Activity Wallpaper: Ambient Visualization of Activity Information

Tobias Skog
Future Applications Lab, Viktoria Institute, Gothenburg, Sweden
www.viktoria.se/fal
tobias@viktoria.se

Abstract
We present *Activity Wallpaper*, an ambient visualization of activity information, based on an analysis of audio data. The design of the visualization is used as example in a discussion about the requirements of information presentation for public spaces.

ACM Classification: H.5.2 [Information Interfaces and Presentation]: User Interfaces

Keywords: Ambient information visualization

INTRODUCTION
When architects design a public space, one aspect they consider carefully is the choice of materials. For example, they may choose to use materials that wear with time, in order to give a space a “memory“ of how people have inhabited it [1]. This wear and tear, however, is very slow and may take decades in becoming noticeable. Computer technology enables us to provide a space with an electronically amplified memory, e.g. by using sensors that capture data about people’s activity and presenting an overview of this data in the space. Ideas along these lines have been explored within HCI research, e.g. in [4] where *The Sound Mirror* and other instances of *Soniture* are discussed; and in *Palimpsest* [8], an installation that allows people to interact with projected video clips of people that have spent time in that space at some earlier point in time.

Today, public spaces are increasingly invaded by computer technology, predominantly in the form of public information displays. Despite this, little effort is spent on finding ways of integrating these displays in the architectural settings in which they are placed. We have proposed the concept of *ambient information visualization* (ambient infovis, for short), visualizations designed to provide subtle information presentation in public places [10]. In this paper, we present the *Activity Wallpaper*, an ambient visualization of activity information based on an anlysis of audio data.

DIS2004, August 1–4, 2004, Cambridge, Massachusetts, USA.

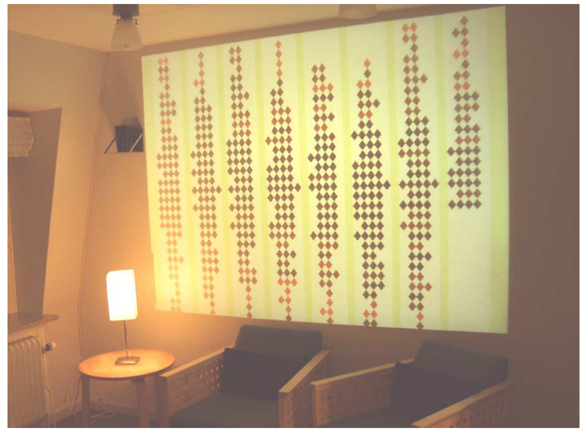

Figure 1: A Projection of the Activity Wallpaper.

VISUALIZATIONS OF ACTIVITY
Several examples of presentations of activity have come out of the HCI field; in one early example of ambient display design [13], awareness of human activity through the use of ambient displays is discussed. Numerous examples of screen-based activity visualizations also exist, some of which are described below.

Related Work
Visualizations of activity are fairly common, but the majority of them concern activity in terms of computer use. This includes activities such as online chat conversations [2], navigation on the world wide web [12] and an inspirational visualization of texts created at an office [9].

Visualizations of human activity in the real, physical world are less common, but they do exist: The *AROMA* system [7], for example, provides mutual awareness information about the activity in between people who are geographically dispersed. It displays visible and audible activity information as subtle changes in an active painting on the wall. Other examples are *Shop Activity* [3], which visualizes the activity in a workshop at MIT Media Lab, and *Presence Era* [11], an interactive installation which allows users to browse through an activity history for the gallery in which it is placed. The latter two uses web cameras as only input, whereas AROMA also has the ability to handle input from microphones, and potentially various sensors.

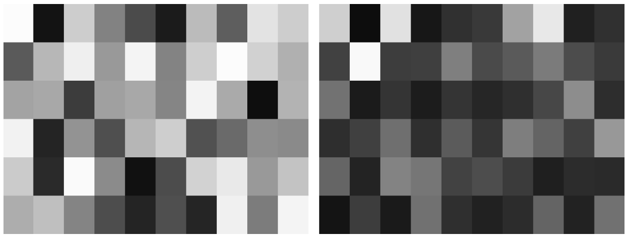

Figure 2: Exhibition Activity Monitor

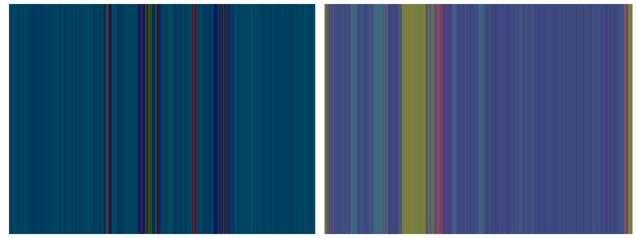

Figure 3: The Motion Painting

Ambient Infovis & Local Activity

Our own previous work contains two examples of visualizations of physical activity, which we will describe in greater detail in the two sections below.

