Towards Automatically Generating Playable Summaries

By Varun Prakash Bhat

A Thesis

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Master of Science

in

Interactive Media and Game Development

August 2020

Primary Advisors:

Prof. Gillian Smith, Associate Professor – CS/IMGD

Prof. Mark Claypool, Professor – CS/IMGD

Readers:

Prof. Jennifer deWinter, Professor – Arts, Communications, and Humanities

Prof. Charles Roberts, Assistant Professor - IMGD

APPROVED

Professor Gillian Smith: _____

Professor Mark Claypool: _____

Professor Jennifer deWinter: _____

Professor Charles Roberts: _____

Abstract

Video games use several summarization techniques in the form of gameplay trailers, reveals, and demo levels. These techniques mostly create summaries that are non-interactive and one-dimensional in medium (either audio, video, or text) which cannot portray the full video game on their own. We propose an approach to create a complete media summary that is also interactive and generate a playable summary level from a collection of Super Mario Bros. levels using user-obtained salient features based on patterns of memorability. We use the Mario AI Framework and the Occupancy-Regulated Extension generator to create the playable levels. We perform an analysis of the obtained features and perform curation on the generated summary levels. For evaluation, we compare the play experiences of the summary levels to those of the selected collection of levels. Although not yet complete, our preliminary evaluation suggests that players input similar adjectives to describe both the play experience of the Super Mario bros. levels and the play experience of the summary levels. With further testing in the future, it should be possible to gauge how much the summary level portrays the original level in terms of memorability.

Contents

Table of Figures

Table of Tables

Chapter 1 - Introduction

Summarization is a method of abridging or shortening a piece of work. This has been explored in several forms of media such as text, audio, and video (Hahn & Mani, 2000). Summarization in video games has been done through methods such as tutorials, demo levels, or reveal trailers. For a consumer, a good summary can provide several benefits such as informed purchases, and entertainment. For the creators of media, a good summary can provide promotion, a better understanding of the market and of the game system, reactions of consumers, and many other benefits.

Often, these methods portray only a small portion of the video game and are static experiences that do not allow for any user input. Demo levels are playable but can be limited in terms of game experience. Our research suggests that there has been no attempt in making a playable summary for a video game which aims to provide a larger scope of game experience than what a demo level provides. We believe this is because a video game has several parts (Hendrikx, Meijer, Van Der Velden, & Iosup, 2013) such as game mechanics, sound, maps, art, story, and many more thereby increasing its complexity and effectiveness.

In this thesis, we attempt to answer the problem of the lack of playable summaries by creating a method of our own that does this. Therefore, we created short, *playable* summary levels of only 3 levels from the Super Mario Bros. (Miyamoto & Tezuka, 1985) that incorporates and portrays user-selected salient features. The summary levels were then curated and only 2 out of the 20 generated levels were selected for final testing. Here, participants were asked to play both, the 3 original levels and the 2 summary levels. Thereafter, we compared the two play experiences for each participant. We also compared the final summary levels that were selected for testing based on participant reviews to find out which of the 2 is a better summary of the 3 original levels.

We chose this game due to the availability of various frameworks and generators (Horn, Shaker, Smith, Togelius, & Dahlskog, 2014) , and the modular levels that can be played independent of each other. The 3 levels that we choose are 1-1, 2-1, and 4-1. These levels are easier in terms of difficulty but are varied enough in terms of level elements. This decision was made because the user studies to obtain the salient features included participants of varying degrees of skill. We also did not include the overground, underground, and the night-time World 3 levels in order to maintain uniformity in visual style.

To create the summary levels, we used the Mario AI Framework (Khalifa, 2019) and the Occupancy Regulated Extension generator (Mawhorter & Mateas, 2010) in our process .The Mario AI Framework – 10th Anniversary Edition was created by Ahmed Khalifa as a research-based framework. The primary purpose of this software is to host several AI algorithms for level traversal in the Super Mario Bros. franchise. It also contains a human agent that provides game control to the user. This human agent is the one used for the purpose of this study. The framework uses the Video Game Level Corpus (Summerville, Snodgrass, Mateas, & Villar, 2016) form of notations for input which are simple and easy-to-understand. It allows for a manual creation and input of a level without any modification to the code. It also provides an in-built emulator to run the level. The ORE generator attempts to generate a Mario level based on a mechanism of piecing level slices together using "anchor points". Furthermore, it uses a notation format that is similar in

structure to the VGLC notations. An automatic conversion method was later added into the ORE generator so that it would be readable by the Mario AI Framework which is explained later.

The salient features obtained from the user study on the 3 original levels gave us insight into certain design principles of the game. We use these principles to define parameters that go towards the creation of the summary level. We created 20 summary levels from the obtained salient features. The level generation count was arbitrarily chosen and was deliberately kept small in order to maintain scope. After some curation, 2 levels were selected for a comparative study which would discern the better summary level. However, this study took place with limited number of participants due to the COVID-19 pandemic.

In this document, Chapter 2 provides a review of previous works done in the domain of summarization in a variety of media. Chapter 3 describes the first user study which was used to obtain the salient features alongwith relevant methodology. Chapter 4 explains the data obtained through the first user study as well as goes into detail on the analysis done on this data. Chapter 5 explains how the obtained salient features were extracted for use in the ORE generator. It also describes the obtained summary levels and the curation applied to them. Chapter 6 provides and analyses the data obtained in the final comparative study. We conclude by providing a brief conclusion as well as a description of the future work that can be performed on this.

Chapter 2 - A review of summarization in media

According to Merriam-Webster, the definition of a summary is "an abstract, abridgment, or compendium especially of a preceding discourse" (Merriam-Webster). Hovy and Lin (1999) proposed in their text summarization system, that:

> "A summary is a text that is produced out of one or more (possibly multimedia) texts, that contains (some of) the same information of the original text(s), and that is no longer than half of the original text(s)."

These definitions of summarization have been considered as the norm and have been explored in various forms of media such as text, audio, and video. There are many text-summarization techniques that have been developed or are currently being developed (Gambhir & Gupta, 2017). This is because text-based media (books, newspapers, magazines, and many more) have been around for a long time and are prevalent even today. Furthermore, text follows a rigid structure that has several constraints in the form of grammar and correctness which are helpful when it comes to writing code for their summarization systems. Hovy and Lin (1999) used a method of tokenization in the SUMMARIST system where they first identified central topics, interpret them according to context, and then generate a summary. One of the problems identified was the problem that most text summarizers and text generators share – the lack of context/meaning comprehension. As accurate as a generated sentence might be, it becomes meaningless if the next generated statement does not make sense in terms of the context. In order to combat this problem, Liu, Luo, Zhang, Xue, and Xu (2017) use a method of semantic extraction and summary generation where they extract the semantics of a body of text separately.

The approach of segmentation and extraction observed in text-based summary systems carries over to other forms of media as well. Peeters, La Burthe, and Rodet (2002) use feature extraction using training models and human-input features. Their definition of a summary is:

> "A representation of the musical piece as a succession of states (possibly at different temporal scales) so that each state represents a (somehow) similar information found in different parts of the piece."

With the use of unsupervised training algorithms, they attempt to find these features, or states which are specific to each audio piece. Using a two-pass system, the piece is first segmented then structured in order to construct the audio summary. However, the main issue with this is that the effectiveness of such a summary is not discussed or explored. The paper admits that the generation of the summary depends on the user choices made (before or after the segmentation process) but does not go into detail as to whether this was tested.

Furthermore, a summary can vary largely according to what the user requests. Hahn and Mani (2000) provide new definitions which inform much of this research. The classification of a summary depends on whether it is an abstract or an extract. Both types have two aspects in common:

- They depict what is salient in the original content
- The aim is to create a summary that is shorter than the original content

A summary is also divided into whether it is generic or user focused. A generic summary is broader and is not targeted towards a specific group. For example, a summary of events on the front-page of a newspaper. Such a summary does not have a target audience and is meant to be read by all. A user-focused summary is narrower and is targeted to a user's interests or focus groups. For example, a news summary in the Finance section of the same newspaper is generally targeted towards people involved with that section. Hahn and Mani (2000) state that generic summaries were more popular but currently, user focused summaries are the norm. However, most of their paper is geared towards showcasing techniques related to text-based summarization (especially news articles, political pieces, national addresses) with a short mention of techniques used in multimedia.

A field that incorporates all the described mediums is the video game industry. It is a complex field that involves the amalgamation of text (narration, story, quests), audio (soundtrack, effects), and video (graphics, cinematics, level design). The automatic summarization of works produced is a difficult task due to involvement of the different mediums. A notable method of summarization in video games would be automated video summary generation method (Mindek, Čmolík, Viola, Gröller, & Bruckner, 2015). This method uses camera views of players in a multiplayer game in order to generate a temporally coherent summary of gameplay. They create an event graph which summarizes the flow of the game by recording the various events that occurred throughout a session. Every single event in the game is captured by a flock of 3D in-game cameras. They also go a step further in terms of semantics by establishing coherence by developing a storyline for the summary. Using video techniques such as stop-motion and focus techniques, they attempt to create an entertaining summary that tries to depict the occurring events with semantics. Their goal is to evaluate their summaries based on successful depiction of the tactical execution by players. Their user study reports that players confirmed the success of their methodology.

Although the effort to summarize a video game through a net sum of game events is admirable, it has some unaddressed issues such as:

- Their user study only addresses the summary in terms of tactical play and therefore involves players who executed those tactics. This is a niche group and the summarization does nothing to address a much broader viewing audience consisting of various age groups and various levels of exposure to gaming
- Since the evaluation of the video summary is only for veteran players, it does nothing to summarize the gameplay for new players or prospective players. A strategy that might be worth attention to a veteran player may not hold the same interest to someone who is not a veteran.

