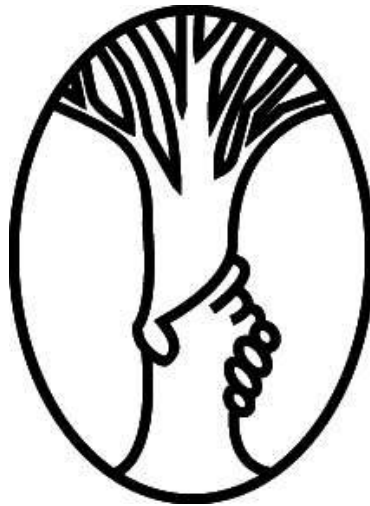


MICHIGAN STATE --- UNIVERSITY



ECE 480 : Senior Design
Design Team 4

Detented Joystick Design : Pre Proposal

ECE 480 Design Team 4

Facilitator

Dr. Robert McGough

Team Members

Scott Friedman

Nathan Hyde

Adi Mathew

Yongjiao Yu

Sponsor

Resource Center for Persons with Disabilities(RCPD)

Project Liaison

Stephen Blosser

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Executive Summary

To create a Joystick input that does not recenter axes and provides the user with a software customizable detenting mechanism. The number of detents as well as Force of each detent must be customizable at the software level. The joystick should have a simple plug-and-play USB interface that can easily be used as a mouse-like input to any connected device.

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1 Introduction

Every year in the United States, approximately 10,000 infants are diagnosed with Cerebral Palsy (CP), a group of disorders affecting brain and nervous system functions. There are several types of CP with varying levels of symptoms, ranging anywhere from abnormal muscle contractions and loss of coordination to partial paralysis and loss of speech capabilities. Many of those affected by CP must rely heavily on assistive technology in order to communicate effectively.

One specific case of cerebral palsy that is being targeted in the initial design is that of Branden Bennett. Branden is a student currently attending Jackson Community College, with hopes to soon transfer to Michigan State University. He suffers from athetoid cerebral palsy, which causes unwanted movements and interferes with his speech and fine motor skills.

An existing method of communication currently used by Branden is the mechanically detented joystick. This joystick can serve as the primary input device to control things such as a desktop computer or a voice synthesizer. These joysticks can provide local stability on specific positions. It allows the user to more effectively remain on a desired option and select it without being impeded by uncontrolled muscle tremors commonly seen in those with CP.

Detented joysticks are often used in conjunction with a user interface screen. This screen displays an active matrix of selectable options that directly correlate to the detent positions found on the joystick. This technology has served as a breakthrough in the advancement of communication for those living with CP.

Though mechanically detented joysticks function well as a means of communication, there are still many improvements that could be made to optimize the functionality and robustness of joystick technology. Currently detented joysticks are designed with a set amount of detents, as specified by mechanical structures within the joystick body. The force required to move the joystick is altered only by adjusting the tension on the spring.

By means of electromechanical components and microcontrollers, detented joysticks could support fully programmable detent forces and quantities through a USB interface. This will allow for a more universal joystick option that caters to a wide variety of individuals with CP. Having this robust design will improve the repeatability and efficiency of production as well as drive down costs for those looking to purchase a detented joystick.

2 Design Specification

Design of the detented joystick will serve as an update to the current model, designed by Stephen Blosser of the MSU Resource Center for Persons with Disabilities department(RCPD). The revised system will allow for greater scalability and functionality, adjustable detent force and greater matrix grid size. Another primary goal is USB connectivity, user friendliness of variable parameters for the user or caretakers.

The reworked input system will utilize a microprocessor and system that converts the mechanical inputs into digital outputs, fewer parts will be involved.

User-scalable variables that will be introduced will be detent force and the number of detents. The implementation of a microprocessor board will then register software commands for adjustability of replaced mechanically controlled systems.

USB connectivity will replace the serial input currently used. Introducing the USB 2.0 standard allows for providing a 5.0 Volt power source for the revisited mechanical system and the microcontroller itself.

3 Current Joystick Model

Mr. Blosser's detented joystick design consists of the following key components that exhibit its mechanical nature [1] :

- 2 Ten toothed cogwheels attached to the X and Y axes of joystick motion.
- The teeth act as the primary detenting force and hence provide a 10x10 matrix of detented joystick motion. Changing the useable matrix would require changing the cogwheels manually.
- One side of each cogwheel plate is partially coated with a reflective covering. This patterned coating reflects and absorbs IR light that falls on it to sensors. The positioning of the joystick is implemented using this rotary encoder as a 4-bit Gray code(Binary code that incrementally change only one bit at a time).
- Input to a digital device is via a Parallel port, making it unusable with smaller portable laptops.

