PM

Weather-Driven Interactive Video

MASTER'S DEGREE PROJECT

Firmino Trindade Coutinho

INTERNATIONAL MASTER OF INTERACTIVE MEDIA DESIGN

UNIVERSIDADE da MADEIRA

A Nossa Universidade

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Abstract

To build this weather-driven interactive video feature, one ingredient, was necessary to know the conditions of the environment of the user, to do so with greater accuracy, a simplified version of a weather station was made using an Arduino and some sensors to measure the environment, the weather of the user's location. Another necessary element, was a tool that could use this collected data and convert it in a meaningful way to the user, contextualise the video content. A digital prototype was developed, combining the framework Processing and the data from the Arduino, that would present the user, the viewer with a video, story that would be contextualised to the user environment, current weather conditions. These videos were a set of 6 parallel stories, not simple weather effects but live video production, aiming to improve the connection with the users between the scene actions and their own environment. To evaluate the relationship between the video weather effects, its content and the user's context, tests were made to measure the impact of this feature on the user experience, resulting in insights, that help to influence and enhance the user's experience. Some suggest that, contextualising the video setting to the user's current environment setting, might not be ideal, even detrimental while other might be beneficial to the user experience.

Resumo

Para construir este projeto de vídeo interativo orientado ao clima, era necessário saber as condições do ambiente em que o utilizador se encontrava e, para fazê-lo com maior precisão, foi construída uma versão simplificada de uma estação meteorológica usando um Arduino e alguns sensores, que fariam a medição do ambiente, da localização do usuário. Outro elemento necessário, era uma ferramenta que pudesse utilizar estes dados e convertê-los, de uma forma significativa para o utilizador, contextualizando o conteúdo do vídeo ao seu ambiente para enaltecer a sua experiência. Para tal, foi desenvolvido um protótipo digital, combinando o framework Processing e os dados do Arduino, que apresentaria ao espectador, um vídeo, uma história que seria contextualizada ao seu ambiente, às suas condições meteorológicas atuais. Estes vídeos são um conjunto de 6 histórias paralelas e não apenas simples vídeo com efeitos meteorológicos. São produção de vídeo ao vivo, com o objetivo de melhorar a conexão com os utilizadores, melhor a confecção entre as ações da cena e seu próprio ambiente, o do espetador. Para avaliar a relação entre os efeitos meteorológicos do vídeo, o seu conteúdo e o contexto do usuário, testes foram feitos para medir esse impacto na experiência do utilizador, resultando em percepções que ajudaram a influenciar e aprimorar a experiência do usuário. Estas descobertas sugerem que, contextualizar a configuração do vídeo com o ambiente atual do espectador, não será o ideal, poderá até mesmo ser prejudicial, enquanto os restantes cenários podem ser benéficos para a experiência do utilizador.

Keywords

Interactive Video; weather-driven; site-specific; location based; storytelling.

Palavras-Chave

Vídeo interativo; conduzido pelo tempo; site específico; baseado em localização; narrativa;

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Chapter I – Introduction

Sensors are devices with the ability to measure physical attributes happening in real time, transforming these readings into signals that people could read. The easy access and combination of sensors, microcontrollers and software prototypes allow the development of numerous applications that can integrate data from the physical environment in multimedia applications. Such integration opens novel ways to perceive, visualize media content and experimentation.

Nowadays, sensors are a lot more than single physical readers, their technology has widened up so much to the electronics stream that can be find everywhere, they are almost ubiquitous, they are used in medical fields, industry, military, investigation, in education, in the streets, in our house, in numerous devices that we use today, such as our mobile phones that have multiple sensors, touch sensors, light sensors, accelerometer, gyroscope, magnetometer, GPS, proximity sensor, microphone, finger print sensor and others more.

With the Internet of Things (IoT) and evolution of other technologies, sensors created a new space in the industry, allowing the appearance of new technologies, newer applications, new use cases for older technologies, an evolution with totally new devices(What Is the Internet of Things (IoT)? I Oracle Portugal, n.d.). IoT's systems have such wide range of applications, so much flexibility that their implementations are only limited by Human imagination, thanks to this, these systems are being adopted, used in other ways more creative and artistic fields(How Artists and Galleries Use IoT Networking to Create Interactive Art Exhibits, n.d.), with functions more relevant than simple monitoring or controlling values or data.

Recommendation systems are a very common method that users encounter nowadays, from social media posts to eCommerce platforms to popular streaming platforms, whether they are aware of it or not. Following the example of YouTube, it recommends video or playlists based on the videos you have watched, videos you have searched, videos that have been watched by similar people and if those have performed well, but these recommendations don't consider the user experience, only tendencies (Nadeem, 2018).

Some studies examine the impact of weather conditions, as an external factor, on television use (Eisinga et al., 2011; Zong et al., 2017), more viewing time on bad weather condition days, with more time in entertainment programs and the opposite in good weather condition days, with more focus on information programs.

Objectives

- Combine various sensors, integrate them with a software prototype that will allow to visualize video content based on the physical environment,
- Explore the relations between the physical environment, the visual effects and the impact of this interactive feature on the user experience.
- Find out if transforming the weather in the video, film or information program, can we apply this knowledge to a recommendation system,
- Find out if the user location, his mood or local weather patterns can be used to for better user experience and suggest a video or playlist,
- Find out if there is an impact on user experience or watching patterns?

Contributions

To find out the impact of this conditions, a physical prototype was built, a simplification of a weather station, to measure the local weather conditions and connected to a digital prototype that produces a response in video, contextualising the video and vice versa, with weather of the user location.

At first, the physical and digital prototype to deliver a contextualised answer in video based on the local weather conditions was developed. For a better evaluation of the impact of this feature on the user experience, three identical storylines were written, and with some post-production, they could morph into six timelines. The experience was evaluated using methods like PANAS questionnaire, an interview, observations and a thematic analysis that provided insights to improve the user experience, demonstrating the relationship between the user own environment and the visual effects of the video.

Prototype tools

A current example of this easier access and adoption to sensors, is Arduino(B_E_N, 2013a), an open-source hardware and software system, a microcontroller not only used by developers but also by designers, creatives and curious people to expand and test the limits of their ideas. This open-source movement also contributed to the sharing of knowledge and propelled a collaboration between people, pushing boundaries, contributing to innovation and creativeness. With this development also came the rapid prototyping, new ideas become a reality very quickly and very cost-effectively.

A second example of this adoption, is Processing(Processing.org, n.d.), a software sketchbook and a platform to learn how to code in the context of visual arts, made to literate people in the visual arts, students, designers, within technology to use processing for learn and prototype their ideas and imagination.

Visual Effects

Visual effect can be described as any imagery created or modified for a video, film or any other motion media, that could not be made or captured during the live action shooting(Okun and Zwerman, n.d.). Most of this process takes place in post-production stage, after the initial images were captured and there is enough footage to begin the editing. Visual effects can be introduced in live-action scenes, from simple graphical objects, to modified characters, add more complex environments or fully build a digital set with fully computer-generated characters.

Setting, Weather

Setting is the surrounding, physical location, the time, the era, the moment of a story. Carefully selecting the setting, a mood can be set to the scene, can evoke feelings or even can revive memories.

In this project, one detail of the setting was more focused, the Weather and how it could affect the story. It´s role, its influence may transform or even prevent a character progression in the plot. Rain, storm, fog, snow, sun, temperature, all these affect the story somehow.

New video experience

As Benjamin Hoguet said, *“Interactive storytelling is the art of telling stories enhanced with technological, social or collaborative interactive features to offer content adapted to new behaviours in a rapidly changing cultural ecosystem.”*(Hoguet, 2014)

Although this project is not focus on interactive storytelling per say, it applies part of this concept, uses an interactive method to tell a story, conveys information between two ends using an intermediate medium, as a feature to transform the story, and it is adapted to a new ecosystem, the sensors domain.

The point that sets this experiment apart, the people power of choice that Hoguet refers, the transformative decision of the viewers to change the story line, this power is left to the “machine”, the medium that conveys the story to the user.

Chapter II - Literature Review/Related Work

In this chapter a summary was made of the work found related to the topic Contextualized Video Visualization and Editing. In the literature review, it was not possible to find another work that resembles the way this project was implemented, more diversified search became necessary to find relationships with the theme proposed in this thesis.

2.1. Automatic Storytelling

Computational Video Editing for Dialogue-Driven Scenes

Computational Video Editing for Dialogue-Driven Scenes(Leake et al., 2017) was a system to edit video of dialogue-driven scenes. The input of their approach was a typical film script and multiple video takes of the same scene, various cameras capturing different frame angles of the entire performed scene. Based on the user chosen set of idioms, ways for conveying action(Schofield and Christie, n.d.) and emotions, the system automatically selects the most suitable video take for the user input and each line of dialogue, generating sequences of two/three seconds align in the timeline. The system builds multiple narrative variations of the same story, it adds new significance to a scene by using variations of the camera framing, transforming its value, building new meanings and emotions to a scene.

Video Editing Based on Object Movement and Camera Motion

In this paper(Wang and Hirakawa, 2006), the authors present an automatic video editing software based on object movement. Using a source video, the users would select an object that they wish to be centred in the video frame and virtual camera would track the selected item, automatically constructing a new video with those camera movements. By selecting different objects of the same scene, the user could manipulate the focus of the spectator, adding or removing significance to the select object. The project being in a preliminary state, the functions were a bit limited, so it misses the more complex editing rules and dynamic camera motions, to add or change the emotion and context of the scenes.

2.2. Tangible Video Editing

Office Voodoo: A Real-Time Editing Engine for Algorithmic Sitcom

The project *Office Voodoo* was an interactive film installation(Lew, 2003), it uses an editing engine to edit live action video segments, assembling it, the film, in fluid manner while respecting continuity rules, a set of rules for making sure the shots work together(Barrance, n.d.; Marner, n.d.). These videos segments would work as a set of parallel streams, the system would cut back and forward, linking those streams, controlling which segment would be played. The user interacts with a custom tangible user interface (TUI), interlinking the digital to the physical world (Shaer and Hornecker, 2009) in a shape of a voodoo doll, representing the characters in the film. This type of interaction allows the user to experience the different narratives in an interactive and compelling way, the user feels that he can impact and transform the story by interacting with the doll, feeling engaged and immersed in the story.

The Tangible Video Editor: Collaborative Video Editing with Active Tokens

Tangible Video Editor (TVE) was a multi-user tangible interface to sequence digital video using various handheld computers identical to tablets embedded in plastic and some tokens representing video transitions (Zigelbaum et al., 2007). Similar to traditional cinema editing techniques and software, the TVE allows to build different narratives, being each device a representation of a video file, by aligning the tokens as the users prefers, users can build their own video sequence. With this method, the TVE attempts to combine the advantages of the digital editing with a physical non-linear editing method with multiple users at the same time. An advantage to this tangible video interface it that it allowed the users to have a better perception of the video files that were available to build the video sequence, although limited in editing proprieties or transitions, this method promotes greater exploration of narrative ideas, promoting user's imagination and a more collaborative ideate process.

2.3. Location Based

iLand: A Tangible Location Aware Narrative Experience

iLand was a location-based experience(Dionisio et al., 2011), designed to transmit oral culture and traditions, a project based in the island of Madeira, in the city of Funchal, mainly on the old town area specially designed foreigners and tourists. iLand was a tangible immersive experience that creates a physical connection between the real space and its tangible details with the story world of the narratives. The short movies were distributed in the real space, they were related with the location where they were played, the users saw and interacted with the same objects and buildings that were portrayed on the videos, enhancing the connection with the space and creating a deeper impact to the user experience.

This experience was managed through PlaceWare (Nisi et al., 2010), a location aware mobile story platform, that works by making the stories available to the users when they reach a specific geographical location.

Puzzle Façade: A Site-Specific Urban Technological Intervention

Puzzle Façade was a study design case aimed to explore the connection between tangible interfaces and architectural spatial proprieties (Puzzle Facade: a Site-specific Urban Technological Intervention, 2014), mainly its façades, exterior walls. This interactive project used the façades of Ars Electronica, morphing the architectural building into a giant Rubik's cube, inviting the passers-by to engage with the interactive experience by solving the game in an urban space through a tangible interface resembling the also a Rubik's cube. With this interaction, the Puzzle Façade created the illusion of a physical connection between the tangible interface and the architectural building, giving the impression that the user was transforming the urban space. Another aspect of this project was that it was designed to fit a specific building, site-specific, but the technology is adaptable and transformable to other architectural places.

2.4. Ambient Related

Ambient Displays: Influencing Movement Patterns

This project was a study made with a set of experiences made to observe and analyse people's movements in a symmetric interior space with parallel exits(Varoudis et al., 2011). The objective was to investigate the influence of ambient displays on the people's path, by augmenting a space with a display, creating a virtual connecting to a near physical space. With this experience, it was observed a significant shift in people chosen direction to follow, but if the ambient display was not augmenting the visual field or depth, was not creating a link between the spaces, it would not influence the participants' path. Creating this virtual link between two physically disconnected space, this project demonstrated that creating, extending the visual connection to a space, it would engage the people to follow certain movement patterns and influence the people's perception of space.

Automatic Environment Adjustment for Emotional Disabilities, React 2 Me

Automatic Environment Adjustment for Emotional Disabilities, or simply called React 2 Me, was a software system that combined several portable hardware, pairing various input and output devices to make an interactive space for people with emotional disabilities (Duvall et al., 2017). It used mostly gaming components designed for a single user such as Kinect, LeapMotion or Philips Hue Light but also could use other more standard devices as mouse, keyboard, and graphical displays. The system would detect behavioural changes, the posture, sounds and movements, automatically adjusting the environment in an unobtrusive manner, it would change something such as the lighting or music of the room, accordingly to the person emotional state.

2.5. Interactive Video

Mr. Sardonicus

Mr. Sardonicus was the first interactive participatory film ever made(Sardonicus (1961) - IMDb, n.d.), with authorship of William Castle, in 1961. The story was about a man who goes on a search for a winning lottery ticket on his father's grave, in the process, Mr. Sardonicus ends up freezing his face in a horrible grimace. While the story unveiled, the audience had a chance to vote on Mr. Sardonicus fate, they would use thumbs handed out before the beginning of the film, thumbs that would glow in the dark. The decision of the users was a mere illusion but created a strong connection between the spectator and the story action development.

HyperCafe: Narrative and Aesthetic Properties of Hypervideo

Hypercafe was an experimental hypermedia interactive film prototype (Nick et al., 1998), a project that was mainly composed of video clips of fictional conversations, placing the user inside a virtual cafe where they would listen to various stories as they moved through the virtual cafe. Trough the experience, the user could choose which narrative to experience, the user can choose which conversation to experience and since the interactive film used a nodal structure that allowed some flexibility, it gave the user some freedom to follow different paths without breaking the story continuity. This was a dynamic and enjoyable interactive work, that breached a traditional linear story flow and added different optional paths to experience the narratives in various manners.

The Boat

The Boat was an online graphic novel, accessible through a browser(The Boat I SBS, n.d.), an interactive short story about a teenage refugee escaping after the Vietnam War. This work was a set of animated illustrations enhanced with sound effects, divided in six chapters where the users can interact with using the manual scrolls or experience it with the automatic scrolling function, combining traditional and contemporary art forms. The users can set the flow of the experience by scrolling manually or let it guide them, enjoying a different method to learn and take in an historical event.

Honda - The Other Side

The Other Side is an interactive film produced by Wieden+Kennedy London(W+K London I Honda - The Other Side, 2015) to promote the new Type R from Honda as a family car and a high-performance vehicle. The short film is composed by two parallel narratives, with similar scenes and camera movements but different in context, one being set on a day environment while the other takes action during the night. To interact with the film, the user had to press the 'R' key on the keyboard, an indirect connection also with the iconic brand 'Type R' and the 'R' button on the car. Pressing the 'R' Key, the 'R' button on the car. By Pressing the key, the spectator would jump between the two narratives, transforming itself temporarily into director, controlling the film and building its own version of the story flow.

2.6. Weather Related

Does Weather Matter? Causal Analysis of TV Logs

In this work, an analysis of how the Weather might affect TV watching patterns was conduct, some conclusions noted were that weather does affect the TV watching patterns, users tended to change the type of content they would watch due to the weather(Zong et al., 2017). In a hotter weather day, users would tend to watch more news and less kids related programs, an explanation they offer to justify this pattern was that being a warmer day, kids would tend to watch less TV and do some outdoor activities. This work also mentions one situation were the users changes the genre of content they were watching in a harsh weather day, users would watch less dramas related programs and the preference was to watch something happier.

