Wifi Camera Obscura

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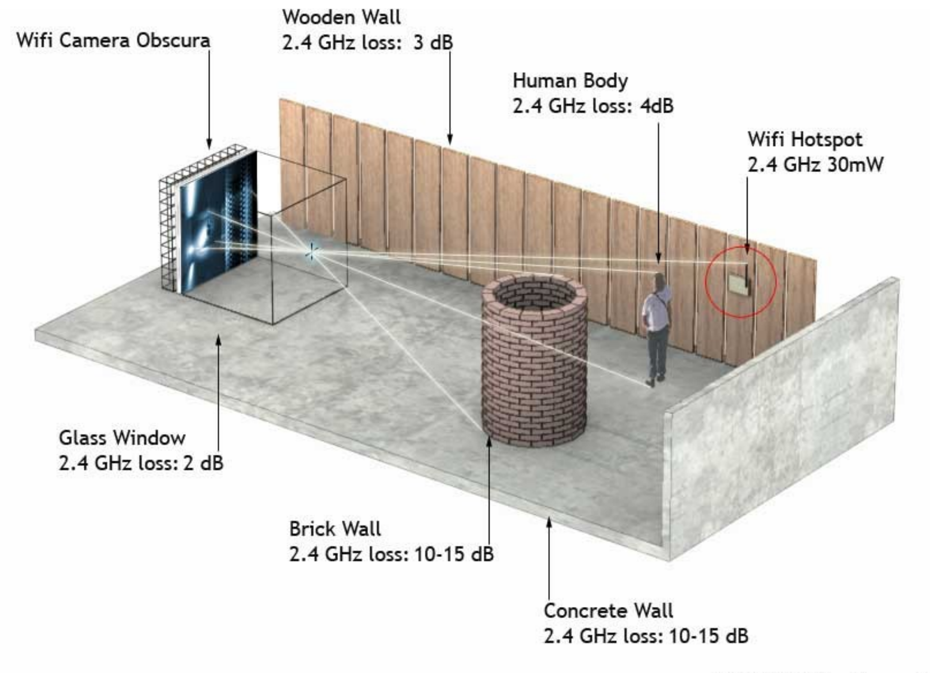
Summary

The camera obscura, just like a large pinhole camera, is a dark room that has one wall punctured by a small hole. Light comes through the hole and projects an inverted image of the exterior scene against the opposite wall.

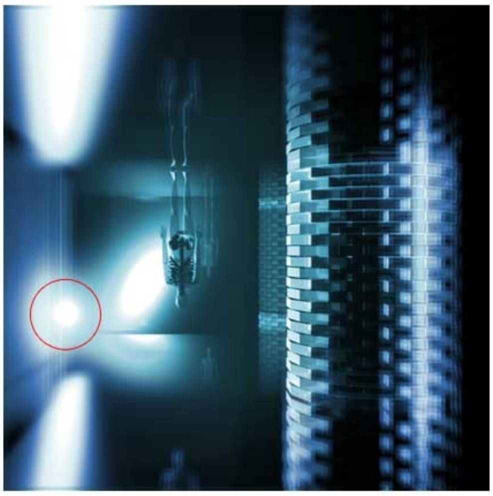
In the age of "englightenment", electromagnetic waves that we knew as "visible light" formed our most ubiquitous medium and was the medium of choice both in "recording" and in "representing". Today, however, we find that increasingly we are creating and responding to non-visual electromagnetic fields: those emanating from our devices and environments. What might a camera obscura for our age look like? What sort of images might it capture? How might it reveal the obscure relationship that we have to our data environments?

We propose in this project to build such a camera obscura, a room that will reveal the electromagnetic space of our devices and the shadows that we create within such spaces, in particular our wifi networks which are increasingly found in coffee shops, offices and homes throughout cities of the developed world. We will take realtime "photos" of wifi space...



2.4 GHz (Wifi) Path Loss data source: Airespace Inc 2005

Camera Obscura image using visible light



Camera Obscura image using Wifi radiowaves

Our camera obscura will be dark to 2.4GHz wifi waves rather than dark to visible light waves. Wifi waves will pass through an aperture or lens in straight lines and will be picked up by an array of sensors tuned to wifi frequencies on the wall opposite the aperture.

