Crisis in the Atlantic
An Artificial Intelligence Driven Interactive Story about Biodiversity recovery

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ABSTRACT

With the global acknowledgment of the joint crisis investing in nature and climate change, the biodiversity of our planet is at risk. Many ecosystems are being destroyed along with many lives in them. We humans must act as quickly as possible to avoid catastrophic consequences. In this dissertation, we present *Crisis in the Atlantic*, an AI-driven interactive game that we designed and developed that aims to be an entertaining way of raising awareness about ocean threats to its audiences. By combining the integration of an exploitable 3D 360º underwater environment and interactions with multiple marine species, through chat conversations and pop quizzes, *Crisis in the Atlantic* means to transmit information and spread awareness about some of the major oceanic issues. The AI characters use a Visual Question Answering model to have conversations with the players. Players have claimed that they have found the game interesting, different from anything they have played, and have learned something useful, through the help of the AI characters, regarding the major oceanic issues during the gameplay.

KEYWORDS

Interactive Storytelling, Ocean Threats, Nature Conservation, Biodiversity, Chatbot, Artificial Intelligence

1 INTRODUCTION

Interactive media and entertainment at the service of nature conservation

With the global acknowledgment of the joint crisis investing in nature and climate change, the biodiversity of our planet is at risk. Many ecosystems are being destroyed along with many lives in them. To reverse these catastrophic consequences, we, as human beings, need to take action as quickly as possible, since we depend deeply on those ecosystems[14]. For the above reasons, in the last decades, sustainability has been growing extremely fast in various areas of research, including areas related to technology[8]. Fields such as digital interactive media and entertainment have taken the opportunity to embrace environment preservation challenges and contributed with interactive media that creates awareness and brings knowledge to a wide variety of audiences[2][10]. The use of digital interactive technology to promote Nature conservation has consistently increased in the last years. As we witness the rise of a new extended reality, one between the real and the virtual, this new hybrid space is seen as an opportunity for people to connect with natural environments, to interact with a great diversity of animals, and to have new experiences of nature[5]. Findings and positive results from these efforts are backed up by extensive scientific proof[20]. Despite the applaudable initiatives, the joint nature and climate change challenge still require efforts to be effectively tackled. This thesis takes this challenge at heart, investing in the innovative combination of Nature preservation and AI-driven Interactive Storytelling and Gaming, to bring awareness, provide information, and propose ways to contribute through small gestures of respect and preservation of our environment.

Storytelling and AI

Storytelling is at the heart of human nature. Digital Interactive Technologies influence the way we tell and deliver stories. Interactive Digital Storytelling (IDS) is quite an extensive and interdisciplinary area of research. Many definitions have been provided, and for the sake of this project, this thesis will adopt Spierling view on the subject, as she defines: "Interactive Digital Storytelling" as a hybrid form of game design and cinematic storytelling for the understanding and creation of future learning and entertainment applications."[23]. Mainly she distinguished the four most influential components or approaches IDS: 1. Generative computer graphics and animated storytelling 2. Human-computer interaction (HCI) 3. Computer game design 4. Artificial intelligence. This thesis project is in fact situated at the crossing of these contributing areas or approaches.

Today, with the new wave of AI technologies applied to the ancient art of storytelling, they are revolutionizing the interactive storytelling industry. Innovative AI algorithms can power a new breed of stories, as the characters can adapt to react to how audiences play. Visual Question Answering is one of the fields in computer science that uses computer vision techniques, natural language processing, and deep learning to answer questions asked about an image[1]. When well used, VQA based characters are able to have short conversations with a player when talking about an image, where the player asks questions, and the bot replies the answer. While these technologies are evolving fast, VQA included, when applied to the old craft of storytelling, they are still on experimental grounds.

1.1 Work Objectives

For the reasons above, *Crisis in the Atlantic* was developed. It is an AI-driven interactive story - game, conceived to entertain, while at the same time, educate, inform and spreading awareness about the ocean threats to an audience of young adults. Moreover, this thesis project looks at the Macaronesian Atlantic ocean as a region to

[1]https://towardsdatascience.com/deep-learning-and-visual-question-answering-c8c8093941bc

protect and cherish, given its high biodiversity, and great cultural and economic value.

The objectives of this thesis project are as follows:

(1) Develop *Crisis in the Atlantic* that is able to spread awareness regarding the major ocean issues while entertaining the players.
(2) Explore and understand the best Artificial Intelligence method to be used in interactive games such as *Crisis in the Atlantic*, and apply it to the game.
(3) Perform a detailed evaluation with the target audience to assess the effectiveness of the game when creating awareness about the mentioned topics, as well as the users' experience with the AI.

The development of this dissertation aims to answer the following research questions:

(1) How can we design an interactive story-game that integrates Artificial Intelligence to spread awareness regarding major marine ecosystem threats?
(2) What Artificial Intelligence method is best suited for an interactive story-game?

2 RELATED WORK

CrA project exploits AI-driven characters to interact with the players and inform them about some of the major Ocean issues, caused by humans, as well as raising awareness towards nature conservation in general. To accomplish its goals, CrA builds on previous efforts developed mainly in three different areas. One area covers chatbots and conversational agents, another one is about interactive games that deal with ocean disasters. The third and more articulated area concerns AI applied to interactive Storytelling and games and in particular story characters that interact with the players using Q&A Dialogues for the players to interact with the characters.