In Search of Light: Enhancing Touristic Recommender Services with Local Weather Data

In this work, the authors presented a new use for a network of sensors, LightBeam, a local-based mobile application to improve tourist's experience (Dionisio et al., 2017). This application was developed to guide tourist, providing real-time suggestions of points of interest based on the current weather, looking for sunlight to improve the holiday experience, by placing multiple sensors around the space and combining its information with the current location of the users to give them suggestions where to go next.

Weather conditions and daily television use in the Netherlands, 1996–2005

This was a study where they examine the impact of the weather conditions on the daily television use, in the Netherlands in a period of nine years, analysing data from 1996 to 2005. Their results supported that people would spend more time watching television in harsh weather conditions, focusing more on entertainment programs and the opposite if they were watching information programs with the same weather conditions.

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Chapter III. – Design space and Prototype

In this chapter, we can see the process that was made to design and develop the prototype, the evolution from the initial planning to the final product. To develop the prototype, instead of using random videos that would represent the weather as a response to the data collected from the sensors, a sample short video, using live action footage, was devised for that function.

For this project, a site-specific monitoring tool of the weather was needed, a tool to measure the weather parameters locally and more precisely instead of using a web service that would give a more general weather data. To do so, some research was made to find related works and hardware that comply with the objective.

3.1 Weather station

Initial research was to investigate weather stations, what do they measure and later, a new research of smaller scale projects that would measure the forecast, ending up looking into Arduino (Sentosa, n.d.) e Raspberry PI (Build your own weather station - Introduction I Raspberry Pi Projects, n.d.) Weather Station Projects. These projects would measure more parameters that were needed for this first approach, so a simplification of this type of tool was made to only gather the needed data, measuring only the luminosity, the precipitation and temperature.

3.2 Hardware

Genuino/Arduino Uno

Genuino/Arduino is an open-source platform used to construct electronic projects, it is compound by a physical programmable board, a microcontroller, and an IDE(integrated Development Environment), a piece of software that runs on the computer, used to write and upload code to the physical board(B_E_N, 2013a).

For this project, it was the microcontroller board used for the project, it is a robust board to easily use with electronics and coding, with a lot of information and documents available for novice users.

DHT11/DHT22 humidity & temperature sensors

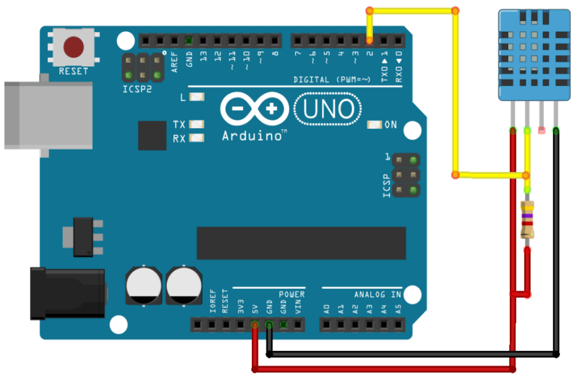


Figure 1 - Schematic diagram to wire the sensor

The DHT11/DHT22 sensors, see (GitHub - adafruit/DHT-sensor-library: Arduino library for DHT11, DHT22, etc Temperature & Humidity Sensors, n.d.), measure temperate and relative humidity, a very used sensors between electronics manufactures and enthusiasts. The sensors have a chip that converts analogue to digital, sending a signal with the temperature and humidity.

The DHT11 and DHT22 work in equal manner, measure the same parameters but have different specifications, being the DHT22 more accurate, falling behind only its market value, marginally more expensive and on its speed to deliver the data requested, 2 seconds versus 1 second on DHT11. Being a better option and the cost not being an influential factor, the DHT22 was sensor used in this project.

Using as reference the tutorial guide of *Rui Santos*(Santos, 2019), to read the temperature and relative humidity from the sensor, The DHT library from Adafruit(GitHub - adafruit/DHT-sensor-library: Arduino library for DHT11, DHT22, etc Temperature & Humidity Sensors, n.d.) was installed. The Adafruit Unified Sensor Library(GitHub - adafruit/Adafruit_Sensor: Common sensor library, n.d.) was also installed to enable the use of previous library.

Following the installation of the necessary libraries, the uploaded example code present on the DHT Sensor library, DHTtester, that would read temperature, humidity and compute the Heat Index, displayed the results in the Serial Monitor.

For now, the temperature was the only measurement needed from the sensor, so the code was cut down to only retrieve the needed data, monitoring the temperature in Celsius with no need to monitor the Humidity or Heat index.

LDR sensor (light dependent resistor)

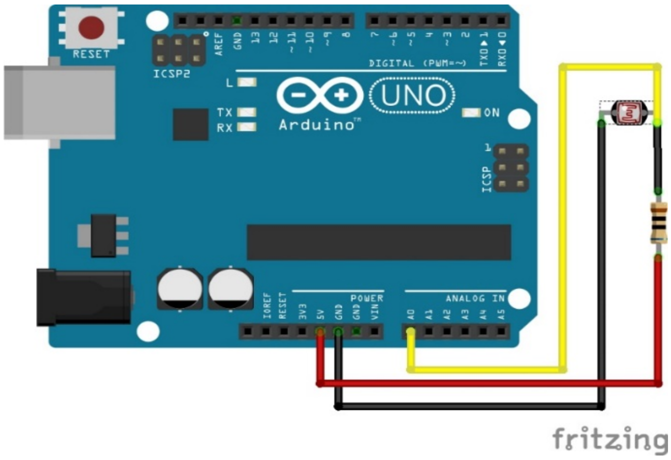


Figure 2 - Schematic diagram to wire the LDR sensor

The LDR (light-depended resistor), is a photoresistor, a variable sensor controlled by light, that when we increase the incident light, its absorbers the electrons which improve its conductivity and decreasing its resistance, in the dark it will assume a resistance in the order of mega Ohm and in an environment exposed with light, it will assume a resistance in the order of a few dozens Ohms.

Using as a reference the project example of *Allan Mota*(Blariston et al., 2017), a first test with the LDR sensor using a simple setup with a red LED, was made to test the correct function of the sensor, covering the sensor of the light, the LED would turn On or Off. A second test with this setup gave another type of feedback, a digital value visible on the Serial Monitor that would return a value of 1024 units, from 0 to 1023. These values had to be converted to something more practical, based on another research, the most convenient unit to convert these 1024 units was illuminance(lx)(Understanding and Interpreting Lux Values - Windows applications, 2018), Lux, the SI unit of illuminance (Illumination convert for lumens and lux, 2019), the intensity of illumination on a surface. To make this conversion, based on the example of *Ashish Kumar*(Ashish Kumar, n.d.), this 1024 units were converted to lux by making some calculations, producing the values present on the Figure 3 - Output value in Lux**Error! Reference source not found.**.

Those calculations where:

1. $R_L=500/lux$
2. $V_0=5*(R_L/(R_L+R))$
3. $V_0=LDR\_value*ADC\_value$
4. $lux=(250/V0)-50$

Where:

- RL is the resistance of LDR
- R is the resistance connected to LDR
- LDR_value is the Analog value read by micro-controller pin
- ADC_value is system_voltage/Resolution of ADC
- V0 is the analogue measured voltage
- lux is illumination calculated

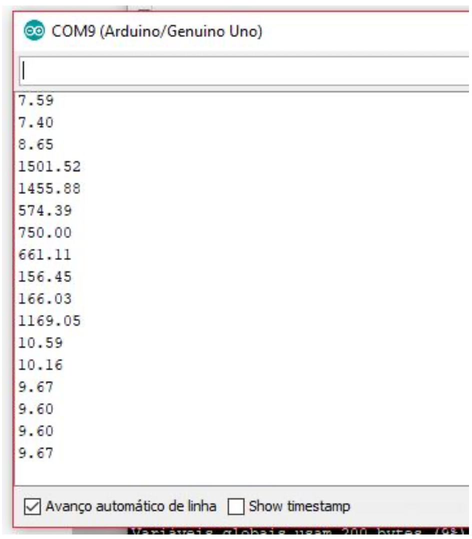


Figure 3 - Output value in Lux

To make sense of these values, a search and comparison between several ranges of interest of lighting conditions (Illumination convert for lumens and lux, n.d., Recommended Light Levels, 2019; Schlyter, 2017) were made. The data found was for common illumination levels, meaning that the data in this ranges were not completely accurate because the Lux values will vary from users' locations and situations. For this project, the data was redistributed to broader levels to simplify its application in the prototype, as it can be seen on the following Table 1 – common Illuminance levels redistributed.

Illuminance (lux)	Conditions
0.001 - 450	Pitch Black/Very Dark to Sunrise
451 - 1000	Dark Overcast Day
1001 - 10000	Cloudy Day
10001 - 30000	Full Daylight
30001 - 130000+	Sun Overhead

Table 1 – common Illuminance levels redistributed

Rain sensor YL-83

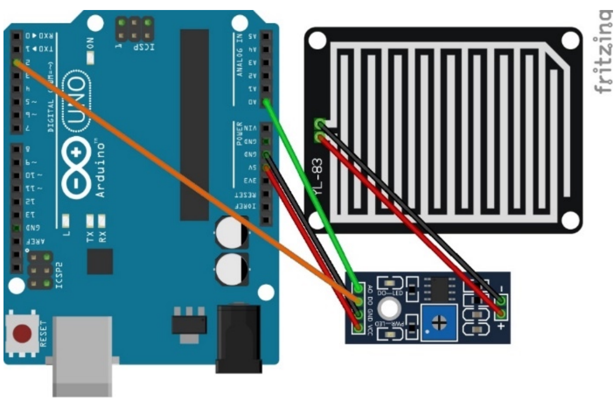


Figure 4 - Schematic diagram to wire the Rain sensor

The Rain sensor is sensor composed by two objects, a raining board and a control module, that can measure the intensity of rain or simply if its presence, raining or not. The first object, the board, has several exposed traces on both sides, oxidation resistant, and it is responsible to detect raindrops. This board is connected to a second object, a module which controls the circuit and takes care of the communication with the microcontroller(Thomsen, 2014), in this case, the Arduino.

The Rain sensor acts as a variable sensor, when the board gets wet, the resistance of the electrical circuit will vary from 100k ohms to 2M ohms when dry(Reichenstein7, 2014) and this type of sensor can easily detect water beyond what a Humidity sensor would detect. The Rain sensor will detect when a raindrop falls through the raining board and can measure its intensity, but for the present project, it was only detecting the presence of rain, gathering data from the digital output. To measure the raining intensity, the resistance would need to be monitored, the analogue output, but was ignored for now as we can see the in the following Figure 5 - Raindrop detection only.

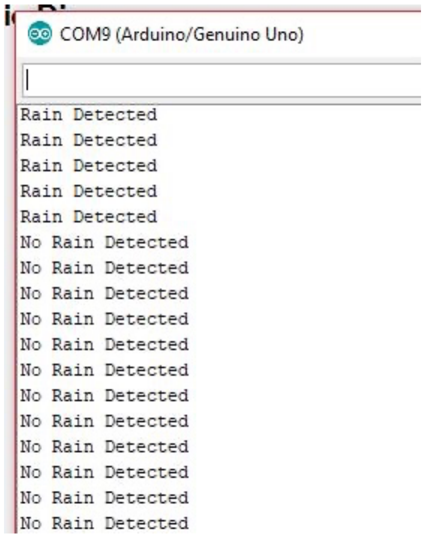


Figure 5 - Raindrop detection only

Complete circuit

Overcoming a couple of complications, all sensors were tested and fully functioning, the next step was to connect all sensors to the microcontroller, to the Arduino and make them work in sync. To do so, the individual code of each sensor was merged into one and with some corrections, all the data could be seen in the Serial Monitor.

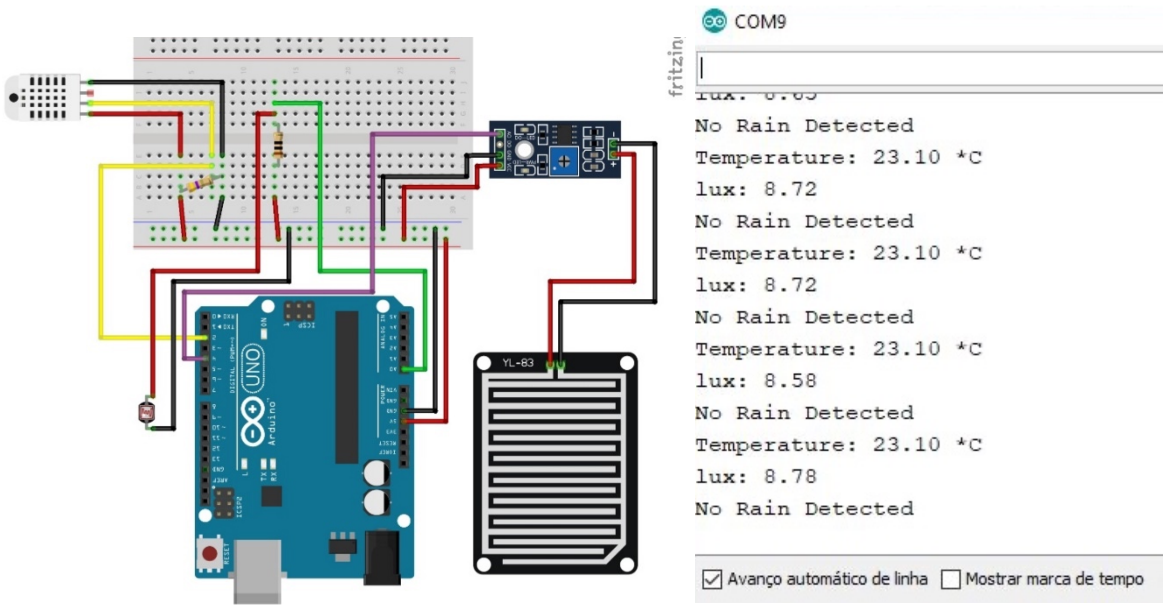


Figure 6 - Schematic diagram to wire all sensors and Output of sensors data

3.3 Frameworks

To use the data from the sensors and play the video sequences, process that is described in detail on the Section 3.5 – Narrative Development, an initially thought was to use the Raspberry Pi, because it could eliminate the Personal Computer and use a more contained package, connecting the Raspberry Pi directly to a projecting tool, but the used one was the Arduino.

To combine the data with the video, various frameworks as OpenFrameworks, Max Msp, Pure Data and Reacktor could be used, but in the end, the used one was the Processing(Processing.org, n.d.), due to the fact of being familiarized and having some experience with this tool.

Raspberry Pi could run the Processing software, but at the time, was not fully compatible, not running in a smoothly manner so a change of the hardware was made for this motive to use Arduino(Arduino Uno Rev3, n.d.) and Processing(B_E_N, 2013b) instead and use the tools separately, Arduino would gather the data from the sensors and Processing running on the a Personal computer, retrieved the data to eventually choosing the narrative that would play based on the sensors data.

Processing

To run the software, as previously mentioned, Processing was used to process the data from Arduino and play the video sequences. To use the data from sensors, Processing had to listen what the Arduino was sending, fortunately, Processing already has a method to do so, a Serial Library specific for this process, to listen to any serial communication from a selected Serial port from the computer(B_E_N, 2013b). To facilitate the transition and usage of this data in the Processing and future work, the data from each sensor was merged into a single string, to send all information needed in one line. Following this simplification, the Rain Sensor data was also converted from a String to a Boolean value, from "No Rain Detected/Rain Detected" to "0/1" as we can see on Figure 7 - Processing, String: Temperature, Lux, Rain.

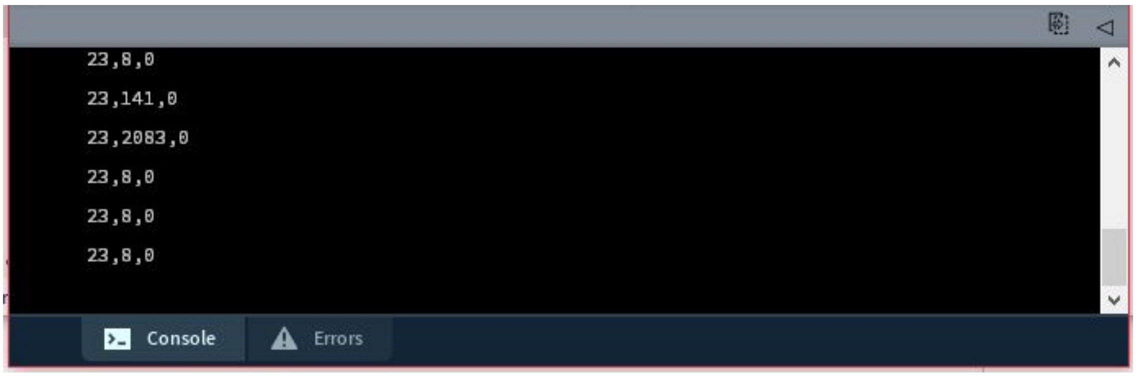


Figure 7 - Processing, String: Temperature, Lux, Rain.

