

Rover Vos

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From gameplay to comic book.

A generative artificial intelligence retelling tool  
that converts voice-recorded TTRPG sessions into  
a multimodal retelling format.

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## MASTER THESIS

submitted in fulfilment of the requirements for the degree of

Diplom-Ingenieurin

Programme: Master's Game Studies and Engineering

Branch of study: Retelling games with Artificial Intelligence

Alpen-Adria-Universität Klagenfurt



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### Evaluator

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Department of Information Technology

Klagenfurt, June 30, 2025



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## Abstract

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## Zusammenfassung

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## Acknowledgments

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# Chapter 1

## Introduction

### 1.1 Motivation and Objectives

Storytelling has a rich history of development starting back as far as humanity can go back. From Neandertals 40.000 years ago making cave drawings in an attempt to share experience and knowledge and 5000 years ago the ancient Egyptians made Hieroglyphics to tell stories and record history. To now YouTubers sharing their experience and people on TikTok are recording and sharing everything they can think of. The medium of storytelling has been innovated time and time again, cave drawings, Hieroglyphics, oral, written texts, printing press, photo, film, and everything now in the digital age. But where are we going next? In a world that is ever-changing, super time hungry and where people are looking for more and more ways to consume and share stories. What is the next form of storytelling? What are new forms of storytelling we can use with new technology? As we are at the advent of a great generative artificial intelligence revolution we should look into the possibilities of AI. How can we use generative AI to create the next form of storytelling?

This thesis aims to look into the possible applicability of generative artificial intelligence and (locally inferred) large language models in combination with game retelling. It will do this by recording Table Top Roleplaying Game (TTRPG) play sessions and using generative artificial intelligence to generate a comic book based on the recording of the players. Giving the players a new way of sharing their experience, a new way of retelling.

Retelling games in combination with artificial intelligence is a new field of research with a small research demand [9]. However with all the newest, easy to work with and well performing opensource generative models like Stable Diffusion [17] and Llama [19] there is a lot of potential for artificial intelligence as a reteller of games. As we can now generate images and text based on prompts and other input (like a voice recording) we can start to use artificial intelligence as a new form of storytelling. The printing press of the AI era.

This thesis started because of a small research demand for this topic in the academic world [9] and a direct request from my supervisor. For my motivation, I see a lot of potential in the usage of AI as a reteller of games. Primarily for video games, because you can track everything the player does and use that for generating. Besides video games, storytelling games like Dungeons and Dragons [20] and other TTRPG systems can also make great use of such a system. By recording a session and converting it with AI there is potential. TTRPGs are already a big part of the retelling on the internet through digital media like Twitch, YouTube and every podcasting platform out there. One of my favourite Dungeons and Dragons podcasts, The Adventure Zone, have converted their adventure into a comic book [14] and Critical Role even converted their story into a TV show [16]. Clearly there is a want for retelling TTRPG adventures. It is also a medium that leverages the usage of AI properly as there are infinite possibilities while playing TTRPG games and every group makes their own story. Thus the requirement for generative artificial intelligence goes up as there is no possible way of making a system that can incorporate everything people can do in a TTRPG game without generative AI.

The main research question of this thesis is: *What are the key design and implementation challenges of a multimodal generative AI tool for converting play sessions into multimodal retellings?* This

In conclusion, this thesis aims to explore the possibilities of generative artificial intelligence in the field of retelling games.

## 1.2 Structure

The basic outline of the research approach of this master thesis is to create an artefact which converts audio-recorded TTRPG play sessions into a comic book. The methodology that will be used is the Design Science Research methodology [7]. This methodology fits nicely with the research goal as it focuses on creating solutions through iterative development with a focus on testing the artefact. It also gives clear steps for both the design process and for a structured literature review which have been used as the skeleton of the thesis.

The first step is to identify the problem and the requirements of the system. This is done through a literature review and interviews with experts in the field. The second step is to design the artefact, which in this case is a tool that converts audio-recorded TTRPG play sessions into a comic book. The third step is to implement the artefact, which will be done using Python and various libraries for audio processing and comic book generation. The fourth step is to evaluate the artefact, which will be done through user testing and feedback from experts in the field. Finally, the fifth step is to communicate the results of the research, which will be done through this thesis and a presentation at a conference.

# Chapter 2

## Topic

### 2.1 Classification

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Slime Molds Systematics	
Classification:	Living organisms
Domain:	Eukaryotes (Eucaryota)
no rank:	Amoebozoa
Class:	Slime Molds
Scientific name	
Eumycetozoa (Zopf, 1884)	
Subclasses	
Dwarf slime molds (Protostelea) True slime molds (Myxogastrea) Cellular slime molds (Dictyostelea, Acrasia) Parasitic slime molds (Plasmodiophorina) Reticulate slime molds (Labyrinthulina)	

Table 2.1: Slime molds Systematics

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- Slime molds and animals:

Slime molds, just like animals, can move independently. However, unlike animals, slime molds do not have limbs or a subdivision of the body.

- Slime molds and fungi:

Slime molds, just like fungi, spread via spores. However, compared to fungi, slime molds have no mycelium (filamentous cells) and no chitin (used to form structure).

- Slime molds and bacteria/single-celled organisms:

Slime molds usually have more than one nucleus, as is the case with bacteria and single-celled organisms.

## Characteristics

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Figure 2.1: Plasmodium of *Physarum polycephalum* (R. Hoyer/Wikipedia. Creative Commons)

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## 2.2 Life Cycle

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# Chapter 3

## State of the Art

### 3.1 Retelling games

Game retelling is the act of reconstructing a past play experience into a new form whether through storytelling, video, illustration, or another medium. It is a way of making sense of what happened during play, translating fleeting moments into shareable narratives. In analog games like TTRPGs, where much of the story unfolds through improvisation and player interaction, retelling can serve many purposes. It preserves memories, communicates the experience to others, and allows for reflection on the themes, decisions, and dynamics that emerged. Whether casually recounted around a table, written into detailed session reports, or adapted into comics and podcasts, game retellings are always interpretive. They emphasize certain moments over others, shift the tone or point of view, and reshape nonlinear, messy play into something structured and communicable.

This process is not only about preserving content it is also an act of authorship. As soon as one begins to retell a game, choices are made about what matters, what is meaningful, and what should be retold. In doing so, the reteller inevitably reshapes the story, turning play into narrative. This transformation forms the foundation for deeper theoretical approaches to game retelling, including those that consider it a form of critique, reflection, or creative reinterpretation. This is double important when it comes to TTRPGs as these are games that are normally are not well recorded and live fully in the minds of the players with a couple spares notes on paper floating in the group.

Recapping is also a form of retelling. Many ongoing TV shows, series, anime, comic books, etc. tend to start each episode with a retelling of the previous episodes. Focusing only on the important aspects and leaving out a lot of the scenes. This is done in an attempt to reengage the watcher/reader and to remind them of the flow of the story so that they understand the story better. The same counts for TTRPG group who are part of a larger story that lasts numerous sessions separated by time. This is done in an attempt to restructure the story and make it clear to all the players to understand where they are in the story.

Retelling a game session, especially a TTRPG like Dungeons and Dragons, is not merely an act of documentation. It is a creative, interpretative, and often critical practice. In transforming a game play experience into a new form, such as a comic book, the storyteller engages in a process of selection, transformation, and framing. This process raises questions not only about how stories are told, but also about what aspects of play are preserved, emphasized, or reimagined. After all a big part of the identity of a TTRPG is its rules and game play structures. Keeping play and the experience of playing in a retelling of a TTRPG is a key factor of conveying the story and the player experience.

Eladhari introduces the concept of game retelling as the fourth layer of narrative. According to Eladhari, this layer exists beyond the embedded, emergent, and interpreted narratives that typically characterize game storytelling. The fourth layer is concerned with post-play reflection and reinterpretation. It allows players, designers, or critics to re-engage with a game experience after the fact, often through a different medium (Eladhari 2018). In this view, retelling is not just about conveying what happened in the game, it is also about creating space for analysis, critique, or emotional processing.

Sych expands on this concept by arguing that critical game retellings can serve as a bridge between personal experience and broader thematic exploration. By combining Eladhari's fourth layer with the idea of "breaking the fourth wall" Sych shows how retellings can expose the mechanics, social dynamics, and ethical tensions of gameplay itself (Sych 2022). This is particularly relevant in TTRPGs, where storytelling and rules are deeply intertwined, and where players often make decisions that reflect not just in-game motivations, but also real-world values and group norms.

Moreover, game retelling in this form invites consideration of what is lost and what is gained in translation. Elements like humor, tension, or spontaneity may be flattened or reshaped, while the visual format offers new tools, framing, symbolism, visual rhythm, to convey meaning. As Eladhari notes, retelling is not just representational it is generative. It produces new readings, new interpretations, and sometimes even new stories.