One of the most important intentions of the project is to develop a 21st century notion of the "picturesque", which encompasses the space of our electromagnetic data bodies. As such, determining where we point our "wifi camera" (which, in its X-ray connotations has various intriguing privacy implications) is as important as determining how to construct it.

Detailed project description

Wifi camera obscura

> *"Wi-Fi (or wifi) is a set of product compatibility standards for wireless local area networks (WLAN) based on the IEEE 802.11 specifications... Wi-Fi was intended to be used for mobile devices and LANs, but is now often used for Internet access. It enables a person with a wireless-enabled computer or personal digital assistant (PDA) to connect to the Internet when in proximity of an access point."*
> *— definition from Wikipedia.org*

Introduction

Electromagnetic fields and their relationship to the use of space have recently featured prominently in the explorations of many artists and technologists. In particular the partners on this project have made significant individual contributions to such explorations in both an artistic and scientific context: Usman Haque, with his project Sky Ear, a floating cloud of balloons and mobile phones that responds to electromagnetic fields in the sky; Adam Somlai-Fischer, with the Aether Induction house, a prototype environment that reveals the textures of mobile phone usage; and Bengt Sjölén, with his work on Radio Sensor Nodes, and a general background in communication engineering.

Hertzian space (a term coined by industrial design theorist Anthony Dunne) has also become prominent in the reburgeoning interest in psychogeography. Locative media has largely concentrated on the mapping possibilities of mobile phones and GPS devices. Here we propose instead to focus on the exploration of wifi space: the 802.11 space that is created by our wireless networks, which are increasingly found in coffee shops, offices and homes throughout cities of the developed world.

Most of us are familiar with buildings where signal strength is variable or rooms where mobile phone calls are possible in one corner though it is impossible in another even to make a connection. There are areas in some buildings where one mobile company's network penetrates while others are unable to. These electromagnetic interactions with built fabric are even more clear with the implementation of wireless computer networks that are used to create local area networks.

In such networks the positions of furniture, the thickness and material qualities of walls, doors and windows or the distance from a base station contribute to the varying quality of a network connection. These variations in field strength suggest a richly textured ethereal cartography of hertzian space, a real (i.e. non-virtual) space that affects us but which we only know about through use of our wireless-capable instruments.

Haque made preliminary explorations into wifi space in 2004 in his project Floatables, which entailed mapping out three dimensional wifi environments using laptop-based signal strength software (see support materials image). At around the same time, Somlai-Fischer and Sjölén were collaborating on Brain Mirror, a system which allowed people to explore, via what appeared to be a normal mirror, a three dimensional simulation of their brain projected into their heads (see support material CD). During a meeting at a conference in Norway in October 2005 it was proposed to unite their approaches and determine a way to produce a 3-dimensional visualisation of wifi-space in realtime.

One of the most important conceptual features of the project is to develop a 21st century notion of the "picturesque", which encompasses both normally visual space and the space of our electromagnetic data bodies. As such, determining where we point our "wifi camera" (which, in its X-ray connotations has various intriguing privacy implications) is as important as determining how to construct it.

Visualising wifi

The difficulty in trying to "capture" wifi space is the conceptual issue of trying to freeze something that is inherently fluid. It is clear to us that the analogy of an X-ray system will be a constructive model to pursue. Some materials are transparent to wifi (e.g. bricks); others are opaque (e.g. steel); or others are semi-transparent (e.g. human body). Further, surfaces vary in the amount that they either absorb or reflect wifi waves. (By "wifi waves" we mean the precise frequencies that are used in wifi networks, or around 2.4GHz, depending on channel).

If one could see with "wifi spectacles", one would not be looking at the wifi network spread itself, but rather one would see those objects that are "illuminated" by electromagnetic waves in the wifi spectrum. (Similarly, when we see with "normal" eyes, we don't actually see light beams, rather we see objects that are illuminated by the light beams, though of course our retinas respond to the light beams). An X-ray works along similar principles: when applied to the human body, materials like muscle are transparent to X-rays, while bones are not: this allows us to view the internal contents of the human body.

In order to construct such a device we have decided to return to first principles: when early inventors wanted to "capture" the image produced by visible light, they built camera obscuras. The attempt was somewhat simplified by the fact that these inventors could already see the objects that they were trying to freeze in image. In trying to build a camera obscura that only reacts to wifi wavelengths we actually have no idea what sorts of images we will produce. The basic concept entails using an array of sensors that respond to wifi wavelengths: each of these sensors (possibly electronic, possibly electro-chemical) will modify its input to create output that is visible to the naked eye, with an intensity that corresponds to its measurement. Particularly complex images will be created in scenes where multiple "illumination sources" are available (i.e. where there is a wifi base station and several wifi-enabled laptops).

