

NEEAR

NAVIGATING AN EDUCATIONAL EXPERIENCE BY AUGMENTING OUR REALITY

A UC Berkeley School of Information Master's 2012 Final Project by:

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Abstract:

Navigating an Educational Experience by Augmenting our Reality (NEEAR) is a mobile augmented reality (AR) tool for “learners” to access expert resources through vertical exploration in a natural environment. Our focus was to design and develop an experience that allows a person to discover information embedded within a specific physical site with individual access to an expert as they guide one’s view of the landscape. We have designed and developed a vertical ecological comparison tool using AR view with video on a tablet. We have edited video recordings of how experts make observations in the field to encourage learners to actively observe their environment. The new interface features we have designed allow for learners to use tablet technology to access expert views from a both a technically and user experience perspective. We used a scientific method framework to develop our project research. We looked to existing approaches and motivation to further our technical understanding of tablet hardware, augmented reality, educational theories, ecological site parameters, and the physical limitations of human perception and sight.

Process

We have chosen Strawberry Creek, a local site on the UC Berkeley campus to conduct research of ecological experts, develop mobile AR tool and evaluate user testing to access expert resources and views. Our project is composed of two parts:

- The first part involves observing and video recording an ecology expert, (Tim Pine) who demonstrated his methodology for outdoor teaching about aquatic habitation on the University of California, Berkeley Campus (UCB). We spent time analyzing how an expert navigates a site and compares/contrasts fully functioning “natural” site to a non-functioning “man-made” site. Key findings were that the expert looked around a lot and noticed things.
- The second part explores the use of mobile augmented reality as an educational tool to engage students with a natural environment. We drew from our “expert” footage, editing key ecological footage to create a lesson plan, which helped to develop a number of prototypes that capture how an expert views the world. Through iterative design thinking and methodologies, we developed a high fidelity prototype and tool. We used a between-subject design experiment type to evaluated and test our assumptions in developing a mobile AR teaching tool that combines expert learning in an ecological setting through comparing and contrasting.

Solution

Our final UI and technical solution is a 180° vertical learning application implemented on a tablet running on the open source Android platform. Our project builds on augmented reality approaches using a sensor based approach based approach to navigate the site and by implementing a variation of the sensor fusion paradigm (Crowley, 1993). We researched and developed new interactions with mobile devices that can allow situated learning experiences to explore ecological systems and sites. This study is the start for much more rigorous testing and development of using mobile AR technologies.

Research Problem

Experts see the world differently. Kruger and Dunning's work on the nature of expertise, for instance, revealed that novices possess poorer skills and competences in a domain than do experts (1999). How can we calibrate people that don't have expert knowledge to seeing the world differently? The social and technical aspects of using mobile technologies to learn has led us to our main research question, of having an expert view to learn in a physical environment. We can access countless amount of information at our fingertips. However, unless we can see what we don't know, we add to the image of a person blindly passing by. Located at UC Berkeley allowed us access to experts and expert observations. We used our advisor's contact, Tim Pine an environment specialists to initially observe. We used our findings of an expert to design a tool for him to asynchronously teach learners about aquatic habitats, addressing outdoor learning. We wanted to design and develop a tool where the User Interface (UI) and User Experience (UX) can invite knowledge transfer in situated learning or situated cognition theory where knowledge is not fully understood until it is applied in a social or physical context. We defined our research problem as:

“How can we use mobile augmented reality to invite learners to explore an outdoor location guided by expert views of an ecological environment?”

Our goal is to design, build, and evaluate our tool, which can help learners engage in learning in physical environments. We hope people will learn that there are different approaches to physical constructions. We hope to learn if designing and building a mobile AR application and a control interface of a hyperlinked website, that we can help further evaluate UI and UX AR technologies that can provide self-learning through sharing expert views.

Background

Existing Approaches / Inspirations and Motivations

There are a number of approaches and related work we researched from an educational theory perspective, technical, design. In this paper we will focus on the design process of combining theories of creativity and learning, augmented reality, in an ecological setting.

An expert's time and availability is limited and expensive; tablet devices have the potential to allow learners to access expert resources as needed. The theme of several Augmented Reality (AR) lectures and panel discussions is that there currently is the rise of the smartphone and tablets - with powerful 3D, 4G, and high-res cameras - combined with significant advances in computer-vision and new that are unleashing the power of AR (Terminator Vision, 2011). This means that our dynamically changing inputs and representations can be designed. This is the background information that motivated our designs.

Educational Theory Motivations

To make sense of these dynamically changing inputs, (computing, visual, environmental) situated cognitive theory helps to provide context and apprenticeship guidance. The 1991 book Situated Learning, defines learning as a situated activity through apprenticeship and community of practitioners to reach the sociocultural nature of learning, remembering, and understanding emphasizing the relational interdependency of agent, world, activity, and knowing (Lave, Wenger 11, 50). It is the cognitive theories of knowledge representation and educational practice of reorganizing mental functioning that propose that human minds develop in social situations. They define the work of Vygotsky's zone of proximal development as a "collectivist" or "societal" perspective where learning is embedded ... in everyday actions (Engestrom 1987 via Lave, Wenger, 49) Unlike the traditional classroom of linguistic and logical (mathematical) memorization, this does not allow for understanding of larger systems. Lave and Wenger describe that "abstract representations, is meaningless unless they can be made specific to the situation at hand (33)". When an expert engages with a site through observation, (s)he will notice patterns from history, natural systems, and other mental models. We want to capture and allow situated learning as experts "see" their everyday world. "Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations (53)." To understand the relationships an experts overlays upon his or her world motivates us to design an augmented reality information overlay tool for expert learning.

Technical Motivations

Designing for the Android platform for tablets (V4.0.3)

We had a lot of options available for developing our application in terms of computing power, embedded sensors and screen sizes. We decided on a tablet since a smart phone did not provide the screen real estate necessary for showcasing the features of our solution.

In addition, we needed a tablet, which would have a three-axis accelerometer and a gyroscope to provide the comfort of 6 degrees of freedom (DOF)¹. We decided to go with the Asus Transformer Prime running Android Ice Cream Sandwich V4.0.3 to develop our NEEAR application. Since Android is an open source application, we were free from the licensing restrictions that come with developing on a commercial application. In addition, since we were dealing with sensors we had to frequently refer to the Android source code, which would not have been possible on a proprietary platform.

Augmented Reality

An AR system is a variation of Virtual Environments (VE). An AR system is one, which supplements reality rather than replacing it completely unlike a virtual environment. (Azuma, 1997)

Soft Augmented Reality Approach:

A soft augmented reality approach is based on approximate location based on the latitude and the longitude of a location of interest. The more successful commercial AR applications like Layar™ (Layar, 2012) and Wikitude™ (Wikitude, 2012) use this approach to create augmented reality view. They use GPS to look at the coordinates of a particular location and then project these on the screen. This creates a means of augmenting the camera preview, which is seen from a smart phone by a text or image overlay having information regarding about the location.

Hard Augmented Reality Approach:

We were faced with a unique challenge because we wanted to implement augmented reality but we were doing it in the vertical direction. Another notable feature of our approach was that our sites were "natural" sites which did not have distinctive man made features. Hence, this was a challenge, as we could not use the standard vision or augmented reality techniques. However, when we look at our problem, it essentially boils down to detect the angles at which a person is holding the device. There is no need to create a vision based platform which is processing intensive and difficult to implement on tablets.

However, the GPS based approaches cannot be used since we needed to detect vertical angles.

