Video Based Environments – State of the Art Foreseeing B-wind Interactive Installation

Mónica Mendes
New University of Lisbon
Media Technologies
Lisbon, Portugal
+351 916433818
monica.mendes@fba.ul.pt

ABSTRACT

Interactive experiences engaged with the use of technologies are increasingly embodied in video based environments. Whereas real-time video has been mainly used as a functional tool for surveillance, targeted for informational and safety purposes, the use of this resource has an enormous potential for artistic exploration, slightly glimpsed through some significant, still technologically shy, art experiments.

With the development of the real-time video interactive installation *B-wind* in mind, this paper highlights the state of the art of video based environments. From a bird's eye view of selected case studies art works concepts, to an insight into the applied technologies, this research aspires to support, to open new perspectives, and to describe the technologies underlying the *B-wind* experience.

Keywords

Live video, video streaming, real-time processing, Motion Capture, Particle System, Experimental Design, Interactive installations, Sustainability, Social responsibility.

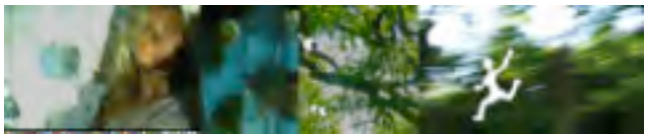

Figure 1. B-wind Interactive installation visuals.

1. INTRODUCTION

Focusing on recent trends, this research project privileges the use of open source tools for the development of the experimental approaches, thus opening new possibilities for innovative ideas.

This paper is structured in two main parts, covering the technologies underlying the B-wind interactive installation development work in progress, preceded by case studies of related projects, where the technologies and contexts are described.

B-wind is an interactive installation, proposed as an RTiVISS experience in the scope of a PhD practice based research in Digital Media.

RTiVISS stands for Real-Time Video Interactive Systems for Sustainability, the acronym for the overall project and research agenda. RTiVISS is an exploratory project that proposes to investigate innovative concepts and design methods regarding environmental and sustainability issues. It is concerned with natural resources, specially forests, and their preservation, through critical research and experimental artistic approaches. The overall project fosters multiplatform access to real-time networked video and allows users to adopt selected forests under surveillance. This achievement enables artistic explorations with digital media in interactive installations that engage the audience senses in unconventional ways.

Considering these premises, can we conceive a project both artistic and functional?

2. RELATED WORKS

The selected case studies presented in this section are examples that somehow inspired the *B-wind* concept, its features or future perspectives. The main topics on the technical issues include:

1. Real-time video streaming
2. Computer vision and physical computing – sensors and devices
3. Motion and particles effects processing
4. Network communications, telecommunications, and telematics.

Conceptually, these compelling references remain as part of the *leitmotif*:

A) *Pigeons Wall*, by Davenport [8] from MIT, an interactive media piece situated in sensor-rich architectural spaces, for its effectiveness on people's behavior, and as scenarios for interaction, exploring the relationships among immersion, interaction, and public space.

B) By exploring the area where design and technology merge, John Maeda's artistic programming projects [19], such as generative *Nature* series, have also been a key inspiration for the theme, as well as his research on simplicity.

C) The computer installation *Interactive Plant Growing*, by Sommerer and Mignoneau [30] at the ZKM dealing with the sensitive relationship between real plants and human viewers, who can initiate and control a 3D real-time growth of virtual plants on the screen through a sensitive interaction with their hands on the real plant.

E) In the *Text Rain* installation, by Camille Utterback, Bolter is assuming digital art as the purest form of experimental design [7].

2.1.1 *Video streaming as input*

Widely used for multiple purposes, diverse approaches with live streaming video and surveillance cameras have been proposed.

