Enhancing Learning through Advanced Projection

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Christiansburg Middle School

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Background

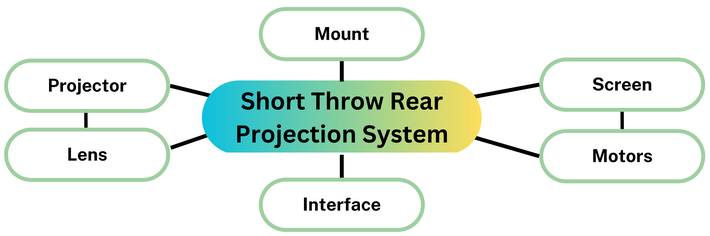
The team helped Christiansburg Middle School enhance their learning experience with a new projector and screen setup. The Customer was provided with a new retractable advanced screen, clear projector, and innovative user friendly interface. The advanced screen and clear projector provide better visuals, making learning more engaging. Presentations will also be more dynamic and memorable. The user-friendly software-based controls foster creativity and confidence, improving the overall learning experience and preparing students for success in the future.

Objectives

Provide an automated short throw rear projector system that is installed in the Christiansburg Middle School. The system is comprised of 2 subsystems, the screen and the projector, and will have the following features:

- ***Enhance*** an already existing projector using a lens system to allow for short throw projection.
- ***Mount*** the projector system in a way that will allow for rear projection on the auditorium stage without taking up large amounts of space.
- ***Incorporate*** an interface with the projector that will allow the user to control the settings and projected image from a location away from the projector.
- ***Outfit*** the auditorium with a screen that allows for projection to be shown in moderate lighting and darker.
- ***Automate*** the screen so that it can be retracted and stored when not in use.

Project Components



- **Interface:** The projector can be controlled from up to 50 ft away via RS232 serial communication using a Python-based software installed on a laptop connected to a USB-to-Serial cable. An easy-to-use graphical user interface allows control of power, volume, keystone, and inputs.
- **Lens:** The projector's lens system allows it to produce a larger image than standard projectors. By adding the lens to the front, it becomes a short throw projector, needing only 12.5ft to project an 18X14ft image without affecting lumens or image quality.
- **Mount:** The sturdy metal mount provides a durable and secure attachment point for the projector and lens attachment arm. It is designed to be mounted high on the concrete wall, ensuring the projector does not shine into anyone standing behind the screen. The black paint finish matches the auditorium's aesthetics.
- **Screen:** The Gerriets OPTILUX screen was chosen because it supports rear projection, provides a gain of 1.48, and is easily stored. It projects bright and legible images and slides in well-lit rooms.
- **Motors:** Two NEMA 34 stepper motors, two drivers, two power supplies, and an Arduino Uno microcontroller were used to motorize the backdrop screen. The selector switch controls motor direction, and two emergency stop buttons to disable motor drivers and power supplies.

Design Process

Hardware

- Motors: The motor system is controlled by an Arduino Uno microcontroller, with a selector switch and emergency stop buttons for user control. The power supplies drive the stepper motor drivers to move the motors according to our code.
- Lens: Calculations were done to determine the required magnification and focal length for the lens. A .43X magnification lens was chosen for flexibility, and the mount was designed using 3D modeling software and 3D printing.
- Mount: Technical drawings were used to create a projector mount, which was CNC cut and painted black to match the room's aesthetics.
- Screen: Extensive design was required for the screen storage system, which ultimately involved flying the screen from the bottom using wires and motors.
- Interface: Rs232 serial communication is used to connect the control laptop to the projector for communication, with necessary drivers installed.

Figure 1: Projector Lens & its 3D printed attachment.

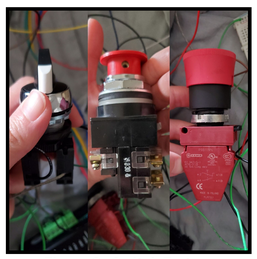


Figure 2: Switch E-stops used to stop the screen.

Figure 3: Projector attached to the mount designed by the team.

Software

- Motors: The Arduino Uno Microcontroller controls the motors via selector switches and an emergency stop button, with code preventing overshoot.
- Lens: The lens mount was 3-D printed from a design created using Solidworks.
- Mount: Solidworks facilitated precise 3D modeling, modifications, technical drawings, and documentation for the projector mount.
- Screen: Motor controlled with the software is used to roll up the screen.
- Interface: Figma was used to design the GUI, Python to code it and enable communication with the projector via Rs232.

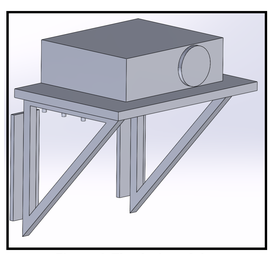


Figure 4: The design of the mount created on Solidworks.

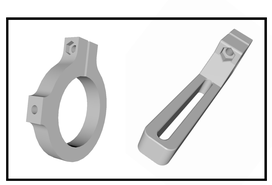


Figure 5: The design of the lens attachment created on Solidworks.

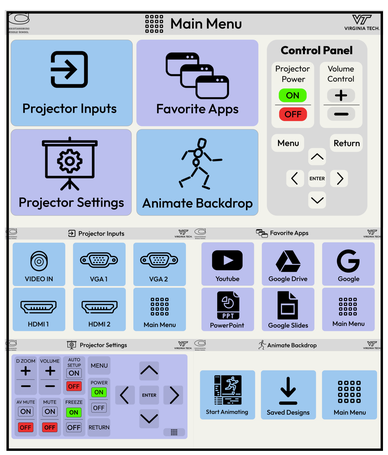


Figure 6: Images of the menus on the Projector Control Software: Main Menu, Projector Inputs, Favorite Apps, Projector Settings & Animate Backdrop.

Calculations

Equation	Projector Without Lens	Projector with Lens	Calculations Done
Throw Ratio = Throw Distance/image Width	1.09-1.77	.5 - .7	12.5ft/(.5-.7) = 25-17.8ft (desired 18ft)
Focal Length = 1/u + 1/v	15.30 - 25.64mm	11.922 - 17.385mm	(1/11.9)-(1/11.8) ~3810mm (desired 3810mm)
Magnification = Image height/object height	1.6x	(.43x)*(1.6x) ~ .6x	Tested manually (desired is .6x.)

Table 1: Calculations of the Projector's Throw Ratio, Focal Length and Magnification with and without the installed lens.

The calculations shown in the table were performed by the team to evaluate the lens, and they validate that the desired specifications have been met through the lens' installation on the projector.

Final Product

The team delivered a short throw rear projection system to Christiansburg Middle School, featuring a high-quality projector, mount, lens, and innovative user interface control. The large, clear screen enhances the immersive and engaging learning experience for students, while the software-based controls foster creativity and confidence. Additionally, the team designed a plan for future motorization and storage of the screen subsystem. Overall, the system provides a cutting-edge solution for improved learning and student success.

Challenges

The installation of the project at Christiansburg Middle School posed challenges in safety and reliability:

- Wireless communication was unreliable, so the team switched to Rs232 serial communication.
- Hardware controls were added to the motor system for safety. The design includes a switch, as well as two emergency stops: one to cut off power supplies and the other to disable the drivers.
- To avoid drilling through the firebreak wall to wire the projector, wires were run along the wall to a junction box, and the mount was attached with fire caulk.

Contact Information

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