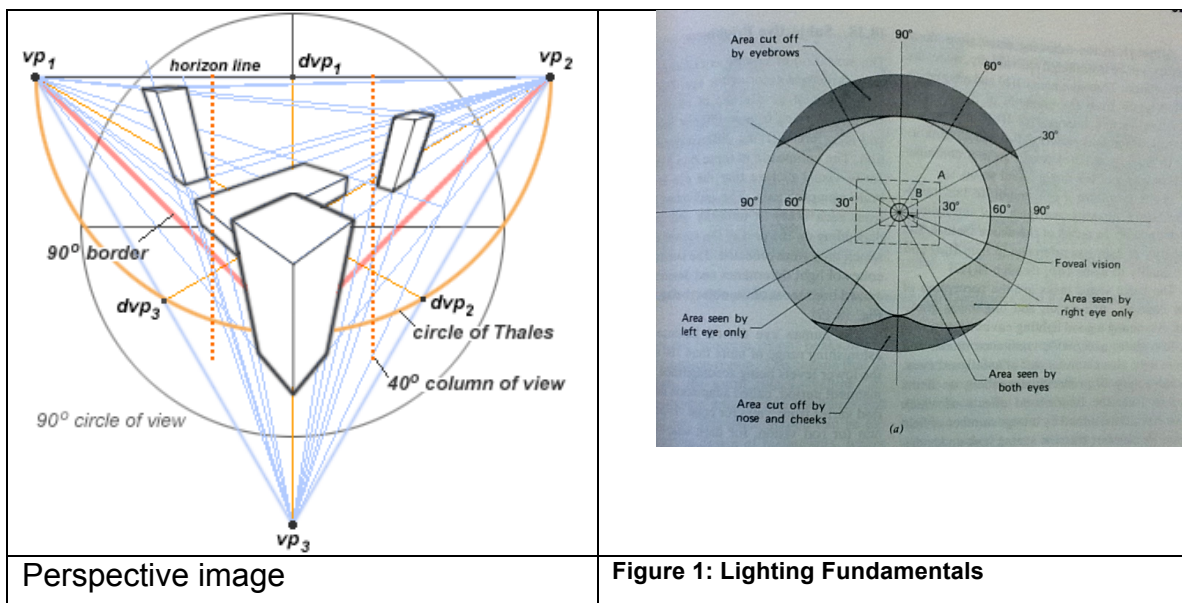
¹ http://www.starlino.com/imu_guide.html

² <http://developer.android.com/reference/android/hardware/SensorEvent.html#value>

Design Motivations

The way we see the world is a representation. When flattening the 3Dimensional world to 2Dimensions on a tablet screen, there are a number of representations that occur. Visual perspective, (from Latin *perspicere*, to see through) is the approximate representation on a flat surface like paper or a tablet screen. The detailed sketchbooks of Leonardo da Vinci in the 1450's presented a new way for artists to capture and manipulate the physical world on a two dimensional plane. A 2001 book by English painter and photographer David Hockney, he describes being able to look at pictures in new ways after his two year research project on projecting real images. This shows that from a design perspective, there are tools to describe the 3Dimensional world.

Many of the design development tools used within this final project was from a previous background in technical drawing. Technical drawing honed skills on manipulating 2Dimensional representations through concepts of foreshortening, where things appear smaller the farther their distance. Euclidian mathematical theories of vanishing points where divisions could be made as planes above and below the horizon line. In knowing how to draw with various scales, one can design a user's approach through site plans, elevations and sections. Also understanding how the human body moves through space and the foveal vision diagrams of site, one can also start to anticipate use.



Design Principles/Rational:

We started our project by observing and video recording how an expert ecology professor Tim Pine engages students at an ecological site. We felt engaged as he would jump into the creek and point at things drawing our attention to details he noticed. For example, he would point out at the natural site that the roots allow for fish to hide thus and the crevices of the rocks invite insects, which the fish eat. While at the man-made site, he would compare how the concrete embedded rocks don't allow for insects thus helping us to understand of ecological systems.

Tim also told us of the tradeoffs from a resource management perspective that the campus is funding money for care and maintenance of the fragile leaf covered ground plane to the concrete path. How can we share his knowledge without adding to the human intervention of upsetting the natural habitat? We developed our design principles from wanting to share our 1:1 engagement with Tim. Below is a discussion of the framework we started to establish to understand and teach others about the site.

Physical Site (Strawberry Creek):

In 1860 the College of California dedicated its new campus between the north and south branches of Strawberry Creek (Urban Design Studies for the Berkeley Campus. 1979). With the need to support the campus and student body, development decisions and urban planning expressions were made that at places did damage to Strawberry creek. Tim Pine, environmental specialist helped to explain the differences of two sites, one that supports the aquatic habitat and one that damages the natural systems. We spent time at the sites (shown in **Figure 2**, below) to research, observe, and document the site to understand the environmental system interactions to design an AR tablet lesson plan.



Figure 2: Strawberry Creek map, Man-made and Natural sites, highlighted in red dots.

Physical Site (Sectional Mapping\Documentation):

After we understood how an expert interacted within the ecological site. We next documented and systematically mapped the site so we can implement our technical and design solutions. We edited eleven (11) videos that map to both the man made and natural Strawberry creek sites. These videos show our expert pointing to things and explaining their relationship to the aquatic habitat. Below is an image that captures the six (6) sections of our site. The transcripts, which we used our video content ultimately was edited to be embedded as resources within our AR tool. The original transcripts are found in the appendix B. We divided up the sectional regions to be named as the following:

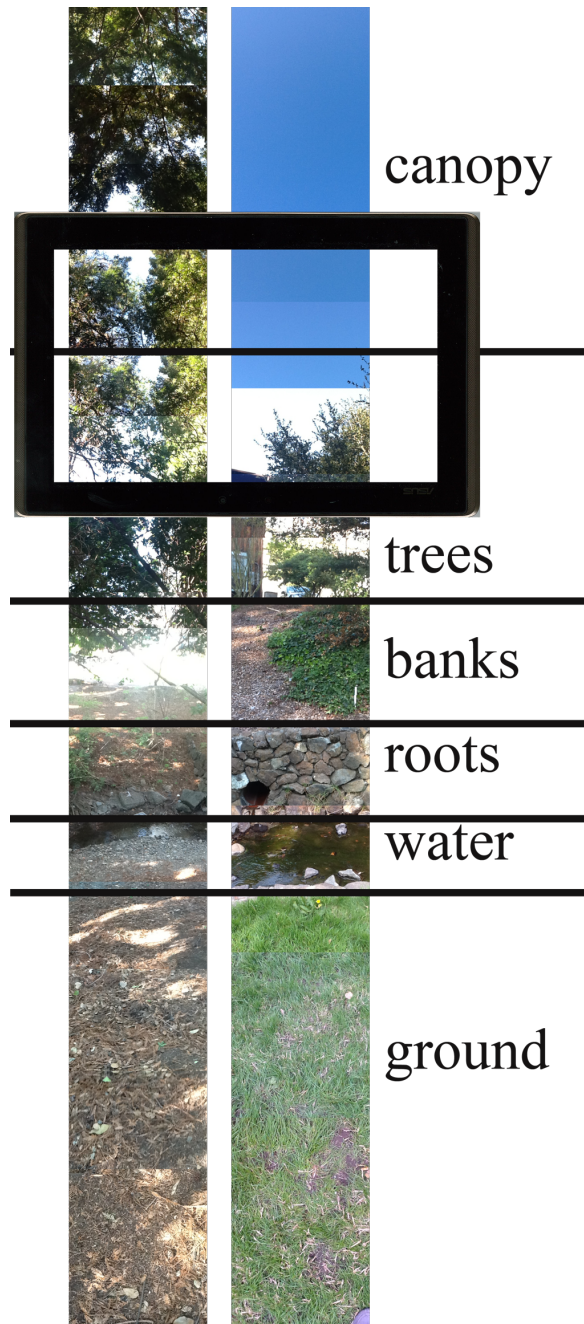


Figure 3: Sectional naming mechanism, with to scaled ASUS tablet overlaying regions.

Design

User Experience Constraints/Implementation

The user experience is tied to the technical implementation (see discussion below Technical Constraints and Implementation). Basically, as discussed we are working with many dynamically changing inputs, from body height to previous tablet use. We developed user experience models and logic to push our design principles, which informed our decisions, as we understood the technical challenges.

Vertical Dynamic Navigation (Seeing/Selecting/Accessing Resources):

When standing in a physical environment we face the constraint that as designers we don't know what the "learner" is looking at or seeing. The camera view is constantly changing. However, there are inputs that the tablet is collecting such as cardinal direction, viewing angle, speed, etc. By using these data points we can design and implement a user interface system. During the design process we limited the camera view to one latitude/longitude point and directed the learner to face a certain direction. This scoped our problem to one of understanding which gyroscope angle was being output from the tablet. As a user experience designer I could apply the background tools of perspective to understand what the user would be viewing. We now have established a framework to design for a sectional 180 degree vertical experience. By designing the approach to the project site, we could now design the interface to allow for personal exploration, learning through comparisons, and dynamic navigation.