Finally, comic-based retelling also offers a lens into how different types of player interaction, such as roleplay, exposition, and rule engagement, manifest in a visual medium. The project thus becomes a way to explore not only how games are retold, but also how different aspects of a game are retold by artificial intelligence.

### **3.1.1 Examples of TTRPG retellings**

### **3.1.2 Artificial Intelligence as a Reteller/storyteller**

## **3.2 Comic books**

Making Comic Books is an art form on its own and to understand how to generate a comic book with AI we need to understand how comic books function as an

artefact: How they are made; How they are structured; How they are read; And what comic books are. This section will look at comic book studies to create a better understanding of comic book creation.

Comic books are a sequential art form[8]. When you take a comic book panel and look at it outside of the context of other panels it is just an image. But when you place them side by side in a sequential order the pictures become a comic book 3.1. Looking at the image we can see that an image of a man holding its hat is just a man holding a hat. But when you place two images of a man holding his hat side by side we can see that it creates a motion of tipping his hat. The panels create an effect of change, an effect of time passing. The space between the panels of comic book panels creates a concept of time in stationary images.

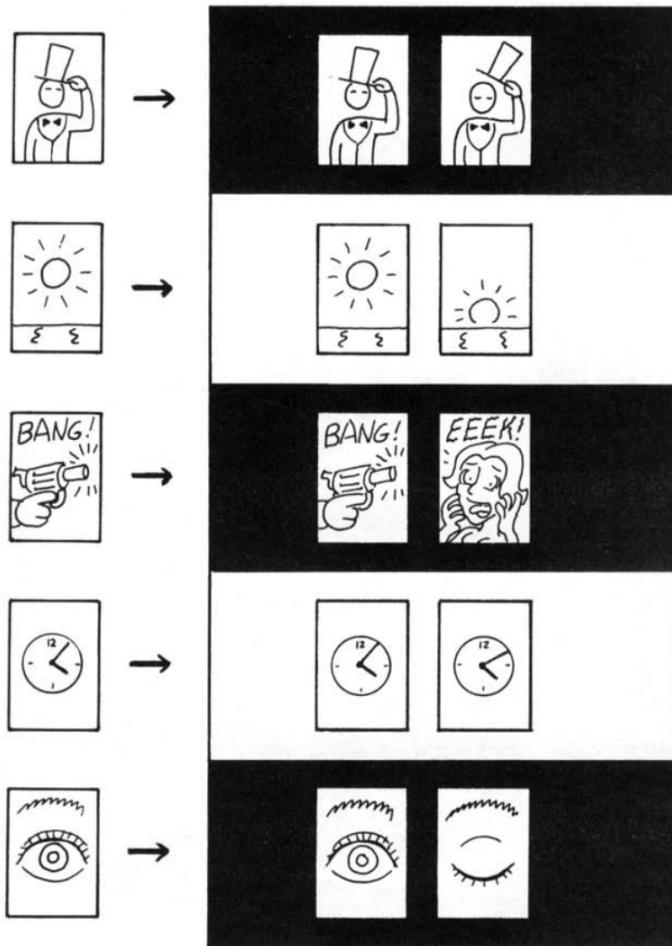


Figure 3.1: Sequential Art page 5 [13]

In terms of art style there are many different flavours of comic books. Most people would think of a classic comic book they read as a child. But there are many more. Manga uses grey scale and generally follow a panel structure. American comics mostly are full colour and follow a panel structure. Manhwa/Webcomics

are in mostly in full colour but are read from top to bottom by scrolling and are primarily read on the web. And these are just some generic descriptions of comic book art style, there are many unique styles out there like Sin City style (REF) and David Finch's art style (REF). Some comics even break the whole concept of panels and use whole pages as panels. Or place panels in panels. Or have panels that are not rectangular, but crooked, round, bend or anything else (Sandman). And some do not even use panels at all but make use of emptiness or use the same character on a long frame multiple time creating a concept of time as you read left to right. The important take away here is that comic books are not just one style, but many different styles.

Iconography is essential to many comic books to communicate those things that can not be easily spoken or written down. In the world of manga we call this unspoken communication *Manpu* 3.2. To quote Matt Alt *Manpu "speak" what can't be easily spoken (or written) in words* [12]. "ZZZ" to indicate someone is snoring or sleeping, a circle with stars and birds above a characters head indicate a state of unconsciousness by an impact of sorts, pages being torn of a calendar indicate time passing and one of my favourite making an L with your thumb and index finger and placing it under your chin to indicate deep thought (or the one I do not like where it represent people acting cool).

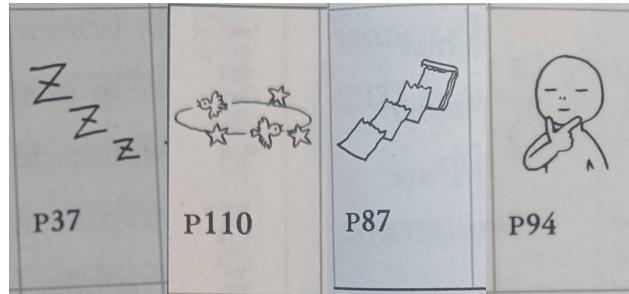


Figure 3.2: Iconography [12]

Text in comic books are most  
So what did we learn from this? And what can we take with us for the artefact creation?

1. Time in comic books. As time passes in between comic book panels we need to make sure that the AI generated comic book has a clear time line. The AI needs to be able to use the time line of the story and how it is told. Connecting panels to each other and create a feeling of time passing.
2. Different panel styles. As we look at the different styles of panels that comic books use we need to ask ourselves to what extend the panel structure is important in an exploratory retelling artefact of games like the one made for this thesis. The panel structure is primarily an artistic expression of the greater whole of the comic book and the story it tells. The artefact is going to need a

structured system to generate panels and it shouldn't have too much freedom to come up with panel structures as this will most likely take away from the retelling of the story or not done very well.

3. Art start. As
4. Text in comic books
5. Iconography

### 3.2.1 Comic Book take aways

## 3.3 AI models

There are many different AI models floating around the internet that could be used as part of the artefact that was made for this thesis. To choice which model to use this chapter talks about different models and why they were chosen for this thesis. In the end Mistral has been chosen as the large language model, FLUX.1 has been chosen for the image generation and Whisper has been chosen for the audio transcription model.

The requirements where these models where chosen on were:

- Open source
- Locally runnable
- Good enough performance
- Ethical considerations as disclosed in section 3.4

### 3.3.1 Large Language Models

Picking a suitable Large Language Model for the project is a quite the impossible task as models keep changing rapidly and new models are released every day. There are many academic papers out there discussing models and their performance, usage and more [1, 4, 11, 21]. However all of these are already more than a year old and as models are changing so fast most of those papers are already outdated, however still very useful. As this paper is not an analysis of AI models but a practical thesis I have asked ChatGPT-4-turbo to give me a list of models with their pros and cons and asked it to make me a table for Latex with the information. The prompts that I used: *I would like to have a table with a comparison of the top 10 large language models. Show the pro's and cons of the models. Add if they are open source and locally runnable.* Followed by: *Can you convert that table to Latex code?*. The results can be seen in table 3.1, the latex code had to be modified to fit the page.

Even here we can see that the models are out of date. Gemini 1.5 Pro is not the latest model as Gemini 2.5 is already released, and LLaMA 3.1 is not the latest model as LLaMA 4 is already released. However, the table does give a good overview of the models that are available and their pros and cons. Primarily the question if they are open source and can be run locally. I used this method not because I see it as a academic valuable method but because I want to use technology and see how useful it could be for academia. Looking at this small experiment we can see that it could be useful, however the data is very outdated and not very useful. It does point us in the correct direction and gives us a good overview of the models that are available.

Model Name	Developer	Pros	Cons	Open Source	Locally Runnable
GPT-4o	OpenAI	Multimodal (text, image, audio); fast and versatile	Occasional hallucinations; high compute needed	No	No
Claude 3.5 Sonnet	Anthropic	Safety-focused; handles long contexts; natural responses	Slower; closed API only	No	No
Gemini 1.5 Pro	Google DeepMind	Strong multimodal support; integrates Google ecosystem	Resource-heavy; limited open variants	No	No
LLaMA 3.1	Meta AI	Open-source; good at translation and code	Requires technical expertise; energy-intensive	Yes	Yes
Mistral Large 2	Mistral AI	Strong reasoning and code generation; long contexts	Commercial license; proprietary	No	Limited (license)
DeepSeek-R1	DeepSeek	Multilingual support; efficient	Limited adoption; less documented	No	No
Mixtral	Mistral AI	Efficient mixture of experts; open-source	Shorter context; niche usage	Yes	Yes
Grok 3	xAI	Good social media integration; open-source focus	Requires subscription; limited distribution	Yes	Possibly (limited)
Command R+	Cohere	Up-to-date info retrieval; good conversational skills	Limited multimodal support	No	No
Phi-2	Microsoft	Open-source; efficient size/performance	Limited multimodal support; some bias concerns	Yes	Yes

Table 3.1: Comparison table of 10 LLM's by ChatGPT-4-turbo

Looking at the options provided we can quickly cut out most of the models as they are not open source and there is no possibility of running them locally. The models that are left are LLaMA, Mixtral and Phi. Out of these 3 models the choice is easy as Mixtral is the only options. Even do the other two models are open source, they are still owned by large American corporations (Microsoft and Meta) which are from personal point of view out of the question to use (More on this in 3.4). Mistral is an privately owned and French company.