2.1 Dialog Systems

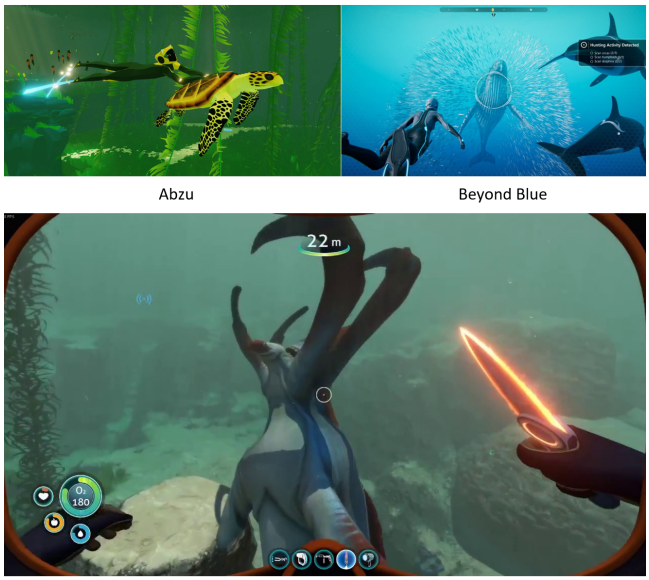
The advances in technology have made our lives have become easier. As humans, we have an obsession with chatting with many of mankind's inventions, either for convenience or even just for amusing purposes. Over time, the obsession has become a need, as it improves regular users' experiences. Dialog systems were created to satisfy those needs. These systems fall into two categories, either Task-Oriented dialog agents or Chatbots, that use natural language to communicate with their users[11].

Task-Oriented dialog agents were created to assist their users by performing tasks for them. This kind of system is based on short dialogues with users and clear to the point. One type of Task-Oriented dialog agent is the AI assistant we have in our smartphones, like Siri, Google Assistant, or Alexa. Many robots, such as the ones at nursing homes, include this type of system in their interface, facilitating the nurses' jobs[11]

Chatbots, contrary to Task-Oriented Dialog Agents, are created to have longer conversations with humans than the other ones are meant to have, as their goal is to emulate a real-life chat with users[11]. They are essentially software programs that are created to have conversations with humans, either by voice or by text[13][19]. They have been around for almost 55 years since the introduction of Eliza in 1966 by Joseph Weizenbaum[19][26].

2.2 Interactive technologies and Nature Conservation Awareness-Raising

Lately, tech-driven industries such as Interactive gaming and entertainment, are engaging in approaches to increase people's awareness regarding complex social issues, such as migrants and integration, climate change, and biodiversity conservation[22]. Interactive activities with nature, such as whale watching or visits to rare and endangered ecosystems for example[9] can cause unnecessary stress to the animals and the natural environment. In these cases, mediation through technology can be beneficial to the ecosystem, bringing the audience in contact with nature without disrupting its course. Approaches such as POSEIDON[21] propose the integration of extended reality and interactive media to deliver a satisfying experience to whale watchers even in absence of the real animals. These are a fruitful avenue for exploration of hybrid technology-nature interactions that spare the animals and the environments from exceeding and unnecessary stress. Other benefits stem from technological mediation to nature conservation. A much larger group of audience can now have access to the digital artifacts and be exposed to pro-nature messages. Games such as Abzû[18], Beyond Blue[25] and Subnautica[3](See figure 1) are examples of those which also include the mentioned hybrid technology-interactions, as the players find themselves immersed in the ocean and interacting with the marine animals.



Abzu | Beyond Blue

Subnautica

Figure 1: Gameplay of Abzû, Beyond Blue and Subnautica[2]

2.3 AI & Storytelling

Interactive storytelling approaches narrative from a more malleable perspective, unlike a printed book or an edited film. Today, AI storytelling tools combine content creation, emotional intelligence,

[2]https://www.engadget.com/2015-06-10-abzu-hands-on.html
https://www.youtube.com/watch?v=U6na3VtpavA
https://www.youtube.com/watch?v=WuhCjQWMJoE

sentiment analysis, and video synthesis in a new category of emerging technology. Ideally, through the use of this technology, the story can be dynamically assembled, and influenced by the player as much as by the author itself. These kinds of technologies are now exploited in the most advanced examples of story-driven computer games.

Interactive storytelling authoring is a complex task. It encompasses several different areas, from psychology, computer science, cognitive science to natural language processing[4]. Each one of these areas plays a very important role in the success of storytelling.

AI techniques are vastly present in Interactive Storytelling[7][16]. Usually employed in virtual environments and 3D animations, techniques such as AI planning systems allow the storytelling to have a diverse plot according to the players' actions and choices[27][7]. These applications are very common in systems that create Character-Based Interactive Storytelling[6]. In the past few decades, many of Character-Based Interactive Storytelling games with AI systems in the background have been created, some examples are Façade[17] and AI Dungeon[24].

2.4 Discussion

Interactive and entertainment technologies have increasingly been employed to promote nature conservation messages and we have seen that Artificial Intelligence plays a big role in Interactive Storytelling applications. Moreover, the introduction of Dialog Agents has simplified our lives and has become mainstream. with all these techniques, this project is concerned with making use of AI(Visual Question Answering) and storytelling to create an interactive game that spreads awareness about Ocean threats and marine biodiversity conservation while entertaining its audience.

3 GAME DESIGN PROCESS OF CRISIS IN THE ATLANTIC

The goal of this thesis is to promote awareness about the oceans and provide an entertaining experience through designing an AI-driven interactive story game. In this chapter, the entire game design process of "Crisis in the Atlantic" is covered, which includes: the requirements, the two possible concepts for the projects, the low fidelity prototypes, the high fidelity design of the chosen concept, the analysis of AI models used in chat interaction, the software architecture, and finally the final prototype.

