Weather Aware: Ambient Weather Display

Perron Jones
Georgia Institute of Technology
pjones35@gatech.edu

Sanat Rath
Georgia Institute of Technology
sanat@gatech.edu

John Pate Hamilton
Georgia Institute of Technology
jphamilton@gatech.edu

Lamine Sissoko
Georgia Institute of Technology
lsissoko3@gatech.edu

ABSTRACT

We design a home weather awareness system to incorporate into your morning routine. It provides a smoother decision making process for what to wear or other situation that depend on the current day's temperature and weather conditions. Although, automation is a key component to this system, automation is not the goal. The goal is to create a resource that can be embedded into one's routine and serve as a resource to the user. Therefore, we went beyond creating the product and performed a study to get critical feedback from test users. This feedback allows us to evaluate many factors, which will be discussed throughout the paper. If there is consistent positive feedback, then it shows that the home weather awareness system stands as an example of technology that can be embedded into a routine, but not take away the unremarkable nature of a routine (the term unremarkable used in this context will be explained later in the paper).

Author Keywords
DigiKits; Kinect; weather; projection mapping; routine.

ACM Classification Keywords
H5.2 [Information Interfaces and Presentation]

General Terms
Design.

INTRODUCTION

"Weather Aware" is a home weather awareness system that is embedded into a user's routine of making decisions based on the real time weather condition and temperature and the current day's weather conditions and temperatures. The system allows the user to interact using simple hand gestures to obtain the desired information mentioned above. The information is displayed from an ambient light source onto a canvas of the user's preference. The weather information is automatically retrieved from Weather Underground. It seems that we are simply trying to create an automation product, but the purpose goes beyond automation. The automation serves as a means to reach our goal. The goal is to create a resource that can be embedded into one's routine and serve as a resource to the user. This goal is motivated by a study on unremarkable computing by Peter Tolmie, James Pycock, Tim Diggins, Allan MacLean and Alain Karsenty. This study focused on using technology as a resource for routines. It brought upon an interesting question of how to design computing to be truly unremarkable and used as a resource, such as a routine. This task must also be accomplished without removing the unremarkable nature of routines.

It may be unclear what it means to be unremarkable. The study by Tolmie et al. included a great example that can explain what "unremarkable" means in the current context. This example speaks of an alarm clock being "unremarkable". The alarm sounds off and the user does not comment or make a remark about the alarm. Here is an excerpt from the study explain the unremarkable nature of the alarm. "If she had commented upon it that would have made it a different phenomena in that through Lucie's total lack of reaction to the alarm she displays her orientation to it as something wholly unremarkable. By manifestly not marking this out she provides for the sense of the going off of the alarm upstairs at seven o'clock in the morning as being a matter of routine, for who would comment upon a feature of their routine as though it were somehow special? Furthermore, this is something she is able to do. That she can choose to not mark out the alarm and to treat it as something unremarkable makes it evident that there is then nothing inherent in the going off of the alarm that obliges her to treat it as a notable or remarkable event. The alarm is unremarkable." [5] This example gives a concrete explanation of "unremarkable".

Now, it is imperative to relate this to our weather system. First, the routine that we are entertaining is when a user checks the weather on an external device such as a smartphone, laptop, television, etc. Once the user gathers the desired information, a decision is made based on the information. For example, the user decides what to wear for the day depending on the weather conditions and temperature or the user may decide on the activities for the day, such swimming, having a picnic, staying inside, or other various situations. This process of gathering weather information serves a nodal purpose. Nodal is defined as "a thing upon which many other things may turn" in the study by Peter et al. [5] In this specific case, gathering the weather is the nodal event, which depends actions that will be taken based on that information. The focus of "Weather Aware" is to serve the same purpose, but incorporate the technology into the user's daily routine, replacing the need to take the extra time to check a smartphone using a weather app or website, boot up a laptop, or any other slight inconvenience. This must also be done without taking away the unremarkable nature of the specific routine of a

user making daily decisions based on the daily nodal action of checking the weather. Therefore, interaction with the technology is limited to simple hand gestures. Success of this technology will result in not only technology serving as resource that can be embedded into one's routine, but it allows a user's immediate environment to blend into the user's daily life.

