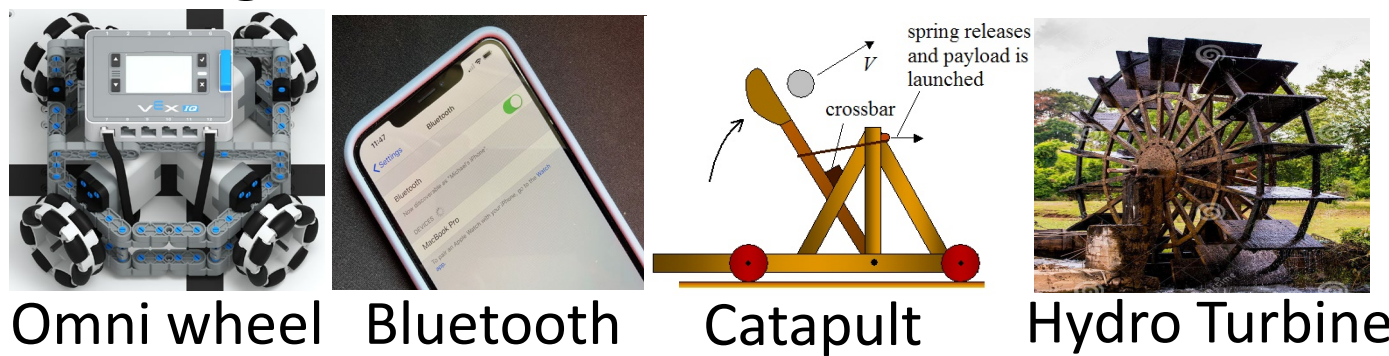


# Omni-motion, Bluetooth-remote-control, and Self-reloading Automatic Catapult

Xinlei Zhang, Jinan Guo, Ze'an He, Juncong Lan, Yile Shen  
Prof. Yingjie Zhang

## Introduction

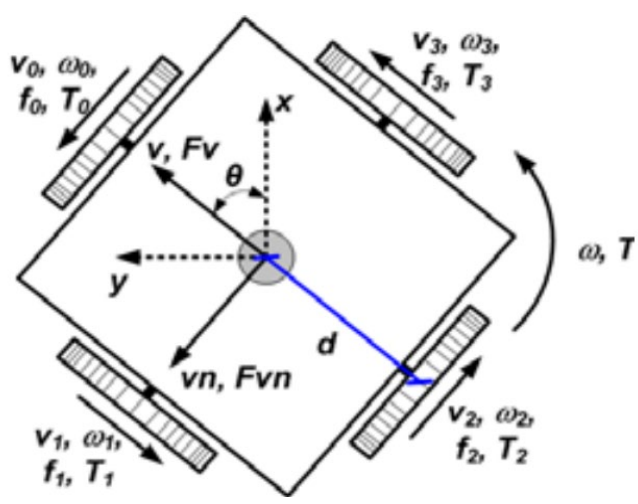
To complete all the tasks, our product should be equipped with motion, remote control, launching and reloading systems. Omni-wheel motion and bluetooth communication are widely-used technology in these days. Even though catapult and hydro turbine are invented in the ancient time, the idea behind them is still worth learning.



## Methodology

### Dynamical Model

Figure (a) presents the configuration of four wheels, as well as all axis and relevant forces and velocities of the model.



$$v(t) = \frac{1}{2}(v_3(t) - v_1(t))$$

$$v_n(t) = \frac{1}{2}(v_0(t) - v_2(t))$$

$$\omega(t) = \frac{1}{4d}(v_0(t) + v_1(t) + v_2(t) + v_3(t))$$

### Shooting Device Designing

Inspired by catapult — an ancient siege equipment, we choose the combination of lever and springs. Figure (b) demonstrates the 3D model of our design. We can adjust the elongation of springs proportional to displacement of screw to suit for different balls.