Personal Exploration:

Our goal was to allow learners to have choice in accessing the videos. The learner could choose where to look and the correct resources would sync with the tablet view. See Appendix C for more description and images of how each view would change when the user would look at different regions. The labels of the regions would change as well as the images with links to various video-recordings. We have also designed interface features to allow learners to control the videos. In both all our testing, learners are allowed to see the videos multiple times, pause, fast-forward, rewind each topic.

Learning through Comparisons:

During the observation period we noticed that when we visited the man-made site, Tim had us imagine the natural site. We therefore wanted to design augmented reality interface to help allow learners to compare/contrast a man-made site vs. a natural site. One of the design features we added was an image of the site Tim referred to in the videos. We were able to match the vantage points and when the learner would point the tablet device to the sky, the tree canopy image would show in the live camera feed and the stark lack of tree canopy would show in the man-made site. We purposely designed a model where all the resources for the natural site were on the left side of the tablet screen and all the man-made resources were on the right side of the tablet. We designed a symmetrical layout so both the camera and vertical image could have 1/3 of the screen area (474x800 pixels). As further discussed below in the technical constraints and Implementation section, we have found it difficult to allow graphics to be placed directly on the camera image. To orient the learner and to have them navigate the site with the tablet, we embedded translucent images that align the sectional labels (see **Figure 3**). However, we cannot allow users to touch or select the camera view of the natural site or the image view of the man-made site. By placing the resources for the man-made on the right hand side, and the natural resources on the left hand side, we want to encourage the users to play with understanding the comparisons. We ran through a number of other designs iterations through paper prototypes that would also help communicate the comparisons (See Appendix F, Figure 19)

Technical Constraints and Implementation:

The problem space and the problem definitions

The essential problem that we tried to solve is to how to create an augmented reality view, which will overlay information on the camera view depending on what active region of the site the subject is looking at. The secondary problem was to create a means of correlating these changes in position with the "artificial street view" on the right hand side. This would enable the user to navigate both the natural and the man made regions of the creek simultaneously.

Approach 1

We did a lot of research on the various approaches, which could be followed to achieve a solution to this problem. Our initial plan was to use a computer vision algorithm, which will solve the issue of detecting the region by means of using computer vision techniques. There is currently an algorithm called PTAM - Parallel Tracking and Mapping for small AR workspaces". (Murray, Parallel Tracking and Mapping for Small {AR} Workspaces, 2007). We recreated the algorithm on our machines and ran it at the site using an external web cam to act as our video camera. However, we quickly discovered that our site being a

"natural" site, there are no significant landmarks, which can be used as distinctive features for the computer vision algorithm. We kept getting a large amount of false positives for the various active regions due to this reason.

Approach 2

We next experimented with a sensor-based approach, which was more suited to solve our detection problem under the given constraints. We found that there were a lot of implementations of augmented reality platforms, which use some form of sensor fusion. Specifically, most of them use these approaches to pinpoint the relative directions of various landmarks with respect to the position of where the user is standing. However, at the time of the implementation of our system, there were no platforms, which did the same thing in the vertical direction i.e. along the height of the subject. This depended on how the person is orienting the device with respect to the ground plane (or any reference plane for that matter).

For any active region to be detected, there are two major things which need to be known, the first is how is the device oriented when the person started the application for doing detection and how this orientation changes when the person is moving the device along the vertical direction. The next was to create a standard way of representing each region within our detection framework. If we defined these accurately, then it would have solved problem of estimating where the subject is looking at given the orientation of the person.

We borrowed the concepts from the self-navigating airplanes using Arduino to detect the angles (Starlino). The main principle behind this approach was the use of the gyroscope, accelerometer and compass to create a 6DOF IMU – (Inertial Motion Unit). We calculated the initial rotation matrix corresponding to our calibrating reference position. The rotation matrix is obtained using the accelerometer readings and the compass readings to calculate the orientation of the device in the earth coordinate system, which is absolute if we assume that the compass is not influenced by the external magnetic fields. Then, at any rotation, we used the gyroscope to calculate the change in this rotation matrix. For this, we needed to calculate the delta rotation matrix at each angle and then multiply this rotation matrix with the initial rotation matrix for each change in the angle, which was received from the gyroscope sensor. This was a computation costly approach. We needed to update and store this rotation matrix whenever it changed.

Approach 3

While testing the above prototype, we made the following observations, which simplified our solution a great deal

- 1) There is no need to track the absolute position of the device with respect to the earth.

- 2) The information required to calculate the pose of the device depends on its relative position with respect to a reference position.
- 3) The angular position change with respect to the calibrated reference orientation will be proportional to the changes in gravity on the device coordinates.

Final Solution

Our final solution used the following strategy

- 1) At any orientation of the tablet, the accelerometer detects the gravity with respect to its canonical x, y and z-axis, which are mentioned in the Android reference.² This is marked as the reference vector against which future changes to the orientation will be measured.
- 2) Consider that now the user moves the tablet up along the vertical direction, this means that the device has changed its orientation in the positive direction with respect to the reference vector (since the direction of the gravity does not change). Conversely, we can say that if we assume that the orientation of the phone did not change, and then the gravity vector has rotated to a new orientation. Hence, we can measure this change by taking the inner product of the reference vector and the initial vector.

Challenges faced with the accelerometer approach and potential solution

We found that if we use only the accelerometer for measurement, then there is a lot of noise, which will creep in due to the small vibrations, which occur due to the user not holding it perfectly still. In order to compensate for this noise, we used the gyroscope measurements. The gyroscope only measures the angular momentum and it is free from the noise, which is introduced in the accelerometer reading due to the small linear accelerations, felt as a result of the small vibrations and shakes. Even this approach did not give good results since the gyroscope had a lot of drift. Hence, it became extremely difficult to calibrate the device. However, these two are interdependent and hence we knew that there would surely be a way, which will solve this issue. Finally, we found the "Balance Filter" (Colton, 2007), which suggested creating a low pass filter for the accelerometer to compensate for the noise and to create a high pass filter for the gyroscope reading and then to combine the two using an "angle complementary filter" or a "balance filter". We tested this solution on the site and it gave us significantly good results and we decided to go with the same.

²<http://developer.android.com/reference/android/hardware/SensorEvent.html#values>

Creating a framework for indexing regions of interest

For the second problem, our solution involved the following, We created a database of the minimum and maximum angles within which each region is detected and then compared the detected angle against this database. Hence, the problem of identification now is translated into a problem of comparison of the detected angle with the maximum and minima of this precompiled database of regions. We used an item-by-item comparison to implement this comparison since our database is not large. As soon as we found that the current angle lies within the angular bounds of a particular region, we marked this region as detected.

Automated Scrolling for the Manmade Site View

Once we had solved the primary issue of detecting the orientation, we had a lot of secondary problems, which were equally important to create a good user experience. One of the features of the application is that it shows a smooth vertical scrolling view of the man made location. However, each of the regions had distinct start and end angular positions and a way was needed to map these positions to a corresponding man made location view. After some brainstorming, we came up with a creative solution. We would first create a large bitmap of the entire man made region which will show the man made region as a vertical perspective projection which will be as close to the view of the man made site as would be seen by the user when looking through the augmented reality view at that site. However, the problem remained that we could not do simple mapping of angles with images regions since that would result in some regions being skipped or appearing at an offset with respect to the detected region in the augmented reality view. This would cause the man made view to jump from one region to the other. But we required a smooth transition between the different manmade regions.

Hence, we created a linear interpolation algorithm, which will take the input as the maximum, and the minimum angles of a region and the maximum and minimum positions of the corresponding region in the man made view. It then pre computes the slope and the constant for each region. Once this is done, the man made view can be made to have a really smooth transition by using the precomputed slope and the constant to linear interpolate the angular values of the natural site to the pixel location of the same region in the image of the man made site for each orientation of the device. Thus, only the relevant values of the bitmap will appear in the man made view for the app.

Evaluation / User Testing & Results:

Hypothesis:

We hypothesize that the NEEAR mobile AR application will help engage learners and gain an expert perspective while comparing two sites. We hypothesize that allowing learners to control the camera view to discover and navigate to embedded situated resources, they will engage with the physical environment more.

