Real-Time Field Show/Stand Music Projected Display

Pamela Gregoretti[1], Samuel Havron[1], Stephen Nam[1]

[1]Department of Computer Science, University of Virginia
85 Engineer's Way Charlottesville, VA USA
{prg5rv, sgh7cc, kn4cs} @ virginia.edu

Abstract. Our Google Glass application is a real-time projected display intended to help college bands learn show routines more efficiently and quickly, using the Cavalier Marching Band as a starting focal point. The user base and tasks were analyzed to produce efficient usability goals and requirements. Despite bands portraying themselves as a cohesive unit, many different users have to be taken into consideration. These include color guard, drum majors, drumline, and band proper. To further explore implementation methods, four prototypes were developed. The first two were storyboards to better communicate needs, tasks, and satisfaction of users towards stakeholders and users. The other two were digital and paper prototypes to investigate the differences between voice and touch navigation, as well as organization of the interface. No high fidelity prototypes were developed. For evaluation, users were issued short in-person yes/no interviews after being properly informed about our design and given short tasks. These tasks related to using the prototypes to learn drill. Users felt that the design was intuitive to use, however they were mixed on if they would actually use a fully developed product if given the opportunity.

Keywords: stand music, college marching band, field show music, hands-free, audio-controlled, head-motion, real-time projected display, percussion, color guard

1 Users and Tasks

1.1 Overview of System

The real-time field show/sheet music projected display is a hands-free, paper-free method of allowing members of a marching band to view music and drill in a seamless, intuitive fashion. By providing members with hands-free access to their music, there is no need to memorize tunes before practicing them on the field while marching. Likewise, quickly finding drill spots and noting transitions from set to set in real time eliminates a significant amount of time that would otherwise be spent

stopping and looking at drill. The device would be synchronized by the commands of the drum majors and band directors. Specifically, drum majors would use a bracelet utilizing an accelerometer, which updates the progression of music in the band members' displays whilst marching in time to the drum majors' conducting. The implementation of this device is envisioned to be similar to existing heads-up display systems, such as Google Glass, though with modifications for a larger display and synchronization with the proposed bracelets.

1.2 Overview of User Base & User Base Details / Distribution

The intended user base for our device is members of a college marching band, broken down into 4 different subgroups: drum majors, wind players, percussion players, and color guard members. Each group is coordinated within themselves and through other groups to facilitate maximum productivity. The user base is intentionally chosen as college students rather than high school students due to the relative experience of college students, who have likely marched in high school and are thus comfortable enough with all aspects of marching band that they can learn this new technology without needing to think about how to achieve their other regular tasks. Exceptional high school marching bands would likely benefit from using the new system, but many would be slowed by including a technology system to learn in addition to seeing drill, visuals, and perhaps music for the first time.

The user base for this system is also intended to be for a large college marching band. For bands that are smaller than about 100 members, this system may not be as necessary to the success of the band as it would be to coordinate over 300 members. While it is a system designed to help members learn easier, it is also intended to facilitate communication on a large scale. Smaller bands do not have as much of an issue when it comes to spreading information.

1.3 User Roles

We will have different user roles depending on if the user is in winds, color guard, percussion, or is a director/drum major.

Those in the winds (trumpet, saxophone, clarinet, etc.) will need to access drill (positions/formations on the field) and sheet music for that week's show. They reflect the user base (young, tech savvy, and familiar with marching band), and will benefit from most core features.

Color guard will not need music due to lack of instruments and will instead need to reference flag work in some way (either visually, vocally, etc). They will still need to reference drill and other visuals. Again, they reflect the user base and will still benefit.

Drumline are similar to winds, except they help keep the tempo for the music and marching with their drums. Drum majors set the tempo, so they will need some sort of reference if they cannot see the drum major and gauge the tempo from their conducting. This reference can be achieved by having a digital metronome on the glasses set by interactions taken by the drum major. They too reflect the user base.

Directors and drum majors main purpose is to guide the band. Directors and drum majors will be able to upload music and drill to the application, as well as make any future changes and send out alerts or itineraries ("Hoo's News"). Thus changes can be made immediately before or at practice, which is more difficult when drill and music is printed on paper. Again, drum majors will be able to set tempo. Drum majors reflect the user base, although directors tend to be older (30-55) but are still familiar with technology and marching band terminology and expectations.

1.4 User Personas

Henry plays the saxophone in his university marching band. He meets with the band for rehearsal three times a week, two hours at a time. The marching band performs a new show each performance, so Henry needs to memorize new music and drill each time. He doesn't spend much time outside of rehearsal to memorize the show, unless the music is difficult. However, he does feel a bit of a time crunch trying to memorize the music, drill, and visuals in such a short time.

Jenny spins flag in her university marching band. She meets with the full band for rehearsal 3 times a week, and a separate guard practice once a week. The band performs a new show each performance, and sometimes the guard doesn't learn flag work until the Monday before Saturday's show. It is a lot for Jenny to adjust to each show, especially since she is a first year. High school bands focus on one show per season, so it is stressful for Jenny to learn work quickly and adjust to changes made later in the week.

Caleb plays the tenor drums in his university marching band. He meets with the full band for rehearsal three times a week, and a separate drumline practice once a week. Even with an extra day of rehearsal, he feels a lot of pressure having to memorize his music and drill. The music is difficult to play, so memorizing it and putting it together with drill is even more difficult. Whenever he has time, he takes out his drum pad to practice and memorize the music so that he does not hold back the full band.

Shauna is a drum major in her university marching band. She conducts the band three times a week for rehearsal (she is not there for drumline practice), helping the band stay in time and relaying the directors' messages to the band. Before each new show, she learns the show by listening to the MIDI recording of the new music while following it on the full band score. Once she memorizes the score and can keep the band in tempo, she tries to find ways to make her conducting more interesting and fitting to the style of the music.

1.5 Task Analysis

Color Guard must learn visual movements quickly. Sometimes remembering phrases in the flag work can be difficult due to the lack of practice time. Thus, guard members would like to be able to have either a video of the work or a list of the flag work names on display. A lot of individual flag moves or phrases have nicknames to help spinners remember the work and what they are referencing. Many members of the guard yell out the work to each other while spinning, but sometimes it is difficult to hear due to distance and the volume of the band. Therefore, having a reference system to the work would not only help individual guard members learn visuals, but help them aid other guard members such as first years or others who are struggling.

This would also help guard members who are in the "front line" or do not have guard members near them to reference work from. Often times spinners who are in the "back line" learn the work easier because they have visual reference from those around with to trigger them to remember what is next in the work. However, this places more responsibility and burden on the front line, especially for first years adjusting to the quick pace of college band.

Color guard captains and directors will also be able to modify flag work as well as send out alerts about changes or cuts, similar to what drum majors will be able to do for the band. They too will need to access drill, but not music.

Drum majors set the tempo though the conducting and will need to be able to get everyone in the band to see them. Sometimes those in the back of a formation or on the field cannot see the drum major that well and can cause the drumline or other members of the band to get slightly off tempo with each other. Therefore drum majors would want a better system to synchronize the band.

Directors and drum majors will also need to be able to alert the band of any immediate changes in plans or music, as well as be able to update drill and music on the spot. Since music and drill is currently sent out electronically and then printed by the members, it is not practical to try and make certain changes when at practice since email cannot be access by most band members.

Drum majors must also learn the music prior to the first practice of a show so they can properly conduct it. They often listen to MIDI's of the music and practice conducting as it plays.

Wind players must be able to see music and drill during the beginning of the week when a lot of the foundational part of the show is being learned. Often drill and music is printed and carried in a binder, which can be difficult to reference or easily lost. Drill/music binders are often hung around the shoulder using string, which can be uncomfortable for certain band members such as tuba or color guard. They are also easily broken. A more efficient system is needed.

Again, this system makes it difficult for changes to be made during practice. It also does not indicate things such as visuals (dances, grabbing their cape, etc). And just like the color guard, they need better systems to communicate with section leaders and directors. Some sections rely on group texting to relay information, which can be ineffective for those without smartphones or when phones cannot be used.

Percussion has similar tasks to wind players, as well as having to set the tempo musically by watching the drum major as they play. Sometimes this can be difficult depending on placement on the field and a better way to synchronize the drum majors and percussion would be nice.

1.6 Usability Goals

One goal is to make it easy for users to navigate between sets of drill and its corresponding set. Marching band practices move quickly and there is not time to wait for something to load or navigate through too many buttons and pages.

We also want to make it where the display can adjust opacity, so it can fade when the user feels most comfortable with the work or needs to learn that part of the show without any references. That leads into our third goal, which is adding features that allow the user to wean of the device and learn the show on their own in preparation of performance day, since the device cannot be worn during shows.

