6CCS3PRJ Final Year
Individual Project Report Title

Final Project Report

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Abstract

Procedural generation refers to content in a medium that is produced algorithmically in lieu of by hand. Most notably, procedural generation algorithms are implemented in video games, for generating levels, terrain and other game contents programmatically. This project takes some of the more prominent algorithms for procedural generation- Lindenmayer Systems, Voronoi Points, Poisson Disk Generation and Simplex Noise- and implements them in a 2D tile-map-oriented RPG-like game in the open-source Godot game engine, and compares their workings and performance. My aim with this project is to (1) increase my knowledge of procedural generation in games beyond the surface level, by going in-depth into some of the algorithms that are used, and (2) use this knowledge to implement said algorithms in a 2D tiled RPG scenario in Godot, then compare how each algorithm works and performs.

Originality Avowal

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April 16, 2023

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Contents

Chapter 1

Introduction

Procedural Content Generation, or PCG, refers to the use of algorithms and programming in lieu of human handiwork to design and implement various contents in video games, such as levels, terrains, trees and cities. A PCG algorithm is ontogenetic when it tries to produce a foreseeable end result as it goes along. For this project, I will be implementing several well-known ontogenetic algorithms in a basic 2D tile-map-oriented RPG-like game, using the open-source Godot game engine, and then comparing how each algorithm carries out the creation of levels in said game, both performance-wise and comparing the kinds of level layouts generated by each algorithm.

1.1   Report Structure

Chapter 2

Background

For my BSc individual project, I will be researching procedural content generation (PCG) algorithms and then implementing them each in a small 3D game made with the Godot Engine (and its domain-specific GDScript language).

2.1 Procedural Generation: Background

Procedural content generation (usually referred to as simply "procedural generation") refers to the creation of levels and other game objects programmatically and algorithmically, in lieu of a human being doing all the work. While procedural generation algorithms can be used to generate a myriad of things, from textures (for things like trees and clouds) to music ("generative music," as coined by legendary musician Brian Eno), by far its most common context is in automated level design, generating level layouts algorithmically in lieu of work from level designers. Game developers may opt to use procedural generation to save time and money designing levels or show off technical prowess in their games.

Procedural generation in video games has a rich history. Pioneering games such as Rogue (1980) took direct influence from tabletop role-playing games such as Dungeons and Dragons, and thus had a player navigate a randomly-generated world that expanded further as they went on. Such games spawned the *roguelike* and *roguelite* genres, which experienced immense popularity in the last decade. In the realm of first-person shooters, 2004's .kkrieger, as seen in Figure 2.1, used procedural generation to create intricate 3D levels and fit them all into a game that takes up just 96 kilobytes of space.

Figure 2.1: The game .kkrieger, which uses procedural generation to design maps while keeping the game at a 96 kilobyte file size.[8]

Other games that use procedural generation in its levels include Elite (originally published in 1984), Elite: Dangerous (2012), Minecraft (2009), No Man's Sky (2012) and Spelunky (2013). The latter game's use of procedural generation has notably been covered by video games journalist Mark Brown in a YouTube video.

Figure 2.2: The roguelike game Spelunky, which uses procedural generation to build intricate levels for the player character to explore.
Source: https://store.steampowered.com/app/239350/Spelunky/

In many cases, these games end up having a **large** number of different environments that each game could generate for its players. However, by procedurally generating them upon the *loading* of the game level, in lieu of loading a layout from disk, they can save a lot of space (albeit with a considerable need for processing power, depending on the game's and algorithms' performance), as seen in Figure 2.1.

Using one or some different procedural generation algorithms, such as the use of Perlin, Simplex or other noise, Voronoï disks and also poisson disk generation, among others, games can

load a seed to randomly generate a level every time it is played, meaning no two playthroughs of a game with procedurally generated content are ever the same.

2.2   Justifying My Choice of Engine: Godot

While a myriad of resources exist for procedurally generated game contents exist for Unity and Unreal, I want to implement them in Godot, for several reasons:

- It's the engine I have the most experience with, having already developed 2 published web games with it.

- It's not got as many resources on procedural generation compared to Unity, Unreal and some other popular game engines, particularly on the side of academic research (that is, there aren't as many papers on procedural generation that pertain to Godot as they do to Unity, Unreal and other engines).

  - However, it is still very powerful and feature-rich (it has its own Open Simplex noise class, for example) and I'm sure I can make procedural generation algorithms work on it.

- Compared to Unity and Unreal, Godot is a very light engine with a feature-rich editor, clocking in at under 100MB, with editors for Windows, macOS, Linux and even the web browser.

By the end of my allotted time, I plan to have implemented several procedurally generated environments in small Godot games, using a myriad of methods (such as Voronoï cells and poisson disk generation) in a myriad of contexts (anything from platformers to first-person games). With these games, I plan for the final report to be the centrepiece of my project, with it containing my research on how each environment was implemented, as well as my findings on the algorithms themselves and how they work.

This is somewhere between a research-oriented project and an implementation-oriented project, as while the produced software artifacts provide valid proof of my understanding of some commonly used procedural generation algorithms and how to implement them in Godot, it is also about how I understand their workings. Nonetheless, the implementations provide the weight behind my project's motivations and are the main focus of this dissertation. They will prove that Godot is just as adept at procedural content generation as the other major players in the game engine space, and I will have gained a wealth of knowledge on PCG in the process.

2.2.1 Note on Differing Versions of Godot

Godot currently is at version 4, which finally received a stable release in 4th March after years of development, but concurrently there is also Godot 3, the previous stable version which is now a **L**ong-**T**erm **S**upport release. The latter version of Godot contains several new features and breaking changes, so any project made in Godot 3 won't readily be compatible with Godot 4 (and vice-versa) without making the necessary changes and conversions. I have access to both versions of Godot and, for all the Godot projects I made and used in this project, I have used Godot 4. Any references to other Godot 3 projects will be clearly denoted as such.

2.3 Justifying My Choice of Scenario: A 2D tile-map RPG-style roaming game

The scenario of my choosing involves a monochrome tile-map created by Kenney.nl in a 2D RPG setting, in which the player character is a hollow "Golem" that is trying to search for and obtain a ring among a large 72x40 village, filled with trees, buildings and emptiness. The player can "chow down" trees by simply going to the cells where trees are and making them disappear. However, the player *will* stop at and collide with any buildings in the tile map. When the player collects the ring, they win the game and are able to either close the window or generate a new village to try and collect *another* ring.

The size of the tile map is determined by taking the window size, 1152x640 in **all** implementations, and then dividing it with the cell size, 16x16 in **all** implementations (again), hence returning a 72x40 tile map size. Using a large tile map like this, with 2880 available cells in total, allows for easy stress-testing of the algorithms, making them generate level layouts that are sufficiently large enough to produce a quantifiable performance result and time that can be easily compared across implementations, such that we can easily measure how one performs over the other. The use of a tile map *this* large with PCG algorithms also makes sense from a game developer's perspective as designing level layouts this large by hand, with such a small cell size as well (inherited from the size of the tile map assets), would add additional time and labour costs to them.

The use of a tiled role-playing game scenario, adapted to already-existing procedural generation algorithms, is relatively unusual in the context of procedural generation. However, it *will* allow me to go a degree beyond the scope of what is usually done for procedural content generation in games, which is usually seen in 2D and 3D roguelikes and platformers, as well as

some other world-building games such as Minecraft and Terrraria, while also producing code that is relatively easy to process through and understand. The ability for the player character to consume trees and remove them from the level layout by moving into them allows that player to easily move around in what would otherwise be very crowded level layouts that would have been near-impossible to traverse. The addition of said player character, as well as the end goal of obtaining a randomly-placed ring within the given level, adds weight to the algorithms' practical use in games made with Godot, and not just for show or solely as demonstrations.

2.4 Justifying My Choice of Algorithms for the Above Scenario

For this project, I intend to use the following procedural content generation algorithms within my scenario:

1. Lindenmayer Systems (or L-Systems)

2. Perlin and Simplex Noise

3. Poisson Disk Sampling/Distribution

4. Voronoï Cells/Diagrams

Using an L-System for generating a level layout is relatively uncommon, compared to its use in generating structures such as trees and buildings. However, I plan to integrate a deterministic context-free L-System (or a "D0L-System") into an implementation of my scenario so I can compare it performance-wise to the other algorithms, and see how the repeated patterns generated from L-System grammars affect comparisons to the other implementations' level layouts.

Perlin and Simplex Noise are far more commonly used for level layouts, so I created an implementation of my scenario with one to see how it compares with the others, speed-wise and layout-wise, and see if it really is the best for my chosen scenario.

Poisson Disk Sampling is usually used for item placement in planes, even with grids, so using a grid-like implementation, I will compare how it works with in a tile map and what differences arise between its use there and in its usual uses.

Though efforts were made to make level layouts as similar as possible across implementations, there are noticeable differences between the level layouts generated by L-Systems, Simplex

noise and Poisson disk samples, and I touch on those when discussing those implementations in the relevant sections of my report.

In my research and implementation of Voronoï Cells I realised the level layouts it generated for my scenario were wholly unique, when compared with the other algorithm implementations, so much so that I had to re-shape my scenario and game mechanics to make both the scenario and levels generated fit with each other. Nonetheless, I believe this will serve as a unique comparison to the other algorithms and will serve as additional knowledge of procedural generation algorithms as well as more work towards understanding how to make them work in Godot games (as proven by my implementations).

Chapter 3

Report Body

In this chapter, I will explain how each of my chosen algorithms work, and how I went around implementing them as a surface-level explanation. I will then briefly compare what challenges I faced for each of my implementations, and how they compare, both performance-wise and with regards to the kinds of layouts they produce, again as surface-level explanations. I go into greater detail on my implementations in the Implementation section, how the level layouts generated in each algorithm compare with each other in the Design & Specification section, and how each implementation compares overall (and also performance wise) in the Evaluation section. For this project, I chose to use the following 4 algorithms.

1. Lindenmayer Systems (or L-Systems)

2. Perlin/Simplex Noise

3. Poisson Disk Sampling

4. Voronoi Cells

3.1 Algorithms

In this section, I will explain how each of the algorithms I implemented work, then I will go into small detail as to how I implemented them. I go into further detail in the "Implementation" section of this report.

3.1.1 Lindenmayer Systems

Hungarian academic Aristid Lindenmayer devised a mathematical model for the reproduction of fungi in 1967.[10] His model involved a string of symbols, each unique symbol denoting a specific action and/or branch. Essentially, running that initial string, called the *axiom*, through a set of rules (called a *grammar*) gives us an ever-expanding string that is then taken as instructions to draw something from. Lindenmayer Systems, or L-Systems, have since been used in several scenarios beyond its initial purpose of modelling fungi, from trees to fractals. In video games, they are frequently used to aid in the creation of foliage in several environments, as well as buildings and, here, level layouts.

A Basic 0L-System

The most basic form of L-System is a *0L*-System, 0 in this case referring to the fact that the grammar is *context-free*.

For this example[2], consider an alphabet V, which consists of the following symbols:

$$F, +, -$$

where F means "to go forward", and $+$ and $-$ denote turning right or left (respectively) a set number of degrees .

Take an axiom ω, for example:

$$F + F + F + F$$

And a set of rules P which, in this case, is of size 1:

$$F \rightarrow F + F - F - FF + F + F - F$$

We can represent this *parametric* L-system in the following form:[15]

$$G = (V, \omega, P)$$

To implement G in Godot, we can take each rule and replace each string in accordance to our one rule, using the replace method, like so:

```
1    string = string.replace(rule["from"], rule["to"]) #Here the rules
         were stored in dictionaries.
```

Figure 3.1: A line of code that demonstrates directly replacing char-
acters in a string according to our L-System grammar's rules.

The first 3 iterations of this operation are shown here:

Figure 3.2: The axiom of the aforementioned sim-
ple L-System with just one rule. String size: 8.
Source: Own work.

Figure 3.3: The first iteration of the aforementioned
simple L-System with just one rule. String size: 59.
Source: Own work.

Figure 3.4: The second iteration of the aforementioned simple L-System with just one rule. String size: 475.
Source: Own work.
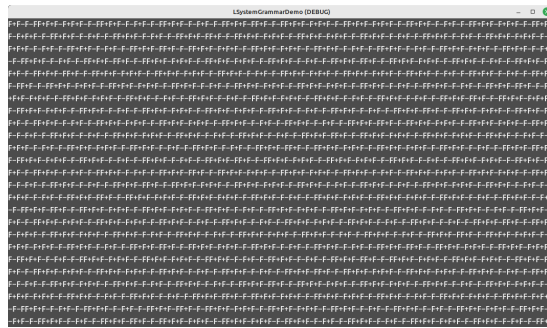
Figure 3.5: The third iteration of the aforementioned simple L-System with just one rule. String size: 3803. The string is too large to show in the window, as you can see here.
Source: Own work.

The resulting string can be used to draw a lattice.[2] Examples of the above grammar in action are below.
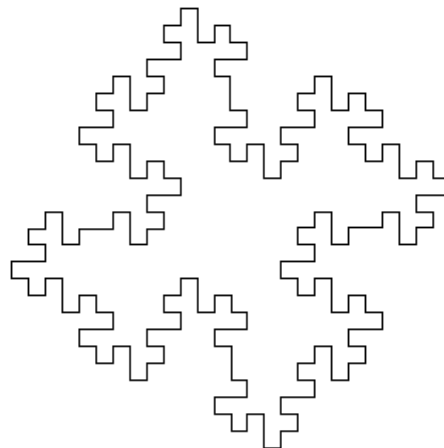
Figure 3.6: A lattice generated with the example grammar on a custom-written Classic Mac OS application specifically written for working with L-Systems.[2]

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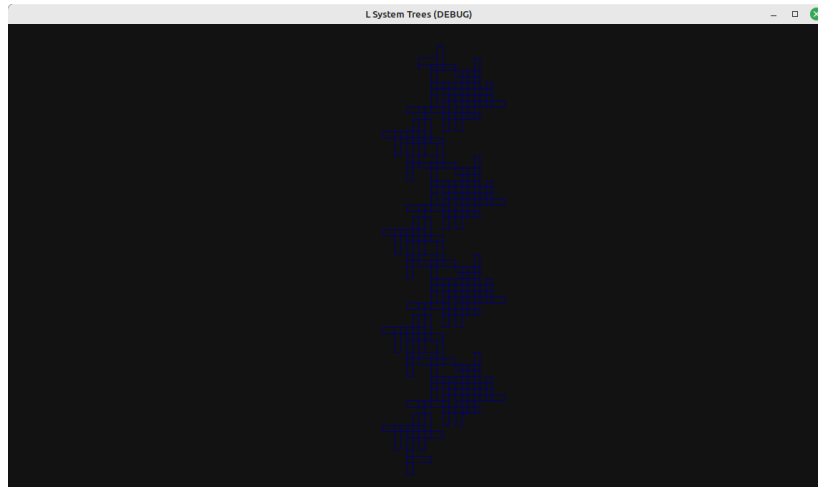
Figure 3.7: A lattice generated with the example grammar on a Godot project for drawing from L-Systems. Source: Initial project written by YouTuber Codat[3][4], and converted to Godot 4 (with the addition of the lattice grammar) by me.[5]

A More Complex D0L-System With More Than One Rule

For handling more than one rule, we can instead use a new string buffer variable where, for each character in our string, we can attain a new string and append it to our string buffer. The resulting string is then returned and interpreted. This can be represented in Godot as demonstrated in Figure 3.8, which uses two functions to perform string replacement. The first function `get_new_replacement` performs the character replacement according to the L-System's grammar rules, while the second function `replace_string` uses a string builder variable to allow for replacement of characters without directly affecting the original string and causing unwanted side effects.

```
1    func get_new_replacement(character: String) -> String:
2        for rule in rules:
3            if rule["from"] == character:
4                return rule["to"]
5        return character
6
7    func replace_string(string: String) -> String:
8        var new_string = ""
9        for character in string:
10            new_string += get_new_replacement(character)
11        return new_string
```

Figure 3.8: Two GDScript functions for replacing characters in an L-System grammar with more than one rule.