### 3.3.2 Image generation models

[2]

## 3.4 AI ethics

Hello

## 3.5 The art of AI prompting

Writing AI prompts is not something you can properly do without thinking about it. Writing proper prompts is a lot like writing code where you need to iterate over the instructions you give the computer to do what you want it to do. It is also known as prompt engineering. There are a lot of nuances to writing prompts and hidden tricks and commands to instruct an AI to get an AI to do exactly what you want it to do. This section discusses the basics of AI prompting and how they have been used in the artefact.

[5]

## 3.6 Three primary forms of player interaction

GPT:

Dungeons and Dragons sessions have three primary forms of player interaction: roleplay, exposition, and rule interaction. These three forms are distinctly different, and in this project they will be used to analyze different parts of the generated comic book to see if the system is better at certain parts.

Roleplay is when players and the dungeon master talk to each other while taking on the role of their characters. The dungeon master often juggles multiple roles, shifting between NPCs as needed. This kind of interaction mostly happens in-character and aligns with what game researchers call the narrativist mode from GNS theory, where the focus is on creating a story together (Edwards 2001). It also maps onto what is known in RPG studies as in-character talk, one of the core communication styles during play (Bowman 2010).

Exposition is when the dungeon master describes a situation, a location, or the mood of a scene. It is about creating a vivid image of what is happening in the game. This is not necessarily roleplaying, but it is key to setting the stage. It sits somewhere between narrativist and simulationist modes in GNS theory, and would be considered out-of-character talk, since it is often descriptive rather than spoken as a character (Bowman 2010).

Rule interaction is where the game mechanics kick in. This is when players roll dice and use other rules of the system to resolve conflicts, check if they hit an enemy, try to jump through a window, activate an ability, or make a persuasion check to convince someone that they are innocent. These moments are very gamist in nature. They are about winning challenges through the rules of the system. In terms of communication, this fits under meta talk, which includes discussing rules, tactics, or numbers, often from outside the fiction (Bowman 2010).

These three types of interaction not only shape how players experience the game, but also how that session is interpreted when turning it into a comic. Based on these three categories the final comic book result will be analyzed to see what is the difference to retelling these parts and to see what the difference is inbetween generation.

# Chapter 4

## Background and Methods

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### 4.1 Programs and Frameworks

#### 4.1.1 Program 1

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#### 4.1.2 Program 2

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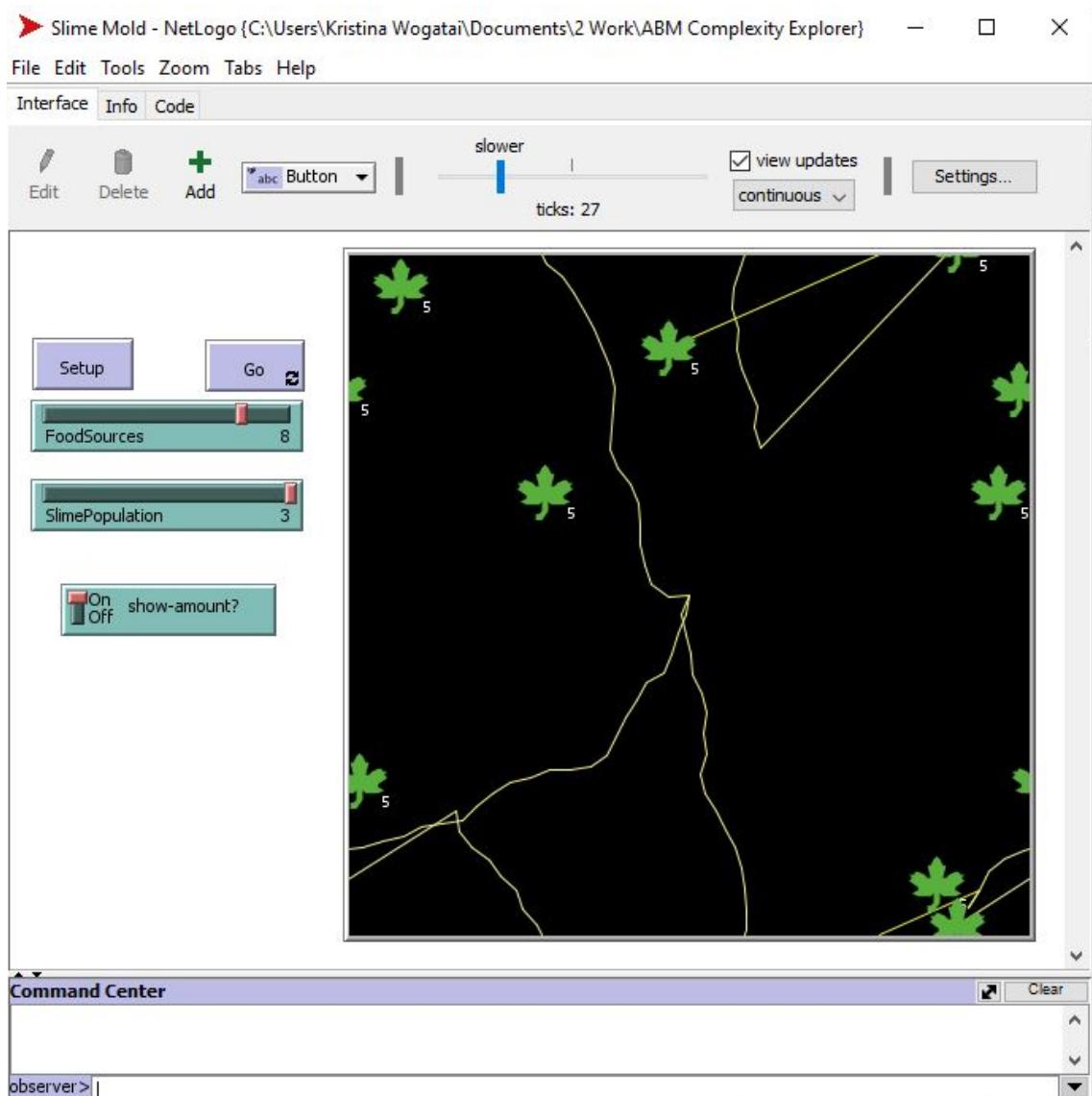


Figure 4.1: NetLogo sample program

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## 4.2 Models and Algorithms

### 4.2.1 Model A

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$$\overrightarrow{X(t+1)} = \begin{cases} \overrightarrow{X_b(t)} + \overrightarrow{vb} \cdot (\overrightarrow{W} \cdot \overrightarrow{X_A(t)} - \overrightarrow{X_B(t)}) , r < p \\ \overrightarrow{vc} \cdot \overrightarrow{X(t)}, r \geq p \end{cases} \quad (4.1)$$

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$$p = \tanh |S(i) - DF| \quad (4.2)$$

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$$\overrightarrow{vb} = [-a, a] \quad (4.3)$$

$$a = \operatorname{arctanh}\left(-\left(\frac{t}{maxt}\right) + 1\right) \quad (4.4)$$

Formula of  $\overrightarrow{W}$ :

$$\overrightarrow{W(SmellIndex(i))} = \begin{cases} 1 + r \cdot \log\left(\frac{bF - S(i)}{bF - wF} + 1\right), & \text{condition} \\ 1 - r \cdot \log\left(\frac{bF - S(i)}{bF - wF} + 1\right), & \text{others} \end{cases} \quad (4.5)$$

$$SmellIndex = sort(S) \quad (4.6)$$

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#### 4.2.2 Sample Algorithm

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$$f(s) = g(s) + h(s) \quad (4.7)$$

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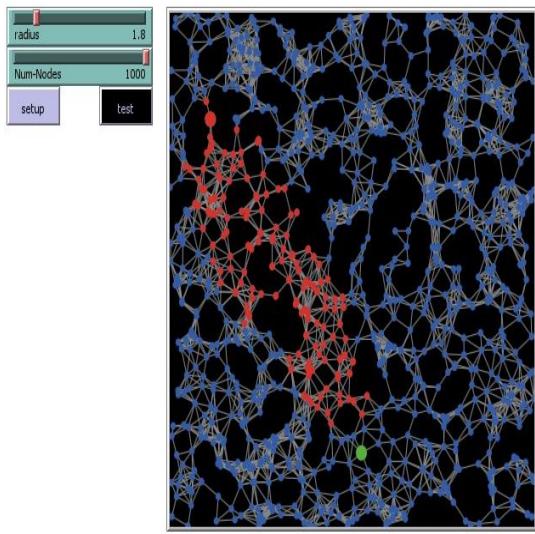


