SafeVision

Collision Detection & Avoidance System

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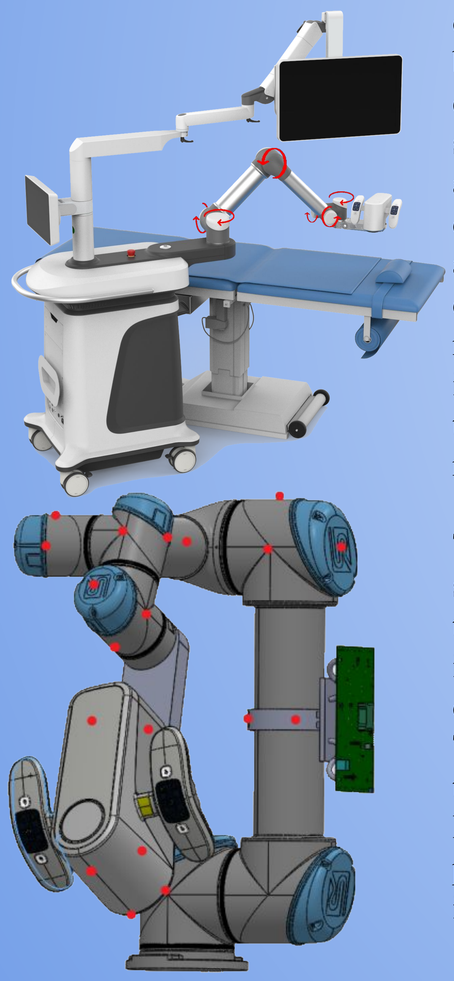
Background

TrueVision Alcon (TVA) has developed a robotic stereoscopic digital microscope mounted on a UR5 robotic arm. The TVA microscope uses digital 3D surgical visualization to aid surgeons in correcting and improving a patient's vision. The robotic arm moves from one position to another during surgery and returns to a storage position once the surgery is completed. During this autonomous movement the arm risks collisions with doctors and equipment in the area.

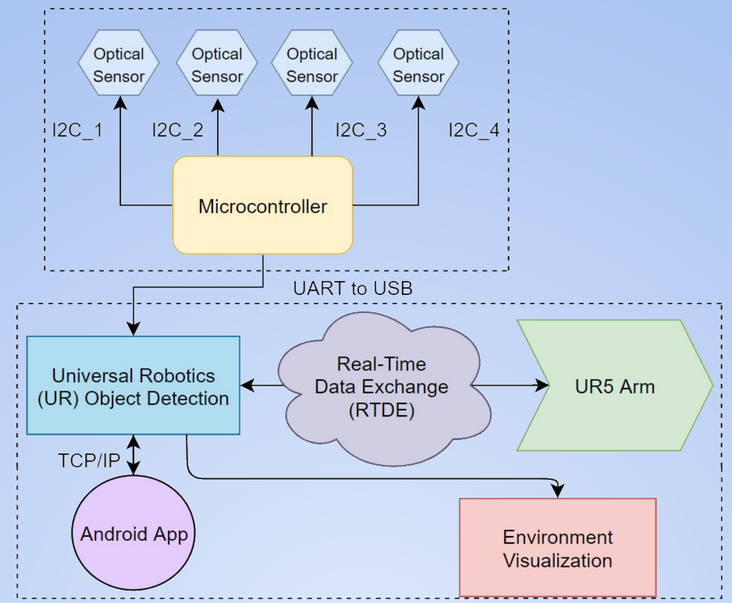
Overview



SafeVision increases ease of use and improves safety by preventing obstacle collisions. Optical distance sensors are attached to the arm which measure the distance to obstacles around the arm. The sensor data is analyzed by the main computer system to intelligently decide when to safely stop the arm and resume operation.

The sensor placement, as shown by the red dots in the left figure, are important in guaranteeing detection of all obstacles. The sensors are connected to the custom PCB with EMI shielded wires to help prevent electrical interference.

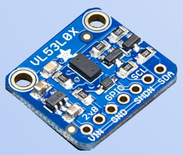
Functional Flow Diagram



Key Components

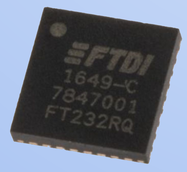
STM32F767ZI

- Arm® 32-bit Cortex®-M7 CPU
- Up to 216 MHz clock speed
- Four I2C buses in Fast Mode



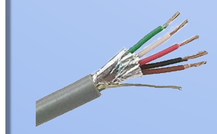
VL53L0X Time-of-Flight Sensors

- Two meter range, 25 degree FoV
- Eyesafe Class 1 laser device
- I2C for parallel busses



FT232RQ

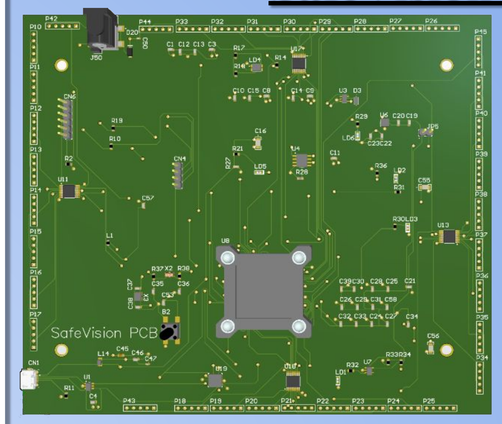
- USB to serial UART interface
- RS232 protocol
- Transfers sensor data from MCU to main control system



Shielded Wires

- Prevent electrical interference from high-current motors during the I2C communication

SafeVision PCB



- 36 I2C outputs for sensor connections
- All on-board components are powered through micro-USB
- Externally connected sensors are powered through the barrel jack on the PCB

Challenges

Arm-arm collision

- Guarantees the arm does not collide with itself.

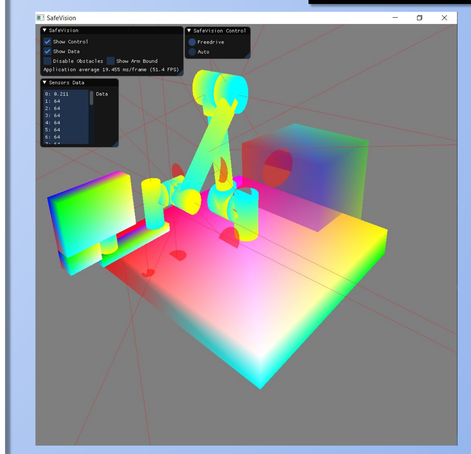
Enabling sensors in motion

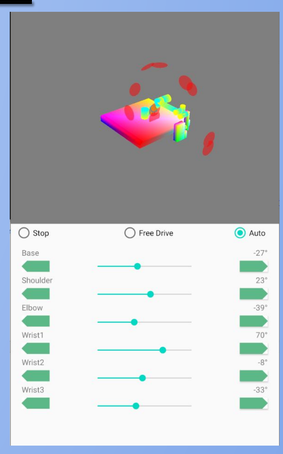
- Only stops when obstacles are detected in motion path.

Minimizing latency

- Given arm speed and the detection range of the sensors, deceleration occurs within a second.

Conclusion





Promising in-person tests show that the arm stops with a single sensor detection. Virtual tests show that the arm stops for obstacles safely with a full setup. An android app was also developed to allow for remote control of the arm. Future work includes testing the physical arm with all sensors.

Alcon

Acknowledgements

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