This can *then* be used to handle more complex grammars that can handle more than one rule in which characters in strings are replaced by other strings of variable length, as before.

The grammar in the following example represents a D0L-System[11], a **deterministic** L-System using a context-free grammar; the grammar in the first example was *also* deterministic.

For this example, consider a new grammar G with the alphabet V, where a and b are the only symbols. We start with the following axiom ω, which is just a. We now have a set of rules P which is, this time, of size *2*:

$$a \rightarrow ab$$

$$b \rightarrow a$$

The first few steps of the resulting derivation can be modelled like so:
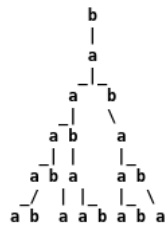
Figure 3.9: The first few steps of a derivation of our example grammar.[11]

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3.1.2 Perlin/Simplex Noise

Traditionally, white noise images, and most other noise types, place noise pixels completely randomly, without each pixel considering the values of its neighbours[12], as you can see in Figure 3.10.

However, there exists several types of **value** and **gradient** noise that *do* take surrounding pixel values into consideration, and will therefore serve more use in building levels in our games.

Value noise simply takes a lattice of points with random values and then interpolates those points based on their surrounding values. This *can* be used as a procedural texture. However, due to the simple nature of the algorithm, it's possible that the difference between several values in a region is minimal, while in other regions the values may differ immensely, resulting in a noise image that is not very smooth.

Gradient noise, on the other hand, takes point lattices and instead calculates the interpolation between tangents.[6] Since both tangents between a curve must be collinear[6], the flat and bumpy curves produced by value noise's interpolation calculations are now much less likely to be returned, as seen in Figure 3.11.[6] This results in noise images of higher and more appealing visual quality as, to quote a response from Stack Exchange by Hernan J. González[9], "it cuts low frequencies and emphasizes frequencies around and above the grid spacing."
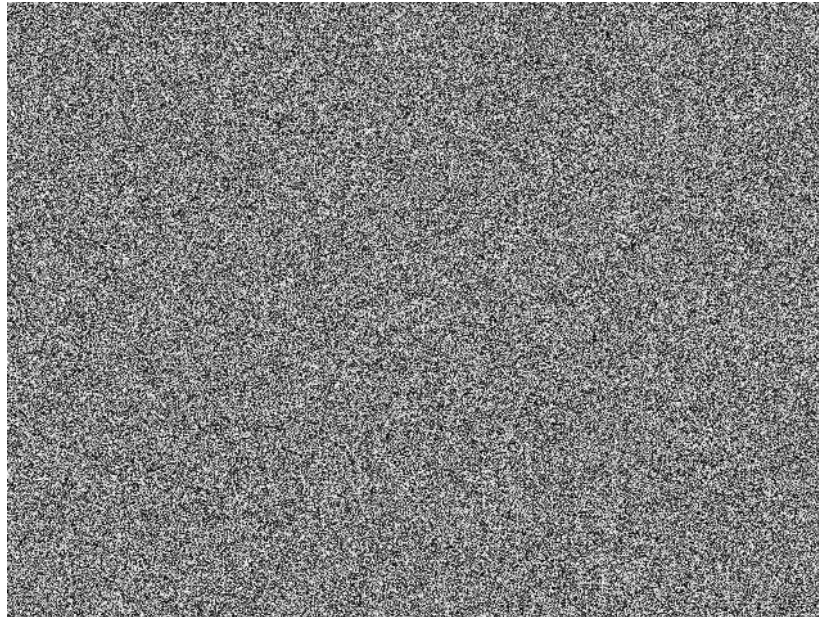

Figure 3.10: A white noise picture generated with Robson's white noise image generator.[14]
Settings: 640 squares horizontally, 480 squares verti-
cally, size of squares 1, colours greyscale, bias none.
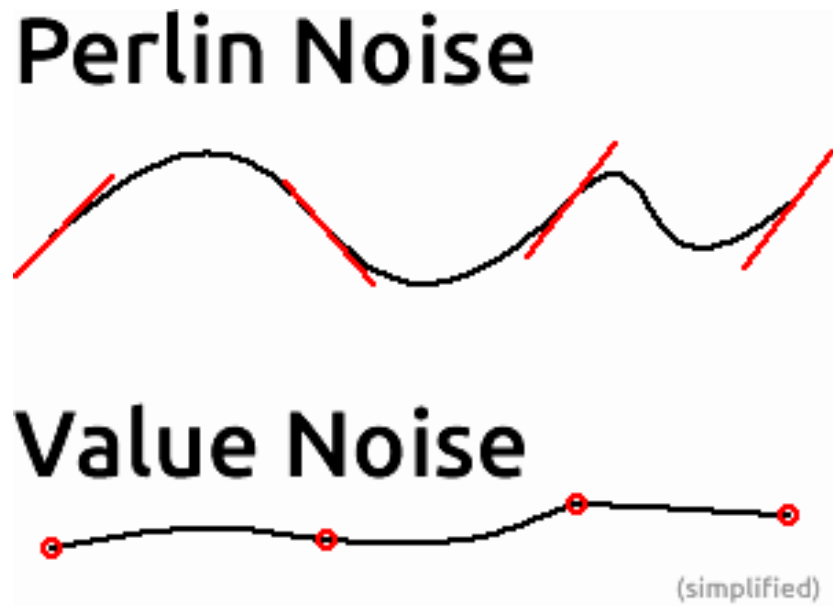
Figure 3.11: A comparison between the kinds of curves produced by Value noise interpolation and Perlin (and other Gradient) noise interpolation.[6]

Two particularly well-known Gradient noise algorithms that are commonly used for procedurally generating levels are the already mentioned Perlin Noise and Simplex Noise, both designed by American Computer Science professor Kenneth H. Perlin, with the former being an improvement on the former. Perlin filed a patent on his work in 2002 that was granted in 2005[13], which prompted the creation of the OpenSimplex noise algorithm[16] for free use; the patent has since expired in 2022, allowing free use to both Perlin and the original Simplex noise.[13]

3.1.3   Poisson Disk Sampling

Poisson disk distributions are an easy way to randomly scatter objects across a field. It's commonly used for tree placement and placement of other random objects. Points are placed over a plane, with a single point placed randomly and subsequent points calculated such that a single point has no other point lying within a given radius of said point. Different implementations of Poisson disk distributions or samples can accommodate multiple radii for points in a plane, and some implementations produce *maximal* samples- that is, a set of samples that fully cover the given plane, while still adhering to the principle that no single point has other points lying within its radius (the implementation I made for this project does **not** guarantee maximality, however).

The following are some examples of Poisson disk distribution in action:

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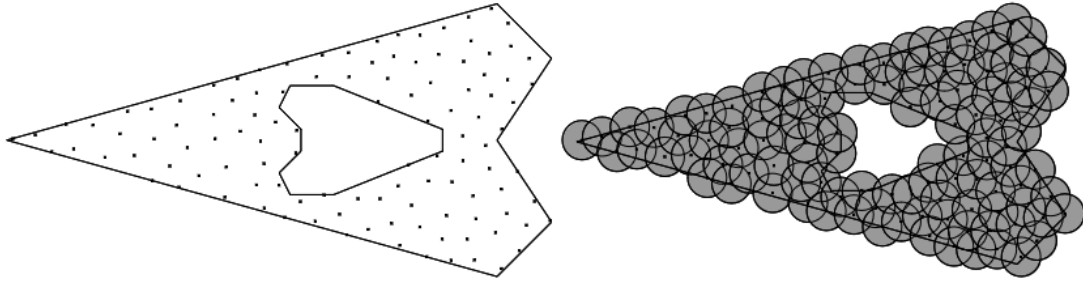
Figure 3.12: A diagram of a maximal Poisson disk distribution
done on a concave plane, with the right side denoting maximality
through the grey disks overlapping but not any points overlapping.[7]
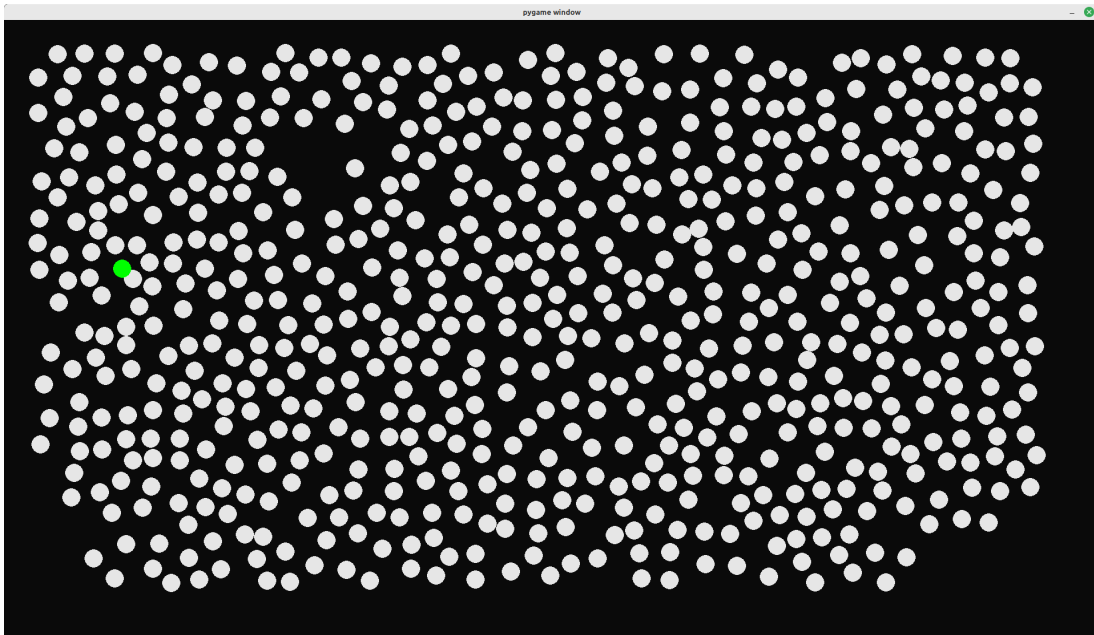
Figure 3.13: An implementation of Poisson disk sampling made in
Pygame.[1] The screenshot was taken *after* all of the samples were taken.

3.1.4 Voronoï Cells

Named after the Ukranian mathematician Georgy Voronoy, Voronoi cells work by taking a
map of points, and randomly selecting a group of points. Within that selected group, cells are
formed by calculating, in each point of the grid, the closest of the selected points to it. That
is, each cell represents the group of points that are the closest to that random point (including
that point in the group as well). The final arrangement of cells represents a Voronoi Diagram
or Voronoi Tesselation.

Distances between points can be calculated with either the Euclidean distance:

$$d_E(p, q) = \sqrt{(q_x - p_x)^2 + (q_y - p_y)^2}$$

or the Manhattan distance:

$$d_M(p, q) = |q_x - p_x| + |q_y - p_y|$$

With the Euclidean distance producing a more "triangulated" tesselation than the Manhattan distance, the geometry of which is more "blocky" and resembles taxicabs (hence its alternate name "Taxicab Geometry").

3.2 Implementations

Here I will describe, at surface level, the methods I went about implementing the above algorithms and what references I used.

3.2.1 Lindenmayer System

The implementation of an L-System was very simple. I took inspiration from a YouTube video on implementing an L-System for drawing line graphics in Godot by Codat.[3] In the code from the Godot 3 project he made in that video[4][3], he created a custom "Rule" class in GDScript, with which he defined new rules. I forked his project, converted it to Godot 4 and used it to create the lattice graphics in Figure 3.7. I did this mainly as a reference for my implementation of L-Systems in the game itself.

With the implementation in my *game*, I adapted the `get_new_character` method in that L-System to work with the dictionary I originally implemented my L-System in. The new `get_new_replacement` method in my implementation allows for there to be more than one grammar rule while the L-System still performs as it should. My original L-System iterated through the original string *directly*, which produced unintended consequences in grammars with multiple rules, as seen here when trying to implement the D0L-System I mentioned earlier[11]:

$$b \to a \to aa \to aaa \to aaaa \to aaaaa \dots$$

By using an empty string buffer and inserting rule replacements there instead, my implementation is now able to perform substitutions accordingly; the correct computation of the D0L-System is denoted in Figure 3.9 and repeated below:

$$b \to a \to ab \to aba \to abaab \to abaababa \ldots$$

With the L-System string parsing algorithm in place, the next step was to paint the cells of each tile. With this, I iterated through every cell of the tilemap using a nested for-loop. With the parsed string, I then accessed the character of the string at an incremented index using an iterator variable I defined before the for-loops. The string consists of three different characters repeated multiple times, "O", "W" and "B". For each string index, if the character is "W", paint a tree, if it is "B", paint a building, and if it is an "O", leave the cell blank and paint nothing. The player and ring then get placed afterwards.