Figure 4.2: NetLogo - A\* Simulation - Search

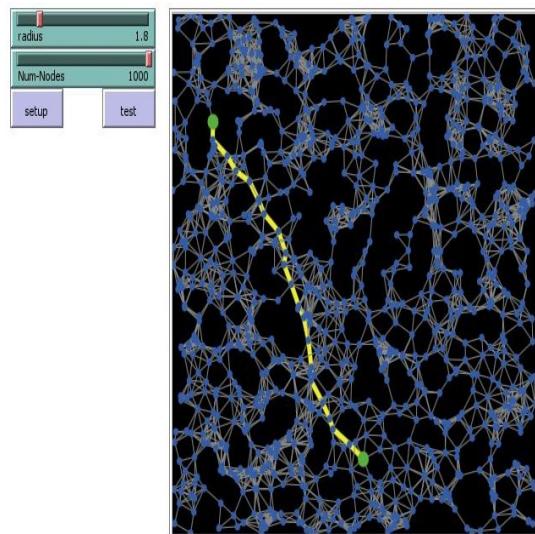


Figure 4.3: NetLogo - A\* Simulation - Shortest Path

# Chapter 5

## Artifact Development

This chapter iterative design process of the artifact.

### 5.1 My Topic

### 5.2 Coding with Python

Python was the only language used in this project. This was chosen as Python is the go to language for programming with AI models (REF) and all major(if not all) models have python support.

Specifically python version 3.12.3 running on a the Windows Subsystem for Linux version 2 (WSL) running Ubuntu 24.04.2 LTS. WSL is a windows feature that allows you to run a Linux environment directly on Windows while in windows without having to run a virtual machine. You control the Linux distribution fully through the terminal.

### 5.3 AI models

#### 5.3.1 Whisper

#### 5.3.2 Llama

#### 5.3.3 Image generating models: Stable Diffusion

The chosen image generation model is Stable Diffusion version stabilityai/stable-diffusion-xl-base-1.0 [18]

# Chapter 6

## Experiments

### 6.1 Experiments and Simulations

### 6.2 The minimal viable product

The minimal viable product (MVP) is a version of a new product that includes only the essential features necessary to meet the needs for initial testing. The goal of an MVP is to validate the product idea with minimal resources and gather feedback for future development. In figure 6.1 you can see the result of the MVP and in figure 6.2 you can see the pipeline that is used for the MVP.

#### MVP pipeline

The MVP pipeline has 4 steps of processing to go from audio recording to comic book. First Whisper Turbo transcribes the audio recording to raw text. Then Llama 3.1 converts the text to a comic book script. The script is then processed by Stable Diffusion XL to generate the comic book panels. Finally, the panels are assembled into a comic book format using a custom python script. The pipeline is shown in figure 6.2. The audio recording is a single track recording of a tabletop role-playing game session. The prompt used for Llama can be seen in listing 6.1. This prompt generates a description of the panel art and a line of dialogue or narration for each panel. The output is a JSON array of objects, where each object contains the panel art description and the text. The panel art description is then given to Stable Diffusion XL to generate the image with no other instructions. The text is used as a caption for the image. The images are then assembled into a comic book format using a custom python script which generates a PDF file with the images and captions.

Listing 6.1: Prompt for Comic Book Script Generation

<sup>1</sup> You are given a segment of a Dungeons & Dragons session transcript:  
<sup>2</sup>

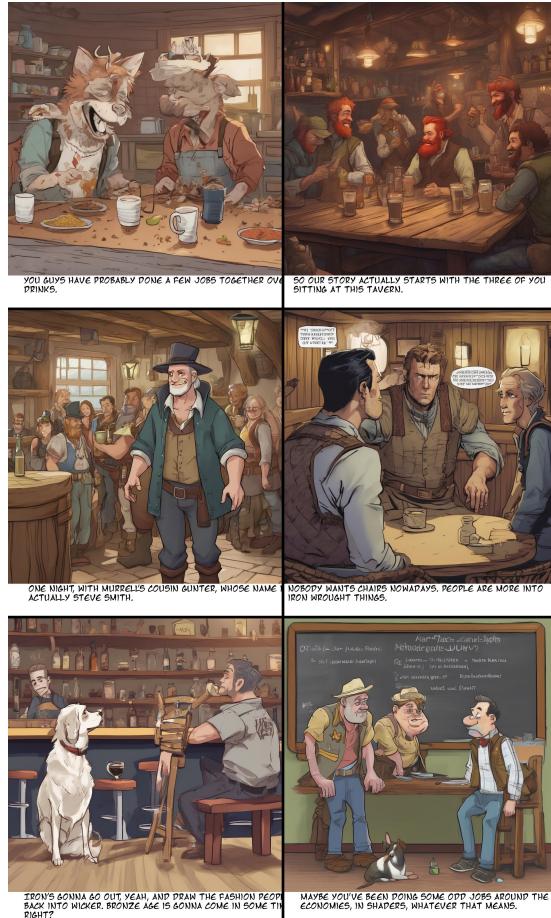


Figure 6.1: The minimal viable product

```

3 Session Content:
4 {content}
5
6 Your task is to transform this into a comic book script, broken down into
    individual panels.
7
8 Each panel must include:
9 - A detailed visual description suitable for image generation (key: "panel
    art")
10 - A line of dialogue or narration (key: "text")
11
12 Instructions:
13 - Structure the output as a JSON array of objects.
14 - Each object must contain exactly two keys:
15 - "panel art": A vivid, standalone description of the panel art. Include
    setting, characters, action, and mood.
16 - "text": A single line of spoken dialogue or narration. Rephrase as a
    proper sentence if needed, but keep the meaning true to the original
    session.
17 - Process the entire input and split it into as many panels as necessary.
18 - Do **not** include any additional explanation, commentary, or text
    outside of the JSON array.
19
20 Output only a valid JSON array. Example format:
21
22 [
23 {
24     "panel art": "A dimly lit tavern filled with laughing patrons. Magnus,
        a red-bearded human, clinks mugs with Taco and Merle at a wooden
        table.",
25     "text": "So our story begins with the three of you sitting at this
        tavern."
26 },
27 {
28     "panel art": "Close-up of Magnus, his face lit by candlelight, a
        sheepish grin on his face.",
29     "text": "Nobody wants chairs anymore. Everyones into wrought iron now."
30 }
31 ]

```

### 6.2.1 Lessons learned

The MVP was a success in terms of validating the product idea and gathering valuable knowledge about the product requirements and limitations. In this section

lessons learned are described in detail and it is discussed how these lesson will be implemented in the next iteration of the product.

## Art

The first thing one might see when looking at the MVP output is the art. The art quality is low, it is not very detailed, the characters are not very expressive and the art style is very inconsistent. There are also a lot of generative AI artifacts, like weird faces and inconsistent human anatomy. Furthermore all these panels are situated in the same tavern, but there is no consistent setting. All these panels also describe 4 different characters and but there is no consistent character design between panels.

## Text

The text has one obvious flaw of clipping outside of the image which is something that needs to be fixed. Other than that when reading the text it is noticeable that it is not really character dialogue, but things the players are saying. Some of the text is player to player dialogue and not in character dialogue which is something that needs to be filtered out. The text also does not make any sense in term of story structure. These are just lines of text.

Looking the entire transcription of the tabletop role-playing game session it can quickly be seen that there is no structure to the text, making it extremely difficult for an LLM to make anything meaningful out of it. Figure X is a expert of the transcript where you can see that it is just a consistent stream of text without any structure.

## Composition

All the panels have a similar camera angle and composition.

### 6.2.2 Solutions

In this section possible solutions are discussed which will be implemented for the next iteration of the product. The goal is to improve the quality of the art, text and composition of the comic book panels.

## Art

Stable Diffusion is a pre-trained model that is made to work for any art style, to create a consistent art style you could write a art style prompt, however this creates issues with the token limit that stable diffusion has. The proper way to do this is by using a LoRA (Low-Rank Adaptation). LoRAs are a way to fine-tune a pre-trained model on a specific task or domain. In this case, a LoRA can be trained on a specific

art style to create a consistent art style for the comic book panels. This will also allow for more detailed and expressive characters. The LoRA can be trained on a dataset of comic book panels in the desired art style. The LoRA can then be used in Stable Diffusion to generate the comic book panels with the desired art style. However since training a LoRA is outside of the scope of this project a pre-trained LoRA from civitai.com will be used. This also comes with the benefit that any LoRA can be used to generate any art style wanted by the user.