Another attempt at summarizing video games is the Steam Labs Experiment 001: Micro Trailers (Steam, 2019). Here, the player is shown 6 second clips of different video games in rapid succession. The main takeaways from all the previous attempts are as follows:

- A summary should be an abridged form of content that is shorter than the original content
- It should include significant events or moments from the original
- The construction of these events into a summary should be coherent and understandable

We use these takeaways in order to inform our summary generation of a collection of Super Mario Bros. levels.

Chapter 3 - Research Questions and Methodology

This chapter lists our Research Questions and explains the methodology used in order to answer them. The Research Questions that we answer are:

1. How can we define and identify the salient features of the collection of Super Mario Bros. levels?
2. How can we incorporate the identified salient features into a summary level using Procedural Content Generation?
3. How does the play experience of the summary level compare to the original play experience?
4. How effective are the incorporated salient features in the summary level?

3.1 Testing Method: User Study

In this thesis, all data is collected in through surveys which immediately follow a supervised, user study. The details of each survey and user study conducted are explained in this chapter (see: 3.4 Phase 1 and 3.6 Phase 3)

3.2 Game of choice: Super Mario Bros

This section explains our reasoning behind choosing Super Mario Bros. as the source game for generating our summary levels.

We chose Super Mario as our game of choice due to the availability of various frameworks and generators, and the modular levels that can be played independent of each other. We used the Mario AI Framework by Ahmed Khalifa and the Occupancy Regulated Extension generator for the creation of the summary level.

The original game has a total of 32 stages divided across 8 worlds consisting of 4 levels. Testing for all these levels was of scope for the current project. For the purpose of this thesis, only 1-1, 2-1, and 4-1 were the collection of levels being considered for the summary generation. These worlds were chosen specifically because they each represent a progression and introduction (see: Appendix A to view the level maps of 1-1, 2-1, and 4-1.

- 1-1 is the tutorial level where a study participant is coached with the controls, most common enemies (Goombas and Koopas), and power-ups that the game generally contains.
- 2-1 is slightly higher in terms of difficulty and provides the participants with their first real challenge in the game. It also introduces the Flying Koopa which is the first flying unit introduced in the game.
- 4-1 is easier in terms of level design but has a new enemy that participants cannot jump onto but must always avoid, i.e. the Spiny.

Figure 3.1 A complete depiction of enemies seen in 1-1, 2-1, and 4-1 (as seen in Mario AI Framework)

3.2 Frameworks and Generators

3.2.1 Mario AI Framework

The Mario AI Framework – 10th Anniversary Edition is a research-based framework. The primary purpose of this software is to host several AI algorithms for level traversal in the Super Mario Bros. franchise. It also contains a human agent that provides game control to the user. This human agent was used in all our user studies for this thesis. The framework uses the Video Game Level Corpus form of notations for input which are simple and easy-to-understand. It allows for a manual creation and input of a level without any modification to the code. It also provides an in-built emulator to run the level. All these qualities made it an ideal framework to use for the purpose of this project

3.2.2 Occupancy-Regulated Extension (ORE) generator

The ORE generator was developed by Peter Mawhorter and Michael Matteas that attempts to generate a Mario level based on a mechanism of piecing level slices together using "anchor points". Their method of generation is like ours which uses arbitrarily selected salient features which is the main reason as to why this framework is being used. Furthermore, it uses a notation format that is similar in structure to the VGLC conventions. A conversion method was later added into the code in order to automate the conversion so that it would be readable by the Mario AI Framework which is explained later.

3.3 Salient Features

We mentioned in our Research Questions as well as in the Framework description above, that we would be using salient features obtained from the collection of Super Mario levels i.e. 1-1, 2-1. and 4-1. This section defines what our salient features are and goes further to define how we are choosing them as well as our reasoning.

For the purpose of this thesis, our salient features were areas or objects within the game that participants found to be memorable after their playtesting session. These areas and objects can be both environmental (e.g. Bricks, Powerup blocks, Coin blocks, Ground tiles), and interactive (e.g. Goombas, Koopas, Piranha plants) elements within the level. We do not consider actions such as jumps, dashes, and kills into our generation method; although we do record them in our playtesting sessions. The reason for this exclusion of player actions is because it would be difficult to find out how every single action corresponds to a selected salient feature. This size of contextual analysis would be out of scope for the nature of this thesis.

We define memorability as the ability to remember areas or objects after a play session, inclusive of all types of emotions experienced. i.e. positive, negative, or neutral. This means that a player could mark any area or object in the level as salient regardless of what emotion they experienced while interacting with that section of the level.

Our goal is to see if salience can be identified in terms of a more abstract and complex term such as memorability. Several studies regarding level generation in Super Mario Bros. have been conducted. These studies use a variety of techniques such as level symmetry (Mariño & Lelis, 2016), generator training and curation (Summerville, Philip, & Mateas, 2015), and rhythm-based generation (Smith, Treanor, Whitehead, & Mateas, 2009). However, these techniques use designers to author and curate their levels while out method takes end-user perspectives and mixes them with the designer perspectives, to generate the summary levels. The reason we use this method is because we believe that video games are created for the end-user and therefore, it is important to include their perspective in the summary level generation. Once we have the perspectives in the form of our salient features, we use the ORE generator to create our summary level. Our evaluation takes place through comparison of adjectives of play which is detailed further in Chapter 6. In order to first identify the salient features for the generation of the summary level, two user studies were conducted over the course of three phases, as described below:

3.4 Phase 1 – Identifying Salient Regions

The first phase is the first user study that helps identify Research Question 1 of the three research questions. In order to identify salient features, we ask users to participate and play through the three levels of Super Mario Bros. i.e. 1-1, 2-1, and 4-1. This phase was divided into 3 stages. Stage 1 is further divided into two sub-stages, A and B.

3.4.1 Stage 1 – Gameplay session of 1-1, 2-1, and 4-1
A. Tutorial

The participants were given a tutorial level to play through in order to get used to the keyboard controls. Since the original game is a controller-based game, we wanted to provide maximum familiarity to both experienced and new participants to make their gameplay experience smoother. The tutorial level was custom-designed and contained 1 gap, 1 enemy, 1 powerup, and 1 obstacle. This was done in order to show participants what kind of mechanics and level design they could expect from the original levels.

B. Gameplay with Narrative

Here, the participants played a level for 15 minutes (maximum) or until they were satisfied and wanted to move on to the next level. The time limit was arbitrarily chosen, and the total study time was limited to 1 hour per participant. We encouraged the players to try and be as natural as possible and. We also allowed them to vocalize their gameplay if they wished to do so. The goal was to provide as much freedom as possible to simulate a comfortable gameplay environment.

Once the users began playing, one researcher sat with them and observed them play. The researcher had three level maps per participant obtained from the Video Game Level Corpus. Whenever a

user expressed something in their gameplay at an area or at a mechanic, the researcher marked this area on the map along with noting down the user's expressions and/or words. We wanted to find out whether the players also found the same areas as salient in the next stage of the study.

3.4.2 Stage 2 – Post-gameplay survey, and interview

Immediately after Stage 1, the players were asked to mark out the sections that they deemed as salient in terms of memorability, i.e. the players were asked to mark sections or areas that they remembered, or thought were memorable after their play experience. They could watch a replay of their gameplay if they needed it.

While the players marked these sections, a short interview was conducted asking the players some questions regarding their gameplay. The questions are given below:

1. Which parts of the level(s) did you find most memorable?
2. Which characters did you like in the gameplay?
3. Which was your most favorite game object to interact with?
4. On a scale of 1-5, how satisfied are you with your gameplay?

The questions are aimed towards trying to understand what key objects played a pivotal role in influencing the player's gameplay experience.

3.4.3 Stage 3 – Demographics survey

The players were asked questions as part of the demographics data such as:

1. Please choose the age group you fall in. (18-28, 29-39, 40-50, 51-61, 62 and above)
2. Please type in your gender.
3. Please type in your race.
4. What genre of video games do you enjoy? (Action, Arcade, FPS, RTS, Platformers, Fantasy, RPG)
5. How often do you play video games? (daily, weekly, monthly)
6. Have you ever played Super Mario Bros. (NES, 1985) before? If not, which other Mario platformers have you played?

3.5 Phase 2 – Incorporating Salient Regions and Generating Summary Levels

The second phase is the analytical phase that incorporates the results obtained from Phase 1 along with the salient features in order to try and answer Research Question 2 i.e. How can we incorporate the identified salient features into a summary level using Procedural Content Generation?

We transcribed the level maps obtained from Phase 1 and transcribed them onto multiple Excel sheets per level per participant. Every cell that was marked as salient in the level map was given a value of 1 in the corresponding cell in Excel. The level maps marked by the researcher were also included in these workbooks following the same principle. Once the maps were transcribed, the cells across multiple sheets per level were added together in order to find the areas of salience in those levels. Each cell in each level has the additive total of the number of times it was marked as salient. This total is the salience score for that cell. The salient cells were then grouped together using a cumulative grouping method to create salient features. For example, if the first group of cells had the salience score of 16, the second group would contain cells having the salience score

of 15 to 16. These groups of cells were our salient features to be inserted into the ORE generator for generation.

After grouping, we curate the salient features to remove repetition. To do this, we choose a threshold after analyzing the salient groups for repetition. The features that had salient scores above this threshold were considered for the generative process while the other features were discarded.

Once curation was complete, the salient features were then mapped into their respective ASCII notations used in the ORE generator to generate 20 different summary levels. These summary levels were then quantitatively analyzed and curated. We used the following parameters to aid our curation process for the generated summary levels:

1. Playability of the level

   We made sure that the levels were playable. We discarded the levels that had no mechanical complexity in terms of enemies and gaps. We also discarded the levels that were extremely difficult or had a very high density of enemies clustered around an area of the level.