Personal user notes should also be able to be made and altered to make the device more personal to their needs and weaknesses. This too should also be adjusted with opacity, as well as any updates from drum majors and section leaders.

Users should also also be able to see notes about visuals within the show. This includes things such as dances, lifting their cape, vocals, and any other variations in movement or marching. Notes such as music changes or cuts will be accessed, as well as any alerts from the drum major or section leaders. Itineraries such as Hoos News will also be available on display.

Tempo will be synchronized with drum major's movements and relayed back to the band. Drum majors must set the tempo for the marching band. An accelerometer bracelet can be worn on the wrist so the glasses can register tempo from their hand movements. Marching band drum majors traditionally conduct with their hands rather than a baton due to batons being difficult to see from the back of a field. This tempo would then be updated on the "tempo" display for the rest of the band. They will also have the option to default to a manually set tempo if the accelerometer cannot be used or recognized. Tempo will be displayed with a metronome either with a blinking light or through audio.

1.7 Usability Requirements

1. 6 hours to memorize without technology -> 4 hours with technology (increase time for raising performance standards)

We want our product to speed up the learning process for band members. Shows may only have as little as 3 practices to be completely learned and mastered, thus time is an important factor.

2. 90% of users will report through a multiple-choice survey that the system felt natural and not distracting to them.

The headset and application should not feel intrusive or distracting, since this will inhibit productive practice time. Our goal is to facilitate learning for the band.

3. 90% of users will report through a multiple-choice survey that the felt more informed about changes in their band by using this device.

An important aspect of the marching band is being aware of what the practice and performance schedules are at all times. Because the band has over 300 members, it can be difficult to make sure that everyone is aware of what is going on. Thus, facilitating communication is another important goal.

4. 95% of users will report through a multiple-choice survey that they felt more prepared by performance day when using this device.

Again, we want the program to help the band with learning shows quickly and more efficiently. A good measure of this is evaluation game day emotions and confidence.

5. Bands will significantly get more drill sets done in one practice when using the device compared to when they do not.

Music and guard work can be practiced outside of band practice, but learning drill must happen at band practice. It takes the biggest chunk out of band practice, so shortening the drill learning stage would allow more time for full show runs and refining small details.

1.8 Conceptual Model

In designing the system, a conceptual framework is envisioned in order to define the boundaries of interaction between the system capabilities and user expectations. Overall, the framework of the system is based on allowing band members to quickly navigate between music and drill that they need to read during practice where they are actively using their hands and mouth to play their instrument and their feet to move from set to set, or occupying their body with show visuals. In order to accommodate

for an environment in which most of the user's body as not able to interact with a traditional electronic device or system, this heads-up display approach will make it simple to show band members what is relevant to their performance at the time, and be able to adjust in real-time as the band members practice. An outline of the system interface is shown below in Figure 1.1, the Home Page.

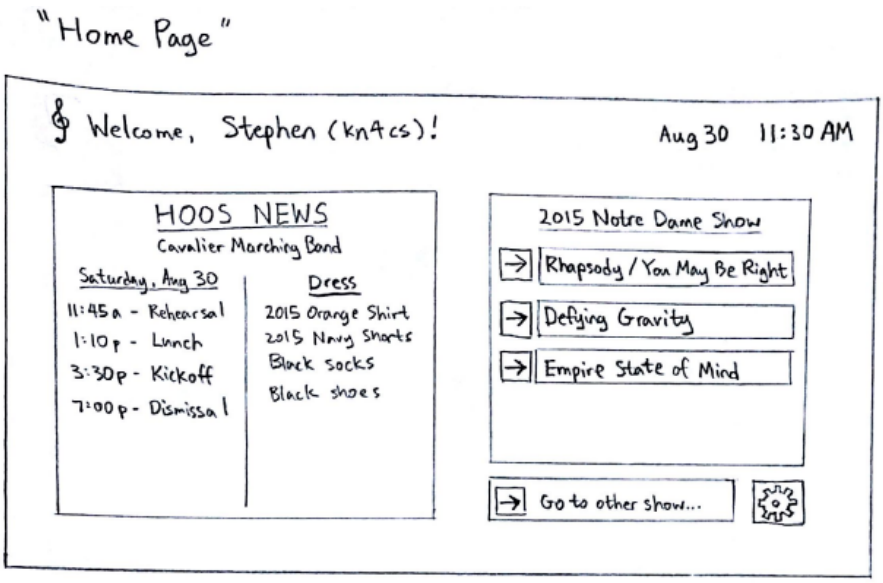

Figure 1.1: Home Page of proposed heads-up display.

As can be seen in the figure, the Home Page is purposed to show band members important rehearsal information, display their identity (name and identification tag), and facilitate quick navigation to the music and drill for a given field show. The users can manipulate these options through vocal commands (before they are playing on the field) or by using their hands in a manner similar to hands-on interaction with Google Glass, in which the users' right hand controls the selection and scrolling of the display. While the band member is actively marching, they are severely limited in their interaction with the display, as they are focusing on their marching tasks. The drum majors' bracelet acts as the control for their display during periods of active marching; the band members need only watch their display for music or drill information as it updates through the progression of their practice session. A view of this performance mode can be seen below in Figure 1.2.

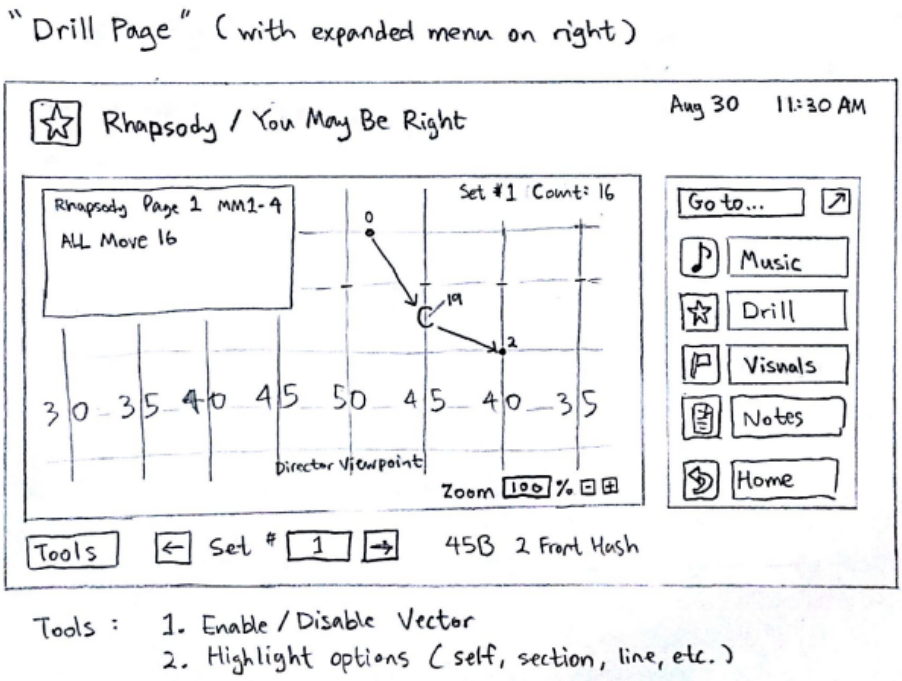

Figure 1.2: Drill Page of proposed heads-up display.

As can be seen in the Drill Page view of the display, band members can quickly review drill before performing; they can see their spot in a given set as well as display a vector pointing to their next set. If they are performing and need to focus on drill rather than music, the drill can update in real-time with the conducting of the drum major due to sets being held for a countable amount of measures; vectors pointing to the band members' next set can provide visual feedback (i.e. turning red and blinking) to alert the band member of the timing of their movement to their next set. Band members will expect this Drill Page to also reveal the relative position of them to other band members; this functionality can be implemented through use of the Tools icon. There, the band member can view the spots of their nearest neighbors in a given set, or their instrument section, or the entire band if they need to get a better idea of the picture of the set. The Drill Page is not intended to track the actual coordinates of the band member, but to display where they are supposed to be in a given set and how they are supposed to navigate efficiently to their next set in a given amount of counts. If there are special conditions for transitioning from one set to the next (e.g. turn to face the direction of travel, high step instead of low step, instrumentation holding), this information can be easily shown via the Notes icon, which has the capability of being displayed in a banner fashion across the top of the display.

Following from the use of the Drill Page during and between performances, the Music Page is a central feature of the system, allowing band members to see the music they need to play in real-time as their performance progresses.