Play the movie

The second step to develop the prototype after having the data from Arduino, was to play the videos. To do so, a first approach was to use the event function *movieEvent(),* that runs a movie when available. To trigger this event, an *if* and *else* method was used, the prototype would then select which video sequence it would play after checking the data from the sensors.

To test this method, a first test with six free sample videos from Pexels.com(Free stock videos · Pexels Videos, n.d.), identified as state A1, A2, B1, B2, C1, and C2, was made. These videos were divided into three groups of two videos, representing the different narratives and the previously defined types of weather or states, Good, Cold and Rainy Weather. Also, the videos of each group of Weather would symbolize a moment of the day, one video acting as Morning/Noon/Afternoon, A1/B1/C1, a moment with more light and the others as Dawn/Evening/Night, A2/B2/C2, moments with less light.

Sequence/state selection

To trigger the event that would change the video segments, the same *If* and *Else* method was used, with some extra statements. To test this second method, two different logics were tested, see Figure 8 - Video selection logic, both being valid and functional.

The first line of thinking, the prototype would begin by checking the pluviosity, verifying the presence of rain, if value was one, it would assume that it was raining. Having positive response, it would continue to check a second step, measure the light and if superior to an X value, it would play video sequence C1, else if inferior, it would play video sequence C2. If the value of the pluviosity was equal to zero, then the prototype would verify another point, verify the temperature. Being this value superior to a defined X value, hot weather, it would check a second step, like the previous one as the pluviosity, it would check the light value to decide if it would play the video sequence A1 or A2. If the temperature value was not superior to the defined X value, the prototype would jump to a final point and verify again the light value to decide if it would play the video sequence B1 or B2.

The second line of thinking would begin by checking the light as a first step and It would check the Pluviosity and the Temperature as the second step. If the value of the light was superior to a defined X value, it would jump to a point where it would decide which of the video sequences A1, B1 and C1 would play. If the light value was not superior to the X value, it would eventually decide which video sequence A2, B2 or C2 it would play.

Both logics were valid, but the code was rewritten with the second method, although they were both valid and functional, the second line of logic needed fewer lines of code and it was simpler to read. Another modification made to the prototype, was the name of the sequence was changed from sequence A1, A2, B1… C1 to numbered from 0 to 5 respectively. Concluded this first test, the actual video sequences were uploaded to a data file to be used by the prototype.

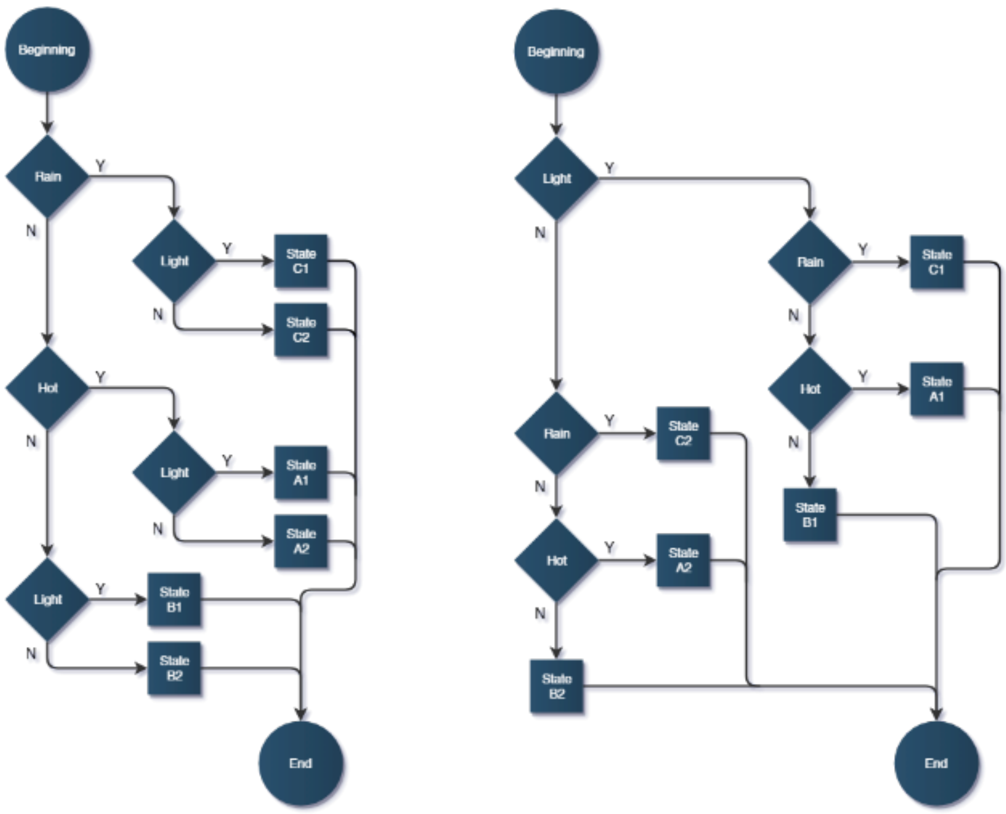


Figure 8 - Video selection logic

Block selection

The video sequences that represented the states of the weather were no longer a single video, being each sequence made of separated video files, blocks, starting with the block numbered 0, finishing at block 30, as seen on the following Figure 9 - Numbered video files. The prototype starts by selecting which video sequence it would play, Hot Weather (0, 1), Cold Weather (2, 3) or Rainy Weather 4, 5), next would select the day or night block. After playing the first block, reaching its end, the prototype would select the next block to continue with the video stream, to do so, at the end of each block, the prototype would check the number of the currently playing Block, to play the next Video/Block in line. To avoid any exceptions or an extra code, every sequence had the same number of blocks/videos, thirty blocks, counting from 1 to 30.

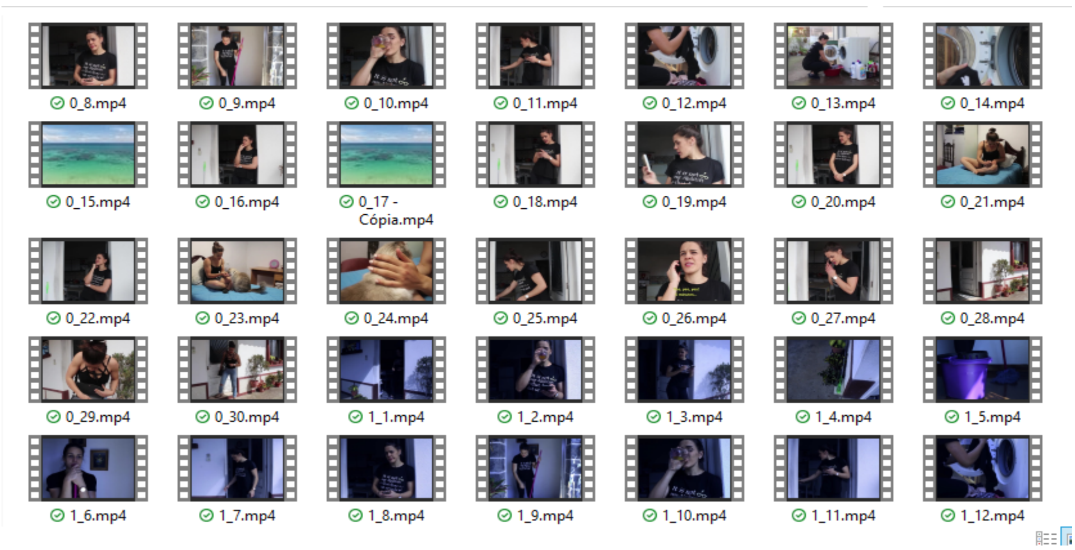


Figure 9 - Numbered video files

Complete movie

The prototype could now use the data from the sensors, use it to check the weather state, to select which narrative line it would begin with, checking the number of the Block at the end of each video and select the next one to play in the video stream.

To initialize the Interactive Video, the prototype had to begin with at least a Video frame before it could verify the State and Blocks it would play. It was planned before to add an opening scene common to all narratives, but it could conflict with the meaning of some of the narratives, having to plan different opening scenes for each one, it was a best option to add a simple two-second dark frame video to give enough time for the prototype to check the data and play the video. Following the same plan of a common video, the final block of the video stream, the final credits, were also common to all narratives. How process worked, it can be seen in the following Figure 10 - Processing State and Block selection.

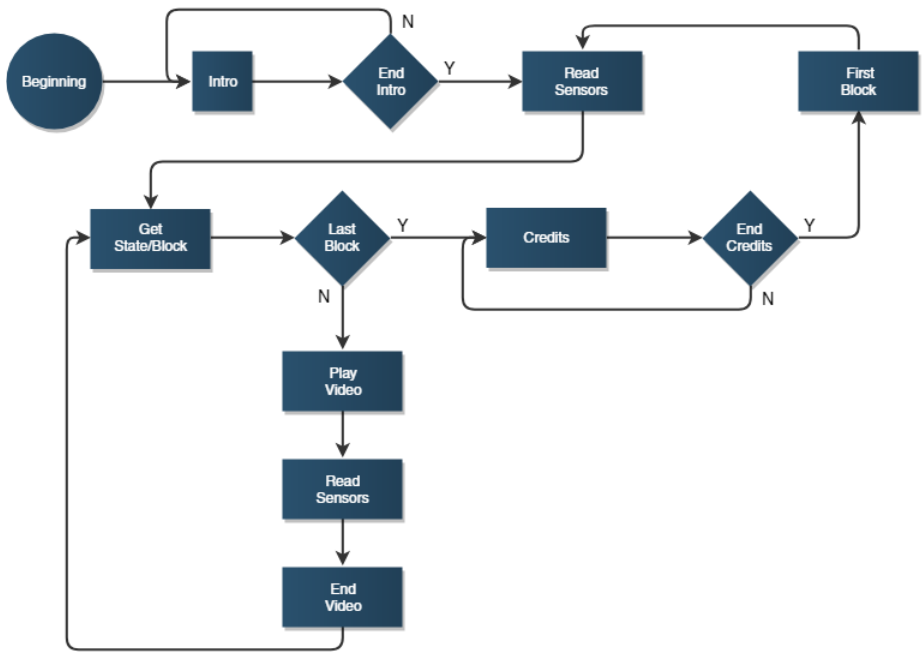


Figure 10 - Processing State and Block selection

Challenges to overcame

One problem that occurred in this stage, was that when the prototype made the change to the next video, next block in line of the narrative sequence, it had a break of around ½ of a second between videos that were pausing the story continuity. This problem was related to the hardware natural limitations.

An attempt has been made to solve this problem with some changes, making the verifications of the State and the Block by running an independent thread(thread() \ Language (API) \ Processing 3+, 2019) in the background, separated from the main action, but this solution created another problem. While there was no longer the extra time between the blocks, the change was happening before the end of the Video segment, cutting short the video and once again affecting the movie continuity.

To not lose more time with this issue, was opted to use the previous code, with the pause and continue with the development of the project.

3.4 System Architecture/Prototype Implementation

Here we can see the system architecture, the architecture of prototype, the structuring of the entire system applications and software components used, how are the applications and components connected and integrated together.

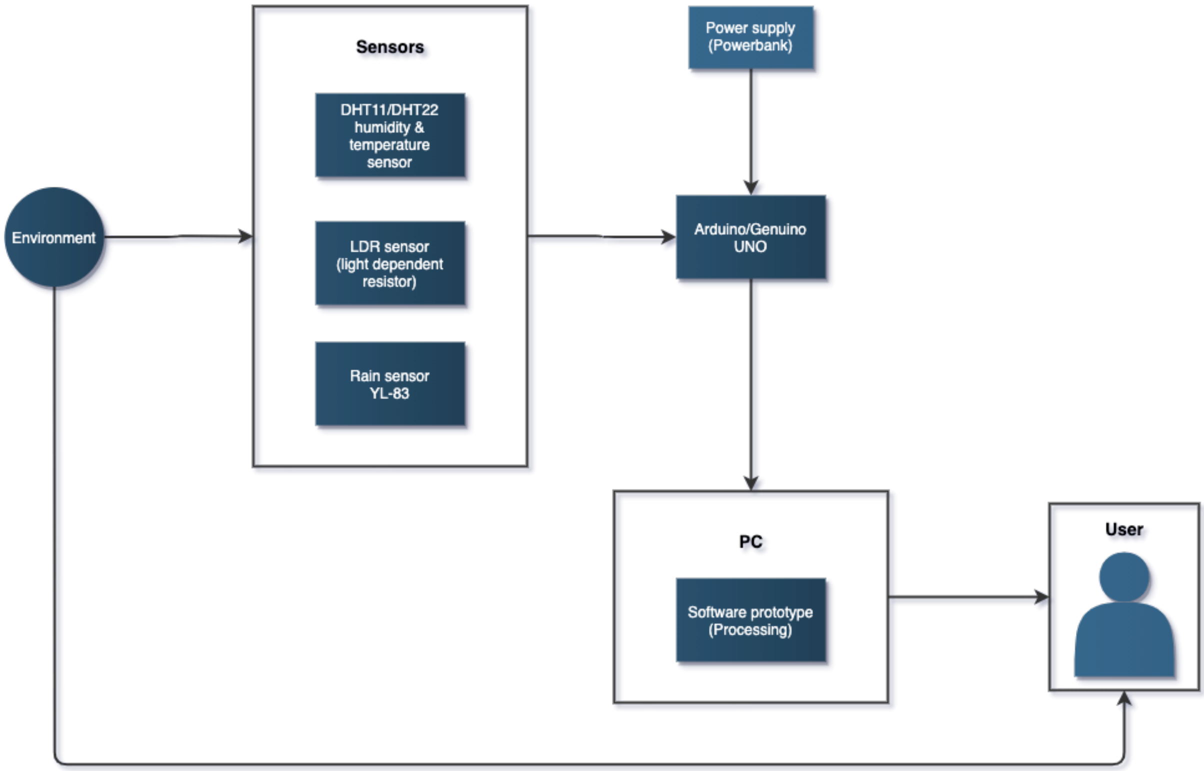


Figure 11 - System architecture

3.5 Narrative Development

To build and write the story for the video, the first step was to define and find out which were the types of environments settings, weather, and which should be adopted to develop the short film, to then, calculate the number of narratives that would be needed to develop for the experiment.

Weather variables

After a quick research and evaluation of the weather states found, the best next step was to simplify the options found, a simplification of the weather states, having into account also the sensors available for the prototype, three parameters were defined.

Luminosity (L) - Temperature (T) - Precipitation/Forecast (F) - Time/Hours (H)

The *Time* variable is ignored because the story has its own time, so real-time will not affect the narrative. To reduce the parameters of each variable and decrease its complexity, only two options for each variable were used, reducing the number of parallel narratives. Having the variables and options, a simple calculus was made to determinate the number of narratives to plan and write.

- *Luminosity: Dark/Light* (L/L^-)*;*
- *Temperature: Hot/Cold* (T/T^-)*;*
- *Precipitation: Rain/Dry* (F/F^-)*;*

$$2^3 = 8$$

Three Variables × Two options = Eight Possible combinations

Options:	**Moment of the day:**	**Notes:**
L T F (Dark, Hot, Dry)	Dawn/Evening/Night	A Spring/Summer hot day
$L\ T\ F^-$ *(Dark, Hot, Raining)*	Dawn/Evening/Night	A hot day with rain
$L\ T^-\ F$ *(Dark, Cold, Dry)*	Dawn/Evening/Night	A Fall/Winter cold day
$L\ T^-\ F^-$ *(Dark, Cold, Raining)*	Dawn/Evening/Night	A Fall/Winter cold raining day
$L^-\ T\ F$ *(Light, Hot; Dry)*	Morning/Noon/Afternoon	A Spring/Summer hot day
$L^-\ T\ F^-$ *(Light, Hot, Raining)*	Morning/Noon/Afternoon	A hot day with rain
$L^-\ T^-\ F$ *(Light, Cold, Dry)*	Morning/Noon/Afternoon	A Fall/Winter cold day
$L^-\ T^-\ F^-$ *(Light, Cold, Raining)*	Morning/Noon/Afternoon	A Fall/Winter cold raining day

Table 2 - Weather Variables and Weather

From the eight resulting combinations, it was opted to reduce to half the number of options to write the short film narrative, reducing from eight to only four, by Ignoring the Luminosity, could be manipulated later in post-producing to recreate the scenes in a darker environment, rebuilding options for the narrative, returning from four to eight combinations again.