Another important aspect of our system is the use of ambient light. The motivation behind our use ambient light by projection mapping is sourced from the study by Andrew Dahley, Craig Wisneski, and Hiroshi Ishii on ambient projection of digital information into architectural space. [2] This allows the user's physical environment to serve as the medium for interaction between humans and digital information. We targeted the functionality of "Weather Aware" to accomplish this method of interaction. "Weather aware" projects digital information onto a selected physical campus, such as a wall, refrigerator, ceiling, etc. to present the information while a user uses gestures to retrieve desired information.

Figure 1. Simple Interface of WeatherAware

We perform a study to obtain feedback of the WeatherAware system from test users. The feedback will allow us to evaluate the following measures of the system:

- Effectiveness of the system
- Ability to incorporate into a user's daily routine
- Impact of the technology on the routine itself

PREVIOUS/RELATED WORK

Past ubiquitous computing research has shown that there is a growing interest in homogenizing the daily life space and information environments [2, 3, 4, 6, 7]. Ambient displays have been the preferred environment to focus on because they make use of "the entire physical environment as an interface to digital information" [7]. The work of Dey and De Guzman has also shown that "display artifacts should present information peripherally, not being conspicuous among the rest of the bedroom artifacts, both as inactive objects and as displays of awareness information; and, display artifacts should be small and already exist in the bedroom" [2]. In other words, ambient displays can be created by enhancing frequently- and easy-to-use objects (e.g. mirrors) that already exist in our daily space.

The i-mirror [6] is a combination camera, projector, and mirror interface with three enhanced applications. The first reflects brightly so viewers in the dark can still see their figures in the mirror. The second uses real-time image processing to make the user look either younger or older. The third records scenes in the room and lets you replay past scenes in the mirror. Three distinct interaction experiences are demanded from a single computing system for i-mirror to work properly.

The AwareMirror [4] is a context-aware mirror that displays information (e.g. scheduling, transportation, weather) relevant to the user after identifying his contextual information [2] through a proximity sensor set to track toothbrush usage. While this mirror has to extrapolate multiple types of meaningful information from the movement of a toothbrush, our system simply has to track hand gestures with a Kinect to know whether or not it should display the user's local weather information.

With WeatherAware, we are attempting to create an information environment via ambient display that focuses on providing a single service -- weather and temperature conditions -- to incorporate into your morning routine whereas the related works above are made more complicated in their development and functionality because they try to provide multiple services that may not necessarily serve as go-to resources.

OUR WORK

Study Overview

In the next section we present the rich user-centered design process that we followed for eliciting information about how best we can showcase information in the form of ambient displays being as subtle as possible. Previous work has shown that without a thorough, well thought out design process, it is difficult to achieve measurable behavioral differences from a field study of an ambient display. [2] Most of the work in this area has focused on exploring novel concepts for ambient environments (ambientROOM) and objects(the Water Lamp and Pin wheel) [1] . Instead, in our experiment, we chose a constant set of information and system of display. Further, we conducted a set of in-depth interviews to decide the 'visual type' that supports the information and the setting that best suits such kind of ambient system. From this, we created a set of three different display ideas and conducted an *in-situ* usability study to collect reactions to and critiques of these displays. We also tried to understand if settings affected the use of ambient displays. We follow this with a discussion of our field study where we found that such displays supported intuitive gestural interactions and were suitable for locations where privacy is less of a concern. We end with a

discussion of the related research that has motivated our work and our planned future work and conclusions.

Target users and Study Design

We chose to work with Georgia Tech students as our target population for three reasons. First, they are early adopters of new technology and would find it easy to integrate to understand the technology behind gestural interfaces. Second, many of them were used to modern weather prediction system and used them quite frequently in everyday life. Third, we had easy access to the mailing lists to send out notifications to learn about their interest and availability. We sent out emails to a selected population explaining the study and the process. We received nine replies, eight of which (five males and three females) finally agreed to the consent process. All our subjects were between the ages of 19 and 25, and were from a range of departments other than the authors. None of the subjects had any involvement with our research, other than the participation described in the paper. Subjects did not receive any payment for the process.