The *Exhibition Activity Monitor* (Figure 2) visualization was created for an exhibition at an art museum. It measures the amount of people that passes in or out through a door by using a photo cell mounted in the door. The visualization consists of 60 rectangular fields in different shades of gray, each representing a time span of one minute; the whole screen thus covering a time span of one hour. If no one passes the door during a minute, the field representing that minute will be black. The more people that pass, the lighter shade of gray the square will be, and if as many as 30 or more people pass during one minute, the square will become white. It starts by filling the field in the upper left corner and then moves from left to right, until the first row is filled. It then starts over at the left end of the second row and so on until the whole screen is filled. When the entire screen is filled, the visualization starts over in the upper left corner, overwriting the information from one hour earlier.

The Motion Painting (Figure 3) is another activity monitor, created especially for exhibition at SIGGRAPH 2001 [5]. The visualization paints thin, vertical lines in different colors from left to right on the screen. It uses a web camera to determine the activity level in a room (or whatever area the web camera is aimed towards). Zero activity is mapped to a "base color" of choice, and the more activity it is in the room, the more the color differs from this base color. The speed with which the lines are painted is set at startup. At the exhibition it was set to a high update rate, in order to make the visualization more interactive. It then took about half an hour to fill the screen with lines. When running in our lab, however, it was usually set at a slower pace, taking an entire day to fill the screen with lines. We found this to be a nicer use of the visualization since it constantly provided an activity history over the latest 24 hours, which is more interesting when you see the display everyday.

Capturing Activity Data

Since we were designing for a public place, we wanted to find a place *outside* the lab to use as a test bed. We believe that use in dynamic, everyday environments has the potential to give us more valuable feedback on our ideas. We decided to design the visualization for a local café, which is good example of the kind of setting that we were looking for. Activity data can be captured in a multitude of ways, e.g. by using cameras, micophones and photo cells, as seen above. We decided to use microphones, mainly for two reasons. Firstly, a microphone can easily be concealed in the room, and secondly, microphones are cheap, readily available and plug-and-play. This enabled us to start prototyping right away, which wouldn't have been the case had we chosen to use a custom built sensor.

Using Amplitude

As an initial stage in developing the audio analysis, we simply used the amplitude of the audio signal as a means of measuring the activity, well aware of that it was a crude tool. It proved to be useful in the early stages of experimenting, but we soon realized that this "naïve" method of measuring activity would not suffice for our purposes. In order to create an interesting and useful display, we needed a more advanced model that would give us a richer output.

Advanced Audio Analysis

We developed an analysis model in MATLAB (http://www.mathworks.com) on a standard PC, running Windows. For privacy reasons, none of the audio data that is captured by the microphone is stored, but is passed on directly to the analysis. The program records for ten seconds, performs the calculations and then outputs the analysis (at a rate of approximately four times per minute) to a Java program drawing the visualization, described later.

The MATLAB program consists of four different modules that analyzes the sound signal and tries to detect different characteristics that are significant for the perceived activity level at the café. The four modules are invoked sequentially and each outputs a normalized value in the range [0-1]. A full documentation of the model can be found in [6].

The four modules are:

- *Center of Gravity Fluctuation Strength* (CGFS): The *center of gravity* is a parameter describing if the signal energy of the sample window is predominantly high or low frequency. The CGFS then, measures fluctuations in this parameter over time.
- *Mean Level Fluctuation Strength* (MLFS): Similar to CGFS, MLFS measures the fluctuation strength over time in the signal, but for amplitude rather than frequency. Speech will generate a low MLFS value, whereas a smooth signal, like a sinusoid will generate a high value.

- *Speech Interference Level* (SIL): Indicates the amount of background noise in the signal. This could be people moving chairs or silverware against china, but also speech from people situated at some distance from the microphone.
- *Low Frequency Modulation* (LFM): Measures the speech rhythm of captured voices. This parameter gives the best results for single speakers, without background noise, but still gives a hint about the general speech rhythm of the people in the room.