Even for a large-sized tile map with 2880 cells, a constant L-System G, with the symbols O, W and B and the following grammar

$$O \to OWO$$

$$W \to WB$$

$$B \to BWO$$

can parse the axiom OWB, paint tile map tiles with the resulting string **and** place the player and ring in just a minimum of 19 milliseconds and a maximum of 22 milliseconds.

3.2.2 Perlin/Simplex Noise

The Simplex Noise implementation works with Godot's built-in Noise library. Within a Sprite2D node's Texture attribute, I set a new "NoiseTexture2D" field inside of it. In its "Noise" attribute I created a new "FastNoiseLite" scene, which generates a noise texture for us to use. The seed can be set in the sprite's script file.

As with my other implementations, there are two separate arrays, one for trees and another for buildings. For each cell in the TileMap, I then took the noise pixel from the generated texture at that exact point (scaling with the cell size accordingly), using the `get_noise_2d` method built-in with Godot, and then, depending on the value retrieved, decided, firstly, whether or not to place a plant/tree tile there and, secondly, whether or not to place a building tile there. As a result, not every cell in the TileMap has tiles on it. On any one of those empty cells, the Player tile will then get placed.

3.2.3 Poisson Disk Sampling

3.2.4 Voronoï Cells

Chapter 4

Design & Specification

4.1 Section Heading

Here, I will provide an abstract level of how I compared the performance of each content generation algorithm and how I made sure each implementation could produce as similar/like-for-like results as possible (and where they *couldn't* do so).

Chapter 5

Implementation

Here I will go a bit deeper as to how I made each algorithm work.

5.1   Section Heading

Chapter 6

Legal, Social, Ethical and Professional Issues

Your report should include a chapter with a reasoned discussion about legal, social ethical and professional issues within the context of your project problem. You should also demonstrate that you are aware of the regulations governing your project area and the Code of Conduct & Code of Good Practice issued by the British Computer Society, and that you have applied their principles, where appropriate, as you carried out your project.

6.1 Section Heading

Chapter 7

Results/Evaluation

Here I will mention how I tested the small games and made sure they ran as they should.

7.1   Software Testing

7.2   Section Heading

Chapter 8

Conclusion and Future Work

The project's conclusions should list the key things that have been learnt as a consequence of engaging in your project work. For example, "The use of overloading in C++ provides a very elegant mechanism for transparent parallelisation of sequential programs", or "The overheads of linear-time n-body algorithms makes them computationally less efficient than $O(n \log n)$ algorithms for systems with less than 100000 particles". Avoid tedious personal reflections like "I learned a lot about C++ programming...", or "Simulating colliding galaxies can be real fun...". It is common to finish the report by listing ways in which the project can be taken further. This might, for example, be a plan for turning a piece of software or hardware into a marketable product, or a set of ideas for possibly turning your project into an MPhil or PhD.

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Appendix A

Extra Information

A.1 Tables, proofs, graphs, test cases, ...

The appendices contain information that is peripheral to the main body of the report. Information typically included in the Appendix are things like tables, proofs, graphs, test cases or any other material that would break up the theme of the text if it appeared in the body of the report. It is necessary to include your source code listings in an appendix that is separate from the body of your written report (see the information on Program Listings below).

Appendix B

User Guide

B.1   Instructions

To run the projects in the .zip file, extract the projects in one folder. Then open Godot 4 (at the moment all projects are Godot 4 projects), and, when opening the Godot editor, click "Scan", then go to that folder and select it. The projects can then be opened in the project manager and edited as needed in Godot. When you click on some of the scenes in the projects, there may be some "exported" variables from scripts that are visible to you in the editor (examples include the "Distance" and "Random Starting Points" variables in the Voronoi Cells project).

Appendix C

Source Code

C.1 Instructions

Complete source code listings must be submitted as an appendix to the report. The project source codes are usually spread out over several files/units. You should try to help the reader to navigate through your source code by providing a "table of contents" (titles of these files/units and one line descriptions). The first page of the program listings folder must contain the following statement certifying the work as your own: "I verify that I am the sole author of the programs contained in this folder, except where explicitly stated to the contrary". Your (typed) signature and the date should follow this statement.

All work on programs must stop once the code is submitted to KEATS. You are required to keep safely several copies of this version of the program and you must use one of these copies in the project examination. Your examiners may ask to see the last-modified dates of your program files, and may ask you to demonstrate that the program files you use in the project examination are identical to the program files you have uploaded to KEATS. Any attempt to demonstrate code that is not included in your submitted source listings is an attempt to cheat; any such attempt will be reported to the KCL Misconduct Committee.

You may find it easier to firstly generate a PDF of your source code using a text editor and then merge it to the end of your report. There are many free tools available that allow you to merge PDF files.

C.2 LSystemGrammarDemo

C.2.1 .gitattributes

```
1  # Normalize EOL for all files that Git considers text files.
2  * text=auto eol=lf
```

C.2.2 .gitignore

```
1  # Godot 4+ specific ignores
2  .godot/
```

C.2.3 project.godot

```
1  ; Engine configuration file.
2  ; It's best edited using the editor UI and not directly,
3  ; since the parameters that go here are not all obvious.
4  ;
5  ; Format:
6  ;   [section] ; section goes between []
7  ;   param=value ; assign values to parameters
8
9  config_version=5
10
11 [application]
12
13 config/name="LSystemGrammarDemo"
14 run/main_scene="res://DemoNode.tscn"
15 config/features=PackedStringArray("4.0")
16
17 [display]
```

```
18

19    window/stretch/mode="canvas_items"

20    window/stretch/aspect="expand"

21

22    [gui]

23

24    common/drop_mouse_on_gui_input_disabled=true

25

26    [physics]

27

28    common/enable_pause_aware_picking=true
```

C.2.4   DemoNode.tscn

```
1    [gd_scene load_steps=2 format=3 uid="uid://bu380we4od0ln"]

2

3    [ext_resource type="Script" path="res://DemoNode.gd" id="1"]

4

5    [node name="DemoNode" type="Node"]

6    script = ExtResource("1")

7    choices = "deterministic"

8

9    [node name="Timer" type="Timer" parent="."]

10

11    [node name="Line2D" type="Line2D" parent="."]

12    points = PackedVector2Array(69, 297)

13

14    [node name="TextLabel" type="Label" parent="."]

15    offset_right = 1152.0

16    offset_bottom = 23.0

17    autowrap_mode = 3

18
```

```
19    [connection signal="timeout" from="Timer" to="." method="
          _on_Timer_timeout"]
```

C.2.5 DemoNode.gd

```
1   extends Node
2
3   # Basic: https://youtu.be/feNVBEPXAcE?t=77 (L = +)
4   # Choices: http://paulbourke.net/fractals/lsys/
5   # Deterministic: https://www1.biologie.uni-hamburg.de/b-online/
        e28_3/lsys.html#D0L-system
6
7   @export_enum("basic", "choices", "deterministic") var choices:
        String = "choices"
8   @export var axiom: String
9   @onready var string: String
10  @onready var timer = \${Timer}
11  @onready var line = \${Line2D}
12  @onready var label = \${TextLabel}
13  @onready var rules: Array[Dictionary]
14
15  func set_values():
16      if choices == "basic":
17          rules = [
18              {
19                  "from": "F",
20                  "to": "F+F"
21              }
22          ]
23          axiom = "F+"
24      elif choices == "choices":
25          rules = [
```

```
26              {
27                  "from": "F",
28                  "to": "F+--FFFF+F+-FF"
29              }
30          ]
31          axiom = "F+F+F+F"
32      elif choices == "deterministic":
33          rules = [
34              {
35                  "from": "a",
36                  "to": "ab"
37              },
38              {
39                  "from": "b",
40                  "to": "a"
41              }
42          ]
43          axiom = "b"
44
45  func _ready():
46      set_values()
47      string = axiom
48      label.size.x = get_viewport().size.x
49      label.text = string
50      timer.start()
51
52  func get_new_replacement(character: String) -> String:
53      for rule in rules:
54          if rule["from"] == character:
55              return rule["to"]
56      return ""
57
58  func _on_Timer_timeout():
```

```
59      var new_string = ""
60      for character in string:
61          new_string += get_new_replacement(character)
62      string = new_string
63      label.text = string
64      print(len(string))
```

C.2.6   icon.svg.import

```
1    [remap]
2
3    importer="texture"
4    type="CompressedTexture2D"
5    uid="uid://cwnnuqmejj04q"
6    path="res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"
7    metadata={
8    "vram_texture": false
9    }
10
11   [deps]
12
13   source_file="res://icon.svg"
14   dest_files=["res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
```

```
22    compress/normal_map=0
23    compress/channel_pack=0
24    mipmaps/generate=false
25    mipmaps/limit=-1
26    roughness/mode=0
27    roughness/src_normal=""
28    process/fix_alpha_border=true
29    process/premult_alpha=false
30    process/normal_map_invert_y=false
31    process/hdr_as_srgb=false
32    process/hdr_clamp_exposure=false
33    process/size_limit=0
34    detect_3d/compress_to=1
35    svg/scale=1.0
36    editor/scale_with_editor_scale=false
37    editor/convert_colors_with_editor_theme=false
```

C.3   ProcGenRPG (L-System)

C.3.1   .gitattributes

```
1    # Normalize EOL for all files that Git considers text files.
2    * text=auto eol=lf
```

C.3.2   .gitignore

```
1    # Godot 4+ specific ignores
2    .godot/
```

C.3.3 project.godot

```
1    ; Engine configuration file.
2    ; It's best edited using the editor UI and not directly,
3    ; since the parameters that go here are not all obvious.
4    ;
5    ; Format:
6    ;   [section] ; section goes between []
7    ;   param=value ; assign values to parameters
8
9    config_version=5
10
11   [application]
12
13   config/name="Proc Gen RPG"
14   run/main_scene="res://tile_map.tscn"
15   config/features=PackedStringArray("4.0", "Forward Plus")
16   config/icon="res://icon.svg"
17
18   [display]
19
20   window/size/viewport_height=640
21   window/stretch/mode="canvas_items"
```

C.3.4 l_system.tscn

```
1    [gd_scene load_steps=2 format=3 uid="uid://d0v18e7ms571f"]
2
3    [ext_resource type="Script" path="res://l_system.gd" id="1_elydp"]
4
5    [node name="LSystem" type="Node"]
6    script = ExtResource("1_elydp")
```

38

C.3.5 l_system.gd

```gdscript
extends Node

class_name LSystem

@onready var tile_map: TileMap = get_parent()
@export var axiom: String = "OWB"
@onready var string: String = axiom
@export var rules: Array[Dictionary] = [
    {
        "from": "O",
        "to": "OWO"
    },
    {
        "from": "W",
        "to": "WB"
    },
    {
        "from": "B",
        "to": "BWO"
    }
]

const FLOWERS_1: Vector2i = Vector2i(3, 7) # "O" = ORANGE
const FLOWERS_2: Vector2i = Vector2i(3, 10) # "W" = WHITE
const FLOWERS_3: Vector2i = Vector2i(3, 13) # "B" = BLUE

func get_new_replacement(character: String) -> String:
    for rule in rules:
        if rule["from"] == character:
            return rule["to"]
    return ""
```

```
32
33    func size() -> int:
34        return tile_map.x_tile_range * tile_map.y_tile_range
35
36    func parse() -> String:
37        var size: int = size()
38        while len(string) <= size:
39            var new_string = ""
40            for character in string:
41                new_string += get_new_replacement(character)
42            string = new_string
43        string = string.substr(0, size)
44        return string
45
46    func paint() -> void:
47        string = parse()
48        var size: int = size()
49        var i: int = -1
50        for x in range(tile_map.x_tile_range):
51            for y in range(tile_map.y_tile_range):
52                i += 1
53                if string[i] == "O":
54                    tile_map.set_cell(1, Vector2i(x, y), 0, FLOWERS_1)
55                elif string[i] == "W":
56                    tile_map.set_cell(1, Vector2i(x, y), 0, FLOWERS_2)
57                elif string[i] == "B":
58                    tile_map.set_cell(1, Vector2i(x, y), 0, FLOWERS_3)
```

C.3.6   tile_map.tscn

```
1    [gd_scene load_steps=4 format=3 uid="uid://bwhvtqld3yo8m"]
2
```

```
3    [ext_resource type="TileSet" uid="uid://c168x78r0tful" path="res://
         Tiles.tres" id="1_l3nwg"]
4    [ext_resource type="Script" path="res://tile_map.gd" id="2_wrxl8"]
5    [ext_resource type="PackedScene" uid="uid://d0v18e7ms571f" path="
         res://l_system.tscn" id="3_ktw1n"]
6
7    [node name="TileMap" type="TileMap"]
8    tile_set = ExtResource("1_l3nwg")
9    format = 2
10   layer_0/name = "Grass"
11   layer_1/name = "Things"
12   layer_1/enabled = true
13   layer_1/modulate = Color(1, 1, 1, 1)
14   layer_1/y_sort_enabled = false
15   layer_1/y_sort_origin = 0
16   layer_1/z_index = 0
17   layer_1/tile_data = PackedInt32Array()
18   script = ExtResource("2_wrxl8")
19
20   [node name="LSystem" parent="." instance=ExtResource("3_ktw1n")]
```

C.3.7 tile_map.gd

```
1    extends TileMap
2
3    @onready var l_system: LSystem = \${LSystem}
4
5    var x_tile_range: int = ProjectSettings.get_setting("display/window
         /size/viewport_width") / tile_set.tile_size.x
6    var y_tile_range: int = ProjectSettings.get_setting("display/window
         /size/viewport_height") / tile_set.tile_size.y
7
```

```
8    const GRASS_1: Vector2i = Vector2i(5, 0)

9    const GRASS_2: Vector2i = Vector2i(5, 1)

10

11   func pick_grass_tile() -> Vector2i:

12       return [GRASS_1, GRASS_2].pick_random()

13

14   func cover_map_with_grass() -> void:

15       for x in range(-50, x_tile_range + 50):

16           for y in range(-50, y_tile_range + 50):

17               set_cell(0, Vector2i(x, y), 0, pick_grass_tile())

18

19   \# Called when the node enters the scene tree for the first time.

20   func _ready() -> void:

21       randomize()

22       cover_map_with_grass()

23       l_system.paint()
```