For the first part of the study, the subjects were interviewed for 10 minutes each. They were asked about the current systems they used for weather prediction and about their coherence with ambient systems. The same set of subjects were asked to return after a period of four weeks to evaluate the concepts in three different sessions of 15 minutes each, followed by a simple three question survey after each session. At the end of the final session they were interviewed again to compare between the visual systems and the settings.

Interviews

We conducted in-depth interviews of the participants in our lab at different time slots assigned. Subjects were introduced to the term 'ambience' and 'home automation' to ensure that they shared a common understanding of these words and were comfortable with them. We collected information about their use of mobile devices and technology in everyday life. We asked them if weather prediction in anyway alters their everyday schedule. They were asked questions of what weather prediction they used every day and what were the common issues they faced with such system. Further, we asked them to show us their favorite systems and talk about it. We went on to show the participants two very distinct weather apps: Solar, by Hollr, Inc (http://thisissolar.com/) and Magical Weather, by Sophiestication Software (http://sophiestication.com/magicalweather/). These iPhone apps were projected on a large screen and participants were asked point out what they liked and disliked about this.

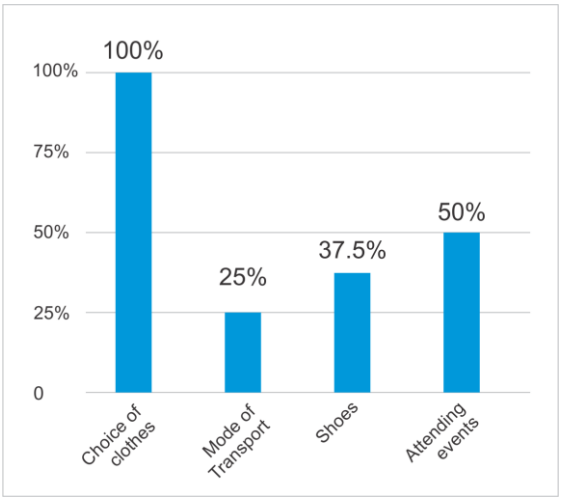

Figure 2. Decisions Based on the Weather Prediction

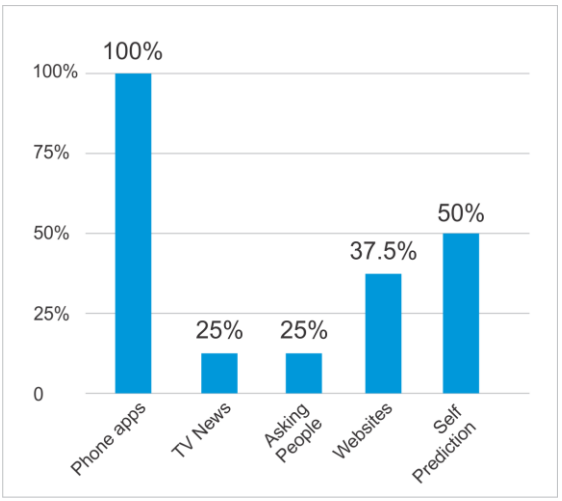

Figure 3. Common Ways of Weather Forecast

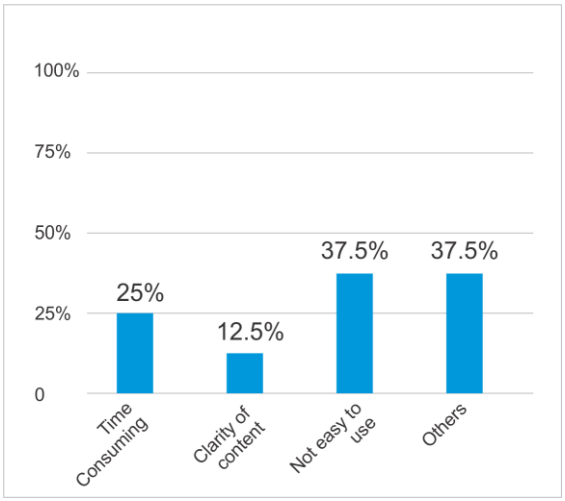

Figure 4. Issues With Current Weather Prediction System

A number of important findings arose from the data we gathered. First, all of our subjects admitted to the fact that

