

RadioActive: Visualizing the Electro-Magnetic Spectrum

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ABSTRACT

We investigated methods for a dynamic visualization of the electro-magnetic spectrum. Through the creation of special "RadioActive Displays," we give once-invisible energy a visual presence. A continuation of the ambient media genre, this experiment presents a novel way to visualize electronic space through the combination of frequency graphs and time-dependent dissolves.

Keywords

Ambient media displays, electromagnetic visualization, radio frequency

INTRODUCTION

Radio frequency communications have become a ubiquitous, yet unnoticed aspect of modern life. Numerous modern devices from cell phones to computers to overhead electric power lines invisibly emit and receive energy in the RF (radio frequency) portion of the electromagnetic spectrum. Having no visual manifestation, patterns and intensities of this activity go unnoticed to all but the electrical engineer. It was our desire to create an ambient media display [1] that not only presents feedback to a viewer of the current electromagnetic activity, but also includes an historical account of electromagnetic intensity levels of the recent past.

SCENARIO

In one manifestation of the system, our "RadioActive" display would be mounted on a wall. At first glance it would appear to be an ordinary picture, such as those commonly found in offices and homes. On closer inspection the viewer would notice that the image shifts in a slow wave-like pattern. He would also notice that placing RF emitting devices such as cellular phone close to the installation increases the amount of movement near the bottom of the image. The specific frequency that is emitted would also determine the position of the increased activity along the horizontal axis. The movement propagates upwards in a "player piano" like fashion, creating a visual history of RF activity over time.

Computer and cell phone use follows daily trends, peaking during the working hours and tapering off into the night. Our system graphically displays the general usage level of these devices, and so also indirectly indicates information that can be recognized from these patterns, such as the time of day. Imagine installing a Radio Active display in a bus terminal so that travelers carrying radio-emitting devices (for example, expensive cell phones and laptops) could be pinpointed as prospective mugging targets. Or most likely and preferably, this display could be placed in a public space to enhance the visual environment in a novel way that is both engaging and informative, becoming a public artifact [2].

IMPLEMENTATION

Choice of Medium

We considered visualizing the RF information through both the auditory and visual channels. Audio, however, is a transient phenomenon, and the historical activity of the radio spectrum would get lost over time. Visualization lends itself to such transformations and metaphorical mappings, as we are able to present data in two dimensions over the image, over time. Additionally, a visual display of data is generally less intrusive than an audio output, which is an important factor when creating an ambient media display [1, 3].

Modification of an existing image vs. computer generated

We decided to augment an existing image rather than use the RF data to generate a completely new image. Generating a new image has the disadvantage of having no point of reference. That is to say that using an existing image allows for comparison between the original and the augmented one, thus emphasizing the change. Using existing static images also has the advantage of being able to swap out the underlying image in order to cater to personal preference; monotony can be avoided by cycling the underlying picture at regular intervals.

Mapping: Deterioration

One unique aspect of our system is that the system exhibits a slow deterioration from the image movement caused by RF energy. This parallels the often damaging effects of RF on real objects. The motion computationally induced by the RF activity slowly discolors the static image. The rate of discoloration at any given point on the image is

proportional to the amount of motion at that point, and so is also proportional to the amount of energy in that specific frequency band. Over time, trends in usage can be found by examining the discoloration pattern. For example, heavy cellular phone use will tend to discolor the band corresponding to the frequency used by the cellular phone. Likewise, high saturation of a given device at a point in time shows discoloration in the corresponding segment of time.

Detection

In order to visualize the radio spectrum, we first break it down into a number of frequency bands with an array of tuned antennae. The power level of each of these outputs is then fed into a computer where the image processing is performed.

Image Processing

The display properties of an image are modified by first mapping it onto a two-dimensional mesh. Sections of the mesh are then deformed based on the inputs of the antenna array. The frequency bands are mapped to the vertices running along the bottom edge of the image. Each of these vertices oscillates along the horizontal axis with an amplitude proportional to the power level of the corresponding frequency band. The remainder of the vertices are calculated using classical spring force equations. This creates an aesthetically pleasing rippling effect. As the device receives more radio frequencies, a more intense ripple effect is created. For example, as a person carrying a cellular phone walks by the installation, the level of ripple in the corresponding band would momentarily increase. In addition to visually representing the immediate power and intensity level of radio frequencies, a history of preceding trends in levels is also illustrated. This is achieved by propagating the oscillation values upwards after a set amount of time has passed.

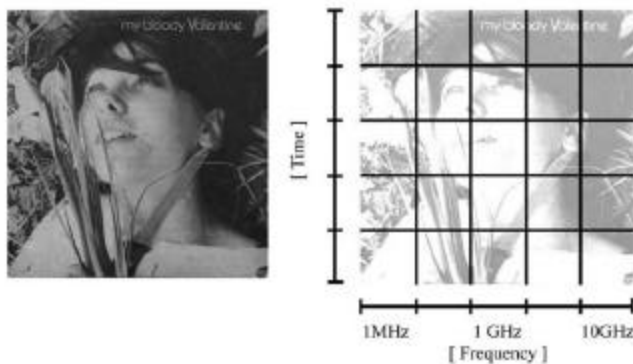


Figure 1. The original image and the image as seen by the computer program. AM radio and ranges from .5 MHz - 1.3 MHz, cell phones from 1 GHz - 3 GHz, and at the high end, 8 - 10 GHz there is radionavigation.

FUTURE APPLICATIONS

While we have chosen here to visualize the invisible—namely the presence of electromagnetic energy, there are other sources of data that would lend themselves to this visualization metaphor. We think in particular physical and non-physical instances of decay, including regressing shorelines, geological erosion, and demographic shifts are appropriate.

CONCLUSIONS

Continuing in the ambient media tradition, we have a data source (RF intensity levels), appropriate medium (existing photograph), metaphorical mapping (waving ripples, decay), and location (public) [1, 3, 4]. There are two important points of divergence: 1) our system not only displays the present state of the data source, but also provides an ongoing history and 2) the display encourages user interaction while remaining peripheral.

Ambient displays have traditionally presented otherwise accessible information (weather, traffic congestion) [1] in the periphery of an individual's attention. While our focus was still to put information into the ambiance, RF information is not readily available, is technically already part of the environment, and does not provide information directly (but rather via predictable social trends)—all of which we feel constitute branches worth exploring in tangible and ambient media displays.

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