Accumulated Memory Landscapes: Real-time On-line 3D Landscapes Based on Prosthetic Memory Data

Abstract

This paper frames the conceptual workspace and development documentation of the art project titled *Accumulated-Memory-Landscapes* (AML). This project is an inquiry on how technology can mediate and enhance human memory by expanding the possibilities of interaction, experiencing and sharing of this. AML appropriates the 3 main steps involved in human memory (Encoding → Storage → Retrieval) and traces parallels between the biological human process and the technological devices and algorithms used for capturing, storing and recalling data. Using a portable wireless electroencephalogram (EEG) and a smart phone, we have built a wearable system able to measure attention levels in any given time. The device records significant moments of the wearer, in the form of image sequences and audio clips, which are then sent, in real-time, to a server that algorithmically processes them. The result is an immersive 3D procedural landscape built from these memories; a space where the wearer and any other individual can experience and share these accumulated memories in more abstract and spacial ways.

Keywords

Memory, electroencephalogram, wearable technology, 3D on-line environments.

Introduction

Wearable technology, cloud computing, and data visualization tools are among the most relevant consumer technologies currently being developed. As mobile devices increase in power and decrease in size, computational devices get closer to our bodies; filling our pockets with limitless possibilities. Likewise, cloud computation, storage and data retrieval are becoming more efficient as mobile networks increase the speed for Internet access and data transfer. With these technological achievements in mind, the idea of personal clouds has become a popular one; spaces for dumping all sorts of data forms captured and generated by those who use mobile and wearable technologies.

Data architects, designers and artists struggle today with the classification, interpretation and representation of the massive cloud of data accumulated in servers. The *what to do with?* question is one which presents new challenges. What for scientists and engineers represent evidence for further biological research or technical development, for artists opens a whole new cross-boundary field of experimentation; where the locality and privacy of the human body and mind expands from the physical and biologically limited space, into the intangible and limitless digital realm.

AML arises from the need of understanding this transitional space between the intimate analogous and the open digital. The exploration starts by redefining ways of interaction between humans and machines in the context of the artwork, and concludes with the design of digital forms of representation for the data outcomes of the process.

Motivation

AML started as a workshop inspired by Jim Campbell's *Accumulated Psycho*, a piece which collects and interprets by averaging the monolith of cultural memory stored in Hitchcock's film *Psycho*.[1] Campbell's piece transmutes the original audiovisual object from its traditional film narrative into contemporary forms of data visualization and representation. By averaging each frame of the film with its previous one, in terms of the entire dataset of pixel information contained in it, while leaving the original audio intact. The piece highlights significant recurring elements in the image and dissolves the rest; it creates a new form of storytelling out of the old one.

AML later became its own inquiry process which aimed to take the idea of captured memory further into a more experiential instance by appropriating ideas and techniques from life-logging technologies.[2]

Conceptual Background

Our forms of interacting with computers are gently transcending the initial limitations presented by the screen, keyboard and mouse, and are currently exploring other forms of interactivity; these could be regarded as more natural user interfaces, closer to human body language and expression. This seamless interaction between user and computer blurs out many ideas, often given for granted, in traditional Human Computer Interaction (HCI) theory; where the human and the machine are inherently separate elements of a single process. [3]

The new paradigm that arises from modern wearable computation highlights a model where the computer is no longer a separate entity and becomes an augmentation of the user's body and mind. Such model proposes the emergence of intelligence as a result of a feedback loop

between a human and a computer, also referred to as humanistic intelligence (HI). [4]

In the context of Accumulated Memory Landscapes (AML), HI establishes a fundamental theoretical and technical framework. The created system for this project involves wearable computing to identify significant moments on the life of the user and capture these, as images and audio, without his/her consent. In other words, the system interfaces with the wearer's body seamlessly and it does not require conscious actuation from his/her part.

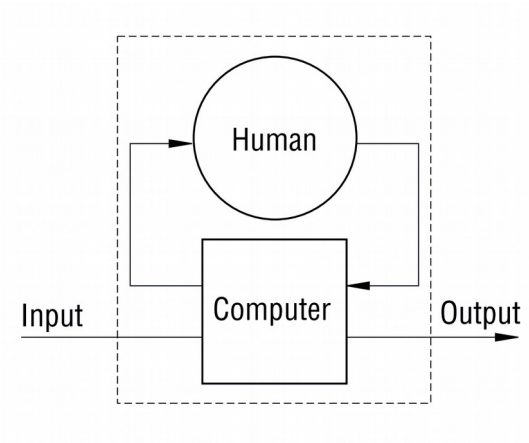

Fig 1. *Humanistic Intelligence Feedback Loop*, Steve Mann, University of Toronto, 2001.