XCoffee, the first webcam publicly known, was created as a means of knowing when a new pot was brewed, looking forward to prevent disruption in work flow by breaking down the barriers of distance. In 1991 the system was constituted by a camera pointed at a coffee pot and custom written software to allow the image to be displayed on all the in the Systems Group at the University of Cambridge Computer Lab researchers group screens: "In the interests of fair play, some of the residents of the Trojan Room salvage a video camera, an old 680x0 VME-based computer, and a framegrabber left over from other projects. They grip the camera in a retort stand and point it at the coffeepot. The machine with the framegrabber executes a specially written server program, and an X-Windows client, which can be run by anybody in the group, grabs images at regular intervals and displays a picture of the pot, icon-sized, in the corner of the workstation screen" [33]. It became a webcam, fin 1993, when the Mosaic browser was introduced – then the server was modified to respond to HTTP requests in order to constantly change the images of the coffeepot camera.

Nowadays, there is an endless number of webcams of every kind, where informational purposes prevail.

Regarding surveillance for forest fire prevention, the gap is being filled with a growing number of international institutions focused on forest research, such as the Forest Data and Information Systems [12], and the GMES Global Monitoring for Environment and Security with the Forest Monitoring Services [17]. Monitoring and maintenance of these systems are major difficulties to overcome.

Ongoing surveillance projects for forest fires prevention include air monitoring with wireless real-time capturing devices installed in flying robots [31].

Educational initiatives, such as *Publico Online*'s, enable the continuous observation of griffins [26] and bats [27] through the use of surveillance cameras.

The observation of a nest of short-tailed hawks is an ongoing project lead by Peter Stepniewicz at the Walt Disney Parks and Resorts. The Animal Programs department wanted to observe t the hawks' behavior, but nest was high up in a tree, and far from the nearest road. To provide reliable power supply, methanol fuel cell, a mobile portable choice which transforms chemical energy directly into electrical energy, enabling to run day and night [11]. For the video, 2 cameras were used, 1 mounted above the nest looking down with infrared LEDs for night illumination, and the other on an adjacent tree, looking towards the nest. A low-power digital video recorder, connected to a 3G cellular modem, allowed viewing the feeds live and uploading snapshots continuously to a remote server.

Information retrieval is certainly a key issue, although not the only motivation: subjective experiences on the use of webcams for sea conditions regarding surf practice [6] reveal potential beyond information. The feeling is mainly poetic, not to be misunderstood as "voyeurism" – a quick look at the framework and detail (not) shown is clear: it's not "what are you doing?" but "what is it like now?"

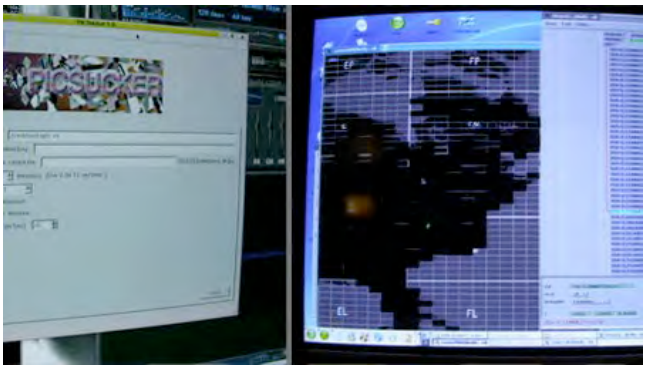

Figure 2. Netlag backoffice with Picksucker

Netlag is an impressive reality video video piece based on outdoor webcams designed by Pleix, a multidisciplinary community of digital artists based in Paris. Conceived for a french art exhibition in 2004, they developped the *Picksucker* software to make a snapshot of 1600 webcams all over the world each 10 minutes (from 29-01-2004 until 30-01-2004 18:40 GTM). The webcams images are placed on a geographical world map & synchronized; from a distance, each pixel on the map is a webcam. This "netlag world webcam map" application generates a living world map, which is an interesting approach to use webcam data because it creates an overview on the real-life system earth especially on the rhythm of live caused due the rise of the sun [26]. Although not streaming, working only with still images that became animated according to time, the ground is set for a proposal with full motion streaming video, as well as being a tool for video searching with geographical indexing and visualization of day/night cycles.

