Smart Voting Joystick for Accessible Voting Machines

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Abstract

Our research team created an accessible dual-axis, force feedback joystick to enable individuals with limited dexterity to independently vote using electronic voting machines. Usability evaluations were conducted with individuals with moderate to severe dexterity and motor impairments to evaluate the Smart Voting Joystick and determine what modifications might be needed to enhance its usability and accessibility. Results indicated that individuals with moderate impairments could successfully use the device without modification, however slight changes would be beneficial for this group. Individuals with severe impairments had difficulties that need to be addressed, including changes to the shape of the joystick and settings. With these simple changes, it is likely that the Smart Voting Joystick would become a viable input device for individuals with wide range of dexterity impairments.

Keywords

Accessible, voting systems, joystick, usability, dexterity

Introduction

Persons with disabilities report encountering a number of barriers to full participation in social and civic life in the United States; significantly, this includes substantial impediments to voting independently. As a result, people with disabilities are less likely to vote than people who do not have disabilities (7% less likely in 2008 and 3% less likely in 2010) (Kaye et al., 2000). The most common barriers to voting cited by people with disabilities are transportation, having an illness, voter registration problems, and problems with voting equipment. They are also far more likely to need help voting, which can infringe on their right to cast a private ballot. Currently, voting equipment that is deemed “accessible” cannot be successfully used by many individuals with disabilities, and the amount of time required to vote using such equipment can be prohibitive (Swierenga & Pierce, 2012).

Manufacturers of accessible voting machines have attempted to create a universal access method that includes a touch screen and a two-button switch. Users without adequate dexterity to use a touch screen have no other choice but to use the two-button switch, which uses step scanning (a technique for using a switch press to advance to the next selection item). This type of interaction requires the user to press buttons hundreds of times to scan through the selections, which is a tedious and difficult task, and users can become frustrated, fatigued, and potentially injured.

This research project addresses the problem by creating an input device that is more usable for people with limited use of their hands and arms. According to the U.S. Census Bureau, 2.8% of the U.S. population has difficulty grasping objects (Brault, 2012). An estimated 125,000 people in the U.S., including many with dexterity impairments, use joystick controls for powered wheelchairs (Fehr et al., 2000; Kaye et al., 2000). Joysticks are used because they offer precise control with minimal effort, even for people with fairly severe dexterity impairments. Due to these advantages, and because many users that are in need of a more accessible input method are already familiar with their use, joysticks are an ideal alternative input device.

Through this project we created a joystick that will enable individuals with dexterity impairments to vote independently. The joystick could be plugged into the binary interface port on existing voting machines, dramatically reducing the effort required to complete the voting process. Thus, the “Smart Voting Joystick” has been designed to enable many individuals with dexterity limitations and disabilities to successfully vote without significant discomfort and within a reasonable amount of time, in contrast to existing options.

Method

Smart Voting Joystick Design

Usability and accessibility experts from Michigan State University (MSU) Usability/Accessibility Research and Consulting (UARC) partnered with rehabilitation engineers from the MSU Resource Center for Persons with Disabilities (RCPD) and a senior engineering student capstone design team from the MSU Department of Electrical and Computer Engineering to create a dual-axis joystick (see Figure 1) with force feedback that interacts via USB interface with a ballot on a computer, to simulate use with an electronic voting system. The Smart Voting Joystick prototype has adjustable tension and provides the user with auditory and haptic feedback; the joystick is used in conjunction with three separate buttons, and was connected to a desktop computer on an adjustable-height table that displayed a sample voting ballot. Buttons were affixed to a mat with hook-and-loop fasteners to keep them securely in place, while still allowing their placement to be adjusted. The joystick is programmable and customizable, and its operation can therefore be modified and refined through firmware upgrades and modifications.

Programmable settings include return-to-center force, force feedback amount, and debounce delay time (with very long debounce times, data entry is slowed to help users with tremors, while with very short debounce times, multiple commands can be sent in quick succession). Customizable elements include the joystick handle and shaft, which can be replaced.

Fig. 1. Smart Voting Joystick with Enter, Review, and Help buttons (from left to right)

Usage and Interaction

In one mode of operation, the joystick simulates a **proportional** return-to-center function, similar to a typical wheelchair joystick. This means that displacement of the joystick handle causes an increase in speed as the handle is moved farther from the center. As the user pushes the joystick handle to the right, for example, it begins to send switch closures for step scanning through the selections on the voting machine. The further the joystick is pushed to the right, the faster the step scanning pulses are sent, allowing the user to step slowly for short distances or to rapidly advance through long lists. A brief haptic pulse enables the user to feel the output pulses and levels of approach to these thresholds as the joystick is moved. This force feedback helps produce a resistive force when moving to different selections of a ballot and improves overall accuracy and control.

Once a user has moved focus to the desired candidate or choice, they press the Enter button to select it. If a user wants to change a selection, they must deselect it using the Enter button, and then scroll to the desired option and press Enter to select it. To advance between contests, users can either move the joystick to the right or left twice in succession (right for next contest, left for previous), or move once in the relevant direction to bring focus to an arrow icon and then press the Enter button. Instructions are presented at the start of the voting process, but if a user wants to view them again, they can press the Help button at any time. If a user wants to review all of their selections on a single page, they can press the Review button.