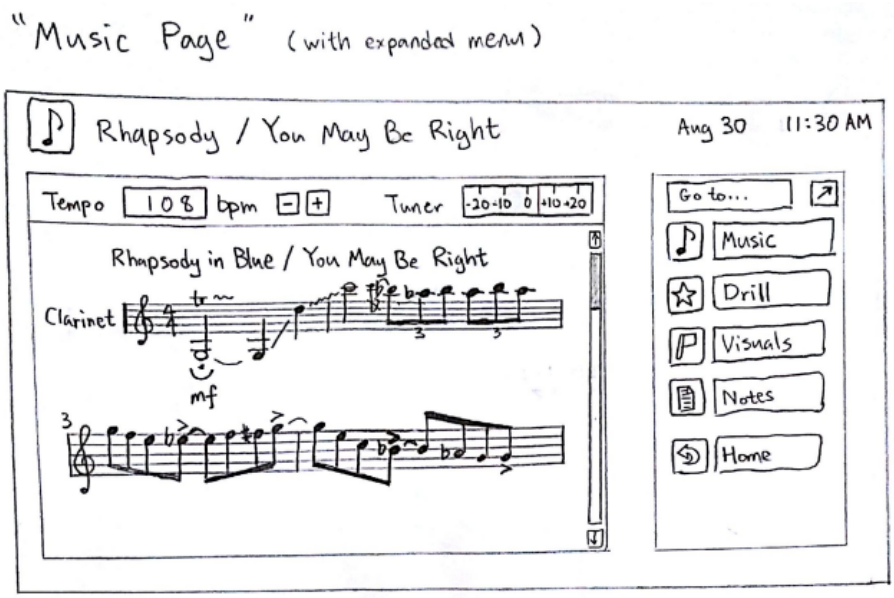

Figure 1.3: Music Page of the proposed heads-up display.

The music page displays 2-3 lines of music at a time, updating in synchronous with the drum major's bracelet. Band members can expect to quickly see the tempo, check whether or not they are in tune, and view any pertinent notes in a banner format at the top of the display. When they are not practicing with the rest of the band, individual band members can practice the piece, adjusting the tempo to their needs and letting the display update with the set internal tempo rather than the tempo coordinated with the bracelet.

Lastly, the conceptual framework of the heads-up system includes a Visuals Page. This page will be of great use to the color guard, who can view their visual movements in a queue fashion and review the moves by watching pre-recorded video recordings.

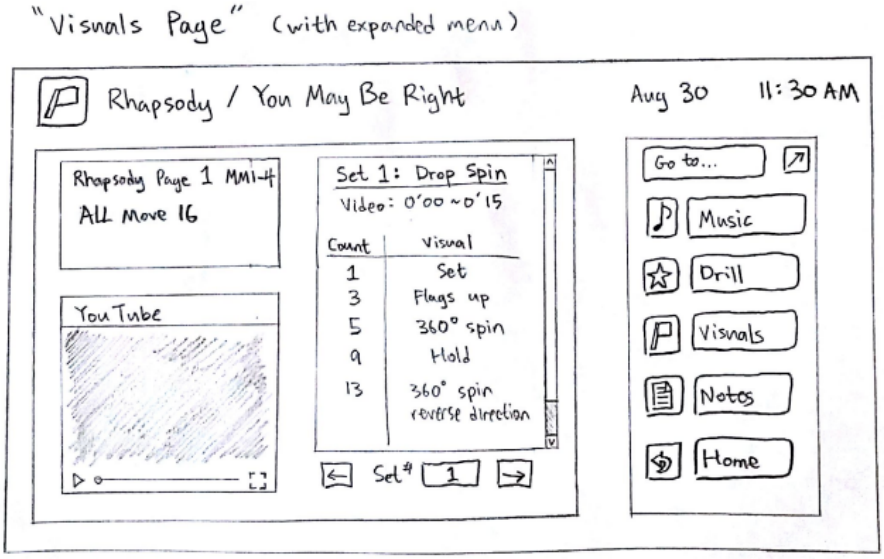

Figure 1.4: Visuals Page of the proposed heads-up display.

The Visuals Page will allow color guard and other band members with visual movements during a show to quickly see what movements are to be performed at each individual set, or during a transition from one set to another. Additionally, video playback of pre-recorded moves can be viewed by band members to help them as needed. As with the drill and music pages, this queue of moves is updated in real-time with the progression of a show, where the upcoming move is indicated in some fashion (e.g. count down until move needs to begin). In order for the video recordings to be pertinent to the color guard and other visuals for wind and percussion players, drill instructors and guard captains will need to record their visuals in advance and upload them to the system. This will require an expectation of the users to commit to producing videos; videos of movements that are repeated can be reused for different shows, however.

Note that in all displays thus far, the toolbar to the right includes an expansion to full screen mode. This mode is automatically invoked whenever the band is performing as a unit in synchronous with the drum major's bracelet. Only Note banners can be displayed in addition to the music or drill or visuals main screen. Together, the conceptual framework of the system is consistent and provides exactly what the band members expect; the boundaries of interaction are clearly shown in a WYSIWYG-esque format, with the exception of the automatic loss of control by individuals as drum majors conduct and the displays update to the drum major's bracelet.

1.9 Conclusion

The user base of this system and their individual personas have been carefully considered to ensure development of the system can be as effective as possible. Each user group has been evaluated in terms of their needs within their group and their needs in interacting with other user groups. The intended type of marching band (large, collegiate) has been defined and design considerations will be made with this type of user base in mind.

Finally, the expectations of the users regarding the interaction with the system has been discussed and considered in terms of the system vision. It is hoped that by exploring the intended user base and their role in using the proposed system, a solution can be reached that is genuinely helpful to the band as a whole. With this, the idea of prototyping comes into play. Several prototypes have been developed, which are further explained and explored in the upcoming sections.

2 Prototyping

2.1 Usability Requirements of Interest

With our prototypes we primarily wanted to focus on accessing information like music, drill, and visuals in an intuitive manner. Since a lot of the interface is predetermined with Google Glass, one of the biggest challenges is testing different capabilities within Google Glass to see which feels the most natural and simple when navigating the application.

For example, we want a band member to be able to locate, access, and view any of the music, drill, or visuals for a given show tune within 5 seconds. Our goal is to test different navigation options within each view, such as swiping, tapping, and voice command. We also wanted to compare hand movements with voice command to see which would feel most comfortable to the user.

Additionally, we wanted to better demonstrate how this technology can work in a marching band setting and add to the learning process. Our application has features useful to all members of the marching band and can make things such as accessing drill and music or remembering changes in the routine easier. It also facilitates organization by maintaining everything digitally rather than on paper, as well as communication by allowing notifications and keeping track of practice schedules. Thus, we wanted to test if users can have many common problems solved and feel that they are benefitting from our application.

2.2 Description of Prototypes

For the first 2 prototypes, we used storyboards. The first one features a member of the color guard using the hand interactions enabled by Google Glass. To help members of the guard learn their routines quickly, the moves are listed on the screen as they practice. If there are any changes made to the routine, color guard users can "scroll" through the list of moves for that routine and modify the list by swapping, deleting, inserting, etc. This can be seen in Figure 2.1 at the end of the document, where all figures for this section are kept for better readability.

The second storyboard prototype features a member of the band using Google Glass to access drill formations as they practice on the field. This is done voice commands to quickly load drill documents indicated through a notification system. Pages can then be swiped through to quickly navigate the document. This can be seen in Figure 2.2.

The first two prototypes were storyboards to help express the real-time applications our product could have at a formal band practice, as well as general problems it solves. This is something that does not need much complexity or detail to it, so quick story sketches were the least amount of work needed to get the point across. Details about interface and exact implementation were not needed, since we were performing user task analysis.

The third prototype is a digital prototype made using GlassSim.com, a free prototyping website for Google Glass applications. When the application is first started up, there is a welcome screen that features the Cavalier Marching Band logo, the user's name and UVA computing ID (Figure 2.3). The user can then swipe right to proceed, leading to the home screen, which features the schedule for the current practice (Figure 2.4). The user can swipe up or down with their hand to scroll through different views for music, drill, or visuals (Figures 2.5, 2.7, and 2.8). The music option would be replaced with a routine viewer for color guard.

The drill viewer features additional options such as zooming in and out using a pinch movement and tapping to enter the vector tool editor (Figure 2.6). The vector tool editor allows the user to make notes of where they are moving to and from for a given formation by adding vectors to the drill image. Pages in the drill document can be navigated through by swiping left and right.

The music viewer and visuals viewer can also be navigated through by swiping left and right. Additionally, the visuals screen can be tapped on to start and stop the visuals recording created by the Drill Instructors.

