

Music Again: Piano Pedal Pressing Device

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Problem Statement

Spinal cord injuries often result in limited motor function, making it difficult for the patient to move the muscles in their arms, hands, feet, and legs (Shepard, 2020). This can make it challenging for these individuals to complete daily tasks independently, such as brushing their teeth, writing, typing, and even playing music. The goal of this project is to design a device that will allow these individuals to independently play an instrument and produce music.

Requirements

Table 1: This table displays the requirements for the prototype

#	level	type	statement
1	1	Functional	Produces music/helps someone make music individually
2	1	User	Usable by patients with spinal cord injuries
3	1	Physical	Durable, shouldn't break easily
4	1	User	Simple to learn how to use
5	1	User	Does not cause significant physical strain for the user
6	2	Cost	Costs less than \$50 along with common devices like a computer
7	2	Functional	Doesn't change the sound the instrument makes or decrease the quality of music
8	2	Functional	Easy to adapt to; playing the instrument with the device is like conventional methods of playing the instrument

Requirements

Table 2: This table continues Table 1, showing the prototype's requirements

9	2	User	Is comfortable for the user and provides them with an enjoyable experience
10	2	Functional	Does not require access to multiple outside resources
11	3	Physical	Does not have too many wires required for hardware
12	3	Physical	aesthetic and visually pleasing
13	3	User	Can be used by various users (can be used by those with varying levels of spinal cord injury and varying motor function abilities)
14	3	Physical	Has adjustable settings so the user can adjust as needed
15	3	Physical	Detachable and Portable, can be used in a variety of different locations

Preliminary Designs

- ❖ Guitar finger extension: The user's hand movements would be mimicked on a larger scale so they could play the guitar with decreased hand motion
- ❖ Trombone slide: Touchpad input would be translated into moving a trombone slide so users could play with reduced hand motion
- ❖ Piano pedal pressing device: Three pistons would push down on piano pedals based on where the user would blow into a breath detector so the user could play more sophisticated music even if they do not have full control of their legs

CDR Designs

Guitar Pick Model



Figure 1: Guitar Pick model 1



Figure 2: Guitar Pick model 2

The first has more reach but not as much movement and the second provides less reach and a wider range of movement.

Trombone Slide Model



Figure 3: Trombone Slide Model 1



Figure 4: Trombone Slide Model 2

A model for how a piston could be connected to a trombone using a special part.

Piano Pedal Pusher Model

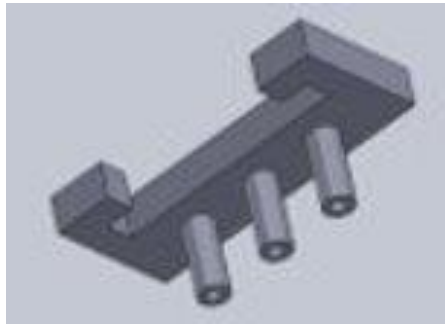


Figure 5: Piano Pedal Pusher Model 1

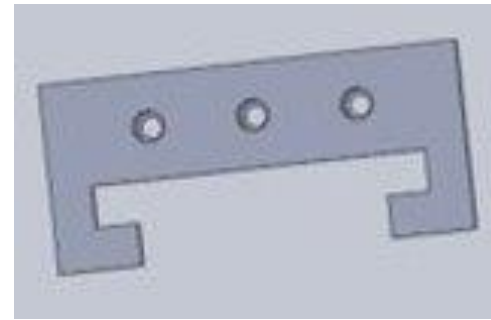


Figure 6: Piano Pedal Pusher Model 2

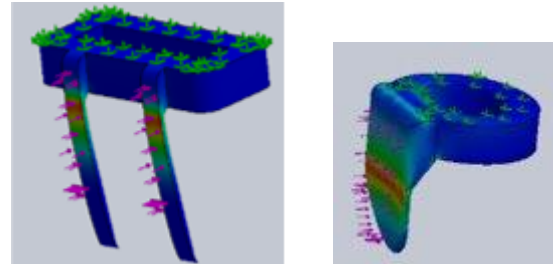
A model for the casing for pistons which would be placed above the piano pedals.

Design Studies: Stress Analysis

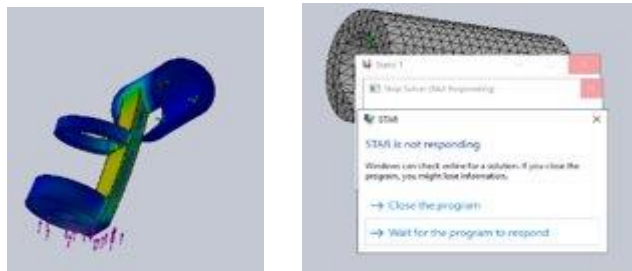
- ❖ Analysis of how each prototype reacted to stress, and how each would break.
- ❖ ABS
- ❖ Standard mesh
- ❖ 10 N force
- ❖ Overall durability of each prototype determined by the resulting stress, displacement, and strain.
- ❖ Though the design itself may stay stable and not break due to a low amount of stress, a large displacement could hinder the overall performance of the design.