weather prediction played a very important role in their lives and they, at some point of time, faced trouble for not checking weather. Secondly, all of the subjects used smartphone apps for checking weather. The reason for this was mainly because it was easy to access and had a quicker interaction. However, three of the eight participants pointed out that smartphone apps need 'awareness' and they had to remember checking the app before leaving home. When asked to show us and talk about their favorite apps, most participants said that they liked the native phone weather app, because it shows directly on the screen without actually opening any app. On asking about the issues with the current system, five of the eight participants pointed out that the apps showed them information in a way that was not easy to grasp while they are on the go. They wanted to have 'short bits' of information with larger fonts on their phone. All of the participants said that they like the simplicity of the application that we displayed and said that they would love to use it in everyday life.

The results of the interviews suggested that the apt ambient weather display should provide minimal but useful information; should be easy to access and use; and would notify the user about the weather changes in a peripheral fashion without being too obtrusive or too obscure. As our subjects pointed out, it would better to add visual cues to enhance immediate cognition.

Ambient Weather Display Concepts

Using the results from the in-depth interview as a foundation for inspiration, we generated three Ambient Display concepts. All the concepts were similar in the following sense - every concept had a kinect (sensor), a projector and same data was displayed across all the concepts with identical gestures (Figure 5). However, the concepts varied among each other based on the type of the audio-visual feedback and the setting or the object on which the projection was made.

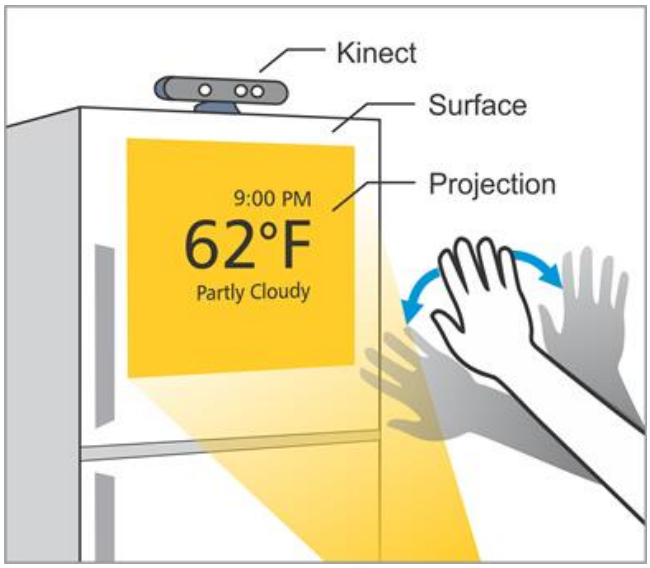

Figure 5. The Concept Setup

WeatherChrome: The projection starts when you wave at the object. It shows the current temperature along with the weather condition outside. As you swipe, it displays the temperature for the next 12 hours in one hour increments. The color of the background changes with the temperature of those hours- Red and blue representing warmer and cooler conditions respectively.

Figure 6. WeatherChrome

AniWeather: On activation the display shows the current temperature and the weather conditon. The background shows an animation of the current weather condition. On swiping left, the display shows the temperature and weather for the next 12 hours in three hour intervals. The animated background changes to the most prevalent weather condition in those 12 hours.

Figure 7. AniWeather

AniWeather with Sound: This concept follows the same interaction as AniWeather but with added feature of sound. The sound changes based on the time and weather condition showed in the display.

In order to present our conceptual designs of Ambient Weather Displays to potential users to gather comments and critiques, each concept was setup in a home like environment and a scenario illustrating how the display could be used was given to participants.

Software Architecture and Physical Setup

The software part of the setup was fairly simple. The kinect captured motion data and sent it to the computer via Processing wrapped with a OpenNI and NITE wrapper Then a Java socket is used to send this information received to the web browser. The gesture is then used to activate swipe left and right on webbrowser. Simultaneously, on the webpage, JSON data received via the wunderground api is shown as the slider moves. The animations were done with CSS3 and Javascript. However, to keep a control on the interactions, a remote controller was added. This was used to deliberately change weather on the browser to study if the subject can actually understand a condition displayed. It also helped to correct any errors the subject might encounter with gestures. This 'weather remote' used "node.js" and "socket.io" to connect to the local host.