- $L\ T\ F \approx L^{-}\ T\ F$
- $L\ T\ F^{-} \approx L^{-}\ T\ F^{-}$
- $L\ T^{-}\ F \approx L^{-}\ T^{-}\ F$
- $L\ T^{-}\ F^{-} \approx L^{-}\ T^{-}\ F^{-}$

After an analysis of the resulting narrative combinations, the number of narratives were again reduced from four to three, because one of the combinations of the weather states. When building the narrative, the option ignored was $L\ T\ F^{-} \approx L^{-}\ T\ F^{-}$ (a hot day with rain), people associate rain with cold weather, it was decided to ignore a storyline exclusively for this option. Another reason is the fact that the scenes captured with rain, if possible, will be captured live, most likely in the winter season and due to logistical problems, it will be a safer choice to leave this option out. So, for the short film, the narratives were constructed taking into consideration these three options in mind:

- $L\ T\ F \approx L^{-}\ T\ F$ *- A Spring/Summer hot day,*
- $L\ T^{-}\ F \approx L^{-}\ T^{-}\ F$ *- A Fall/Winter cold day,*
- $L\ T^{-}\ F^{-} \approx L^{-}\ T^{-}\ F^{-}$ *- A Fall/Winter cold raining day.*

Narrative structure(Hoguet, 2015),

A Parallel structure was chosen to reduce the number of different scenes that compose the film. By using this structure, the narratives could be adapted to the already build narrative to another weather context. There are some advantages of applying a parallel structure, the possibility of comparing a point of view, lets the user “hear” and “see” what takes place in each different narrative, visualize its space and temporalities, turning the user for a moment into a director. Unfortunately, there are some inconveniences that come attached to this narrative structure like the connection between each “stream”, jumping between the narrative lines, sometimes it might not always be clear, it can be depicted as a set of individual takes or scenes joined in a timeline, not being clear to the user, the flow of the story.

Another narrative structure that could be used was a Branching structure, this method would give the user a bigger sense of freedom, a better connection between each scene, turning the experience more enjoyable and enhancing the replicability of the experience. The reasons to choose a Parallel structure versus the Branching structure were logistical. A Branching structure would be more complexed, with many "branches", having each connection its own unique conditions, adding more time and costs to produce.

3.6 Script & Pre-Production

An aspect considered to plan the story was the need to contextualize the narratives with the real-life environment, a response equal to the weather outside, the playing scene would mimic the weather captured in real-life at real-time. Due to the complexity of the project and taking also into consideration the time available to produce, a simpler script to function as a sample for the project was written for the short film and some guidelines were followed:

- Stick to one location and develop a short film idea with only one or two characters,
- Aim for that sweet spot somewhere between 5 and 20 minutes,
- Have at least two scenes, a sequence,
    - Ex.: porch and kitchen,
- Parallel universes,
    - Same hour, different weather and/or temperature.

The short film story was written with the concept parallel universes/storylines in mind, a set of parallel narratives were planned to interlace between them, respecting continuity editing, combining more-or-less related shots into a sequence. The parallel narratives would differ slightly in some scenes to be contextualized to the present weather but being similar enough to maintain continuity editing when changing narratives. It was considered when writing the script that these parallel "streams" would change between them depending on the sensor data, serving as a response equal to the present local weather.

Another guideline when planning the scrip for the short film, the narratives had to change between the present and a previous moment of the day or past, interrupting the chronological sequence by interpolating past events, known as flashbacks.

One-liner

A Short Film of a young girl in the intimacy of her house, bored, thinking about her day to day and remembering some past moments.

The premise

A Saturday of a young woman in the boredom of her house where the protagonist is depicted in an everyday day life moment that is common to us all, rarely portrayed and waiting the moment to leave the house.

Good weather script

INT./EXT. KITCHEN

By the kitchen, the girl appears by the door,
Leaning on the door, drinks a juice.

CUT TO:

Focus on an object she was looking for when doing her chores.

The Swiffer she didn't know where it was, on the ground.

Picks it up and puts it to the side.

CUT TO(FLASHBACK):

INT. HALLWAY

She is cleaning the Hallway using a mop.

BACK TO(PRESENT):

INT. KITCHEN

GIRL
(a bit annoyed)
oh well, it's done.

CUT TO(FLASHBACK):

INT. HALLWAY

Pick up the mop and goes inside.

BACK TO(PRESENT):

keeps drinking her juice and checks the time.

GIRL
Must be finished by now

CUT TO(FLASHBACK):

INT./EXT. SIDE OF THE HOUSE

She is filling up the washing machine.
Holds a sports bra.

CUT TO(FLASHBACK):

EXT. RUNNING

She is running outside

GIRL
(with a proud face)
It was a good workout

BACK TO(PRESENT):

While remembering the workout, she thinks.

GIRL (CONT'D)
Most of it

CUT TO(FLASHBACK):

CONTINUATION OF WORKOUT SCENE
playing around/playing with the phone.

BACK TO(PRESENT):

(Phone - Connection with
previous scene)

Continues with her phone for a couple more seconds.
Puts it on the side and checks her nails.

GIRL
Oh already!?/Should do them again!

CUT TO(FLASHBACK):

INT. BEDROOM
Painting her nails.

BACK TO(PRESENT):

GIRL
(With a little smile)
So good to have Me time!

CUT TO(FLASHBACK):

INT. BEDROOM
Petting her cat.
A noise of a phone vibrating.

(Phone vibration - same
time as petting the cat,
connection to the present
scene.)

BACK TO(PRESENT):

Phone rings...

GIRL
(look at it a bit
surprised)
Hello!? Almost ready, in an instant

Runs to her room to get dressed.

CUT TO:

EXT. FRONT PORCH
Leaves house in a hurry.
Turns back, forgets her phone,

Leaves running

For the other scripts, cold weather script and Rainy weather script, please refer to the appendix A and B.

Storyboard

Bad/rainy weather storyboard page 1

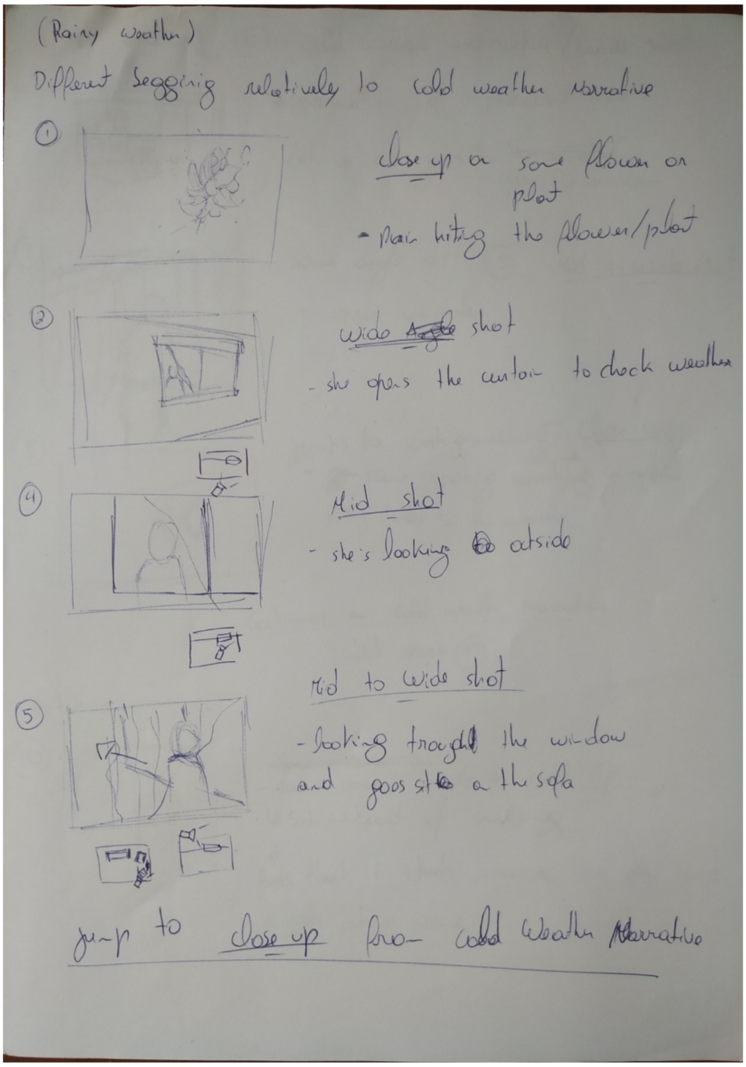


Figure 12 - Pag.1 Rainy Weather storyboard

For the other example of storyboard sketch, rainy weather board, please refer to the appendix page C.

3.7 Production

Having the script written and storyboard ready, the planning process to capture the footage started. The process has divided into four days, capturing the most scenes as possible, considering the location and schedule to have constant light and weather conditions.

Footage

The footage was captured live, as far as possible, with real-time weather to avoid using digital effects simulating weather phenomenon's, maintaining weather effects credibility. The three narratives were captured simultaneously in a non-linear method, filming identical scenes of the parallel narratives on the same day to save time and resources.

Cinematographic technique

Initially, the short film was idealized to be captured using stable and static camera angles, but being the story more a description of a day of person life, a *Shaky cam* or *Jitter Cam* (Jitter Cam - TV Tropes, n.d.) technique was used, previously a documentary technique, is now used in more common media, where a perfectly proportioned shot is intentionally disrupted giving the impression of a hand-held camera, compelling the viewer to pay a closer attention to what is currently happening.

3.8 Post-Production

Having the scenes captured, the editing phase of the short movie begun, the sound was correct, and some missing sounds were added. The colours temperature was manipulated and corrected, the background soundtrack was tested, and in the end, title and sub-titles were added. This stage began at the same time as the shooting process, it helped to identify some problems with the footage, having to reshoot one scene for the Good/Hot Weather narrative and other small errors were fixed with some editing "magic". To edit the footage, the software used was video editor Adobe Premiere Pro, again, due to the familiarity with software.

Luminosity

An element that was planned to be worked on post-production was to change luminosity, as present on the following image, to transform a day scene into a night scene. It was a more feasible effect to do in post-production, turning a day scene into a darker scene that capturing the footage in a darker environment. Filming in dark setting would involve other production methods and costs(Huegel, n.d.) that could compromise que quality of the image. This effect was applied to all narratives that would represent a darker, moment of the short movie, moments in the beginning or end of the day.

Figure 13 - Light to dark manipulation

Colour temperature

To emphasise the difference between Good Weather and Cold/Rain Weather narratives, the Good Weather narratives were presented with a more vivid colour, giving the impression of a warmer environment and hotter moment of the day and the Cold/Rainy Weather scenes had a more blueish colour tone, decreasing the perceived temperature of the scene, adding a colder and more depressing effect to the narrative as present on the following image.

Figure 14 - Colour temperature manipulation

Rain

Originally planned to be captured live, the rain scenes were meant to be captured during the production phase to maintain a higher credibility. Due to schedule inconveniences and to avoid water exposition of sensible hardware, the initial plan was discarded, and the effect was added later, as a post-production effect, to the Rain narratives. To do so, an overlay of raining effect on the selected videos was used to create the necessary illusion, implying that it was raining as Figure 15 - Colour manipulation and rain Overlay presents, this way completing the Rainy Weather necessary scenes.

Figure 15 - Colour manipulation and rain Overlay

Sound

Most of the sound we could ear on the short movie was captured live, directly from the environment pictured on the scenes. The exception to this, were the sounds of the mobile phone vibrating and the rain falling. The vibrating sound of the mobile phone was added when editing the video takes, after the video was captured, because it was not audible enough, manipulated and cut to match the action of the picking up the phone. Against the original plan, the rain effect was also added in post-production, it needed a sound to match, a sound of raining outside and a muffled sound of raining to mimic a person listening from inside the house.

Music

For the project, two music tracks were use from the composer Armando Trovajoli(Trovajoli, n.d.), one as background music and another for the final credits.

When working with the soundtracks, prepping the background music, ideally, the music tempo would match the action of the movie scenes and would enhance some emotions of the scene, but the way how the prototype works, using Blocks and changing between them, by not being a unique sequence, the music wouldn't be matched with the narrative, when using the final exported versions of the Blocks, video takes, the music wouldn't be synchronized. To remedy this problem, the background music was eliminated from Blocks in the editing process and was played separately on the prototype, initiating right at the beginning of the videos, and ending when the prototype detects the last block where the music fades out.

The previous issue was not found with the credit's scene, being a common Block to all narratives, the background music from the final scene could be exported with the final video take, saving processing power.

3.9 Housing

To collect the data and protect the prototype from the outside environment and the climate conditions, a case was needed to hold the hardware, a simple junction box would be enough to do the task, but in this case the light sensor and temperature sensor would be too exposed because both sensors had to be placed on the exterior of the case. Also, because this being an interactive installation, a more worked and appealing housing was a must.

House references

Based on some references, as Figure 16 - House Design References, birdhouses and some other simple contemporary houses, a housing prototype was designed and built using prototyping material to test the design options. To design the housing that would hold the hardware, a set of guidelines were defined to make sure that all sensors would function correctly and mounted in a position that would benefit the capture of its data.

Figure 16 - House Design References

Guidelines

- Protect the Arduino and peripherals from the outside environment,
- Enough interior space for expansion or to add more hardware,
- Easy access to the hardware and peripherals,
- Enough light for the LDR sensor,
- LDR sensor in an upright position, preferably the at top part of the housing with no shadow interference,
- Temperature sensor in the exterior but protected, under the house would be the optimal choice and separated from Arduino and other peripherals, to avoid false temperature readings,
- Rain sensor also in an upright position, diagonally mounted to avoid storing water and avoid false readings,
- Size +- 200x200mm.

Designing the house

Some design studies of the house were made with a simple format and preferably easy to build in mind. Having some sketches completed, see Figure 17 - Design possibilities for the housing, each option was analysed and evaluated. The pros and cons of each sketch were defined to then reach a final design, a minimalist house, more appealing than a simple junction box.

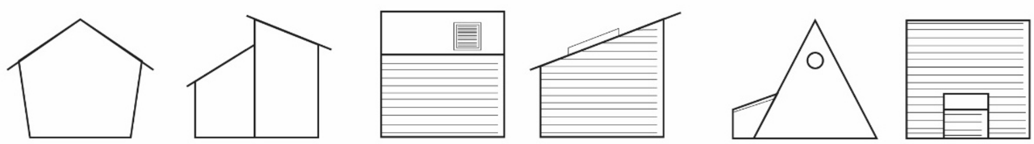


Figure 17 - Design possibilities for the housing

Having the exterior of the house defined, the next step was to do some studies of the interior structure, see Figure 18 - Housing structure, interior partitions that would give some strength to the House and hold the hardware, Arduino and its peripherals. The house was designed to have four partitions, the top section, top floor, was designed to hold the LDR, the light sensor, protect the light sensor from the rain and let the sensor only be exposed to the light, the second section, second floor, was to hold the Arduino and the breadboard, the third section, first floor, its function was to hold a PowerBank to eventually make the prototype portable in a future improvement.

The last section, bottom part of the housing, was design to only have some space left to hold the DHT22 sensor, temperature sensor, protect it from from the rain and direct light, but exposed to outside air.

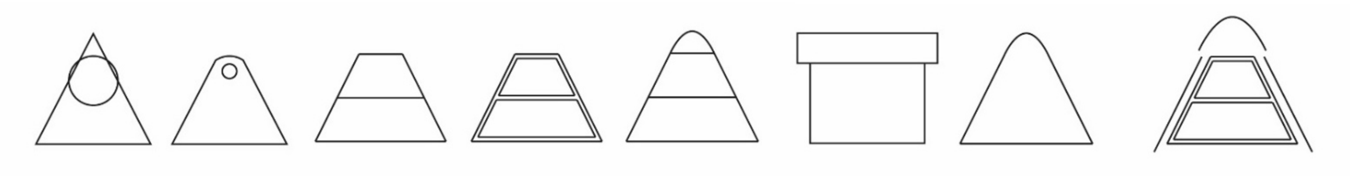


Figure 18 - Housing structure

Housing prototype

Having the exterior shape and interior structure designed, a first prototype of the house was made with k-line material, a material similar to cardboard, easy to cut and work around, to test the design guidelines and proportions. Completed the structure, the sensors were mounted into the housing, tested again to verify its reading and data. Concluded the first prototype for the house, see Figure 19 - Prototype house with Arduino and Peripherals, some points to improve the house and structure were noted, more space in the interior for the Arduino and peripherals, also for a future improvement with a WI-FI shield and battery would be a good improvement and the access to the Hardware also needed to be rethought, the side access on the first prototype as a bit too narrow.

Figure 19 - Prototype house with Arduino and Peripherals

Chapter IV – Evaluation

In this chapter, we describe the evaluation on the Weather-Driven Interactive Video experiment, some reflections and other insights were described based on the user studies that were conducted. In order to understand the relation between the contextualised weather video, its visual effects, how contextualising a video to the user current location/weather would impact the user's experience, a study was design to evaluate this positive or negative influence of this features.

