Sinister Stooge
Design Document

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February 13, 2015—March 5, 2015

Abstract

We will design, build, and test an articulated robotic arm. The rotational motion of the arm will be driven by stepper motors.

1 War Council 1
February 13, 2015

Project History:

- CalHacks: Servo 2-joing arm
- HackSC: Cam-driven Hammer, Myo
- Bevel Gearmotor joint
- Lantern Modulex

Procedural Improvements:

- Formal Project Proposal
  - Schedule
  - Milestone Dates
  - Target Event
- Ongoing Documentation
  - Concept Sketches
  - Ongoing LaTeX doc
  - Private Github Repo
  - Data Logging
- Evaluations & Revision
  - Peer Revision / Diagram approval
  - Quality Control
  - Professional Design Review
- Bill of Materials
  - Ordering List
  - Budget

Future Goals:

- Research Sponsorship
- Open Source
- Expanded Team
- Research Club
- Present at Maker Faire Bay Area (May 16–17, 2015)

Brainstorm:

- Arm
- Pennyboard
- Hand
- Animatronic
- Smart Backpack
- Smart Light
- Holograms

Action Items:

- Research holographic projection techniques
  - USC Spinning Mirror:
    `http://youtu.be/eNWJ9XtRhLw`
  - Volumetric Helix:
    `http://makezine.com/2012/06/18/hacktastic-horizontal-helical-3d-display/`
  - Laser Display

- Define scope/specifications for mechanical arm
  - Hydraulic/Industrial
  - Machine Learning System
  - Force Feedback System

2 War Council 2
February 20, 2015

Discussion Topics:

- 3D projector may require high-speed projector
- Leap Motion & Solidworks
- Mechanical Arm

Design Matrix:

Projector	Arm	LeapCAD
Requres high-speed projector	Stability and accuracy	Working with Solidworks API
Working with Solidworks API	Stepper motors	No hardware
Stable projection surface	Goal: balancing and throwing	

Decision:

The holographic projector poses the problem of creating a good image while allowing for a reasonable refresh rate. This is a project that will require more funding and knowledge of optics to complete. We are removing this project from the list.

Using Leap-Motion to control CAD software could be a useful and interesting to develop. We could develop a deeper understanding of Solidworks and the Leap-Motion. However, the scope of this project is more suitable for a Hackathon. Therefore, we will shelve this project until a suitable occasion.

The mechanical arm can be applied to a large scope of tasks. Creating a mechanical arm with a focus on precision and stability makes it a particularly useful for machine learning and automation. In particular, three test cases stand out to us: writing letters on a whiteboard, balancing a hammer, and throwing a ball. By creating an accurate, quick, and stable arm, we establish a hardware platform upon which to experiment with machine learning.

3 Design Brief
February 23, 2015

Modularity:

The mechanical arm will designed to be modular. Addition or extension of joints should be simple and uncumbersome, with exception of extra load from the weight of the additional joint. The parts of each joint should be as universal as possible, and support the specified selection of motors.

Motor Links:

- http://www.adafruit.com/products/324
- https://www.pololu.com/product/2267
- https://www.pololu.com/product/1477
- http://www.anaheimautomation.com/products/stepper/stepper-motors.php?tID=75&pt=t&cID=19
- http://www.kollmorgen.com/en-us/products/motors/stepper/hi-torque/km-series/

4 War Council 3
February 26, 2015

Decided on project name: Sinister Stooge.
Each joint houses a motor-driver board.
All boards are controlled via an Arduino.
Arduino and sensors connected to a computer.

Bill of Material:

1. NEMA 23 Stepper Motor ($35.50): http://www.automationdirect.com/adc/Shopping/Catalog/Motion_Control/Stepper_Systems/Stepper_Motors_-z-_Cables/STP-MTR-23055 (Be sure to find Center of Mass upon receival)
2. Shipping ($6.00): NEMA 23 from Automation Direct
3. 0.5 inch Aluminum Plate ($):
4. 3 x 3 x 0.125 Box Beam ($):
5. Turntable ($2.12): http://www.mcmaster.com/#6031k16/=w3g7z1
6. 10-32 Screws ($7.42): http://www.mcmaster.com/#92196a266/=w3ge8k
7. 6-32 Screws ($3.55):http://www.mcmaster.com/#92949a144/=w3gbh1

5 Prototype Proposal
February 27, 2015

Purpose:

Fabricate an axial joint that is representive of all axial joints in the system. This joint is to be

used for calibration and load testing, as well as system analysis.

This joint should be able to balance a tilt sensor (`https://www.sparkfun.com/products/10313`).

Deliverables:

1. Single axial joint with the following functionalities:
   - 270 degree rotation
   - 10 lb-in of torque
   - No noticable deflection under specified load
   - Less than 1 degree of undetected backlash
   - Full range of motion in under 0.5 seconds.
2. A system to convert voltage detected from an Arduino to a graphic interface on laptop. It must have the following functionality
   - Plots desired sensory input on laptop screen in real time.
   - Saves plots as files (either interface into MatLab or as images)

Deadline:
March 9, 2015 — Arduino to PC Sensory Plotter complete
March 16, 2015 — Mechanical Axial Joint complete

6 Mechanical Analysis

301 Box Beam:

For the prototype, each joint will be attached to a 3 inch by 3 inch by 0.125 inch thick box beam made of 6061-T6 Aluminum. For the purpose of finding the weakest point in the arm, stress analysis will be run on each possible point of failure.

For the box beam to deform noticably or reach the yield strength of aluminum, around 88500 in-lb of axial torque is required. Because this value is significantly higher than the maximum possible torque output of any mounted motor, it is safe to say that deformation of the box beam is not the most likely point of failure. The safety factor on this part is over 5000.

7 Package Arrivals March 5, 2015

Both the Automation Direct motor and the McMaster Carr turntable have arrived. We will contact Plethora in San Francisco on Friday, March 7, regarding manufacturing of parts 101_Motor_Plate and 102_Connector_Plate.