4 Design Concepts

The primary concepts to be aware of in designing a joystick for CP patients is that

- The forces exerted on the joystick will be much greater in magnitude than compared to a gaming joystick.
- The joystick should detent and must NOT return to center unlike a conventional joystick.

To effectively design such a joystick, the parameters that would determine normal use must be measured. The primary variable to measure in the planning stage would be the exact forces exerted on the current joystick model. This would enable accurate setting of thresholds at which to activate the detenting mechanism as well as the minimum force with which to provide a functional detent.

The most important part of this design for the end user, is the detenting mechanism. To avoid using a purely mechanical system and to reduce the cap on the number of detents posed by the older design, use of rotational parts such as the cogwheels were abandoned. Detenting and motion will now be provided by a pair of actuators, one connected to both X and Y axes. The actuators will let the user control motion but will periodically 'reverse' direction of motion to provide the feel of a detenting force to the end user.

In addition to measuring forces and providing detents, the design will require a fairly robust position sensing solution along both axes. This would serve as the input to the microprocessor, which in turn will be fed via USB to the end user's software. Along with the input, the position coordinates will be used to calculate detenting positions along the axis of travel, depending on the number of detents required by the user.

USB input will be implemented using a USB development board's port. The benefit of using such a method is the ability to test port functioning within the supplied IDE. This reduces chances of errors occurring in the software side when bringing all the above components together into a single working model. Final prototyping will use a standarding Windows HID firmware to interface with the joystick, so as to prevent the end-user needing to download a 'custom' driver for the joystick.

5 Microprocessors and Chip Programming

5.1 Hardware Decisions

The microprocessors that will be used must primarily satisfy the aforementioned design goals, namely :

- Provide a simple plug and play USB output for the end user
- Allow the end user to easily change variable values such as the number of detents and force of each detent, without any hardware use.

To be able to provide a user with such options without investing in multiple components and hardware level interfacing is of equal importance from an engineering standpoint. The boards and microprocessors must therefore satisfy the following technical considerations

- 6+ Input and Output pins
- PWM capable outputs
- Operating Voltage of 5 Volts, which allows for use of USB's V_{dd}
- At least 16 MHz Clock Speed with adequate programmable memory

For these reasons the boards chosen are :

1. Arduino UNO
2. PJRC Teensy++ 2.0

In addition to these boards, microprocessors could be used for further positioning and Analog/Digital conversions. This would depend on the implementation of the mechanical design. A 20 MHz clock would be required by certain microprocessors to make the clock speeds compatible with a USB interface's 48 MHz requirement. The microprocessors that would best suit these requirements are

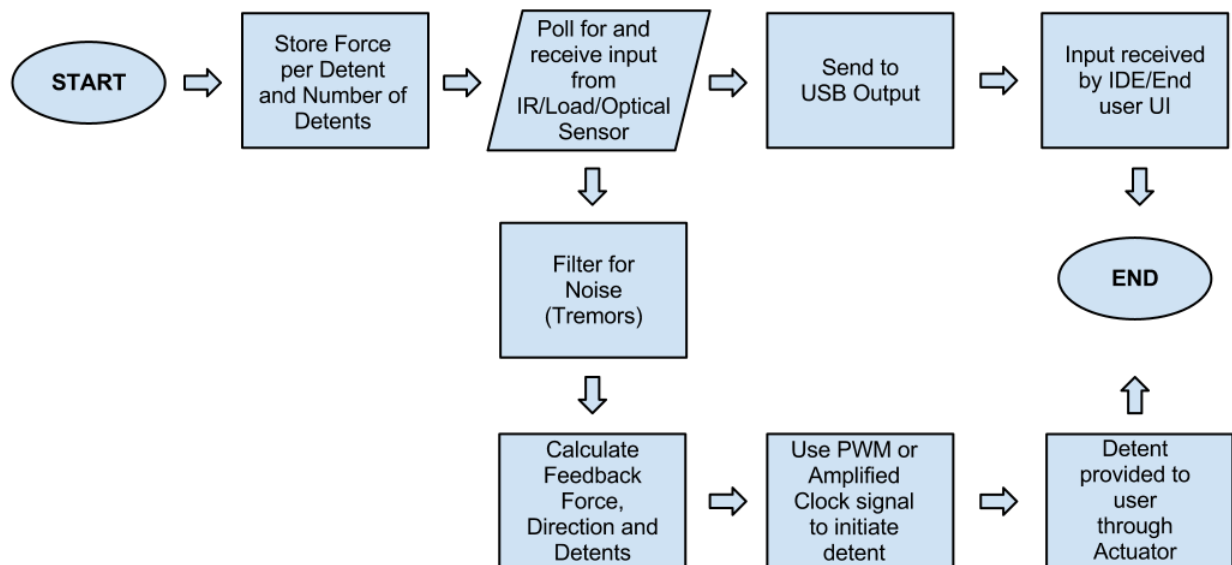
1. Microchip PIC16F688 [3]
2. ATMEL ATmega328 [2]

