Design of a One-Eyed Face Tracking Robot to Facilitate Human-Robot Interaction

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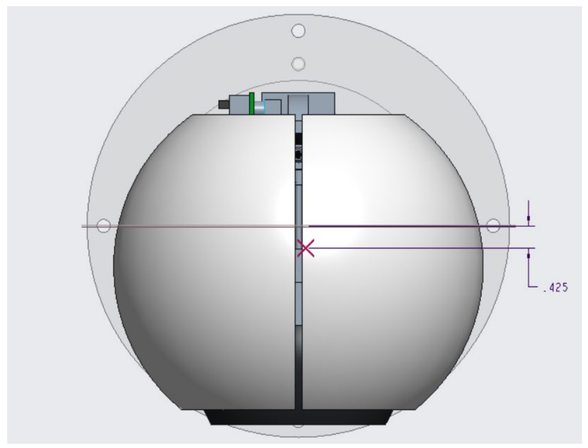
ABSTRACT

Eye contact is one of the most important parts of communication between humans. It shows that a person is listening and paying attention to what is being said. Modern robotic assistants like Amazon Echo or Google Home seem to be missing this crucial part, leaving the user with nothing to focus on when they are speaking to the robot. This project seeks to mitigate this issue with the design of Mr. I, a one-eyed face tracking robot that a user would be able to maintain eye contact with. The goal is to make it easier for a person to have a conversation with the robot, facilitating human-robot interaction. The project was successful in that regard as the robot accurately tracks faces and peer feedback has been largely positive.

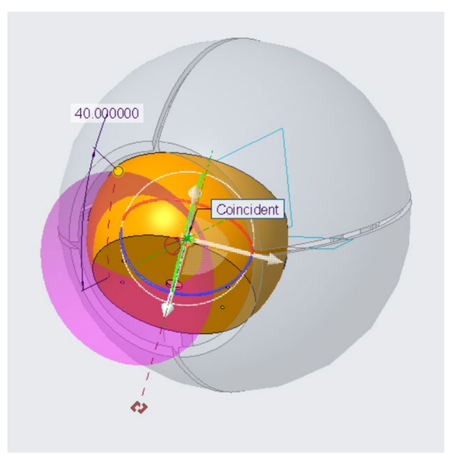
PRELIMINARY DESIGN

- Three degrees of freedom
  - Two servos for pan and tilt, stepper for rotation
- Eye:
  - Logitech C615 Webcam
  - Pan and tilt: two servos
- Head:
  - Mounting block
  - Four plates
- Body:
  - Slender but must support weight of the mechanism
  - Aluminum
  - Mounting brackets
- Base:
  - 1:6 gear ratio, wide enough to counteract tipping

CAD Model



Center of Gravity



Cone of Rotation

MOTIVATION

- $8.03 billion industry in 2021 and is expected to grow to $32.9 billion by 2030 [1].
- Human-robot interaction
- Black box: Existing household robots have little human component
- Eye mechanism could facilitate communication through eye contact
- Humanoid robots: The Uncanny Valley [2]
- One-eyed characters

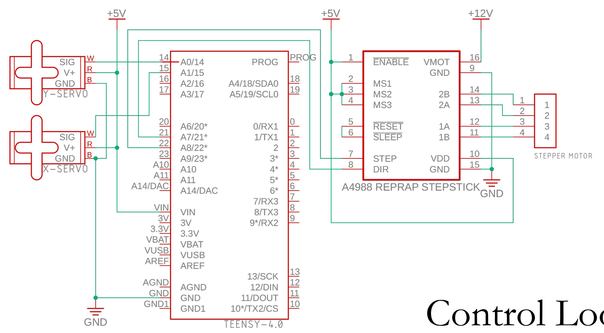
MANUFACTURING

- 3D Printed custom parts
- CNC milled aluminum body
- Laser cut base
- Spray painting to finish head pieces
- Magnets for servicing & repair

