MCEN 5115 - Mechatronics Graduate Project

3D Printed Motorized Ironman Helmet

December 6, 2025

Instructor:
Derek Reamon

Project By:
Luke Jensen

Table of Contents

Table of Figures

Introduction

The goal of this project was to implement a mechatronic system in tandem with the course project throughout the semester. A 3D printed, wearable Iron Man helmet was selected to create a functional servo driven faceplate inspired by the motion seen in the films. The final system integrates a mechanical linkage mechanism driven by micro servos, an Arduino Nano microcontroller, and illuminated see-through LED eyes.

Design Process

The project utilized the MK46 Iron Man helmet model, with 3D-printable files provided by Walsh3D. All components were fabricated using FDM printing with PLA. After printing, the parts were test-fit (seen in Figure 1) for wearability and to start iterations of the mechanism.

Figure 1: Raw 3D Print Test Fit.

The main challenge of the project came from the linkage mechanism providing the faceplate motion. The original iteration of the mechanism was tested and discovered to bind against the helmet geometry halfway through the path of motion. The 3D modeling software Blender, was used to evaluate the system digitally (shown in Figures 2 and 3), leading to the final iteration of the mechanism to drive the motion. The electronic system was benchtop tested while the code was being developed to integrate the mechanical system with servos and a button input interface.

Once all systems were evaluated, they were integrated into the helmet following surface finishing and paint work.

Mechanical System

The mechanical system consists of the faceplate assembly, dual servo driven links, secondary helper links, and hinge points fixed inside the dome of the helmet. This subsystem translates the rotational motion of the servos into an arc motion for the faceplate.

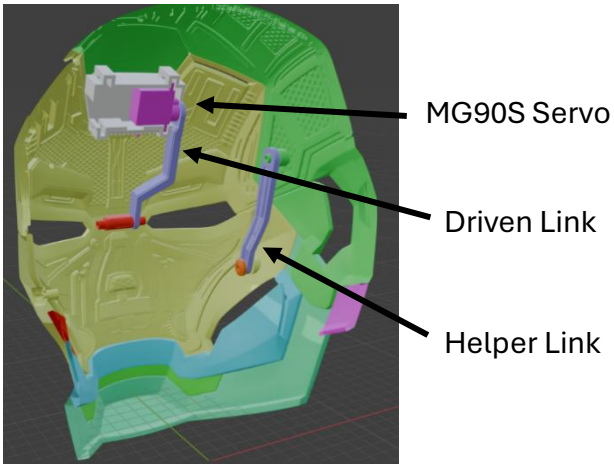

Figure 3: Blender Model of Mechanical System.

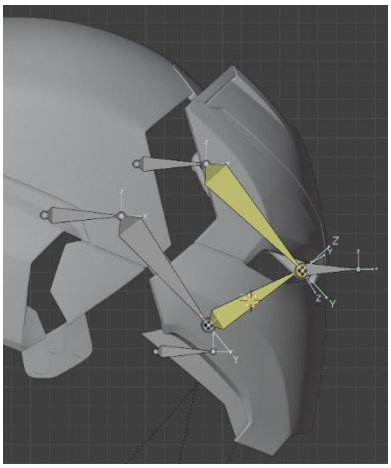

Figure 2: Blender Model of Motion Simulation.

The first iteration of the linkage used too long of servo driving arms. This forced the helper links into collisions with the inner geometry of the faceplate as it was moving and caused binding before the motion was completed. Blender was used to digitally evaluate the mechanism and determine the next iteration's links and pivot point location.

The final configuration uses two servo driven arms pivoted towards the upper end of the faceplate, and secondary helper arms that "push" the bottom of the faceplate out during the arc path.

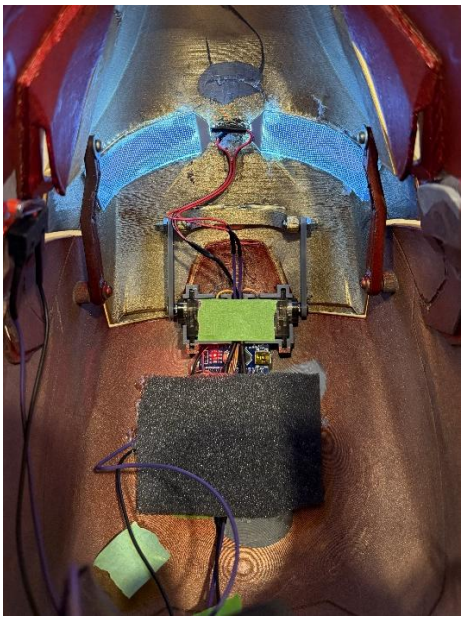

Figure 4: Mechanical System in Operational Helmet.