## Character consistency

To create consistent characters between panels there are 5 different approaches that can be taken. LoRA's can be used for each character creating a very consistent character design. This does require each character to have a LoRA trained on it meaning that you need to have art of the character to start with. This would also mean that the images would be generated with multiple AI's generating images and then having to combine them. The second option would be image-to-image reference chaining. With this method you give SDXL a reference image of the character and then generate the panel with the character art as a reference.

The easiest and least consistent manner would be to use consistent prompting. This means that you give the same prompt for each panel with the character description in it. This will however not create a very consistent character as each iteration of the prompt will interpret the prompt differently. Resulting in many different smaller inconsistencies. This however would be a good step if the other methods would be too time consuming to implement. It would most likely require two iterations of generating the image, one for the character and one for the panel art. As the number of tokens in the prompt would be too high to generate the panel art and character art in one go.

Inpainting is a technique where you alter part of an image so that it fits your desired effect. You select an area of the image and then fill it in with a new image, generated by AI. This gives you a way to control very specific parts of an image and finetune an image. Normally this requires a lot of manual work where you have to cut out the area which has to be painted in. It would however be possible to use computer vision to detect the character in the image and then use that as a mask for the inpainting. This might result in a very good solution, but there are potential issues with multiple characters in the same panel.

Lastly an option could be using ControlNet. This is a technique where you use a pose reference images to control the pose of the character in the image.

In the end it would most likely be best to use most of the above techniques in combination to create the best possible result. Create a LoRA to have consistent character art, use inpainting to place the art on top of the panel art and use ControlNet to control the pose of the character.

## **Scene consistency**

In the current comic page of the MVP each scene is taking place in the same tavern, but the tavern is not consistent between panels. Most solutions given in the previous section on character consistency could be used here as well, however as there are way more variables possible for locations creating a LoRA is impossible and would defeat the purpose of using AI. You could however let AI create images of a tavern and the use those images as reference materials for future uses of that tavern. Meaning you need to keep track of scenes and locations so that you can bring back the same panels in later parts of the comic book.

## **Text**

To fix the text that is in the panels of the comic books the first step would be to fix the transcript of the game session. As is always the case with AI: Garbage in is garbage out. Fixing the transcript will also have effect on the other parts of the comic book, as there will be a clearer structure to the text which can be used in a better way to generate images and create structure between panels. To fix the transcription there are a few that need to be taken.

After transcribing the audio recording with whisper there are 3 steps we can take to increase the usability of the text. First we need to use a Punctuation and Capitalization Restoration model to fix the text by adding punctuation and capitalization to the text. This will make the text more readable and easier to understand. The second step would be to use Speaker Diarization to identify the different speakers in the text. This will benefit with knowing who said what at which time and allows to have accurate character dialogue. Furthermore this makes it so that the Game Master can be identified as someone who plays multiple characters. A tool to do this is Pyannote Audio, an open-source toolkit written in Python for speaker diarization. Lastly combine the cleaned up whisper transcription with the speaker diarization to create a structured text file.

The next step is to then use an LLM to check all the text and identify what is character to character and what is player to player speech. Creating a clear divide between what does and what does not belong in the comic book. For the game master the same thing needs to happen, but then it is required to identify which character they are playing at that moment. Then an LLM would need to convert the text into real sentences which make sense in the context of the scene as something a someone in the English language would say.

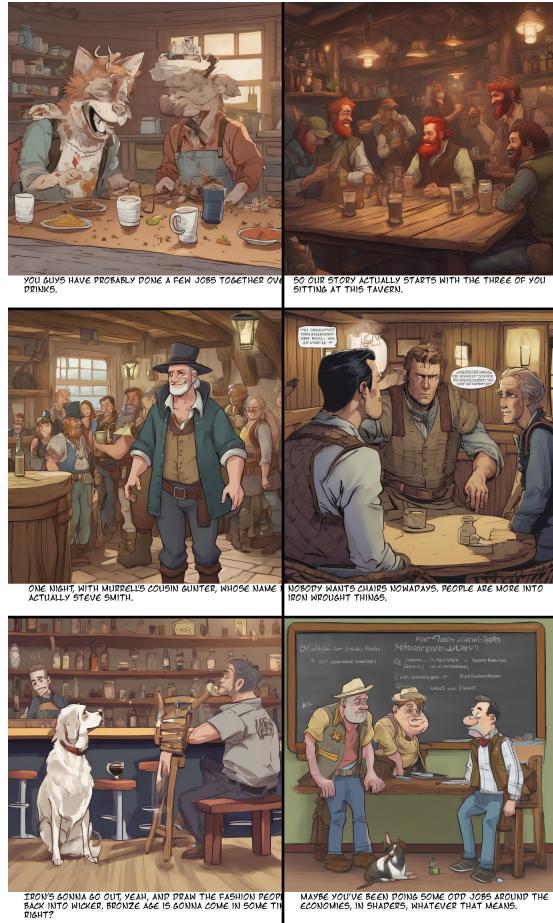


Figure 6.2: The minimal viable product pipeline

### 6.2.3 The minimal viable product

## 6.3 Small experiments

### 6.3.1 The language of TTRPGs

Models like Whisper are trained on a wide variety of audio data, however this is primarily normal language usage. Because of this I anticipate that there will be a large issue with transcribing many fantasy words and terms, thus a small experiment has been done to identify if this is truly a problem. For this experiment 10 fantasy creature names have been recorded and whisper transcribed these 10 names. Only 1 out of the 10 names were transcribed correctly and 2 out of 10 where almost correct 6.1. This is inaccuracy is a big issue when transcribing any fantasy game session as it will interfere with many important key moments and key names during a session/campaign. When the group meets a monster called a "Slaad" and Whisper transcribes this as "Nod" it will quite confusing to understand what is going on in the story.

To generate an accurate transcription of the names a custom model needs to be trained on specific fantasy words and terms, however this is way outside of the scope of this thesis. In addition it is also very difficult as Fantasy names are fantasy names for a reason and people can just come up with new names all the time. Integrating thousands of names however could still be valuable as it will most likely catch most cases.

Correct Name	Transcribed name
Owlbear	Halber
Goblin	Goblin
Rakshasa	Raksasa
Dracolich	Draco Lich
Quasit	Kwasi
Slaad	Nod
Drow	Drought
Illithid	Illidan
Cambion	Kempion
Ankheg	Hank Man

Table 6.1: Comparison of monster names and whisper transcribed versions

## 6.4 Generating the comic book script

The iterative design process of generating the comic book script after the MVP version was a crucial step to improve the quality of the comic book panels. From

having a one-shot approach where we gave the entire transcript to the LLama 3.1 model, we moved to an adaptive panel generator which has a structured approach to data and keeps track of the context. In this section all the iterative steps are described and what did and did not work in chronological order.

## MVP

For the MVP of the artefact the entire transcript of the tabletop role-playing game session was given to Llama 3.1 and see what it would generate. The LLM was asked: "You are given a Dungeons and Dragons session transcript. Convert it into a comic book script." This resulted in two results: The LLM crashed as the token limit was exceeded or it gave things that had nothing to do with the input and hallucinated everything. A quick fix to this was to cut the transcript into smaller chunks of text which resulted in an interesting result as it actually gave a comic book script. It was given 2 scenes of text which were hand cut out of the transcript. However as the LLM was not instructed to give a structured output it was useless as every time the program was run it would give a different output. The last step was to create a structured prompt for the LLM which is the prompt in 6.1. This resulted in a consistent JSON format output which could then be used to generate images.

## Cleaning up the transcript

When you feed an audio recording to Whisper it transcribes the audio as one long sentence. There is no punctuation or any idea of sentences structure. This way it is impossible to keep track of who said what and when. To fix this the transcript needs to be cleaned up. The first step is to use a Punctuation and Capitalization Restoration model [10] to add punctuation and capitalization to the text. This will make the text more readable and easier to understand for an LLM. The second step is to use Speaker Diarization to identify the different speakers in the text. The tool used to do this was pyannote 3.1 [3, 15], an open source python library which is super easy to use and broadly used by people (15 million download per month). Lastly combine the cleaned up whisper transcription with the speaker diarization to create a structured JSON file. This new transcript file 6.2 is what created the foundation for the entire comic book generator.

Listing 6.2: Session transcript JSON

```
1 {
2     "panel_index": 0,
3     "speaker": "SPEAKER_02",
4     "text": "Our story actually starts with the three of you...",
5     "start": 0.0,
6     "end": 2.96
7 },
8 ...
```

**Scene detection**

**Line based chunking**

Every line or every X lines

**LLM based chunking**

Scene cutting

**LLM based filtering**

Ask the LLM to decide if a line of text is player or character speech. Into giving it a chunk instead.