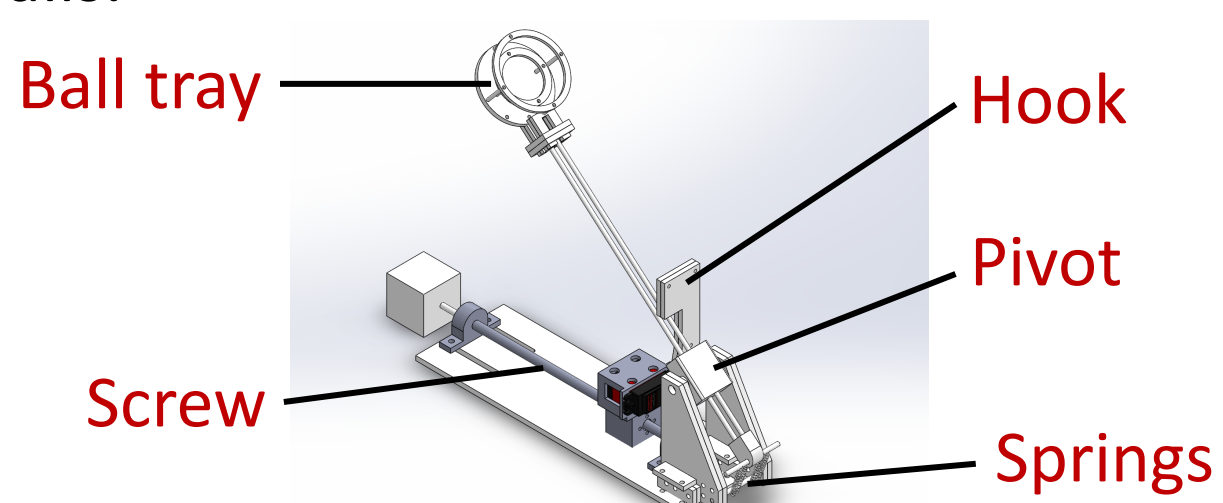


Figure (b)

### Reloading Device Designing

To satisfy the demand of storing balls of different sizes, we design a structure like hydro turbine whose clapboard is detachable. One cell is for small ball, and joining two cells can be suitable for big balls.

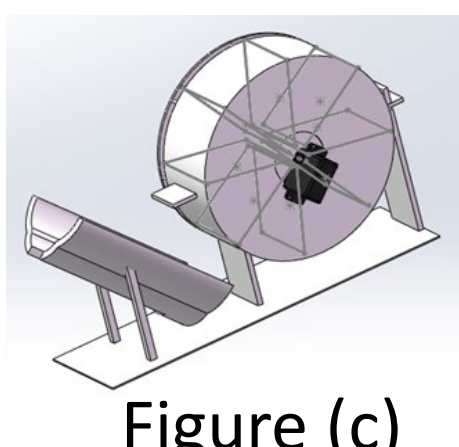
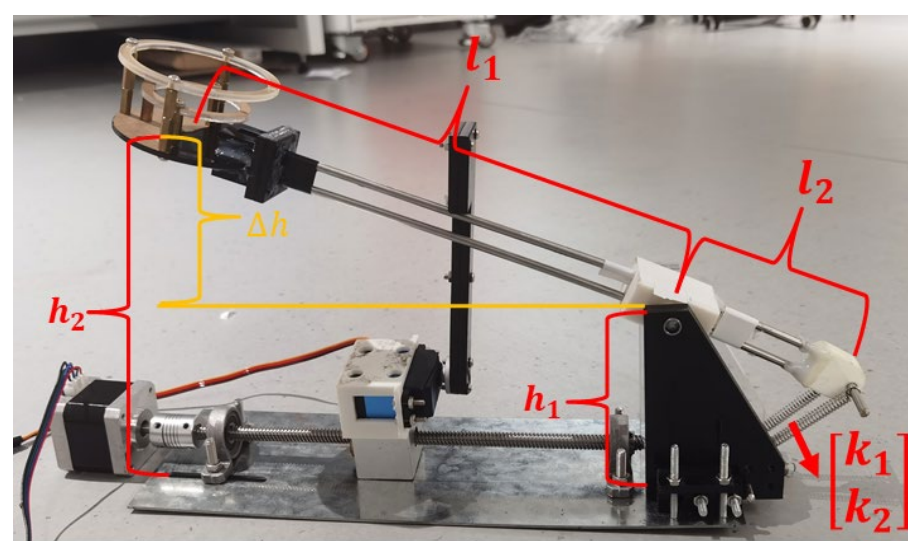


Figure (c)