This prototype was digital because we wanted a clearer view of the interface to better explain navigation and other features. It also shows that most tasks are universal for members within the band. We also wanted to focus solely on how hand interactions

would affect the interface. However, we are still open to changes in lay out and navigation and did not want something of higher fidelity like videos or Wizard of Oz.

The last prototype is a paper prototype of the interface. It doesn't follow Google Glass's interface and functionality as well as the previous prototype because we wanted to analyze how voice command could affect the interface. Thus, interface capabilities that would indicate using hand movements were removed to create limitations. There are still similarities between the two prototypes to highlight the core features we want to implement.

In Figure 9 we see that we wanted the application to have a home page that listed the practice schedule, time and date, and the user's name and UVA computing ID. Users can navigate away from this page by saying commands such as "Open Defying Gravity music/drill" or "List other shows."

The drill view can be zoomed in or switched to another page by saying commands such as "zoom in," "zoom out 50%," and "go to next page." The menu also reminds the user of other pages they can navigate to by saying commands such as "access music" (Figure 2.10).

Guard and band visuals are also viewable (Figure 2.12). This view allows commands such as "play visual," "change count 5 to toss," and "switch to next set." Again, there is the menu listing other pages that can be navigated to. The music viewer has similar commands to the drill page such as "go to next page" and "go to next song" (Figure 2.11). It also lists the tempo and tuner that is set by other users such as the drum major, percussion, and directors.

We made this prototype out of paper because we knew we would be making a lot of design changes this early in the design stage. This can be seen with the changes in our other prototypes.

2.3 Design Details

A lot of the conceptual modeling is already completed due to the use of Google Glass. However, that is why we chose to use it. We wanted the interaction to feel natural, like swiping through pages of a book, timeline lists, etc. Our interface mimics how band members scroll through drill binders or music binders on the field, or access information about the practice and drill on their phones. This means that our current implementation should feel natural and easy to learn, as well as quicker and more efficient.

Guard members also like to yell out the routine work as they practice on the field to help group synchronization, or test their memorization of the routine by quickly writing down the work on a scrap piece of paper. This is reflected in our way of listing guard work in sequential order as guard members practice.

We also wanted to map the information in a way that made sense in the third prototype. Scrolling up and down accesses different "views" or different categories of information such as music or drill. Swiping left and right or tapping then navigates that information. This organization makes it clearer what the user can and cannot do at a given view by using simple and intuitive interactions. Voice commands can then override this when big navigation changes must be made instantly.

The last prototype models a display similar to a website to emphasize how users interact with the interface through voice and not directly through physical manipulation like in the 3rd prototype.

2.4 Design Questions / Important Differences

Our first two prototypes are very different from the last two in the purposes they serve. Storyboarding allows us to highlight situations that our application applies to and can help marching band practice. Storyboarding allows us to quickly and cheaply communicate the roles our system will have in our users' lives. The need for the device are clear and applicable to many of our users. All guard members must learn drill quickly and remain synchronized, while all members of the band must quickly learn their drill spots and consistently be aware of them. These issues are quickly solved with our application, and satisfaction from the users is depicted. Explanations of tasks and needs are important to communicate to stakeholders and users.

The last two prototypes highlight interface and interaction design such as voice command and hand movement, as well as information organization. They were purposefully made to implement extreme cases (only voice command and only hand movement) to study which interactions felt more natural and necessary to the users. We could have used paper prototyping to display the interface, but since Google Glass is a visual device, we felt that a digital mock up better portrayed how the application would look combined with the user's viewpoint. This allows more detail than storyboarding or paper prototyping, but efficiently conveys what we aim to accomplish without involving too much work.

The hand movements feel more intuitive with things such as navigating drill, music, and visuals. However, voice commands seem better when doing large navigation jumps such as viewing drill and wanting to quickly to look at sheet music, or looking at drill from a previous show. This year we often practiced the Macy's show as well as that week's show within the same day, meaning that these large jumps between shows were often necessary. Therefore it is unclear as to what aspects of each prototype users would prefer. These differences could be further analyzed using Wizard of Oz prototyping or a smaller program coded on another platform.

We also can use these two prototypes to see if Google Glass is best for our user base. Google Glass has specific ways things can be implemented, which may not fit best for

our application. Users may prefer to quickly look at their phone than wear a headset, which means something similar to the last prototype's layout could be implemented on a mobile app with touch command implementation. However, others may prefer a Google Glass approach since its design naturally prevents information overload, something that occurs in our last prototype with the cluttered design.

2.5 Conclusions

Our goals with our prototypes was to better communicate the roles our program serves for marching band members as well as analyze how information should be navigated. Google Glass allows combinations of physical interaction and voice command, however we did not want to offer too many commands that could overwhelm or confuse our users. Thus we created two prototypes, each focusing solely on voice command or hand movements.

Our last two prototypes highlight many pros and cons between different implementations. The third prototype maps information in a way that is intuitive by navigating music, drill, etc by swiping up and down and pages of drill and music by swiping left and right. This style also allows users to edit drill using the vector tool, something that cannot be done with voice command easily. However, it does not allow quick navigation jumps like with voice command.

The last prototype offers other pros besides quick navigation jumps such as a different way of presenting information. There is a menu side bar as well as a more explicit explanation of what you are viewing with titles and interface frames. This can also offer insight if using another platform would be better for our project.

While our prototypes helped answer design questions, it raised others that can be answered through further prototyping such as Wizard of Oz or more low fidelity prototyping, as well as proper evaluation of our current prototypes.

3 Evaluation

3.1 Evaluation Plan

Our prototypes went through a formal evaluation in the form of a usability study on university marching band members to assess strengths and weaknesses to consider in further development of the prototypes. Several research questions were formed that form the basis of the evaluation plan, as listed below:

(1) How does storyboard exposure prior to using the prototype aid in overall usage?
(2) How intuitive* is the touch input prototype to use?
(3) How intuitive* is the voice input prototype to use?
(4) Do participants learn drill sets in a reasonable amount of time, using the prototype?
***Intuitive** for the evaluation is defined as: achieving a set of usability tasks in a minimal number of input commands, as well as a minimal amount of mistake inputs, whilst taking a reasonable amount of time to learn 2 sets of marching drill.

Figure 3.1: Research questions for evaluation.

Data collection for the evaluation will address these research questions with both qualitative and quantitative results. To assess the first research question, a qualitative survey was given to participants, as printed below:

An analysis of survey results, coupled with observations during testing provided a reasonable answer to the first research question posed for evaluation. Addressing the second and third research questions was done by following a set of common tasks typical of a regular marching band rehearsal. An outline of the tasks (posed as questions for the participant) is as follows:

Test subjects navigate the same path for voice and for touch:

1. Where is your dot in set 1 for the show? (offset from yard line/hash/sideline)
2. What note does the show's song end on? How many counts is it?
3. What time does Macy's drill rehearsal begin?
4. How many counts is the Heisman visual at the end of the song?

Figure 3.3: Tasks to evaluate prototype input method usability.

Collectively, the tasks presented by each of the questions provide a gauge for the usability of the touch and voice input prototypes, with the number of commands and number of mistake commands recorded for analysis. Question 1 tests how well the subject can navigate to and interpret from the drill screen of the prototype; users must take advantage of the zoom capability and switching views to arrive at the answer to the question. Question 2 tests how well the subject can navigate to and through the music screen of the prototype; scrolling capability and reading the music on the page is needed to answer the question. Question 3 tests how well the subject can navigate to and read the announcements screen of the prototype. Question 4 tests how well the

subject can navigate to and read the visuals screen of the prototype; knowledge of starting and pausing the visuals video is needed to answer this question.

These questions are addressed in data collection by counting the number of command inputs the test subject uses to achieve the goal; the number of mistakes (i.e. command inputs that did not advance the user towards the goal) was also counted. To answer the fourth and final research evaluation question, the tasks described above were extended to the following tasks that the participants needed to complete:

Learning drill from the prototype:

1. Go to set 1 of the drill.
2. Look ahead to set 2 in the drill and use the vector tool to look ahead at the path from set 1 to set 2.
3. Go to set 2 and perform the visual on counts 13 and 14 of the show.

Figure 3.4: Tasks to evaluate drill set learning.

Completing these tasks allows the participant to accomplish a typical expectation of a marching rehearsal, whilst also further testing usability of their given input method prototype. Question 1 tests how well the subject can find their dot in the drill with the prototype and physically get to their spot. Question 2 tests how well the subject can look ahead in the drill to the next set and see how it is connected to their current set by using the vector tool. Question 3 tests how well the subject can navigate to a new drill spot by following the vector, and view associated visuals for set 2.