The tests were a mix between face-to-face and video calls, they had a duration of 15 to 25 minutes for each test/interview.

4.1 Evaluation methods and pilot study

A study was designed to evaluate the Weather-Driven Interactive Video concept, and the Arduino/Processing prototype.

For this user test, it was necessary to determine the relationship between the user's feelings, their mood, before the experiment and measure their emotions after running the test, to evaluate if there was an impact on the on them, positive or negative after being exposed to the video experiment. To do so, a quantitative study was need, and two options were considered, Self-assessment manikin (SAM)(Bradley and Lang, 1994) and the Positive and Negative Affect Schedule (PANAS)(Crawford and Henry, 2004).

First method evaluated was SAM, developed by Bradley & Lang, a non-verbal pictorial assessment technique, based on three states, pleasure, arousal and dominance. This method is composed of a set of three pictures connected to a scale that may vary from 9 to a 21-point scale, measuring the response level to those states. This method seemed too abstract for what it was intended to measure, not giving enough detailed feedback about the experience, so it was opt to use the PANAS, Positive and Negative Affect Schedule scale instead, more informative and less incline to interpretations, more accurate results when evaluating the effect on the user' experience.

Positive Affect and Negative Affect Schedule

PANAS(Crawford and Henry, 2004), was developed in 1988 by psychologists David Watson, Lee Anna Clark, and Auke Tellegen, with the intention to measure someone’s positive or negative affect, how a person was feeling in a specific moment. There are a few versions of the PANAS scale that were created or modified over the time, versions dedicated for other specific context in mind (Riopel, n.d.), there was no need to use any other alternative version of this method so, the original version was the one used for this tests.

PANAS is a questionnaire made-off two groups of ten words, total of twenty states, describing feelings or/and emotions. It can be used to measure past experiences or immediate effects of an exercise, it is sensitive to sudden or momentary changes, which it is useful to measure the effect of this experiment, a contextualized video for the users’ experience. To measure the response level to those emotions/feelings, PANAS users a five-point scale to evaluate if the sentiment, state of mind applies to the user in that moment, the user must choose the level of affect, of those twenty different states, words, describing various emotions and feelings, to indicate the extent of that emotion or feeling at that moment. To evaluate the positive or negative effect of the experiment, a sum is made with the ten positive words as for the ten negative words, resulting in a value that will range from ten to fifty units or points, for both cases.

Figure 20 - PANAS questionnaire, example

To have a better understanding of the reasons why the users felt in a certain way, reason behind this positive or negative reaction to this experience, it was necessary a method that would provide some illumination and interpretation of these events, a method more descriptive than the previous method.

A qualitative study was made, after the experiment and PANAS questionnaire, a quick six questions interview was conducted, and a thematic analysis was made to the transcript interview in a later moment to acquire extra information and findings.

Interview

An interview allows to gather more in-depth information, user preferences or opinions, and, in this case, also a method to measure their immersion with the video experience, evaluate their experience with this feature. In order to have the correct answers, the right questions were necessary, to do so, the work *Development of a Questionnaire to Measure Immersion in Video Media* (Rigby et al., 2019), by Jacob Rigby, was used as a reference to build a set of questions for the interview. To not extend the test and not overwhelm or annoy the user, the interview was a composition of six questions, each one with a specific target in mind.

1. Did you feel you were focused on the video? (Attention)
2. Did you feel that you were trying your best to follow the events of the video? (Concentration)
3. Could you picture yourself in the scene of the events shown in the video, do you remember any past memory? (Memory, recognition/recall)
4. Did you feel motivated to keep on watching or were you trying to keep watching? (Curiosity, Comfort)
5. Would you say you enjoyed watching the video or something else? (Enjoyment, Comfort/Discomfort?)
6. Would you like to watch more of this, or similar content, in the future? (Enjoyment, Comfort/Discomfort?)

Thematic Analysis

Thematic analysis is a method to analyse qualitative data (Braun and Clarke, 2006), data as a set of texts, good method to follow when trying to find out something about people's views, opinions, knowledge, experiences or values, trough interview transcripts, social media profiles, or survey responses, examining the data for common themes, topics or patterns that tend to be repetitive.

There are different approaches to consider when analysing the data for a Thematic analysis, we can consider a deductive, inductive approach, semantic, latent, critical and constructionist approaches (Braun and Clarke, 2017a). Inductive, Semantic and Realistic approaches are normatively used in conjunction, the same applies for Deductive, Latent and Constructionist approaches. Deductive implies analysing the data to find some codes that would reflect our preconceived themes that we would expect to find, based on our previous knowledge. Inductive approach implies allowing the data to generate themes, even if they seem irrelevant. Semantic approach means analysing the data as it is, its explicit meaning. In the Latent approach involves deciphering and finding hidden meanings underlined in the transcription. The Realistic approach focus essentially in reporting the data we assume as evidence of the reality. The Constructionist way focus on describing a new reality that is created by the data, a new meaning.

Starting from a point where there were some predefined assumptions, the followed approach was the opposite to these criteria, to avoid any bias judgment while reading the data, an Inductive, both Semantic and Latent, and the Constructionist approach were followed, to analyse the data and generate valuable findings. Aside from which approach might be selected or used, the process of Thematic Analysis is as follows:

5.2 Transcribe text a get familiar with it,
5.2 Coding,
5.2 Generating the themes,
5.2 Review
5.2 Define final themes,
5.2 Report findings.

Pilot study

Before the actual study, it was conducted one pilot study with two participants to evaluate the study plan, the future user tests. Both tests were made without the physical prototype, only using the videos, one contextualised and another non-contextualised version, less logistical constraints and took approximately 20 minutes to conclude each test. After a quick simplistic explanation of what was being tested, the users answered the PANAS questionnaire, to evaluate their state, that took around 5 minutes to conclude. Immediately after, one of the users experienced a contextualised video, same setting weather as is current environment, on the computer screen, for a period of 3 to 4 minutes, and the other user tested a non-contextualised video, for a similar period. After this exercise with the users, again, they answered the PANAS questionnaire to detect any change in their mood or state that could be a consequence of the Video experience, taking another 4 to 5 minutes. Afterwards, a short interview was conducted to acquire more information. The questions had the objective of finding and detecting how the participant felt about the experience and its content.

In the end, a quick discussion occurred to evaluate the study and the interview questions. This was helpful to train the study protocol, to improve the interview questions, make them clear, make sure they would generate good data for the study.

Another issue to solve was the weather itself, it would be hard to coordinate tests, participants schedules and the weather conditions to test all scenarios. To solve this, some tests would have to be made through video call to other parts of the world, that would match the necessary weather conditions. This meant that the prototype readings of the environment would not match their environment, so, in these cases the prototype was replaced with a montage that would match the users' environment weather context, users would see a video, shared on the video call, with the same weather setting has the one they were currently placed at.

Participants

To run these user tests, sixteen participants, fourteen men and two women, ages ranging from 22 to 34 years old, all with or studying in higher degree of study, from bachelor to PhD, were recruited to participate in these tests. Two participants were foreigners, from Asia, other four were Portuguese but with foreign origin, from South America and West Europe, and the remaining ten were locals.

User	**Gender**	**Age**	**Education**	**Background**
1	Male	24	Master	Computer Science
2	Male	28	Bachelor	Interactive media Design
3	Male	24	Bachelor	Design
4	Male	23	Bachelor	Computer Science
5	Male	22	Bachelor	Marketing
6	Male	30	Bachelor	Urban planning
7	Male	32	PHD	Computer Science & interactive technologies
8	Female	29	Bachelor	International relationships and Languages
9	Male	30	Bachelor	Design
10	Male	34	Bachelor	Computer Science
11	Male	28	Master	Computer Science
12	Female	32	PHD	Computer Science & interactive technologies
13	Male	26	Bachelor	Computer Science
14	Male	29	Bachelor	Computer Science
15	Male	32	Master	Mechanical engineering
16	Male	34	Master	Telecommunications and electronics engineering
Average		≈28,56	Standard deviation	≈3,85

Table 3 - User demographics

4.2 Evaluation results

The scores of the PANAS questionnaire were evaluated and separated in groups, different contexts, different scenarios that it evaluated. The interviews were made after the second PANAS questionnaire and the answers, were transcribed. A thematic analysis was made after on the transcribed text to find out more about the participants views and experiences.

Measuring the impact of the weather-driven interactive video on the user's experience with PANAS questionnaire

One of the objectives was to evaluate the relationship between the physical environment and this weather-driven interactive video feature on the experience of the user. A good approach was to run a non-contextualised test also to have comparable data with the contextualised user test and get other insights that we might have missed by only conducting a contextualised weather video.

As mentioned before, it was necessary to measure the user feelings/emotions before and after the experiment to evaluate if there was any impact on the users after being exposed to the video experiment, the test started with the users filling up the PANAS questionnaire. The users choose the level of affect, on twenty different levels, words, describing various emotions and feelings, to indicate the extent of that emotion or feeling at that moment. The users were presented with different video environments, the weather context was different for some of them, some users were presented with a bad weather video setting, some with a cold weather setting, some with a hot weather video setting and another three groups were presented with the exactly opposite video setting to their context, a non-contextualised video representing a bad, a cold and a hot weather video setting.

	Before		After			Before		After	
Contextualised	Positive Affect	Negative Affect	Positive Affect	Negative Affect	**Non-Contextualised**	Positive Affect	Negative Affect	Positive Affect	Negative Affect
User 1	30	20	25	14	User 3	35	10	30	10
User 2	21	10	22	10	User 4	39	23	44	21
User 5	43	14	40	16	User 8	25	15	28	17
User 6	40	41	40	40	User 10	26	11	16	10
User 7	30	10	29	10	User 12	26	11	23	10
User 9	41	10	42	10	User 14	29	13	25	11
User 11	28	25	31	22	User 15	37	10	35	10
User 13	34	13	31	17	User 16	33	13	36	10
Median	**32**	**13.5**	**31**	**15**		**31**	**12**	**29**	**10**

Table 4 – PANAS results, Contextualised vs non-Contextualised overall data

	Before		After			Before		After	
Contextualised	Positive Affect	Negative Affect	Positive Affect	Negative Affect	**Non-Contextualised**	Positive Affect	Negative Affect	Positive Affect	Negative Affect
Light rain					**Light rain**				
User 1	30	20	25	14	User 12	26	11	23	10
User 11	28	25	31	22	User 14	29	13	25	11
User 13	34	13	31	17	User 16	33	13	36	10
Median	**28**	**20**	**31**	**17**		**29**	**13**	**25**	**10**
Light cold					**Light cold**				
User 2	21	10	22	10	User 3	35	10	30	10
User 7	30	10	29	10	User 8	25	15	28	17
User 9	41	10	42	10	User 15	37	10	35	10
Dark cold					**Dark cold**				
User 5	43	14	40	16	User 4	39	23	44	21
Median	**35,5**	**10**	**34,5**	**10**		**36**	**12.5**	**32.5**	**13.5**
Light Hot					**Light Hot**				
User 6	40	41	40	40	User 10	26	11	16	10
	40	**41**	**40**	**40**		**26**	**11**	**16**	**10**

Table 5 – PANAS results, Contextualised and non-Contextualised divided by scenarios

Contextualised – Rainy day, afternoon

A contextualised weather video was run with 3 users. From the PANAS questionnaire, the contextualised video made an impact in their state, the Positive Affect score was reduced, with one exception, user 11, and Negative Affect was accentuated, with another exception, user 13. In general, the contextualized weather video had negative affect on their experience, making them feel slightly more "negative" mood or even bored.

Opposite, Non-contextualised – Night, hot day

The same test was made with another 3 users, but this time, the participants were exposed to a non-contextualised video, a video where the weather was contextualised with the opposite weather the users were currently at the time of the experiment, a video with low light but hot weather. Like the previous group, the non-contextualised video made an impact in their state, the Positive Affect score was reduced, with one exception, user 16, but the Negative Affect was less affected that the previous the experience, the change was less significant, users seemed to turn to a more neutral state.

Contextualised – Cold day, afternoon

3 other participants viewed another contextualized video, where the weather conditions were like their current environment, in this case, a slightly cloudy and cold day. In this test, the PANAS questionnaire results showed and a variation on the Positive affect, only by one point, User 2 and 9, increased by one point while user 7, decreased by the same margin, 1 point also. The experience had no Negative affect, no changes at all. The contextualized weather seemed it had not made any significant impact, positive or negative, the participants remained in a similar state after the experiment as they were before it.

Opposite, Non-contextualised - Night, hot day

For the opposite test, non-contextualised video experiment, two of the participants showed no change, turning into a more neutral state. For the other participant, the non-contextualised seemed to contribute positively for His experience, both Positive affect and Negative affect scores increased slightly, follow an opposite trend to the other two participants.

Contextualised – Cold day, Evening/Night

This test was made at the end of the day, after work, the user seemed to be in a relaxed mood. After being exposed to the contextualised weather video, a Cold evening scenario, the participant mood showed no significant fluctuation, remained in a relative relax state, even calmer or moving to a neutral state. It seems it had not positive or negative affect on the participant experience.

Opposite, Non-contextualised - Hot day, Midday

The other participant was exposed to the opposite scenario, a nice hot day video context. The PANAS questionnaire results show that this non-contextualised had a positive affect but also a negative effect on the user experience. The participant became slightly more vivid, excited but at the same time fluctuating slightly to depressing mood for missing the good weather or experience related to the summer period, but the overall experience was positive.

Contextualised – Clear hot day

A participant saw to the contextualised weather video to his current environment, a nice clear hot day. This contextualised video seems it did not result in a significant change on this user experience, the PANAS questionnaire, the Positive affect score was reduced by 1 unit and the Negative affect remained the same. The participant remained in the same state, mood, He was in before the experience.

Opposite, Non-contextualised – Cold dark day

In this scenario, a participant tried the opposite scenario, a non-contextualised weather video, a Cold dark day. The PANAS questionnaire results show a significant impact, the biggest one from all tests, on this participant experience. The Positive affect score was impacted by 10 units, reducing from a score of 26 to 16 and the Negative affect score, dropping a single unit, 11 to 10. This non-contextualised weather video seemed it had no apparent negative effect on the user mood but affected is energy, His excitement was reduced, He turned into a more neutral or relax state, He became bored.

Relationship between the participants physical environment and the visual effects with an observation, interview and thematic analysis

Observations

From the user test, most participants mentioned changes in their state of mind, their mood, negatively and positively, some of these variations were due to their present environment, weather context and external elements, while others mention variations when doing the experiment and after the video experience.

It was noticeable some trends after the experiment, at the moment of the tests, the environment, weather context and the video experiment weather effects, impacted the participants mood and overall experience. The users feeling more in a negative state of mind, were generally in a darker, melancholic environment, and this was enhanced by a dark rainy weather period. When experiencing the contextualized video, same weather context as their own, the change in their mood was more pronounced, in comparison with other user tests, in some cases feeling worse than they already were. In the interview, some users recall some memories that made them feel some discomfort when viewing the contextualized video, but when experiencing a non-contextualized video, an opposite weather context, some users felt slightly better or just moved into a more neutral state.

The participants feeling a bit more positive, were generally in a lighter environment, with more natural light and not in a rainy day or bad weather period. They seemed to remain in the same state or improve slightly depending on the experience they participated in, most did not recall any significant memories and seemed also to feel more relaxed in general when experiencing a contextualized video.

Interview

To get more information about the user experience, to evaluate the relationship between their environment and the video environment they were watching, an interview was conducted, to find out how the contextualized weather video could affect their attention, their memory or would it change their behaviour. These interviews were a mix between face-to-face and video calls, they had a duration of 5 to 10 minutes for each interview.

Most users were able to focus on the task at hand, most were able to see the contextualised and non-contextualised weather video, and follow the events on the video, the changes in the timeline, with exception of the user 1, who was slightly distracted with His surroundings and user 11 who was not in a good moment of His day prior to the experiment, was having to do some effort to concentrate on the test.

Some questions were about their connection with the events portraited on the video, immersion, empathy with the character, did they recall any memory or past event, any discomfort or enjoyment. While experiencing the contextualised weather video, some users remember some past experiences and felt the same as the character in the portraited video, like user 1 and 13, had a *déjà vu,* recalled doing the same action, users 1 and 9 felt cold, the same as the character was experiencing in a scene of the video.

Most users did not mention any discomfort while doing the user test and would keep watching the video if it continued. An exception was User 11, referring some discomfort by the end of the video. He had to try to keep focus on the action, it was a bad weather day and watching a contextualised weather video did not help His experience. Nonetheless, User 5 was able to relax. He was in a dark cold environment also, but no rain, and the contextualised video was beneficial for his experience.