We set the display up in three different settings: the ceiling, the wall (side wall), and on an object, such as a refrigerator. These three setting were chosen to study an apt location for such ambient displays. Care was taken such that the physical objects such as the sensor and the projector appear as unobtrusive as possible. For example, in the setting placed on an object, where the subject interacts with the display on the refrigerator, the kinect was camouflaged inside a box of cheerios.

Figure 9. Kinect hidden inside Cheerios box

Field Study: Evaluation of Concepts

Once we completed the implementation of the three ambient weather displays, we deployed them in the field 2 days. The purpose of the field study was to investigate the link between various ambient cues and cognition; and to show quantitatively that our ambient displays provide significantly better responses than traditional weather apps. We also wanted to understand which among the three systems related better to the user and in which setting. We also explored these effects through exit interviews with our users.

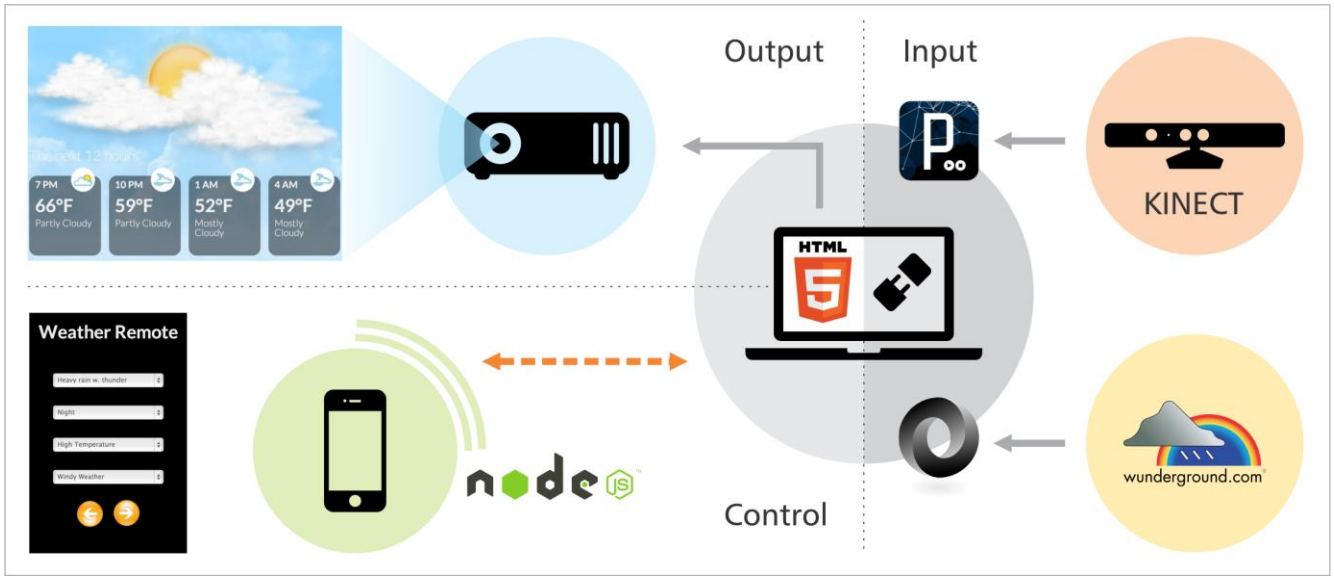

Figure 8. Architecture of Weather Aware

Method

The same eight participants we had interviewed before, were asked to come in and evaluate the product. Subjects were assigned different concepts and settings based on latin square method to reduce any kind of sequence effects. Before starting the evaluation, the subjects were given a short introduction to Kinect as well as description of the system to ensure a common starting ground. In each session of 15 minutes, the participants were asked to use the product in the three different settings for four minutes and think aloud as they were using the product. The one minute in between these semi-sessions were used to change the setting (ex. changing the setting from on an object to on the side wall) while one observer questioned the participant about their reactions to the particular setting. At the end of each session of 15 minutes, the participants were asked to fill out a short survey on the particular prototype. At the end of all three session, the participant was asked to compare the three systems in the concluding survey.

