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Remote control cylinder

Abstract

This project consists in the development of a remote controlled cylinder that uses servo motors to displace a mass in its center, which causes the cylinder to move. The final prototype that was built has a PMMA-based structure with a diameter of 32 cm. It is controlled using a C.H.I.P. Pro microcontroller and a dedicated board extension. The board includes two I2C slaves: a driver for four servo motors and a 6-axis IMU. Finally, the power supply is assured by a pack of three AA batteries. All the programming was made using JavaScript. The cylinder can be controlled remotely and can roll forwards and backwards, stop and keep itself balanced on a gentle slope. In addition, to make the control of the prototype easier, a web page was coded, which includes buttons and sliders. The movement characteristics of the cylinder have also been studied. This kind of design opens the doors to new types of vehicles with cylindrical or spherical wheels for the future of mobility.

Introduction

In the last twenty years, research in the field of spherical robots has been actively undertaken. The results, though, nearly always put forward an approach in which there is an internal drive mechanism, whose wheels lay on an outer, rigid shell. Here, we wanted to explore other possibilities to induce movement to a sphere. Yet, due to time and means restrictions, we had to focus on the 2D version: a cylinder.

The goal was therefore to achieve designing and building a remotely controlled cylinder that rolls when its center of mass is displaced using a technology that could be adapted to a sphere. It was also important to achieve that independently from any institution and to allow all the results to be open-source, so that anyone keen to remake what was done during the project could do so.

Methods

First of all, various approaches have been investigated, but it has quickly been realised that the most feasible solution was to use three servo motors placed on an equilateral triangle outside the cylinder and to connect them to a mass in the center with rigid bars. Once the approach was chosen, we had to find a mathematical formula that links the position of the mass in the center to the angles of the servo motors. Then, preliminary prototypes were built. We had access to a laser cutter to cut the base structure for the cylinder. This allowed to run first tests with basic arduino programs, which showed that the chosen approach was working. This led to the development of a dedicated PCB extension that would act as a shield on the microcontroller we chose: a C.H.I.P. Pro. The final phase was writing the code and debugging, which was done in JavaScript.

Also, the software that was developed is under MIT licence, whereas the hardware is under CERN OHL.

Results

The final prototype we built shows that the technology that we adopted works very well to make a cylinder roll. The features that we managed to obtain are for the cylinder to roll backwards and forwards at different speeds (with a maximum speed of 1.03 m/s), stop and remain balanced on a gentle slope (max. 3°). However, the cylinder works the best on hard and flat surfaces. The last prototype has an acrylic glass base structure, a diameter of 32 cm and weights ~ 1380 g. The power supply consists of a pack of three AA batteries, which gives it a theoretical autonomy of ~ 9.8 hours in standby and ~ 3.7 hours rolling. The control of the cylinder is done through a web page and is therefore easy and intuitive for anyone.

Discussion

In general, the results are really satisfying, because they prove the efficiency of the method that we invented. Also, they are several advantages that this approach provides, compared to the one generally used in spherical robots, which is placing a little car inside it. First of all, the mass that we move can be placed exactly in the center of the sphere, which allows it to roll freely, nearly without any energy costs. In addition, the whole sphere would only be made of one part, since all the components are connected together. So, the relative position between the outer shell is always known, because it is not possible for the shell to slip under the wheels of the drive mechanism, like in a standard approach.

Conclusions

We have theoretically and practically shown that it is possible to use three servo motors to displace a mass in the center of a cylinder and therefore generate motion. If the project was to be continued, it would be highly interesting to build a sphere working on the same principle.

SURPLUS

This implies that very diverse fields such as mathematics, physics, programming, electronics and mechanics had to be explored and partly understood to be combined in the final prototype.

Often, pop culture and science-fiction in particular reflect the interest of a society for a certain subject. In the last 50 years, they have been various cases of spheres that can move in an autonomous way in movies and TV series. An easy example is BB-8, a robot with a spherical body that appeared on screen for the first time in 2015, in *The Force Awakens* (Star Wars).

Since this project required designing, modeling and building, it is very interdisciplinary. To realise this project, knowledge from five different fields had to be acquired. These fields are mathematics, physics, mechanics, electronics and programming.