Methodology:

We evaluated our tool with a between-subject design methodology. We observed 6 School of Information participants. Initially we selected a control group and an experimental AR group. Both our control group and experimental group had the same resources (same sectional labels and same edited video footage). The only difference between the control group and AR group is the navigational AR interface (See Figure 4). We were consistent in each testing so as to not provide demonstrations of how to use our technology or ask leading questions. We introduced our participants to the site and verbally reviewed directions to 1) hold the tablet 2) point the person to face the creek 2a) showed the AR group how to calibrate their device and 3) for both Control and AR group gave the instructional goal to click through and listen to about ~6 minutes of an expert ecologist speaking about Strawberry Creek. Each student spent approximately 20 minutes exploring the natural strawberry creek site while the experimenter “shadowed” each participant through video-recording. After spending time with the application the students were interviewed with the following questions and answers found in Appendix D.

Results:

We tested for the ability for participants to intuitively access the expert video and for learning and engagement. Our hypothesis was both correct and incorrect. Most of the students could answer the questions for content comprehension, but this was most likely because our entire pool was a masters’ student. Both Control and AR group mentioned they liked being at the site to learn about the lifecycle system because they could look at what Tim was talking about. Both groups also like comparing and intuitively understood there was a comparison happening between the natural and man-made site. Some surprises occurred when 2 of the 3 participants in the website control group commented that it was hard to orient themselves while listening to the video. The control group looked up and down much more, holding the tablet as a book comfortably out in front of them with their elbows at their waist. Where as the students in the AR group watched most of the videos while simultaneously looking through the camera view. They seemed more focused and engaged with the site as their full attention was to the videos and looking at what Tim was pointing to; not needing

to re-orient themselves. We felt that we were successful in transferring an experts view to a learner through using the AR application

The UI design and technical algorithms were also working as all of the students could intuitively figure out how to access the videos. The information and calibration was able to match providing the same experience no matter a learner's height and so was adaptive to the individual. We need further or more precise questions/observations to conclude if AR is able to transfer knowledge more efficiently.

In conclusion, in tying back to situated learning theories we believe AR interfaces can provide learners with a sense of agency and power to help them engage as if an expert person was standing beside.

Future Directions

As discussed above, we observed students interacting with the AR features differently from the Control group. We also noticed edge cases from our pool of participants that can provide additional technical and design implementations. We have organized our next steps to include small tweaks that do not require a technical redesign. And steps that would require new/different algorithms that would allow for further user interactions and user experience development. Our discussions stem from our user testing evaluations.

Body Positioning is an assumption:

We assumed that a person would be standing erect when looking at the ground. One tester bent her knees to look at the ground. She also started walking around to get closer to the creek. We had only given verbal directions to stand in one place. Perhaps she was so engaged with the content that she naturally took steps to get closer. We had to stop the experiment because we were afraid she was going to fall down the 30 degree bank slope. This however, provides several technical and design opportunities. We can re-implement the zoom function and design an intuitive user interface to allow learners to gain a closer view with a touch of the screen. We also could create an algorithm to know where the user is located and provide haptic feedback if the user is in danger. We also would like to extend our user testing to a student who is physically disabled to see how our data collection would react to someone for example in a wheelchair. A request of a small diagram of a person's arms was requested to know how to stand and use the tablet.

Additional Information to spur curiosity:

Many of the participants in the AR group requested that additional information be provided. This seems to indicate that they were more engaged by the expert and wanted more information. They requested resources like additional tips – i.e.:

“fun facts” or historical image overlays. None of the control group asked for additional information possibly because all the resources were laid out and explicit and required no curiosity or navigation. Whereas, the AR group had to physically explore the site by bending their arms down to look at the ground to above their heads to see the sky. For those students that are kinesthetic learners, this body engagement might help to understand the information. Perhaps the body movement and engagement of a learner could be an additional feature “unlocking” different resources, tying into creativity and learning theories of play.

Provide more focus:

One design recommendation to help with focus – is to make the video feed larger to be able to see as well as block the man-made or natural image to focus the user on content and expert pointing. Although quality of video recording becomes a variable, we can start to make the size of the video feed more apparent. We can also make the user controls of skipping, rewinding, or fast-forwarding videos more apparent. To address issues of time management, we could also design an interface to allow learners to know how many videos they have seen or how many they have to go.

Hone / Add more features with current system:

- Re-implement zooming feature.
- Incorporate horizontal motion and panning.
- Provide animated body positioning directions to show users how to interface with tablet.
- Make the video fill a larger portion of the tablet screen.
- Provide indication of how much material is left to review or has been reviewed.

To engage students more with Augmented Reality information we need to technically develop different approaches. Currently it is difficult to calibrate the regions and providing real feedback to matching where the user is looking to allowing information resources be present. We would need to discover a new technical implementation to re-design our system to allow users to select information on the camera view itself, as it is constantly moving. When/If we can figure this technical challenge out, we can do the following:

Re-design Technical implementation:

- Allow more information to be embedded within the AR views. As users view the regions detect and allow more information to be discovered.

Re-design User Experience Implementation:

- Enlarge video feed to encourage focus on content.
- Provide more intuitive user interface to skip videos or keep track of which videos have been watched.

Add more features with more extensible system:

- Provide a content administration front-end so more experts can share their information about a specific physical site.
- Create an app, which will define the regions of interest dynamically by taking inputs from an instructor so that an instructor can design the lesson.

How Do you Measure?

If we were to conduct this test again we could count the number of times a learner looks up and down from the website, since we did not allow them to “see through” the tablet. Some additional thoughts on measuring and evaluating are that we could not find much precedent for quantitatively and qualitatively understanding engagement. Only from the interviews did we realize that most of the students that were in our control group spent most of their time orienting themselves. Whereas the AR group watched through the camera feed while watching the videos, might not be paying attention. Is there a way to measure those students using AR may spend less cognitive effort at understanding the context? We also should have also included more quantifiable a yes/no question for understanding our features. In retrospect, a few examples could be if the participant noticed the icons or text changing at the AR group navigated through various regions. Many comments from the AR group commented on liking the sense of control of choosing which videos to watch in whichever order. The control group had to keep force stopping and restarting the application so threw off our time measurement as a way of engagement.

Acknowledgements:

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We would also like to acknowledge a number of lectures, hackathons, and events that we were able to attend which helped us understand augmented reality / tablet UX, and physical/digital environment. We also could not have successfully completed without the help of our classmates and alumni and the

School of Information at UC Berkeley who helped be our sounding board to define our problems.

We would like to thank C Sharada Prasad, Deepak's roommate who generously lent his Android tablet for our initial prototypes.

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Glossary:

Users

- “Learners” – is our users / audience for which we are designing our tool. We applied Creativity and Education concepts as design principles, which often write about children. However we applied accessing information to a person wanting to gain information.

Site – Project Location

- "Natural site" refers to our Strawberry Creek site which does not have any prominent man made artifacts like (concrete channels or banks). buildings which are part of it.
- “Man-Made site” refers to human interventions that do not support aquatic habitat such.

Technology

- ASUS Android Transformer Prime tablet: will be used interchangeably with the words tablet, device and smartphones.
- Arduino:
- Accelerometer:
- Gyroscope:
- Camera view: refers to the "preview" that is shown by a smartphone before its capturing any photograph. Its the live preview of the world streamed through the smartphone camera
- “Region of Interest”: Refers to any of the regions which are to be detected by the device. In case of our proof of concept, we have 6 regions of interest for the site. These regions can be thought of regions which will be focused on by the region as a user scans the horizon from the top to the bottom.
 - At any point of time, the user will use the NEEAR app to look at a region. This region will be denoted as "the active region" henceforth. This means that the user is looking at any one of the above points of interest and this region is now an active region as compared to the 5 other regions which are not.
- Calibrating the application: means to hold the device parallel to the "ground plane" which is the global ground plane and then using this as the baseline orientation.

Appendix:

A. Observations: Site, Expert, Students, High School Teachers, Camera Views

From a global perspective, there are a number of invisible systems located on our campus. We are afforded world-class professors and experts in their field that we can interview and observe to understand how they see the sites we pass everyday. We observed and analyzed the information within the site, expert, how students and teachers interact with learning, and how a camera captures the site. Below is our documentation of all most relevant findings.

B. Strawberry Creek / Transcripts

We edited video footage of Tim Pine giving informational on-site lectures at Strawberry Creek. He would point to areas drawing student's attention to both man-made and natural site elements. In designing a lesson plan, we captured and edited original footage to best describe and teach about aquatic habitation.