It was asked to the users if they would like this concept to be applied in a recommendation system, to recommend them a movie or video, if they would like it, some were reticent on the idea, others find it meaningful or that it would make a low impact. Others commented that the concept was a bit too abstract to evaluate any effect of this concept and a few thought it might be an extra point to add to a recommendation system for some specific scenarios or with some intentions to motivate or influence the viewers.

Thematic analysis

To do the thematic analysis, the transcription coding and the generation of themes, was made following the method of Virginia Braun and Victoria Clarke(Braun and Clarke, 2017b).

First analysis

After getting familiarised with and transcript of the interviews, Figure 21 - Highlights to build codes, it was time to code the data, which meant highlighting key sections of the transcription text and building up some short labels to describe the text, these were the codes (method one)

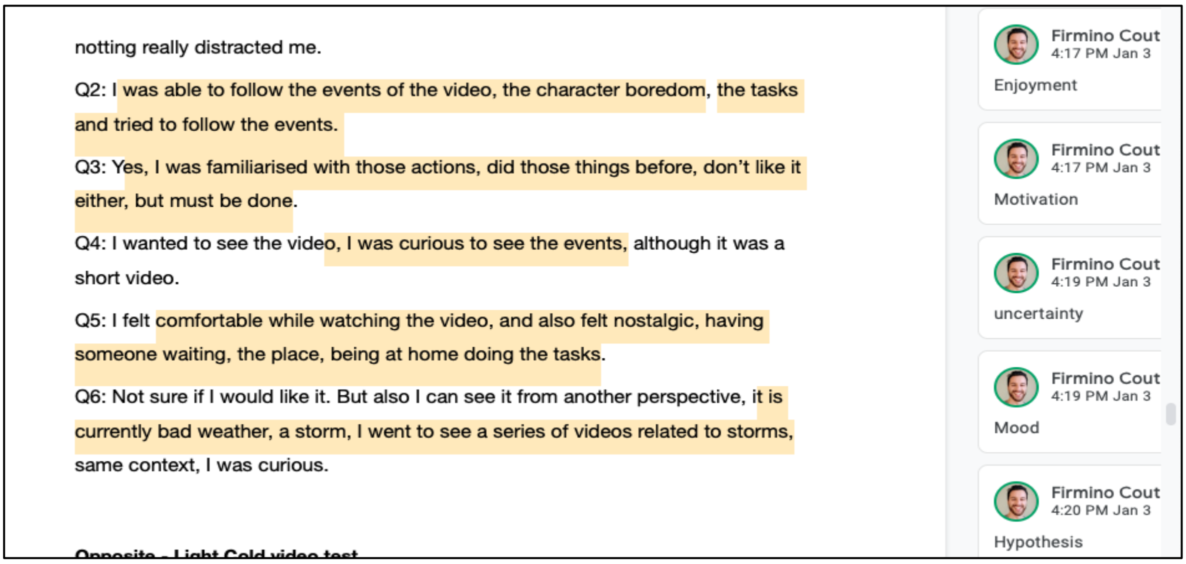


Figure 21 - Highlights to build codes

Picking up these codes, took a deep look at them, tried to analyse them, find any pattern or similarities between the codes and came up with some possible broader themes to connect them, Figure 22 - Themes generated from the codes.

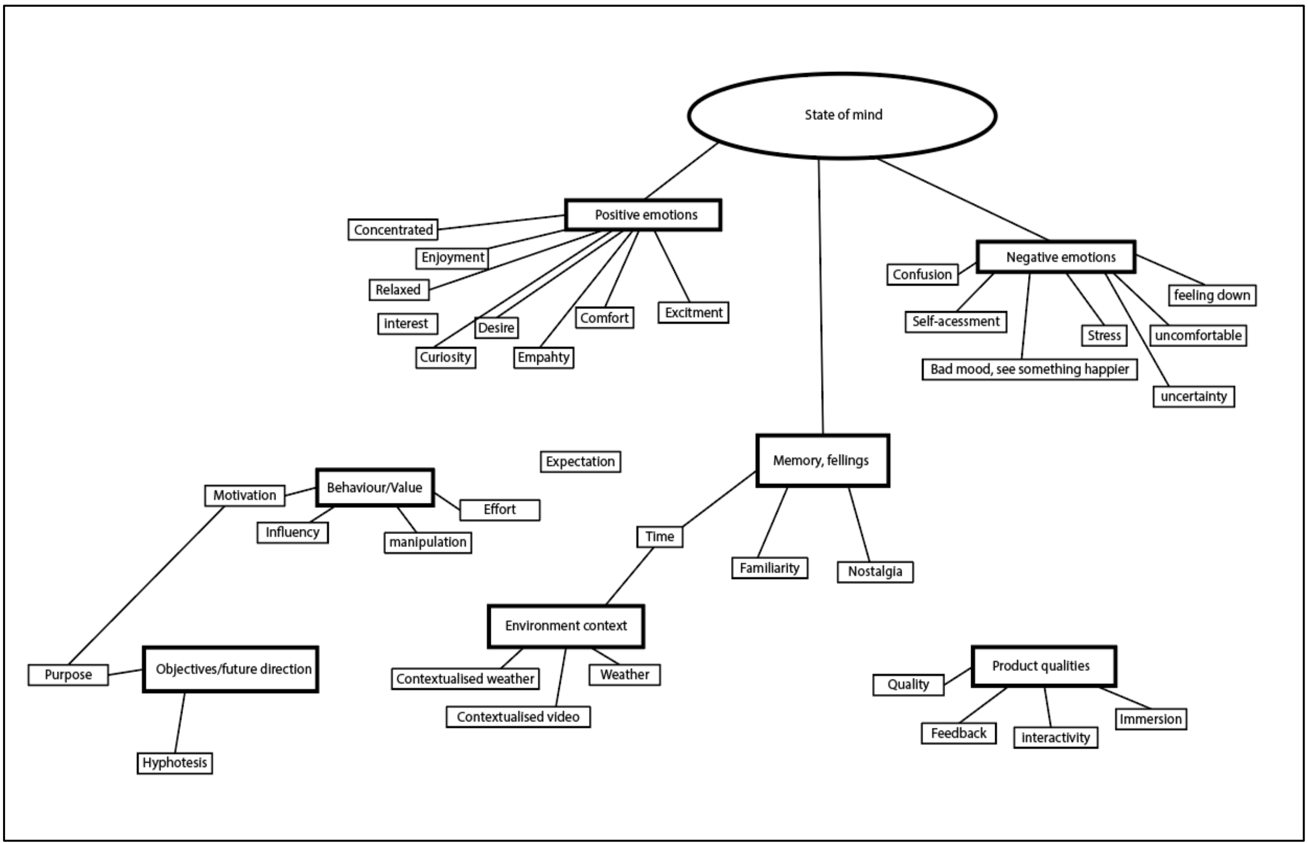


Figure 22 - Themes generated from the codes

Having the themes, had to make sure they were an accurate representation of the data, so a revision of the themes was made, comparing the themes with the transcriptions, to understand if it was missing anything, are these themes a part of the data or do we need change something, having the final list of themes, Figure 23 - First results from Thematic Analysis.

The themes that resulted from this thematic analysis, seemed poor, the results were not explicit enough to reach concrete ideas. The participants did similar tests, but there were some differences, users were presented with different video environments, the weather context was different for some of them, and that might have impacted some of the answers, resulting in opposing conclusions, making it difficult to reach a valid conclusion, this was another option to find other inferences, to get more specific details and have a better overview of each case.

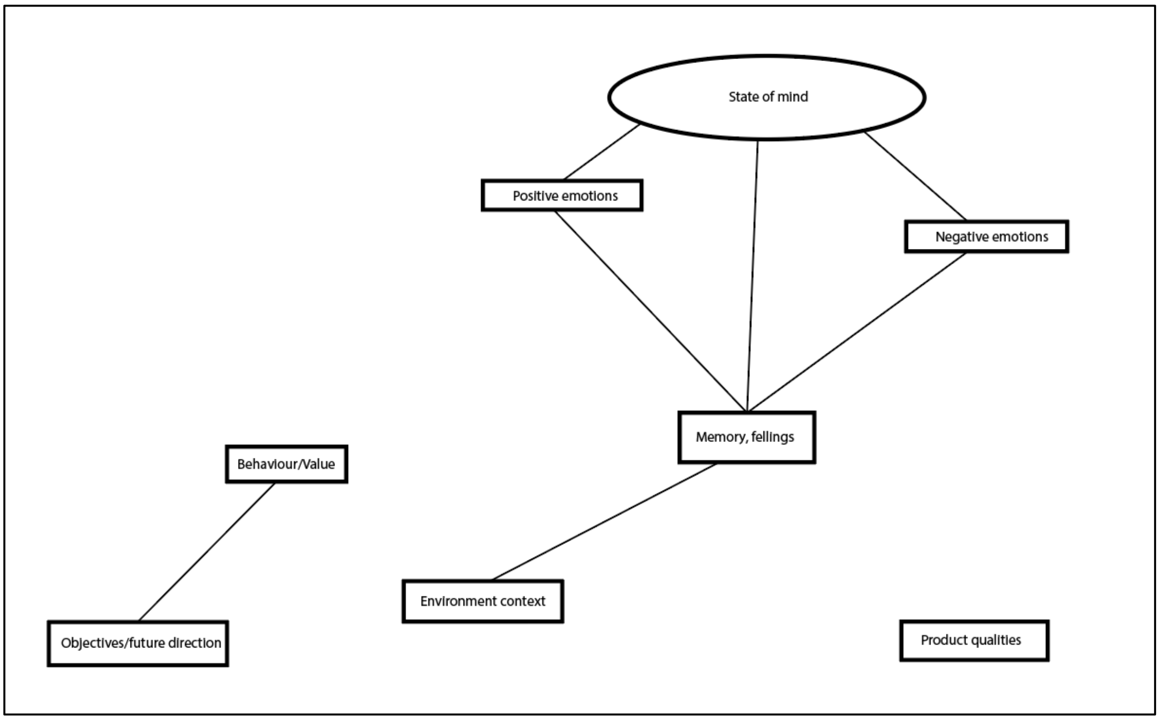
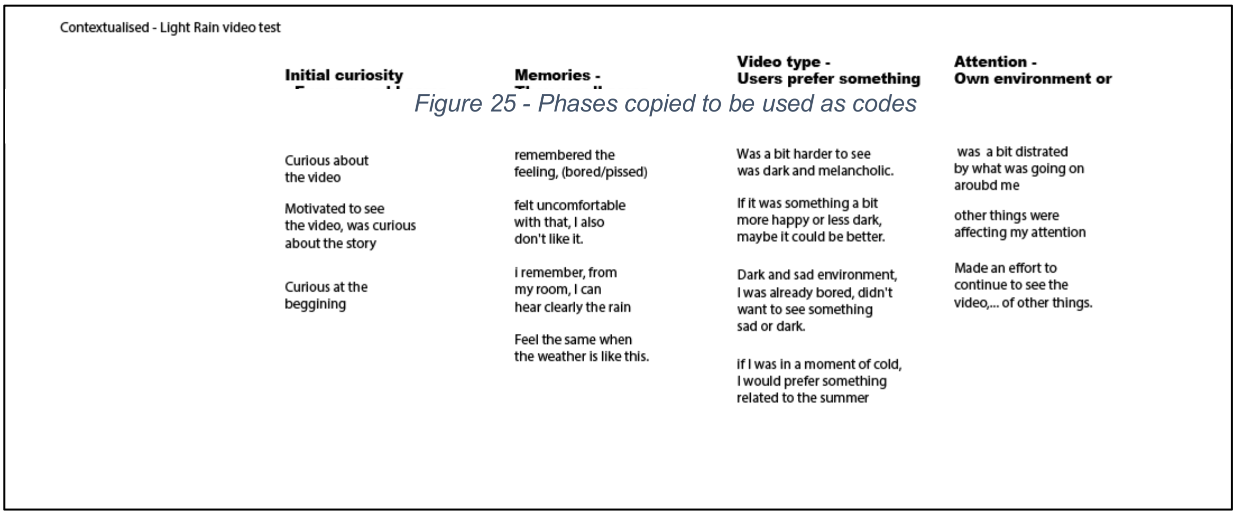


Figure 23 - First results from Thematic Analysis

Second analysis

Instead of highlighting key sections and generating single term codes, labels representing that transcription line, Figure 25 - Phases copied to be used as codes, the phrase itself is used to create the themes.

Picking up those codes(phrases), trying to analyse them, find any pattern or similarities between the terms and come up with some possible broader theme, in a similar way as the first method, to find a common title or phrase, to connect them. With this option, it was also possible to do this theme analysis for each video weather context, instead of having a single big bundle of themes as a result.



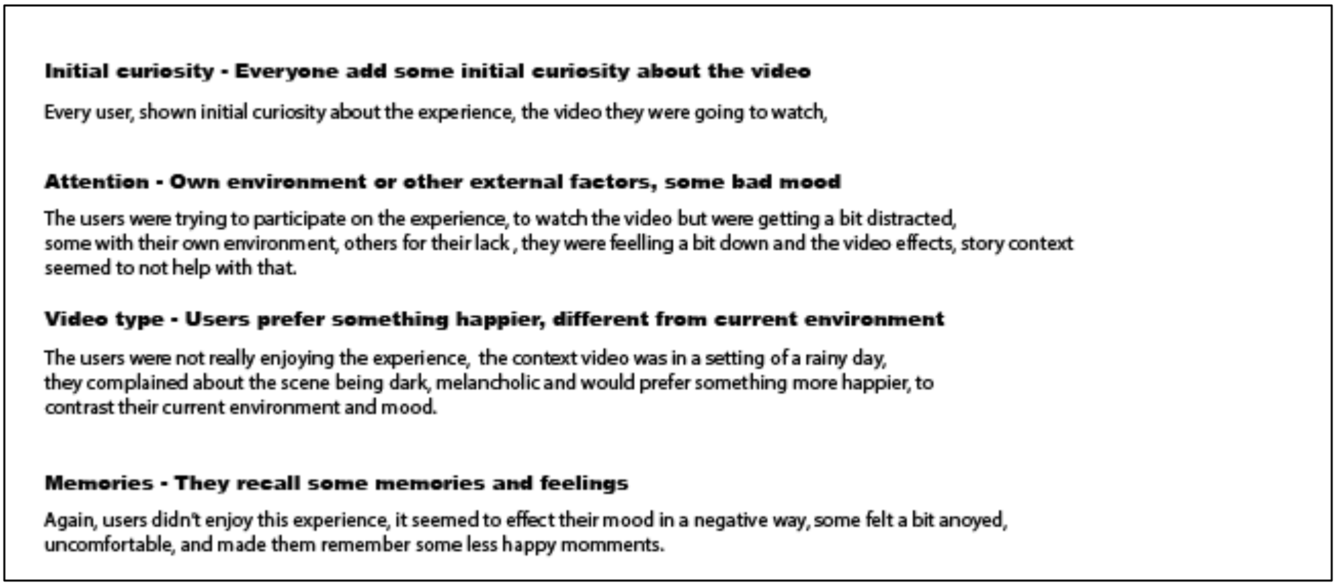
Contextualised - Light Rain video test

Initial curiosity	Memories -	Video type - Users prefer something	Attention - Own environment or
Curious about the video	remembered the feeling, (bored/pissed)	Was a bit harder to see was dark and melancholic.	was a bit distrated by what was going on aroubd me
Motivated to see the video, was curious about the story	felt uncomfortable with that, I also don't like it.	If it was something a bit more happy or less dark, maybe it could be better.	other things were affecting my attention
Curious at the beggining	I remember, from my room, I can hear clearly the rain	Dark and sad environment, I was already bored, didn't want to see something sad or dark.	Made an effort to continue to see the video,... of other things.
	Feel the same when the weather is like this.	If I was in a moment of cold, I would prefer something related to the summer	

Figure 25 - Phases copied to be used as codes

Figure 25 - Phases copied to be used as codes

Having the themes, and to make sure they were an accurate representation of the data, a new revision was made, comparing the themes with the transcriptions, to have a final list of themes for each video weather context, representing each group of user tests. The last step was to transform those themes, phrases into individual notes or key-points, less arbitrary to analyse and better to build a focussed report, Figure 26 - codes transformed into themes.



Initial curiosity - Everyone add some initial curiosity about the video

Every user, shown initial curiosity about the experience, the video they were going to watch,

Attention - Own environment or other external factors, some bad mood

The users were trying to participate on the experience, to watch the video but were getting a bit distracted, some with their own environment, others for their lack , they were feelling a bit down and the video effects, story context seemed to not help with that.

Video type - Users prefer something happier, different from current environment

The users were not really enjoying the experience, the context video was in a setting of a rainy day, they complained about the scene being dark, melancholic and would prefer something more happier, to contrast their current environment and mood.