To collect other qualitative data on the usability of the given prototype, an exit survey was given to each participant as follows:

Overall survey of the usability of the prototype (YES/NO answers):

1. Would you use this system (developed fully into Google Glass) for learning music/drill in band?
2. Were the prototypes intuitive to use?
3. Is this system potentially preferable to traditional ways of learning music/drill/visuals?

Figure 3.5: Exit survey.

Numerous confounding factors that affect the quality of the data collected were considered in the evaluation plan. Having all subjects read through the storyboard prior to testing sets a control for their understanding of the overall conceptual model of the prototypes. This will help reduce confounding factors in their understanding of the goal of the system.

By limiting data collection on usability of input methods to a count of the discrete number of commands used (both commands which advance the subject to their goal or mistake commands which lead the subject away from their goal), the evaluation was able to quantitatively measure the intuition of the prototypes using an

approximation that is significant for answering the evaluation research questions. This does not limit the subject to confounding factors such as time constraints. Recording the time subjects need to learn 2 sets of drill evaluates whether a threshold "appropriate" amount of time has passed for them to achieve their goal using the prototype. This controls for confounding factors by realistically evaluating if the prototype can teach a subject drill in a reasonable amount of time or not.

3.2 Methodology

Each participant was given a set of tasks to complete using a distinct prototype; one participant used the voice-input prototype, while the other two used the touch-input prototype. Enough quality observations were recorded to determine the factors surrounding ease of use associated with each prototype, and further testing was not needed, despite the small number of participants. Each test begin with the participants reading through the storyboard prototype to gain an understanding of the system goal and general usage behaviors. The participant was then presented with several tasks that emulate typical marching band rehearsal schedules (see Figure 3.3), followed by a task of learning drill sets and various tools that aid it (see Figure 3.4). Accompanying the figures is a description of the methodology and goals of each task within the test.

3.3 Summary of Results

Upon completion of the prototype testing, participants were given a survey (Figure 3.2) on the role of the storyboard prototype in their understanding of the conceptual model of the system. The results are shown below:

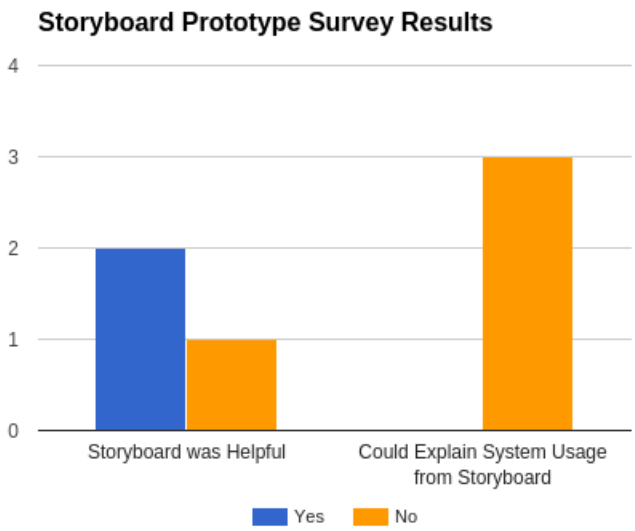

Figure 3.6: Storyboard survey results.

Participants were also asked to complete an exit survey (Figure 3.5) on the usability of the system and future direction for prototype development; the results of the survey are as follows:
Collecting data for each prototype evaluation consisted of 5 points of interest; a survey of the storyboard, a record of the average number of commands used in each prototype to navigate through the interface and learn drill, the average number of mistake commands during navigation and learning of drill, an exit survey, and a reasonable time expectation of participants for completing the test. These points of interest generated results from which several useful conclusions were drawn about the usability of each prototype.

The participants (n=3) in the study were a subset of the target audience: university marching band members. They comprised of two wind players and a color guard member from the Cavalier Marching Band at the University of Virginia. These participants were ideal candidates for testing the prototypes, as they were familiar with the needs of marching band members and held expectations of a digital replacement for paper drill, music, and visuals. Although the number of participants that were tested on were few, the quality of the data collected provided critical insight as to further evolution of the prototypes; this supports Don Norman's model of testing a minimal amount (5 users) in a usability study (Nielsen, 2012).

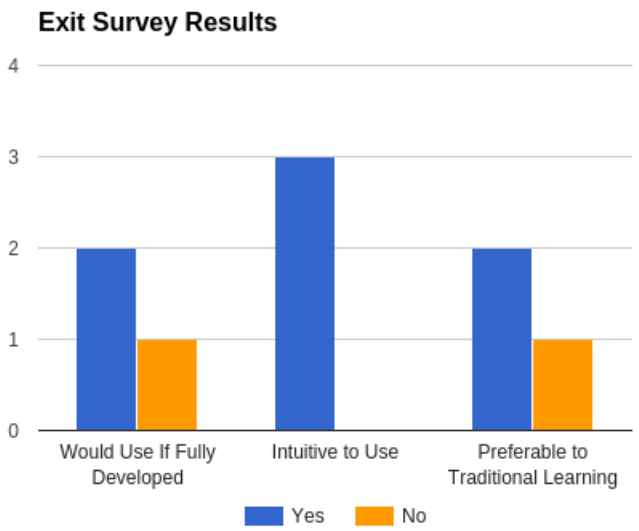

Figure 3.7: Exit survey results.

Additionally, the data collected on the average number of commands used to complete the testing (drill and associated tasks) was recorded for each prototype used:

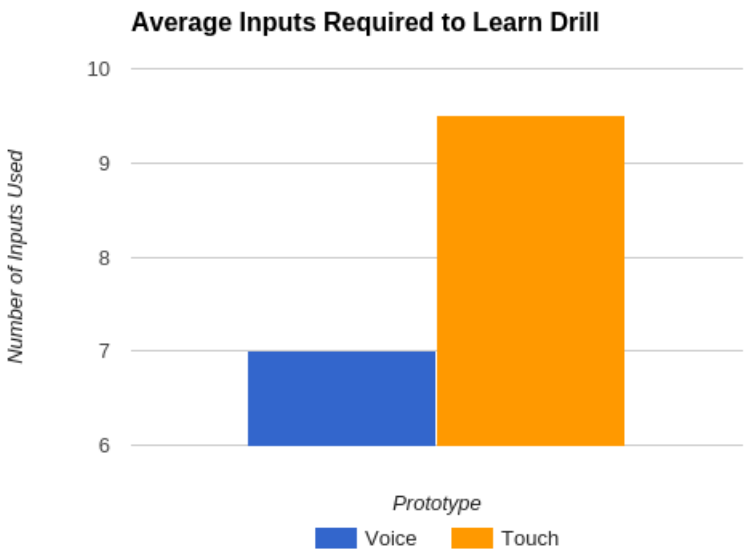

Figure 3.8: Average input commands needed to learn drill.

Following from this, the average number of mistake commands in learning the drill and associated tasks are listed below:

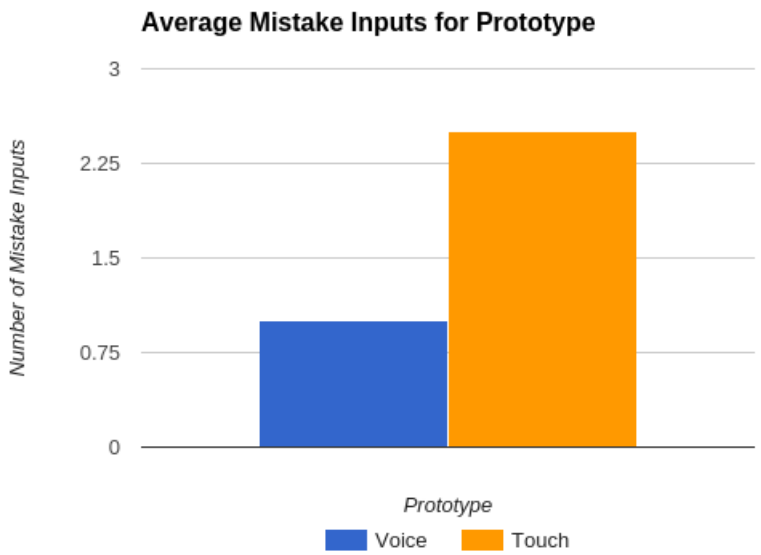

Figure 3.9: Average mistake input commands in learning drill.