2. XY scatter analysis

   We performed a XY scatter analysis based on the distribution of enemies and gaps versus powerups. Based on the graph, we chose two levels from two ends of the spectrum as our summary levels to be used for testing in the next phase. The idea was to see as to which side of the spectrum of complexity had the more ideal summary level.

3.6 Phase 3 – Evaluating the Summary Levels

The third phase involved the testing of the generated summary levels and gauged how the experience fared to the original levels' gameplay experience. We attempt to answer Research Questions 3 (the comparison of play experiences between the original levels and the summary level) and Research Question 4 (the effectiveness of the salient features in the summary level) in this phase. The methodology used for Phase 3 had a similar format as Phase 1. It was divided into 4 stages. Stage 1 is further divided into two sub-stages, A and B. The entire process was conducted online via Zoom and Discord interviews.

3.6.1 Stage 1 – Gameplay session of 1-1, 2-1, and 4-1
A. Tutorial

The players were given the same tutorial level as Phase 1 to play through in order to get used to the keyboard controls.

B. Gameplay with Narrative

The users played through the same levels as mentioned in Phase 1. No notes or level maps were used in this sub-stage.

3.6.2 Stage 2 – Post-gameplay survey of 1-1, 2-1, and 4-1

Immediately after Stage 1, the users were sent a link to a survey of questions related to their gameplay experience. The users were asked to turn off screen sharing for this duration. The questions asked in this survey were:

1. Please choose the adjectives that describe your "entire" play experience:

   okay, meh, enthralling, interesting, simple, lacking, boring, drab, difficult, rich

2. Please type in any additional adjectives that may apply to you.
3. Please type in 5 moments that you thought were "memorable" in your play experience

We ask for the adjectives for a comparative analysis between the experiences of the original level gameplay experience and the summary gameplay experience. We use them to see if people chose or used the same or similar adjectives to describe their gameplay experience. This will help answering Research Question 3 i.e., How does the play experience of the summary level compare to the original play experience?

3.6.3 Stage 3 – Gameplay session of summary levels

The users were asked to play through the two selected summary levels (Section 3.5) which were selected after the XY scatter analysis. The format was the same as Stage 1 of this phase. However, the participants did not play through a tutorial level in this Stage.

3.6.4 Stage 4 – Post-gameplay survey of summary levels

The users were given a survey that had questions regarding their play experience. The demographics survey was also given during this stage after the experience-based questions. The questions asked were:

1. Please choose the adjectives that describe your "entire" play experience:

   okay, meh, enthralling, interesting, simple, lacking, boring, drab, difficult, rich

2. Please type in any additional adjectives that may apply to you.
3. Please type in 5 moments that you thought were "memorable" in your play experience
4. Which level/levels is/are a better summary?

   Case 9, Case 19

5. Please explain your choice above
6. Do you think the summary level(s) successfully summarized the original levels?
   Yes, No, Maybe, Can't say
7. If you selected yes above, then on a scale of 1-5 how much would you rate the summary/summaries? (Please rate both summaries individually if you selected "both" for Q6
8. If you selected any other option than "Yes" in Q6, please explain your choice below.

The survey provides data to help understand and do a comparative analysis of experiences of the original levels versus the summary levels. Analysis of the survey results can help answering Research Question 3 i.e., How does the play experience of the summary level compare to the

original play experience? It also helps answer Research Question 4 i.e., How effective are the incorporated salient features in the summary level? The demographics survey contained the same list of questions as asked in Phase 1, Stage 3 in section 3.4.3

3.7 Consent Forms

The studies were approved under the exempt category by the IRB at WPI. The serial number for the same is 19-0695. The consent form can be found attached in the appendices section for both the studies. The players were informed about what they would be doing in both the studies. They were also informed that only recordings of their play experiences, and audio recordings of their narratives would be taken. All consent forms were signed prior to the beginning of the study. No other personal or identifying information was collected or stored in any format.

Chapter 4 - Phase 1 (Identifying Salient Regions)

This chapter explains Phase 1 of the three phases introduced in Chapter 3, section 3.1. It goes into more detail regarding the specifics of the Mario AI Framework. Phase 1 helps us answer Research Question 1 i.e. How can we define and identify the salient features of the Super Mario Bros. levels?

4.1 Introduction

As discussed in Section 3.2 Frameworks and Generators, we used the Mario AI Framework as our emulator in our user studies. The levels are read-in using the Video Game Level Corpus notations. We chose and studied 1-1, 2-1, and 4-1 (see: Section 3.2 Game of choice: Super Mario Bros).

1-1 is the tutorial level where the player is coached with the controls, most common enemies (Goombas and Koopas), and power-ups that the game generally contains. 2-1 is slightly higher in terms of difficulty and provides the player with their first real challenge in the game. It also introduces the Flying Koopa which is one of the first enemies having a unique behavior. 4-1 is easier in terms of level design but has a new enemy that the player cannot jump onto but must always avoid, i.e. the Spiny (see: Figure 3.1 for a full list of enemies encountered).

4.2 Mario AI Framework vs. Super Mario Bros.

There are some differences in the emulator from the original Super Mario Bros. which are as follows:

4.2.1 Graphics

Certain environmental elements such as clouds and bushes are missing. Level 4-1 does not have Lakitu dropping the Spinys but rather they spawn on the map as any other Goomba or Koopa. Although these elements were noticeably missing (as seen in the post play interviews), it was not enough to detract from the salience map marking. Since the core structure of the levels were almost identical to the ones that the original game had, people did not seem to have much trouble in locating said elements on the level maps provided to them.

4.2.2 Level Design

In the original game, the player could not move back to a previously visited area of the map that has moved off-focus from the camera. However, the framework does not impose a lock on the camera and the player can move back as far as required. We believe that the issue that is created due the lack of camera lock is the respawning of enemies. If a player moves back away from an enemy's spawn area and then returns to it, the enemy will respawn. These bugs do not provide a major issue when implementing the framework to the study.

4.2.3 Speed

The original game is slower as compared to the Mario AI Framework. The jumps are smaller, and Mario moves a lot slower. The framework, however, is much faster in terms of gameplay. This is something that was most noticeable to the veteran players. The players became acclimated to this element of the framework after a few respawns. We observed that some players took notice of the mobility and respawning enemies while the others did not. However, all players continued their play session while taking these factors in stride.

4.3 Modifications to the Mario AI Framework

There are some other level elements that were modified according to the needs of the study:

4.3.1 Lives and respawns

In the original game, the player started out with 3 lives and they had to keep taking 1up mushrooms or collect 100 coins to gain 1 life point. If the player died before collecting an extra point, the game was over for them. If the player collected a single life point, then they respawned at their current death location with a small invulnerability duration. This mechanic was modified in the framework in two iterations for the purpose of the study. The first iteration had the player start out with 3 lives. If the player lost all 3, the game was over, and they had to move on to the next level.

However, there were several problems with this iteration. First, we felt that it would destroy the concept of replayability. As seen in the study, players who were dying constantly in 2-1 were even less inclined to play it again just due to the sheer frustration of not being able to progress. The goal of the study is not to gauge the level difficulty or a player's skill but to provide players a base to identify memorable elements of their gameplay. Keeping a mechanic that destroys player progress would make them frustrated and therefore decrease replayability. This would take away from the game experience and was something we wanted to prevent.

Second, it reduces the play time of the users. Since the goal is to gain memorable sections, we want the players to play as much as possible. The more people play a level, the higher the chances are for them to either cement the areas that were memorable for them or find more memorable areas by progressing further in the level (greater level completion = greater memorable areas).

In order to combat this, the second iteration had two important changes. First, the life cap was removed, and players were given infinite respawns. Second, the respawn zone was moved to the very start of the level. This gave the players more replay ability and freedom to try out whatever style of play they desired.

4.3.2 Keyboard Inputs

For the purpose of the study, we collect the keyboard data of the player's inputs while the game is being played. This feature did not originally exist in the Mario AI Framework which needed to be implemented. The method logs the key inputs of the player in-game and prints them to an Excel sheet with their respective timestamps. The precision is up to the nearest millisecond and it always begins at 0 seconds from the beginning of the gameplay session of each level.

4.3.3 Other Quality of Life Updates

The original framework did not contain sounds of the game universe. That was rectified by adding the various sounds that accompanied Super Mario Bros. in order to maintain a level of immersion. The various jumps and interaction sounds were put in along with the main Super Mario Bros. soundtrack that plays in a loop. Since the underground and over-ground levels are not a part of the study, those tracks were not included.

4.4 User Study

We recruited 18 users of ages 18 and above for Phase 1 through mailing lists such as dl-imgd-majors@wpi.edi, and dl-imgd-grads@wpi.edu. The users were informed that their gameplay

(screen recording + keyboard inputs) and the vocal narrative of the play (provided by the user) would be recorded. The users were asked for their consent to do this through a consent form. The mixed group of players were chosen in order to gain salient features that both experienced and inexperienced players found memorable.

4.4.1 Level Maps

As discussed in Chapter 3, section 3.1 both the players and the researchers had level maps that were sourced from the Video Game Level Corpus. These level maps were printed onto paper and then divided into 1x1 grids of 16 rows. The reason for this is that the framework reads in the level data in the form of 16 rows in order to render the level. This method of division made is easier to port the physical data into a usable, digital format.

Once the players and researchers marked their respective sections, both parties' level maps were manually transcribed onto Excel. Due to the markings being uneven, certain rules were laid down:

- A cell is considered salient if it's fully marked.
- In the case that a cell is partly marked, it's considered as salient only if it includes a game object.