	Video Transcript - natural - 10.27.2011 - TimPine.mov
:16	So that is one place to start is the channel. How the creek flows here. One concept in creek habitat is a system of ripples and then pools. What we see here is ripple. The pool down here where is where it's down here where it's slowing down. Scours the ...one very interesting
:50	the bank held together with the root structure from the trees that actually are growing out of the bank. The trees are growing here because their roots can get right underneath the channel. Even in drought cycles When the ... The trees do really well with the ebb and flow of rain. The roots are integral The trees are also very integral from
1:33	Refuge in the pool. The refuge in the pool. The spawning and breeding takes place where it's shallow and can lay their eggs.
	Then looking up from the bank to the shrubs. This is an interesting mix here. Those are volunteer trees. Seeded by bird eat these tiny plums. That in turn springs up a new plant. Before Europeans came here and started bring. Same size shrubs. They would have been native berry. Fickleberry, current species, Native blackberry. That would have been made up of embankment shrub.

	They often played an important role. They overshadow the channel and keep it nice and cool. The biggest factor ... How much channel
	Temperature of water is how much direct sunlight especially at noon hour. Most of the high quality habitat in Northern California is Cold water habitat. You need cold water to support Salmon. You only get that with an intact canopy.
3:26	<p>Keeping with the theme with looking up.</p> <p>Trees that arc over. Trees that start to arc over. Shade is incredibly important for keeping water nice and cool. But also, all of the leaves that fall out of the canopy become the main source of food for the foodchain. As the leaves start to decay and break down, small invertebrates and insects.</p> <p>On top of that the fish eat small insects. Wading birds will eat those fish.</p>
4:19	Back in the day, humans would eat the fish. What we see here is an intact riparian habitat. That includes everything from the channel to the banks all the way up to the canopies.
4:42	Within the channel there are reaches that are still high quality. I can show you sections of the campus where there is contrast. Where there is no canopy.
5:07	When I take classes on tours I try to do the visual comparison, so the content is well etched into their brain.

	Video Transcript - manmade - 10.27.2011 – TimPine.MOV
:18 - :45	The main things to notice here... with Taylor's kind of 360 look at the creek, first of all we have an artificial creek bank and bed here, this is actually concrete channel rather than natural stones and different sizes of gravel and sand. This is literally they took several trucks of concrete and poured it right here at the bottom. They tried (you can see they tried) to randomly place boulders and stones to suggest a natural bed. but it doesn't function at all the way a natural creek would.
:46 - 1:15	There is no spaces to allow creatures hide underneath. You can't get under a rock to hide because there is no under to get here, it's actually set in the concrete. There is a complete absence or virtual absence of the small insects that are required to actually to start a food chain. No insects means no fish, means no wading birds, which means broken aquatic habitat.
	Then you also notice, the banks themselves are manmade. This is stone set into concrete. Same thing here. The

	problem with this is remember how I showed you the root structure in the other video, how many spaces there were? The creek cannot create an undercut so there are no place for fish to hide here either. You really have an exposed creek channel, and the water cannot even penetrate underneath the channel because it's not porous.
1:52	What we have now is that trees that are grown here cannot rely on the channel. They are going to have to rely on water above.
2:03	If you look at the banks, we have tried to restore somewhat. It's a large buckeye. Behind that is the big leaf maple. Behind that, the tallest one is an elder. All of these trees here are 10 years or less in age, it's going to take a long time for them to mature and before their canopies start to overarch the channel to shade it. This channel also picks up a lot of heat. As the water runs down this hardscaped channel, a lot of heat energy is absorbed by the water flowing through here. This is not good for our aquatic food chain it prefers colder water.
2:44	So, that is not the least of it.
2:46	Now look at what's planted on this bank over here. This is a lawn. As much as people like to lie on them and have picnics on them. They are really tough to be adjacent to a creek channel.
	(Because) First thing, how does it stay green like this especially in the arid west? It's irrigated right? When we irrigate lawns we are bound to have runoff. The layperson may say...
3:18	What is wrong with supplemental water that runs into a creek?
	First thing, water that comes out of our sprinklers is chlorinated water. It's the same water we drink. There is chlorine added to make it safe to drink. Well, that might be okay on the grass, but it's literally a poison on the habitat. It will sterilize a certain segment of the habitat. Number one -- chlorinated water is terrible.
3:47	Number two, to make it lush and green at least once a year, fertilizers are applied. This promotes the rapid growth of algae. Typically it would not be present in the quantities and mass. Occasionally they may put herbicides here. What they call pre-emergent herbicides. We want to make sure it's just grass and not other weeds popping up here. A portion of that can washes off.
4:24 - 4:48	Last but not least, this place encourages people to come and concentrate and anyone that leaves trash it's easy for food wrappers to roll down the hill. So there's lots of things that

	can be done to make this creek more functional, like the section we say over here. This is not healthy creek habitat.
--	---

C. NEEAR Screen Shots

Augmented Reality Application (NEEAR)

Below is a series of screen shots from a few of the regions at Strawberry creek. (In total there are 6 regions, and 12 expert areas) The left view is from a live camera feed. The right man-made view is activated through navigation.

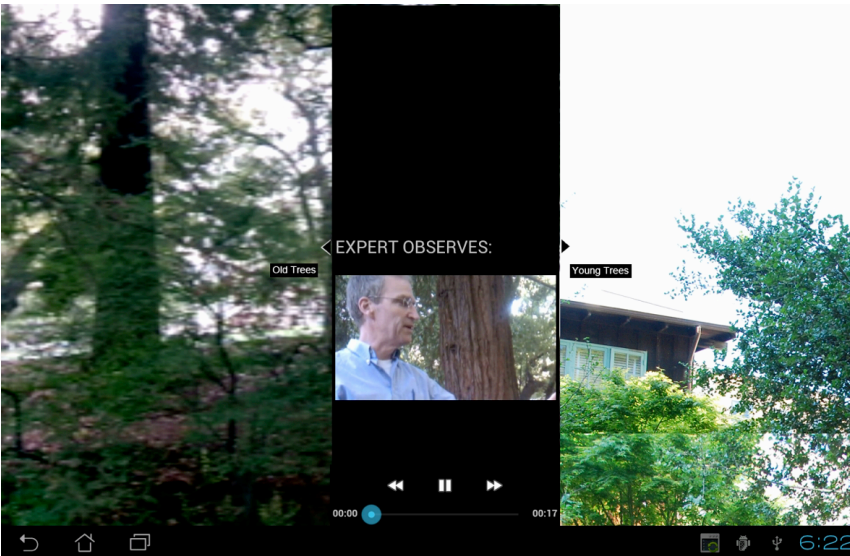


Figure 4: Video is activated and controls are shown



Figure 5: Learner has selected Old Trees video resource to watch



Figure 6: As learner navigates up, the labels stick to the physical environment



Figure 7: Learner has detected Roots region

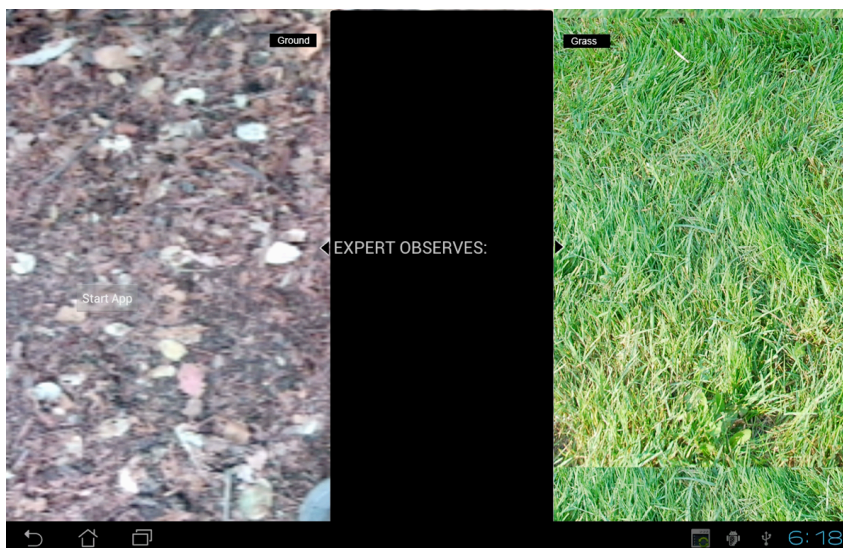


Figure 8: Calibration Start Screen



Figure 9: Learner calibrates parallel to ground plane.