Given this, what assumptions can be made about the activity level at the café? We found the three most interesting features to be *MLFS*, *SIL* and *LFM*. The MLFS parameter provides a rough measure of the amount of speech in the audio signal, suggesting how crowded the café is. SIL measures the background noise, which can be caused by background speech or just general hubbub from people moving around. LFM indicates how animated the discussions in the area around the microphone are.

DESIGNING THE VISUALIZATION

When designing the visualization, there was a number of issues to consider, such as what information to display, how much historical data to incorporate, what display technology to use, etc. These issues are discussed below.

Making Use of the Analysis Model

We chose to use two of the parameters from ouput by the analysis model: *MLFS* and *SIL*, which we found to be two good parameters. Contrasted against each other they form an interesting "activity space" where the values from the parameters meet. The MLFS parameter indicates whether or not the café is crowded and the SIL parameter reflects how calm or noisy it is. Contrasting these values against each other gives us four "states" in between which statistical data will move, as can be seen in Figure 4. The reason for discarding the third parameter that we initially found interesting, LFM, was that this parameter works better for input signals with one single or a few speakers. This condition is not representative of the café environment, thus we chose not to include it.

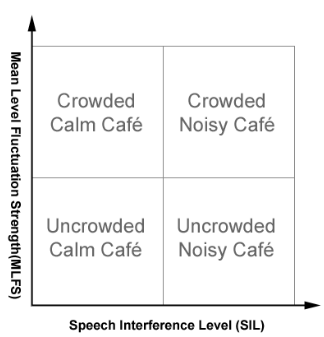

Figure 4: The four "states" in between which the out-

Displaying Activity History

Simply visualizing the current activity level at a location is not very relevant, since if you are located in a place you can determine the current activity level there by yourself. Hence we need to record a history of the activity to make the display interesting and allow for people to relate the current activity level to other points in time such as "this time yesterday" or "Tuesday morning".

We decided to let the display show a week of historical data, based on the hypothesis that "a week" is a time frame that people in our society are likely to have their everyday lives structured by, in some sense. We wanted the layout of the display to be structured in a way that would allow the users to intuitively grasp this structure. We chose to structure the time along two axes where one represent the *day of week* and the other the *time of day*. The display has eight columns, one for each day in the past week, and each column is divided into 30 rows, each corresponding to 1/30 of the time the café is open (Figure 5 A). The café doesn't open the same time every day (8 AM on week days, 10 AM on weekends), so the rows are aligned to make each row correspond to the same time of day for all days. This means that on the weekends, when the café opens later, the first few rows won't display any activity, simply since the café is not open at that hour.

Display Technology

When we first started developing the visualization, we intended to run it on a LCD-screen, mounted on a wall. The large size of the room in the café where we wanted to display the visualization discouraged us from this solution, since we feared that display would disappear rather than blend in. Using a larger screen did not seem appealing either, since that would be more of an intrusive element in the environment. Hence we chose to use a projector, which allowed us to enlarge the visualization, while still keeping it an integrated part of the room.

Appearance

The choice of a projector as a display method somewhat affected the way we could design the visualization, e.g. in terms of color choices, since visualizations with dark backgrounds tend to be hard to read when projected. This caused the change of appearance from Figure 5 B, to the one in Figure 5 C, which is inspired by patterns from wallpapers and tapestries. This choice was made since we wanted the projection to be an integrated part of the wall, much in the same way as a wallpaper or mural.

Current data is written in the rightmost column, from top to bottom, as the day passes. The history of the seven preceding days are read from right to left, so that the leftmost column represent the activity from a week ago.. Also note the "blank" space at the beginning of two of the columns, indicating that there was no activity.

