ARTiVIS DIY Forest Surveillance Kit

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Abstract

Surveillance has become ubiquitous. From video cameras in public places to Internet-enabled devices, wireless sensor networks and flying drones, privacy is becoming a scarce resource. What if, instead of resisting the use of surveillance technology, we could harness it for the public good? *ARTiVIS* is a research project exploring how real-time video can be used as a powerful tool for environmental awareness, activism and artistic explorations. *ARTiVIS* aims to create a citizen-run peer-to-peer forest surveillance network through the use of affordable open source hardware and software, such as the DIY kit we are developing both online and in community workshops.

Keywords: Real-Time Video, Surveillance, Sustainability, DIY, Open Hardware, Internet of Things.

Fig. 1. *ARTiVIS DiY Forest Surveillance Kit* development during workshop, kit components, and deployment in the wild. Photo © Mónica Mendes.

Living in places that have been extremely exposed to forest fires like Portugal [1], makes us very sensitive to the destruction of forest patrimony by fire hazards, which also applies to a world scale. In fact, "Globally, 95 percent of all fires are caused by various human activities" [2]. Despite previous measures [1, 3, 4], a serious approach regarding prevention remains pertinent and urgent [2].

ARTiVIS – *Arts, Real-Time Video and Interactivity for Sustainability* [5] – is a research project in digital media exploring the use of real-time video of forests for sustainability purposes. The project's aims are:

» To create digital contexts of aesthetic contemplation of nature by exploring the beauty and danger of trees and forest fires;

» To raise awareness on the natural environment by establishing a bond between people and forests, using technology in artistic contexts;

» To empower local populations with a way to share the beauty of their forests and help prevent forest fires through monitoring by online communities;

» To explore new ways to use real-time streaming video of forests for awareness, activism and artistic purposes;

» To help prevent forest fires by extending surveillance systems to on-line communities through "the emotion of real-time" monitoring.

To achieve these aims, we are creating interactive experiences that are meant to stimulate awareness and prevention of fire related damages to the forests, while engaging community members to participate with a sense of wonder and enthusiasm.

The ARTiVIS outputs are a tradeoff between aesthetic pleasure from contemplative observation and interactive experiments with real-time videos of forests. With the goal of promoting a more sustainable world through digital media and experimental design, the outcomes of this iterative process include:

» Interactive installations for public exhibition that use real-time video of forests as raw material, such as *B-Wind!* [6], *Hug@ree* [7], and *Play with Fire* [8];

» The prototype design of an online video sharing platform, in order to display real-time forest videos and corresponding artistic explorations, working as the ARTiVIS community hub;

» The design of an open source hard-ware and software DIY (Do-It-Yourself) forest surveillance kit that repurposes surveillance technology to bring people and their communities together to protect their forests. Resulting video streams and collected data will be uploaded and become part of the online platform network.

We foresee that these interactions will provide the experience of contact with nature – contributing to a feeling of belonging, strengthening the relationship with the forest, and leading to local communities' growth and empowerment. The online platform was initially conceived as the core output of the ARTiVIS project, under the general concept of participative video surveillance [9]. This platform combines existing technologies that are customizable and that provide the needed resources for fast prototyping, enabling a proof of concept to evaluate the structure proposed. The ARTiVIS platform is conceived as a libre and open framework, with open data free for use and development, using open formats, and with open content. Altogether, these factors contribute to enhance creative explorations with the real-time video stream or video archives of the forests.

The platform is designed to link forest video streaming nodes provided by members of the community with consumer nodes like art installations or community surveillance users. The goal is to achieve a fully distributed peer-to-peer platform for forest video streaming. This openness is becoming a mainstream approach in the design of interactive environments and was adopted as an effective setting for fast prototyping and to empower community sharing.

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Page numbering begins at 1 at the start of the paper.

As with contemporary development methods in digital media, ARTiVIS also explores the potential of experimental approaches in local contexts where mobility is crucial for its implementation, like real-time video connectivity, contributing to local communities' growth and empowerment. Moreover, "mobile devices and network infrastructures open the possibility for new forms of information access or storytelling while visiting physical places" [10].