C.3.8   icon.svg.import

```
1    [remap]

2

3    importer="texture"

4    type="CompressedTexture2D"

5    uid="uid://b45qexb3wmhym"

6    path="res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"

7    metadata={

8    "vram_texture": false

9    }

10

11   [deps]

12
```

```
13   source_file="res://icon.svg"
14   dest_files=["res://.godot/imported/icon.svg-218
        a8f2b3041327d8a5756f3a245f83b.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
22   compress/normal_map=0
23   compress/channel_pack=0
24   mipmaps/generate=false
25   mipmaps/limit=-1
26   roughness/mode=0
27   roughness/src_normal=""
28   process/fix_alpha_border=true
29   process/premult_alpha=false
30   process/normal_map_invert_y=false
31   process/hdr_as_srgb=false
32   process/hdr_clamp_exposure=false
33   process/size_limit=0
34   detect_3d/compress_to=1
35   svg/scale=1.0
36   editor/scale_with_editor_scale=false
37   editor/convert_colors_with_editor_theme=false
```

C.3.9   roguelikeSheet_transparent.png.import

```
1   [remap]
2
3   importer="texture"
```

```
4    type="CompressedTexture2D"
5    uid="uid://13ktp0qup5xb"
6    path="res://.godot/imported/roguelikeSheet_transparent.png-22
         f6b70da04549e371d1f15fe9d96005.ctex"
7    metadata={
8    "vram_texture": false
9    }
10
11   [deps]
12
13   source_file="res://roguelikeSheet_transparent.png"
14   dest_files=["res://.godot/imported/roguelikeSheet_transparent.png
         -22f6b70da04549e371d1f15fe9d96005.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
22   compress/normal_map=0
23   compress/channel_pack=0
24   mipmaps/generate=false
25   mipmaps/limit=-1
26   roughness/mode=0
27   roughness/src_normal=""
28   process/fix_alpha_border=true
29   process/premult_alpha=false
30   process/normal_map_invert_y=false
31   process/hdr_as_srgb=false
32   process/hdr_clamp_exposure=false
33   process/size_limit=0
34   detect_3d/compress_to=1
```

C.4   VoronoiCellsGD4

C.4.1   .gitattributes

```
1   # Normalize EOL for all files that Git considers text files.
2   * text=auto eol=lf
```

C.4.2   .gitignore

```
1   # Godot 4+ specific ignores
2   .godot/
```

C.4.3   project.godot

```
1    ; Engine configuration file.
2    ; It's best edited using the editor UI and not directly,
3    ; since the parameters that go here are not all obvious.
4    ;
5    ; Format:
6    ;   [section] ; section goes between []
7    ;   param=value ; assign values to parameters
8
9    config_version=5
10
11   [application]
12
13   config/name="Voronoi Cells"
14   run/main_scene="res://tile_map.tscn"
15   config/features=PackedStringArray("4.0", "Forward Plus")
16   config/icon="res://icon.svg"
17
```

```
18    [display]

19

20    window/size/viewport_height=640
```

C.4.4 tile_map.tscn

```
1     [gd_scene load_steps=5 format=3 uid="uid://d6lxnr5bdh1w"]

2

3     [ext_resource type="Texture2D" uid="uid://cpign73sfbsrt" path="res
         ://monochrome_packed.png" id="1_o183d"]

4     [ext_resource type="Script" path="res://tile_map.gd" id="2_lf4lw"]

5

6     [sub_resource type="TileSetAtlasSource" id="
         TileSetAtlasSource_6h0bd"]

7     texture = ExtResource("1_o183d")

8     0:0/0 = 0

9     1:0/0 = 0

10    2:0/0 = 0

11    3:0/0 = 0

12    4:0/0 = 0

13    5:0/0 = 0

14    6:0/0 = 0

15    7:0/0 = 0

16    8:0/0 = 0

17    9:0/0 = 0

18    10:0/0 = 0

19    11:0/0 = 0

20    12:0/0 = 0

21    13:0/0 = 0

22    14:0/0 = 0

23    15:0/0 = 0

24    16:0/0 = 0
```

```
25    17:0/0  =  0
26    18:0/0  =  0
27    19:0/0  =  0
28    20:0/0  =  0
29    21:0/0  =  0
30    22:0/0  =  0
31    23:0/0  =  0
32    24:0/0  =  0
33    25:0/0  =  0
34    26:0/0  =  0
35    27:0/0  =  0
36    28:0/0  =  0
37    29:0/0  =  0
38    30:0/0  =  0
39    31:0/0  =  0
40    32:0/0  =  0
41    33:0/0  =  0
42    34:0/0  =  0
43    35:0/0  =  0
44    36:0/0  =  0
45    37:0/0  =  0
46    38:0/0  =  0
47    39:0/0  =  0
48    40:0/0  =  0
49    41:0/0  =  0
50    42:0/0  =  0
51    43:0/0  =  0
52    44:0/0  =  0
53    45:0/0  =  0
54    46:0/0  =  0
55    47:0/0  =  0
56    48:0/0  =  0
57     0:1/0  =  0
```

```
58      1:1/0  =  0

59      2:1/0  =  0

60      3:1/0  =  0

61      4:1/0  =  0

62      5:1/0  =  0

63      6:1/0  =  0

64      7:1/0  =  0

65      8:1/0  =  0

66      9:1/0  =  0

67      10:1/0  =  0

68      11:1/0  =  0

69      12:1/0  =  0

70      13:1/0  =  0

71      14:1/0  =  0

72      15:1/0  =  0

73      16:1/0  =  0

74      17:1/0  =  0

75      18:1/0  =  0

76      19:1/0  =  0

77      20:1/0  =  0

78      21:1/0  =  0

79      22:1/0  =  0

80      23:1/0  =  0

81      24:1/0  =  0

82      25:1/0  =  0

83      26:1/0  =  0

84      27:1/0  =  0

85      28:1/0  =  0

86      29:1/0  =  0

87      30:1/0  =  0

88      31:1/0  =  0

89      32:1/0  =  0

90      33:1/0  =  0
```

```
 91    34:1/0 = 0
 92    35:1/0 = 0
 93    36:1/0 = 0
 94    37:1/0 = 0
 95    38:1/0 = 0
 96    39:1/0 = 0
 97    40:1/0 = 0
 98    41:1/0 = 0
 99    42:1/0 = 0
100    43:1/0 = 0
101    44:1/0 = 0
102    45:1/0 = 0
103    46:1/0 = 0
104    47:1/0 = 0
105    48:1/0 = 0
106    0:2/0 = 0
107    1:2/0 = 0
108    2:2/0 = 0
109    3:2/0 = 0
110    4:2/0 = 0
111    5:2/0 = 0
112    6:2/0 = 0
113    7:2/0 = 0
114    8:2/0 = 0
115    9:2/0 = 0
116    10:2/0 = 0
117    11:2/0 = 0
118    12:2/0 = 0
119    13:2/0 = 0
120    14:2/0 = 0
121    15:2/0 = 0
122    16:2/0 = 0
123    17:2/0 = 0
```

```
124    18:2/0 = 0

125    19:2/0 = 0

126    20:2/0 = 0

127    21:2/0 = 0

128    22:2/0 = 0

129    23:2/0 = 0

130    24:2/0 = 0

131    25:2/0 = 0

132    26:2/0 = 0

133    27:2/0 = 0

134    28:2/0 = 0

135    29:2/0 = 0

136    30:2/0 = 0

137    31:2/0 = 0

138    32:2/0 = 0

139    33:2/0 = 0

140    34:2/0 = 0

141    35:2/0 = 0

142    36:2/0 = 0

143    37:2/0 = 0

144    38:2/0 = 0

145    39:2/0 = 0

146    40:2/0 = 0

147    41:2/0 = 0

148    42:2/0 = 0

149    43:2/0 = 0

150    44:2/0 = 0

151    45:2/0 = 0

152    46:2/0 = 0

153    47:2/0 = 0

154    48:2/0 = 0

155    0:3/0 = 0

156    1:3/0 = 0
```

```
157    2:3/0 = 0

158    3:3/0 = 0

159    4:3/0 = 0

160    5:3/0 = 0

161    6:3/0 = 0

162    7:3/0 = 0

163    8:3/0 = 0

164    9:3/0 = 0

165    10:3/0 = 0

166    11:3/0 = 0

167    12:3/0 = 0

168    13:3/0 = 0

169    14:3/0 = 0

170    15:3/0 = 0

171    16:3/0 = 0

172    17:3/0 = 0

173    18:3/0 = 0

174    19:3/0 = 0

175    20:3/0 = 0

176    21:3/0 = 0

177    22:3/0 = 0

178    23:3/0 = 0

179    24:3/0 = 0

180    25:3/0 = 0

181    26:3/0 = 0

182    27:3/0 = 0

183    28:3/0 = 0

184    29:3/0 = 0

185    30:3/0 = 0

186    31:3/0 = 0

187    32:3/0 = 0

188    33:3/0 = 0

189    34:3/0 = 0
```

```
190    35:3/0 = 0

191    36:3/0 = 0

192    37:3/0 = 0

193    38:3/0 = 0

194    39:3/0 = 0

195    40:3/0 = 0

196    41:3/0 = 0

197    42:3/0 = 0

198    43:3/0 = 0

199    44:3/0 = 0

200    45:3/0 = 0

201    46:3/0 = 0

202    47:3/0 = 0

203    48:3/0 = 0

204    0:4/0 = 0

205    1:4/0 = 0

206    2:4/0 = 0

207    3:4/0 = 0

208    4:4/0 = 0

209    5:4/0 = 0

210    6:4/0 = 0

211    7:4/0 = 0

212    8:4/0 = 0

213    9:4/0 = 0

214    10:4/0 = 0

215    11:4/0 = 0

216    12:4/0 = 0

217    13:4/0 = 0

218    14:4/0 = 0

219    15:4/0 = 0

220    16:4/0 = 0

221    17:4/0 = 0

222    18:4/0 = 0
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223    19:4/0 = 0

224    20:4/0 = 0

225    21:4/0 = 0

226    22:4/0 = 0

227    23:4/0 = 0

228    24:4/0 = 0

229    25:4/0 = 0

230    26:4/0 = 0

231    27:4/0 = 0

232    28:4/0 = 0

233    29:4/0 = 0

234    30:4/0 = 0

235    31:4/0 = 0

236    32:4/0 = 0

237    33:4/0 = 0

238    34:4/0 = 0

239    35:4/0 = 0

240    36:4/0 = 0

241    37:4/0 = 0

242    38:4/0 = 0

243    39:4/0 = 0

244    40:4/0 = 0

245    41:4/0 = 0

246    42:4/0 = 0

247    43:4/0 = 0

248    44:4/0 = 0

249    45:4/0 = 0

250    46:4/0 = 0

251    47:4/0 = 0

252    48:4/0 = 0

253    0:5/0 = 0

254    1:5/0 = 0

255    2:5/0 = 0
```

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256    3:5/0 = 0
257    4:5/0 = 0
258    5:5/0 = 0
259    6:5/0 = 0
260    7:5/0 = 0
261    8:5/0 = 0
262    9:5/0 = 0
263    10:5/0 = 0
264    11:5/0 = 0
265    12:5/0 = 0
266    13:5/0 = 0
267    14:5/0 = 0
268    15:5/0 = 0
269    16:5/0 = 0
270    17:5/0 = 0
271    18:5/0 = 0
272    19:5/0 = 0
273    20:5/0 = 0
274    21:5/0 = 0
275    22:5/0 = 0
276    23:5/0 = 0
277    24:5/0 = 0
278    25:5/0 = 0
279    26:5/0 = 0
280    27:5/0 = 0
281    28:5/0 = 0
282    29:5/0 = 0
283    30:5/0 = 0
284    31:5/0 = 0
285    32:5/0 = 0
286    33:5/0 = 0
287    34:5/0 = 0
288    35:5/0 = 0
```

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289    36:5/0 = 0

290    37:5/0 = 0

291    38:5/0 = 0

292    39:5/0 = 0

293    40:5/0 = 0

294    41:5/0 = 0

295    42:5/0 = 0

296    43:5/0 = 0

297    44:5/0 = 0

298    45:5/0 = 0

299    46:5/0 = 0

300    47:5/0 = 0

301    48:5/0 = 0

302    0:6/0 = 0

303    1:6/0 = 0

304    2:6/0 = 0

305    3:6/0 = 0

306    4:6/0 = 0

307    5:6/0 = 0

308    6:6/0 = 0

309    7:6/0 = 0

310    8:6/0 = 0

311    9:6/0 = 0

312    10:6/0 = 0

313    11:6/0 = 0

314    12:6/0 = 0

315    13:6/0 = 0

316    14:6/0 = 0

317    15:6/0 = 0

318    16:6/0 = 0

319    17:6/0 = 0

320    18:6/0 = 0

321    19:6/0 = 0
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322    20:6/0 = 0
323    21:6/0 = 0
324    22:6/0 = 0
325    23:6/0 = 0
326    24:6/0 = 0
327    25:6/0 = 0
328    26:6/0 = 0
329    27:6/0 = 0
330    28:6/0 = 0
331    29:6/0 = 0
332    30:6/0 = 0
333    31:6/0 = 0
334    32:6/0 = 0
335    33:6/0 = 0
336    34:6/0 = 0
337    35:6/0 = 0
338    36:6/0 = 0
339    37:6/0 = 0
340    38:6/0 = 0
341    39:6/0 = 0
342    40:6/0 = 0
343    41:6/0 = 0
344    42:6/0 = 0
345    43:6/0 = 0
346    44:6/0 = 0
347    45:6/0 = 0
348    46:6/0 = 0
349    47:6/0 = 0
350    48:6/0 = 0
351    0:7/0 = 0
352    1:7/0 = 0
353    2:7/0 = 0
354    3:7/0 = 0
```

```
355    4:7/0 = 0
356    5:7/0 = 0
357    6:7/0 = 0
358    7:7/0 = 0
359    8:7/0 = 0
360    9:7/0 = 0
361    10:7/0 = 0
362    11:7/0 = 0
363    12:7/0 = 0
364    13:7/0 = 0
365    14:7/0 = 0
366    15:7/0 = 0
367    16:7/0 = 0
368    17:7/0 = 0
369    18:7/0 = 0
370    19:7/0 = 0
371    20:7/0 = 0
372    21:7/0 = 0
373    22:7/0 = 0
374    23:7/0 = 0
375    24:7/0 = 0
376    25:7/0 = 0
377    26:7/0 = 0
378    27:7/0 = 0
379    28:7/0 = 0
380    29:7/0 = 0
381    30:7/0 = 0
382    31:7/0 = 0
383    32:7/0 = 0
384    33:7/0 = 0
385    34:7/0 = 0
386    35:7/0 = 0
387    36:7/0 = 0
```