3.4 Conclusions & Final Thoughts

The results of testing participants yielded several useful observations about the usability of a given prototype, as well as the general demographic interest in further development of the prototypes. It is apparent from the average number of commands used (Figure 3.8) and average number of mistake commands used (Figure 3.9) that the voice input prototype resulted in less mistakes and less commands needed to complete the given tasks. Despite the small amount of participants involved in the usability study, qualitative observations during testing support the experiences reflected in the results shown.

The touch input prototype proved to be more of a hindrance to completing tasks than the voice input prototype; this was especially apparent when switching between different "views" or modes of the system (e.g. drill, visuals, music, announcements screens). Transitions between views were unintuitive, in part due to the spatial mapping of the touch input seemingly irrelevant to the desired action (a double tap allowed for switching views, a single tap allowed for selecting an option within a view, and left and right slides allowed for navigation within a view). The touch input prototype proved useful in navigating within a view, such as for scrolling through music sheets and selecting tools; mistakes were most evident during transitions between views, as the need to double tap as many times as needed to arrive at the correct view was cumbersome.

The voice input prototype performed better than the touch input prototype in both qualitative observations and quantitative results (Figure 3.8, 4.9). The commands needed to transition from views was simple: state the view sought, and the view is instantly presented. This eliminated the need for multiple transitions to arrive at the proper view, which plagued the touch input prototype. The voice input prototype was sufficient within views as well; commands needed to manipulate tools in music, visuals, and drill sets were apparent and listed onscreen in a helpful manner; some voice commands were intuitive, such as play/pause commands for viewing visuals and view names for transitions. However, using the vector tool during drill sets was not as intuitive for voice input as it was for touch input, nor as fluid as several interactions within views as for the touch prototype.

Based on the qualitative and quantitative results of each prototype tested, the voice input prototype is more intuitive and simple to use than the touch input prototype. However, some interactions within views themselves were easier to complete using the touch input prototype; a hybrid voice and touch input prototype may provide the best next direction for the system development, as the context in which a method of input is used in evidently impacts the quality of the interaction.

Survey results of the storyboard utility in learning the conceptual model of the system were mixed (Figure 3.6). 2 of the 3 participants felt that the storyboard generally aided their understanding of system usage, though all 3 participants reported that the storyboard prototype exposure alone would not be sufficient to using the system proficiently. The purpose of the storyboard prototype, to expose the participants to the general use of the system and reach an understanding of the conceptual model, was consistent with the results of the survey, despite it not resulting in practical system usage knowledge.

The exit survey provided insight as to what further system development is feasible (Figure 3.7). Though opinions on the potential of the system to replace traditional learning methods were mixed, all participants agreed that the system was overall intuitive to use and achieved its purpose, replacing physical drill, visuals, and music sheets, in a sufficient manner. Most participants reported that they would use the system if it were fully developed; this feedback supports subsequent iterations of system prototypes for testing. Based on the prototype results, developing a hybrid input method model that combines the best qualitative results from each respective prototype is a clear next step for the technology. Further improving upon the usage of the touch input prototype could also lend to stronger qualitative and quantitative results in further iterations of the prototype.

Acknowledgements / Honor Code

"On my honor, I pledge that I have neither given nor received help on this assignment."

Signed: Pamela Gregoretti, Samuel Havron, Stephen Nam

References

1. Mutual Mobile Glass Simulator
   glasssim.com
2. Nielsen, J. (2012, June 4). How Many Test Users in a Usability Study? Retrieved December 8, 2015, from http://www.nngroup.com/articles/how-many-test-users/

Figures

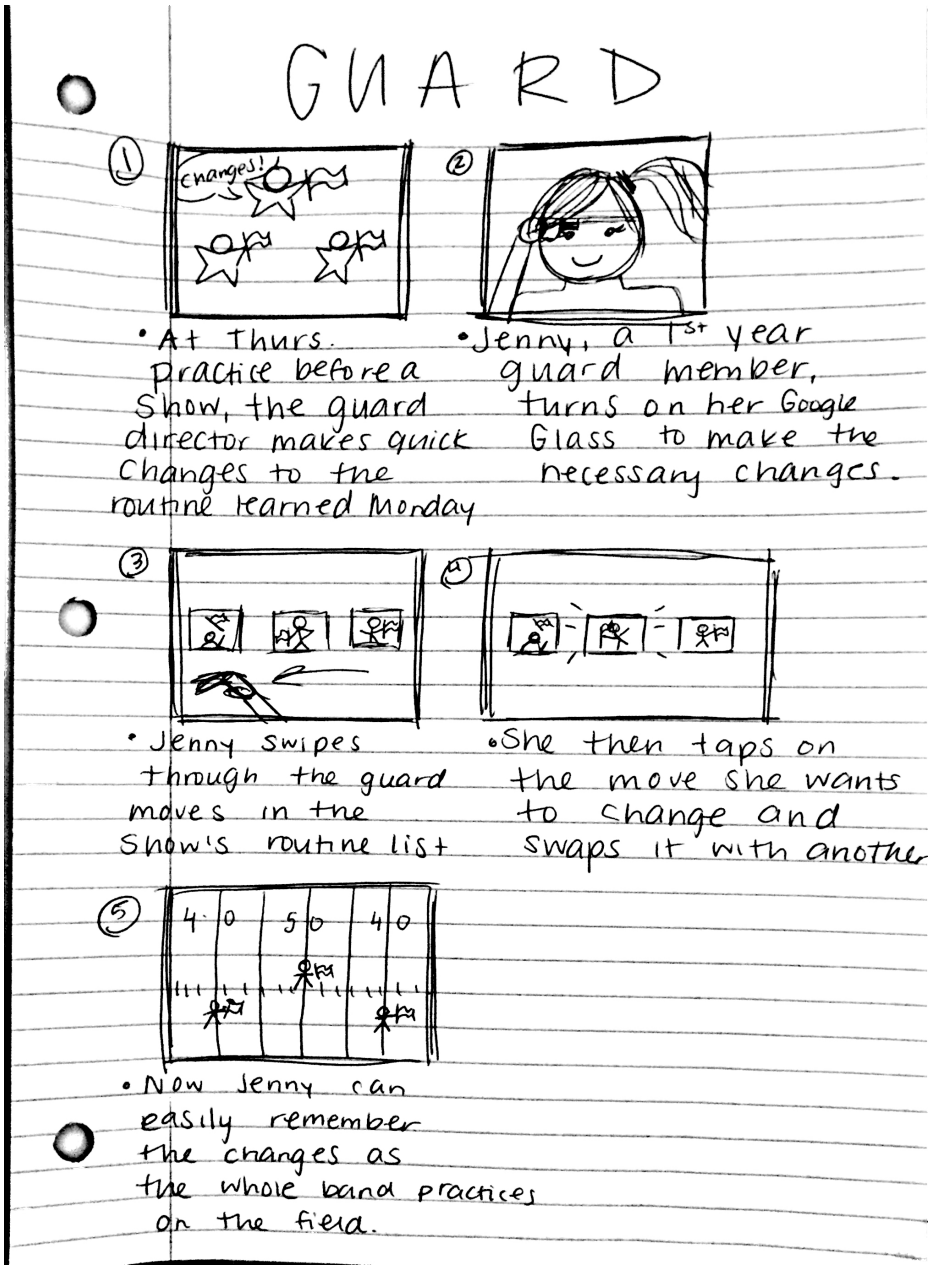
GUARD
1
changes!
2
• At Thurs. practice before a show, the guard director makes quick changes to the routine learned Monday
• Jenny, a 1st year guard member, turns on her Google Glass to make the necessary changes.
3
4
• Jenny swipes through the guard moves in the show's routine list
• She then taps on the move she wants to change and swaps it with another
5
4 0
5 0
4 0
• Now Jenny can easily remember the changes as the whole band practices on the field.