A Memory Prosthesis

The main purpose of the wearable device designed for AML is to act as a memory prosthesis; a mechanism which seamlessly participates on the user's encoding and recording of experienced moments. In this context it is imperative to have clarity on the fact that such a system proposes the enhancement of memory rather than an precise imitation of the biological process. Therefore AML traces a parallel between human memory and technological processes of data capture, storage and retrieval, thus enabling a machine to act on behalf of its human user.

One way of defining memory is as our ability to encode, store and recall information in the form of experiences; a three step process. In neurological terms, this can be regarded as parallel signal processing threads which involve the activation and interaction of certain neurons; these will eventually be re-called to execute the recorded pattern while retrieving the memories; these are often presented to a human in the form of images or sounds. [5]

In order to enable an artificial device to act as a memory prosthesis, we first had to define the technologies involved and their significance in the process of capturing relevant human experiences as a audiovisual elements.

In general terms, science mostly agrees on attributing the brain as the most relevant organ involved in human memory. Therefore, enabling our wearable system with a comfortable, easy to use and wear, portable and wireless electroencephalogram (EEG). The Neurosky Mindwave Mobile, one of a handful of consumer level EEGs which have enabled artists and designers to explore brainwave activity and its implementations in creative practices. EEG technology is widely used by neurologists and psychologists worldwide to study how the brain behaves during different experiences and states of mind, including the previously described memory process.

There is a vast body of research regarding the classification and interpretation of EEG data, types of memory and their relation to different areas of the brain. [6] Nonetheless our particular approach was not the development of EEG classifiers for determining human emotional or psychological states, nor defining memory types or mimicking how memory happens in the brain. Our aim was augmenting memory through technological means, based on moments of high attention. In other words, regardless of how the brain operates during the encoding process of memory, our goal was to enhance the user's experience by providing him/her access to moments which registered high focus or high levels of attention during the waking state. For this, we appropriated Neurosky's Esense Attention algorithm, already enabled in the portable EEG used during the process. [7] The Atkinson–Shiffrin memory model demonstrates how attention operates during the act of memory; showing enough evidence to support our prosthetic memory model. [8]

In our model the artificial encoding process happens by means of the portable EEG and smart phone (camera and microphone), the recording happens due to cloud computing (on-line server) and the retrieval element (remembering), in our model, becomes the client/browser application.

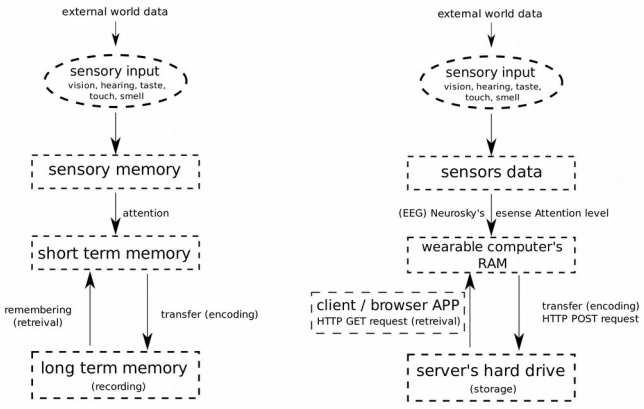

Fig 2. *Parallel between Atkinson–Shiffrin memory model and AML's memory prosthesis model*, AML team, 2015.

Augmenting The Brain's Capabilities

On the other end, our model proposes the use of an on-line server to enhance the natural brain capabilities in very basic ways. Naturally, human beings are equipped with long term memory storage which allows later retrieval of data, nevertheless the sharing capabilities of these memories are limited to the subject's ability to

accurately express him or herself by means of language, body expression, speaking, etc.

AML opens a whole new dimension to the idea of sharing and experiencing these memories by using a public virtual space to accumulate these and render them as 3D immersive environments. This not only enables the user to recall and experience his/her memories as a space but also allows anyone to experience other people's intimate space of memories and moments of life.

When a user enters a memory-scape, he/she find him or herself embodying a first person point of view within a digital space which feels, in many ways, like a video game. The user can walk and look around, climb hills and go under water. Once in a while he/she will notice the audio clips captured by the memory prosthesis somewhere within the space; as these sounds are randomly distributed around the landscape. The sounds are untouched audio-clips from a particular moment in the owner's life. Each clip is kept intact as a way to anchor the memory (abstracted as a 3D terrain) with the original life experience.

AML proposes a method through which memories become a space and object of exploration, interaction, sharing and experimentation.

Description of The System

The system is comprised of three main components: the wearable device, a server for cloud computation and a client/browser application.