3.1 Requirements Specification

We define three different general requirements for the game to achieve the objective based on synthesizing the findings from the prior-art:

(1) Awaking the players' interest in the ocean
To make a good first impression on the player and with the ocean as our main theme, *Crisis in the Atlantic* needs to convey a visually and aesthetically strong portrait of the ocean, and its biodiversity elements. The more a user feels attracted to the environment, the more they will want to explore every corner of it.
(2) Engaging the players with the ocean biodiversity elements
As an interactive game, connections between the users and the animals must be made. One simple way for people to connect is through visual and verbal communication, thus chatbots were taken into the equation while developing the communication section of the game.
(3) Providing a way to transmit knowledge to the players
Crisis in the Atlantic is designed to have an educational component. To engage users in the learning process, the learning should be delivered through visual and interactive mechanisms.

Each of the general requirements is targeted the objective. In addition to the general requirements specified, there are several technical requirements to make the developed project suitable:

(1) Deployment
The project should be deployed from a desktop application.
(2) Stability
To ensure a smooth user experience, the game should be as stable as it can get, that is, it should have the least amount of bugs possible.
(3) Latency
The response time from the AI should be the least possible.
(4) Accessible
The key bindings should be the standard ones.
(5) AI without retraining
The project should attempt to utilize AI in a way that utilizes existing datasets as the cost of retraining is too high.
(6) Interchangeable components
The project should have a malleable architecture being able to add or remove components of the game without affecting the experience.

With all the requirements defined, it was time to begin working on the project, beginning with the game concepts and low fidelity prototypes for each concept.

3.2 Concepts development and Low-Fidelity Prototyping

Based on the defined requirements two game concepts were sketched and evaluated as low fidelity prototypes, using the whiteboard platforms Miro[3] and prototyping tool Figma[4], to identify the most suitable one to carry forward to the final game prototype.

Regardless of the concept, both require the players to interact with the characters via chat. Although the goals of the chat interactions are different in each concept, the development should be the same. Visual Question Answering would be the perfect tool for this kind of situation since both the image and the questions asked by the player are the inputs of the VQA model, and the output of the model is the answer the player wants.

Prototype Concept I: Amnesia in the Atlantic

The concept of *Amnesia in the Atlantic* was the player awoke in an unknown environment, without memory. The player then explores the environment collecting clues by asking other fish about who they are.

Exploring the environment. The player was being placed in a 360º underwater habitat, where they were able to interact and converse

[3]https://miro.com/
[4]https://www.figma.com/

with several local animals. Before chatting with the animals, the player could and should look around and explore the habitat of those animals.

Communicating with the animals. The goal of this prototype is to find out which species it belongs to. To gather the clues, the player will have to communicate with each animal (See figure 2), asking them questions about themselves, such as characteristics, habits, etc. The other animals will give the answers, generated by the VQA model, the player seeks. Just like in real life, where hearing only one side of the story is insufficient, the statements given by one animal could be not enough. In that case, the player can exit the chat and find himself in a 360º underwater habitat, where they can interact with animals of other species. This process can be repeated until the player figures out the species they belong to.

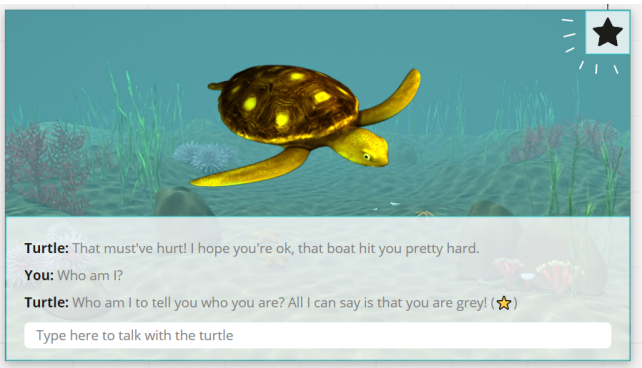


Figure 2: Low fidelity Prototype I - chat

Presenting the species. When enough clues are gathered, the player can decide to guess the breed of the character. In case the selection was the correct one, a pop-up screen would appear to present the species that was chosen for that "chapter". This section would be used in the educative section at the end of the game, where the information about the species is presented to the user in more detail.

Prototype Concept II: Crisis in the Atlantic

Similarly to *Amnesia in the Atlantic*, the player is immersed in a 360º underwater environment in *Crisis in the Atlantic(CriA)*. This time, we can see some traces of some significant ocean hazards. Each of the three locations has one species; the purpose is for the player to chat with the creatures, and figure out what is causing the risks to their habitat.

Environment Exploring & Finding the animal. The player will be immersed in a 360º underwater environment and they need to explore the map and locate the animal of that level/habitat.

Communicating with an animal. The user needs to communicate with the animals in this prototype too. The animal will present four different blurred images, in which one of them depicts one of the causes of a serious biodiversity threat, and the player must ask questions about the image itself to find out what is the cause of the threat in question.

Finding out the cause. After asking several questions to the animal, the player can then select the image they think is the correct one and confirm their choice. If the image selected is the correct one, all images will lose their blurriness, and the animal would say something about the image, explaining better the cause of the threat(See Figure 3).

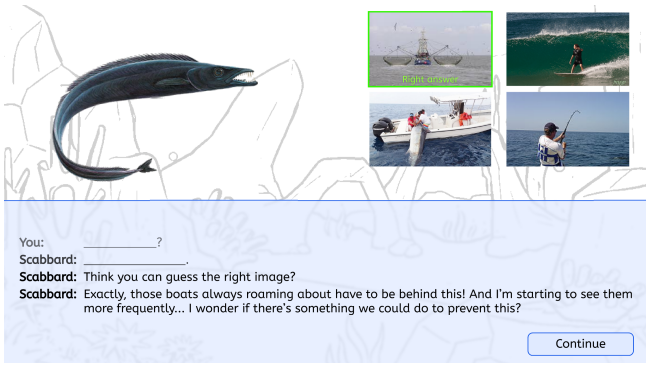


Figure 3: Low fidelity Prototype II - Image selection

Multiple levels. There are various animals, which bring up a distinct threat each. An interactive button will bring up a map where the player can select a destination within the map and a new environment with unique characteristics and a different animal will appear on the screen. When every level has been explored and the causes of the ocean threats found, that will be the end game.