Memories - They recall some memories and feelings

Again, users didn't enjoy this experience, it seemed to effect their mood in a negative way, some felt a bit anoyed, uncomfortable, and made them remember some less happy momments.

Figure 26 - codes transformed into themes

Contextualised - Light rain video test

Although the users showed some initial interest, some curiosity about the experience they were about to watch, during the rainy days, especially dark ones, the users were generally in a “lower” mood, they had some trouble keeping focussed on the video and, showing a contextualized video would enhance their negative emotions, in some cases making users recall some less happy memories. A couple users stated that they felt uncomfortable during the test, that they did not enjoy the experience and would prefer something non-contextualised to their own environment, something less emotional, something “happier”.

Opposite - Light rain video test

The users that saw the non-contextualised video were also feeling a bit “down”, in a similar mood as the contextualised group, they showed curiosity for the experiment and, because it was the opposite video experiment, it helped them stay focused longer and to see the video till the end. This time, no user commented any discomfort while experiencing the non-contextualised video, their mood wasn't enhanced in a negative way, but some users revealed a positive effect, they noticed the different weather context and that helped them turn into a more relaxed state. Some users even commented they felt nostalgic and recalled some good memories, summer and holidays related.

Contextualised - Light/Dark Cold video test

The users that participated on the contextualised video with a cold weather context, commented also some struggles focussing, although less than previous setting (Rain weather context), they could go out or move around easily. Some users said that they would also prefer something happier, non-contextualised to their own environment, but in this case, no one stated any discomfort or annoyance by the experiment, as in the previous setting, they did not mention any bad emotion or memory that was accentuated. One physical effect that was reported, some users said that, for a moment, they felt cold.

For the users in the same weather context but in a later moment of the day, was noticeable that the users were feeling a bit more relax, not so active, sitting indoors to stay away from the cold, they also mention they felt cold, the experience made them focus on that physical felling and another comment was, the need for a hot beverage or something warm the “soul”.

Opposite - Light/Dark Cold video test

As for the non-contextualised video about the cold weather context, as the previous contextualized setting, users were curious about the experience, about what they were about to see. One difference, although users were in a similar mood, they did not mention any struggles to focus on the experiment, keep their interest for longer, till the end of the video and were curious for what would come next, after the end of the story.

In this non-contextualised experiment, the users said the felt a bit more comfortable with this version, they have noticed the different weather context and it made them feel more relax and, in some cases, as in the non-contextualised rain weather, they felt nostalgic, remembered some good memories, related to the summer and holidays season, they desired to go back to that moment.

Contextualised - Light Hot video test

For the hot weather contextualised video, was noticeable the difference of the energy levels of the users, they were way more active, and was also much easier for them to experience the video, stay in focus and follow the events pictured on the video. Another remark was that the users were feeling more motivated and able to think in more complex subjects or themes, although diverging their answers sometimes to other directions, it was better to discuss other interactions or discuss other effects of this type of interactions.

Their emotional state tended to keep the same or move in a more positive way but never moving in a negative way.

Opposite - Light Hot video test

In the non-contextualised version of the Hot weather experiment, the users were in the same state of mind as the previous contextualised video experiment, they were able to keep focused, maintain their curiosity and follow closely the events of the video to the end of the experiment. Users did not comment on any discomfort or annoyance while participating in this version of the experiment, they were not impacted by the opposite weather, users seemed to stay in the same state of mind, or moved into a more neutral, more apathic state.

4.3 Discussion

By transforming the weather in the video, film or information program, although not very significant, we can see a slight change on the viewer emotional state, their mood, especially when they are in a dark or bad weather context.

To improve the viewer experience in a dark bad weather context, rain, the results of the user tests, suggest presenting the user with a non-contextualised weather video, in other words, showing the viewer content, which setting is a brighter and colourful environment. About the content of the video, the action or story, would preferably be something less serious, happier, because their level of attention would tend to be diminished and harder to convey serious content. If there is a need to share, present serious content in this scenario, it would be a better bet to do so, at evening, end of the day, because the viewer, although still in a less happy mood, will be able to digest some more serious content. The tendency will be for them (the viewers) to be a bit more relaxed by the end of the day, after work, at dinner hours, so they will be not so bored, and their attention span will be higher dan an earlier moment of the day.

Similar to the previous scenario, viewers that were in a cold weather context, the results of the user tests, also suggest presenting the user with a non-contextualised weather video, but there is more flexibility, so the viewer call also be presented with contextualised weather video content. These viewers were in a better mood relative to the those in the harsh weather context, but still their focus was diminished, viewers will prefer less serious content but will be able to digest it better, users will feel less discomfort or will be less annoyed by any serious content. As commented before, it will be preferable to share serious content by evening or end of the day.

For those viewers that are in a better weather context, they tend to be in a better mood, their attention levels will be higher, and they will be able to assimilate more demanding content, complex subjects or themes, that might need some form of discussion or other complex interactions. So, in terms of contextualised or non-contextualised weather content, the impact on the viewers experience seems meaningful. In the case of presenting non-contextualised weather content, this will not impact the viewers mood, but it might reduce their output levels of energy, becoming more relaxed, calm, a preferable moment for not so serious content, lighter content.

If it is the wish is to improve the viewers experience, in a moment of harsh weather, a non-contextualised weather and lighter content is advised. If you need to convey serious or more demanding cognitive content, it will be preferable to deliver it at evening or end of the day. For a cold weather scenario, the same advice applies although, viewers will accept, tolerate better serious content. For a good a good weather scenario, serious content, complex cognitive content will be accepted easily. Non-contextualised weather content might not be beneficial, might impact negatively, making viewers lose interest and disconnect and, if so, a lighter content is advised.

This knowledge applied in a recommendation system, can be used to provide a better user experience and suggest a video or playlist, creating an impact the user experience and watching patterns.

Chapter V - Conclusion

In this project, it was designed and built a sensor-based prototype, a digital prototype was developed to allow the visualization of video content based on the user's location and weather context, an evaluation to find out how this weather-driven interactive feature would impact the user experience, the relationship between the video weather effects, its content and the user's context was conducted, resulting in some findings were not expected.

The initial intent for this work, was to combine these simple devices, these sensors, and build an application that would read the environment and translate this information into a new way to visualise media, contextualise the video content, its weather setting to the user location. The content of the video was scripted, shot and produced to have a length of around four minutes, and it was composed by six stories, 6 parallel timelines, and the user would visualise one of the timelines contextualised to his present weather situation. From the user test results, the feedback that was gathered, simply contextualizing the videos to the user's location and weather context, in some cases, was proved not enough to enhance the user's experience in a positive way, provoked an opposite effect by generating some discomfort to the viewers, which it can be intentional. The initial concept was not changed after these findings but, the results suggest that some users would enjoy more, a content that would not follow their current weather environment, a non-contextualised version would be advised, for a positive experience.

Recommendation systems are a common method that users encounter nowadays, and, in terms of video, the recommendations are based on the videos the viewers have watched, videos searched, videos that have been watched by similar people. These systems are in a continuous iteration and well set underway but, nevertheless, these recommendations do not consider the user experience as one key factor, rather translate tendencies and recommend videos based on those. Contributing to that progress, contextualising the videos to the user context, their environment, their current weather, can contribute positively to the field, a way to improve the recommendation systems performance, generating a bigger impact and enhancing the user’s experience.

5.1 Limitations

Sample size and homogeneity

The first limitation of the project is the sample homogeneity and size, most users were male, 14 were male versus 2 females, and its size might have created barriers to find relationships from the data, although, for qualitative research, the sample size is less relevant.

No significant research studies

Another limitation was a lack of research studies on the topic, there was no work that resembles the way this project was implemented, so a more diversified search became necessary to find relationships with the theme proposed in this thesis.

Access to people and timing

The third limitation was the access to people and the variation of the weather, to test and have access to the different test scenarios, it was necessary to have people available at different times of the day, plus waiting for certain weather conditions to test the contextualised videos. This was a constraint, but it did not prevent from following through with the studies, it was a matter of preventing the users that their contribution will be needed and dispersing the user test for a couple of months when the weather was less stable.

5.2 Future improvements

Portability

The final step in the plan for the prototype hardware was to make it portable, to do this, a battery(PowerBank) and a WI-FI Shield(Arduino Wi-Fi Shield - DEV-11287 - SparkFun Electronics, n.d.) to access the data from the Arduino wirelessly would be needed. This step was not accomplished, the Shield wasn’t available when building the prototype, and was not a priority for its development.

Another root to follow could be change the hardware from an Arduino to a RaspberryPi and Software to OpenFrameworks, the experience would benefit by being develop in a more compact and portable prototype to enhance the experience of watching the contextualised videos.

Genre

The scripts that were wrote, the narratives, were made with a dedicated focus on its weather setting and not emphases on the story itself, resulting in a video with common day to day actions. Developing the story aspect or explore the video genre and the weather context, could it provide insights for these recommendation systems, could we recommend a movie genre with contextualised weather that would benefit the user experience.

Narrative structure, nodal

The narrative structure used for this project was linear structure, where the storyline develops in a straight line with a couple moments of flashbacks, but in essence, does not change aside the weather's setting.

Another narrative structure that could be explored is a Nodal structure, a more flexible but also complex structure, where the story can unravel in different storylines and finishing with different or equal endings.

This would imply develop more the interactive aspect of the prototype, moving away from the weather-driven interactive feature and enhancing the user role in the selection of the actions of the video.

Music

Another field that can be explored with this concept, would be music. Could we follow the same process but explore the relationship between the user weather context and music genre, could we find insights that would suggest the type of music to play based on the user environment and improve the recommendation systems related to music.

References

Arduino Uno Rev3. n.d. https://store.arduino.cc/arduino-uno-rev3 (accessed June 22, 2019).

Arduino Wi-Fi Shield - DEV-11287 - SparkFun Electronics. n.d. https://www.sparkfun.com/products/retired/11287 (accessed August 8, 2019).

Ashish Kumar. INVOOTECH (Innovation & Technology): HOW TO CONVERT THE LDR (Light Dependent Resistor) VALUE TO LUX n.d. https://invootech.blogspot.com/2017/06/how-to-convert-ldr-dependent-resistor.html (accessed March 29, 2019).

B_E_N. What is an Arduino? 2013a. https://learn.sparkfun.com/tutorials/what-is-an-arduino (accessed July 19, 2019).

B_E_N. Connecting Arduino to Processing. LearnSparkfunCom 2013b. https://learn.sparkfun.com/tutorials/connecting-arduino-to-processing/all (accessed March 29, 2019).

Barrance T. Continuity: Shoot and Edit so your Movie Makes Sense - Learn about film n.d. https://learnaboutfilm.com/film-language/sequence/ (accessed April 11, 2019).

Blariston, Mota A, Josuel, Larissa, Abdon M, César L, et al. Sensor de Luz com LDR e Arduino | Portal Vida de Silício 2017.

Bradley MM, Lang PJ. MEASURING EMOTION: THE SELF-ASSESSMENT MANIKIN AND THE SEMANTIC DIFFERENTIAL. vol. 25. 1994.

Braun V, Clarke V. Thematic analysis - The University of Auckland. Univ Auckl Website 2017a. https://www.psych.auckland.ac.nz/en/about/thematic-analysis.html (accessed June 23, 2021).

Braun V, Clarke V. Thematic analysis - The University of Auckland. Univ Auckl Website 2017b.

Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006;3:77–101. https://doi.org/10.1191/1478088706qp063oa.

Build your own weather station - Introduction | Raspberry Pi Projects. n.d. https://projects.raspberrypi.org/en/projects/build-your-own-weather-station (accessed

June 22, 2019).

Crawford JR, Henry JD. The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. Br J Clin Psychol 2004;43:245–65. https://doi.org/10.1348/0144665031752934.

Dionisio M, Nisi V, van Leeuwen JP. iLand. Proc. fifth Int. Conf. Tangible, Embed. embodied Interact. - TEI ’11, New York, New York, USA: ACM Press; 2011, p. 407. https://doi.org/10.1145/1935701.1935803.

Dionisio M, Paulino T, Suri T, Autzen N, Schöning J. "In search of light" Proc. 19th Int. Conf. Human-Computer Interact. with Mob. Devices Serv. - MobileHCI ’17, New York, New York, USA: ACM Press; 2017, p. 1–8. https://doi.org/10.1145/3098279.3122140.

Duvall S, Spurlock S, Duvall R. Automatic Environment Adjustment for Emotional Disabilities 2017.

Eisinga R, Franses PH, Vergeer M. Weather conditions and daily television use in the Netherlands, 1996-2005. Int J Biometeorol 2011;55:555–64. https://doi.org/10.1007/s00484-010-0366-5.

Free stock videos · Pexels Videos. n.d. https://www.pexels.com/videos/ (accessed May 6, 2019).

GitHub - adafruit/Adafruit_Sensor: Common sensor library. n.d. https://github.com/adafruit/Adafruit_Sensor (accessed June 24, 2019).

GitHub - adafruit/DHT-sensor-library: Arduino library for DHT11, DHT22, etc Temperature & Humidity Sensors. n.d. https://github.com/adafruit/DHT-sensor-library (accessed June 24, 2019).

Hoguet B. Les structures narratives interactives 2015. https://pt.slideshare.net/benhoguet/les-structures-narratives-interactives (accessed June 5, 2019).

Hoguet B. What is interactive storytelling? - Benjamin Hoguet - Medium. Dec 5, 2014 2014. https://medium.com/reinventing-storytelling/what-is-interactive-storytelling-46bfdd2a8780 (accessed August 20, 2019).

How Artists and Galleries Use IoT Networking to Create Interactive Art Exhibits. n.d. https://www.aeris.com/news/post/how-artists-and-galleries-use-iot-networking-to-create-interactive-art-exhibits/ (accessed September 29, 2021).

Huegel J. Photographing in Dark Indoor Settings n.d. https://www.picturecorrect.com/tips/photography-in-dark-indoor-settings/ (accessed June 21, 2019).

Illumination convert for lumens and lux. 2019. http://www.dmslighting.com/tools/illuminationconverter.html LB - FbHA.

Illumination convert for lumens and lux. n.d.

Jitter Cam - TV Tropes. n.d. https://tvtropes.org/pmwiki/pmwiki.php/Main/JitterCam (accessed June 21, 2019).

Leake M, Davis A, Truong A, Agrawala M. Computational video editing for dialogue-driven scenes. ACM Trans Graph 2017;36:1–14. https://doi.org/10.1145/3072959.3073653.

Lew M. Office Voodoo: a real-time editing engine for an algorithmic sitcom. ACM SIGGRAPH 2003 Conf. Abstr. Appl., 2003.

Marner TSJ. A realização cinematográfica n.d.

Nadeem M. How YouTube Recommends Videos. Jully 7 2018. https://towardsdatascience.com/how-youtube-recommends-videos-b6e003a5ab2f (accessed November 28, 2020).

Nick N", Sawhneyt ", Balcomt D, Smith I. Narrative HyperCafe: and Aesthetic Properties of Hypervideo. 1998.

Nisi V, Oakley I, Posthuma De Boer M. Locative Narratives as Experience: a new perspective on Location Aware Multimedia Stories. ArTech 2010 2010. https://www.m-iti.org/node/9265 (accessed August 16, 2019).

Okun J, Zwerman S, editors. The VES Handbook of Visual Effects. n.d.

Processing.org. n.d. https://processing.org/ (accessed June 23, 2019).

Puzzle Facade: a Site-specific Urban Technological Intervention. Provocat. Work. DIS 2014, June 21–25, 2014, Vancouver, BC, Canada, 2014, p. 4. https://doi.org/10.1145/2598784.2602791.

Recommended Light Levels. 2019.

Reichenstein7. Arduino Modules - Rain Sensor. Instructables; 2014.

Rigby JM, Gould SJJ, Brumby DP, Cox AL. Development of a questionnaire to measure immersion in video media: The Film IEQ. TVX 2019 - Proc. 2019 ACM Int.

Conf. Interact. Exp. TV Online Video, Association for Computing Machinery, Inc; 2019, p. 35–46. https://doi.org/10.1145/3317697.3323361.

Riopel L. What is the Positive and Negative Affect Schedule? (PANAS). What Is Posit Negat Affect Sched n.d. https://positivepsychology.com/positive-and-negative-affect-schedule-panas/ (accessed April 5, 2021).

Santos R. DHT11/DHT22 Sensor with Arduino 2019.

Sardonicus (1961) - IMDb. n.d. https://www.imdb.com/title/tt0055200/ (accessed December 7, 2019).

Schlyter P. Radiometry and photometry in astronomy. Stock Sweden 2017;03. https://stjarnhimlen.se/comp/radfaq.html.