SurveillanceSaver is a screen saver that displays more than 1000 surveillance cameras worldwide, " an addictive live soap opera for more than 30.000 people that downloaded it and watching it since november 2007". When the computer is idle, we get to see a live feed of what's going on in other parts of the world. The process of searching for an article about finding Axis network cameras via Google led to experiments with network surveillance cameras and the development of a simple OS X screen saver showing randomly the images of hundreds of these surveillance cameras that were not protected. The images of axis network cameras can be simply found by searching for their unique URL [39].

Fabrica [34] acts like a VJ system mashing and re-collaging images from around the globe in real-time, as they are captured from live CCTV and Webcams.

Ethical considerations were addressed in *Rara Avis* teleportation experiments by bio artist Kac [25] and the controversial movie *Faceless* by film maker Luksch [18] using only CCTV footage.

At her recent exhibition at the MoMA, *The Artist is Present* [1], Marina Abramovic proposes new concepts for performance, anchored on the use of video:

A) as the work of art itself – videoart, videoperformances

B) as the means of documenting perfomance

C) as live video for performances, a proposal for the space and time of the piece through a multimedia setup that is not limited to its presentation at the Museum, but expands to an online platform, and records video for ulterior exhibitions.

2.1.2 The :O effect of creative coding

Open source tools are valuable not only as creative tools, but also for learning, with good resources to develop and share with the community.

Figure 3. The :O effect whilst watching an OF application.

OpenFrameworks (OF) is a set of open source libraries in C++ created by Zachary Lieberman and Theodore Watson with the aim of simplifying and encouraging experimentation with programming and allow the creation of creative high performance applications that combine graphics, video, and audio with interactivity. Its simple, modular structure allows it to be easily expanded to integrate the open-source libraries for C and C++. Due to the processing requirements, handling real-time video is one of the areas of application where the *openFrameworks* is extremely useful [3]. The code is written to be both cross platform and cross compiler. The API is designed to be minimal and easy to learn. The code is optimized with very few classes, and inside of those classes, very few functions. The code has been implemented so that within the classes there are minimal cross-referencing, making it quite easy to reuse or to extend. OF precursors are mainly the *Processing* development environment, and the ACU Toolkit, a privately distributed C++ library developed by Ben Fry and others in the MIT Media Lab's Aesthetics and Computation Group [23].

Advantages encompass its high performance, simplicity, multiplatform, easy to expand and adding new functionalities, and easy to adapt objects to our goals, and adjustable to working process – with C and C++ programmer tools. On the other side, the disadvantages are that OF requires low level code C++ knowledge, the tools setup is still complex, and the code and documentation are in constant change for development.

Alternatives to OF: *Cinder* (also in C++, by the Barbarian group; it's more complex to use, created as a professional tool, in a recent release), *Processing* (a tool created to teach programming, with the disadvantage of being written in Java, which implies slower response for heavier data), *PureData* (open source alternative to *Max MSP Jitter*; dataflow (we don't write code, we define how the info is processed), *Flex SDK* (writes programs as a regular programming language in *ActionScript*) [3].

Processing is a reference in creative coding. It is based in Java, created by Casey Reas, Ben Fry and the Processing community.

OpenCV (Open Source Computer Vision) is a library of programming functions for real-time computer vision, with hundreds of optimized algorithms. Uses range from interactive art, to mine inspection, stitching maps on the web on through advanced robotics [22].

Made with *openFrameworks* by Theo Watson and Emily Gobeille (2007), *Funky Forest* is an interactive ecosystem where children create trees with their body and then divert the water flowing from the waterfall to the trees to keep them alive [32]. The Moomah Edition of the installation expands on the original by introducing four seasons, each with a unique environment and creatures to match, and also featuring an interactive particle system. The whole process behind Funky Forest was recently presented "This Happened", a series of events focusing on the stories behind interaction design, and is fully documented in video, with further information on the software challenges and the cameras setup [13].

Figure 4. Interacting with Funky Forest

Parque, by Rui Madeira (2009), is also an interactive installation with an ecological message: "the growth of a forest is determined by the amount of attention it receives". The system recognizes vertical movements as inputs for making trees vector graphics grow – the children can create new trees or grow existing ones. The application was created in C++ using openFrameworks, and the movement detection using openCv's optical flow and a custom openCV based contour tracker that calculates persistent contour identification over time. Trees and grass are constructed using particles and springs, and computer vision is running on a separate thread to enhance the responsiveness of the system [19].