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388    37:7/0 = 0
389    38:7/0 = 0
390    39:7/0 = 0
391    40:7/0 = 0
392    41:7/0 = 0
393    42:7/0 = 0
394    43:7/0 = 0
395    44:7/0 = 0
396    45:7/0 = 0
397    46:7/0 = 0
398    47:7/0 = 0
399    48:7/0 = 0
400    0:8/0 = 0
401    1:8/0 = 0
402    2:8/0 = 0
403    3:8/0 = 0
404    4:8/0 = 0
405    5:8/0 = 0
406    6:8/0 = 0
407    7:8/0 = 0
408    8:8/0 = 0
409    9:8/0 = 0
410    10:8/0 = 0
411    11:8/0 = 0
412    12:8/0 = 0
413    13:8/0 = 0
414    14:8/0 = 0
415    15:8/0 = 0
416    16:8/0 = 0
417    17:8/0 = 0
418    18:8/0 = 0
419    19:8/0 = 0
420    20:8/0 = 0
```

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421    21:8/0 = 0
422    22:8/0 = 0
423    23:8/0 = 0
424    24:8/0 = 0
425    25:8/0 = 0
426    26:8/0 = 0
427    27:8/0 = 0
428    28:8/0 = 0
429    29:8/0 = 0
430    30:8/0 = 0
431    31:8/0 = 0
432    32:8/0 = 0
433    33:8/0 = 0
434    34:8/0 = 0
435    35:8/0 = 0
436    36:8/0 = 0
437    37:8/0 = 0
438    38:8/0 = 0
439    39:8/0 = 0
440    40:8/0 = 0
441    41:8/0 = 0
442    42:8/0 = 0
443    43:8/0 = 0
444    44:8/0 = 0
445    45:8/0 = 0
446    46:8/0 = 0
447    47:8/0 = 0
448    48:8/0 = 0
449    0:9/0 = 0
450    1:9/0 = 0
451    2:9/0 = 0
452    3:9/0 = 0
453    4:9/0 = 0
```

```
454    5:9/0  =  0

455    6:9/0  =  0

456    7:9/0  =  0

457    8:9/0  =  0

458    9:9/0  =  0

459    10:9/0  =  0

460    11:9/0  =  0

461    12:9/0  =  0

462    13:9/0  =  0

463    14:9/0  =  0

464    15:9/0  =  0

465    16:9/0  =  0

466    17:9/0  =  0

467    18:9/0  =  0

468    19:9/0  =  0

469    20:9/0  =  0

470    21:9/0  =  0

471    22:9/0  =  0

472    23:9/0  =  0

473    24:9/0  =  0

474    25:9/0  =  0

475    26:9/0  =  0

476    27:9/0  =  0

477    28:9/0  =  0

478    29:9/0  =  0

479    30:9/0  =  0

480    31:9/0  =  0

481    32:9/0  =  0

482    33:9/0  =  0

483    34:9/0  =  0

484    35:9/0  =  0

485    36:9/0  =  0

486    37:9/0  =  0
```

```
487    38:9/0 = 0

488    39:9/0 = 0

489    40:9/0 = 0

490    41:9/0 = 0

491    42:9/0 = 0

492    43:9/0 = 0

493    44:9/0 = 0

494    45:9/0 = 0

495    46:9/0 = 0

496    47:9/0 = 0

497    48:9/0 = 0

498    0:10/0 = 0

499    1:10/0 = 0

500    2:10/0 = 0

501    3:10/0 = 0

502    4:10/0 = 0

503    5:10/0 = 0

504    6:10/0 = 0

505    7:10/0 = 0

506    8:10/0 = 0

507    9:10/0 = 0

508    10:10/0 = 0

509    11:10/0 = 0

510    12:10/0 = 0

511    13:10/0 = 0

512    14:10/0 = 0

513    15:10/0 = 0

514    16:10/0 = 0

515    17:10/0 = 0

516    18:10/0 = 0

517    19:10/0 = 0

518    20:10/0 = 0

519    21:10/0 = 0
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520    22:10/0 = 0
521    23:10/0 = 0
522    24:10/0 = 0
523    25:10/0 = 0
524    26:10/0 = 0
525    27:10/0 = 0
526    28:10/0 = 0
527    29:10/0 = 0
528    30:10/0 = 0
529    31:10/0 = 0
530    32:10/0 = 0
531    33:10/0 = 0
532    34:10/0 = 0
533    35:10/0 = 0
534    36:10/0 = 0
535    37:10/0 = 0
536    38:10/0 = 0
537    39:10/0 = 0
538    40:10/0 = 0
539    41:10/0 = 0
540    42:10/0 = 0
541    43:10/0 = 0
542    44:10/0 = 0
543    45:10/0 = 0
544    46:10/0 = 0
545    47:10/0 = 0
546    48:10/0 = 0
547    0:11/0 = 0
548    1:11/0 = 0
549    2:11/0 = 0
550    3:11/0 = 0
551    4:11/0 = 0
552    5:11/0 = 0
```

```
553    6:11/0 = 0
554    7:11/0 = 0
555    8:11/0 = 0
556    9:11/0 = 0
557    10:11/0 = 0
558    11:11/0 = 0
559    12:11/0 = 0
560    13:11/0 = 0
561    14:11/0 = 0
562    15:11/0 = 0
563    16:11/0 = 0
564    17:11/0 = 0
565    18:11/0 = 0
566    19:11/0 = 0
567    20:11/0 = 0
568    21:11/0 = 0
569    22:11/0 = 0
570    23:11/0 = 0
571    24:11/0 = 0
572    25:11/0 = 0
573    26:11/0 = 0
574    27:11/0 = 0
575    28:11/0 = 0
576    29:11/0 = 0
577    30:11/0 = 0
578    31:11/0 = 0
579    32:11/0 = 0
580    33:11/0 = 0
581    34:11/0 = 0
582    35:11/0 = 0
583    36:11/0 = 0
584    37:11/0 = 0
585    38:11/0 = 0
```

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586    39:11/0 = 0
587    40:11/0 = 0
588    41:11/0 = 0
589    42:11/0 = 0
590    43:11/0 = 0
591    44:11/0 = 0
592    45:11/0 = 0
593    46:11/0 = 0
594    47:11/0 = 0
595    48:11/0 = 0
596    0:12/0 = 0
597    1:12/0 = 0
598    2:12/0 = 0
599    3:12/0 = 0
600    4:12/0 = 0
601    5:12/0 = 0
602    6:12/0 = 0
603    7:12/0 = 0
604    8:12/0 = 0
605    9:12/0 = 0
606    10:12/0 = 0
607    11:12/0 = 0
608    12:12/0 = 0
609    13:12/0 = 0
610    14:12/0 = 0
611    15:12/0 = 0
612    16:12/0 = 0
613    17:12/0 = 0
614    18:12/0 = 0
615    19:12/0 = 0
616    20:12/0 = 0
617    21:12/0 = 0
618    22:12/0 = 0
```

```
619    23:12/0 = 0

620    24:12/0 = 0

621    25:12/0 = 0

622    26:12/0 = 0

623    27:12/0 = 0

624    28:12/0 = 0

625    29:12/0 = 0

626    30:12/0 = 0

627    31:12/0 = 0

628    32:12/0 = 0

629    33:12/0 = 0

630    34:12/0 = 0

631    35:12/0 = 0

632    36:12/0 = 0

633    37:12/0 = 0

634    38:12/0 = 0

635    39:12/0 = 0

636    40:12/0 = 0

637    41:12/0 = 0

638    42:12/0 = 0

639    43:12/0 = 0

640    44:12/0 = 0

641    45:12/0 = 0

642    46:12/0 = 0

643    47:12/0 = 0

644    48:12/0 = 0

645    0:13/0 = 0

646    1:13/0 = 0

647    2:13/0 = 0

648    3:13/0 = 0

649    4:13/0 = 0

650    5:13/0 = 0

651    6:13/0 = 0
```

```
652    7:13/0 = 0

653    8:13/0 = 0

654    9:13/0 = 0

655    10:13/0 = 0

656    11:13/0 = 0

657    12:13/0 = 0

658    13:13/0 = 0

659    14:13/0 = 0

660    15:13/0 = 0

661    16:13/0 = 0

662    17:13/0 = 0

663    18:13/0 = 0

664    19:13/0 = 0

665    20:13/0 = 0

666    21:13/0 = 0

667    22:13/0 = 0

668    23:13/0 = 0

669    24:13/0 = 0

670    25:13/0 = 0

671    26:13/0 = 0

672    27:13/0 = 0

673    28:13/0 = 0

674    29:13/0 = 0

675    30:13/0 = 0

676    31:13/0 = 0

677    32:13/0 = 0

678    33:13/0 = 0

679    34:13/0 = 0

680    35:13/0 = 0

681    36:13/0 = 0

682    37:13/0 = 0

683    38:13/0 = 0

684    39:13/0 = 0
```

```
685    40:13/0 = 0

686    41:13/0 = 0

687    42:13/0 = 0

688    43:13/0 = 0

689    44:13/0 = 0

690    45:13/0 = 0

691    46:13/0 = 0

692    47:13/0 = 0

693    48:13/0 = 0

694    0:14/0 = 0

695    1:14/0 = 0

696    2:14/0 = 0

697    3:14/0 = 0

698    4:14/0 = 0

699    5:14/0 = 0

700    6:14/0 = 0

701    7:14/0 = 0

702    8:14/0 = 0

703    9:14/0 = 0

704    10:14/0 = 0

705    11:14/0 = 0

706    12:14/0 = 0

707    13:14/0 = 0

708    14:14/0 = 0

709    15:14/0 = 0

710    16:14/0 = 0

711    17:14/0 = 0

712    18:14/0 = 0

713    19:14/0 = 0

714    20:14/0 = 0

715    21:14/0 = 0

716    22:14/0 = 0

717    23:14/0 = 0
```

```
718    24:14/0 = 0
719    25:14/0 = 0
720    26:14/0 = 0
721    27:14/0 = 0
722    28:14/0 = 0
723    29:14/0 = 0
724    30:14/0 = 0
725    31:14/0 = 0
726    32:14/0 = 0
727    33:14/0 = 0
728    34:14/0 = 0
729    35:14/0 = 0
730    36:14/0 = 0
731    37:14/0 = 0
732    38:14/0 = 0
733    39:14/0 = 0
734    40:14/0 = 0
735    41:14/0 = 0
736    42:14/0 = 0
737    43:14/0 = 0
738    44:14/0 = 0
739    45:14/0 = 0
740    46:14/0 = 0
741    47:14/0 = 0
742    48:14/0 = 0
743    0:15/0 = 0
744    1:15/0 = 0
745    2:15/0 = 0
746    3:15/0 = 0
747    4:15/0 = 0
748    5:15/0 = 0
749    6:15/0 = 0
750    7:15/0 = 0
```

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751    8:15/0 = 0

752    9:15/0 = 0

753    10:15/0 = 0

754    11:15/0 = 0

755    12:15/0 = 0

756    13:15/0 = 0

757    14:15/0 = 0

758    15:15/0 = 0

759    16:15/0 = 0

760    17:15/0 = 0

761    18:15/0 = 0

762    19:15/0 = 0

763    20:15/0 = 0

764    21:15/0 = 0

765    22:15/0 = 0

766    23:15/0 = 0

767    24:15/0 = 0

768    25:15/0 = 0

769    26:15/0 = 0

770    27:15/0 = 0

771    28:15/0 = 0

772    29:15/0 = 0

773    30:15/0 = 0

774    31:15/0 = 0

775    32:15/0 = 0

776    33:15/0 = 0

777    34:15/0 = 0

778    35:15/0 = 0

779    36:15/0 = 0

780    37:15/0 = 0

781    38:15/0 = 0

782    39:15/0 = 0

783    40:15/0 = 0
```

```
784    41:15/0 = 0

785    42:15/0 = 0

786    43:15/0 = 0

787    44:15/0 = 0

788    45:15/0 = 0

789    46:15/0 = 0

790    47:15/0 = 0

791    48:15/0 = 0

792    0:16/0 = 0

793    1:16/0 = 0

794    2:16/0 = 0

795    3:16/0 = 0

796    4:16/0 = 0

797    5:16/0 = 0

798    6:16/0 = 0

799    7:16/0 = 0

800    8:16/0 = 0

801    9:16/0 = 0

802    10:16/0 = 0

803    11:16/0 = 0

804    12:16/0 = 0

805    13:16/0 = 0

806    14:16/0 = 0

807    15:16/0 = 0

808    16:16/0 = 0

809    17:16/0 = 0

810    18:16/0 = 0

811    19:16/0 = 0

812    20:16/0 = 0

813    21:16/0 = 0

814    22:16/0 = 0

815    23:16/0 = 0

816    24:16/0 = 0
```

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817    25:16/0 = 0
818    26:16/0 = 0
819    27:16/0 = 0
820    28:16/0 = 0
821    29:16/0 = 0
822    30:16/0 = 0
823    31:16/0 = 0
824    32:16/0 = 0
825    33:16/0 = 0
826    34:16/0 = 0
827    35:16/0 = 0
828    36:16/0 = 0
829    37:16/0 = 0
830    38:16/0 = 0
831    39:16/0 = 0
832    40:16/0 = 0
833    41:16/0 = 0
834    42:16/0 = 0
835    43:16/0 = 0
836    44:16/0 = 0
837    45:16/0 = 0
838    46:16/0 = 0
839    47:16/0 = 0
840    48:16/0 = 0
841    0:17/0 = 0
842    1:17/0 = 0
843    2:17/0 = 0
844    3:17/0 = 0
845    4:17/0 = 0
846    5:17/0 = 0
847    6:17/0 = 0
848    7:17/0 = 0
849    8:17/0 = 0
```