Schofield G, Christie M. D 5.1 SPECIFICATION OF CINEMATIC IDIOMS Title of Deliverable Specification of Cinematic Idioms (Revised Version) and Title WP5-Cinematography. n.d.

Sentosa A. Arduino Weather Station (AWS): 4 Steps (with Pictures) n.d. https://www.instructables.com/id/Arduino-Weather-Station-AWS/ (accessed June 22, 2019).

Shaer O, Hornecker E. Tangible User Interfaces: Past, Present, and Future Directions. 2009.

The Boat I SBS. n.d. https://www.sbs.com.au/theboat/ (accessed April 6, 2019).

Thomsen A. Sensor de chuva YL-83. 18 Fevereiro 2014 2014. https://www.filipeflop.com/blog/sensor-de-chuva-yl-83/ (accessed July 5, 2019).

thread() \ Language (API) \ Processing 3+. July 26 2019:1. https://processing.org/reference/thread_.html (accessed August 8, 2019).

Trovajoli A. Sensual Jazz - Armando Trovajoli. Casanova 70 (Original Motion Pict Soundtrack) n.d. https://www.youtube.com/watch?v=MJ5IZzaHqq4 (accessed May 28, 2019).

Understanding and Interpreting Lux Values - Windows applications. 2018. https://docs.microsoft.com/en-us/windows/win32/sensorsapi/understanding-and-interpreting-lux-values (accessed March 11, 2019).

Varoudis T, Dalton S, Alexiou K, Zamenopoulos T. Ambient Displays: Influencing Movement Patterns. Vancouver, BC, Canada, 2011.

W+K London I Honda - The Other Side. 2015. http://wklondon.com/work/the-other-side/ (accessed November 2, 2019).

Wang Y, Hirakawa M. No Title. New York, New York, USA: ACM Press; 2006. https://doi.org/10.1145/1133265.1133287.

What Is the Internet of Things (IoT)? I Oracle Portugal. n.d. https://www.oracle.com/pt/internet-of-things/what-is-iot/ (accessed September 29, 2021).

Zong S, Kveton B, Berkovsky S, Ashkan A, Vlassis N, Wen Z. Does Weather Matter? Proc. 26th Int. Conf. World Wide Web Companion - WWW '17 Companion, New York, New York, USA: ACM Press; 2017, p. 883–4. https://doi.org/10.1145/3041021.3054221.

(Blank on purpose)

Annex

Annex A - COLD WEATHER STORYLINE

COLD WEATHER STORYLINE:

INT. LIVING-ROOM

In the living room, girls appear and sit on the sofa, holding a cup of tea or hot chocolate,

CUT TO:

Focus on an object she was looking for when doing her chores. The Swiffer she didn't know where it was, next to the TV table.

GIRL

Why is it there!?

CUT TO(FLASHBACK):

INT. HALLWAY

She is cleaning the Hallway using a mop.

(Rubs her hands to warmup)

BACK TO(PRESENT):

INT. LIVING-ROOM

Holds the Swiffer and puts it aside.

GIRL

(a bit annoyed)

oh well.

CUT TO(FLASHBACK):

INT. HALLWAY

Pick up the mop and goes inside.

BACK TO(PRESENT):

keeps drinking her juice and checks the time.

GIRL

Must be finished by now!

CUT TO(FLASHBACK):

INT./EXT. SIDE OF THE HOUSE

She is filling up the washing machine.
Holds a sports jacket.

CUT TO(FLASHBACK):

EXT. RUNNING

She is running outside

BACK TO(PRESENT):

INT. LIVING-ROOM

While remembering the workout, she thinks.
GIRL
(With a proud face)
I'm getting better!

CUT TO(FLASHBACK):

CONTINUATION OF WORKOUT SCENE

Stops running and checks her watch.
She sneezes.

BACK TO(PRESENT):

(Sneezing - Connection
with previous scene)
sneezes and wraps herself with a blanket

GIRL
Should take warmer clothes next time
A moment passes by, and she looks at her nails

GIRL (CONT'D)
Oh already!?/Should do them again!

CUT TO(FLASHBACK):

INT. BEDROOM

Painting her nails.

BACK TO(PRESENT):

INT. LIVING-ROOM

GIRL
(With a little smile)
So good to have Me time!

CUT TO(FLASHBACK):

INT. BEDROOM

In the bed stretched with her computer,
Touches some keys,

(Sound of the vibrating phone,)
(Phone vibration - same time as pressing the keys, connection to the present scene.)

BACK TO(PRESENT):

INT. LIVING-ROOM

Phone vibrates/rings...

GIRL
(Look at it a bit surprised)
Hello!? Almost ready, in an instant
Runs to her room to get dressed.

CUT TO:

EXT. FRONT PORCH

Leaving the house in a hurry.
Stops.

GIRL
So cold!

Turns back, for a scarf.
Leaves running.

Annex B - RAINY WEATHER STORYLINE

RAINY WEATHER STORYLINE (SIMILAR TO COULD WEATHER NARRATIVE):

INT. LIVING-ROOM

She looks through the window in the living-room and then sits on the sofa, holding a cup of tea or hot chocolate,

CUT TO:

Focus on an object she was looking for when doing her chores. The Swiffer she didn't know where it was, next to the TV table.

GIRL

Why is it there!?

CUT TO(FLASHBACK):

INT. HALLWAY

She is cleaning the Hallway using a mop.

(Rubs her hands to warmup)

BACK TO(PRESENT):

INT. LIVING-ROOM

Holds the Swiffer and puts it aside.

GIRL

(a bit annoyed)

oh well.

CUT TO(FLASHBACK):

INT. HALLWAY

Pick up the mop and goes inside.

BACK TO(PRESENT):

keeps drinking her juice and checks the time.

GIRL

Must be ending!

Gets up, opens the window to check the weather.

CUT TO(FLASHBACK):

INT./EXT. SIDE OF THE HOUSE

She is filling up the washing machine.
Holds a sports jacket.

CUT TO(FLASHBACK):

EXT. RUNNING

She is running outside

BACK TO(PRESENT):

INT. LIVING-ROOM

While remembering the workout, she thinks.

GIRL
(With a proud face)
I'm getting better!

CUT TO(FLASHBACK):

CONTINUATION OF WORKOUT SCENE

Starts raining, she runs away.

BACK TO(PRESENT):

(Rain in her face -
Connection with previous
scene)

closes window and cleans her face.
Goes back to the sofa, wraps herself with a blanket.
A moment passes by, and she looks at her nails.

GIRL
Oh already!?/Should do them again!

CUT TO(FLASHBACK):

INT. BEDROOM

Painting her nails.

BACK TO(PRESENT):

INT. LIVING-ROOM

GIRL
(With a little smile)
So good to have Me time!

CUT TO(FLASHBACK):

INT. BEDROOM

In the bed, petting her cat.
Touches the cat,

(Sound of the vibrating phone,)
(Phone vibration - same time as pressing the keys, connection to the present scene.)

BACK TO(PRESENT):

INT. LIVING-ROOM

Phone vibrates/rings...

GIRL
(Look at it a bit surprised)
Hello!? Almost ready, in an instant

Gets up and Runs to her room to get dressed.

CUT TO:

EXT. FRONT PORCH

Leaving the house in a hurry.
Stops, sees that it is still raining

GIRL
(Annoyed face)

Turns back, for an umbrella.
Leaves running.

Annex C – Storyboard sketch – one example

Bad/rainy weather storyboard page 2

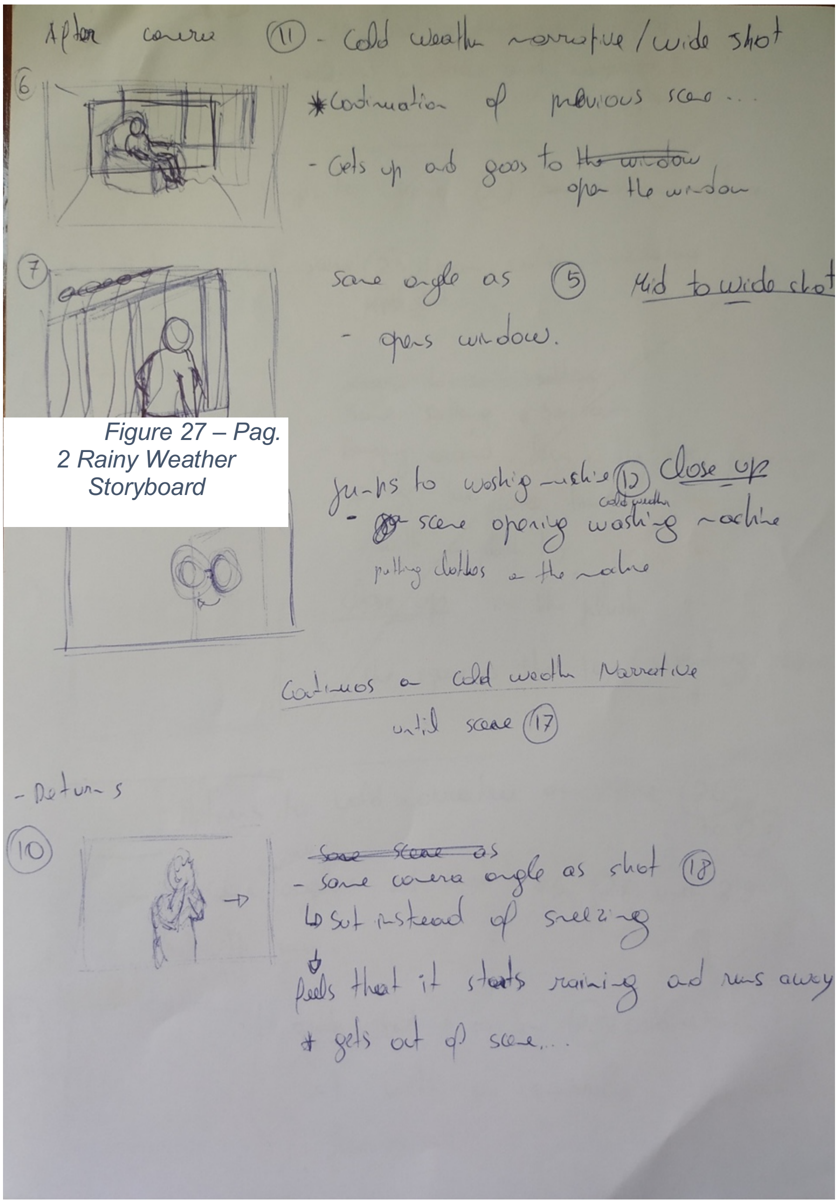


Figure 27 – Pag. 2 Rainy Weather Storyboard

Bad/rainy weather storyboard page 3

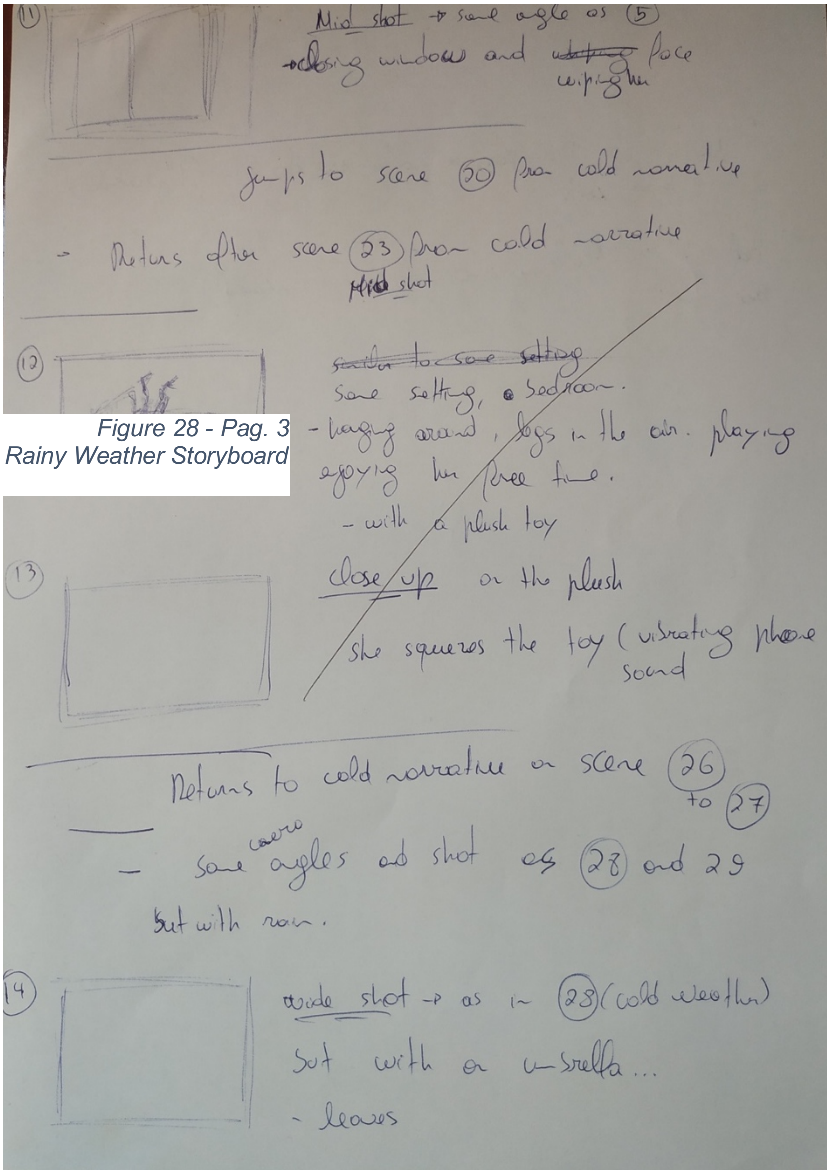
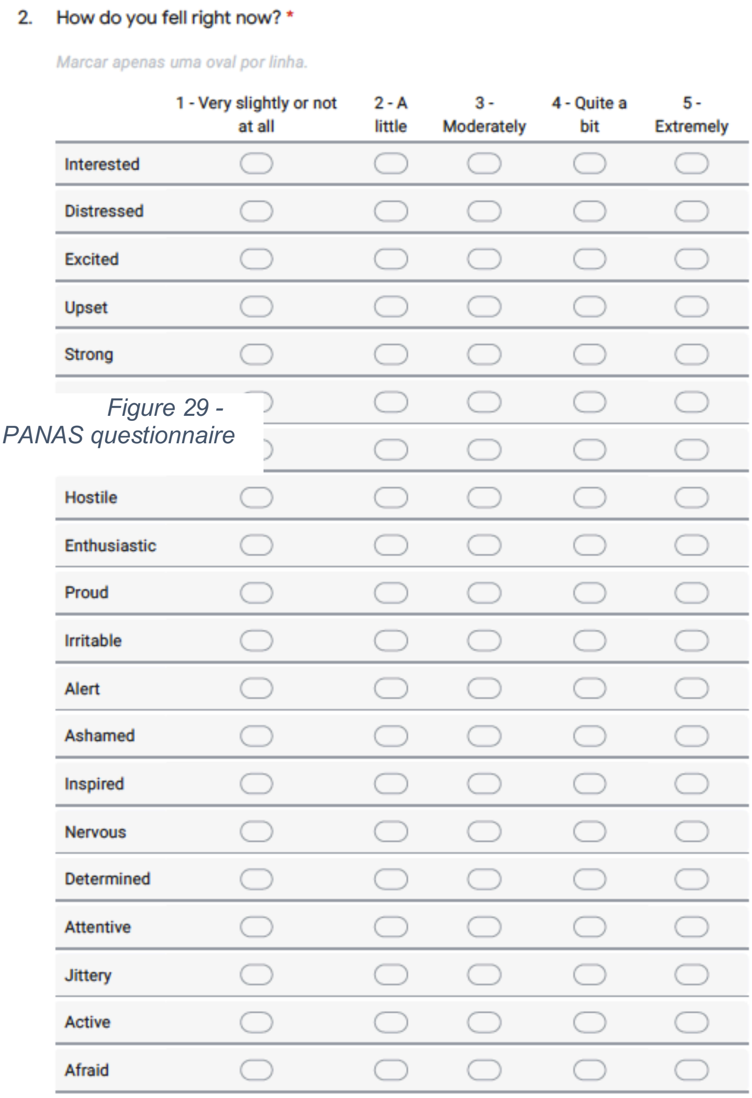


Figure 28 - Pag. 3 Rainy Weather Storyboard

Annex D – PANAS questionnaire



2. How do you fell right now? *

Marcar apenas uma oval por linha.

	1 - Very slightly or not at all	2 - A little	3 - Moderately	4 - Quite a bit	5 - Extremely
Interested					
Distressed					
Excited					
Upset					
Strong					
[illegible]					
[illegible]					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
Nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Figure 29 - PANAS questionnaire