Figure 2.1

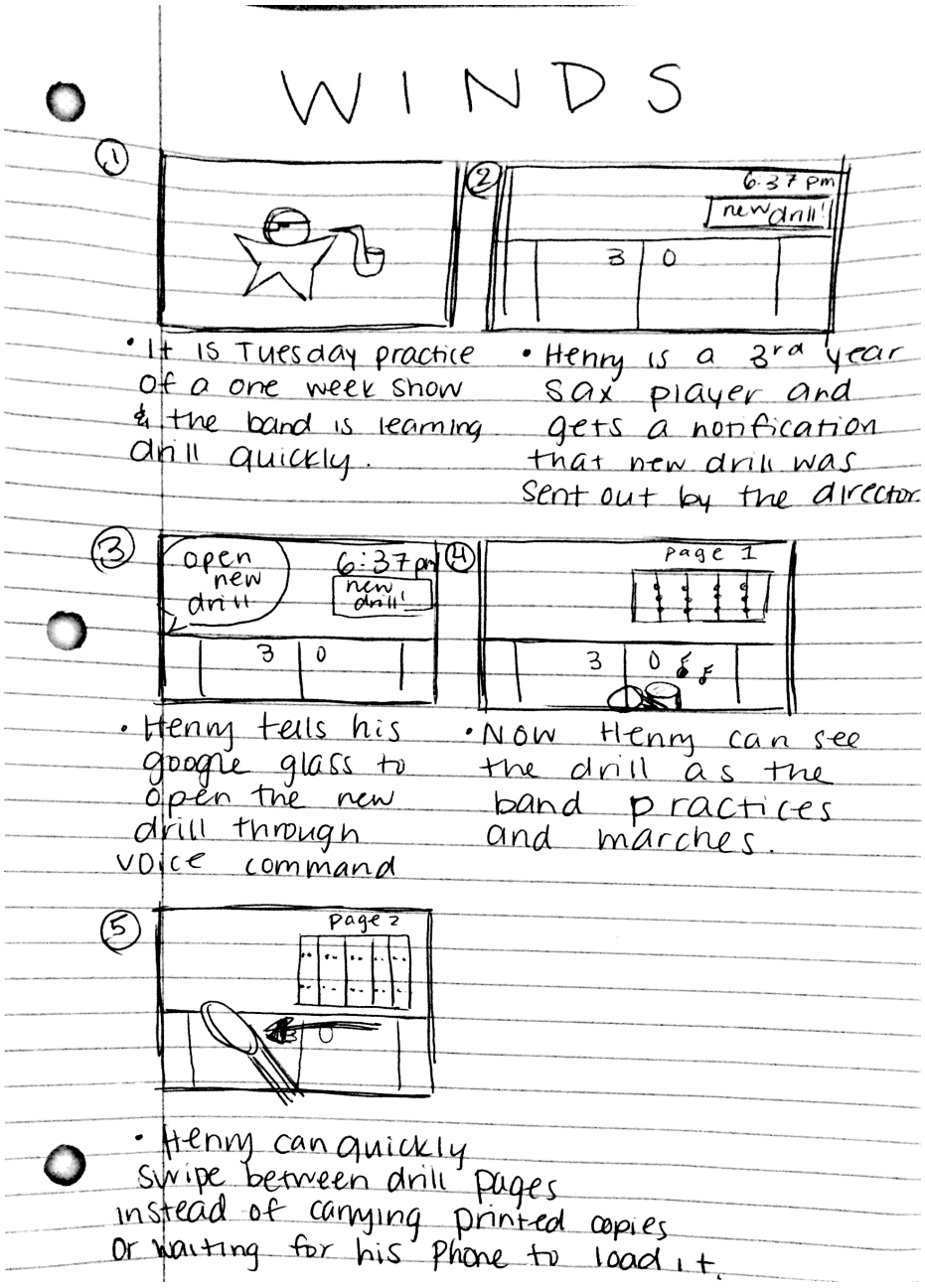
WINDS
1
2
6:37 pm
new drill!
3
0
• It is Tuesday practice of a one week show & the band is learning drill quickly.
• Henry is a 3rd year sax player and gets a notification that new drill was sent out by the director.
3
open new drill
6:37 pm
new drill!
3
0
4
page 1
3
0
• Henry tells his google glass to open the new drill through voice command
• Now Henry can see the drill as the band practices and marches.
5
page 2
0
• Henry can quickly swipe between drill pages instead of carrying printed copies or waiting for his phone to load it.