```
850    9:17/0 = 0

851    10:17/0 = 0

852    11:17/0 = 0

853    12:17/0 = 0

854    13:17/0 = 0

855    14:17/0 = 0

856    15:17/0 = 0

857    16:17/0 = 0

858    17:17/0 = 0

859    18:17/0 = 0

860    19:17/0 = 0

861    20:17/0 = 0

862    21:17/0 = 0

863    22:17/0 = 0

864    23:17/0 = 0

865    24:17/0 = 0

866    25:17/0 = 0

867    26:17/0 = 0

868    27:17/0 = 0

869    28:17/0 = 0

870    29:17/0 = 0

871    30:17/0 = 0

872    31:17/0 = 0

873    32:17/0 = 0

874    33:17/0 = 0

875    34:17/0 = 0

876    35:17/0 = 0

877    36:17/0 = 0

878    37:17/0 = 0

879    38:17/0 = 0

880    39:17/0 = 0

881    40:17/0 = 0

882    41:17/0 = 0
```

```
883    42:17/0 = 0

884    43:17/0 = 0

885    44:17/0 = 0

886    45:17/0 = 0

887    46:17/0 = 0

888    47:17/0 = 0

889    48:17/0 = 0

890    0:18/0 = 0

891    1:18/0 = 0

892    2:18/0 = 0

893    3:18/0 = 0

894    4:18/0 = 0

895    5:18/0 = 0

896    6:18/0 = 0

897    7:18/0 = 0

898    8:18/0 = 0

899    9:18/0 = 0

900    10:18/0 = 0

901    11:18/0 = 0

902    12:18/0 = 0

903    13:18/0 = 0

904    14:18/0 = 0

905    15:18/0 = 0

906    16:18/0 = 0

907    17:18/0 = 0

908    18:18/0 = 0

909    19:18/0 = 0

910    20:18/0 = 0

911    21:18/0 = 0

912    22:18/0 = 0

913    23:18/0 = 0

914    24:18/0 = 0

915    25:18/0 = 0
```

```
916    26:18/0 = 0
917    27:18/0 = 0
918    28:18/0 = 0
919    29:18/0 = 0
920    30:18/0 = 0
921    31:18/0 = 0
922    32:18/0 = 0
923    33:18/0 = 0
924    34:18/0 = 0
925    35:18/0 = 0
926    36:18/0 = 0
927    37:18/0 = 0
928    38:18/0 = 0
929    39:18/0 = 0
930    40:18/0 = 0
931    41:18/0 = 0
932    42:18/0 = 0
933    43:18/0 = 0
934    44:18/0 = 0
935    45:18/0 = 0
936    46:18/0 = 0
937    47:18/0 = 0
938    48:18/0 = 0
939    0:19/0 = 0
940    1:19/0 = 0
941    2:19/0 = 0
942    3:19/0 = 0
943    4:19/0 = 0
944    5:19/0 = 0
945    6:19/0 = 0
946    7:19/0 = 0
947    8:19/0 = 0
948    9:19/0 = 0
```

```
949    10:19/0 = 0
950    11:19/0 = 0
951    12:19/0 = 0
952    13:19/0 = 0
953    14:19/0 = 0
954    15:19/0 = 0
955    16:19/0 = 0
956    17:19/0 = 0
957    18:19/0 = 0
958    19:19/0 = 0
959    20:19/0 = 0
960    21:19/0 = 0
961    22:19/0 = 0
962    23:19/0 = 0
963    24:19/0 = 0
964    25:19/0 = 0
965    26:19/0 = 0
966    27:19/0 = 0
967    28:19/0 = 0
968    29:19/0 = 0
969    30:19/0 = 0
970    31:19/0 = 0
971    32:19/0 = 0
972    33:19/0 = 0
973    34:19/0 = 0
974    35:19/0 = 0
975    36:19/0 = 0
976    37:19/0 = 0
977    38:19/0 = 0
978    39:19/0 = 0
979    40:19/0 = 0
980    41:19/0 = 0
981    42:19/0 = 0
```

```
982    43:19/0 = 0
983    44:19/0 = 0
984    45:19/0 = 0
985    46:19/0 = 0
986    47:19/0 = 0
987    48:19/0 = 0
988    0:20/0 = 0
989    1:20/0 = 0
990    2:20/0 = 0
991    3:20/0 = 0
992    4:20/0 = 0
993    5:20/0 = 0
994    6:20/0 = 0
995    7:20/0 = 0
996    8:20/0 = 0
997    9:20/0 = 0
998    10:20/0 = 0
999    11:20/0 = 0
1000   12:20/0 = 0
1001   13:20/0 = 0
1002   14:20/0 = 0
1003   15:20/0 = 0
1004   16:20/0 = 0
1005   17:20/0 = 0
1006   18:20/0 = 0
1007   19:20/0 = 0
1008   20:20/0 = 0
1009   21:20/0 = 0
1010   22:20/0 = 0
1011   23:20/0 = 0
1012   24:20/0 = 0
1013   25:20/0 = 0
1014   26:20/0 = 0
```

```
1015    27:20/0 = 0
1016    28:20/0 = 0
1017    29:20/0 = 0
1018    30:20/0 = 0
1019    31:20/0 = 0
1020    32:20/0 = 0
1021    33:20/0 = 0
1022    34:20/0 = 0
1023    35:20/0 = 0
1024    36:20/0 = 0
1025    37:20/0 = 0
1026    38:20/0 = 0
1027    39:20/0 = 0
1028    40:20/0 = 0
1029    41:20/0 = 0
1030    42:20/0 = 0
1031    43:20/0 = 0
1032    44:20/0 = 0
1033    45:20/0 = 0
1034    46:20/0 = 0
1035    47:20/0 = 0
1036    48:20/0 = 0
1037    0:21/0 = 0
1038    1:21/0 = 0
1039    2:21/0 = 0
1040    3:21/0 = 0
1041    4:21/0 = 0
1042    5:21/0 = 0
1043    6:21/0 = 0
1044    7:21/0 = 0
1045    8:21/0 = 0
1046    9:21/0 = 0
1047    10:21/0 = 0
```

```
1048    11:21/0 = 0

1049    12:21/0 = 0

1050    13:21/0 = 0

1051    14:21/0 = 0

1052    15:21/0 = 0

1053    16:21/0 = 0

1054    17:21/0 = 0

1055    18:21/0 = 0

1056    19:21/0 = 0

1057    20:21/0 = 0

1058    21:21/0 = 0

1059    22:21/0 = 0

1060    23:21/0 = 0

1061    24:21/0 = 0

1062    25:21/0 = 0

1063    26:21/0 = 0

1064    27:21/0 = 0

1065    28:21/0 = 0

1066    29:21/0 = 0

1067    30:21/0 = 0

1068    31:21/0 = 0

1069    32:21/0 = 0

1070    33:21/0 = 0

1071    34:21/0 = 0

1072    35:21/0 = 0

1073    36:21/0 = 0

1074    37:21/0 = 0

1075    38:21/0 = 0

1076    39:21/0 = 0

1077    40:21/0 = 0

1078    41:21/0 = 0

1079    42:21/0 = 0

1080    43:21/0 = 0
```

```
1081    44:21/0 = 0
1082    45:21/0 = 0
1083    46:21/0 = 0
1084    47:21/0 = 0
1085    48:21/0 = 0
1086
1087    [sub_resource type="TileSet" id="TileSet_3drs5"]
1088    sources/0 = SubResource("TileSetAtlasSource_6h0bd")
1089
1090    [node name="TileMap" type="TileMap"]
1091    tile_set = SubResource("TileSet_3drs5")
1092    format = 2
1093    script = ExtResource("2_lf4lw")
```

C.4.5   tile_map.gd

```
1     extends TileMap
2
3     var points: Array[Dictionary] = []
4     const EUCLIDEAN: String = "Euclidean distance"
5     const MANHATTAN: String = "Manhattan distance"
6     @export_enum(EUCLIDEAN, MANHATTAN) var distance: String = MANHATTAN
7     @export_range(2, 6, 1) var random_starting_points: int = 4
8     var x_tile_range: int = ProjectSettings.get_setting("display/window
          /size/viewport_width") / tile_set.tile_size.x
9     var y_tile_range: int = ProjectSettings.get_setting("display/window
          /size/viewport_height") / tile_set.tile_size.y
10
11    # Called when the node enters the scene tree for the first time.
12    func _ready() -> void:
13        randomize()
14        for x in range(-50, x_tile_range + 50):
```

```
15          for y in range(-50, y_tile_range + 50):
16              set_cell(0, Vector2(x, y), 0, Vector2(0, 0))
17      var start_time: float = Time.get_ticks_msec()
18      define_points(random_starting_points)
19      paint_points()
20      var new_time: float = Time.get_ticks_msec() - start_time
21      print("Time taken: " + str(new_time) + "ms")
22

23  func paint_points() -> void:
24      for point in points:
25          set_cell(0, Vector2(point["x"], point["y"]), 0, point["type"
                ])
26          for citizen in point["citizens"]:
27              set_cell(0, Vector2(point["x"] + citizen["dx"], point["y"]
                    + citizen["dy"]), 0, point["type"])
28

29  func _squared(x: int) -> int:
30      return x ** 2
31

32  func calculate_points_delta(x: int, y: int, p: int) -> float:
33      if distance == EUCLIDEAN:
34          return sqrt(_squared(points[p]["x"] - x) + _squared(points[p
                ]["y"] - y))
35      return abs(points[p]["x"] - x) + abs(points[p]["y"] - y)
36

37  func define_points(num_points: int) -> void:
38      var types: Array[Vector2i] = [Vector2i(0,1),Vector2i(1,1),
                Vector2i(2,1),Vector2i(5,1),Vector2i(6,1),Vector2i(4,2)]
39      for i in range(num_points):
40          var x: int = randi_range(0, x_tile_range)
41          var y: int = randi_range(0, y_tile_range)
42          var type: Vector2i = types.pick_random()
43          types.erase(type)
```

```
44          points.append(
45              {
46                  "type": type,
47                  "x": x,
48                  "y": y,
49                  "citizens": []
50              }
51          )
52      for x in range(x_tile_range):
53          for y in range(y_tile_range):
54              var lowest_delta: Dictionary = {
55                  "point_id": 0,
56                  "delta": x_tile_range * y_tile_range
57              }
58              for p in range(len(points)):
59                  var delta: float = calculate_points_delta(x, y, p)
60                  if delta < lowest_delta["delta"]:
61                      lowest_delta = {
62                          "point_id": p,
63                          "delta": delta
64                      }
65                  var active_point: Dictionary = points[lowest_delta["
                        point_id"]]
66                  var dx: int = x - active_point["x"]
67                  var dy: int = y - active_point["y"]
68                  active_point["citizens"].append(
69                      {
70                          "dx": dx,
71                          "dy": dy
72                      }
73                  )
```

C.4.6   icon.svg.import

```
1    [remap]
2
3    importer="texture"
4    type="CompressedTexture2D"
5    uid="uid://du4v6taw8ssax"
6    path="res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"
7    metadata={
8    "vram_texture": false
9    }
10
11   [deps]
12
13   source_file="res://icon.svg"
14   dest_files=["res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
22   compress/normal_map=0
23   compress/channel_pack=0
24   mipmaps/generate=false
25   mipmaps/limit=-1
26   roughness/mode=0
27   roughness/src_normal=""
28   process/fix_alpha_border=true
29   process/premult_alpha=false
```

```
30    process/normal_map_invert_y=false

31    process/hdr_as_srgb=false

32    process/hdr_clamp_exposure=false

33    process/size_limit=0

34    detect_3d/compress_to=1

35    svg/scale=1.0

36    editor/scale_with_editor_scale=false

37    editor/convert_colors_with_editor_theme=false
```

C.4.7   monochrome_packed.png.import

```
1     [remap]

2

3     importer="texture"

4     type="CompressedTexture2D"

5     uid="uid://cpign73sfbsrt"

6     path="res://.godot/imported/monochrome_packed.png-6
          b9bd1c64dd50f72acd3afd14d1ac34f.ctex"

7     metadata={

8     "vram_texture": false

9     }

10

11    [deps]

12

13    source_file="res://monochrome_packed.png"

14    dest_files=["res://.godot/imported/monochrome_packed.png-6
          b9bd1c64dd50f72acd3afd14d1ac34f.ctex"]

15

16    [params]

17

18    compress/mode=0

19    compress/high_quality=false
```

```
20    compress/lossy_quality=0.7

21    compress/hdr_compression=1

22    compress/normal_map=0

23    compress/channel_pack=0

24    mipmaps/generate=false

25    mipmaps/limit=-1

26    roughness/mode=0

27    roughness/src_normal=""

28    process/fix_alpha_border=true

29    process/premult_alpha=false

30    process/normal_map_invert_y=false

31    process/hdr_as_srgb=false

32    process/hdr_clamp_exposure=false

33    process/size_limit=0

34    detect_3d/compress_to=1
```

C.5   PoissonGD4

C.5.1   .gitattributes

```
1    # Normalize EOL for all files that Git considers text files.

2    * text=auto eol=lf
```

C.5.2   .gitignore

```
1    # Godot 4+ specific ignores

2    .godot/
```

C.5.3   project.godot

```
1   ; Engine configuration file.
2   ; It's best edited using the editor UI and not directly,
3   ; since the parameters that go here are not all obvious.
4   ;
5   ; Format:
6   ;   [section] ; section goes between []
7   ;   param=value ; assign values to parameters
8
9   config_version=5
10
11  [application]
12
13  config/name="Poisson Sampling Project"
14  run/main_scene="res://tile_map.tscn"
15  config/features=PackedStringArray("4.0", "Forward Plus")
16  config/icon="res://icon.svg"
17
18  [display]
19
20  window/size/viewport_height=640
21
22  [rendering]
23
24  renderer/rendering_method="gl_compatibility"
```

C.5.4   tile_map.tscn

```
1   [gd_scene load_steps=5 format=3 uid="uid://f2kv7fettdo7"]
2
3   [ext_resource type="Texture2D" uid="uid://c3bpsm4r8t504" path="res
        ://monochrome_packed.png" id="1_uucm3"]
4   [ext_resource type="Script" path="res://tile_map.gd" id="2_iyhvf"]
```

```
 5
 6    [sub_resource type="TileSetAtlasSource" id="
        TileSetAtlasSource_j4usm"]
 7    texture = ExtResource("1_uucm3")
 8    0:0/0 = 0
 9    1:0/0 = 0
10    2:0/0 = 0
11    3:0/0 = 0
12    4:0/0 = 0
13    5:0/0 = 0
14    6:0/0 = 0
15    7:0/0 = 0
16    8:0/0 = 0
17    9:0/0 = 0
18    10:0/0 = 0
19    11:0/0 = 0
20    12:0/0 = 0
21    13:0/0 = 0
22    14:0/0 = 0
23    15:0/0 = 0
24    16:0/0 = 0
25    17:0/0 = 0
26    18:0/0 = 0
27    19:0/0 = 0
28    20:0/0 = 0
29    21:0/0 = 0
30    22:0/0 = 0
31    23:0/0 = 0
32    24:0/0 = 0
33    25:0/0 = 0
34    26:0/0 = 0
35    27:0/0 = 0
36    28:0/0 = 0
```