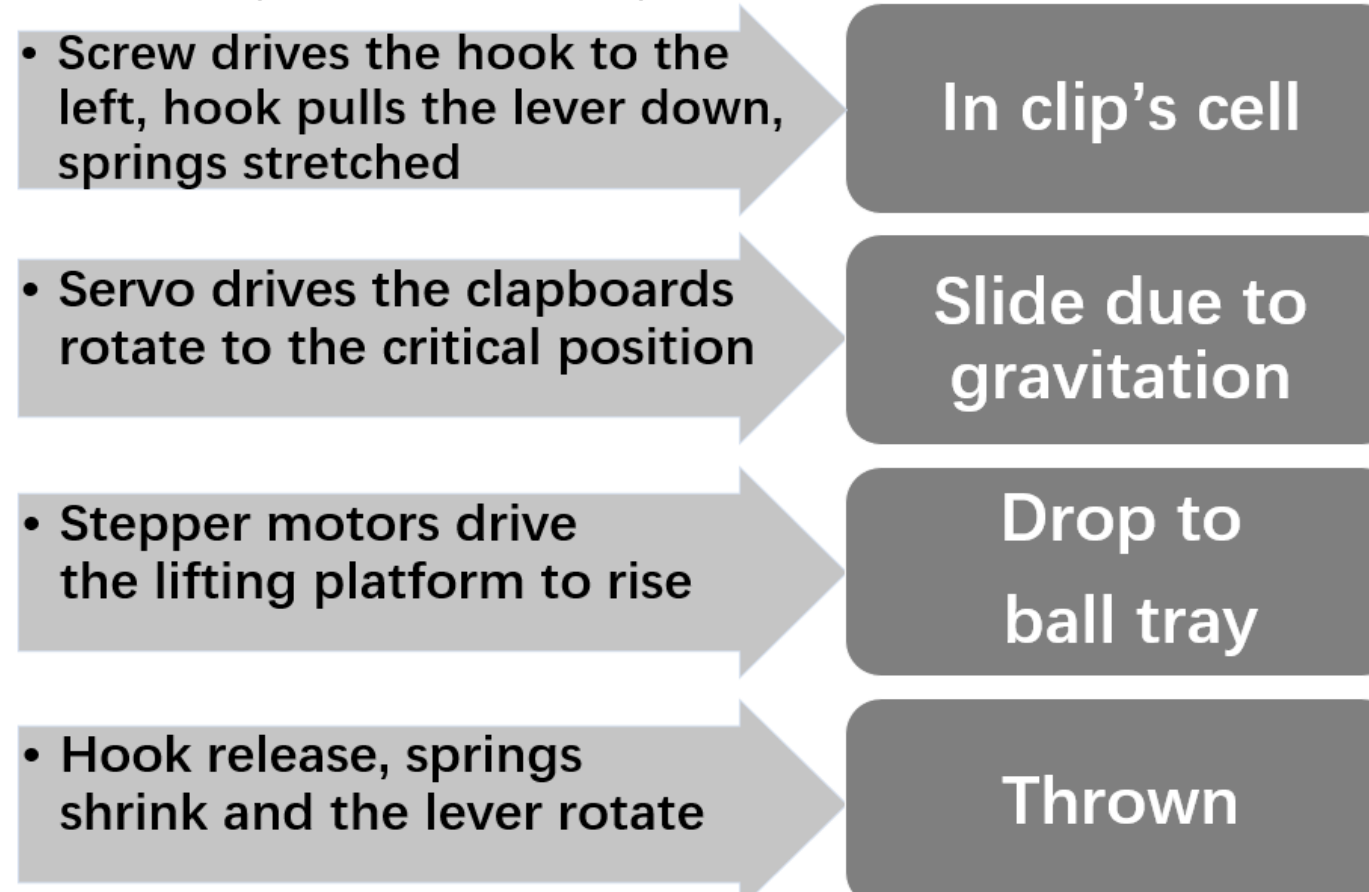
## Procedure and Results

### Parameters



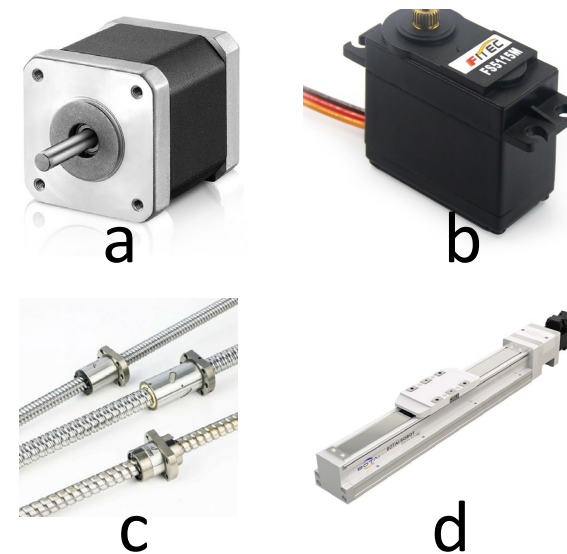
$l_1$	21cm
$l_2$	8cm
$h_1$	11.5cm
$h_2$	21.5cm
$\Delta h$	10cm

