Ping Pong Ball Cannon

Project overview

Ping Pong Ball –cannon is a device which shoots ping pong –balls with either manual command from joystick or automatic command by machine vision. Shooting process is completely autonomous and user only needs to load more balls in the loading tube while operating in fully automatic mode.

Cannon can be controlled in manual mode where movements can be controlled by a joystick. In this mode user can trigger the cannon but actual shooting and reloading are still automated.

In fully automatic mode cannon shoots targets defined in the machine vision software. Camera is mounted inside the box facing forward. User can adjust settings of machine vision in separate software on laptop, for example user can set safe colors, calibrate the aiming etc.

Technical description

Links to the various attached technical documents:

- CAD models (Creo)
- Technical drawings (PDF)
- STEP file of the whole assembly
- Pneumatic schematic (PDF)
- Electrical schematic

Mechanical components

The Ping Pong Ball Cannon consists of four different sections. Box, rotating table, barrel assembly and the loading mechanism.
Box is a stationary part and is used as a sturdy frame. Almost all of the equipment is attached to the box. All the necessary connectors for manual operation are found on the side of the box. Box is manufactured from 15 mm thick PVC sheet.

Rotating table serves as mounting point for the barrel and the loading mechanism. One servo is used for the panning motion of the cannon. There is also a small slot to denote the front middle position of the table. Table can be adjusted to the middle position by loosening the middle screw and starting up the cannon. Then the servo drives to the middle position automatically and the table can be rotated accordingly.

The barrel and the loading mechanism is attached to the table with a hexagonal mounting bracket. The cannon tilt movements are controlled also by a single servomotor connected to the mounting bracket. The axle between the bracket and the servo is only connected by one screw. This might cause problems as slippage which causes the barrel zero position to shift. Correcting this problem requires the removing of the tilt-servo, restarting the cannon so the servo drives itself to the middle point and then reattaching it to the barrel when it is horizontal.
Loading mechanism loads new ball in the barrel once cannon has fired. Loading holes are located in the barrel and loading barrel. When the loading cylinder moves the holes become aligned and new ball drops in to the barrel from loading tube. Cylinder movements have been limited so that cylinder's force at extreme positions is not stressing any plastic parts. If the loading barrel is removed, careful adjustment is needed that loading mechanism is not stressed by the cylinder. Cylinder speed and force can be controlled by pressure regulator and adjustable constrictor inside the box.

**Electrical components**

The project required following electrical components:

- ATX power source
- Arduino Duemilanove
- 16x2 Character LCD
- 2-axis joystick with 4 buttons + switch
- Key switch
- 2 x Hobby servo
- 2 x 24V Pneumatic valve
- 2 x 5V relay
- 2 x Diad
- 10 Ohm power resistor
- 2200 uF capacitor
- Bunch of 0.5W resistors

**Software**

Two pieces of software were used in the project. The processing software that runs on the computer handles the machine vision and the arduino software reads the signals from the joystick and controls the cannon itself. The processing software was open source, and can be found at the website [http://projects entrygun.rudolphlabs.com/](http://projects entrygun.rudolphlabs.com/).

**Components and budget**

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<th>Material/Component</th>
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<th>Comments</th>
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<td>POM for turning table</td>
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<td>Servos</td>
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Safety

There are a few of safety considerations when operating this machine. Please read carefully before trying operating the cannon.

Electrical Safety

Inside the box care has to be taken to avoid electrical shock. If you are unsure about anything unplug mains cable before touching anything.

Live parts inside the box can be found on the back of the mains connector and on the power supply module. Back of the mains connector is energized to mains voltage regardless of the power switch position when plugged in. While power switch is in the on-position, heat sinks of the power supply are energized to ~130 VDC. Also there might be hazardous voltages present even after machine has been unplugged due to high voltage capacitors in the power supply.

Mechanical Safety

Loading actuator is pressurized as soon as air supply is connected. Care has to be taken also while operating the cannon to avoid pinching fingers between the loading mechanism, especially if loading tube has been removed. Never try to manually load the cannon without loading tube while pneumatic system is pressurized.

While Ping-Pong-balls are relatively light relative to their size, eye protection must be worn when being in the line of fire while the cannon is energized.

Performance

Based on the slow motion video of the firing cannon we managed to calculate a rough approximation of the muzzle velocity of the ball. Since the camera recorded at 240 fps and the ball moved approximately 0.192 m in the time of two frames, this gives us a velocity of 23 m/s or 83 km/h.

User manual

Setup

Setting up the cannon is fairly straightforward. The power cable, pressure cable, and joystick cable are all connected to the left side of the cannons lower structure. The two USB-cables (for the web camera and arduino board) found inside the lower structure of the cannon are connected to a computer. At this moment, do not yet connect the arduino cable to the computer (white cable).

The computer needs to have the processing software found on the following site in order to be able to analyze the webcams picture and communicate with the arduino.

http://projectsentrygun.rudolphlabs.com/

The setup for the processing program can be found here. Replace the settings.txt file located at Processing_Turret_06_13\data with the one provided in order to use the same setup for the program as we used.

When starting up the cannon, first turn on the main power switch located at the left side of the lower structure, and then connect the arduino cable to the computer.

The switch located at the cannons control panel enables and disables the cannons ability to fire and reload. The left and right button located at the top of the joystick increases and decreases the time the cannon shoots air when the cannon is fired. The on off switch sets the cannon in manual (off) or automatic (on) mode.

Manual mode

Moving the joystick controls the cannons pan and tilt movement. The trigger on the joystick fires and reloads the cannon in one sequence. The big center button on top of the joystick is for manual reloading.

Automatic mode

In autonomous mode the cannon shoots at any target it finds. Various settings for its functionality can be set trough the processing software.

If the automatic mode is not working (the processing programs diagnostics section says that it is not connected to any arduino), it might be due to that the processing program is not connected to the arduino. The connection can be edited from the processing programs diagnostics section. Full instructions for the processing software can be found on the website.
Conclusions and suggestions

Current firing system works reliably but in the current state the ball trajectory is very unpredictable. This happens because of the placement of the O-ring at the end of the barrel. When the ball launches past the O-ring there is no barrel left to keep the flight of the ball in the right direction. Furthermore the ball spins in a random direction after launch which further damages the trajectory. For future improvements the launching principle would have to be revised in order to achieve better accuracy. One solution would be to replace the current barrel with a longer one, thus still enabling enough pressure to be built behind the O-ring and the ball, but also allowing the installation of a Hop-Up device at the later part of the barrel. The Hop-Up would give the ball a backspin which would probably lead to a more controlled trajectory.

Other possible improvements would be making the functionality of the cannon more reliable. Sometimes the whole cannon freezes during reloading and it is as of the moment unclear whether it is the software or power supply that is causing it. As of the moment the balls sometimes also gets stuck at the O-ring.

Attachments
Code

The programming was done in the arduino environment. The control of the cannon is based on arduino built-in libraries. A copy of the code can be found down below.

Arduino Code (.ino)

Circuit diagram