Analysis and conclusions of low fidelity prototypes

Both prototypes were analyzed in detail, considering parameters such as gameplay experience, educative purposes, and whether or not the game is enjoyable.

Amnesia in the Atlantic protocol is fairly simple, commands are easy, as it only requires the mouse and the keyboard just to navigate and to type in the questions. It contains facts about that the species of the player's character, like their habitats, etc. as educative content. Animal interaction and exploration of a 3D world were included to improve the users' enjoyment of the game.

As for *Crisis in the Atlantic*, the gameplay experience is similar to the previous one. The educative content, unlike *Amnesia in the Atlantic*, concerns the ocean threats that are affecting the animals´ habitat. The exploration of a 3D environment and the interaction with multiple animals were also included to improve the enjoyment of the game.

Since the two prototypes are similar, to make a decision, the pros and cons of each prototype in aspects that are different have been highlighted. In *Amnesia in the Atlantic*, there is only one goal, to figure out the species of the character portrait by the player. This means that the player has the freedom to talk to whichever animal they want. However, this also means that most of the game can be skipped. When the player is chatting with the animal, there are no visual references to help the player. Aside from the previous disadvantages, the COCO dataset[5], from which the VQA dataset[6]

[5]https://cocodataset.org/#home
[6]https://visualqa.org/

is constructed, does not have many marine animals categories, meaning the VQA model could not perform as well. In *Crisis in the Atlantic*, unlike *Amnesia in the Atlantic*, the player has to go through every map to finish the game. One big advantage is that educational content is displayed at the end of each map, meaning more knowledge will be transmitted to the user. Another advantage is when chatting with each animal, the player will have blurred images displayed on the screen, giving them a reference to think of the questions. However, the obligation to go through every animal and map also means that less freedom is given in this prototype compared to *Amnesia in the Atlantic*.

After weighing all of pros and cons, *Crisis in the Atlantic* was chosen to be continued. The deciding factor was that *Amnesia in the Atlantic* relies on images of marine species in the conversation stage, COCO dataset not covering those categories, and one of the technical requirements is "AI without retraining", it's impossible not to rule it out.

3.3 Crisis in the Atlantic development

With the concept for the project decided, the development of the high fidelity prototype follows. This hi-fi prototype will include the aspects that lacked in the low-fi prototype as well as add other features. Before the development of the final prototype, the architecture of the game software, which will include three different layers, was drafted. AI and Visual Question Answering models were explored to generate the responses given by the animal the player. The final step was to develop the final prototype, taking into account what could be improved from the first hi-fi prototype, the architecture of the software, and finally incorporating the AI model, establishing a connection between the AI model and the game component.

High fidelity prototype

Following the requirements established previously, to create a desktop application, Unity 3D was used as the game development tool, with the scripts written in C#.

Game Introduction. The low-fi prototype was missing an introduction. A brief introduction text appears when the game starts so that the player gets familiar with the game objectives.

Game Main Menu. Like a regular game, the addition of the main menu was necessary. To keep the game simple, user-friendly, and intuitive, only three buttons were added to the main menu: **Play** for the player to launch the game, **Tutorial** will take the player to a tutorial about the AI conversational part, **Controls** will show the player the keys used to play the game.

3D environment. When the player presses the play button, they will be transported to a 3D underwater world. The player can explore the environment using the keys found in the controls screen. The environments were designed to be as realistic as possible, to awaken the players' interest in underwater water habits. While exploring the habitat, the encounter with the marine animal of the environment will eventually happen(Figure 4). In addition to collisions with the walls and the ground, an upper limit was set, so that the player does not leave the environment. The environment also features a few touches of green and blue, lens distortion effect, and fog effect to simulate the deep ocean effect.

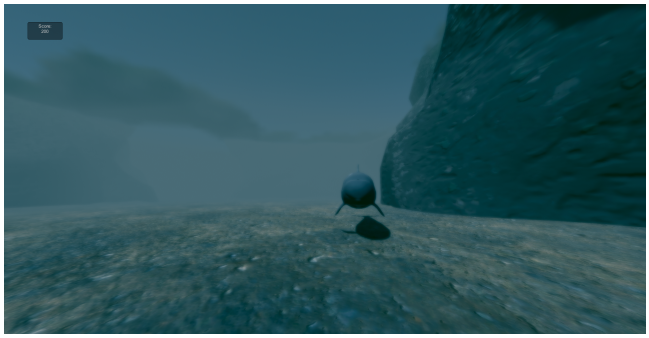


Figure 4: High fidelity Prototype - Encounter

Game Scoring. A small GUI box is used to keep the score. The scoring system gives the best feedback on a player's performance and concentration throughout the game[15]. The scoring system was implemented with the intention of awaking the competitive side of each player, to avoid unfocused players.

Communicating with an animal. Upon the collision with the animal, the player will start a conversation with the animal(Figure 5). Just as mentioned in the low-fi prototype, 4 blurred images are presented to the player, one of which is related to a cause that is destroying the habitat of that specific animal. The player will now have to ask questions about the image to try to figure out the correct one.

