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Patiny Océane, 26.07.2000

Remote control cylinder

Design, construction and programming of a robotic cylinder that rolls when its center of mass is displaced

Introduction

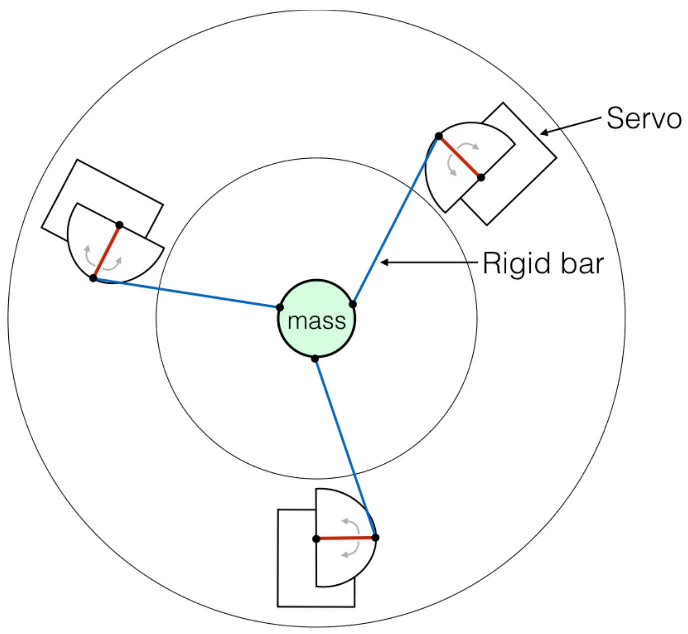

Figure 1: Method used to displace the center of mass of the cylinder.

Even though many scientific papers of the past twenty years have presented advances in the field of **spherical robots**, the ones that suggest to **displace the center of mass** of the sphere to induce the movement are rare. This project introduces an innovative approach to this problem. The technology is **tested on a cylinder** that is remotely controlled through a web page.

Our approach. Use the coordinate movement of three **servos motors** connected with rigid bars to a **mass in the center** of the cylinder to displace the mass and make the whole system roll (see Figure 1).

Methods

Mathematics. The mathematical part consists is finding a formula that expresses the **angle of the three servo motors** (a) depending on the position of the mass that is moved (see on the right).

$$a = f(x, y, R, s, d) = \frac{2y^2R - (R-x)\Delta}{2(y^2 + (R-x)^2)} \pm \frac{y\left[4\left(y^2R^2 - R(R-x)\Delta + y^2(s^2 - R^2) + (s^2 - R^2)(R-x)^2\right) - \Delta^2\right]^{\frac{1}{2}}}{2(y^2 + (R-x)^2)}$$

Where $\Delta = x^2 + y^2 + s^2 - d^2 - R^2$.

Mechanics. To build the cylinder, we had access to various machines from the Made@UC **makerspace**, which allowed to make exactly the parts that were needed. Also, **prototyping** led us to find the best materials and techniques to build the cylinder, with an **aesthetic** and **efficient** design.

Figure 2: Metal turning a part of the cylinder.

Electronics. A **C.H.I.P. Pro** is used as the micro-controller of the cylinder. Moreover, two I2C peripherals were needed: an **accelerometer** and a **servo driver**. Therefore, to have long-lasting, reliable electric connection, we decided to design and produce a **dedicated extension PCB** that would link the MCU to the peripherals.

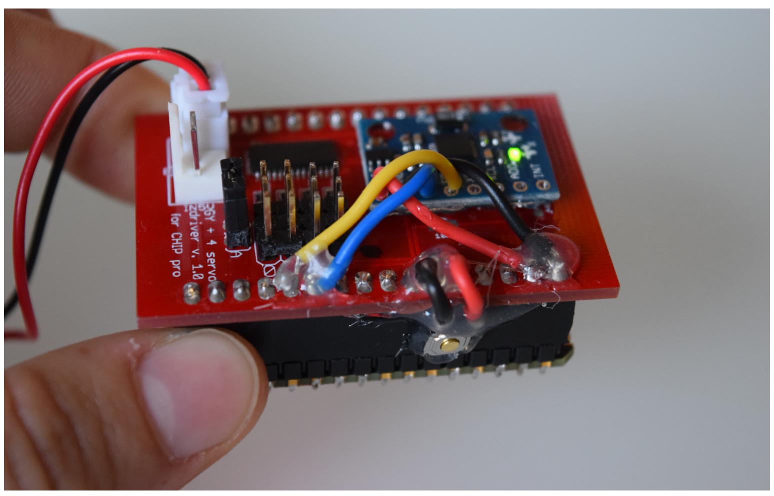

Figure 3: Extension PCB soldered and tested.

