

Summary of Accomplishments for Phase II SBIR Project

Model-based Software for Configuring Switch Scanning Systems

Progress Report – Accomplishments from 2/1/2015 to 1/31/2016

During this project period, we have completed Tasks 1 and 2, to design and implement the Scanning Wizard software and evaluate its utility and usability. This puts us approximately 2 months ahead of the schedule outlined in the Phase II proposal. We also completed two tasks not explicitly described in the Phase II proposal but useful for providing solid evidence to validate the software and guide its development. Details of the accomplishments for this period are provided below.

Completed Task 1.

Task 1, from the Phase II proposal, is to “design and implement the Scanning Wizard software, using an iterative user-centered approach, resulting in a fully functional beta-level application that will run on multiple platforms.” We have completed this goal, with the following accomplishments:

1. Define and prioritize requirements. We prioritized requirements for Scanning Wizard to define an initial set of requirements for the minimum viable product (MVP). Completing the MVP is the focus of Task 1.
2. Implement an effective software development process. We use an agile development process, involving weekly iteration planning and daily 5-minute standup meetings. To track progress toward the MVP and organize our daily development work, we use Pivotal Tracker and Basecamp. Version control and deployment of source code and other assets is achieved using Sourcetree, grunt scripts, and other tools.
3. Design and implement Scanning Wizard software. Click-through design prototypes were developed using Sketch and trialed with practitioner users. Design prototypes were then implemented in javascript, HTML, and CSS, using the Ember JS development framework. The Scanning Wizard software includes a Switch test, a Scan test, performance reports for each test, and a final report listing customized recommendations for the user.
4. Monitor technical quality and accuracy. All development is test-driven, so that all new code includes a companion unit or integration test that validates its accuracy. Currently 813 automated unit and integration tests are run and monitored for success before every source code commit or deployment.
5. Involve users. In parallel with the software design and development, we carried out 3 rounds of in-depth sessions with 6 practitioners, to gather feedback on the state of the software at regular intervals. Each session included an independent walkthrough by the user, while an investigator observed, followed by specific questions on particular aspects of the software. We also obtained feedback from attendees at the RESNA 2015 Conference Developers’ Forum and the Michigan Augmentative and Alternative Communication Conference.

This is the initial MVP, containing the highest-priority features to make a working end-to-end system. There are still numerous useful features in the backlog for future development. The software is currently deployed at www.scanningwizard.com.

Completed Task 2.

Task 2, from the Phase II proposal, is to “Evaluate utility and usability in a laboratory protocol simulating actual use of the product.” Twelve practitioners completed a usability protocol that involved an independent walkthrough, a simulated Scanning Wizard session with data from a single-switch scanning user, and a usability survey at the completion of the activities. Specific target metrics for usability were defined before the study began (e.g., acceptable completion rate, completion time, error rates, and usability ratings).

Results suggest that Scanning Wizard has high usability for practitioners. All target metrics were met, including 100% task completion, almost-zero error rate, 20-minute run-through time, and positive usability ratings. Across all ten usability questions, the average response was 4.46 out of a possible 5, with a 95% confidence interval of [4.16, 4.76].

Scanning Wizard has high utility for practitioners. First, subjective questions related to utility received high ratings (LikelyUse avg = 4.25, WorthEffort avg = 4.67). Second, in a simulated exercise using a switch-user’s actual data, use of Scanning Wizard reports enhanced practitioner’s ability to make relevant and useful recommendations for that user.

Additional Task: Validation of Scanning Wizard Recommendations.

The purpose of this task was to see whether Scanning Wizard recommends the same changes that were used successfully in Phase I. The current version of the Scanning Wizard software makes 17 recommendations regarding the setup of an individual's single-switch scanning system. In our Phase I study, we generated the same type of recommendations in a largely manual process. The Phase I recommendations were very successful in enhancing users' performance significantly, so they provide a good benchmark for what Scanning Wizard ought to recommend under the same circumstances. Given the same data, a high agreement between Scanning Wizard recommendations and our Phase I recommendations would provide confidence in the validity of Scanning Wizard's automated approach.