Findings

Most of the participants felt that all of the concepts were "Clean" and "Interactive" and served a good purpose without being obnoxious. Participants also pointed out the fact that seeing the actual weather instead of just looking at the numbers connected them more with the system. One particular subject after evaluating the AniWeather with sound weather in the setting on the ceiling said "It completely surrounded me in the atmosphere of the current weather conditions. It was like I took a step outside, but I didn't even move from my current position." Although all participants thought that the interactions in all three cases were easy, about 40% of the participant found AniWeather more intuitive than the Weather Chrome prototype.

On asking what they did not like about the prototypes, few participants raised the concern that they could not find the temperature or weather for the following day using the system. Two persons felt that their hands might get tired using this product for a long time. Other issues related to the physical viability of the prototype including poor recognition, bulkiness of the device and the contrast of the projection were also talked about. For a setting of on the side wall, where the display was placed on the wall over the refrigerator, a participant pointed out that it is too high for her to see. Although many participants could identify the sounds in the concept 'AniWeather with Sound', they felt that the sounds might get intimidating sometimes or there might not be enough sounds to convey the exact weather conditions outside. One participant also commented that such a system might get repetitive and boring after a few days.

On comparing the prototypes we found out that many participants preferred the animating display over the static color display. Interestingly, they found the AniWeather

	Ease of Use	Clarity of Content	Learnability	Utility	Overall Experience
WeatherChrome	3.75	3.38	3.88	3.50	3.49
AniWeather	4.13	4.00	4.25	4.13	4.15
AniWeather with sound	3.75	4.00	4.13	4.13	4.09

Table 1. Comparison Between Prototypes

easier to use than the WeatherChrome and the AniWeather with sound prototype. Both Aniweather prototypes with or without sound scored the same, and better than WeatherChrome with regards to clarity of content. Subjects also found the AniWeather prototype easier to learn than the other two systems. When asked about the usefulness of such systems, both the animating displays scored higher than the WeatherChrome prototype. It is really interesting to point out that, when asked about the overall experience, participants scored the AniWeather more than the AniWeather with sound prototype.

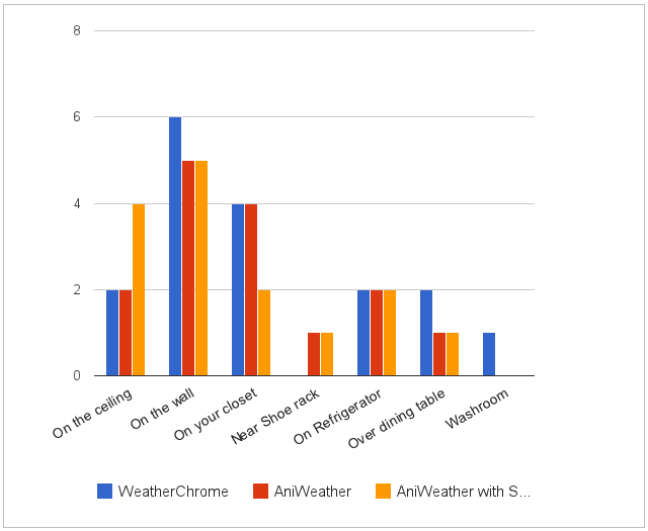

Figure 10. Places in Which Ambient Displays can be Effective

To know the ideal location of such a system according to the participants, we asked them to mark all the places in their house where they can imagine such a system will be effectively used. More than 65% of the participants thought that the wall would be the best place for projecting the system. The response also suggested that although AniWeather with sound fairs more effectively on the ceiling, it is actually less probable for the subjects to use in display weather on the closet. When ask about the reason for this choice, participants replied that such a system might get intimidating if it's get activated immediately after then open the closet.

As a general review of ambient display systems, exactly 75% of the participants felt that such that such weather displays can be useful for daily use. Seven out of eight

participants also felt that such installments if done gracefully could blend in with their everyday life. We also asked the participants what other information apart from Weather could they use such systems for. Two of the eight participants said that it would be really helpful if they could see some kind of notification for their everyday schedules displayed alongside. They also asked if we could integrate date and seasons with the concepts.