We imagine that the images produced will look something like a cross between room-scale X-rays and thermal camera images, though the resolution of such images will be limited by the array resolution. We also expect objects in the space to appear "glasslike", since many household and everyday objects are semi-transparent to wifi waves. However, because of the unique manner in which wifi waves are absorbed/reflected/transmitted by objects in our spaces, we believe that such a camera will provide a whole new way of looking at the world.

The project components

The project consists of three distinct components:

1. a "scene": this is a space were wifi is in use, which people can enter into and contribute to or interrupt wifi signals.

2. a "camera obscura": this is a wifi-dark room, which people can enter into, in which no stray wifi signal entry is possible. An array of sensor pixels will populate the wall opposite the "aperture". If these pixels create visual output (e.g. with LEDs to indicate the wifi strength at each particular point) then people will be able to see the result of the inverted image of the scene processed against one of the walls. And if they stand in between the aperture and the display wall they will be able to create data "shadows".

3. a "display screen": by taking the realtime feed from the sensor array the output of the camera will also be displayed at another location, either back in the "scene", on the other side of the camera or possibly even at an exterior remote location. (This could even be internet-enabled).

Contructing the Wifi camera obscura

Taking cues from ancient camera obscuras, we will construct a room that is dark to the medium we want to record — we will build a "faraday cage" of sorts that prevents all access to wifi networks. We will then create a hole in one wall of this cage and against the opposite wall we will have a sensor array that measures at each point the signal level of particular wifi networks. The sensor-pixels will then form an image (either in the same space or possibly in another space) of the wifi space outside.

Though we will naturally draw on the techniques of radio telescopes, X-ray CCDs (the devices that digital X-ray machines employ) and wifi network signal measuring tools, this is a project that understandably requires a lot of research and development — it involves building new technology that has never before been created. For this reason the budget is weighted heavily on time spent by the multi-disciplinary team to research, design and create it. We are also interested in the potential for using an "electro-chemical" approach if this seems possible; this would require finding materials that respond physically to wavelengths in the 2.4GHz range.

The design and construction process will involve iterative prototypes that begin with single pixels and culminate in a full array of pixels. Ideally, in the final implementation we would like to have a resolution of approximately 3000 pixels, which could form an array of 100 x 30 pixels. (precise orientation and format to be determined as we describe below).

We would draw on the history of design of radio telescopes (which use arrays of antennas, dispersed in an area many times larger than the wavelength of the radiation they are attempting to detect). In such an implementation the direction of the antennas could be altered, effectively "scanning" the view; in this way we may be able to have much higher amplification compared to a mere "pinhole"

We may find that it is better to work with a system in which there is a single pixel (or row of pixels) which sweeps across an area to form a larger 2 dimensional image.

For the aperture, we will experiment with both:

- a fixed hole and an array of small antennas and

- a moving hole (for example employing 2 circular shapes moving with rotating axis on the edge of the other; or employing a moving metal block with one hole in it) and just one (or a few) antenna(s).

We will build custom designed antennas, which from our past experience we have determined can be built quite small simply by "folding" the length of the antenna; this appears to have little negative impact on effectiveness. For example a 2.4GHz antenna in a wireless mouse occuppies approximately 7 mm x 18 mm and is simply zig-zagging for a total length of slightly more than a 3 cm quarter wave. We therefore expect to be able to build pixels approximately 2x2 cm in dimension.

We envisage the construction process as a series of "subprojects" which may include:

- antenna testing: with directional antennas, we would create a grid of antennas all pointing through the same focal point, to simulate the presence of a hole but with no box needed at all - a little like having "lenses" on each sensor. (The use of the pringle can and USB wifi dongles to extend wifi's reach is a well-known hack amongst free wireless network enthusiasts).

- sensor pixel prototypes: making an array of sensors showing radio energy on different frequencies and possibly timeslots to visualize data bursts on wifi networks.

- array prototype: a grid of coffee cans with either access points or usb wifi dongles with firmware patched for listening to determine what sort of traffic might be picked up.