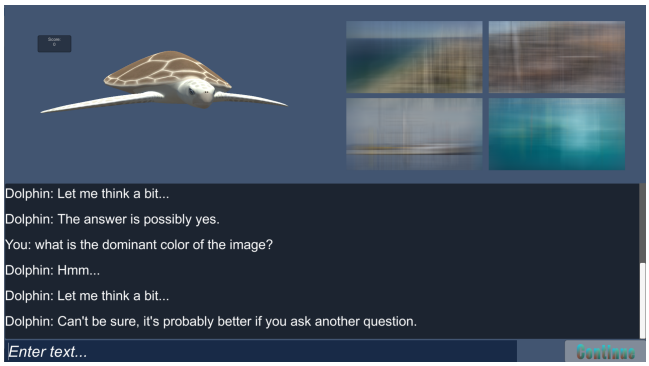


Figure 5: High fidelity Prototype - chat

End Game. Following the selection of the right image, unlike in the low fidelity prototype, a quiz will emerge after each talk, conveying knowledge and making it more participatory at the same time.

Testing educational outcomes. To evaluate and reinforce the educational requirements about the awareness about oceans, a quiz was added(Figure 6). The animal, during the quiz, asks the player a question about an issue relating to the ocean threat discussed throughout the conversation.

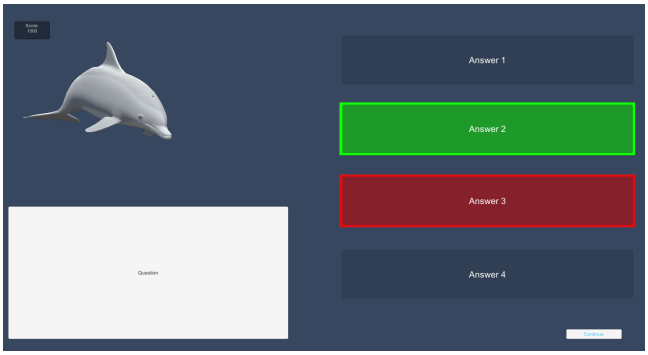


Figure 6: High fidelity Prototype - Quiz

Game software architecture

Component-based architecture to simplify development and deployment of the project. One of the advantages of developing this way is that the system is much more malleable and adaptive, and every layer can be used in another system without major changes. The game is composed of three main components: Gameplay, AI and a Service Component(See figure 7). The gameplay component is essentially the front end of the game, where the user interface is presented, the AI component is where the data is processed and the VQA model runs, and finally, the service component takes care of the communications between the other two components(using HTTP requests when communicating with gameplay component), working as a bridge.

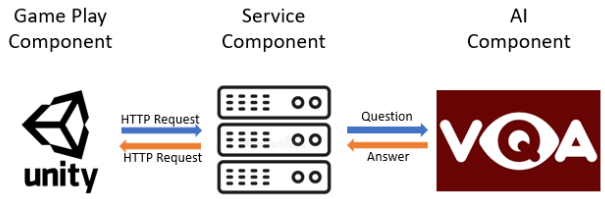


Figure 7: Game software architecture

Gameplay component. The gameplay component is represented by the interface that the game presents. Every feature were developed in Unity 3D, with the scripts written in C#. Some shaders were used to create some specific visual effects. The Post-processing package from the Unity asset store was utilized to create effects of an underwater environment, such as the lens distortion, depth of field, etc.

The communication between this component and the service component was done through HTTP requests. The requests are generated using the UnityWebRequest system[7]. The information is then sent to the service component which contains an API that allows the establishment of those HTTP requests. When the answer generated by the VQA model is available, it is sent back to the gameplay component, also with HTTP requests.

[7]https://docs.unity3d.com/Manual/UnityWebRequest.html

AI component. The AI model is written in Python3, using the libraries TensorFlow and Keras. No web requests are needed to communicate with the service component as they are written in the same script. This component takes care of most of the Machine Learning VQA model, to generate answers to specific questions to specific images. The model used was a pre-trained RNN+CNN model, from Patrik Savla[8], as well as the weights for the model.

Service component. The purpose of this component is to establish a connection between the gameplay component and the AI component. For this component, a service was created with a RESTful application program interface(API). REST APIs are a structure style of an API with more flexibility. they manage data through HTTP requests[9]. There are four many types of requests: **GET** to request information, **PUT** to update the existing data, **POST** to send new data and finally **DELETE** to delete data from the API. This service is developed in Python3, using the framework Flask. Only POST requests were integrated as there only is a need to send new data. The service runs locally in the URL((http://localhost:5000/image_name)).

AI and Visual Question Answering Model

During the conversations, the animals' objective is to answer the players' questions, leading them to the images that represent the causes of the marine issues. These answers are generated using a machine learning model that combines a Convolutional Neural Network and a Recurrent Neural Network trained with the VQA dataset.

Visual Question Answering. It is a field of computer science that encompasses many fields[12]. The VQA's purpose is to process open-ended text-based questions, generating answers to the question asked regarding the image[1]. It is trained with a dataset that includes over 200.000 images, 600.000 questions, and almost 8.000.000 answers[1].

Pre processing data. The VQA model used in this project is developed by Pratik Savla[10]. However, the model is incomplete as the pre-processing part of the model is missing, for both images and questions. To pre-process the data in this project, it was added a CNN model and a spaCy language model to the AI component of the game.

To extract the features of an image, VGG16, a 16-layer CNN was loaded. As seen in the top part of figure 8, an image is used as the input of the VGG16, which, after multiple layers, returns the features of the image in the form of a tensor[11]. To extract the features of the question(See top part Figure 8), the AI component will split the question into tokens. Before processing them, a large English model from SpaCy, "en_vectors_web_lg", was loaded. By inserting the tokens into this model, it will return a list of vectors[12], which are the features of the question.