Stress Analysis Results

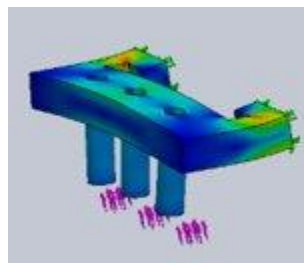
Guitar Pick Model:



Trombone Slide Model:



Piano Pedal Pusher Model:



Design Decisions

- ❖ After having designed the CAD models for our prototypes, we realized that the piano pedal pressing device would be the best choice to move forward with since it had a straightforward objective and would be potentially applicable to more patients
- ❖ When designing more of the pieces, we decided that the ideal choice for how to push down the pedals would be to use a motor as opposed to a piston since the code is easily implementable and the extent to which it runs can be carefully controlled
- ❖ We also decided to switch the input method to buttons rather than a breath-controlled device due to our time and materials constraints

Project Designs: Design 2.1

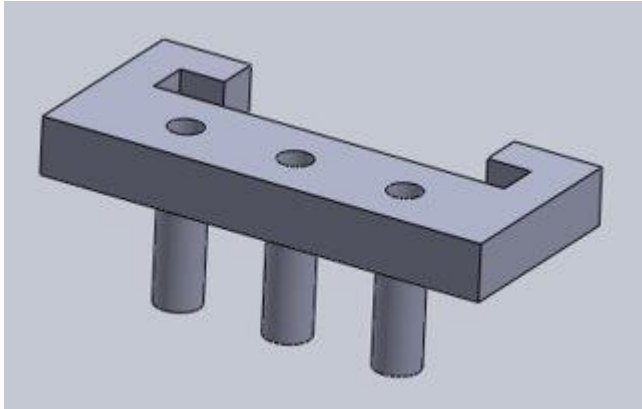


Figure 7: Piano Pedal Pusher Model 2.1 (Top View)

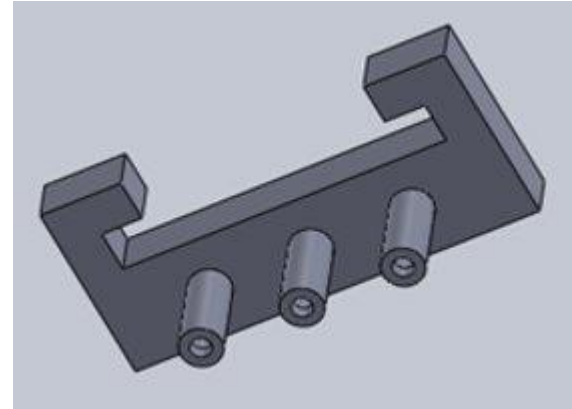


Figure 8: Piano Pedal Pusher Model 2.1 (Bottom View)

The initial prototype only included the base, without any sort of pushing mechanism, but the intended pushing mechanism was three pistons, one at each circular hole.

Project Designs: Design 2.2

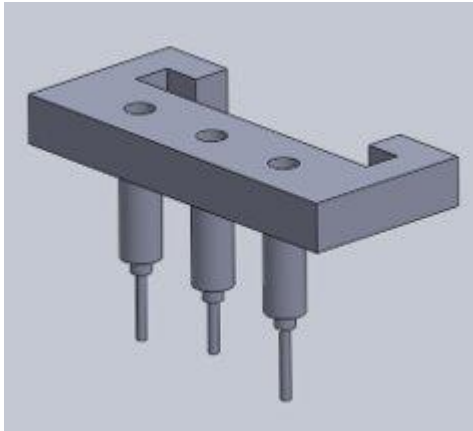


Figure 9: Piano Pedal Pusher Model 2.2 (Top View)

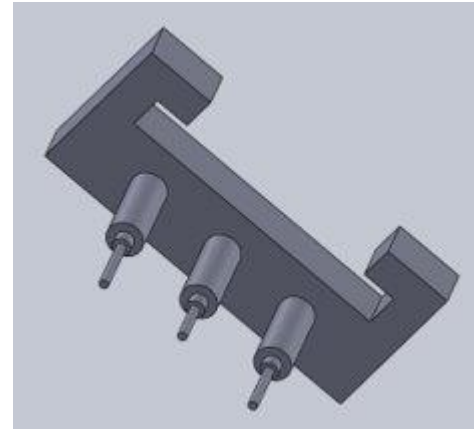


Figure 10: Piano Pedal Pusher Model 2.2 (Bottom View)

This design added the pistons to Design 2.1. Though these aren't real pistons, they illustrate what actual pistons would look like if attached to Design 2.1.