Evaluation

UARC researchers evaluated the usability of the Smart Voting Joystick, testing the joystick's potential for improving access to voting by collecting qualitative and quantitative data on the usage of the joystick prototype from one-on-one sessions with six participants (five male and one female) with varying degrees of dexterity and motoric disabilities. All participants were between 30 and 60 years old. All had voted in a federal or state election previously: Three using a paper ballot at a polling place (one independently and two with the assistance of another person), and three had voted via absentee ballot. All used a desktop computer regularly, four via keyboard and mouse, and two via joystick. After analysis, the sample was split into two groups: those with moderate dexterity impairments (Group 1; four participants), and those with severe dexterity impairments (Group 2; two participants). Moderate dexterity impairments include muscular weakness, while severe impairments include spasticity and limited motor control.

Participants used the Smart Voting Joystick to interact with a digital version of the NIST Test Ballot, presented on a computer simulating a voting system, in separate sessions in the UARC lab. Participants were asked to vote according to a specific set of Voting Instructions, which indicated the selections they were to make for each contest. The joystick was assessed by measuring the percentage of accurate votes, the mean time that participants spent voting the ballot, the mean time to go back and change a vote, the types of errors committed by users, user satisfaction and accessibility ratings, user comments and feedback while voting, and user feedback at the end of the session. While the Smart Voting Joystick can be customized, the same joystick handle and programmable settings were used for all participants.

Results and Discussion

Most participants said that they would like to use the Smart Voting Joystick to vote in the future and that they would recommend it to others who had similar dexterity limitations. Participants gave a variety of suggestions to improve the joystick and buttons, and a few encountered problems that would need to be corrected before they could successfully use it to vote independently.

Group 1

Three of the four participants with moderate dexterity impairments (Group 1) completed the ballot with 100% accuracy, and the remaining participant had only one incorrect vote.

Table 1. Group 1: Participants with moderate dexterity impairments

Participants	Time spent voting the sample ballot	Time to go back and change a vote	Percentage of accurate votes
Participant 1	10:33	00:36	96%
Participant 3	6:58	00:26	100%
Participant 5	8:53	00:21	100%
Participant 6	10:51	00:38	100%

Across all participants in Group 1, the mean time to vote was 9 minutes and 19 seconds, and the mean time to change a vote was 30 seconds. Moderators provided minimal assistance to three participants. For example, the moderator directed a user to go back to a prior contest after they accidentally moved past it without voting and became confused.

Participants were generally successful and accurate in voting with the Smart Voting Joystick. The majority noted that the amount of force feedback and return-to-center force should be reduced and that a shorter, thicker joystick would be easier to use. While some participants were not confident that the joystick would work for everyone with dexterity or motor impairments, they indicated that they would recommend it to those whose impairments or needs are similar to their own.

Group 2

Participants in Group 2 made more errors than Group 1, namely unintended actions and incorrect inputs due to more limited fine motor control (strength did not appear to be an issue). Their time and effort required to vote were therefore greater than for participants in Group 1.

Table 2. Group 2: Participants with severe dexterity impairments

(*Task not successfully completed)

Participants	Time spent voting the sample ballot	Time to go back and change a vote	Percentage of accurate votes
Participant 2	*	*	*
Participant 4	29:39	5:38	87%

One of the participants used the ballot successfully with minimal assistance (similar to participants in Group 1), while the other was unable to vote the full ballot. The participant that did not complete the task encountered difficulties due to the lack of a support for their arm, though the size and shape of the Smart Voting Joystick also contributed. This participant required significant assistance throughout the session, and their session was therefore treated as informational, being used for qualitative, not quantitative data. The two participants in Group 2 used a wide variety of techniques to vote with the joystick, including operating the joystick with their chin or forehead.

While one participant did successfully complete the voting task, it is clear that the prototype, in the configuration used for testing, does not currently meet the needs of users with severe dexterity and motor impairments. Both participants strongly endorsed a joystick in principle, and noted that modifications to the Smart Voting Joystick would make it a viable input.

Conclusion

The usability evaluation of the Smart Voting Joystick demonstrated that it is a viable input for users with moderate dexterity impairments. Users with severe dexterity and motor impairments should also benefit from the joystick once minor changes to the design and interface are made, including different button debounce time as well changes to the size, shape, and feedback settings of the joystick.

The Smart Voting Joystick represents a major advancement in technology to allow people with dexterity and motor impairments to vote independently, and to do so in a reasonable amount of time and without major negative consequences (such as fatigue or discomfort). Election officials around the country have expressed interest in the Smart Voting Joystick, suggesting that it could make an appearance at polling places in the future. With minor changes to improve its usability, the Smart Voting Joystick has strong potential for commercial development and inclusion in voting system designs.

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http://elections.itif.org/projects/grants/round-2-funded-projects/michigan-state-university/

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