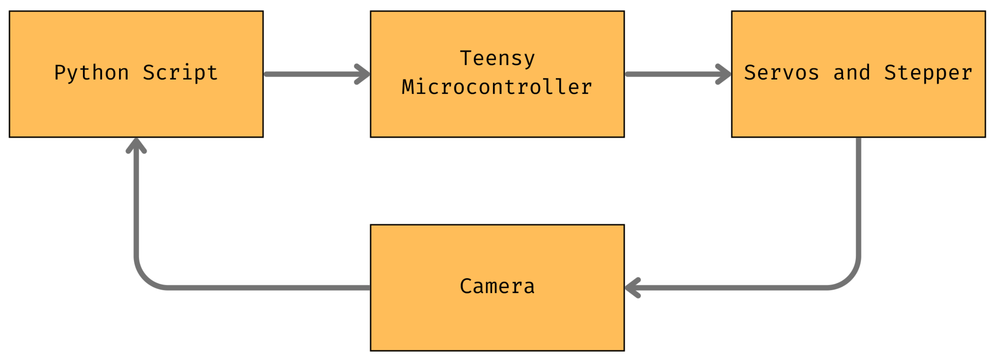
Final Model

ELECTRONICS & SOFTWARE

Wiring Schematic



Control Loop



- Teensy 4.0, Patton Robotics daughter board
- DS3218MG servo, NEMA 14 stepper with 200 steps/360°
- Arduino on Teensy for actuators, Python on laptop for facial recognition
- Integration with serial data over USB [3]

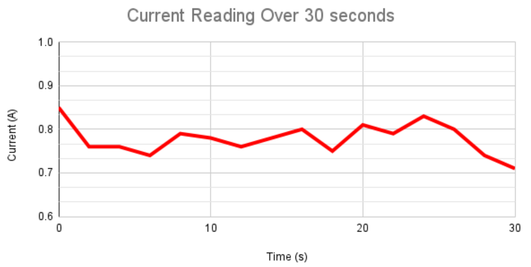
RESULTS AND DISCUSSION

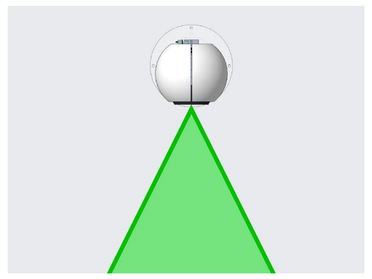
Safety Metrics: Velocity

Motor	Software Limit (rad/s)	Average Recorded Velocity (rad/s)
X-Servo	0.75	0.20
Y-Servo	0.98	0.26
Stepper	5.24	1.06

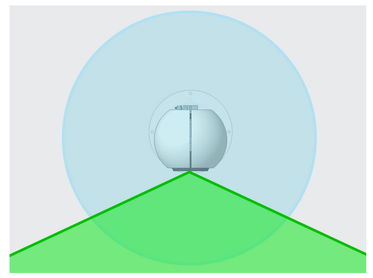
Motor movement in image

Motor	Correlation (pixels/deg)
X-Servo	7.28
Y-Servo	7.98
Stepper	0.25





Base FOV: 60°



FOV with actuation: 130° + 360°

- Maximum user movement: 11.55 m/s per meter
- Loop closure time: 3.1 seconds
- Peak current: 0.88A, Average current 0.78A
- Nominal battery life: 28.79 hours, 22.4Ah 8 AA batteries
- Facial recognition: lighting, multiple people, accessories, skin tone
- Peer feedback positive: would rather talk to this than a black box

FUTURE WORK

- Choosing which face to focus on in multiple people
- Speaker and microphone integration
- Modern components for noise: stepper, TMC2208
- Different colors or design variations
- Improve assembly process: standardize screws
- Materials and manufacturing methods
- Custom PCB and ATmega328P to replace Teensy 4.0
- Raspberry Pi for standalone operation
- AI integration for natural human voice interaction

REFERENCES: [1] Polaris Market Research, "Household Robots Market Size Global Report, 2022 - 2030," Polaris, Nov. 2022. https://www.polarismarketresearch.com/ (accessed Apr. 19, 2023). [2] Masahiro Mori and Karl F. Macdorman, "The Uncanny Valley: The Original Essay by Masahiro Mori - IEEE Spectrum," IEEE Robotics & Automation Magazine, no. June 2012, Jun. 2012, [Online]. Available https://api.semanticscholar.org/CorpusID:209316176. [3] PowerBroker2, "pySerialTransfer." Apr. 08, 2023. Accessed: Apr. 20, 2023. [Online]. Available: https://github.com/PowerBroker2/pySerialTransfer