The Wearable Device

Our memory prosthesis prototype uses ready made technologies with customized software in order to achieve a very simplified version of the first step involved in human memory; the encoding.

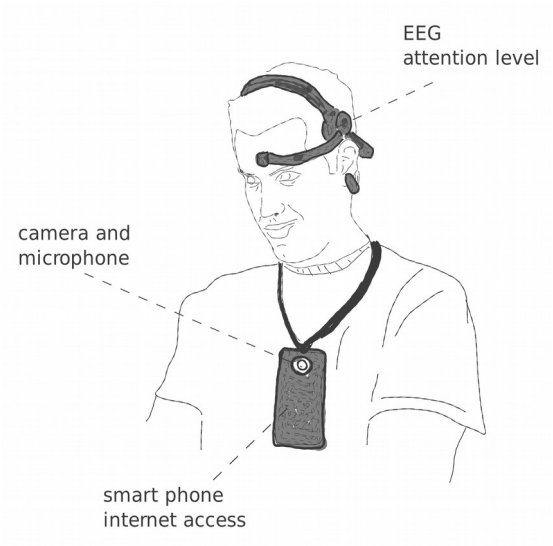

Fig 3. *Sketch of wearable system*, AML team, 2015.

As mentioned earlier, within the context of AML, we used the attention classifier develop by Neurosky and embedded in all of their consumer level EEGs. Therefore, the wearable device developed for AML basically reads the level of attention of the wearer every second and sends it, via blue-tooth, to the user's phone. The application on the mobile device then compares the incoming value with a given constant threshold and determines whether the person is having a moment of significant focus or not. Every time the level of attention reaches or surpasses the threshold in the algorithm, the phone starts capturing images of the wearer's current experience, through the embedded camera on the device and records audio through its microphone. This initial step of the total AML system concludes by sending the captured footage to the on-line server awaiting to process the images and render the 3D memory-landscape.

The Server

On-line, a server bridges the real-time activity happening on the wearer's side with the final outcome presented to any user who enters the memory landscape through a web browser. The server constantly listens to any HTTP request emitted by the wearable device, this request comes in as a POST containing the binary data of the captured image. The image is then reconstructed on the cloud and converted into a gray-scale picture. The algorithm takes the previously recorded and processed image (technically the accumulation of all previous images) and average its pixel information with the new image. This process repeats itself indefinitely as long as there is a wearer posting data to the server. The result is a 2048px by 2048px composed image which blends all of the visual memories of the wearer into one single gray-scale picture, this, later, becomes the height map of the 3D landscape rendered every time a client calls the server through a browser.

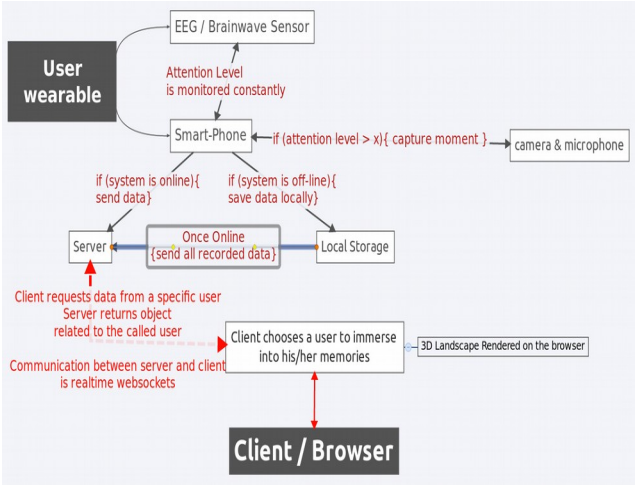

Fig 4. *System's elements interaction*, AML team, 2015.

In order to keep the entire system dynamic and scalable, the server was programmed to allow new users to register and create an address to store the captured memories. Every wearable device is identified by the server through its unique ID, therefore during every single HTTP POST request done by the wearable device, the server responds by allowing the writing and reading of the collected memories in and from the unique path assigned to that particular ID. This allows the entire application to grow dynamically without constant administration and modification of the server.

The Client/Browser Application

When a client logs into the server a series of scripts get executed. At this stage the system uses WebGL technologies to create the on line 3D environment. 3D rendering is always a slow process and the fact that this whole application runs on the cloud makes things even slower. In order to optimize the rendering and therefore smoothen the client's experience, AML uses shaders technologies and WebGL. [9] Some of the code involved in the development of AML was possible thanks to the research of MOVES Institute in Monterey, CA. [10]

The main script involved on the landscape generation can easily be broken into a few elements:

- Retrieval of the memory data from the server.
- Height map generation.
- Scene creation, lighting, camera and rendering.
- Client access and experience.