VQA model. Once the data features are extracted, they are input into a feed-forward network and an RNN composed of Long

[8]https://github.com/PratikSavla/Visual-Question-Answering
[9]https://searchapparchitecture.techtarget.com/definition/RESTful-API
[10]https://github.com/PratikSavla/Visual-Question-Answering
[11]https://neurohive.io/en/popular-networks/vgg16/
[12]https://applied-language-technology.readthedocs.io/en/latest/notebooks/part_iii/04_embeddings_continued.html#

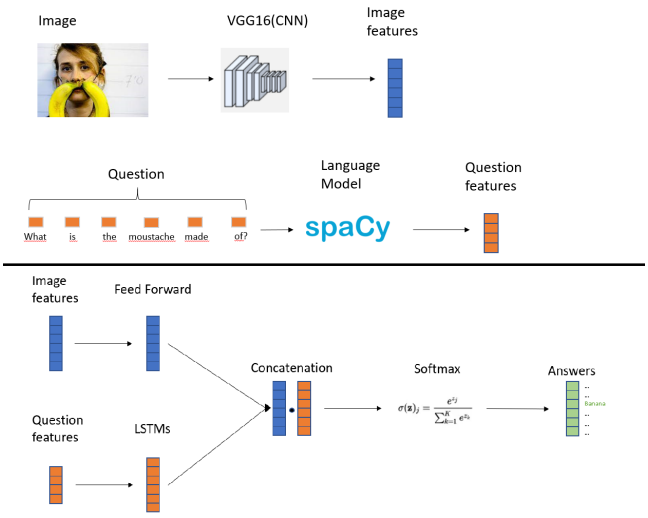


Figure 8: Data preprocessing and VQA model structure

Short-Term Memories(LSTMs)(See bottom part Figure 8). The first feed-forward network will take the image features to return a re-shaped vector. The RNN will take the question features and turn them into another vector. The model concatenates both networks are concatenated and later uses the softmax function[13] to determine the probabilities, or the confidence level, of each answer(Figure 8). The answer with the highest confidence level is then selected, re-structured, and sent back to the service component and in turn, sends it to the gameplay component, via HTTP requests.

Final Functional Prototype

Following the development of both the AI component and the service component, as well as collecting the mistakes from the first high fidelity prototype, the final prototype was developed, also with Unity and C# scripts. This version includes menus that were not included in the first hi-fi prototype, it had some design touches and sounds added, to improve the user experience.

Start Screen & Cut Scene. In the high fidelity prototype, there was a lack of a start menu, which was added in this final prototype. This menu(Figure 9) includes a box the title of this AI-drive interactive story-game. The introductory menu in the hi-fi prototype presents a very dense text, which is not easy to read. To solve this problem, a new cut scene(Figure 9) was added to in this final prototype, appearing when the button "Play" is clicked in the start menu. In this new scene, the animals present in the game appear, explaining that their habitat is getting destroyed and asking the players to find them. To facilitate the reading, the text is presented in short sentences and in chat balloons.

Main Menu & Controls Screen &Pause Menu. The Main Menu did not suffer many changes in this prototype. Apart from a few design touches is still includes only 3 buttons, "Play" to start the game, "Tutorial" to have a simple guide for the AI conversational

[13]https://machinelearningmastery.com/softmax-activation-function-with-python/

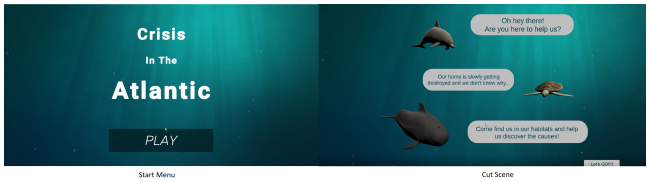


Figure 9: Start Screen and Cut Scene

part of the game, and the "Controls" button to inform the users of the keybindings of the game(Figure 10).

As mentioned, the "Controls" button leads to a panel where the keybindings are explained. Those key binds include the movements, both of the player's character and the camera, along with the key to trigger the pause menu. These controls are the standards for regular first-person games, meeting this way the technical requirement **Accessible** defined earlier in this chapter.

The Pause Menu, triggered when "P" is pressed, will also freeze every aspect of the game. This menu, just like the Main Menu, has 3 buttons, one for resuming the game, which can also be done by pressing the "P" key again, a second one to revert to the Main Menu, and the last to exit the game, closing the application.

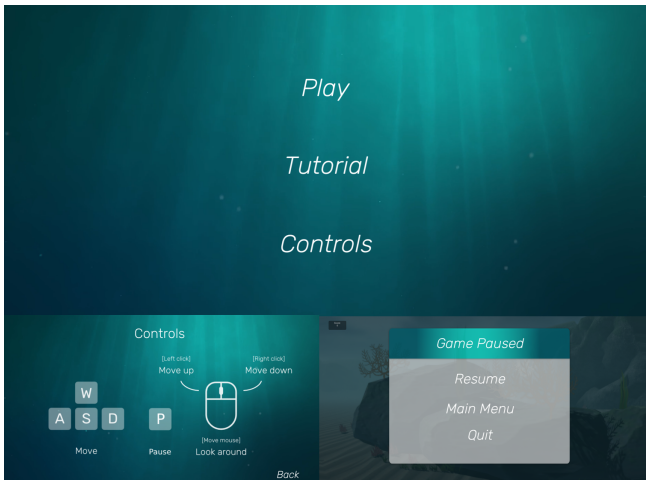


Figure 10: Main Menu, Controls Screen and Pause Menu

The game starts with the push of the button "Play". In this final prototype, the maps did not have many changes, the size and the terrains remain unchanged. The few additions were: in every map, there have been added different stational species such as corals(Figure 11), etc., and also a few external objects. E.g. in the 2nd scenario(Figure 11), we can see plenty of objects polluting the ocean. In the 3rd scenario, we can see a sunk ship(Figure 11). Most of the details that were added extra in all of these maps are related to the issues that are later discussed by the animals.