```
37    29:0/0  =  0

38    30:0/0  =  0

39    31:0/0  =  0

40    32:0/0  =  0

41    33:0/0  =  0

42    34:0/0  =  0

43    35:0/0  =  0

44    36:0/0  =  0

45    37:0/0  =  0

46    38:0/0  =  0

47    39:0/0  =  0

48    40:0/0  =  0

49    41:0/0  =  0

50    42:0/0  =  0

51    43:0/0  =  0

52    44:0/0  =  0

53    45:0/0  =  0

54    46:0/0  =  0

55    47:0/0  =  0

56    48:0/0  =  0

57    0:1/0  =  0

58    1:1/0  =  0

59    2:1/0  =  0

60    3:1/0  =  0

61    4:1/0  =  0

62    5:1/0  =  0

63    6:1/0  =  0

64    7:1/0  =  0

65    8:1/0  =  0

66    9:1/0  =  0

67    10:1/0  =  0

68    11:1/0  =  0

69    12:1/0  =  0
```

```
70    13:1/0  =  0
71    14:1/0  =  0
72    15:1/0  =  0
73    16:1/0  =  0
74    17:1/0  =  0
75    18:1/0  =  0
76    19:1/0  =  0
77    20:1/0  =  0
78    21:1/0  =  0
79    22:1/0  =  0
80    23:1/0  =  0
81    24:1/0  =  0
82    25:1/0  =  0
83    26:1/0  =  0
84    27:1/0  =  0
85    28:1/0  =  0
86    29:1/0  =  0
87    30:1/0  =  0
88    31:1/0  =  0
89    32:1/0  =  0
90    33:1/0  =  0
91    34:1/0  =  0
92    35:1/0  =  0
93    36:1/0  =  0
94    37:1/0  =  0
95    38:1/0  =  0
96    39:1/0  =  0
97    40:1/0  =  0
98    41:1/0  =  0
99    42:1/0  =  0
100   43:1/0  =  0
101   44:1/0  =  0
102   45:1/0  =  0
```

```
103    46:1/0 = 0
104    47:1/0 = 0
105    48:1/0 = 0
106    0:2/0 = 0
107    1:2/0 = 0
108    2:2/0 = 0
109    3:2/0 = 0
110    4:2/0 = 0
111    5:2/0 = 0
112    6:2/0 = 0
113    7:2/0 = 0
114    8:2/0 = 0
115    9:2/0 = 0
116    10:2/0 = 0
117    11:2/0 = 0
118    12:2/0 = 0
119    13:2/0 = 0
120    14:2/0 = 0
121    15:2/0 = 0
122    16:2/0 = 0
123    17:2/0 = 0
124    18:2/0 = 0
125    19:2/0 = 0
126    20:2/0 = 0
127    21:2/0 = 0
128    22:2/0 = 0
129    23:2/0 = 0
130    24:2/0 = 0
131    25:2/0 = 0
132    26:2/0 = 0
133    27:2/0 = 0
134    28:2/0 = 0
135    29:2/0 = 0
```

```
136    30:2/0  =  0
137    31:2/0  =  0
138    32:2/0  =  0
139    33:2/0  =  0
140    34:2/0  =  0
141    35:2/0  =  0
142    36:2/0  =  0
143    37:2/0  =  0
144    38:2/0  =  0
145    39:2/0  =  0
146    40:2/0  =  0
147    41:2/0  =  0
148    42:2/0  =  0
149    43:2/0  =  0
150    44:2/0  =  0
151    45:2/0  =  0
152    46:2/0  =  0
153    47:2/0  =  0
154    48:2/0  =  0
155    0:3/0  =  0
156    1:3/0  =  0
157    2:3/0  =  0
158    3:3/0  =  0
159    4:3/0  =  0
160    5:3/0  =  0
161    6:3/0  =  0
162    7:3/0  =  0
163    8:3/0  =  0
164    9:3/0  =  0
165    10:3/0  =  0
166    11:3/0  =  0
167    12:3/0  =  0
168    13:3/0  =  0
```

```
169    14:3/0 = 0
170    15:3/0 = 0
171    16:3/0 = 0
172    17:3/0 = 0
173    18:3/0 = 0
174    19:3/0 = 0
175    20:3/0 = 0
176    21:3/0 = 0
177    22:3/0 = 0
178    23:3/0 = 0
179    24:3/0 = 0
180    25:3/0 = 0
181    26:3/0 = 0
182    27:3/0 = 0
183    28:3/0 = 0
184    29:3/0 = 0
185    30:3/0 = 0
186    31:3/0 = 0
187    32:3/0 = 0
188    33:3/0 = 0
189    34:3/0 = 0
190    35:3/0 = 0
191    36:3/0 = 0
192    37:3/0 = 0
193    38:3/0 = 0
194    39:3/0 = 0
195    40:3/0 = 0
196    41:3/0 = 0
197    42:3/0 = 0
198    43:3/0 = 0
199    44:3/0 = 0
200    45:3/0 = 0
201    46:3/0 = 0
```

```
202    47:3/0 = 0
203    48:3/0 = 0
204    0:4/0 = 0
205    1:4/0 = 0
206    2:4/0 = 0
207    3:4/0 = 0
208    4:4/0 = 0
209    5:4/0 = 0
210    6:4/0 = 0
211    7:4/0 = 0
212    8:4/0 = 0
213    9:4/0 = 0
214    10:4/0 = 0
215    11:4/0 = 0
216    12:4/0 = 0
217    13:4/0 = 0
218    14:4/0 = 0
219    15:4/0 = 0
220    16:4/0 = 0
221    17:4/0 = 0
222    18:4/0 = 0
223    19:4/0 = 0
224    20:4/0 = 0
225    21:4/0 = 0
226    22:4/0 = 0
227    23:4/0 = 0
228    24:4/0 = 0
229    25:4/0 = 0
230    26:4/0 = 0
231    27:4/0 = 0
232    28:4/0 = 0
233    29:4/0 = 0
234    30:4/0 = 0
```

```
235    31:4/0  =  0

236    32:4/0  =  0

237    33:4/0  =  0

238    34:4/0  =  0

239    35:4/0  =  0

240    36:4/0  =  0

241    37:4/0  =  0

242    38:4/0  =  0

243    39:4/0  =  0

244    40:4/0  =  0

245    41:4/0  =  0

246    42:4/0  =  0

247    43:4/0  =  0

248    44:4/0  =  0

249    45:4/0  =  0

250    46:4/0  =  0

251    47:4/0  =  0

252    48:4/0  =  0

253    0:5/0  =  0

254    1:5/0  =  0

255    2:5/0  =  0

256    3:5/0  =  0

257    4:5/0  =  0

258    5:5/0  =  0

259    6:5/0  =  0

260    7:5/0  =  0

261    8:5/0  =  0

262    9:5/0  =  0

263    10:5/0  =  0

264    11:5/0  =  0

265    12:5/0  =  0

266    13:5/0  =  0

267    14:5/0  =  0
```

```
268    15:5/0 = 0
269    16:5/0 = 0
270    17:5/0 = 0
271    18:5/0 = 0
272    19:5/0 = 0
273    20:5/0 = 0
274    21:5/0 = 0
275    22:5/0 = 0
276    23:5/0 = 0
277    24:5/0 = 0
278    25:5/0 = 0
279    26:5/0 = 0
280    27:5/0 = 0
281    28:5/0 = 0
282    29:5/0 = 0
283    30:5/0 = 0
284    31:5/0 = 0
285    32:5/0 = 0
286    33:5/0 = 0
287    34:5/0 = 0
288    35:5/0 = 0
289    36:5/0 = 0
290    37:5/0 = 0
291    38:5/0 = 0
292    39:5/0 = 0
293    40:5/0 = 0
294    41:5/0 = 0
295    42:5/0 = 0
296    43:5/0 = 0
297    44:5/0 = 0
298    45:5/0 = 0
299    46:5/0 = 0
300    47:5/0 = 0
```

```
301    48:5/0 = 0
302    0:6/0 = 0
303    1:6/0 = 0
304    2:6/0 = 0
305    3:6/0 = 0
306    4:6/0 = 0
307    5:6/0 = 0
308    6:6/0 = 0
309    7:6/0 = 0
310    8:6/0 = 0
311    9:6/0 = 0
312    10:6/0 = 0
313    11:6/0 = 0
314    12:6/0 = 0
315    13:6/0 = 0
316    14:6/0 = 0
317    15:6/0 = 0
318    16:6/0 = 0
319    17:6/0 = 0
320    18:6/0 = 0
321    19:6/0 = 0
322    20:6/0 = 0
323    21:6/0 = 0
324    22:6/0 = 0
325    23:6/0 = 0
326    24:6/0 = 0
327    25:6/0 = 0
328    26:6/0 = 0
329    27:6/0 = 0
330    28:6/0 = 0
331    29:6/0 = 0
332    30:6/0 = 0
333    31:6/0 = 0
```

```
334    32:6/0 = 0
335    33:6/0 = 0
336    34:6/0 = 0
337    35:6/0 = 0
338    36:6/0 = 0
339    37:6/0 = 0
340    38:6/0 = 0
341    39:6/0 = 0
342    40:6/0 = 0
343    41:6/0 = 0
344    42:6/0 = 0
345    43:6/0 = 0
346    44:6/0 = 0
347    45:6/0 = 0
348    46:6/0 = 0
349    47:6/0 = 0
350    48:6/0 = 0
351    0:7/0 = 0
352    1:7/0 = 0
353    2:7/0 = 0
354    3:7/0 = 0
355    4:7/0 = 0
356    5:7/0 = 0
357    6:7/0 = 0
358    7:7/0 = 0
359    8:7/0 = 0
360    9:7/0 = 0
361    10:7/0 = 0
362    11:7/0 = 0
363    12:7/0 = 0
364    13:7/0 = 0
365    14:7/0 = 0
366    15:7/0 = 0
```

```
367    16:7/0 = 0

368    17:7/0 = 0

369    18:7/0 = 0

370    19:7/0 = 0

371    20:7/0 = 0

372    21:7/0 = 0

373    22:7/0 = 0

374    23:7/0 = 0

375    24:7/0 = 0

376    25:7/0 = 0

377    26:7/0 = 0

378    27:7/0 = 0

379    28:7/0 = 0

380    29:7/0 = 0

381    30:7/0 = 0

382    31:7/0 = 0

383    32:7/0 = 0

384    33:7/0 = 0

385    34:7/0 = 0

386    35:7/0 = 0

387    36:7/0 = 0

388    37:7/0 = 0

389    38:7/0 = 0

390    39:7/0 = 0

391    40:7/0 = 0

392    41:7/0 = 0

393    42:7/0 = 0

394    43:7/0 = 0

395    44:7/0 = 0

396    45:7/0 = 0

397    46:7/0 = 0

398    47:7/0 = 0

399    48:7/0 = 0
```

```
400    0:8/0  =  0
401    1:8/0  =  0
402    2:8/0  =  0
403    3:8/0  =  0
404    4:8/0  =  0
405    5:8/0  =  0
406    6:8/0  =  0
407    7:8/0  =  0
408    8:8/0  =  0
409    9:8/0  =  0
410    10:8/0 =  0
411    11:8/0 =  0
412    12:8/0 =  0
413    13:8/0 =  0
414    14:8/0 =  0
415    15:8/0 =  0
416    16:8/0 =  0
417    17:8/0 =  0
418    18:8/0 =  0
419    19:8/0 =  0
420    20:8/0 =  0
421    21:8/0 =  0
422    22:8/0 =  0
423    23:8/0 =  0
424    24:8/0 =  0
425    25:8/0 =  0
426    26:8/0 =  0
427    27:8/0 =  0
428    28:8/0 =  0
429    29:8/0 =  0
430    30:8/0 =  0
431    31:8/0 =  0
432    32:8/0 =  0
```

```
433    33:8/0 = 0
434    34:8/0 = 0
435    35:8/0 = 0
436    36:8/0 = 0
437    37:8/0 = 0
438    38:8/0 = 0
439    39:8/0 = 0
440    40:8/0 = 0
441    41:8/0 = 0
442    42:8/0 = 0
443    43:8/0 = 0
444    44:8/0 = 0
445    45:8/0 = 0
446    46:8/0 = 0
447    47:8/0 = 0
448    48:8/0 = 0
449    0:9/0 = 0
450    1:9/0 = 0
451    2:9/0 = 0
452    3:9/0 = 0
453    4:9/0 = 0
454    5:9/0 = 0
455    6:9/0 = 0
456    7:9/0 = 0
457    8:9/0 = 0
458    9:9/0 = 0
459    10:9/0 = 0
460    11:9/0 = 0
461    12:9/0 = 0
462    13:9/0 = 0
463    14:9/0 = 0
464    15:9/0 = 0
465    16:9/0 = 0
```

```
466    17:9/0  =  0
467    18:9/0  =  0
468    19:9/0  =  0
469    20:9/0  =  0
470    21:9/0  =  0
471    22:9/0  =  0
472    23:9/0  =  0
473    24:9/0  =  0
474    25:9/0  =  0
475    26:9/0  =  0
476    27:9/0  =  0
477    28:9/0  =  0
478    29:9/0  =  0
479    30:9/0  =  0
480    31:9/0  =  0
481    32:9/0  =  0
482    33:9/0  =  0
483    34:9/0  =  0
484    35:9/0  =  0
485    36:9/0  =  0
486    37:9/0  =  0
487    38:9/0  =  0
488    39:9/0  =  0
489    40:9/0  =  0
490    41:9/0  =  0
491    42:9/0  =  0
492    43:9/0  =  0
493    44:9/0  =  0
494    45:9/0  =  0
495    46:9/0  =  0
496    47:9/0  =  0
497    48:9/0  =  0
498    0:10/0  =  0
```

```
499    1:10/0 = 0
500    2:10/0 = 0
501    3:10/0 = 0
502    4:10/0 = 0
503    5:10/0 = 0
504    6:10/0 = 0
505    7:10/0 = 0
506    8:10/0 = 0
507    9:10/0 = 0
508    10:10/0 = 0
509    11:10/0 = 0
510    12:10/0 = 0
511    13:10/0 = 0
512    14:10/0 = 0
513    15:10/0 = 0
514    16:10/0 = 0
515    17:10/0 = 0
516    18:10/0 = 0
517    19:10/0 = 0
518    20:10/0 = 0
519    21:10/0 = 0
520    22:10/0 = 0
521    23:10/0 = 0
522    24:10/0 = 0
523    25:10/0 = 0
524    26:10/0 = 0
525    27:10/0 = 0
526    28:10/0 = 0
527    29:10/0 = 0
528    30:10/0 = 0
529    31:10/0 = 0
530    32:10/0 = 0
531    33:10/0 = 0
```