Figure 2.2

Figure 2.3

Figure 2.4

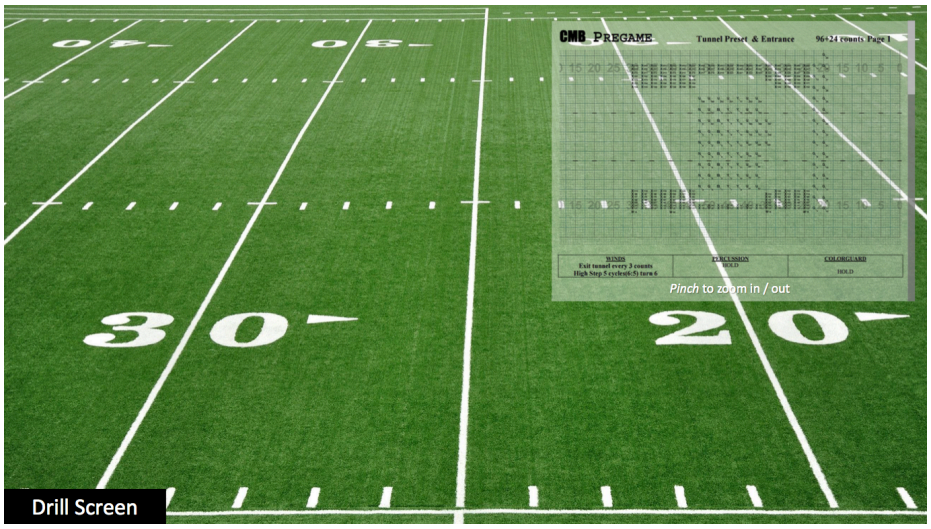

Figure 2.5

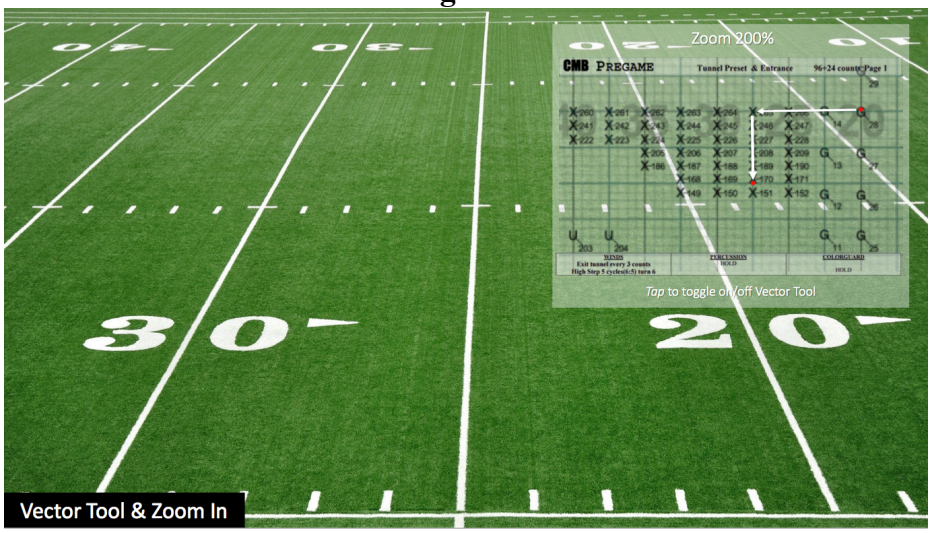

Figure 2.6

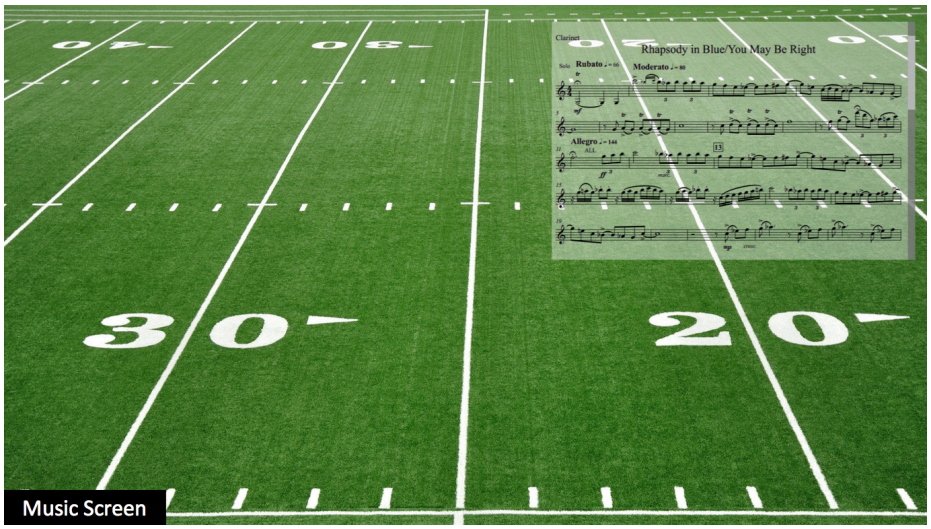

Figure 2.7

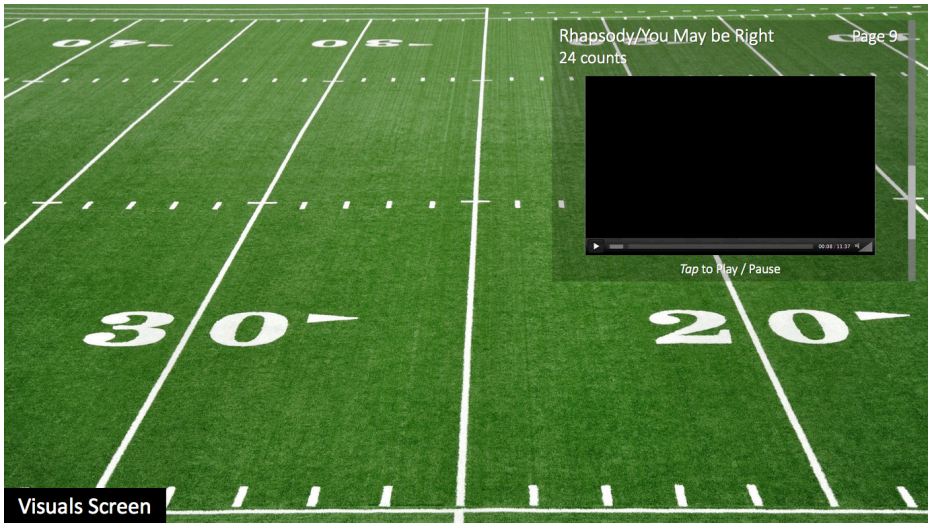

Figure 2.8

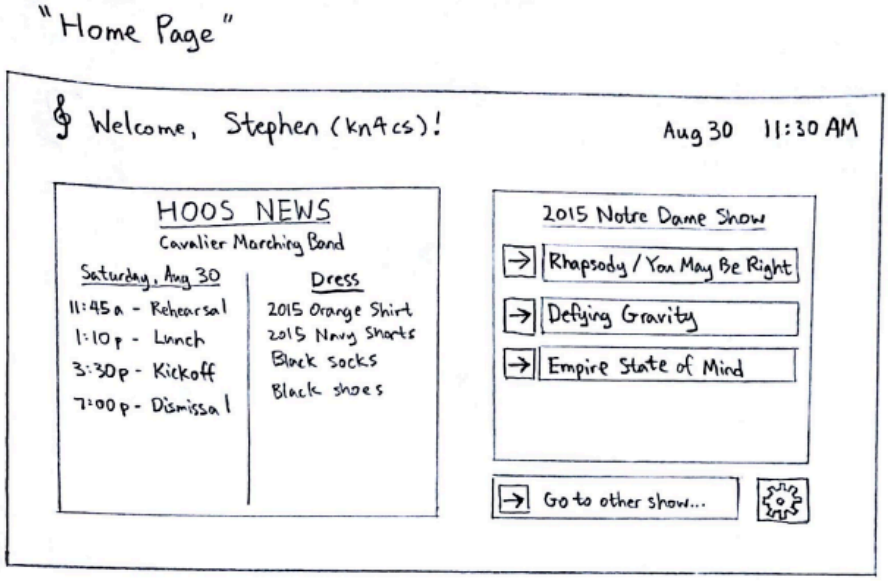

Figure 2.9

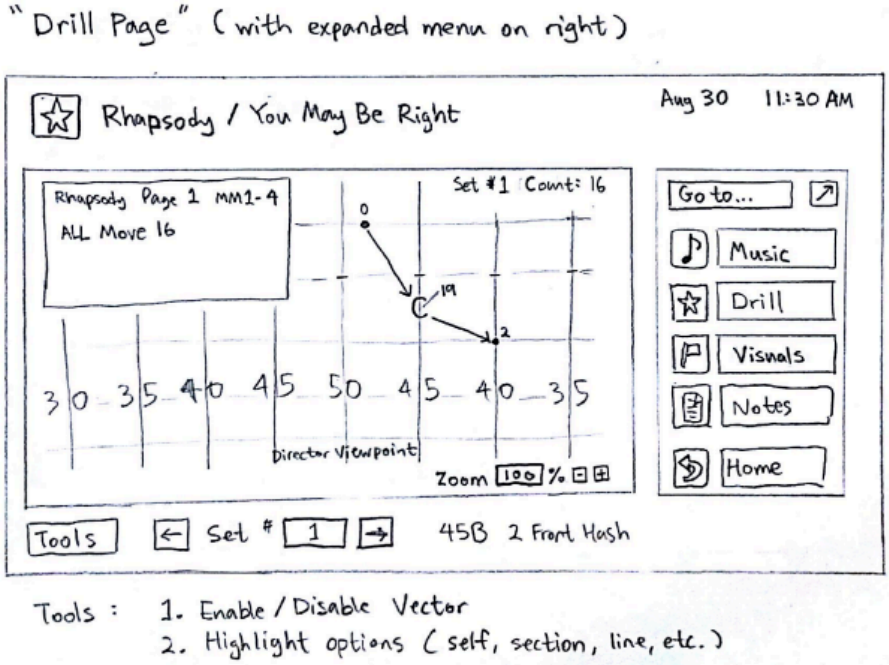

Figure 2.10

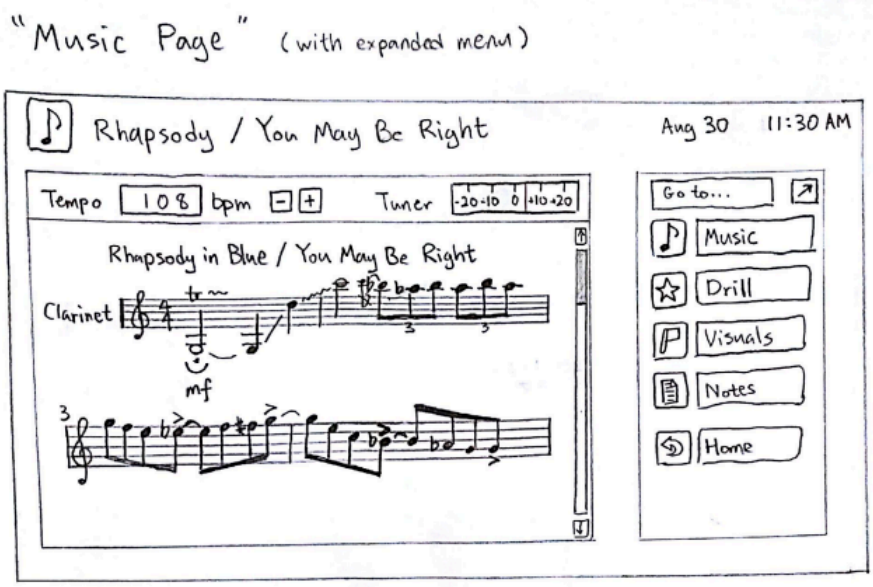

Figure 2.11

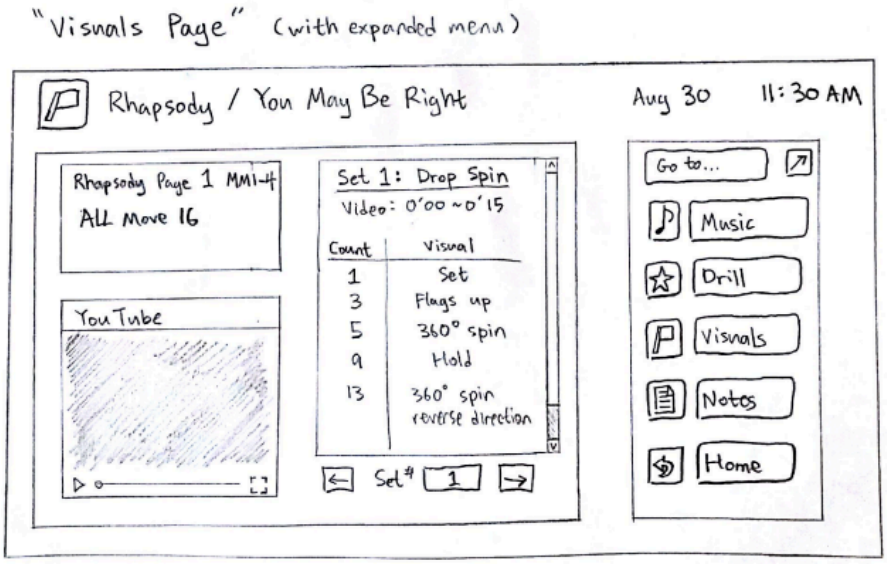

Figure 2.12