This paper presents the design and development of the *ARTiVIS DIY Forest surveillance Kit*. The initial motivation for this kit came from the limitations found in standard IP Cameras during the development of the interactive installations in the ARTiVIS project. These cameras usually do not allow customization of their imaging sensors and lenses for different purposes, have very limited ability to interface with external sensors and are limited to using wi-fi and ethernet for networking.
We have designed this kit to overcome these limitations and to empower individuals and communities to deploy autonomous video streaming nodes that connect to the ARTiVIS network and can be used as source material for aesthetic contemplation, environmental activism and artistic experimentation.

Related Work

Community-run sensor networks are an emerging paradigm of social empowerment made possible by the combination of open, low cost hardware and Internet connectivity. Existing examples of these networks can be found in the *Safecast* network for radiation monitoring [11], the *AirPi* network for weather monitoring [12] or the *Blitzortung* network for storm detection and localization [13].
Over time it has become significantly easier to create these sort of networks, by taking advantage of open source platforms like *Thingspeak* [14], *MediaSense* [15] and *Nimbits* [16]. More recently, we have noticed the appearance of projects like *Sapphire* [17] and *Smart Citizen* [18] that combine an open, customizable hardware base with a generic cloud infrastructure.

The interest in opening up imaging hardware is not new. While the *OpenIPCam* project [19] provides a solid Linux-based replacement firmware for some popular models of commercial IP surveillance cameras, the *Apertus* project [20] goes one step further and hosts a community developing a high-definition professional quality digital video camera from the ground up.

The server infrastructure needed for hosting a centralized video streaming network is an important concern for a community-based project. In order to reduce these costs and to avoid having a single point of failure in our network, we are looking into peer-to-peer video streaming strategies such as those proposed by the *Goalbit* [21] and the *P2P Next* [22] projects.

Refarm the City is a good example of the kind of approach that has informed the design of the ARTiVIS hardware kit for surveillance. Their work is based on community developed open source hardware sensor nodes for urban farmers [23]. Additionally, their field work strategy of knowledge dissemination is undertaken through workshops organized in local communities in areas in which there is good potential for becoming new urban farms.

Another important reference is the *Vigília Open Design* project. This system involves the development of new sensors that enable the automatic capture of a wide variety of field data including images in real-time, which allow people "to draw tables with indices of fire risk, to detect fires in the shortest time, to act faster and in coordination in case of fire, and to accurately evaluate the real impact of fires already extinct" [24]. *Vigília Open Design* has some overlap with the ARTiVIS kit, and we are paving the way for future collaboration.

Kit Design

An *ARTiVIS DIY Forest Surveillance Kit* is composed of a series of hardware modules that can be chosen from common off-the-shelf parts depending on cost, power, network bandwidth or infrastructure restrictions. These hardware modules are controlled by a set of software modules connected to the ARTiVIS online platform. In technical terms, the kit is provided as:
» Open documentation that allows anyone to build similar hardware;
» An open hardware reference implementation that is used for community workshops and to develop the ARTiVIS interactive experiences;
» Open source software that runs on the hardware and can interface with the platform.

Hardware Components

The *Power Module* provides power to the whole kit. For the kit's intended function in remote forest locations it is important that it is autonomous in terms of power. This can be accomplished by using a rechargeable power supply, such as a lead or solid state battery coupled with a generating power source like a solar panel, a small wind turbine or a fuel cell.

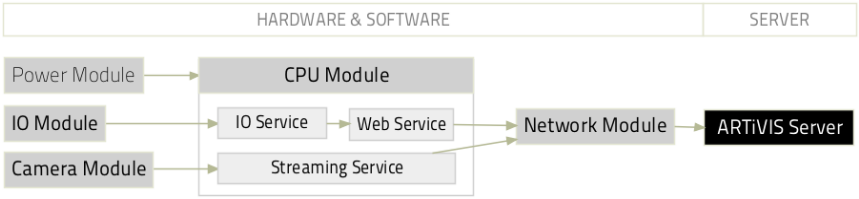
The *CPU Module* (Central Processing Unit) connects to all the other hardware modules and runs the ARTiVIS node software. Since the kit's design should take into account both portability and energy efficiency requirements, our first prototypes were based on the *Raspberry Pi* [25], a popular low-cost single-board computer.