Communicating with an Animal. In this section, the player is expected to ask the animals questions about a certain image(Figure 12). This question is processed by the AI component. The answer presented to the player is first synthesized in the service component,

Figure 11: Scenarios of the game

so that it is not a single-word answer. Those answers depend also on the confidence level. To make the conversation a little less robotic, a few phrases were pre-generated for this final functional prototype. The mechanics of the chat interaction is explained mainly in the tutorial. Considering that there is a possibility to skip the tutorial, in the first map, upon the collision with the dolphin, a message would pop up, explaining what the next steps would be. There were also some design changes, just like in the rest of the game. The changes will be addressed later in this chapter.

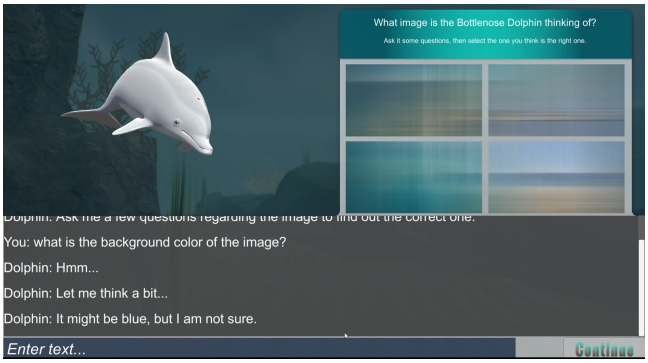


Figure 12: Chat - Final Prototype

Quiz. As mentioned earlier, the introduction of the quiz was to make the game more interactive. With the game having an educative branch, an interactive way, the quiz(Figure 13), of transmitting knowledge about the ocean threats would make the game more entertaining and less tedious. With three animals in the game, three themes will be addressed and therefore, three quizzes will need to be answered to finish the game. In the high fidelity prototype, the idea of the quiz was introduced, but no real questions were added, nor the answers. The lack of content was resolved in this final version of the game, with the questions being, as mentioned, related to the ocean threat correspondent to the environment. There was also a layout change on the position of the questions and answers.

Final Screen. The user will be provided with a final screen, which was not implemented in the last prototype, after completing the entire game. In this final screen(Figure 14), the score of the player will be displayed, as well as some advice about the ocean and its importance in our ecosystem.

Hi-Fi prototype and final touches. The first high-fidelity prototype has just about every functionality of the game, however, design-wise, it was very poor. After having all the final features implemented, many graphic designs and visual touches were made to make the game more attractive.

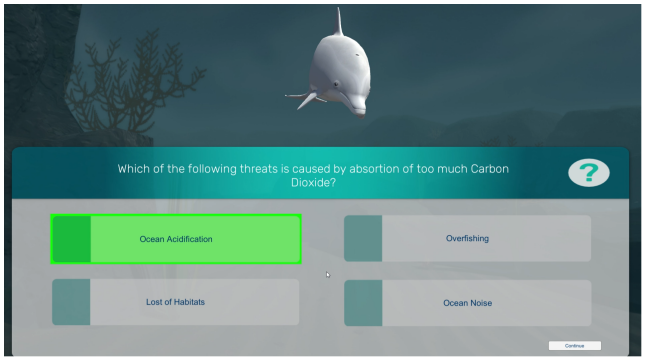


Figure 13: Quiz - Final Prototype

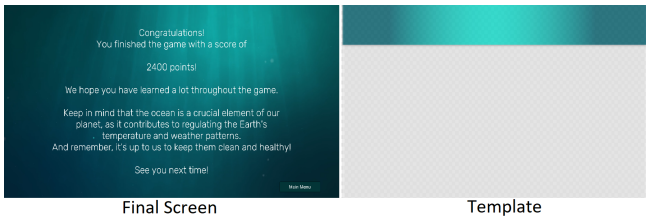


Figure 14: Final Screen, Template - Final Prototype

The font Rubik[14] was used for pretty much every text present in the game, to maintain consistency. A template(Figure 14) was added in every part of the game where there is text presented, apart from the final scene. In the case of quizzes and the conversation parts of the game, a screenshot of the habitat/environment was added as a background, so that the players would still feel playing the same game. A greenish video with lights coming from the top, which resembles the deep ocean was used as the background video of every menu in the game. Aside from these UI changes, A few visual settings for when in the underwater environment were also changed. The depth of the field, lens distortion, and fog volume, as well as the color filters, were adapted for a better view.

Sound. Sound is a very important factor in a game. There were not any sounds in the high fidelity prototype, but they were added for this final prototype. For the exploitation of the environment, A background sound of water bubbling was added, to make the environment more realistic. A list of sounds was also added for both the dolphin and the whale. The turtle does not get any sound addition as turtles don't make much noise in real life. The list of sounds was programmed to play randomly every few seconds. These sounds could only be heard within a sphere of a certain radius of the animal. The closer to the animal, the louder is the sound. And lastly, a couple of sounds were added in the interactive section of the game. Whenever the player chooses an option, the sounds would vary whether the option is the correct or the incorrect one.

[14]https://fonts.google.com/specimen/Rubik

4 EVALUATION

4.1 Evaluation Objectives

With the final functional prototype developed, a user evaluation was conducted. The goal was to check how did the game stand in relation to the research questions proposed before, which were: 1- How can we design an interactive story-game that integrates Artificial Intelligence to spread awareness regarding major marine ecosystem threats? 2- What Artificial Intelligence method is best suited for an interactive story-game?

To be able to provide an answer to those questions, we needed to evaluate the following factors:

Marine Ecosystem Awareness: if the players were becoming more aware of the ocean threats after playing the game.

Chatbot: If the players had a pleasant user experience with the chatbot, determining if it was the right choice to integrate VQA into the game.

Game Usability: If the game was playable, that is, if the usability of the system was good.