5.2 Software Implementation

The software accompanying the joystick will control the number of detents, detent force, matrix size, and force feedback. Two data streams leaving the microprocessor will provide force feedback and the end user navigation, through use of the joystick:

1. The number of detents and detent force will be defined software and sent to the microprocessor.
2. Force feedback will be calculated for input variables following noise cancellation/cleanup of the signal. PWM or a digital out with a clock signal with an amplifier will allow for the microprocessor read sensors to process force feedback.
3. Data recorded from the sensors will be filtered and read. Resulting data will then be sent through USB as output to the end program for navigation.

Below is a flowchart for how input, detenting and software output will be handled.



6 Budget

Item	Cost
Microcontroller board (Arduino, Teensy, etc.)	\$25-75
Two actuators with position and force sensing	\$200-400
Power source	Possibly connect to chair source
Mounting components/Linkage	Sourced from Stephen Blosser for no/little cost
Packaging	Provided by Stephen Blosser
Shipping	\$100

7 Cost Justification

Actuators: The two linear actuators found in the joystick will compose the bulk of the budget. These will by and large be the most important components within the joystick to provide the necessary force and position feedback to Branden. These actuators need to have high speed abilities, while also providing high enough forces to withstand the hand movements of the user. Size will also be a constraint for these actuators as they need to fit within a reasonably sized casing.

Microcontroller: The microcontroller is the other main component of the joystick budget. It has the role of precisely controlling the movement of the two actuators and relaying their positions to the user interface. There are reasonably priced boards on the market that can accomplish this task, leaving more of the budget available for the actuators.

Power Source: The electronic components within the joystick can draw power from the on-board battery on Branden's wheelchair; however, if it is determined more power is necessary, this may also become a component of the budget.

Mechanical components (Mounting, Packaging): Dr. Stephen Blosser has the capability to provide mechanical components through his machine shop at little to no cost.

8 Team Management

8.1 Schedule/Plan

Due to the design constraints previously discussed, development of this product will be done in four phases. Phase One is researching State of the Art, as there is a mechanically inclined product currently being used in market. Phase Two will consist of applying electromechanical devices to accomplish our goals and meet or exceed specifications. Phase Three will consist of prototype development. Prototype packaging, hardware and software will take the majority of our schedule (about 60% of timeline). Phase Four involves prototype testing and final product development. This four-phase plan will supply ample time and ensure a superior product in terms of usability, quality and cost.

8.2 Team Members

This section introduces the ECE 480 Design Team Four personnel vital to the success of this product and their technical and non-technical roles. The roles depicted below are considered as the minimum requirement. Each Team Member is committed to excellence and will participate in the successful completion of this product.

Team Member	Non-Technical Role
Scott Friedman	Team Manager
Peter Ossian	Web Master
Aditya Mathew	Document Preparation
Yongjiao Yu	Presentation Preparation
Nathan Hyde	Lab Coordinator

Team Member	Technical Role
Scott Friedman	Electro-Mechanical Design Lead/Testing Support
Peter Ossian	Hardware Design/Software Support
Aditya Mathew	Hardware Design/Software Lead
Yongjiao Yu	Testing Lead/Packaging Support
Nathan Hyde	Packaging Lead/Electro-mechanical Support

9 Sources

- [1] S. Blosser, ECE 480 Sponsor Liaison Meeting, 2221 Engineering Building, Michigan State University, Sept. 10, 2012
- [2] Atmel® ATmega328 Data Sheet(2009, PDF)
http://www.atmel.com/dyn/resources/prod_documents/doc8161.pdf
- [3] Microchip® PIC16F688 Data Sheet(2007, PDF)
<http://ww1.microchip.com/downloads/en/devicedoc/41203d.pdf>