### Experiment procedures



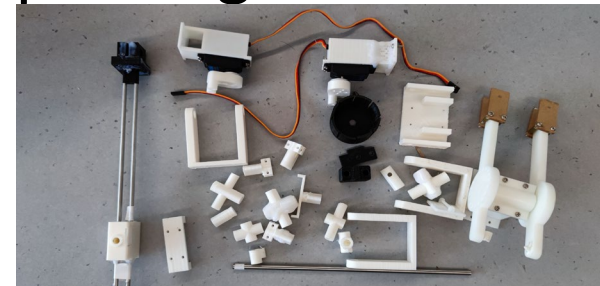
### Equipment

- a. Stepper motors x3
- b. Servos x2
- c. Screw
- d. Slipway

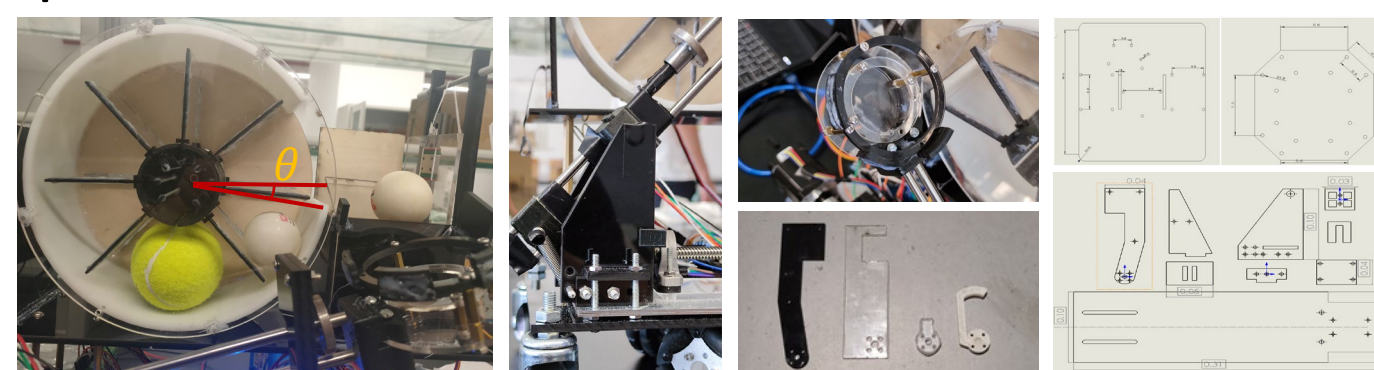


### Materials

**Plastics:** 3D printing connectors



**Acrylic plate:** hydro turbine, lifting platform, hook, ball tray, pedestal and some mounting plates.



**Armor plate:** higher intensity for shooting device installation.

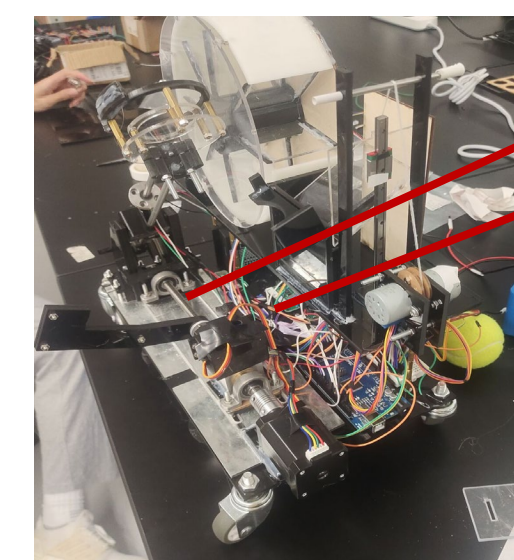
**Steel rods:** lever



### Problems

The squash is of high friction causing difficulty in smooth reloading.  
Lead screws can be worn out over time.

## Discussion and Analysis



Center of Gravity  
Center of Geometry

Stable motion requires precise control of four wheels' speed. Although we've already used PID algorithm and the speed can converge to the target value we preset, the motion is still unstable and shaky in the start-up phase due to the offset of the center of the gravity, as shown in Figure (a).