A group of 20 young adults, with all kinds of backgrounds, were asked to participate in the user testing. This evaluation was done by having the users fill out two questionnaires, one before and the other one after playing the game, as both assess their ocean threats awareness. Afterward, the players answered a set of questions in interview style, about the game and the chatbot. It has the objective to assess the usability of chatbot[15] and the system[16], as well as if the game has fulfilled its purpose of stimulating Marine Ecosystem Awareness.

4.2 Protocol and Measures

The entire evaluation phase was conducted following an ad hoc designed protocol, specifying each one of the steps of the evaluation process, including two questionnaires for the players to fill out, as well as the questions to be asked during the final short interview. With all the conditions met, here is the ordered list of the tasks to be performed during the entire evaluation process:

(1) Welcome the participants, thank them for participating in the evaluation and collaboration. Contextualize the game, the procedure of the evaluation, and its goals.
(2) Hand in and ask them a consent form written to inform the users about this user study, and asking for their permission.
(3) Ask the user to fill out Pre-Questionnaire (detailed below). A brief questionnaire to assess their knowledge on the subjects of ocean threats and AI chatbots. To keep the privacy of the users during the evaluation, a user ID was assigned to each one of the users.
(4) Boot up the background service and the game and ask the user to play it.
(5) Take notes while the user plays the game. Those notes can be their comments about the game, reactions, etc. The user ID is registered next to the notes.
(6) Ask the player to fill out a Post-Questionnaire (detailed below). this one, much more complex than the one before as this includes multiple questions concerning marine life and ocean threats, questions about chatbot usability, and system usability.
(7) Conduct a small interview to ask a few questions to the player, mostly regarding the game itself and the AI chatbot.

The Pre-Questionnaire will ask the users were asked if they are familiar with both the AI chatbots and the main Ocean threats caused by humans, in case positive, they will be asked to write down a few. The Post-Questionnaire is divided into three parts, awareness spreading, the chatbot, and finally the system. In the first part, the form asks the users whether they have learned anything useful from the game or not. There are a few more questions to prove the users' knowledge, to avoid lies in the previous questions. In the second part of the Post-Questionnaire, the intention was to assess the experience that the users have while chatting with the chatbot. Chatbot Usability Questionnaire[17] was used to evaluate this parameter. Finally, in the last part of the questionnaire, the goal is to evaluate the usability of the system, or in this case, the game. System Usability Scale[18] was used to assess the game usability.

At the interview conducted as the final stage of the evaluation, questions about the game and the AI chatbot were asked to back up the results obtained from the questionnaires. Besides the metrics previously mentioned, the game itself presents a scoring system, which allows us to evaluate the performance of the player.

4.3 Results

With the Pre and Post Questionnaires, we could conclude that the players do have some learning experience while playing the game as we can see, from the results of the Post-Questionnaire, that 85% of the users answered that they have learned something useful. This result is backup up by the answers to the questions asked later to actually evaluate the player's knowledge. The players' investment in the game also backs up the previous results. The scoring system implemented in the game, although not an official metric of evaluation, gives an idea of how invested the players were during the game. With eleven out of twenty participants scoring over 75% of the maximum possible score, we can deduce that the majority of the players, if not all, were concentrated on the game.

Regarding the chatbot, by calculating the Chatbot Usability Questionnaire score, a preview of its general performance can be concluded. Having a score of almost 69 out of 100 is an indication that it might be an medium good performer. This was backed up by the interview conducted with the users at the end of their testing process. The second research question is answered with these results. Chapter 2 shows that games that integrate an AI model to support a conversation-based section increase the interactivity between the users and the characters of the game. Contrary to some games mentioned before[17][24], *Crisis in the Atlantic* focuses more on factual storytelling rather than dramatic storytelling, leading to exclusion of social bots, and making the VQA the perfect AI method to be integrated into the game. The positive results of the user experience the participants have had with the chatbot powered by VQA can confirm the choice of VQA being the best AI method to be integrated into an interactive story-game.

[15] https://www.ulster.ac.uk/__data/assets/pdf_file/0009/478809/Chatbot-Usability-Questionnaire.pdf
[16] https://measuringu.com/sus/
[17] https://www.ulster.ac.uk/__data/assets/pdf_file/0009/478809/Chatbot-Usability-Questionnaire.pdf
[18] https://measuringu.com/sus/

About the game usability, System Usability Scale was used, and a score of 70 out of 100 was obtained, indicating that the game had an above the average performance. To back this up, the feedback received from the final interview indicates that most players liked the game and the interface. By creating sub-aquatic 3D environments for the players to explore, interacting with different marine animals, whose answers are generated by an AI model, and having pop quiz interactions, where the quizzes contain educational content about the major marine issues, we answer the first research question. The positive outcome of the knowledge absorption part also backs up the answer to the first research question. There are, however, many things to be improved, especially regarding the AI chatbot's performance.

5 FUTURE WORK AND CONCLUSION

5.1 Future work

In future work, the game could be expanded in a variety of ways. Further levels could be included, more languages could be supported, more interactions could be added, e.g. picking up the trash from the ground. The most important avenues to be explored are perhaps developing a Virtual Reality platform for the game, creating a new AI model that could support regular conversations as well, and not only questions about the images, and finally having the VQA model retrained with categories of marine species, getting this way better performance in this type of game.

5.2 Conclusion

Contributions

During this project, multiple concepts have been drafted and multiple prototypes developed. With the development of the final prototype, including a gameplay component, a service component, and an AI component to run the VQA model, as well as the testing of the prototype, we were able to achieve the requirements set at the beginning of the project, those were to develop *Crisis in the Atlantic* to spread awareness about the major oceanic issues and entertaining players, explore the best AI method to be used in this kind of game, and finally perform a detailed evaluation assessing the effectiveness of the game regarding awareness-raising and AI user experience. The results gathered during the user evaluation process, along with the study of related work, allowed us to answer the two research questions proposed at the beginning of this thesis.

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