Every cell that was marked as salient on the level maps was given the value of '1' in its corresponding sheet at the corresponding cell location. Once the values were set, they were added together to generate a salience map for each level as shown in Figures 4.1, 4.2, and 4.3.

```
                  1       1       1       1       1       1       1       1       1       1       1
                  1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
          1       1       1       1       1       1       1       1       1       1       1       1
```

Figure 4.1 An example of how salient features were marked in Excel

```
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
0 0 2 3 3 3 4 5 5 5 5 5 5 2 2 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
0 0 3 4 4 4 6 7 7 7 7 7 7 2 2 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 2 2 2 2 2 2 2 2 1 1 1 1 0 0 0 0 0
1 1 5 6 6 6 10 11 11 11 11 11 10 3 3 2 0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 2 2 3 3 3 3 3 3 3 3 3 2 2 2 2 1 5 5 5 4
1 2 6 7 7 7 13 16 16 15 13 13 12 4 3 2 0 0 0 0 0 1 1 1 1 1 1 2 2 2 2 3 3 2 2 4 4 4 3 3 3 3 4 4 3 3 3 3 1 5 5 5 4
1 2 7 8 8 8 13 16 16 15 13 13 12 4 3 2 0 0 0 0 0 1 1 1 2 2 2 3 2 2 2 3 3 2 2 6 6 6 5 5 5 5 6 6 4 3 3 3 3 1 5 5 5 4
1 2 7 8 8 8 13 16 16 15 13 13 12 4 3 2 0 0 0 0 0 1 1 1 2 2 2 4 3 3 2 3 3 2 2 6 6 6 6 6 6 6 7 6 4 3 3 3 3 1 5 5 5 4
1 2 8 9 9 9 14 17 17 16 13 13 12 4 3 2 0 0 0 0 0 1 1 1 2 2 2 4 3 3 2 3 3 2 2 6 6 6 6 6 6 6 7 6 4 3 3 3 3 1 4 4 4 3
1 2 8 9 9 9 14 16 16 14 13 13 12 4 3 2 0 0 0 0 0 1 1 1 2 2 2 4 3 3 2 3 3 2 2 6 6 6 6 6 6 6 7 6 4 3 3 3 3 1 3 3 3 2
1 2 8 9 9 9 12 14 14 12 11 11 10 3 3 2 0 0 0 0 0 1 1 1 2 2 2 4 3 3 2 3 3 2 2 6 6 6 6 6 6 6 7 6 4 3 3 3 3 1 3 3 3 2
1 2 8 9 9 9 12 14 14 12 11 11 10 3 3 2 0 0 0 0 0 1 1 1 2 2 2 4 3 3 2 3 3 2 2 6 6 6 6 6 6 6 7 6 4 3 3 3 3 1 3 3 3 2
```

Figure 4.2 An extract of the salience map for level 1-1

```
1  1  1  1  1  1  1  1  1  1  1  1  0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 1 0
1  1  1  1  1  1  1  1  1  1  1  1  0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 1 0
2  2  2  3  3  3  3  3  2  2  2  2  0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 6 6 6 6 5 3
2  2  2  4  4  4  4  4  2  2  2  2  0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 2 3 4 4 4 4 4 3 2 2 2 2 2 2 2 2 6 6 6 6 5 3
2  2  2  4  4  4  4  4  2  2  2  2  0 0 0 0 0 0 0 0 0 0 1 1 3 3 3 4 5 6 6 6 6 6 5 4 4 4 4 3 3 3 3 7 7 7 7 6 4
7  7  7  8  8  8  8  8  7  4  2  3  1 1 1 1 1 1 1 2 2 2 2 5 5 5 6 6 7 7 7 7 7 6 5 5 5 5 4 4 4 4 4 8 8 8 8 7 5
17 17 17 17 17 17 17 17 16  5  2  4  2 2 2 2 2 2 2 4 4 3 3 9 9 10 12 12 12 12 12 12 12 12 10 10 10 10 9 8 8 8 8 9 9 8 7 6 5
19 19 19 19 19 19 19 19 19  6  3  5  2 2 2 2 2 2 2 4 4 3 3 15 15 17 20 20 19 18 16 16 16 16 13 13 13 13 12 11 11 11 11 11 11 10 8 5 4
20 21 21 21 21 21 21 21 20  6  3  6  3 3 3 3 3 3 3 5 5 3 3 15 15 17 20 20 19 18 16 16 16 17 14 14 14 14 13 12 12 12 12 12 12 11 9 6 5
20 21 21 21 21 21 21 21 20  6  3  6  3 3 3 3 3 3 3 5 5 3 3 15 15 17 19 19 19 19 18 16 17 18 19 17 17 17 17 16 15 15 15 15 15 15 14 12 7 6
21 22 23 23 23 23 23 22 21  6  3  6  3 3 3 3 3 3 3 5 5 3 3 15 15 16 16 15 15 14 13 14 15 17 17 17 17 17 16 15 15 15 15 15 15 14 12 7 6
21 22 23 23 23 23 23 22 21  6  3  6  3 3 3 3 3 3 3 5 5 3 3 14 14 15 15 14 15 14 13 14 15 17 17 17 17 17 16 15 15 15 15 15 15 14 12 7 6
21 22 23 23 23 23 23 22 21  6  3  6  3 3 3 3 3 3 3 5 5 3 3 14 14 15 15 14 15 14 13 14 15 17 17 17 17 17 16 15 15 15 15 15 15 14 12 7 6
```

Figure 4.3 An extract of the salience map for level 2-1

```
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 5 6 6 6 5 2 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 7 10 10 10 9 3 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 4 8 11 11 11 10 3 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
4 4 4 4 4 3 2 2 2 2 2 2 2 2 2 2 2 4 4 8 11 11 11 10 3 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
7 11 11 11 11 6 4 2 2 2 2 2 2 2 2 2 2 4 4 7 10 10 10 9 2 2 2 1 1 1 1 2 2 2 2 2 2 2 2 2 2
7 12 12 12 12 6 4 2 2 2 2 2 3 3 3 3 3 3 3 5 5 9 12 12 12 11 3 3 3 2 2 2 1 1 2 2 2 2 2 2 2 2
7 12 12 12 12 6 4 2 2 2 2 2 3 3 3 3 3 3 3 5 5 9 12 12 12 11 3 3 3 2 2 2 1 1 2 2 3 3 3 3 2 2 2 2
6 11 11 11 11 5 4 2 2 2 2 2 3 3 3 3 3 3 3 5 5 8 10 10 10 10 3 3 3 2 2 2 1 1 2 2 3 3 3 3 2 2 2 2
3 5 5 5 5 4 3 3 3 3 3 3 4 4 4 4 4 4 4 6 6 8 8 8 8 4 4 4 3 2 2 1 1 2 2 4 4 4 4 3 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 6 6 8 8 8 8 4 4 4 3 2 2 1 1 2 2 4 4 4 4 3 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 6 6 8 8 8 8 4 4 4 3 2 2 1 1 2 2 4 4 4 4 3 2 2 2 2
```

Figure 4.4 An extract of the salience map for level 4-1

The darker regions with the higher numbers show the amount of people that thought those regions were salient. i.e., memorable. The lighter regions show the areas that people thought were the least salient. All the salient regions in Excel map to their corresponding level regions. We use these regions as our salient features for the generation of the summary level. The numbers in the regions act as our frequency values. These features were then matched with their respective ASCII notations and grouped according to their respective frequencies in order to be moved into text files. These text files act as the input for the Occupancy-Regulated Extension (ORE) generator in order to generate the summary level.

4.4.2 Demographics

18 participants completed this stage of the user study, all aged over 18. Out of the 18 participants, 17 were aged between 18-28 while 1 participant was between 51-61. 9 participants (50%) reported that they enjoyed playing platformers. The most popular category was the Action genre at 14 participants (78%). 10 participants (56%) reported playing games Daily, 4 Weekly (22%), 2 Monthly (11%), 1 Never (5%). 13 out of the 18 participants (72%) had experience in the Super Mario Bros. (NES, 1985) while 4 participants (22%) had experience with the Super Mario universe on other handheld devices (e.g. Wii, Original Gameboy, SNES). 1 participant chose not to answer this question.

All 18 participants self-reported gender and race using their own descriptors. 7 people (39%) identified themselves as 'Female', 10 people (56%) identified themselves as 'Male', and one chose not to respond. 12 people (67%) identified themselves as 'White', one (5%) as 'half Chinese, half White', one (5%) 'African American', one (5%) 'Indian', two (11%) 'Asian', and one chose not to respond.

4.5 Answering Research Question 1

RQ1: How can we define and identify the salient features of the Super Mario Bros. game?

For the purpose of this thesis, we define and identify the salient features as the sections that users marked as memorable after their play session. These salient features required curation via analysis which will be explained further in the following chapter.

Chapter 5 - Phase 2 (Incorporating Salient Regions and Generating Summary Levels)

This chapter explains Phase 2 of the three phases introduced in Chapter 3, section 3.2. It details the specifics of the Occupancy-Regulated Extension (ORE) generator. It also answers Research Question 2. How can we incorporate the identified salient features into a summary level using Procedural Content Generation?

5.1 Introduction

The ORE generator generates a Mario level based on a mechanism of piecing level slices together. These level slices are vertical areas of Mario levels that contain anchor points in each slice. The anchor points are potential places that Mario can be in each slice. The ORE generator iteratively pieces these slices together using the anchor points, to create a level.

The input for the ORE generator is in the form of text files. These text files contain ASCII notations that represent the Mario level components and the slices that contain them. The Mario AI Framework also uses text files containing ASCII notations to render the level for our user studies. However, the notations for the generator and the framework are different from each other. We resolved the difference by introducing a method to automatically convert the ORE notations into the format used by the Mario AI Framework.