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Programming. All the code was written in **JavaScript** and is run using **Node.js** and a Shell.

How to control the cylinder?

1. Connect to the "**CylinderControl**" WiFi (password is "**CylinderControl**").
2. Go to a web browser.
3. Type "**172.16.1.1**" in the address bar and press **Enter**.
4. **Control** the cylinder using one of the three possible features.

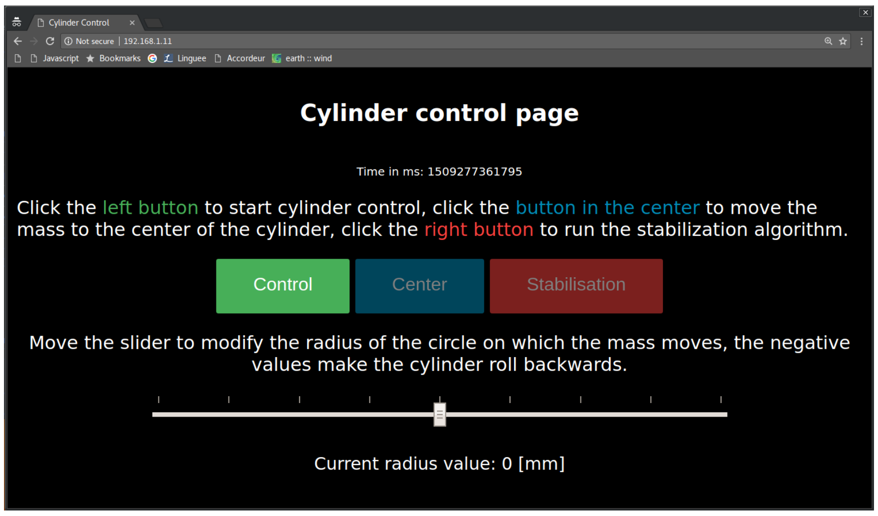


Figure 4: Final control web page (mobile friendly).

Results

Material: 6mm acrylic glass
Power supply: 3 AA batteries
Autonomy: ~3.7 hours
Maximal speed: 1.03 m/s
Maximal slope: 3°

Diameter: 32 cm
Total mass: 1380 g
Price: ~69 CHF
Can roll on hard and flat surfaces

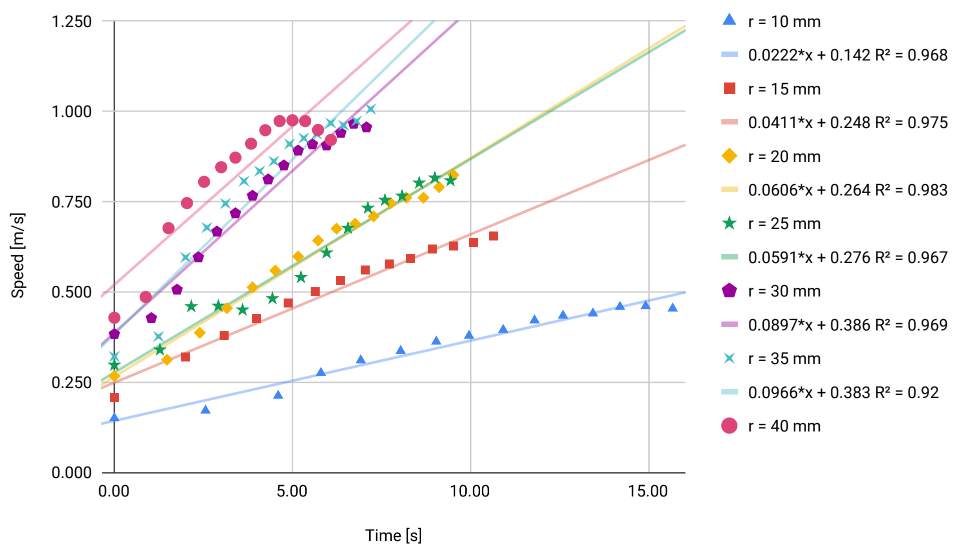


Figure 5: Speed of the cylinder versus time for different mass' radii with linear trendlines.