Figure (a)  
Offset of the center of gravity

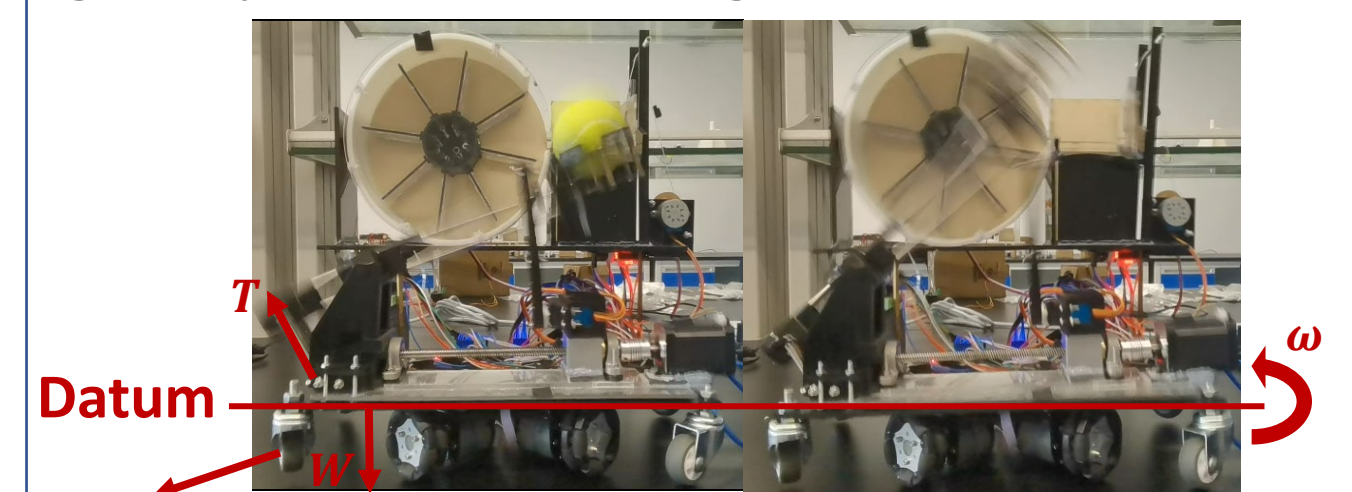
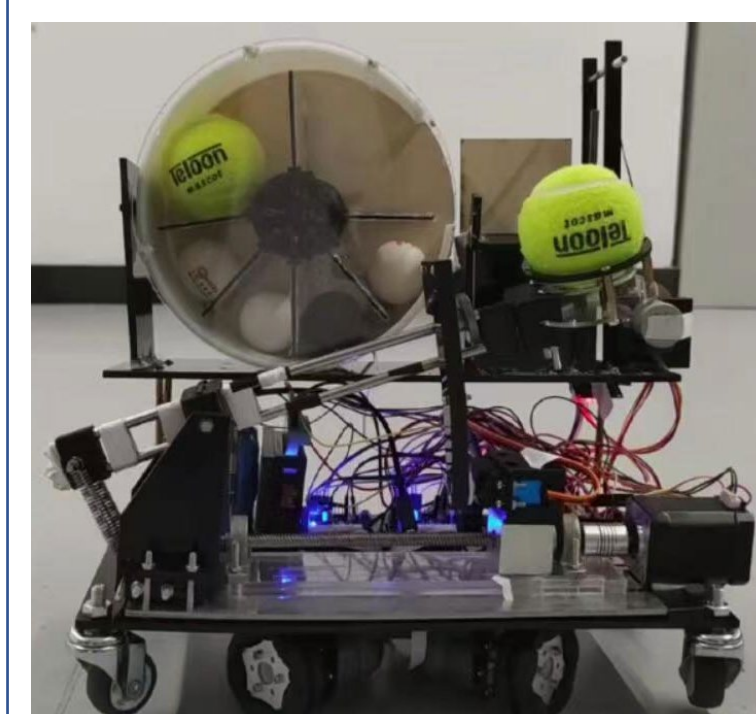


Figure (b) Just launch  
Figure (c) During launch

Figure (b) and Figure (c) show the vibration caused by the recoil of launching. We damp down the effect of this vibration by adding four extra support wheels.

## Conclusions



The Finished Product

The final product can successfully complete all the tasks, but there're still many aspects to improve, like the instability of motion, the recoil of launching...

## Acknowledgement

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