**Context aware LLM based chunking**

**Adaptive panel generating**

## 6.5 Experimental setup

To test the system on tool functionality, but primarily to test for the design requirements of a retelling system 3 different TTRPG sessions have been recorded and converted to a comic book. These comic books were then handed to the players and feedback was acquired using the INSERTHERE questionair. The comicbooks have also been crossreferenced with each other and with the original recording to see if there are differences in the generated comic book, but which are the same in the sessions.

### Experimental sessions

One Dungeons and Dragon 5th edition dungeon master hosted 3 sessions with 2 or 3 players. Each session was the same scenario and lasted 1 to 2 hours. This setup was chosen as this makes the experiment as consistent as possible, but with important possible deviations.

Dungeons and Dragons 5th Edition was chosen as the TTRPG of choice, because there is easy access to many people with a lot of playing experience of this game. It is one of, if the the largest, TTRPG game that is currently being played. It is important to have a game which people know how to play, because I want to minimise the rule based conversations in the recording as much as possible. Rule conversations are an extra dimension of complexity for the system and this should be avoided as much as possible.

## **Participant feedback**

Participants have been asked feedback based on a customized version of the IN-SERTHERE questionnaire.

### **6.5.1 Analyzing the generated comic books**

# Chapter 7

## Conclusion

### 7.1 Summary

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### 7.2 Further Work

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#### 7.2.1 Idea 1

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vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

### 7.2.2 Idea 2

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# Chapter 8

## workplace

### 8.1 Design Science Research

This thesis is based on the Design Science Research (DSR) methodology [7] and Computing as a discipline [6].

Computing as a discipline presents us with a framework for designing artefacts from an engineering point of view. It gives us four steps to solve a given problem:

1. State requirements
2. state specifications
3. design and implement the system
4. test the system

For the requirements of this thesis we need to very specific as the thesis is working with two different requirements at the same time. The main research question is looking for the requirements of a comic book generating artefact thus the requirements of the research project should be linked to finding these artefact requirements. But that means that the requirements of the artefact itself can not be part of the requirements of the research project. The artefact requirements are part of the conclusion of the thesis.

#### 8.1.1 Diverting from the DSR methodology

In DSR you should start

---

### 8.2 Retelling games

Most people play games during their personal down time and do not really think about games outside of leisure context (REF). However there are also a lot of people

that play games a lot and make it part of their lives. Looking at social media platforms like X, YouTube, Reddit, TikTok, etc. we can see that the sharing of gaming stories is a very big part of the internet. This sharing of stories can also be called retelling. Where people retell their personal stories about their gaming experiences. Retelling is not limited to games as the art of retelling is as old as humans and is a very big part of human culture(REF).

What is the essence of retelling?

When talking about game retelling

### 8.2.1 Difference between retelling and storytelling

### 8.2.2 State of the art of retelling

People share their gaming stories in many different ways. To have an holistic view of game retelling this section discussed the different forms of retelling video games.

Oldschool: talking Podcast YouTube Game play recording Podcasting Storytelling

An argument for Streaming. For completion sake I want to mention streaming and unedited playthrough videos here as well. Streaming is a weird one when it comes to retelling as it is not a retelling of an experience, but a live experience.

*Reteller is an agent that produces and narrates a sequence of events, for the benefit of either human players or spectators[9].*

Retelling is one of the largest if not the largest cultural phenomenon out there. I would even say that the retelling is one of the reasons the internet has become as big as it is. All forms of social media became the behemoths they are because of people retelling their lives. Academics would not exist if we did not retell everything we do in the form of papers, books, lectures, etc. For this thesis- it is important to know what retelling is, how people interact with it, what the core aspects are of a retelling and which moments of the gameplay session are important and should be part of the retelling.

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# Appendix A

## NetLogo Code

### A.1 NetLogo Main

### A.2 SISMO NetLogo Main Function

```
1 __includes["math_functions.nls" "setup.nls"
  "network-creation.nls" "a-star.nls"]
2 ;; 6 breeds needed in total, 3 for slime mold (plasmodia,
   pseudopodia, tubes), 1 for food source and 2 for A* algorithm
   ( networkpoints, searchers)
3 breed [ plasmodia plasmodium ]
4 breed [ pseudopodia pseudopodium ]
5 ;; The tubes are used to indicate the shortest path between the
   center and the feed source
6 breed [ tubes tube ]
7 ;; foods represent the foodsources
8 breed [ foods food ]
9 ;; the networkpoints and searchers are used for the a*algorithm
10 breed [ networkpoints networkpoint ]
11 breed [ searchers searcher ]
12
13 globals [
14   ;; to control the form of the visible chemical field
15   scale-factor
16   ;; sets the probability for pseudopodia to hatch a new
     pseudopodium
17   hatch-probability
18 ]
19
20 pseudopodia-own [
21   ;; stores the path in a list of lists with x y coordinates
22   path-list
```

```

23 ]
24
25 foods-own [
26    ;; each food source should have an amount of nutrients
27    nutrient-value
28    ;; the chemical level describes the radius of the food source
29    ;;; in which the pseudopodia can perceive the food
30    chemical-level
31    ;; for the visibility of the chemical field
32    intensity
33 ]
34 tubes-own [
35    ;; stores the path in a list of lists with x y coordinates
36    path-list
37 ]
38
39 searchers-own [
40    memory ; Stores the path from the start node to
41    here
42    cost ; Stores the real cost from the start
43    total-expected-cost ; Stores the total expected cost from
44    Start to the Goal that is being computed
45    localization ; The searchers position
46    active? ; is the searcher active? That is, we
47    have reached the node, but we must consider it because its
48    neighbors have not been explored
49 ]
50
51
52 patches-own [
53    light-level ;; represents the light energy from all light
54    sources
55 ]
56
57 setup ;;
58      ;;; defines where to place which component of the
59      ;;; simulation at the beginning and initialize the global
60      ;;; variables
61
62 to setup
63    clear-all calls the clearing functions like clear-globals
64    etc.
65    clear-all
66    ;;; set global variables
67    set hatch-probability 0.15
68    set scale-factor 10
69    ;;; call make functions to create breeds

```

```

60  make-plasmodia
61  make-foods amount-foodsources
62  make-pseudopodia amount-pseudopodia
63  ;; next line is responsible for the visibility of the chemical
   concentration in the air
64  ask patches [ generate-field ]
65  ;; Resets the tick counter to zero, sets up all plots, then
   updates all plots
66  reset-ticks
67 end
68
69 to go
70  ifelse any? foods with [ nutrient-value > 0 ]
71  [
72    ask foods [
73      ;; There is a bug where food sources are created randomly
         and untraceable. This causes the pseudopodia to hang on
         this food source. Because it takes negative values and
         iterates forever. With this code this bug is fixed.
74      if nutrient-value < 0 [ die ]
75    ]
76    ask pseudopodia
77    [
78      let foodsource one-of foods-here
79      ifelse foodsource != nobody
80      [
81        let path-list-to-provide-to-tube path-list
82        ask foodsource
83        [
84          if show-nutrient-value [ set label nutrient-value ]
85          set nutrient-value nutrient-value - 1
86          if nutrient-value = 0 [
87            ;; create the network for the a star algorithm
88            create-pseudopodia-network turtle-set turtles-on
               patch-ahead 0
89            ;; get one pseudopodia on the foodsource to set the
               destination x,y coordinate for the a* algorithm
90            let one-pseudopodia-here one-of pseudopodia-here
91            run-a-star 0 0 ([xcor] of one-pseudopodia-here)
               ([ycor] of one-pseudopodia-here)
92            die
93          ]
94        ]
95        ;; calculates a random float number between 0 an 1
96        if random-float 1 <= hatch-probability
97        [

```

```

98      ; ; create new child from pseudopodia, replace the
99      ; ; zeros in the path-list to indicate, that it is a
100     ; ; copy
101    hatch-pseudopodia 1
102    [
103      let new-path-list replace-zeros path-list
104      set path-list new-path-list
105    ]
106  [
107    ; ; movement of the pseudopodia → bounce of the wall,
108    ; ; movement and sense chemotaxis from food
109    bounce
110    wiggle
111    look-for-food
112  ]
113  ; ; if the a * buildet a tube display it
114  ask tubes[
115    let i 0
116    while [ i < length path-list - 1]
117    [
118      let x-1 [ xcor ] of item i path-list
119      let y-1 [ ycor ] of item i path-list
120      setxy x-1 y-1
121      let col [ pcolor ] of one-of neighbors
122      set i i + 1
123    ]
124    die
125  ]
126  tick
127 ]
128 [
129  stop
130 ]
131 end
132
133 to look-for-food
134  ; ; find chemotaxis in the area of a food source
135  let foodsource one-of foods in-radius 5
136  if (foodsource != nobody)
137  [
138    ; ; if there is chemotaxis ahead move towards the center
139    face foodsource
140  ]