5.2 Modifications to the ORE generator

As discussed in Section 5.1, the ORE generator required one modification: Automatic conversion to desired notation output format

A method was introduced into the ORE generator which converted the native level notations into the required format that could be read by the Mario AI Framework so that the Mario AI Framework could be used as the testing platform. The graphics and the music of the ORE generator are drastically different from the Super Mario Bros. due to the usage of the Infinite Mario environment. This does not however, create any issues with the actual level generation, so we chose not to alter that part of it. Figure 5.1 displays the equivalency chart of all known notations in the ORE generator and their counterparts used in the Mario AI Framework.

Furthermore, the ORE generator does not have a native way of printing the generated level into an ASCII text file. We need this file in order to set it as input into the Mario AI Framework. Therefore, we introduced another method into the ORE generator that works simultaneously with the method for notation conversion. Once the salient features were extracted, these methods used the features to convert and print them out.

ORE symbol	Object in-game	Mario AI Framework symbol
M	Mario	M
F	Exit	N/A
s	Spiny	y
S	Winged spiny	Y
g	Goomba	E,g
G	Winged goomba	G
k	Green koopa	k
K	Winged green koopa	K
r	Red koopa	r
R	Winged red koopa	R
.	Block (pyramid)	#
Þ	Mushroom block	?, @
?	Coin block	Q, !
!	Life up block (invisible)	1
#	Block (brick)	S
€	Coin	C
!	Mushroom	U
!	Life up block	L
¢	Coin	o
[	Pipe	t
f	Flower pipe	T
+	Block (ground)	X

Figure 5.1 Conversion chart of notations

5.3 Extraction of salient features

In Chapter 4, Section 4.4.1, the areas marked as salient by our users were moved into Excel Sheets. Each Excel Sheet contained the cell data for one level out of the 3 levels selected from Super Mario Bros. This next step details the process that we used, to extract salient features from the Excel Sheets. These salient features were then used by the ORE generator to generate our summary levels. The process of extracting the salient features is as follows:

1. Each cell in the Excel Sheets have a salience score attached to it. These scores were the number of users that had deemed the cell-region as salient in the Super Mario level. The scores first were converted to a range between 0 to 1. This was done because the Occupancy-Regulated Extension (ORE) generator took input in this format.
2. The cells were then grouped together based on arithmetic progression where the difference between their scores was 1. For example, the first grouping contained all the cells having the score f_{max}. The second grouping contained all the cells having the scores f_{max} to $(f_{max} - 1)$. Figure 5.2 shows an example of grouping done for cells in the level 1-1. Each cell's respective salience score is displayed alongside the equation that determines the grouping.
3. Once the grouping of cells was complete, we needed to decide on a cutoff point for each cell grouping for each level. The cutoff point would tell us which features would go into the ORE generator and which features would be discarded. This was done in order to prevent repetition, since the cells with lower salience scores included most of the cells from the higher scores.
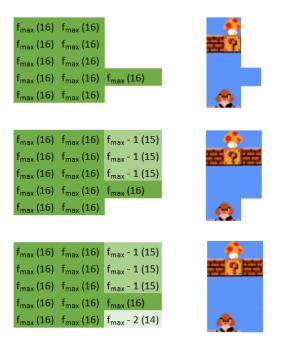
Figure 5.2 Salient cell-region grouping for 1-1 along with their salience scores

5.3.1 Curating salient features

In order to decide which group of cells to keep and which to discard, we first analyzed the salient cell-groupings manually to find repetitions. Based on this analysis, we choose a threshold for the cell-groupings for each level. We use a cumulative distribution curve to depict this threshold for each level's Excel Sheet. An example of this curve for the Excel sheet of level 1-1 is shown in Figure 5.3. The points marked in green are the salient cell-regions that are taken into consideration for generation of the summary levels in the ORE generator. The red points are the salient cell-regions that were discarded.
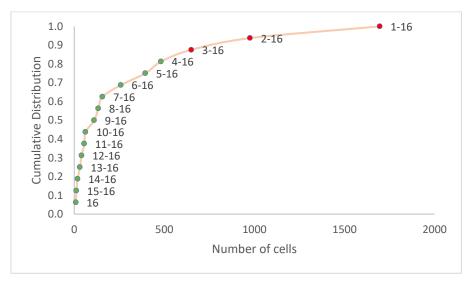

Figure 5.3 Probability (Y-axis) vs the Number of cells (X-axis) for 1-1

The curve represents the distribution of cells that have a particular salience score or higher. For example, in Table 5.2 we see that the percentage of a group of cells having the salience score of 16 is 6.25%. Similarly, the percentage of a group of cells having a salience score ranging from 15 to 16 would be 12.5%.

	Salience Score	Number of cells	Probability
*	16	9	0.062500
*	15-16	12	0.125000
*	14-16	19	0.187500
*	13-16	32	0.250000
*	12-16	41	0.312500
*	11-16	56	0.375000
*	10-16	63	0.437500
*	9-16	111	0.500000
*	8-16	134	0.562500
*	7-16	157	0.625000
*	6-16	259	0.687500
*	5-16	395	0.750000
*	4-16	482	0.812500
	3-16	650	0.875000
	2-16	976	0.937500
	1-16	1696	1.000000

Table 5.1 Probabilities of salient cell-regions in 1-1

The starred rows in Table 5.1 depict the salient cell-regions for 1-1. A collection of such salient cell-regions for all 3 levels are taken into consideration for generation of the summary levels in the ORE generator. We decided to include salient cell-regions that are situated on the left-side of the curve because of the availability of more unique regions without repetition.

5.3.2 Slice input and anchor point placement
The ORE generator uses anchors in order to determine the placement of level chunks in the output level. These anchors are placed manually and represent the areas which Mario can occupy in the level providing certain conditions are met. For the purpose of this thesis, we place only two anchor points per level slice. The criteria for their placement are based on the following factors:

1. There are platforms available for the placement

It is necessary that the anchor points be placed on a platform in order to eliminate the possibility that Mario spawns in mid-air. However, some salience chunks are pockets of air due to the nature of the manual marking of zones in playtesting. Therefore, these sections do not contain any anchor points since they do not have any platforms and are summarily discarded.

2. There are no nearby enemies to the said platform

It is also necessary that Mario should have a safe start at the beginning of the level, following the design principles of the original game's level. Therefore, we make sure enemies are not present

near Mario's spawn zone by making sure our anchors have at least a 2-tile separation from enemies.

Once the anchor points were marked, all that needed to be done was to run the generator to create our summary levels. It is nearly impossible to test all the levels the ORE can generate. As a result of this, the first 20 levels generated by the ORE were taken as the potential summaries for the purpose of this thesis.

5.4 Summary level generation and curation

The goal of the study is to generate a summary level based on memorability, but it is paramount that the game be mechanically playable. Some factors that can make the level unplayable or difficult would be:

- The game having recurring gaps between single ground tiles causing the player to be extremely careful with their jumps
- The game having several enemies clustered around a single area or zone making it difficult to navigate through

All the reasons mentioned above increase the difficulty by being frustrating regardless of the skill level of the player. Therefore, we needed to do some curation of the levels being generated. In order to perform curation, a criterion was required to select which of the 20 levels to use as summary levels. Although the goal is to select a single, summary level in the end we needed to select two different levels for the final study in order to do a comparative analysis of the easier and more difficult levels.

5.4.1 Curation of summary levels

In order to curate the possible summary levels, some statistical analysis was done.

- First a count of the number of enemies (n_e), number of gaps (n_g), and number of powerups (n_p) was taken for each of the 20 possible cases of summary levels. An example of this is shown in Figure 5.5 for Level Case 20.
- Then, a scatter plot of the 20 levels was generated as shown and tallied in Figure 5.4

The scatter plot represents the Level Cases in terms of difficulty through the selected parameters – enemies, gaps, and powerups. Although there are several other aspects that determine the difficulty of a level, we wanted to focus only on the statistical parameters that were clearly defined and obtainable in each level. The enemies and gaps add to the mechanical difficulty of the level while the powerups give the user a boost which in turn reduces difficulty. Therefore, the Level Cases (represented by dots) to the left of the scatter plot shown in Figure 5.4 represent the easier Level Cases due to a higher amount of powerups in them. The Level Cases to the right of the scatter plot represent the more difficult Level Cases due to a higher number of enemies and gaps.
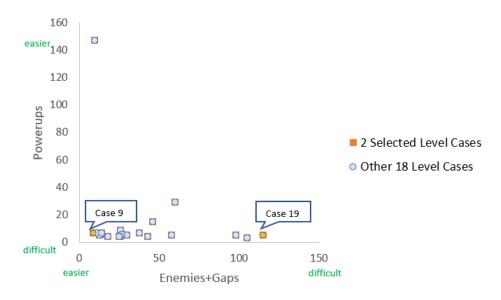
Figure 5.4 Scatterplot of the 20 Level Cases

We selected Level Case 9 and Level Case 19 as our summary levels (represented by orange dots) for the comparative analysis in Phase 3. We ignore the one outlier in the plot at (150,3) because of the sheer amount of powerups which disturb the visual aesthetic of the level.

Our rationale for the levels we picked was:

- Since the curation was done on a statistical analysis in terms of difficulty, we wanted to test two ends of the spectrum to determine which end was more favorable
- In order to gain some meaningful data, a comparative analysis with the summary level was needed. However, no known summary level for Super Mario levels exists as per our research. Therefore, we sample two clusters to compare between them.

