Nub-troller: Video Game Controller for Double Arm Amputee

Design Team

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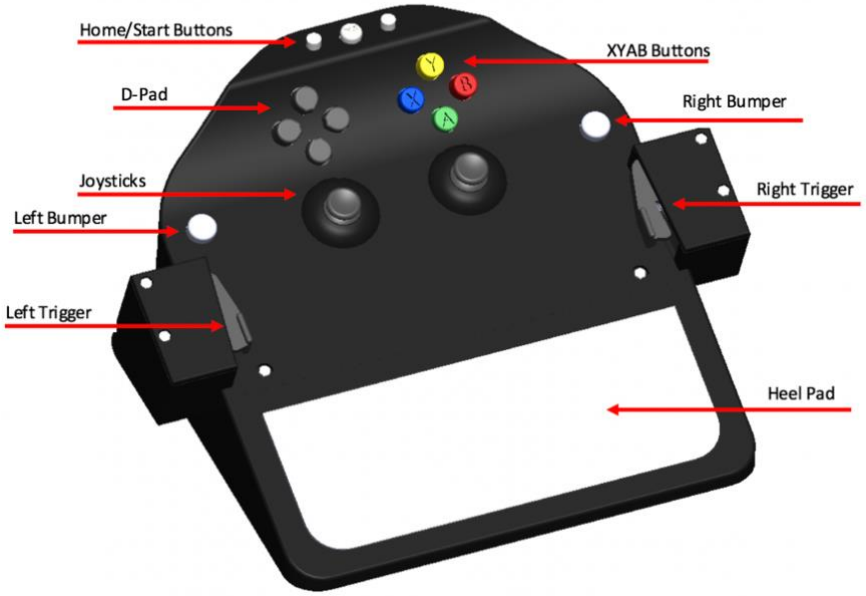
Abstract

The purpose of this project is to design and build a foot operated video game controller with analogous functionality to an existing handheld controller for Mary Dague, a double arm amputee. Because Mary is an avid video game player, a controller designed specifically for use with her feet will allow her to widen her gaming options and reduce her likelihood of injury. To design a solution effectively and specifically for Mary, anthropometrics and foot operated devices were researched while simultaneously working with Mary to develop her design requirements. Combining Mary's generated design needs with anthropometric research, several preliminary designs were drafted. Using feedback from Mary, the final design was developed and features customized button size and stiffness, optimal button placement, a comfortable resting angle, and an ergonomic curvature. Mary will receive a final design informed by iterative testing of a working prototype.



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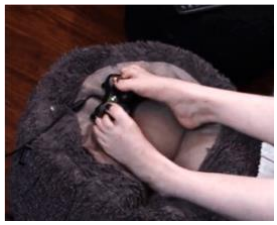
The Need for Project

The client needed a video game controller that allowed her to play with her feet as well as one would with their hands.

The client, Mary Dague, is a war veteran who lost both her arms in combat. Being an avid gamer, she began using her feet to play video games after the loss of her arms. She currently uses an Xbox 360 game controller propped up on a cushion. She has adapted well enough to play, but certain button combinations are difficult for her. The client's biggest difficulty is using the triggers while playing. She has to let go of any other buttons she was holding to grab the trigger with the side of her foot. The client wants a more accessible controller, so that her ability to game is no longer hindered, and her options are no longer limited.



Mary's Current Set-up

The Design Project Objectives and Requirements

The project objective is to design a comfortable foot-operated video game controller that is functionally analogous to a hand-held controller.

Design Objectives

Since this project relies on user-based design, the design objectives and requirements were developed through communication with the client supplemented with background research. The main objective of this design was to enable the trigger buttons on the controller to be operable while using the joysticks. This would enable the client to play games that require more complicated button combinations. In addition, since the client is operating the controller with her feet, it is important that she is able to *index*, having a comfortable 'home' position where she can place her feet.

Design Requirements

The controller must withstand foot-forces and be able to be held by the client's feet. In addition, the controller should not require any upper extremities when playing. It should also include discrete separation of all buttons and an acute angle between the controller and the floor.

Design Concepts Considered

We developed five initial design concepts and narrowed down exceptional features using client feedback.

The *first design strategy* involved each group member conceptualizing a controller that fit the initial design requirements given by the client. Each design differed in overall button layout and trigger and bumper locations. From user feedback, a flat controller design where the button placements echoed the original placements of an Xbox 360 controller and the triggers and bumpers were moved toward the sides was chosen for iteration design. This would allow for the client to still use the controller similarly to how she uses a traditional controller but would allow access to the bumpers and triggers with the side of her foot.