Results showed that Scanning Wizard's recommendations matched those generated in Phase I very closely. Across 8 subjects, there were 131 possible agreements between Scanning Wizard and Phase I settings. Scanning Wizard matched the Phase I settings for 113 of these; and disagreed 18 times, for an average accuracy of 86%. The largest source of disagreement was instances in Phase I where user preference overrode the original recommendation. If those are removed from consideration, agreement is above 90%.

Additional Task: Psychometric Study, Part I

The main purpose of this study was to provide a better understanding of expected performance and psychometrics (normative data, test-retest reliability, and intra-test reliability). In this project period, we collected and analyzed Switch and Scan data from people who do not have impairments, as the first part of a psychometric study. (Part II of this study will collect similar data from people with motor impairments who are single-switch users, in the next project period.) The typical performance for these unimpaired individuals can be compared to our Phase I switch users, providing a rough guide for the distinction between actual switch users and users with no physical impairments. The data may also determine what, if any, refinements are needed for our difficulty score approach.

Ten subjects without impairment ran through the Switch test twice and the Scan test four times in a single-session protocol.

The Switch Test demonstrated good test-retest reliability, with an ICC of 0.96, even though subjects had never used a switch or the Switch test before. This suggests that the test can be fairly administered as a measure of switch skill without orientation or significant practice, aside from the 3 trials of built-in practice. Subjects had no observable trouble understanding the test, either, and made very few extra hits.

The Switch Test results also suggest that we can reduce the number of trials required in each phase of the test. The test as administered required 10 trials per phase, or 30 trials across all 3 phases. Our analysis shows that 6 trials per phase gives the same Difficulty Score and average Trial Time as 10 trials or 8 trials, for data from unimpaired subjects as well as from actual switch users in Phase I. We've therefore set the trials per phase to 8 trials, thus shortening the test by 20%.

The Scan data provided exploratory insights into skill development and performance during scanning. While we can (and did) measure the switch response and duration times during the Scan Test, results confirmed that those measurements are best considered as a complement to, rather than a replacement for, the Switch Test. The Switch Test provides an opportunity to screen for an inadequate switch setup, and the Scan Test really isn't appropriate for this.

Summary: We have made significant progress in this project period, completing two of the four major tasks proposed for the project. Results to date support two of the three main criteria for determining success in Phase II: (1) Technical quality tests have demonstrated the accuracy of all measurements and calculations performed by the software; and (2) Usability tests have demonstrated high usability and satisfaction for practitioners. We still need to implement additional features and involve more single switch users to completely satisfy these first two criteria. And we need to conduct the efficacy study to address the third and final criteria: (3) Use of Scanning Wizard must arrive at scanning system settings that will increase TER for subjects by 100% or more. These activities will be conducted in the next project period.

Closeout Report – Accomplishments from 2/1/2016 to 1/31/2018

In the first project period (2/1/2015 to 1/31/2016), we successfully completed Tasks 1 and 2, to design and implement version 1 of the Scanning Wizard software and evaluate its utility and usability. We also completed two tasks not explicitly described in the Phase II proposal but useful for providing solid evidence to validate the software and guide its development. These accomplishments were detailed in the Progress Report submitted in 2017.

In the final project period, we completed Tasks 3 and 4, thus completing all of the major goals of the project. Scanning Wizard is now a complete web application, available at scanningwizard.com. Details of the accomplishments for this period are provided below.

Completed Task 3.

Task 3, from the Phase II proposal, is to “expand and refine the beta-level software into a more robust and complete product.” We have completed this goal, with the following accomplishments:

1. Survey users of the early Scanning Wizard software. After Year 1, the minimum viable product (MVP) version of Scanning Wizard was available for people to use. To prepare for the next round of software development, we included a survey on the last screen of Scanning Wizard. 27 practitioners replied to the survey, regarding the most important features to add or strengthen in Scanning Wizard, as well as specifics about how they would want those features to work. Survey results showed that enhanced data management was the highest priority, to support central data storage and user accounts, prevent data loss, and provide flexible data sharing, while still allowing full use of software with or without an internet connection. Several key new test features were also identified by respondents, including support for users who have visual impairments, have literacy difficulties, or are two-switch scanners. Finally, the survey also provided an opportunity to get users’ qualitative opinion about the software, which was quite positive, as shown in Figure 1.