Project Designs: Design 2.3

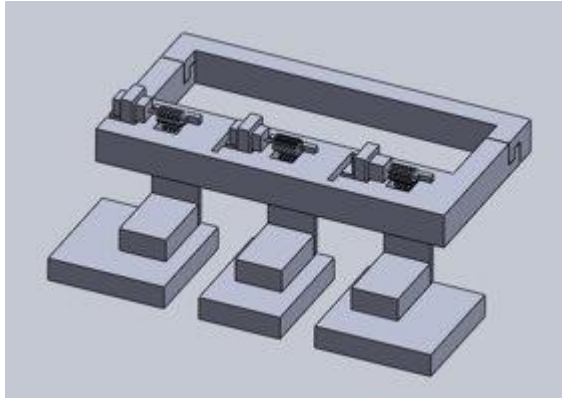


Figure 11: Piano Pedal Pusher Model 2.3 (Top View)

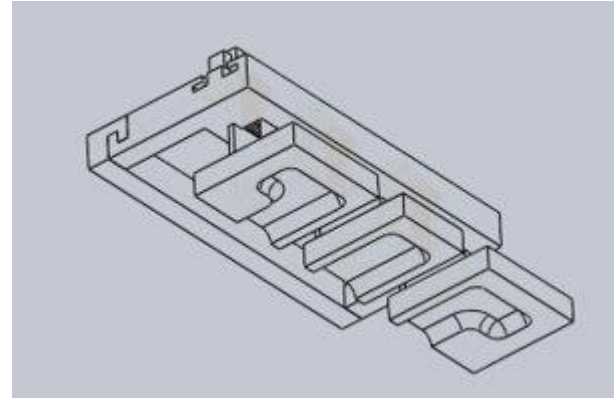


Figure 12: Piano Pedal Pusher Model 2.3 (Bottom View)

The final device uses gears to change the positions of the piano pedal pushers. These piano pedal pushers consist of a block with a piano pedal imprint underneath them, which are attached to a rod with teeth on the top of it, which connects to the motor which causes the rod to go both up and down. This model currently only has the physical model, and doesn't include electronic components such as buttons, motors, or Arduinos, that would need to be used in order to have the design be fully functional, but this component should be relatively simple to incorporate, as there shouldn't be much code involved, only code controlling each motor, and connecting those methods to when a specific button is pressed.

Design 2.3: Methods

- ❖ The model would be 3D printed out with a sturdy material and be attached to a piano
- ❖ 3D print the CAD parts files with a durable material
- ❖ Assemble the mechanism as in the CAD assembly
- ❖ Attach the model to the piano above the pedals
- ❖ Attach three motors, one to each gear of the CAD parts
- ❖ Connect the motors to a breadboard and an Arduino following <https://www.youtube.com/watch?v=TkA2LJctU1c>
- ❖ Connect three buttons to the breadboard and Arduino following <https://www.the-diy-life.com/multiple-push-buttons-on-one-arduino-input/>
- ❖ Write the code to associate each button to a corresponding motor
 - When the button is pushed, the motor should extend the cylinder
 - When the button is released, the motor should reverse direction and retract the cylinder

Design 2.3: Requirements

Table 3: This table displays the requirements for the final prototype and if they were met

#	level	type	statement	Final Design
1	1	Functional	Produces music/helps someone make music individually	Yes
2	1	User	Usable by patients with spinal cord injuries	Yes
3	1	Physical	Durable, shouldn't break easily	Yes
4	1	User	Simple to learn how to use	Yes
5	1	User	Does not cause significant physical strain for the user	Yes
6	2	Cost	Costs less than \$50 along with common devices (computer, etc.)	No
7	2	Functional	Doesn't change the sound the instrument makes or decrease the quality of the music	Yes
8	2	Functional	Easy to adapt to; playing the instrument with the device is similar	Yes

			to conventional methods of playing the instrument		
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Design 2.3: Requirements

Table 4: This table continues Table 3, displaying the requirements and if they were met

#	level	type	statement	Final Design
9	2	User	Is comfortable for the user and provides them with an enjoyable experience	Yes
10	2	Functional	Does not require access to multiple outside resources	Yes
11	3	Physical	Does not have too many wires required for hardware	Yes
12	3	Physical	aesthetic and visually pleasing	No
13	3	User	Can be used by various users (can be used by those with varying levels of spinal cord injury and varying motor function abilities)	Yes
14	3	Physical	Has adjustable settings so the user can adjust as needed	No

15	3	Physical	Detachable and Portable, can be used in a variety of different locations	Yes
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Next Steps

- ❖ The model would be 3D printed out with a sturdy material and be attached to a piano
- ❖ A circuit with an Arduino would be developed that would activate a series of motors depending on what button is pressed, and reverse them when the button is released
- ❖ The motors would be attached to the piano
- ❖ Sensors could be added and connected to the Arduino to ensure the motors do not cause damage to the mechanism or the piano

Takeaways

- ❖ It is always good to have multiple ideas and choose from them what works
 - Finding alternatives for the pistons really helped with our designs

- ❖ Multiple plans should be made in case an unexpected limiting factor comes along
 - We could have produced alternative plans at an earlier point which may have allowed us to complete more of the project

Instructables QR Code