Figure 5. Making trees grow in *Parque*

Hand from Above is an experience where Chris O'Shea (2009) playfully challenges our perception of spaces and objects, enabling virtual and real to coexist in real-time. The code was

written using openFrameworks and openCV. "Unsuspecting pedestrians will be tickled, stretched, flicked or removed entirely in real-time by a giant deity" – the reactions demonstrate immediate engagement, and there's an emotional response on the participants side. The inspiring demo evidences how significant scale is in a project like this nature [24].

Figure 6. *Hand from Above* reigns

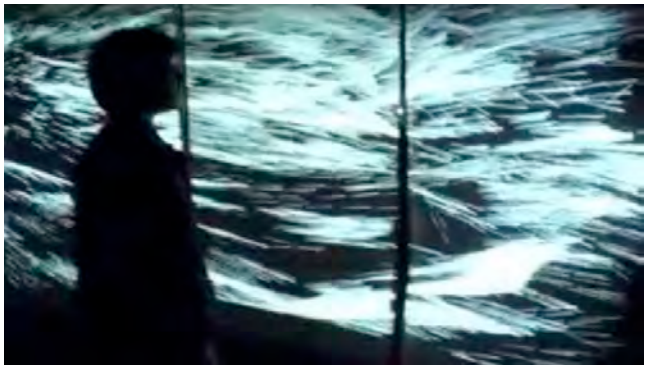

Figure 7. Wiill.0.W particles flow

Will.0.W1sp, by Kirk Woolford, (2006) is an interactive installation exploring our ability to recognize human motion without human form. The experience was created using *Processing*. It uses particle systems in real-time to create characters or "whisps" with their own drifting, flowing movement, but which also follow digitized human movements. The resulting visual effects representing result are very expressive, energy metaphors! *Will.0.w1sp* invites visitors to chase after intangible characters which continually scatter and reform just beyond their reach. The central point of the physical environment is a curved screen allowing projections at human scale while giving space to move and avoid visitors through the use of a combination of video tracking and motion sensors. "The installation systems perform real-time motion analysis both on the prerecorded motion capture sequences and the movement of the audience to determine how to route the particles across the scene. The motion vectors are simultaneously fed to an audio system to create sound flowing in synch with the imagery. In addition to generating the particle systems, the computer watches the positions of viewers around the installation. The overall intention is to present viewers with something human-like, foreign, and aware of their presence. In order to trigger the parts of the visual system tuned to human movement, the movement driving the particles is captured live using motion capture techniques. While the installation is running, the system decides whether to smoothly flow from one motion sequence into another or make an abrupt change in movement. These decisions are based on position and overall amount of movement of observers in the space" [38].

Figure 8. Delicate Boundaries extend projection surface

Delicate Boundaries, an idea conceived by Chris Sugrue (2007) and developed collaboratively using *openFrameworks*. The code includes *Fluids System, Particle Systems,* and *Vector Field* [35]. This approach is especially inspiring for the interaction that goes beyond the screen to our own body as projection surface. After experiencing the installation during its presentation in the scope of the UM Festival in Lisbon, the feeling is very effective on its suggestiveness.

3. B-WIND INTERACTIVE INSTALLATION

3.1 Concept: the B-wind experience

What is the feeling of becoming the wind, an invisible power with a visible physical effect on trees? Will you cherish the leafs, or will you trigger a hurricane? [21]

B-wind is a RTiVISS experience where users have the opportunity to perform an invisible character, the wind, triggering effects in site and at the remote forest.

The performative potential and the human scale motivate a choreographic approach that raises awareness on space and on the poetry of movement, whereas simultaneously empowering the users by demonstrating a real immediate interaction effect. Users are invisible, the physical presence being subtracted from the visual interface, and the result of their actions is presented in the real-time video through emphasized visual effects.