Fig 1. Words used by respondents to describe Scanning Wizard in one word.

2. Continue an effective software development process. As in the previous project period, we use an agile development process, involving weekly iteration planning and daily 5-minute standup meetings. To track progress and organize our daily development work, we use Pivotal Tracker and Basecamp. Version control and deployment of source code and other assets is achieved using Sourcetree, grunt scripts, and other tools.
3. Design and implement enhancements to Scanning Wizard software. Click-through design prototypes were developed using Sketch and trialed with practitioner users. Design prototypes were then implemented in javascript, HTML, and CSS, using the Ember JS development framework. The Scanning Wizard software includes a Switch test, a Scan test, performance reports for each test, and a final report listing customized recommendations for the user. The main features developed in this project period are:
 - a. Comprehensive admin data management for practitioners. This includes: 1) the ability to view each client they have worked with, as well as all previous reports for tests conducted with that client; and 2) complete control over deleting clients or individual test data, as well as adding new clients.
 - b. Optional user account and central data storage. This greatly reduces the chance of unintentional data loss. It was implemented to allow for offline use when an internet connection is not available, with syncing to the server occurring automatically when an internet connection

is made. A Guest mode (without user account) is still available, so users are not required to have an account in order to use Scanning Wizard.

- c. Support for switch users who are not fully literate. All tests in the wizard can now be performed in a no-text mode, to broaden the relevant user population.
 - d. Support for switch users who have visual impairments. We added some test modes that make it easier for these users to perform the tasks.
 - e. Support for 2-switch users. In addition to the original single-switch mode, Scanning Wizard can now be run in a 2-switch mode. Features c, d, and e combine to increase the target population that can use and benefit from the wizard.
 - f. Improve robustness on tablet platforms such as the iPad.
4. Monitor technical quality and accuracy. All development is test-driven, so that all new code includes a companion unit or integration test that validates its accuracy. The codebase includes 1302 automated unit and integration tests are run and monitored for success before every source code commit or deployment.
 5. Involve users. In addition to the user survey and 3 previous rounds of user feedback activities in the previous project period, we continued to involve users and gather input at regular intervals. This included in-depth sessions with local practitioners, as well as demo sessions at the RESNA 2016 Conference Developers' Forum and other conferences.

The current Scanning Wizard software includes the highest-priority features to make a working end-to-end system. The software is available for use at www.scanningwizard.com.

Completed Task 4.

Task 4, from the Phase II proposal, is to “Evaluate the efficacy of Scanning Wizard in a field study involving a variety of practitioners and scanning users.” This study allowed us to measure the usability of Scanning Wizard as well as its effectiveness in enhancing text entry rate. Ten people who use switch scanning and ten practitioners used Scanning Wizard in the initial session. In each initial session, a practitioner and a switch user ran through the Scanning Wizard software together. The session was recorded in screen-capture video. The switch user and the practitioner completed a short survey after the run-through. Specific target metrics for usability were defined before the study began (e.g., acceptable completion rate, completion time, error rates, and usability ratings). Usability was high, based on survey responses averaging over 4.5 out of 5, and qualitative feedback was very positive. Target metrics for task completion, error rate, and task time were also met.

Five switch users were able to complete the multi-week protocol, using settings on their own scanning system that were recommended from the initial Scanning Wizard session. Using these revised settings, text entry rates improved by an average of 71%, ranging from 29 to 172% improvement. All subjects kept the new settings to use for their daily life at the end of the study.

Summary: We have completed all four Tasks originally proposed for this project, resulting in a fully deployed Scanning Wizard web application which is used around the world by practitioners and switch users. Two of the three main criteria for determining success in Phase II have been completely met: (1) Technical quality tests have demonstrated the accuracy of all measurements and calculations performed by the software; and (2) Usability tests have demonstrated high usability and satisfaction for practitioners as well as switch users. The third and final criteria is: (3) Use of Scanning Wizard must arrive at scanning system settings that will increase TER for subjects by 100% or more. Task 4 demonstrated an average improvement of 71%, which is not quite at the 100% level but is still an important gain for these individuals. Combined, these results suggest that Scanning Wizard is a useful tool for improving the configuration of scanning systems for people who use switch scanning to communicate.