```

```

141 end
142
143 to wiggle
144   rt random 40
145   lt random 40
146   if not can-move? 1 [ rt 180 ]
147   fd 1
148   ;; create a new entry for the path list (with x and y
      coordinates and 0 because the step from this pseudopodia is
      new)
149   let xycoordinate (list xcor ycor 0)
150   set path-list insert-item (length path-list) path-list
      xycoordinate
151 end
152
153 to bounce
154   ;; bounce off left and right walls
155   if abs pxcor >= max-pxcor - 1
156   [
157     ;; if "at the end of the world" face towards center and move
        one forward
158     face patch 0 0
159     ;; move one forward otherwise it will get stuck at the edge
        of the world
160     fd 1
161   ]
162   ;; bounce off top and bottom walls
163   if abs pycor >= max-pycor - 1
164   [
165     ;; if "at the end of the world" face towards center and move
        one forward
166     face patch 0 0
167     ;; move one forward otherwise it will get stuck at the edge
        of the world
168     fd 1
169   ]
170 end

```

### A.3 SISMO NetLogo Setup

```

1 ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;
2 ; ; Setup Procedures ; ;
3 ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;
4

```

```

5 ;; create slime population
6 to make-plasmodia
7   create-plasmodia 1
8   [
9     set size 5
10    set shape "cloud"
11    set color yellow
12  ]
13 end
14
15 ;; create pseudopodia
16 to make-pseudopodia [number]
17   create-pseudopodia number
18   [
19     ;; for the pseudopias we need the same starting position as
20     ;; for the plasmodium. Because it spreads from the center
21     set color yellow
22     set shape "dot"
23     set path-list []
24     set path-list insert-item 0 path-list (list xcor ycor 0)
25     pen-down
26   ]
27 end
28
29 to make-foods [ number ]
30   create-foods number [
31     set shape "circle_2"
32     set color orange
33     set size 2
34     ;; create random coordinate
35     ;; If you want to generate a random number between a custom
36     ;; range, you can use the following format: minnumber +
37     ;; (random-float (maxnumber - minnumber))
38     let randomxcoord (min-pxcor + 3) + (random-float ((max-pxcor
39       - 3) - (min-pxcor + 3)))
40     let randomycoord (min-pycor + 3) + (random-float ((max-pycor
41       - 3) - (min-pycor + 3)))
42     setxy randomxcoord randomycoord
43     set nutrient-value 50 + (random (150 - 50))
44     set chemical-level 23
45     set intensity 50
46     set label-color red
47   ]
48 end

```

```

45
46 ;; patch procedure
47 to generate-field
48   set light-level 0
49   ;; every patch needs to check in with every light
50   ask foods
51     [ set-field myself ]
52   set pcolor scale-color orange (sqrt light-level) 0.1 ( sqrt (
53     20 * max [intensity] of foods ) )
53 end
54
55 ;; do the calculations for the light on one patch due to one
56   light
56 ;; which is proportional to the distance from the light squared.
57 to set-field [p] ;; turtle procedure; input p is a patch
58   let rsquared (distance p) ^ 2
59   let amount chemical-level * scale-factor
60   ifelse rsquared = 0
61     [ set amount amount * 1000 ]
62     [ set amount amount / rsquared ]
63   ask p [ set light-level light-level + amount ]
64 end

```

## A.4 SISMO NetLogo Network Creation

```

1 to create-pseudopodia-network [breeds]
2   ;; extract the pseudopodia breed from the agentset to access
      the list of pseudopodias
3   let pseudos [pseudopodia] of breeds
4   ;; iterate through all pseudopodias to check if they have an
      intersection
5   let coordinates-list [path-list] of item 0 pseudos
6   if length coordinates-list = 1
7   [
8     ;; in case there is only one pseudopodium
9     set coordinates-list lput item 0 coordinates-list
       coordinates-list
10    ]
11  let i 0
12  while [ i < length coordinates-list - 1]
13  [
14    ;; get current coordinates from all coordinates
15    let coordinates item i coordinates-list
16    let j length coordinates - 1

```

```

17    ; ; we start backwards, to insert the intersection on the
18    right place, otherwise it would mess up the order of the
19    sequence
20    while [ j > 0]
21    [
22        if item 2 item (j - 1) coordinates != 1 and item 2 item
23        (j) coordinates != 1
24        [
25            let x-1 item 0 item (j - 1) coordinates
26            let x-2 item 0 item (j) coordinates
27            let y-1 item 1 item (j - 1) coordinates
28            let y-2 item 1 item (j) coordinates
29            ; ; Compare current pseudopodia with itself (to also
30            calculate the interfaces of itself) and compare
31            current with other pseudopodias.
32            ; ; One doesn't need to compare pseudopodia one with
33            pseudopodia two and than again pseudopodia two with
34            pseudopodia one.
35            ; ; Therefore iterate only for example pseudopodia two
36            with three, four five and so on
37            let k i
38            while [ k < length coordinates-list - 1 ]
39            [
40                ; ; get coordinates to compare from the list of all
41                coordinates
42                let coordinates-to-compare item k coordinates-list
43                let l length coordinates-to-compare - 1
44                while [ l > 0]
45                [
46                    ; ; if the coordinates are a copy of a parent skip
47                    the comparison
48                    if item 2 item (l - 1) coordinates-to-compare != 1
49                    and item 2 item (l - 0) coordinates-to-compare !=
50                    1
51                    [
52                        ; ; Defining the comparison coordinates
53                        let x-1-compare item 0 item (l - 1)
54                        coordinates-to-compare
55                        let x-2-compare item 0 item (l)
56                        coordinates-to-compare
57                        let y-1-compare item 1 item (l - 1)
58                        coordinates-to-compare
59                        let y-2-compare item 1 item (l)
60                        coordinates-to-compare

```

```

45      ; ; If the intersection points are already
46      ; ; connected, do not perform an intersection
47      ; ; calculation.
48      if (x-1 != x-1-compare) and (y-1 != y-2-compare)
49          and (x-2 != x-2-compare) and (y-2 !=
50              y-2-compare) and (y-2 != y-1-compare) and (x-2
51              != x-1-compare)
52      [
53          ; ; calculate intersection points
54          let intersection-coordinate-result
55              intersection-point x-1 x-2 x-1-compare
56                  x-2-compare y-1 y-2 y-1-compare y-2-compare
57          ifelse (intersection-coordinate-result != [])
58              and (intersection-coordinate-result != (list
59                  0 0 1)) and (not empty?
60                      intersection-coordinate-result)
61      [
62          ; ; if show-intersection-points is set, than
63          ; ; mark the intersection points with an X
64          if show-intersection-points
65              [
66                  hatch 1
67                  [
68                      set shape "x"
69                      set color red
70                      set size 1
71                      set xcor item 0
72                          intersection-coordinate-result
73                      set ycor item 1
74                          intersection-coordinate-result
75                  ]
76              ]
77          ; ; The intersection point is set at the
78          ; ; correct position in the coordinates list
79          ; ; and the network around the intersection
80          ; ; point is built.
81          ; ; The network points are created only if
82          ; ; there doesn't exist a network point on this
83          ; ; coordinate.
84          set coordinates insert-item (j) coordinates
85              intersection-coordinate-result
86          set coordinates-to-compare insert-item (1)
87              coordinates-to-compare
88              intersection-coordinate-result
89          ; ; check if there are existing network points,
90          ; ; if not create some and link them, if they

```

```

          exist create the missing one and connect
          them
69   let first-point one-of networkpoints with
       [ xcor = x-1 and ycor = y-1]
70   let intersec-point one-of networkpoints with
       [ xcor = item 0
         intersection-coordinate-result and ycor =
           item 1 intersection-coordinate-result]
71   if(first-point = nobody)
72   [
73     hatch-networkpoints 1
74     [
75       setxy x-1 y-1
76       set hidden? not show-network
77       set shape "circle"
78       set size .5
79       set color blue
80       set label ""
81       set first-point self
82     ]
83   ]
84   if(intersec-point = nobody)
85   [
86     hatch-networkpoints 1
87     [
88       setxy item 0
89       intersection-coordinate-result item 1
90       intersection-coordinate-result
91       set hidden? not show-network
92       set shape "circle"
93       set size .5
94       set color blue
95       set label ""
96       set intersec-point self
97     ]
98   ]
99   ask first-point [create-link-with
100    intersec-point]
101
102   let second-point one-of networkpoints with
103    [ xcor = x-2 and ycor = y-2]
104   if(second-point = nobody)
105   [
106     hatch-networkpoints 1
107     [
108       setxy x-2 y-2