Electronics System

The electronics system followed a common wiring diagram used in existing cosplay mechanisms. An Arduino Nano was selected due to its small form factor. Two MG90S metal geared micro servos were used to achieve the motion. Although an MG996R high torque servo was also considered to reduce complexity of coding two servos mirrored as well as providing more torque, but space constraints prevented this solution.

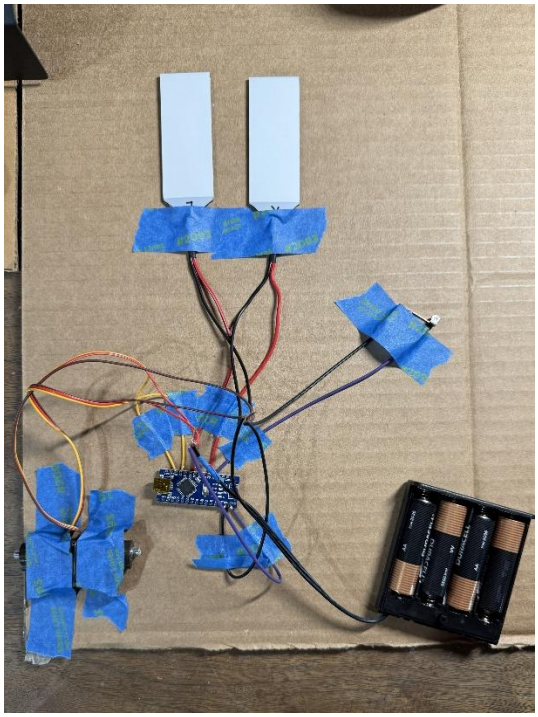

Figure 5: Bench Top Wiring Test.

The final configuration utilizes the VarSpeedServo library to control the motion and the OneButton library to allow multiple operations using only one button. The system was powered via a 4x AA battery pack that provides ~6V of power.

Finally, the system includes two clear flexible LED deflectors that provide the movie-accurate glowing effect of the eyes. The Arduino triggers the LEDs to perform movie accurate flicker effects as the faceplate closes, turns off when it opens, and allows manual shutoff via a OneButton double-click.

Integration

Once benchtop testing was completed, the electronics were installed into the helmet to tune and refine the mechanical system. Integration revealed that the first linkage iteration configuration created collision, which resulted in the redesign of the servo driven arms and pivot point.

After the full system was operational, minor adjustments were made to servo angles to allow both servos to operate mirrored and symmetric. After fine tuning, the placement of the servos and pivot points were finalized, the helmet was disassembled for finishing.

Finishing

The helmet went through a full post processing, including sanding, filler priming, and repeated smoothing until the layer lines and scratches no longer remained. Metallic gold was applied as a base coat to all parts of the helmet. The parts that remain gold were set aside and the rest got painted with a metallic candy red top layer to achieve the iconic Iron Man finish. A protective clear coat was applied to seal and protect the surface. Once cured, all electronics and mechanical components were reinstalled, and foam padding was added for comfort while wearing.

Results

The final helmet successfully demonstrates a functional servo-driven faceplate with motion inspired from the on-screen Iron Man suit ups. The faceplate opens and closes using a single button input, and the LED eyes automatically illuminate when the faceplate is closed and turn off when open.

This project highlighted several opportunities for future improvements.

- Designing an optimized linkage system that could be customized for the geometry of different helmet models could increase efficiency of the faceplate motion.
- Exploring alternative servo solutions or actuation mechanisms would help with challenges of torque limitations and spatial constraints.
- Printing the helmet in engineering plastics to give it more resistance to heat and improved mechanical properties.

Overall, this project met its objective of integrating a mechatronic system. The final product of a functional servo driven Iron Man helmet provided valuable learning with mechanical linkages and new skills with electronics and control systems.

Figure 6: Finished Helmet Closed.

Figure 7: Finished Helmet Open.