B-wind works with particle systems for responsive expressive wind effects, as if translating motion into abstract poetry. This proposal is connected to the motto of the "butterfly effect" [9], for the wind waves provoked by the subtle flickering have the "hurricane effect" in a remote place. A prototyped component includes the power to apply the wind effect to the forest itself – the motion tracking in the installation having a real amplified effect on the real trees and in real-time, using a microcontroller controlling a fan that produces the wind, which is visible in the framework in the video.

Confronted with such possibilities, multiple questions arose during the user experience: is this pleasant, is it strange? Will

the participants “spread the wings” and feel the freedom to cherish the trees? Will they explore the superpower of generating wind, somehow “competing against the machine”? Or, as children, “competing against the machine”? Or, as children, exploding in energy, will they join the celebration of nature without processing causes or consequences – just being?... the wind!

Figure 9. B-wind sketch: interaction at exhibition and forest

3.2 Underlying technologies

Technically, *B-wind* is realized as two interconnected installation spaces. The first one presents the user with a projection of a live video stream of a remote forest space. A camera records the user's full body motion in real-time using and a custom video processing software written in *openFrameworks* and *openCV* analyses this motion data and uses it to graphically render particle effects showing the user's influence over the live video stream.

Simultaneously, it sends control signals to wind generators in the remote forest location. At the remote location, custom software also written in *openFrameworks* receives the network control signals and forwards them to an *Arduino* based electronic control circuit that controls the power and motions of an array of fans. A video stream is captured at the remote location and is streamed in real-time to the installation space using Darwin Streaming Server and decoded on site using a custom *GStreamer* pipeline.

Figure 10 B-wind system architecture | V 2.0

All the components in the research have to do with telepresence and the use of telecommunications. *B-wind* mandatorily handles with the main standard requirements for all real-time games applications: input prediction and lag compensation.

The system developed involves three main components:

1. a working prototype of the fan turning on and rotating according to the X axis mouse movements, to be upgraded into a version with the video tracking of the user captured by the webcam at the installation

2. the real-time video being captured, and the code for the streamed video to be processed in *openFrameworks*

3. particle fields effects to be generated from the user's performance at the local installation, captured by the same tracking webcam, and to embed in the streamed video of the remote location

All of them will be interconnected, communicating through wireless networks over internet protocols with the lowest net lag achieved. What *B-wind* proposes is, in fact, close to the telematic experiences envisaged in visionary scenarios in science fiction movies!

The ultimate technological challenge of the *B-wind* interactive environment, is to be responsive and able to provide an immersive experience that inspires the kind of evasion of *the magic circle*, which is when we abstract from reality and get into the game, “a temporary alternate reality”. As Salen and Zimmerman write about the magic circle in *Rules of Play*, it’s “a fantasy world with its own rules. By stepping into that fantasy world, bounded by the magic circle, we agree to compete without lasting antagonism. We agree to experiment with new identities without jeopardizing our real world credentials" [16].

3.2.1 Tools used: openFrameworks, GStreamer, openCV, Darwin Streaming Server, QuickTime Broadcaster

Getting deeper into the process implementation of the project, we can finally specify some of the functionalities of the applications featured in *B-wind*.

The video is captured at the forest by a network webcam and, by using *QuickTime Broadcaster*, the video streams through a wireless network to the server where the open software *Darwin Streaming Server* has been previously installed (FBAUL’s). From there it is sent, at last, to the installation. At that exhibition destination, *openFrameworks* gets the uncoded H264 video from its container, codifies and converts it to RGB, drawing the video that is streamed (currently with a lag of 9 seconds caused by the network, considering the tests with a good frame rate).

Finally, effects such as particle fields can be embedded after being processed in *openFrameworks*, constituting the video that is projected at the interactive installation.

To work with computer vision and real-time video manipulation, *OpenFrameworks* is the chosen tool – for its processing rates, as the code is optimized, it provides more responsiveness than other applications.

On image processing and computer vision issues, in order to use the video tracking as input data for the source of particles, movements and gestures are mapped as wind actions. Drawing storyboards for movement indexing and mapping is part of the method. These cataloguing processes that can be similar to choreographic notation.