Control Static Website

This is our control static website that has all the same video recordings that are accessed through touching the hyperlinks on our tablet.

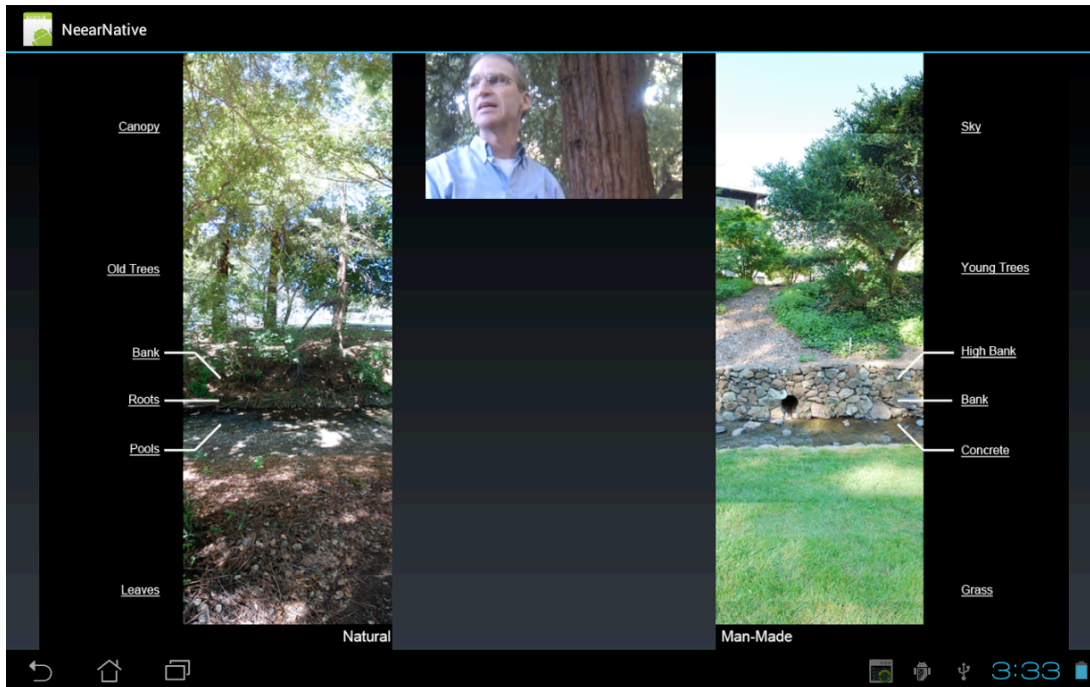


Figure 10: Control Group Static Website

D. User Testing

Testing questions:

Gender:

☐

Female

☐

Male

☐

Choose not to answer

Name: First, Last, or write: Anonymous

Background Focus: UX, Engineering, Design, etc.

Height: Feet, Inches

Question 3: What learning environment do you prefer? traditional

☐

inside classroom

☐

1:1 tutoring

☐

interactive labs

☐

on my own

☐

Other:

Evaluation Question 1: Please list all items that you remember in the natural environment and their purpose. ex: trees -- purpose is for shade.

Evaluation Question 2: Please list all items that you remember in the man-made environment and how it does not help to support an aquatic habitat.ex: concrete -- does

not allow for pooling water.

Question 3: What role does a canopy play in an aquatic habitat?200 word limit.

Question 4: What were some of the issues associated with the grass lawn at the man-

made site?200 word limit.

Question 5: What things not mentioned in the video did you notice about the creek?

Question 6: What else would you want to know?200 word limit.

Question 7: What did you like about this technology?200 word limit.

Question 8: What do you not like? Or what would you change with the application?
Suggestions? 200 word limit.

Testing results:

In total we had 6 users for our user testing of which:

- 3 in the AR group
- 3 in the control group

==Rose:AR, April 27, 2012, 10:30am==

* Gender: female

* Name: rose g

* Background focus: engineering

* Height: 5'-5"

* learning environment: interactive labs

* Question 1: canopy for shade; stream for aquatic life

* Question 2:

* Question 3: shade

* question 4:

*Question 5: non-aquatic life. Ex. Diagnostics

* Question 6:She likes learning from an expert, but she wishes she could ask questions.

* Question 7: interactive native ability to explore public spaces personally. Liked that she could stop and change. If she wasn't interested in the sky she could look away. She like learning privately in a public space.

* Question 8: compare and contrast of man made vs. nature was hard to keep track of; split screens takes a while to get use to. She photo was too real and she was looking for the grass. She also wishes to know how many videos she has seen.(1 of 11).

User Testing Comments (Leslie Tom): We had to stop the experiment short because the student started walking to the creek while looking through the tablet viewer. With a 30 degree slop in the bank, we were afraid she may slip.

==Rami: AR==

- * gender: male
- * name: rami
- * background focus: business
- * height: 6'-2"
- * learning environment: interactive labs
- * question 1: roots/foliage / grass / ground
- * question 2: concrete / sky
- * question 3: don't know
- * question 4: don't know
- * question 5: I was distracted from the video. I was exploring the site and going up and down. The water level was not mentioned. How full it is in the winter? How deep it is?
- * question 6: I was expecting like this. It was a good idea. C
- * question 7:

==Natarajan: AR==

- * Gender: Male
- * Name: Anonymous
- * Background focus: Engineering
- * Height:
- * learning environment:
- * Question 1: canopy for shade; stream for aquatic life
- * Question 2: concrete doesn't allow insects to hide, grass add chlorine and fertilizer makes algae grow.
- * question 3: canopy helps keep the pool cool
- * question 4: too much runoff
- * question 5: I wanted to know about the guage. Some fun fact.
- * question 6: I get the idea of correlating the video to the place. Trying to geo tag the video ti the place. Each video tells a story about the fragment of the creek. It corresponded well the video being played. It helped me to relate where I was looking. Liked the videos were short
- * question 7: The transition for the concrete one seems contrived. Get better realistic images for the concrete one. The video changes too fast. The stories are interesting. Annotations.

==Karthik: Control==

- * Gender: male
- * Name: Karthik
- * Background focus: engineering
- * Height: 5'-11"
- * learning environment: interactive labs
- * Question 1: trees, aquatic life, fish, birds, insects, streams, roots, european trees
- * Question 2: pesticides, high bank, grass, concrete
- * Question 3: habitat of birds, sunlight, long roots will act like banks
- * Question 4: fertilizers goes into water stream which leads to growth of algae, no natural habitat.
- * question 5: There were the stream, fish , insects and holes in the roots and no holes in the man made site. There is a food chain happening. The roots feed fish which feed the birds. I noticed the trees and the banks
- * question 6:
- * question 7:
- * question 8: I will need to improve the experience. There should be a pause in the interface, a start stop button. There should be ways to keep the context.

==Monica: Control==

- * Gender: female
- * Name: MonicaR
- * Background focus: information technology
- * Height: 5'-9"
- * learning environment: traditional classroom
- * Question 1: canopy for shade; trees have root systems which has shelter for pooling, eggs are found in shallow spaces, shrubs hold the bank together, the leaves are food for the smallest critters, stream for aquatic life
- * Question 2: concrete doesn't allow insects to hide because there is no nook or crannies, grass add chlorine and fertilizer makes algae grow. Sky has no shelter. High bank is man-made.
- * question 3:
- * question 4: Grass sterilizes. Fertilizer is done twice a year and creates algae.
- * question 5:
- * question 6:
- * question 7: I thought it was fun to look at the natural scene like he was talking about. Sometimes I'm [distracted.to](#) see exactly where the camera was pointed.. I like that you could see the pools in the roots. It is nice you could match up the vista exactly. It's one of those things, I'm here, but where am I exactly and where is the picture frame? It being really close it good but it does create a few distractions.
- * question 8: Something that was distracting was that you couldn't see his head. I kept trying to scroll down.