Enemies	Count
Spiky	0
Wing Spiky	0
Goomba	1
Wing Goomba	0
Green Koopa	2
Wing Green Koopa	1
Red Koopa	0
Wing Red Koopa	0
Flower Pipe	0
Powerups	
Mushroom (? Brick)	7
Life Up Invis	0
Mushroom brick	0

Type	Total
Enemies	4
Gaps	10
Powerups	7

Figure 5.5 Count of ne, ng, and np for Level Case 20

Level Case	Enemies+Gaps	Powerups
1	46	15
2	14	6
3	13	5
4	60	29
5	10	147
6	58	5
7	30	5
8	98	5
9	9	7
10	26	9
11	105	3
12	27	6
13	18	4
14	11	7
15	26	4
16	43	4
17	25	4
18	38	7
19	115	5
20	14	7

Table 5.2 : Count of (ne + ng) and np for all levels [Selected Level Cases in yellow]

5.5 Answering Research Question 2

RQ2: How can we incorporate the identified salient features into a summary level using Procedural Content Generation?

We use a combination of statistical analysis and generative randomness in order to curate and incorporate the salient features into a summary. The statistical analysis allows us a form of control in order to prevent unplayable artifacts. We go further to curate the levels in terms of difficulty to ensure that the users in the study in Phase 3 can play these levels before answering questions that relate to various emotions experienced in their gameplay session. These questions also help us gauge which of the summary levels is a better summary than the other.

Chapter 6 - Phase 3 (Evaluating the Summary Levels)

This chapter explains Phase 3 of the three phases introduced in Chapter 3, section 3.2. It goes into more detail regarding the criteria that we used for our evaluation of our summary levels. It needs to be noted that the original plan was to have at least 15 participants evaluating the final 2 summary levels. However, due to the COVID-19 pandemic, we were able to test only for 5 users whose results are displayed and analyzed below.

As discussed in Chapter 3, section 3.3, this phase was divided into 4 stages:

- In Stage 1, we conduct a gameplay session for the 3 selected, original levels of Super Mario Bros. i.e. 1-1, 2-1, and 4-1.
- In Stage 2, we conduct a survey concerning Stage 1. Here, we gather adjectives describing play experience and obtain the memorable moments experienced by the player in Stage 1.
- In Stage 3, we conduct a gameplay session for the 2 summary levels. i.e. Level Case 9 and Level Case 19.
- In Stage 4, we conduct a survey concerning Stage 3. Here, we gather adjectives describing the play experience and obtain the memorable moments experienced by the player in Stage 3. We also ask participants to tell us which of the 2 Level Cases was a better summary of the original levels.

6.1 Stage 1 – Gameplay session of 1-1, 2-1, and 4-1

In this stage, participants played through the 3 original Super Mario Bros. levels. i.e. 1-1, 2-1, and 4-1.

6.1.1 Demographics

We recruited 5 participants through email and chat room messages for this study. All 5 participants belonged to the age bracket of 18-28. 2 participants (40%) reported that they enjoyed playing Platformers. The most popular categories were Action and Role-Playing Games. 1 participant (20%) reported playing games Daily, 3 Weekly (60%), and 1 Monthly (20%).

1 participant (20%) had experience in the Super Mario Bros. (NES, 1985) while 3 participants (60%) had experience with different Mario titles on other handheld devices (e.g. Wii, DS) or had played Mario knockoffs. 1 participant (20%) had only seen Super Mario but had never played for an extended period. They went on further to say that they hadn't played many platformers at all.

All 5 participants self-reported gender and race using their own descriptors. 1 participant (20%) identified themselves as "Pangender", 2 participants (40%) identified themselves as "Female", and 2 participants (40%) identified themselves as "Male". 1 participant (20%) identified themselves as "Irish-Mexican", 1 participant (20%) identified themselves as "Caucasian", and 3 participants (60%) identified themselves as "White".

6.1.2 Procedure

All 5 participants were given consent forms that detailed the user study, our purpose, and that they would have to do. They were also informed that their gameplay and audio would be recorded. The observer did not speak during the session to allow for an uninterrupted play experience except when a question was asked of them by a participant. Each participant shared their screen during gameplay and turned their screen sharing off when they were filling the survey in Stage 2.

1. Participants first played through a tutorial level that helped them get familiarized to the Mario AI Framework as well as keyboard controls.
2. The participants then played through the 3 original Super Mario Bros. levels. i.e. 1-1, 2-1, and 4-1 in that order. They had unlimited lives and could replay as much as they wanted. When the timer for each level ran out, they could restart the level as well. The participants moved to the next level to play whenever they wanted to.
3. After the participants had played through the 3 levels at least once, they were asked if they wanted to replay any of them. If the participant answered in affirmative, they could play that desired level again. If the participant answered in negative, then the gameplay session ended there.

Once the gameplay session was over, the participants were asked to turn their screen sharing off. Following this, they were sent the link to the first survey which began Stage 2.

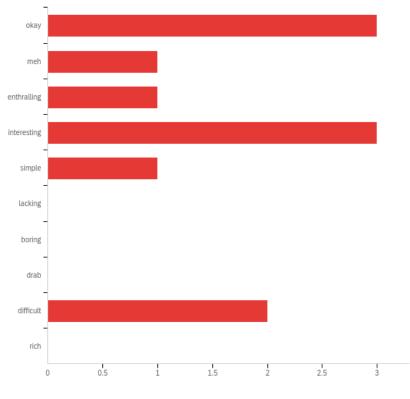## 6.2 Stage 2 – Post-gameplay survey of 1-1, 2-1, and 4-1

Stage 2 is where the participants filled out a survey. This survey collected information pertaining to their play experience in Stage 1. Each participant was each given a unique, identification number at the beginning of the survey. They were asked to turn off screen sharing for this duration. The questions asked were:

1. Please choose the adjectives that describe your "entire" play experience:
   (Each participant could select multiple adjectives for Question 1)

   okay, meh, enthralling, interesting, simple, lacking, boring, drab, difficult, rich

2. Please type in any additional adjectives that may apply to you.
3. Please type in 5 moments that you thought were "memorable" in your play experience

For Question 1, 1 participant (20%) marked the experience as "meh", 1 participant (20%) marked the experience as "enthralling", 1 participant (20%) marked the experience as "simple", 2 participants (40%) marked the experience as "difficult", 3 participants (60%) marked the experience as "okay", and 3 participants (60%) marked the experience as "interesting".

A visualization of the data for the adjectives is shown in Figure 6.1

Figure 6.1 Question 1 responses (Survey 1)

Table 6.1 shows a breakdown of these responses by individual participants as indicated by their respective identification numbers

Test identification number	Response
5	okay
6	okay, meh, enthralling
8	interesting, difficult
9	interesting, simple, difficult
10	okay, interesting

Table 6.1 Adjectives per participant for the original levels' play experience (Survey 1)

For Question 2, 2 participants (40%) chose not to respond to this question while 3 participants (60%) had additional adjectives to add that described their play experience. Out of the 3 participants, participant with the number 10 added "focused, frustrated, satisfied" as their adjectives, participant with the number 6 added "frustrating" as their adjective, and participant with the number 5 added "frustrating, because lag" as their adjectives.

For Question 3, we received a wide variety of responses, which are tabulated and displayed in Table 6.2.

Id. No.	Moment #1	Moment #2	Moment #3	Moment #4	Moment #5
5	a long line of goombas came at me in level 2-1	introduction of spiny in 4-1	had to hop onto a small island platform on 4-1	knocking out goombas with turtle shells in 2-1	having to hop over the line of spinies going over the cliff in 4-1
6	Reaching new secion of 2-1 after failing multiple times	Goombas appearing from off-screen suddenly in 2-1	Deciding whether or not to replay 2-1 each time	Completing 4-1 on the first try	Seeing the spiky turtle dudes (forgot those were a thing)
8	Recognizing the beginning of 1-1	Constantly running into the 2nd koopa on 2-1	Running out of time on 2-1 at the wall just before the flag	Seeing the spinies in 4-1	Finally completing 2-1
9	Almost made it to the end of 2-1 and freaked out and died	Finally completed 2-1	Found out 4-1 was actually way easier than 2-1	Found out I could restart to reset mushrooms	Found out mushrooms and blocks did not reset when you did
10	finally beating level 2	double jumping a whole line of gumbas	getting the mushrooms	losing a life with the mushroom but being invincible long enough to survive a couple more foes	making it through the flying turtles

Table 6.2 Responses for the 5 memorable moments of the play experience (Survey 1)

Each column in Table 6.2 shows the 5 memorable moments that the participants identified in their play experience. This question took a text input and therefore the moments are shown in verbatim for each participant.

6.3 Stage 3 – Gameplay session of summary levels

In this stage, participants played through the two selected summary levels i.e. Case 9 and Case 19. The framework used to play these levels remains the same as before i.e. Mario AI Framework. Participants were asked to turn their screen-sharing back on so that recording could be done.

6.3.1 Procedure

Once again, the observer did not speak during the session to allow for an uninterrupted play experience except when a question was asked of them by a participant. Each participant shared their screen during gameplay and turned their screen sharing off when they were filling the survey in Stage 4. Here, participants did not play through a tutorial level like they did in Stage 1 and directly jumped into plying Level Case 9 and Level Case 19 (see: Appendix A for images of the two levels)

1. The participants were asked to pick a Level Case to play first. It did not matter which one they picked.
2. Like Stage 1, the participants could move on to the remaining Level Case whenever they wanted to. They had unlimited lives and could replay as much as they wanted. When the timer for each level ran out, they could restart the level as well.
3. After the participants had played through the 2 Level Cases at least once, they were asked if they wanted to replay any of them. If the participant answered in affirmative, they could play that desired level again. If the participant answered in negative, then the gameplay session ended there.

Once the gameplay session was over, the participants were asked to turn their screen sharing off. Following this, they were sent the link to the second survey which began Stage 4.