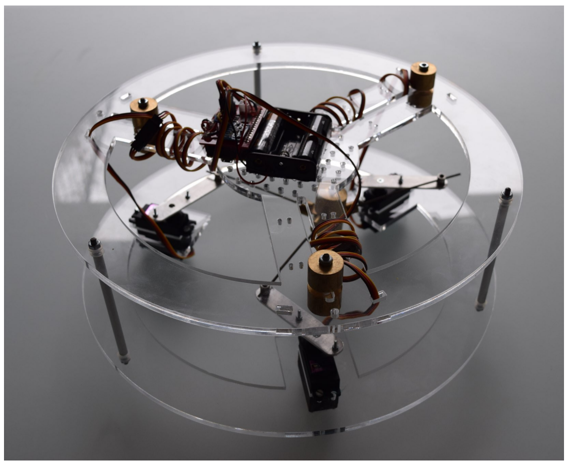


Figure 6: Last cylinder prototype.

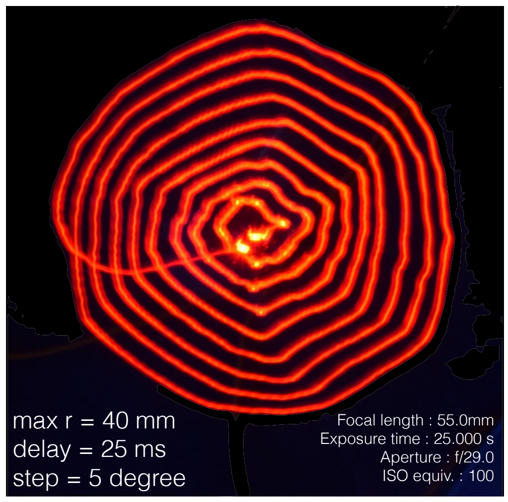


Figure 7: Long aperture picture of the mass' movement when moving on a spiral.

Discussion

In general, the results are really satisfying, since we are able to make the cylinder roll forwards and backwards and stop. Even though its maximal speed is not very high, it could be easily increased if **stronger motors** or a **heavier mass** in the center were used. In addition, the remote control is really efficient and allows anyone to test the cylinder's control.

Conclusions

We have shown that it is possible to use three servo motors to displace a mass in the center of a cylinder, which therefore leads it to roll. The goal would now be to **extend the same principle to a sphere**.

In addition, various applications in the fields of **personal transportation** and **surveillance** could also be considered, as shown in Figure 8.

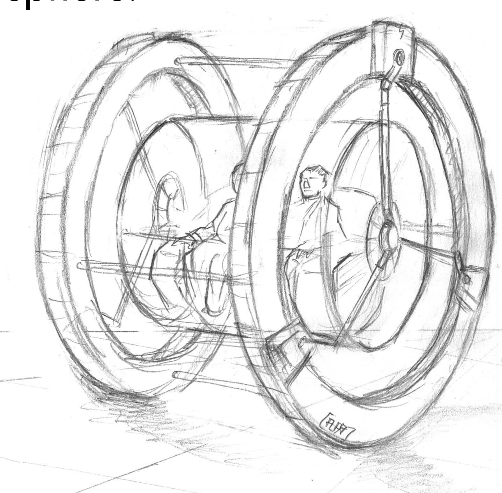
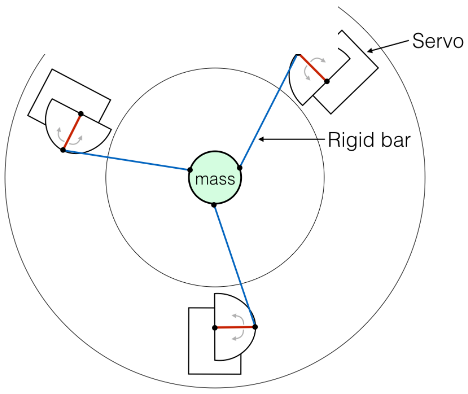


Figure 8: Hypothetical use of the cylinder's concept applied to personal transports.


Servo
Rigid bar
mass