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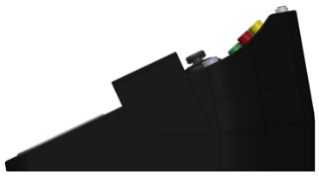
The *second design strategy* involved using the flat controller design as a base and designing two separate trigger mechanisms for the client to consider. The first design altered trigger and bumper locations to allow easier access and prevent both from being pressed at the same time accidentally. The second design kept the bumpers in the same locations but altered the triggers to function by rotating either foot outward from the center. Either side of the controller had a large footpad containing the buttons for that side, and a rotation of the foot would cause all of the buttons to move with the pad. This would keep the buttons in line with the foot as the pad was rotated.

Recommended Design Concept

A foot-operated video game controller ergonomically customized for Mary Dague's feet.

Isometric View of Controller



Side View of Controller

Front View of Controller

Design Description

The video game controller was designed with Mary's needs in mind. This includes bringing the triggers and bumpers from the back to the sides, a curved surface for the XYAB and D-pad buttons, moving the joysticks to be side by side, moving the start, back, and home buttons to the top where they Mary will not accidentally press them, and making the controller surface an angle for comfort.

Experimental Investigations

Two investigations were used to assure that the controller is functionally analogous to a handheld controller: *lag testing* and *force vs. displacement testing*.

Lag testing will be performed to measure the time between pressing a button and seeing its effect on-screen. Testing involves comparing the lag time of a modified controller with an existing Xbox360 controller by using a solenoid to press each button every 4 seconds, and software to calculate the time between the button press and the computer processing the button press. The difference between the two controllers must be less than 100ms to the threshold found by studies of lag in video games, or else the user will notice a frustrating delay.

Force vs. displacement testing will be performed to quantify button stiffness, allowing simple integration of different buttons based on user feedback. Testing will be performed by using a motorized linear slide in conjunction with a force transducer to record the force applied for each button vs the displacement of the button. These values will be compared with the existing controller and will be used to determine an optimal stiffness using feedback from Mary.

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Key Advantages of Recommended Concept

The key advantages of this design include sizes, button placement, curvature, resting angle, and button stiffness.

Sizes

Handheld controllers are designed ergonomically for hands. The shapes, curves, and sizes of the buttons and controller itself were created to fit into two hands. The controller design is ergonomically designed for Mary's feet. The size of the controller is significantly larger and flatter than the handheld controller and the buttons are larger for her toes to press with more accuracy.

Curvature

The curvature of the controller allows for the buttons to be angled towards Mary's toes and to have the buttons further away taller so when she tries to press one of those buttons, she will not accidentally press the closer buttons at the same time. Because of these advantages, the curve allows for more comfort and ease while playing.

Resting Angle

The angle of the overall body of the controller allows Mary to rest her feet in a natural and comfortable position while playing video games. This position helps prevent long term stress injuries from occurring.

Button Placement

Mary's biggest issue with her current setup is that she is not able to click the trigger and bumper buttons effectively. She must take her foot off all the other buttons to wrap her foot around the handheld controller meaning she is not able to play certain games that require her to press a variety of buttons together for a certain move/function. The controller design has the triggers and bumpers located on the sides so she is able to have access to the bumpers and triggers while using the joystick and XYAB buttons at the same time. The placement of triggers being on the sides allows for her to use medial rotation of the foot which she said is something that she would prefer to do rather than lateral rotation and is better to avoid long term stress injury as well.

The buttons were all placed to fit Mary's foot size specifically because this is a customized design. The joysticks were moved so that they are both controlled by the balls of her feet for easier use. The D-pad and XYAB buttons were also moved so that her toes can easily reach them while the balls of her foot are using the joysticks.

Button Stiffness

The stiffness of the buttons take into account that Mary's feet use a lot more force than hands do while playing video games. She has made comments about the handheld controller buttons breaking after a long period of use because they cannot handle the constant force that her feet use to press the buttons. Adding springs to the buttons in the controller allow for a longer life of the controller.

Financial Issues

Large 3D printed parts incurred the majority of the projects cost.

The cost of the design as it was produced was $550. Most of this cost ($500) was for the 3D prints for the parts, the rest of the cost was for the electrical components. Though the prints were very expensive this method was still efficient due to the low number of models produced. The cost of the plastic parts could be massively reduced if produced in high volume using injection molding but there is no plan to increase the scale of production, as this is a customized design.

Recommended Improvements

User accuracy and comfort could be enhanced by increasing component stiffness and adjusting the geometry.

One major improvement to this design would be to further increase the amount of stiffness in the buttons and joysticks. When selecting buttons, feel and reliability were considered which resulted in a compromise on the stiffness. Increasing the general stiffness in the controller's components was a main goal of this project because it allows for better joystick control and reduces the chance of accidental button actuation. Another aspect of this design that could be improved with time is the controller's geometry. The controller was designed around the client's foot size but small adjustments in relative distances could likely improve the user's comfort even further.