```

```

105      set hidden? not show-network
106      set shape "circle"
107      set size .5
108      set color blue
109      set label ""
110      set second-point self
111      ]
112    ]
113    ask intersec-point [create-link-with
114      second-point]
115
116    let first-compare-point one-of networkpoints
117      with [xcor = x-1-compare and ycor =
118        y-1-compare]
119    if (first-compare-point = nobody)
120    [
121      hatch-networkpoints 1
122      [
123        setxy x-1-compare y-1-compare
124        set hidden? not show-network
125        set shape "circle"
126        set size .5
127        set color blue
128        set label ""
129        set first-compare-point self
130      ]
131    ]
132    ask first-compare-point [create-link-with
133      intersec-point]
134
135    let second-compare-point one-of networkpoints
136      with [xcor = x-2-compare and ycor =
137        y-2-compare]
138    if (second-compare-point = nobody)
139    [
140      hatch-networkpoints 1
141      [
142        setxy x-2-compare y-2-compare
143        set hidden? not show-network
144        set shape "circle"

```

```

145      ask intersec-point [create-link-with
146          second-compare-point]
147      ]
148      ;; if there are no intersection points just
149          build-network x-1 y-1 x-2 y-2
150      ]
151      ;; Links are created between the network points
152          and these are then colored yellow to match
153          the rest of the simulation.
154          ask links [set color yellow]
155          ]
156          set 1 1 - 1
157          set k k + 1
158          ]
159          set j j - 1
160          ]
161          set i i + 1
162      ]
163  ]
164 end
165
166 to build-network [x-1 y-1 x-2 y-2]
167    ;; check if there are existing network points, if not create
168    some and link them, if they exist create the missing one
169    and connect them
170    let first-point one-of networkpoints with [xcor = x-1 and ycor
171        = y-1]
172    let second-point one-of networkpoints with [xcor = x-2 and
173        ycor = y-2]
174    if(first-point = nobody)
175    [
176        hatch-networkpoints 1
177        [
178            setxy x-1 y-1
179            set hidden? not show-network
180            set shape "circle"
181            set size .5
182            set color blue
183            set label ""
184            set first-point self
185        ]

```

```

182 ]
183 if (second-point = nobody)
184 [
185   hatch-networkpoints 1
186   [
187     setxy x-2 y-2
188     set hidden? not show-network
189     set shape "circle"
190     set size .5
191     set color blue
192     set label ""
193     set second-point self
194   ]
195 ]
196 ask first-point [create-link-with second-point]
197 end

```

## A.5 SISMO NetLogo Math Functions

```

1 ;; calculation of the intersection points (line-line
    intersection)
2 to-report intersection-point [x1 x2 x3 x4 y1 y2 y3 y4]
3   let point []
4   let t-numerator (x1 - x3) * (y3 - y4) - (y1 - y3) * (x3 - x4)
5   let t-denominator (x1 - x2) * (y3 - y4) - (y1 - y2) * (x3 - x4)
6   let u-numerator (x1 - x3) * (y1 - y2) - (y1 - y3) * (x1 - x2)
7   let u-denominator (x1 - x2) * (y3 - y4) - (y1 - y2) * (x3 - x4)
8   if (t-denominator = 0) or (u-denominator = 0) [
9     report point
10    ]
11   let t t-numerator / t-denominator
12   let u u-numerator / u-denominator
13   ;; there is an intersection if 0.0 <= t <= 1.0 and if 0.0 <= u
14   <= 1.0
15   if (t >= 0) and (t <= 1) and (u >= 0) and (u <= 1)
16   [
17     set point (list (x1 + t * (x2 - x1)) (y1 + t * (y2 - y1)) 0)
18   ]
19   report point
20 end
21 ;; next two functions are for replacing the zeros in the
    coordinate list of a pseudopodium.
22 to-report replace-zero [the-list]

```

```

23  if item 2 the-list = 0
24    [ report replace-item 2 the-list 1 ]
25  report the-list
26 end
27
28 to-report replace-zeros [lists]
29  report map [ i → replace-zero i] lists
30 end

```

## A.6 SISMO NetLogo A\* Algorithm

```

1 ; Auxiliary procedure to test the A* algorithm between two
  random nodes of the network
2 to run-a-star [x-start y-start x-end y-end]
3  ask networkpoints [set color blue set size .5]
4  ask links with [color = yellow][set color grey set thickness 0]
5  let start one-of networkpoints with [xcor = x-start and ycor =
  y-start]
6  ask start [set color green set size 1]
7  let goal one-of networkpoints with [xcor = x-end and ycor =
  y-end]
8  ask goal [set color green set size 1]
9  ; We compute the path with A*
10 let path (A* start goal)
11 ; if any, we highlight it
12 if path != false
13 [
14  highlight-path path
15  let tube-path []
16  foreach path [ x → set tube-path lput x tube-path]
17  ;; hatch tube to make it visible
18  hatch-tubes 1
19  [
20   set path-list tube-path
21   set color yellow
22   set size 2
23   setxy 0 0
24   set pen-size 8
25   pen-down
26  ]
27 ]
28 end
29

```

```

30 ; Searcher report to compute the heuristic for this searcher: in
      this case, one good option
31 ; is the euclidean distance from the location of the node and
      the goal we want to reach
32 to-report heuristic [#Goal]
33   report [distance [localization] of myself] of #Goal
34 end
35
36 ; The A* Algorithm es very similar to the previous one
      (patches). It is supposed that the
37 ; network is accesible by the algorithm, so we don't need to
      pass it as input. Therefore,
38 ; it will receive only the initial and final nodes.
39 to-report A* [#Start #Goal]
40   ; Create a searcher for the Start node
41   ask #Start
42   [
43     hatch-searchers 1
44     [
45       set shape "circle"
46       set color red
47       set localization myself
48       set memory (list localization) ; the partial path will
              have only this node at the beginning
49       set cost 0
50       set total-expected-cost cost + heuristic #Goal ; Compute
              the expected cost
51       set active? true ; It is active, because we didn't
              calculate its neighbors yet
52     ]
53   ]
54   ; The main loop will run while the Goal has not been reached
      and we have active searchers to
55   ; inspect. Tha means that a path connecting start and goal is
      still possible
56   while [not any? searchers with [localization = #Goal] and any?
      searchers with [active?]]
57   [
58     ; From the active searchers we take one of the minimal
      expected cost to the goal
59     ask min-one-of (searchers with [active?])
      [total-expected-cost]
60     [
61       ; We will explore its neighbors, so we deactivated it
62       set active? false

```

```

63      ; Store this searcher and its localization in temporal
       ; variables to facilitate their use
64      let this-searcher self
65      let Lorig localization
66      ; For every neighbor node of this location
67      ask ([link-neighbors] of Lorig)
68      [
69          ; Take the link that connect it to the Location of the
           ; searcher
70          let connection link-with Lorig
71          ; The cost to reach the neighbor in this path is the
           ; previous cost plus the lenght of the link
72          let c ([cost] of this-searcher) + [link-length] of
           ; connection
73          ; Maybe in this node there are other searchers (comming
           ; from other nodes).
74          ; If this new path is better than the other, then we put
           ; a new searcher and remove the old ones
75          if not any? searchers-in-loc with [cost < c]
76          [
77              hatch-searchers 1
78              [
79                  set shape "circle"
80                  set color red
81                  set localization myself ; the location of the new
                   ; searcher is this neighbor node
82                  set memory lput localization ([memory] of
                   ; this-searcher) ; the path is built from the
83                      ;
84                      ; origin
85                      ; search
86                      ; set cost c ; real cost to reach this node
87                      ; set total-expected-cost cost + heuristic #Goal ;
                           ; expected cost to reach the goal with this path
88                      ; set active? true ; it is active to be explored
89                      ; ask other searchers-in-loc [die] ; Remove other
                           ; seacrhers in this node
90              ]
91          ]
92      ]
93      ; When the loop has finished, we have two options: no path, or
         ; a searcher has reached the goal
94      ; By default the return will be false (no path)
95      let res false

```

```

96 ; But if it is the second option
97 if any? searchers with [localization = #Goal]
98 [
99 ; we will return the path located in the memory of the
100 let lucky-searcher one-of searchers with [localization =
101 #Goal]
102 set res [memory] of lucky-searcher
103 ]
104 ; Remove the searchers
105 ask searchers [die]
106 ; and report the result
107 report res
108 end

109 ; Auxiliary procedure the highlight the path when it is found.
110 ; It makes use of reduce procedure with
111 ; highlight report
112 to highlight-path [path]
113 let reduced reduce highlight path
114 end

115 ; Auxiliaty report to highlight the path with a reduce method.
116 ; It recieives two nodes, as a secondary
117 ; effect it will highlight the link between them, and will
118 ; return the second node.
119 to-report highlight [x y]
120 ask x
121 [
122 ask link-with y [set color yellow set thickness .4]
123 ]
124 report y
125 end

126 ; Auxiliary nodes report to return the searchers located in it
127 ; (it is like a version of turtles-here,
128 ; but fot he network)
129 to-report searchers-in-loc
130 report searchers with [localization = myself]
131 end

```