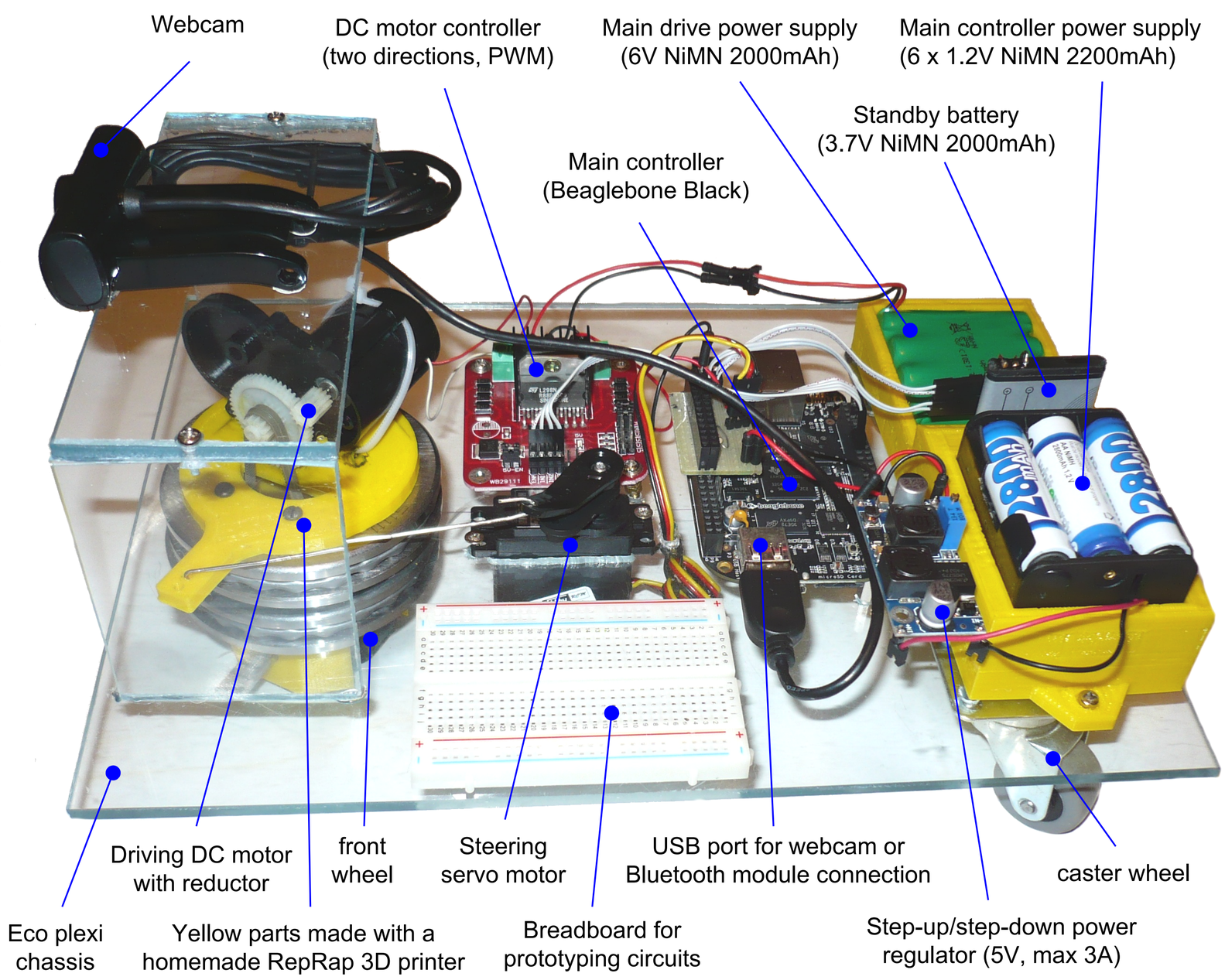
2. Problem formulation

Let us consider an exemplary planar rigid body subjected to an eccentric external force. A control task is tracking of a desire trajectory (circular or eight-curve). It is proposed to use the computed torque technique to control in closed-loop system with PD feedback. A vehicle position error is estimated based on a front camera view.

3. Prototype

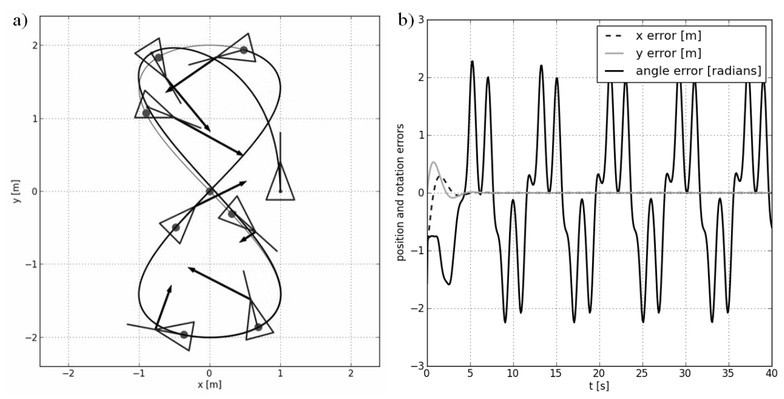
Picture on the right presents a prototype of an underactuated vehicle with caster wheels on the back and a front driven wheel. Control algorithms are performed using a minicomputer. A feedback position signal is generated using a camera (relative position with respect to orientation points or a trajectory printed on the ground). It is also possible to control the vehicle manually using Bluetooth module.

Beaglebone Black minicomputer:
- 1GHz ARM Cortex-A8 processor
- 512MB of DDR3 RAM
- 2GB eMMC drive
- USB host
- ethernet
- HDMI
- PWM, ADC, DIO, UART, SPI, CAN, timers
- Linux Ångström
- programing in C/C++/Python/others
- low cost



4. Mathematical modeling

A simple mathematical model of the presented vehicle was also studied. Before creating a control law for any system one should check its accessibility and controlability. Numerical simulation shows problems with control process stability. Unsteady and chaotic-like behaviors of the system appears when control inputs are limited (maximum steering angle).



Exemplary numerical simulation results

5. Feature plans

More precise system identification and steering algorithms should be investigated to achieve best control results. Some adaptive control methods connected with stability prediction are possible here.

Contact

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