==Kristine: Control==

- * gender: female
- * name: anonymous
- * background focus: design
- * height: 5'-9"
- * learning environment: interactive labs
- * question 1: leaves: nutrition / fish; roots grow deep; trees - shade + protection roots.
- * question 2: grass- chlorinated water; rocks; sky - lack of shade
- * question 3: protection
- * question 4: causes chlorinated water to flow into the bank.
- * question 5: I was distracted by the dob. Bushes of things. Branches that have fallen, helpful explanations
- * question 6: The explanations were helpful. Felt like having a tour guide.
- * question 7: I was not sure if the user just focus on the videos or should look at natural surroundings doing both at different times.

D: Android Tablet Specifications

Via: <http://www.welectronics.com/ULTRA-MOBILE-PCs/ASUS-EEE-PAD-TRANSFORMER-PRIME.HTML>

OVERVIEW:

ASUS Eee Pad Transformer Prime 32GB 10.1 Inch Android Tablet With a slim, lightweight design and a 10.1-inch WSVGA IPS capacitive display made from durable and scratch-resistant glass that is viewable at angles up to 178°, the versatile Eee Pad Transformer is the perfect tablet for anyone who wants to enjoy multimedia on the move, but still wishes to have easy access to the web, email, and other productivity applications. A custom user interface provides easy access to the many features of the Android 3.2 (Honeycomb) operating system, while the NVIDIA® Tegra™ 2 chipset provides full support for Adobe®

Flash® 10.2, 1 smooth HD video conferencing and playback, a lightning fast web experience, and incredible mobile gaming performance. The optional docking station turns the Eee Pad Transformer into PC mode with a QWERTY keyboard, while extending battery life up to 16 hours.² Front and rear cameras make for easy video chat and digital photography, which can be played back in video on HDTVs via a mini HDMI output port, making it a true mobile entertainment device.

SPECIFICATIONS:

General 2G Network N/A
Size Dimensions 8.3 mm thickness
Weight 586 g
Display Type Super IPS+ LCD, capacitive touchscreen
Size 1280 x 800 pixels, 10.1 inches (~149 ppi pixel density)
Multitouch Yes
Protection Corning Gorilla Glass
- ASUS Waveshare UI
Sound Alert types N/A
Loudspeaker Yes, with stereo speakers
3.5mm jack Yes
- SRS Sound enhancement
Memory Card slot microSD, up to 32GB
Internal 32GB storage, 1 GB RAM
Data GPRS No
EDGE No
Speed No
WLAN Wi-Fi 802.11 b/g/n, Wi-Fi hotspot
Bluetooth Yes, with A2DP
USB Yes, v2.0
Camera Primary 8 MP, 3264x2448 pixels, autofocus, LED flash
Features Geo-tagging
Video Yes, 1080p
Secondary Yes, 1.2 MP
Features OS Android OS, v3.2 (Honeycomb), upgradable to v4.0
Chipset Nvidia Tegra 3
CPU Quad-core 1.3 GHz Cortex-A9
GPU ULP GeForce
Sensors Accelerometer, gyro, compass
Messaging Email, Push Email, IM
Browser HTML, Adobe Flash
Radio No
GPS Yes, with A-GPS support
Java Yes, via Java MIDP emulator
Colors Amethyst Gray, Champagne Gold
- micro HDMI port
- MP3/WAV/WMA/AAC player
- MP4/H.264/H.263 player
- Polaris Office editor (Word, Excel, PowerPoint; PDF viewer)
- Organizer
- Predictive text input
Battery Standard battery
Stand-by
Talk time Up to 12 h

E. Process Documentation

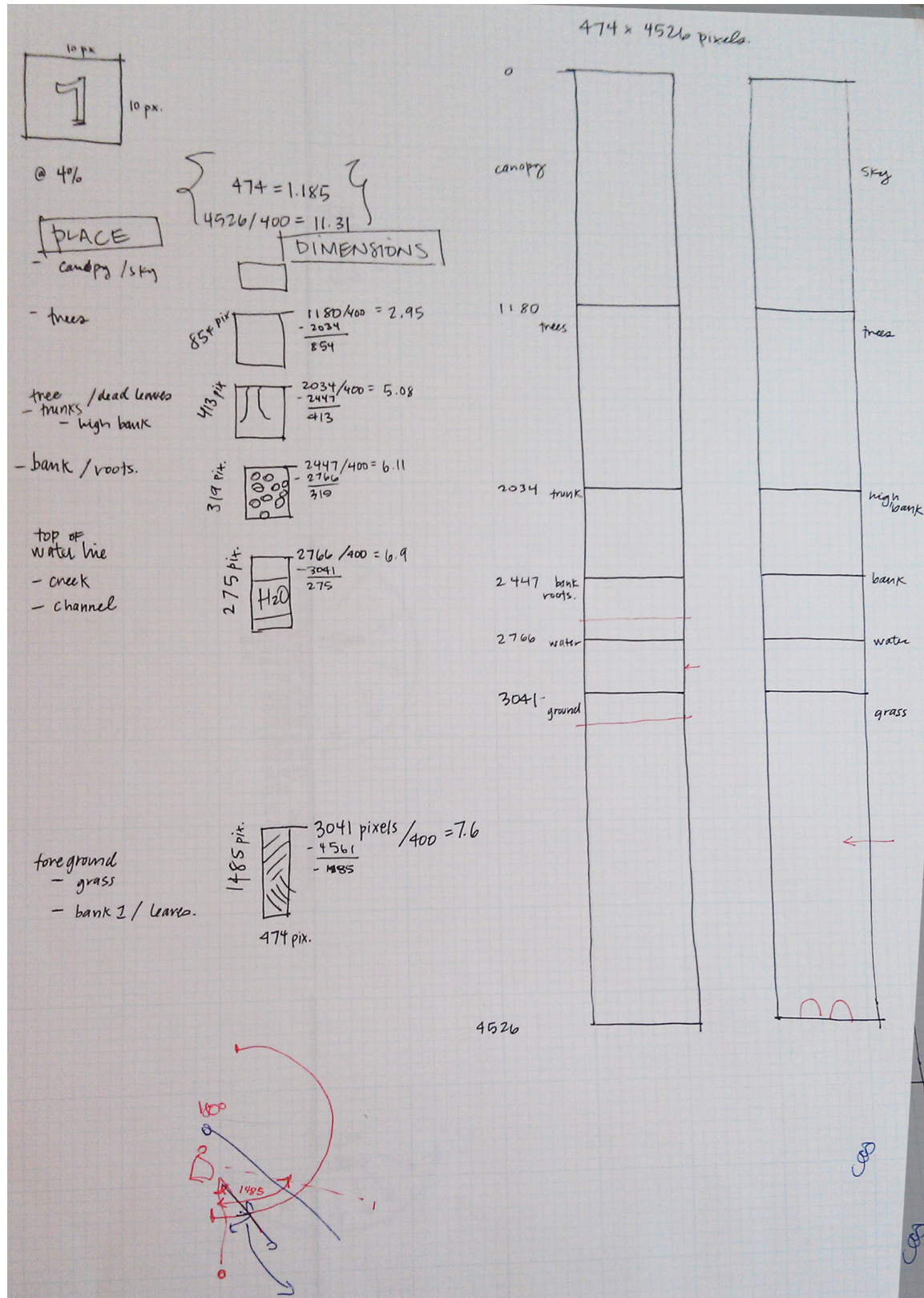


Figure 11: Calculations for pixel sizes.

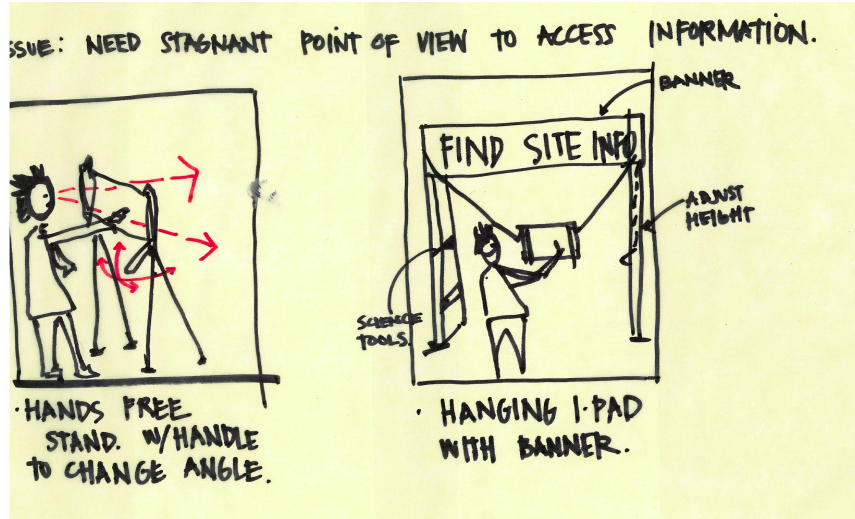


Figure 15: How a person's body interacts with tablet and site.