The *Camera Module* connects to the CPU Module and provides the images to the CPU for live video streaming.
At its simplest configuration, the Camera Module can just be a good USB webcam connected to the CPU Module, but for a more integrated solution we are looking towards interfacing high quality image sensors like the Raspberry Pi Camera Module.

The *IO Module* interfaces the CPU Module with a set of sensors and actuators that can be read and/or controlled remotely. For this we can use an *Arduino* [26] board or a similar microcontroller-based Input/Output hardware or rely on the CPU module's native GPIO (General Purpose Input/Output) functionality.

The *Network Module* provides an interface to the Internet for the CPU Module. In the first prototypes we used any network connectivity available to the test board, like wi-fi or ethernet, but for the final reference design we will make use of external USB modems that provide 3G or 4G/LTE connectivity as

Fig. 2. *ARTiVIS DiY Forest Surveillance Kit* system architecture.



these are more likely to be available in remote forests than wifi or wired Ethernet.

Software Components

The kit's CPU Module runs a set of software applications that allow the kit to perform its task and interface the hardware with the online *ARTiVIS server*.

The *Streaming Service* is the heart of the system. At its core there is a video processing pipeline based on the *GStreamer* framework [27] that captures the live images from the Camera Module, encodes them using a free lossy codec like *Ogg Theora* [28] or *WebM* [29], and streams them to the ARTiVIS server for online distribution. It could also optionally record the video locally for backup purposes.

The *IO Service* interfaces with the IO Module hardware, multiplexing access and providing to applications a "virtual firmware" API that abstracts the underlying hardware, thus permitting access to the sensors and actuators connected to the IO Module. It also provides a *Websocket API* [30] that allows for external control and connectivity to and from the ARTiVIS server to enable the uploading of sensor data to the platform and the downloading of actuator commands.

The *Control Service* is a web application that runs on an embedded web server on the CPU Module and provides a simple way for the kit's owner to control and configure it.

The *ARTiVIS Server* is currently based on *Icecast* [31] as a streaming server and we are exploring the use of open data syndication platforms like *GISS* [32] for video and *ThingSpeak* regarding sensor data.

Development Process

Early development work on the kit's design was performed throughout the development of the ARTiVIS interactive installations. Initial hardware prototypes were done during the first part of an artist in residency program at *Madeira Interactive Technologies Institute* [33], to connect with the *SINAIS* project, and are being further developed in order to become part of the ARTiVIS project's final setup.

Recognizing that "to prevent and control destructive forest fires, the involvement of communities is crucial" [2], we propose to foster people's participation from the project's outset, involving the ones who wish to participate in the expansion of the raw material database through community workshops. In these workshops, participants can assemble an open hardware kit for forest surveillance, help with the kit's development and experiment with real-time video streaming for creative applications.

By promoting these community workshops, not only can we teach participants how to set up their own ARTiVIS node, but we can also explore with them the potential of participatory surveillance through the possibilities offered by real-time video streams of forests.

Conclusions and Future Work

In this paper we have presented the design and development of the *ARTiVIS DIY Forest Surveillance Kit*, a flexible open hardware kit for video streaming built from low cost open hardware components and custom open source software. The kit has been successfully used as a video source in the deployment of ARTiVIS interactive installations and as the base for streaming video experiments in community workshops.

Current development work involves improving streaming reliability and the user experience regarding the setup and configuration of the kit. Future work will be focused on building a solar energy module to allow testing autonomous deployments in forest locations, and on developing the IO module for connecting sensors and actuators.

Further iterations will allow the registration process for the ARTiVIS online platform and a broad dissemination of this open source hardware and software surveillance kit [34]. Moreover, we foresee a growing developer community sharing "the emotion of real-time" – whether this means that they adapt the project kit to specific environments with other purposes (such as replacing expensive hardware setups that remotely watch animal behavior), collaborate on maintenance, or even pursue unanticipated projects.

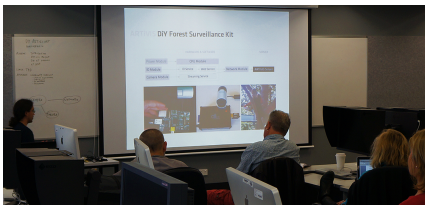


Fig. 3: Presentation of the DiY Forest Surveillance Kit workshop at ISEA 2013 in Sydney. Photo © Mónica Mendes.

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