6.4 Stage 4 – Post-gameplay survey of summary levels

We conducted two different surveys here because we wanted separate sets of adjectives for each of the play experiences. The two sets of adjectives could later be compared against each other to find out if there were any differences.

Each participants' test identification number remained the same as the previous survey in Stage 2. They were asked to turn off screen sharing for the duration of this survey as well. The questions that were asked in this survey were:

1. Please choose the adjectives that describe your "entire" play experience:
   (Each participant could select multiple adjectives for Question 1)

   okay, meh, enthralling, interesting, simple, lacking, boring, drab, difficult, rich
2. Please type in any additional adjectives that may apply to you.
3. Please type in 5 moments that you thought were "memorable" in your play experience
4. Which level/levels is/are a better summary?

   Case 9, Case 19
5. Please explain your choice above
6. Do you think the summary level(s) successfully summarized the original levels?

Yes, No, Maybe, Can't say

7. If you selected yes above, then on a scale of 1-5 how much would you rate the summary/summaries? (Please rate both summaries individually if you selected "both" for Q6

8. If you selected any other option than "Yes" in Q6, please explain your choice below.

We breakdown the responses to all the questions in the survey below.

6.4.1 Question 1

Please choose the adjectives that describe your "entire" play experience: (Each participant could select multiple adjectives for Question 1)

1 participant (20%) marked the experience as "enthralling", 1 participant (20%) marked the experience as "meh", 2 participants (40%) marked the experience as "okay", 2 participants (40%) marked the experience as "simple", 2 participants (40%) marked the experience as "interesting", and 3 participants (60%) marked the experience as "difficult".
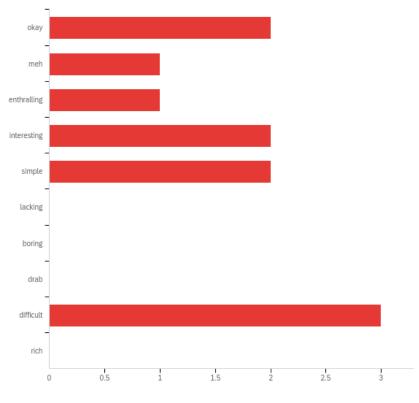

Figure 6.2 Question 1 responses (Survey 2)

Table 6.3 shows a breakdown of these responses by individual participants as indicated by their respective identification numbers.

Test identification number	Response
5	okay
6	okay, meh, simple
8	difficult
9	enthralling, interesting, simple, difficult
10	interesting, difficult

Table 6.3 Adjectives per participant for the summary levels' play experience (Survey 2)

6.4.2 Question 2

Please type in any additional adjectives that may apply to you.

1 participant (20%) chose not to respond to this question while 4 participants (80%) had additional adjectives to add that described their play experience. Out of the 3 participants, participant with the number 10 added "engaged, frustrated" as their adjectives, participant with the number 9 added "mysterious (cause the levels were a little weird), unnerving (for the same reason)" as their adjective, participant with the number 8 added "Artificial, odd" , and , participant with the number 6 added "indifferent" as their adjectives.

6.4.3 Question 3

Please type in 5 moments that you thought were "memorable" in your play experience.

We received a wide variety of responses, which are tabulated and displayed in Table 6.4.

Id. No.	Moment #1	Moment #2	Moment #3	Moment #4	Moment #5
5	flying koopas in case19	challenging jumping in case9	coin blocks on bottom case9	waiting for lines of enemies to pass case19	using koopas to kill goombas case19
6	Finishing case9 on the first try	Falling repeatedly on case19	Giving up on case19 after the first try	Repeatedly falling into gaps on the same spot in case19 (about 15 seconds in)	Seeing case19 for the first time as compared to case9
8	Realizing I could not dash over the blocks in case 9	Carefully hopping block to	Running forward without any	Jumping into one of the flying koopas	The glitched pipe that was cut in half in case 19

		block in case 9	obstacles in case 9	near the end of case 19	
9	Realizing case 9 was just an empty void	Beating case 19	Dying to the first paratroopa every time in case 19	Trying to sprint through all of case 19	The first time playing case 19
10	narrowly missing the flying turtle when it bounced under a "?" box	realizing that case 9 did not have any enemies	getting the flower and changing colors	learning how to time running under the flying turtles	my first time being able to run smoothly through a large portion of case 19

Table 6.4 Responses for the 5 memorable moments of the play experience (Survey 2)

Each column in Table 6.4 shows the 5 memorable moments that the participants identified in their play experience. This question took a text input and therefore the moments are shown in verbatim for each participant. A total of 25 moments were collected across 5 participants. Out of these, "Case 9" was mentioned 9 times while "Case 19" was mentioned 14 times.

6.4.4 Question 4 and Question 5

Q4: Which level/levels is/are a better summary? Case 9, Case 19
Q5: Please explain your choice above

For Question 4, every participant (5 out of 5) reported Case 19 to be the better summary. When asked for the reason for their choice (in Question 5), the participants said the following

Id No.	Please explain your choice above. (above indicates Question 4)
5	I found 19 more enjoyable and a better combination of both platforming and enemy interaction.
6	Case19 felt more representative of the common mechanics/patterns in the first three levels. Case9 seemed very uniform and plain, and did not really incorporate the same elements of gameplay as case19.
8	Case 9 really did not feel like a mario level, while case 19 seemed to have at least some similar structure to the example mario levels.
9	Case 9 was very empty, did not have many enemies, and did not feel quite like a real Mario level.
10	Case 19 had a wide range of enemies and obstacles, with challenges, and this made it feel like a better summary of overall gameplay

Table 6.5 Responses for Question 5 (Survey 2)

6.4.5 Question 6

Do you think the summary level(s) successfully summarized the original levels? Yes, No, Maybe, Can't say

1 participant (20%) marked "No", 2 participants (40%) marked "Maybe", and 2 participants (40%) marked "Yes". Here, "Yes" means that the summary level that participants chose in Question 4 successfully summarized the original levels. "No" means that the summary level that participants chose in Question 4 did not successfully summarize the original levels.

Table 6.6 shows the breakdown of these responses:

Id No.	Response to Question 5
5	Maybe
6	Maybe
8	No
9	Yes
10	yes

Table 6.6 Breakdown of responses received for Question 5 (Survey 2)

6.4.6 Question 7

If you selected yes above, then on a scale of 1-5 how much would you rate the summary/summaries? (Please rate both summaries individually if you selected "both" for Q6)

Participant number 10 gave a rating of 5 while participant number 9 gave a rating of 4 to Case 19. Here, the rating of 1 is a "bad experience" and 5 is an "excellent experience". This distinction was made clear to the participants during the survey-filling.

6.4.7 Question 8

If you selected any other option than "Yes" in Q6, please explain your choice below.

The explanation given by each participant for their choices in Question 6 is shown in Table 6.7. Only participants who responded either "No" or "Maybe" were asked to answer this question.

Id No.	Please explain your choice above.
8	As stated above case 9 really did not feel similar to any of the example levels, and while case 19 was more similar it presented new structures rather than referencing anything in the examples as would be expected of a summary.
6	It is unclear whether the summary levels effectively summarize the other levels- while there was a similar progression of gameplay elements in case19, the experience was different after already having played through the first 3 levels. I was more inclined to

	give up sooner as I was already frustrated from playing the original levels, which may have helped to correlate the experience of struggling with case19 to struggling with 2-1.
5	I did not get far enough into case9 to see if it was a good summary, but case19 felt like an ok summary of the different ways to fight enemies and platform from the previous levels.

Table 6.7 Responses to Question 8 (Survey 2)

6.3 An analysis of the data

Although the sample space of 5 participants is quite small, certain patterns and trends were observed which are described below:

Test identification number	Adjectives used to describe original levels' play experience (Stage 1)	Adjectives used to describe summary levels' play experience (Stage 3)
5	okay	okay
6	okay, meh, enthralling	okay, meh, simple
8	interesting, difficult	difficult
9	interesting, simple, difficult	enthralling, interesting, simple, difficult
10	okay, interesting	interesting, difficult

Table 6.8 Comparison of adjectives chosen to describe both play experiences

Test identification number	Adjectives used to describe original levels' play experience (Stage 1)	Adjectives used to describe summary levels' play experience (Stage 3)
5	frustrating, because lag	N/A
6	frustrating	indifferent
8	N/A	Artificial, odd
9	N/A	mysterious (cause the levels were a little weird), unnerving (for the same reason)
10	focused, frustrated, satisfied	engaged, frustrated

Table 6.9 Comparison of self-input adjectives to describe both play experiences

In the two survey stages i.e. Stage 2 and Stage 4, we had asked users to choose adjectives from a list, and to self-input any adjectives that described their play experience in the prior stages. Stage 2 asked for adjectives that described the play experience of Stage 1, where the participants played the original Super Mario levels. Stage 4 asked for adjectives that described the play experience of Stage 3, where the participants played the summary levels.

Table 6.8 shows that the set of adjectives chosen to portray the play experiences of Stage 1 and Stage 3 were similar. The number of times these adjectives were used, however, were different for

each stage. Furthermore, each participant chose different adjectives to describe the two play experiences.

Table 6.9 shows a comparison between the adjectives that participants self-input to portray the play experiences of Stage 1 and Stage 3. It was observed that participants tended to use "frustration/frustrating" as an adjective for the play experience pertaining to the original Super Mario Bros. levels. The places that read "N/A" in Table 6.9 are places where people chose to not self-input any adjectives that described their play experience of the summary levels (Stage 3).

Furthermore, in most of the identified memorable moments, participants seemed to find sections/areas with a certain level of mechanical complexity to be worth mentioning. This is either characterized by avoiding or killing enemies, jumping over them, grabbing powerups, and being able to clear levels. From Table 6.2, we can assume that people found clearing a level (especially 2-1) to be most memorable. This is characterized by 3 participants (60%) mentioning this as one of their memorable moments.