The movements in the videos created this indexing are analyzed by OF for the pixel changes, so the movement is the only action in the scene. Everything that is stable is subtracted, allowing the movement to be identified and isolated. Mapping instances of wind is iteratively done throughout the development of the project. Lexical

explorations – the breeze, the hurricane, gust, gale – and correspondences create visuals and sounds in response to motion. Generically, these motion inputs are analyzed and inform the system of the changes occurred, then activate the creation of the correspondent desired output.

For streaming and recording the video, a prototype with *GStreamer* is fully working in Linux, but in MacOSX is still a complex issue, for it requires custom intervention on the libraries of the operating system. So far, the info has been passed to the developers of *openFrameworks* in order to develop a simpler solution to *use GStreamer* on *OSX*.

Work in progress encompasses the software code for *Arduino* and *openFrameworks* to control the fan by mapping the mouse X (/rtiviss_wip/bwind_fan_control), video streaming using gStreamer (/rtiviss_wip/bwind_streaming) and motion tracking experiences (/rtiviss_wip/bwind_tracker).

As for the hardware for recording and streaming, we'll be using AXIS 211W Network Camera, a wireless outdoor IP camera, which will allow for high performance with resolution video to be sent directly to the server by a wireless network. The superior image quality obtained with progressive scan at 30 frames per second is delivered in VGA resolution (640x480 pixels) [4].

Figure 11. Circuit with fan setup, and motion tracking tests.

3.2.2 Physical computing working with the Arduino microcontroller, sensors, motors, servos and fans

Overtaking space limitations, this experience recalls telepresence, too. A challenging idea is the power to apply the wind effect in the forest itself – the motion visual tracking in the installation will have a real amplified effect on the real trees and in real-time, by triggering physical devices producing the visual effect of wind on the framework visible in the video screen. Microcontrollers such as *Arduino* communicating with wind generators machines can be a departure point for accomplishing this behavior. Previous work with wind fans has been essayed by André [15] and Bruno and Rita [2], although in different contexts and scale.

Reinforcing the wind visual effects with real wind in the installation is a feature to implement, assuming the redundancy to enhance the visual impact of the image perceived by the user.

The *B-wind* prototype with the physical computing is also an iterative process that is now on the passage from a first working version to an intermediate standalone setup able to deliver a more powerful output.

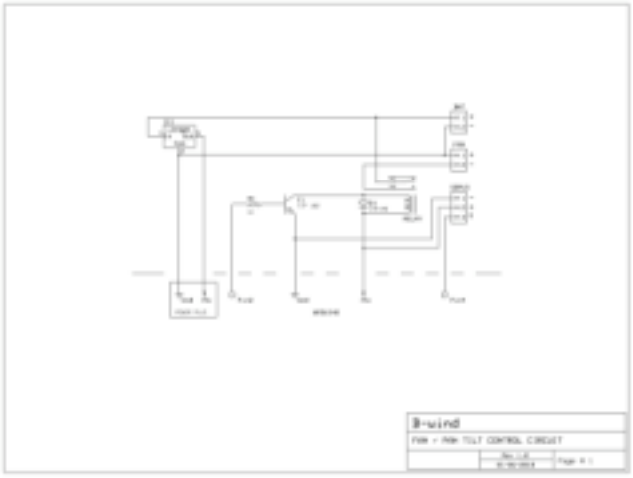

Figure 12. Arduino based fan electronic circuit.

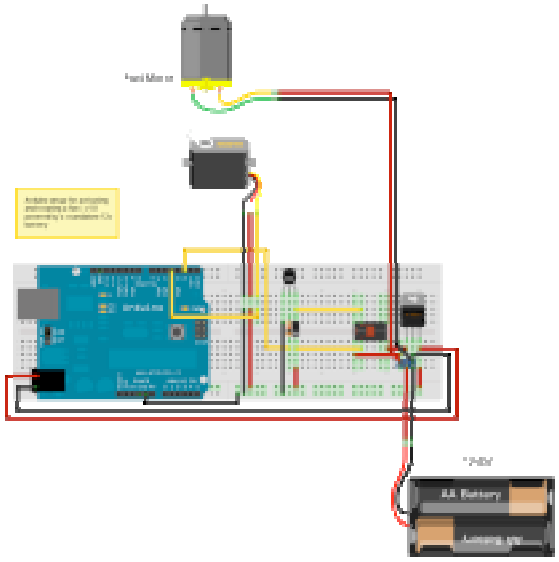

Figure 13. Electronic circuit represented using Fritzing.