- focusing: making a 4x4 pixel camera with 16 wifi accesspoints and 16 directed antennas for long distance directed wifi-links and a pinhole camera house or lens system/dish for focusing.

- sensor pixels + focusing: bringing the two together in a particular space

- sensor pixels + focusing + "environment": a camera obscura that may be entered into.

It must be emphasised that, since this is a project that involves developing technology that has not been attempted before, we outline here merely our intended strategies, rather than actual work schedule: we don't know which tactics will work. However, as we consider ourselves three equal partners it is important for all of us together to be involved in every stage of the design of the project (rather than the usual model of artist applying the science created by someone else). It is therefore difficult before beginning the design to outline exactly what each stage will be; however, the three of us are all accustomed to working using an iterative, cumulative process — a process which usually results in robust, sophisticated and serendipitous constructions.

The "scene"

As discussed earlier, the positioning of the Wifi Camera Obscura is crucial because of the privacy implications of being able to "visualise" data/network topographies. Placed in a public space (like a cafe) this would have a particular affect on the use of that space. This might for example make us more aware of how much information about us leaks out of our buildings, seeps out of our devices and is accessible to anyone with the appropriate bit of hardware or software. The camera obscura will show how our spaces, physical and virtual, are no longer exclusively our own. This has profound implications on the transformation of the notion of "picturesque". It is vital at this point to consider the wider aesthetic, ethical and lyrical implications that this condition affords us. We do not, yet, know exactly why/where the camera obscura will be placed in a particular context but we are certainly aware of the issues surrounding contextualisation.

The visualisations

Please refer to accompanying image in the support material.

Though there is no way for us to ascertain what these will look like without building the camera to see them, we imagine that they may be similar to the images produced by x-ray machines: they may be greyscale or colour, will show objects and materials that have varying transparency to wifi networks and may reveal multiple sources of wifi networks.

For example, if the wifi camera obscura room is located near to a cafe where several people are using the public wifi to access networks then one might see an image (albeit inverted — this will be corrected for in the display system) that reveals one bright source (the access point) and several other less bright points (the laptops with wifi) as well as people and tables creating wifi "shadows" in front of the sources.

The team

The three partners have experience in quite distinct areas, but have enough in common to bridge such differences. Furthermore, though this is the first time that all three will be working together, Haque has in the past collaborated with Somlai-Fischer (Low Tech Sensors and Actuators project; the Open Source Architecture Experiment); and Somlai-Fischer has collaborated with Sjölén (on Brain Mirror and Ping Genius Loci).

The iterative approach we will pursue is important for us, because it allows us all to participate in all technological and aesthetic decisions. Notionally, however, we may categorise ourselves as, one, an "artist" bringing an appreciation of the notion of the relationship of the body to the "soft" space of electromagnetic fields; two, an "architect" bringing expertise on the use of space and architectural fabric as well as the use of communication technologies in an architectural context; and three, an "engineer" brings experience both in radio frequency circuit construction and in the use and development of open/free technology.

Budgeting

The project budget is heavily weighted towards time for the three participants to research, design, develop and construct collaboratively and iteratively. This is important because they expect to be involved simultaneously at every stage of the project.

There are a number of different stages in the development of the final piece. We are accustomed to working with "low-tech" prototypes, and hacking together existing technology and software. We therefore don't envisage having to expend a lot on individual prototypes. However, we do expect to make *many* different prototypes in order to explore fully all possible approaches. For this reason we intend to spend a relatively large amount of the material budget (approx. 40%) on early prototypes.

When we come to build the "final" version we expect to have custom-built circuits produced in runs of several thousand. Of course, this requires relatively large initial setup charges so the actual number we build will depend on the approach that we eventually decide to take to create the pixel/sensors.

The main development site will be in Budapest, Hungary, in the studios of Aether Architecture (Somlai-Fischer) and so the other two partners expect to travel every couple of months to Budapest in order to carry out research. The rest of the time, they will be in constant contact using free internet communication software (e.g. Skype, ichat/aim video conferencing and Subethaedit collaborative text production), an approach that they are very familiar with since they employ it consistently throughout their work processes.

Finally, we expect to release the resulting information as a well-designed booklet/pdf online; for this we require fairly robust website hosting for a couple of months since from past experience (releasing our Low Tech report as a PDF, which resulted in almost 20,000 downloads in the first couple of weeks) we need to be prepared for an early surge in demand.