In Table 6.4, we see that most of the memorable moments were from Case 19. The variety in challenge as well as level elements (presence of enemies, powerups, and level of interactivity) that the level provided made it more memorable than its counterpart, Case 9. Therefore, an argument can be made towards selecting levels that are situated more towards the right-side of the XY scatter shown in Chapter 5, Figure 5.3. However, this cannot be confirmed until the levels are tested with a larger sample space.

6.4 Answering Research Questions 3 and 4

RQ3: How does the play experience of the summary level compare to the original play experience?

Judging by the adjectives, we can say that the play experience of the summary levels is like the original levels. However, when asked if the summary level of choice (Case 19) successfully summarized the original levels the players were more varied with their responses; ranging from affirmative to negative, and in-between. Both experiences were a combination of "okay, meh, enthralling, interesting, simple, difficult, frustrating, engaging, artificial, odd, mysterious, and indifference" in terms of adjectives describing the play experience. Other methods of comparing the play experience might exist and can be researched such as analyzing the gameplay recordings to find audio/narrative cues, and analysis of keyboard inputs to find correlations between key input behavior; but those are not being researched in this thesis due to scope.

RQ4: How effective are the incorporated salient features in the summary level?

In terms of adjectives gathered, it can be said that the incorporated salient features are very effective due to the similarity in adjectives between the two play experiences. However, due to the split in responses to the question that asked whether the chosen summary level (Case 19) was a successful summary, it can be safely concluded that the answer to this Research Question remains inconclusive, at best.

Conclusion

Mainstream media creates summaries in various formats for various types of source material. However, most of these summaries are not interactive and cannot be explored. Furthermore, video game summaries come in the form of gameplay trailers, reveals, demo levels, or game reviews which are either very short or cannot be satisfactory representatives of the full artifact.

The end-goal of creating a representative format of a work that can be digested by the end-user has been a pre-existing field of interest. Our ideal goal is to create playable summaries based on a framework that would hold true for most, if not all games. This would give the end-user a freedom of choice in their gameplay decisions as well as give artists and creators a clear idea of what players found memorable.

This thesis provides a method to summarize video games that involves in creating playable artifacts that contain features obtained from real player data. We focus on generating a playable summary for a collection of Super Mario Bros. (NES, 1985) levels. Our method focuses on generating the playable summaries in the form of playable levels which are formed out of salient regions from the original Super Mario levels. These salient regions are identified via human subject studies, which are then analyzed and curated throughout various phases in the thesis. The selection of the salient regions is based on patterns of memorability that are identified by the participants. The thesis is divided into 3 phases. We conducted a user study as a part of Phase 1 that allowed us to obtain the patterns that help us identify the salient regions in our levels. We analyze these salient regions in Phase 2 in order to determine the suitable input for the ORE generator. Then, we select 2 summary levels out of 20 generated levels as our final summaries. We then compare the play experience of the summary levels against the play experience of the original levels via another user study in Phase 3.

Upon analysis of the survey results in Phase 3, we found that most users used similar adjectives to describe both the summary as well as original level play experience. Participants could not seem to agree unanimously on whether the summary levels were successfully able to summarize the original 3 levels. Unfortunately, due to the COVID-19 pandemic, 6.1 Stage 1 couldn't get the required sample size in order to complete the study. However, all participants unanimously chose Case 19 to be the better summary. We believe this is because Case 19 was more challenging and interesting (had better mechanics, more enemies, lots of interactions happening on-screen) as compared to Case 9. Our future work will look towards building upon these characteristics.
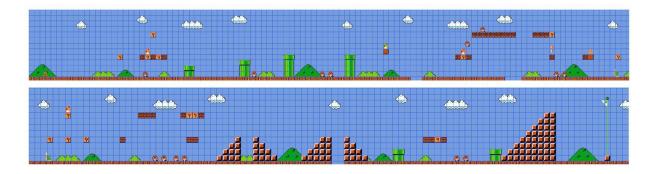
Future Work

This thesis can be expanded upon in various ways. The core idea revolves around obtaining salient features through user studies of 3 Super Mario Bros. levels to generate a summary level. However, provided enough time and resources, a salience map could theoretically be created for all the levels of Super Mario Bros. and mirrored into a summary level. This would give a larger dataset to derive conclusions from. Furthermore, the sample space of users in user studies could be vastly increased to receive more conclusive data. The method of evaluating the summary levels is one-dimensional. Although several data points such as audio recordings, keyboard inputs, gameplay recordings, player annotations, and post-game interview were collected, they were not fully used to generate the summary level. The reason for this was because the ORE generator is context-independent and therefore there were several ways one could format the data and input it. Future work could also include exploring the various data formats, all the while looking into other generators that can effectively use them.
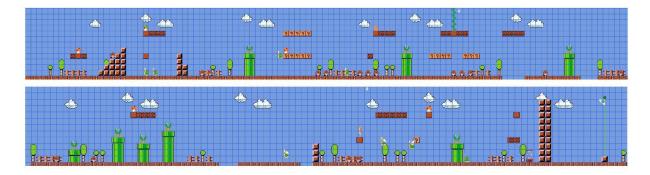
References

Gambhir, M., & Gupta, V. (2017). Recent automatic text summarization techniques: a survey. *Artificial Intelligence Review, 47*(1), 1-66.

Hahn, U., & Mani, I. (2000). The challenges of automatic summarization. *Computer, 33*(11), 29-36.

Hendrikx, M., Meijer, S., Van Der Velden, J., & Iosup, A. (2013). Procedural content generation for games: A survey. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 9*(1), 1-22.

Horn, B., Shaker, N., Smith, G., Togelius, J., & Dahlskog, S. (2014). *A comparative evaluation of procedural level generators in the mario ai framework.* Paper presented at the Foundations of Digital Games 2014.

Hovy, E., & Lin, C.-Y. (1999). Automated text summarization in SUMMARIST. *Advances in automatic text summarization, 14*, 81-94.

Khalifa, A. (2019). Mario-AI Framework. Retrieved from https://github.com/amidos2006/Mario-AI-Framework

Liu, W., Luo, X., Zhang, J., Xue, R., & Xu, R. Y. D. (2017). Semantic summary automatic generation in news event. *Concurrency and Computation: Practice and Experience, 29*(24), e4287.

Mariño, J. R., & Lelis, L. H. (2016). *A computational model based on symmetry for generating visually pleasing maps of platform games.* Paper presented at the Twelfth Artificial Intelligence and Interactive Digital Entertainment Conference.

Mawhorter, P., & Mateas, M. (2010). *Procedural level generation using occupancy-regulated extension.* Paper presented at the Proceedings of the 2010 IEEE Conference on Computational Intelligence and Games.

Merriam-Webster. (Ed.) Merriam-Webster.

Mindek, P., Čmolík, L., Viola, I., Gröller, E., & Bruckner, S. (2015). *Automatized summarization of multiplayer games.* Paper presented at the Proceedings of the 31st Spring Conference on Computer Graphics.

Miyamoto, S., & Tezuka, T. (1985). Super Mario Bros.: Nintendo.

Peeters, G., La Burthe, A., & Rodet, X. (2002). *Toward automatic music audio summary generation from signal analysis.*

Smith, G., Treanor, M., Whitehead, J., & Mateas, M. (2009). *Rhythm-based level generation for 2D platformers.* Paper presented at the Proceedings of the 4th International Conference on Foundations of Digital Games.

Steam. (2019). Steam Labs - Micro Trailers. Retrieved from https://store.steampowered.com/labs/microtrailers https://store.steampowered.com/labs/microtrailers

Summerville, A. J., Philip, S., & Mateas, M. (2015). *Mcmcts pcg 4 smb: Monte carlo tree search to guide platformer level generation.* Paper presented at the Eleventh Artificial Intelligence and Interactive Digital Entertainment Conference.

Summerville, A. J., Snodgrass, S., Mateas, M., & Villar, S. O. (2016). The VGLC: The Video Game Level Corpus. *Proceedings of the 7th Workshop on Procedural Content Generation.*
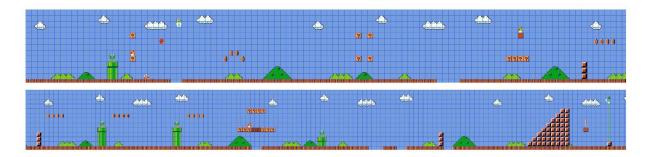
Appendix A

This section contains the level maps for 1-1, 2-1, and 4-1, divided into 1x1 grid squares. These are the same level maps provided to users in the study to obtain the salient regions as shown in Section 4.4.1 Level Maps. All images in Appendix A are sourced from the Video Game Level Corpus. Maps are split into two halves for better visibility.
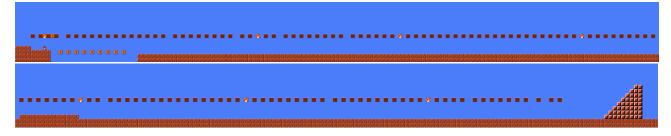

A 1: Level Map of 1-1
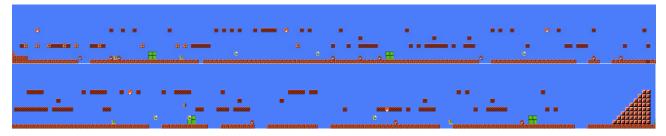

A 2: Level Map of 2-1

A 3: Level Map of 4-1

The following level maps are the maps for Case 9 and Case 19 which are our two summary levels. Maps have been split for better visibility.

A 4: Level map of Case 9

A 5: Level Map of Case 19