DISCUSSION

The experiment resulted in number of interesting findings. These findings help us understand how the system can be embedded into a user's routine and what combination of features will allow us to accomplish our intended goal of creating a resource that can be embedded into one's routine and serve as a resource to the user.

Important notes from study

One of the very strong point that comes out of the entire study is the fact that audio cues do not necessarily add up for an exciting and intuitive interface. The fact that, AniWeather scores higher than AniWeather with Sound is the testimonial to this fact. Subjects commented that sounds might get awkward and intimidating in a social context and might not solve the purpose in a group setting. For a system to be unobtrusive, animation and sound might cast separate tangential points- one adding the other subtracting: animations adding to the spatial virtue of the information whereas sound diminishing the value of the content by adding one more sensory perception not requested by the context. In case of a constant sound being played at every instance of the same weather, the user might easily get bored and in some case, frustrated. As one participant points out "I would not have this active as an ambient display if there is constant sound playing. If I start it on demand, then the visual is good enough to give me an instant answer."

The second important point that needs our attention is the setting in which such an ambient display can be used. As one participant remarked, "I am actually not sure if I would keep it in front front my bed. I am scared. If another form of tracking was offered as an option, then I will more safe to place it anywhere."Concerns of privacy was evident from this kind of model because it used a camera to detect the user and monitor the gesture. This is a situation that the system should take into account when being released to the public.

Evaluation of system

There are three measures taken into account when evaluating "Weather Aware". Those three measures, mentioned previously, are:

- Effectiveness of the system
- Ability to incorporate into a user's daily routine
- Impact of the technology on the routine itself

The study provided ample data that will address these measures. According to our study results, 75% of participants agreed to the weather display aspect of the system being useful in their everyday lives. Also, approximately 89% of participants confirmed that the overall system will blend gracefully into their daily life. The users' comments on the system being "clean" and "interactive" without being "obnoxious" proves there is little to no effect on the unremarkable nature of the user's routine of making decisions based off weather conditions and temperature. This also proves the system adds more efficiency to the user's routine. Interaction with the user's surrounding environment is faster and more effective than using an external device to gather weather information. Proof of it being more effective is backed by user comments from the study, such as "It completely surrounded me in the atmosphere of the current weather conditions. It was like I took a step outside, but I didn't even move from my current position." This connection with the environment definitely aids the user's decision making process. Therefore, the system serves as an effective resource in the user's routine.

The current system proves it can be incorporated gracefully into the user's routine based off of information mentioned previously. However, there are a few obstacles observed by some of the test users that can combat this graceful incorporation. Poor recognition of hand gesture was mentioned by one of the users. The Kinect was not 100% accurate when detecting gestures. This can serve as an interruption into the user's routine. The bulkiness of the system can be an obstacle in the way of incorporating the system. The user must go through the trouble of arranging space to allow for "Weather Aware" to be installed into their home. Such an issue can possibly lead to a negative impact on the unremarkable nature of the user's routine by causing the user to deviate from his or her standard procedure. Operational malfunction is another situation where the technology can have a negative impact on the routine itself. This would cause a major deviation from the user's regular pattern of action by leading to a troubleshooting process instead of a decision making process based off of the original desired information. Furthermore, these cons are conditional and do not serve as a permanent barrier to accomplishing our overall goal.

Overall, the system is very effective, able to be gracefully incorporated in a user's routine, and does not completely remove the unremarkable nature of the routine itself. Therefore, the system can be embedded into a user's routine to serve as an effective resource in the context where the user gathers weather information to make succeeding decisions.

FUTURE WORK

The future work consists of steps that will rid of two cons that were mentioned previously.

First, we will minimize the size of the system to remove the bulkiness and allow it be a better fit in the home. Next, we will attack the issue of poor gesture recognition by the Kinect. An alternative is to a simpler gesture that provides less room for error.

These steps will removes a few obstacles in the way of our current goal.

CONCLUSION

"Weather Aware" tested to be a substantial system to be able to serve as technology that can be embedded in a user's routine successfully. Throughout the process of testing users on the prototype, it was proven that projection mapping of ambient light serves as an effective way to deliver information to humans by utilizing their surrounding environment. Overall, this was a successful study and produced technology that accomplished the overall goal outline.

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