Collision Avoidance
With
Depth Detection Camera

C – camera
A – arm
T – tracking
Introduction

- Supporting system for eye surgery
- High-end electronic microscopes attached to robotic arm
- A collision could damage the sophisticated and sensitive microscope
Goals and General Design

- Use depth/object detection to avoid robotic arm collision
- Mount 3D cameras onto/around the surgical cart
- Rotate the cameras to track arm position
System Design

Jetson / GPU Device
- Object Detection
- Arm Tracking
- Multi-System Communication

STM 32 Microcontroller
- Step Motor Driver

Intel Realsense Camera

Step Motor x2

UART

USB 3.0

3D Printed Mount

Socket

One More Similar System For Other Angle
STM32 and Step Motor

STM32 Microcontroller  Motor Driver  Step Motor

PWM & GPIO  4 Bit Step Info
Depth Detection Camera

Intel Realsense D435i

- Active IR technology
- High resolution RGB camera
- SDK for most programming language
- USB 3.1 which requires a high-level micro controller
3D Printed Mount

- 360 degree turning angle both vertically and horizontally
- Two sets for different perspective point
Color Detection

1. Generate a color mask from RGB image
   - Get a 2-D array of 0 and 255
   - Mark pixels of selected color range with 255

2. Return a Geometric center
   - Use OpenCV2 package
   - Use the center point to tracking the robotic arm
First Attempt on Raspberry Pi

Failed because of the limitation of Raspberry Pi and CPU intensive algorithm
Current Design

Jetson Based

- GPU on-board
- Faster object detection
- Detect all direction of the whole arm simultaneously
Image Postprocessing

1. Color Mask:
   - Use our own kernel to remove noise

2. Depth Frame:
   - Use filter to smooth the depth image
   - Hole filling
Object Detection

Robotic Arm
(Green Covered)

Ignored Device
(Red Covered)

Inner Bound
(For Comparison)

Outer Bound
(For Detection)

Ignored Bound
(Skip Part)

fps = 28.3
Main Program

Tracking

Streaming & Object Detection

Top

Start

Color Center

Blocking Information

Communication with Second System
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