3.3 Next steps

The very next iterations will take place at the AZ artistic residence by the present members of the multidisciplinary team developing the current project. Works will start with the setup of the interactive installation with the components developed so far.

The idea is to start by accomplishing the whole installation cycle, ie, the video is being captured, then sent to the installation, and there it's simply projected, followed by tracking the movements to extract control to the fans, send it back to the fans, and be able to create this feedback loop, which is when they see themselves at the installation, to manipulate the exterior, and then the image seen from outdoors is presented back at the installation. How to connect both? With graphical interfaces – visualizing movement, giving the participants the idea that they are, in fact, really

controlling something – it's the challenge to make users believe that what they're doing *really* has an impact. The implementation of the outdoor webcam will require field work at the surrounding area of *O Espaço do Tempo* with trees, and experiences on short distance wi-fi communication. Latency problems may prejudice the immersion feeling, so, in order to to reduce latency, testing the local network between the installation and the forest where the live video is being captured.

The other side to develop later is when the installation is working, to be broadcasted live in an online platform, which will be essential for tests, for remote control, and for feedback analysis.

Limitations to safeguard and overcome include telecommunications issues related with network signal, strength and speed. Power supply for wind production is currently being evaluated and tested. Options in process for an upgrade: decision on wether build a 12v independent circuit, to assume a potentially noisy unsustainable generator, or an expensive set [11]. A DiY kit is the preference to test, for the independence, concept coherence on reusing equipment, low power supply 12v and compatibility with renewable sustainable energies, being an open source good for learning, teaching, and creating instructables. A disadvantage may be a less expressive effect on real trees, which may imply on a smaller scale for the outdoor setup.

Wind machines as the ones used in cinema would provitde much more expressive and impressive visual effects, but would be dependent on support for high cost, and would be a closed platform.

Installation added functionalities will integrate an extra webcam at the installation. The use of cameras for video tracking open new possibilities, such as triangular movements.

The camera for tracking will also continually record video of users at the installation and archiving for task analysis and for qualitative and quantitative data source on users behavior and social impact, respectively, in order to analyze the overall feedback. Recorded video will also constitute raw material for video demos, with potential for expressive scenes selection, interaction systematization, cataloguing, and timelapses, to name a few.

Further developments integrate real-time video input from diverse places displaying correspondent day times, and a large scale for a naturally immersive environment.

Figure 14. QT Broadcaster and OF communicating!

4. CONCLUSIONS AND FUTURE WORK

B-wind was conceived in the scope of a PhD research project exploring networking practices and actions that contribute to change the current behavior regarding environmental protection, promoting new activities to move society towards more inclusive modes of production and sharing knowledge for the design of a better world. It is currently being actively developed in a collaborative residency by members of the three Audiência Zero creative labs in Portugal – LCD, altLab, and xDA – and is scheduled to premiere at the residency's result showcase and exhibition during the month of July 2010 at *O Espaço do Tempo*.

Efforts will be done to have statistics data on the users' input when experiencing the *B-wind* interactive installation – valuable information that will be processed and be used to assess users' engagement and effective results. Realizing that, the tracking camera will be continuously archiving what it is recording to inform the system for the fan movement and the particles effects, and an extra camera will be added at the installation, shooting from a panoramic point of view, where

An ever-growing database will be constantly archiving the video footage. Archives are to be used as an information database, and also as a poetic source for artistic creation. They will be used both as a broad source of raw video regarding nature for artistic experimentation and for rapid prototyping, providing access to diverse resources, such as footage to be compressed, and also for the most diverse educational and research purposes related to the theme.

A further output of this task will be in the form of guidelines for using generic wireless webcams in remote sites, so that the results of this project can be repurposed in other places and contexts with related content.

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