Figure 16: Paper prototypes

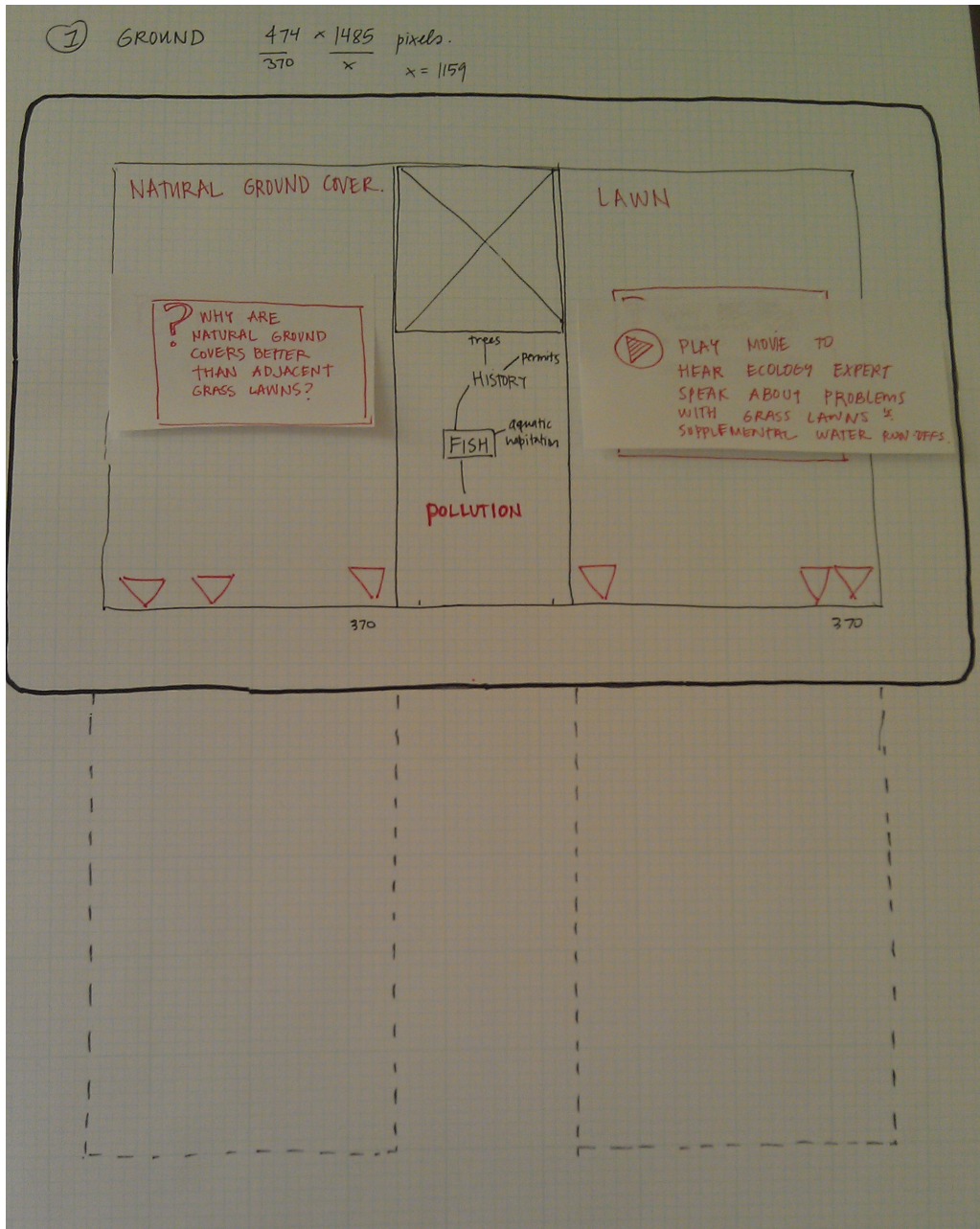


Figure 17: 1:12 region sketches, with tablet interface.

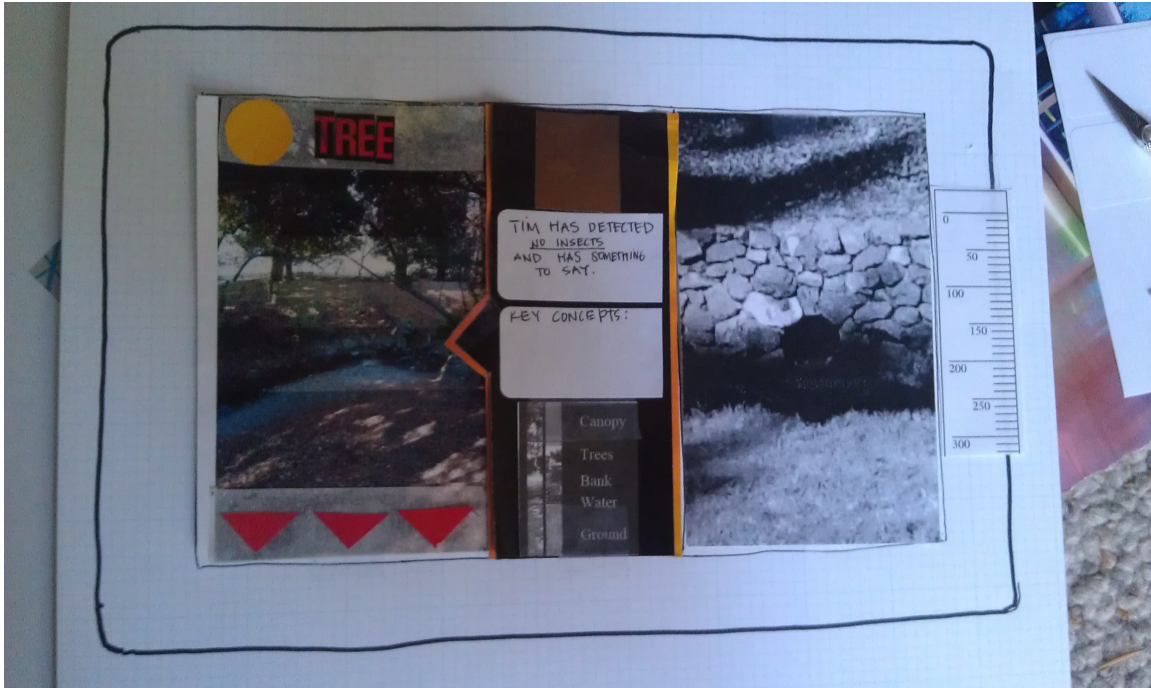


Figure 18: UI UX Montage

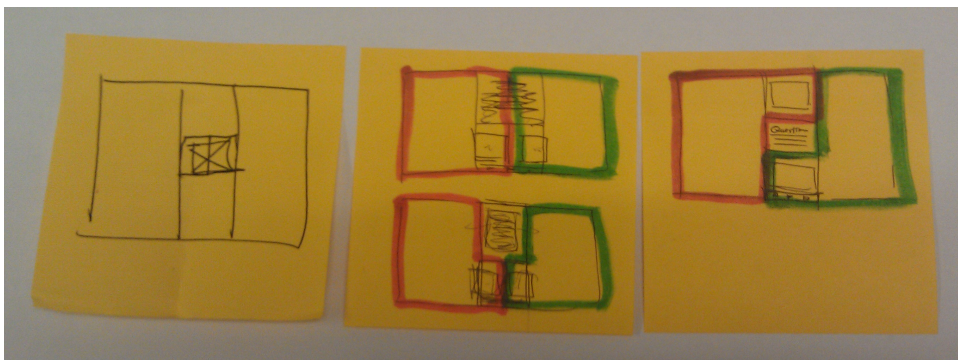


Figure 19: Learning through Comparisons, paper prototypes