From this point onwards it is important to clarify that when referring to the *client*, we mean anyone with a computer and Internet access who browses into the AML server.

On the landing site the client chooses which memory landscape he/she wishes to experience and immediately logs into the selected 3D space. During this process, the server catches the ID (wearable device/user identification) collects the accumulated memory image (averaged gray-scale picture described previously) and iterates through every single pixel of it. Lets keep in mind ant this point that the image's dimensions in X and Y is equal to the width and depth of the generated 3D world. In other words we have an image of 2048 pixels on the X axis and 2048 pixels on the Y axis which directly correlates to the 2048 pixels wide (Y axis) and 2048 pixels deep (Z axis) of the 3D environment. At this point the world, although still invisible to the client, is a 3D space containing only a plane geometry (ground) of the same dimensions of the space. To put it differently, the browser renders a plane mesh which takes its total number of vertices from the the total amount of pixels in the composed memory image and distributes the vertices along the X and Z axises according to the position of each pixel, at the same time it generates a height for each vertex (Y position value) based on the amount of color of the corresponding pixel. This Y position of each vertex is achieved by iterating through each pixel in the image and retrieving it's gray value; a number within the range of 0 to 255. The obtained integer is then mapped onto the y position or height of that particular vertex on the plane mesh geometry.

After a few seconds, the client finds him or herself immersed in a 3D landscape directly rendered from the accumulations of memory images from a particular user.

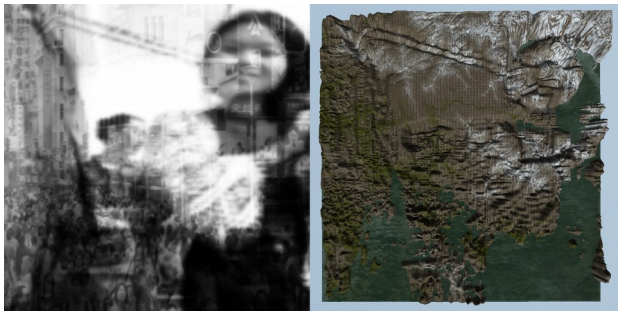

Fig 5. *Comparison between accumulated memory image (left) and aerial view of 3D generated landscape (right),* AML team, 2015.

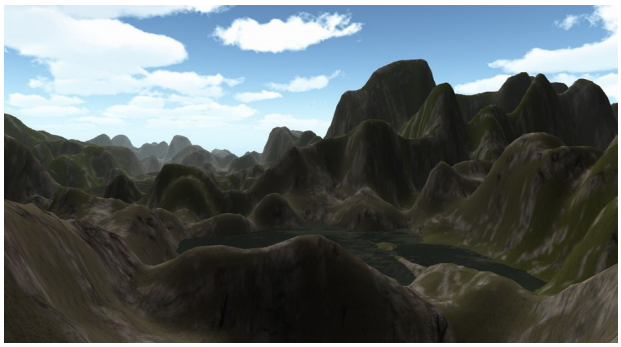

Fig 6. *Real-time Rendered Landscape,* AML team, 2015.

Experiments and Results

Besides the original proposed usage of the system , other experiments were conducted during a public workshop.

One of these involved the recording of people's brain activity while being exposed to 10 different well known art paintings. The data collected was later used to run the images (paintings) through an algorithm that accumulated these (blended them together); giving more importance, in terms of the influence of the pixel data in the averaging and blending process, to those images which captured more attention from the subject/user during the observation test.

The averaged image was then used to render a 3d-online landscape. Any user can enter this space and experience it from First Person View, he/she might also encounter the artworks used during the experiment inside this landscape; almost like totems inside this world.

Fig 5. *Artworks / Paintings used during the experiment*, AML team, 2015.

Fig 7. *Landscape showing some of the totems created from the artworks/paintings*, AML team, 2015.

Fig 8. *Comparison between accumulated memory image (left) and aerial view of 3D generated landscape (right)*, AML team, 2015.

Conclusions

In this paper we exposed the process behind the production and testing of Accumulated-Memory-Landscapes (AML); a system which enables the recording of memories of a particular user in audiovisual forms and processes these through an on-line application which creates 3D environments out of the collected data. We discussed the conceptual framework from which the project is born and we proposed ways of addressing these ideas by means of technology.

Although AML is, in principle, proposed as an artwork, it opens a pertinent discussion in various fields of technological applications. AML rethinks the current forms of human-computer interaction by proposing a more natural and seamless way of relationship between user and machine. It questions the boundaries of the human body and psyche by extending some of the most intimate aspects of the human being into open/public digital spaces. The research brings valuable information on how to address the complex topic of human memory through simple technological user interaction without deepening into the less known aspects of the brain and mind.

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