The color is determined by the noise level, as indicated by the SIL parameter. The more the color diverts from the

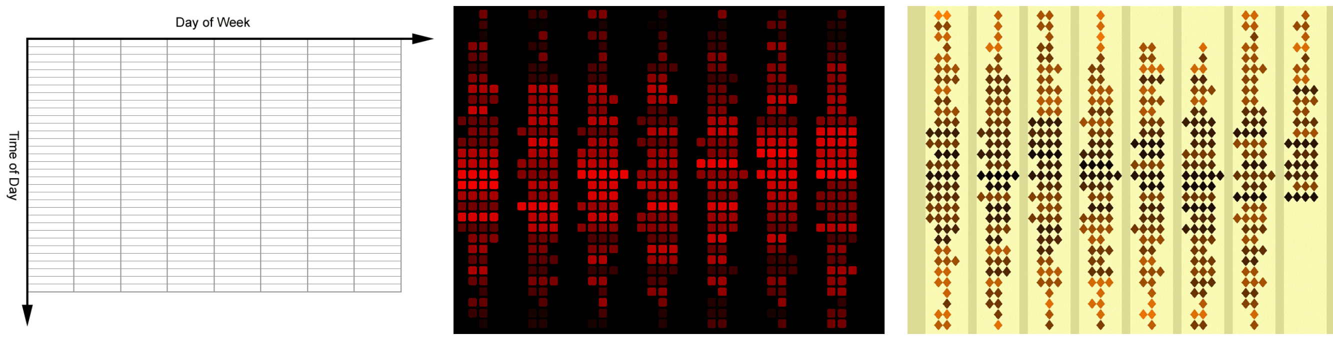

Figure 5: Development of the visualization (*A*, *B* & *C*). *A* shows how time is mapped, *B* shows a visualization sketch and *C* shows the visualization after modifications for use with a projector.

background, the noisier the café is. The number of "dots" (0-5) in each row represents the crowd (indicated by the MLFS parameter), so that the more dots, the bigger the crowd was at that point.

By looking at the resulting visualization, patrons can see how the activity level at the café has fluctuated over the last week, revealing phenomena like lunch hour peaks or quiet weekend mornings.

DISCUSSION

Previous activity visualizations have for the most part consisted of mappings from fairly simple, uninterpreted sensor data to some output. We argue that more advanced analyses of activity, like the one used here, have the potential of revealing more aspects of activity and how these aspects interrelate. This opens up for analyses and interpretations of activity, which hopefully will yield even more interesting displays.

Here, we have presented the Activity Wallpaper, an ambient visualization of activity that is intended to act as an amplified memory for a public place; in this case a café. By making the activity history visible in the café, we hope to enhance its aura and give the patrons a feel for how the place is inhabited.

A projection of the visualization can be seen in Figure 1.

ACKNOWLEDGEMENTS

My colleagues at FAL, especially Lars Erik Holmquist and Sara Ljungblad for valuable comments.

REFERENCES

1. Alexander, C. (1977) *A Pattern Language.* Oxford University Press.
2. Donath, J, Karahalios, K, and Viégas, F. (1999) Visualizing Conversation. In *Proceedings of HICSS 32*, 1999
3. Fry, B. (2003) *Shop Activity.* http://acg.media.mit.edu/people/fry/shopactivity/
4. Hallnäs, L. & Redström, J. (2001) Slow Technology - Designing for Reflection. In P*ersonal and Ubiquitous Computing*, Vol. 5, No. 3, pp. 201-212. Springer
5. Holmquist, L.E. & Skog, T. (2003) Informative Art: Information Visualization in Everyday Environments. In *Proceedings of GRAPHITE 2003*, pp. 229-236.
6. Lukic, B. (2003) *Activity Detection In Public Spaces,* M.Sc. Thesis, Royal Institute of Technology, Stockholm, Sweden.
7. Pedersen, E. & Sokoler, T. (1997) AROMA: Abstract Representation of Presence Supporting Mutual Awareness. In *Proceedings of CHI 1997*, pp. 51-58.
8. Piper, B. & Agamanolis, S. *Palimpsest* http://www.medialabeurope.org/hc/projects/palimpsest/
9. Redström, J, Ljungstrand, P & Jaksetic, P. (2000). The ChatterBox: Using Text Manipulation in an Entertaining Information Display. In *Proceedings of Graphics Interface 2000*.
10. Skog, T., Ljungblad, S. & Holmquist, L.E. (2003). Between Aesthetics and Utility: Designing Ambient Information Visualizations. In *Proceedings of InfoVis 2003*, pp 233-240.
11. Viégas, F. *Artifacts of the Prescence Era.* (2003) http://web.media.mit.edu/~fviegas/ICA/
12. Wexelblat, A & Maes, P. (1999) Footprints: History-Rich Tools for Information Foraging In *Proceedings of CHI 1999*.
13. Wisneski, C. et al. (1998) Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information. In *Proceedings of CoBuild 1998.*