```
532    34:10/0 = 0
533    35:10/0 = 0
534    36:10/0 = 0
535    37:10/0 = 0
536    38:10/0 = 0
537    39:10/0 = 0
538    40:10/0 = 0
539    41:10/0 = 0
540    42:10/0 = 0
541    43:10/0 = 0
542    44:10/0 = 0
543    45:10/0 = 0
544    46:10/0 = 0
545    47:10/0 = 0
546    48:10/0 = 0
547    0:11/0 = 0
548    1:11/0 = 0
549    2:11/0 = 0
550    3:11/0 = 0
551    4:11/0 = 0
552    5:11/0 = 0
553    6:11/0 = 0
554    7:11/0 = 0
555    8:11/0 = 0
556    9:11/0 = 0
557    10:11/0 = 0
558    11:11/0 = 0
559    12:11/0 = 0
560    13:11/0 = 0
561    14:11/0 = 0
562    15:11/0 = 0
563    16:11/0 = 0
564    17:11/0 = 0
```

```
565    18:11/0 = 0

566    19:11/0 = 0

567    20:11/0 = 0

568    21:11/0 = 0

569    22:11/0 = 0

570    23:11/0 = 0

571    24:11/0 = 0

572    25:11/0 = 0

573    26:11/0 = 0

574    27:11/0 = 0

575    28:11/0 = 0

576    29:11/0 = 0

577    30:11/0 = 0

578    31:11/0 = 0

579    32:11/0 = 0

580    33:11/0 = 0

581    34:11/0 = 0

582    35:11/0 = 0

583    36:11/0 = 0

584    37:11/0 = 0

585    38:11/0 = 0

586    39:11/0 = 0

587    40:11/0 = 0

588    41:11/0 = 0

589    42:11/0 = 0

590    43:11/0 = 0

591    44:11/0 = 0

592    45:11/0 = 0

593    46:11/0 = 0

594    47:11/0 = 0

595    48:11/0 = 0

596    0:12/0 = 0

597    1:12/0 = 0
```

```
598    2:12/0 = 0

599    3:12/0 = 0

600    4:12/0 = 0

601    5:12/0 = 0

602    6:12/0 = 0

603    7:12/0 = 0

604    8:12/0 = 0

605    9:12/0 = 0

606    10:12/0 = 0

607    11:12/0 = 0

608    12:12/0 = 0

609    13:12/0 = 0

610    14:12/0 = 0

611    15:12/0 = 0

612    16:12/0 = 0

613    17:12/0 = 0

614    18:12/0 = 0

615    19:12/0 = 0

616    20:12/0 = 0

617    21:12/0 = 0

618    22:12/0 = 0

619    23:12/0 = 0

620    24:12/0 = 0

621    25:12/0 = 0

622    26:12/0 = 0

623    27:12/0 = 0

624    28:12/0 = 0

625    29:12/0 = 0

626    30:12/0 = 0

627    31:12/0 = 0

628    32:12/0 = 0

629    33:12/0 = 0

630    34:12/0 = 0
```

```
631    35:12/0 = 0
632    36:12/0 = 0
633    37:12/0 = 0
634    38:12/0 = 0
635    39:12/0 = 0
636    40:12/0 = 0
637    41:12/0 = 0
638    42:12/0 = 0
639    43:12/0 = 0
640    44:12/0 = 0
641    45:12/0 = 0
642    46:12/0 = 0
643    47:12/0 = 0
644    48:12/0 = 0
645    0:13/0 = 0
646    1:13/0 = 0
647    2:13/0 = 0
648    3:13/0 = 0
649    4:13/0 = 0
650    5:13/0 = 0
651    6:13/0 = 0
652    7:13/0 = 0
653    8:13/0 = 0
654    9:13/0 = 0
655    10:13/0 = 0
656    11:13/0 = 0
657    12:13/0 = 0
658    13:13/0 = 0
659    14:13/0 = 0
660    15:13/0 = 0
661    16:13/0 = 0
662    17:13/0 = 0
663    18:13/0 = 0
```

```
664    19:13/0 = 0
665    20:13/0 = 0
666    21:13/0 = 0
667    22:13/0 = 0
668    23:13/0 = 0
669    24:13/0 = 0
670    25:13/0 = 0
671    26:13/0 = 0
672    27:13/0 = 0
673    28:13/0 = 0
674    29:13/0 = 0
675    30:13/0 = 0
676    31:13/0 = 0
677    32:13/0 = 0
678    33:13/0 = 0
679    34:13/0 = 0
680    35:13/0 = 0
681    36:13/0 = 0
682    37:13/0 = 0
683    38:13/0 = 0
684    39:13/0 = 0
685    40:13/0 = 0
686    41:13/0 = 0
687    42:13/0 = 0
688    43:13/0 = 0
689    44:13/0 = 0
690    45:13/0 = 0
691    46:13/0 = 0
692    47:13/0 = 0
693    48:13/0 = 0
694    0:14/0 = 0
695    1:14/0 = 0
696    2:14/0 = 0
```

```
697    3:14/0 = 0
698    4:14/0 = 0
699    5:14/0 = 0
700    6:14/0 = 0
701    7:14/0 = 0
702    8:14/0 = 0
703    9:14/0 = 0
704    10:14/0 = 0
705    11:14/0 = 0
706    12:14/0 = 0
707    13:14/0 = 0
708    14:14/0 = 0
709    15:14/0 = 0
710    16:14/0 = 0
711    17:14/0 = 0
712    18:14/0 = 0
713    19:14/0 = 0
714    20:14/0 = 0
715    21:14/0 = 0
716    22:14/0 = 0
717    23:14/0 = 0
718    24:14/0 = 0
719    25:14/0 = 0
720    26:14/0 = 0
721    27:14/0 = 0
722    28:14/0 = 0
723    29:14/0 = 0
724    30:14/0 = 0
725    31:14/0 = 0
726    32:14/0 = 0
727    33:14/0 = 0
728    34:14/0 = 0
729    35:14/0 = 0
```

```
730    36:14/0 = 0
731    37:14/0 = 0
732    38:14/0 = 0
733    39:14/0 = 0
734    40:14/0 = 0
735    41:14/0 = 0
736    42:14/0 = 0
737    43:14/0 = 0
738    44:14/0 = 0
739    45:14/0 = 0
740    46:14/0 = 0
741    47:14/0 = 0
742    48:14/0 = 0
743    0:15/0 = 0
744    1:15/0 = 0
745    2:15/0 = 0
746    3:15/0 = 0
747    4:15/0 = 0
748    5:15/0 = 0
749    6:15/0 = 0
750    7:15/0 = 0
751    8:15/0 = 0
752    9:15/0 = 0
753    10:15/0 = 0
754    11:15/0 = 0
755    12:15/0 = 0
756    13:15/0 = 0
757    14:15/0 = 0
758    15:15/0 = 0
759    16:15/0 = 0
760    17:15/0 = 0
761    18:15/0 = 0
762    19:15/0 = 0
```

```
763    20:15/0 = 0
764    21:15/0 = 0
765    22:15/0 = 0
766    23:15/0 = 0
767    24:15/0 = 0
768    25:15/0 = 0
769    26:15/0 = 0
770    27:15/0 = 0
771    28:15/0 = 0
772    29:15/0 = 0
773    30:15/0 = 0
774    31:15/0 = 0
775    32:15/0 = 0
776    33:15/0 = 0
777    34:15/0 = 0
778    35:15/0 = 0
779    36:15/0 = 0
780    37:15/0 = 0
781    38:15/0 = 0
782    39:15/0 = 0
783    40:15/0 = 0
784    41:15/0 = 0
785    42:15/0 = 0
786    43:15/0 = 0
787    44:15/0 = 0
788    45:15/0 = 0
789    46:15/0 = 0
790    47:15/0 = 0
791    48:15/0 = 0
792    0:16/0 = 0
793    1:16/0 = 0
794    2:16/0 = 0
795    3:16/0 = 0
```

```
796    4:16/0 = 0
797    5:16/0 = 0
798    6:16/0 = 0
799    7:16/0 = 0
800    8:16/0 = 0
801    9:16/0 = 0
802    10:16/0 = 0
803    11:16/0 = 0
804    12:16/0 = 0
805    13:16/0 = 0
806    14:16/0 = 0
807    15:16/0 = 0
808    16:16/0 = 0
809    17:16/0 = 0
810    18:16/0 = 0
811    19:16/0 = 0
812    20:16/0 = 0
813    21:16/0 = 0
814    22:16/0 = 0
815    23:16/0 = 0
816    24:16/0 = 0
817    25:16/0 = 0
818    26:16/0 = 0
819    27:16/0 = 0
820    28:16/0 = 0
821    29:16/0 = 0
822    30:16/0 = 0
823    31:16/0 = 0
824    32:16/0 = 0
825    33:16/0 = 0
826    34:16/0 = 0
827    35:16/0 = 0
828    36:16/0 = 0
```

```
829    37:16/0 = 0
830    38:16/0 = 0
831    39:16/0 = 0
832    40:16/0 = 0
833    41:16/0 = 0
834    42:16/0 = 0
835    43:16/0 = 0
836    44:16/0 = 0
837    45:16/0 = 0
838    46:16/0 = 0
839    47:16/0 = 0
840    48:16/0 = 0
841    0:17/0 = 0
842    1:17/0 = 0
843    2:17/0 = 0
844    3:17/0 = 0
845    4:17/0 = 0
846    5:17/0 = 0
847    6:17/0 = 0
848    7:17/0 = 0
849    8:17/0 = 0
850    9:17/0 = 0
851    10:17/0 = 0
852    11:17/0 = 0
853    12:17/0 = 0
854    13:17/0 = 0
855    14:17/0 = 0
856    15:17/0 = 0
857    16:17/0 = 0
858    17:17/0 = 0
859    18:17/0 = 0
860    19:17/0 = 0
861    20:17/0 = 0
```

```
862    21:17/0  =  0

863    22:17/0  =  0

864    23:17/0  =  0

865    24:17/0  =  0

866    25:17/0  =  0

867    26:17/0  =  0

868    27:17/0  =  0

869    28:17/0  =  0

870    29:17/0  =  0

871    30:17/0  =  0

872    31:17/0  =  0

873    32:17/0  =  0

874    33:17/0  =  0

875    34:17/0  =  0

876    35:17/0  =  0

877    36:17/0  =  0

878    37:17/0  =  0

879    38:17/0  =  0

880    39:17/0  =  0

881    40:17/0  =  0

882    41:17/0  =  0

883    42:17/0  =  0

884    43:17/0  =  0

885    44:17/0  =  0

886    45:17/0  =  0

887    46:17/0  =  0

888    47:17/0  =  0

889    48:17/0  =  0

890    0:18/0  =  0

891    1:18/0  =  0

892    2:18/0  =  0

893    3:18/0  =  0

894    4:18/0  =  0
```

```
895    5:18/0 = 0
896    6:18/0 = 0
897    7:18/0 = 0
898    8:18/0 = 0
899    9:18/0 = 0
900    10:18/0 = 0
901    11:18/0 = 0
902    12:18/0 = 0
903    13:18/0 = 0
904    14:18/0 = 0
905    15:18/0 = 0
906    16:18/0 = 0
907    17:18/0 = 0
908    18:18/0 = 0
909    19:18/0 = 0
910    20:18/0 = 0
911    21:18/0 = 0
912    22:18/0 = 0
913    23:18/0 = 0
914    24:18/0 = 0
915    25:18/0 = 0
916    26:18/0 = 0
917    27:18/0 = 0
918    28:18/0 = 0
919    29:18/0 = 0
920    30:18/0 = 0
921    31:18/0 = 0
922    32:18/0 = 0
923    33:18/0 = 0
924    34:18/0 = 0
925    35:18/0 = 0
926    36:18/0 = 0
927    37:18/0 = 0
```

```
928    38:18/0 = 0
929    39:18/0 = 0
930    40:18/0 = 0
931    41:18/0 = 0
932    42:18/0 = 0
933    43:18/0 = 0
934    44:18/0 = 0
935    45:18/0 = 0
936    46:18/0 = 0
937    47:18/0 = 0
938    48:18/0 = 0
939    0:19/0 = 0
940    1:19/0 = 0
941    2:19/0 = 0
942    3:19/0 = 0
943    4:19/0 = 0
944    5:19/0 = 0
945    6:19/0 = 0
946    7:19/0 = 0
947    8:19/0 = 0
948    9:19/0 = 0
949    10:19/0 = 0
950    11:19/0 = 0
951    12:19/0 = 0
952    13:19/0 = 0
953    14:19/0 = 0
954    15:19/0 = 0
955    16:19/0 = 0
956    17:19/0 = 0
957    18:19/0 = 0
958    19:19/0 = 0
959    20:19/0 = 0
960    21:19/0 = 0
```

```
961    22:19/0 = 0

962    23:19/0 = 0

963    24:19/0 = 0

964    25:19/0 = 0

965    26:19/0 = 0

966    27:19/0 = 0

967    28:19/0 = 0

968    29:19/0 = 0

969    30:19/0 = 0

970    31:19/0 = 0

971    32:19/0 = 0

972    33:19/0 = 0

973    34:19/0 = 0

974    35:19/0 = 0

975    36:19/0 = 0

976    37:19/0 = 0

977    38:19/0 = 0

978    39:19/0 = 0

979    40:19/0 = 0

980    41:19/0 = 0

981    42:19/0 = 0

982    43:19/0 = 0

983    44:19/0 = 0

984    45:19/0 = 0

985    46:19/0 = 0

986    47:19/0 = 0

987    48:19/0 = 0

988    0:20/0 = 0

989    1:20/0 = 0

990    2:20/0 = 0

991    3:20/0 = 0

992    4:20/0 = 0

993    5:20/0 = 0
```

```
994    6:20/0 = 0

995    7:20/0 = 0

996    8:20/0 = 0

997    9:20/0 = 0

998    10:20/0 = 0

999    11:20/0 = 0

1000   12:20/0 = 0

1001   13:20/0 = 0

1002   14:20/0 = 0

1003   15:20/0 = 0

1004   16:20/0 = 0

1005   17:20/0 = 0

1006   18:20/0 = 0

1007   19:20/0 = 0

1008   20:20/0 = 0

1009   21:20/0 = 0

1010   22:20/0 = 0

1011   23:20/0 = 0

1012   24:20/0 = 0

1013   25:20/0 = 0

1014   26:20/0 = 0

1015   27:20/0 = 0

1016   28:20/0 = 0

1017   29:20/0 = 0

1018   30:20/0 = 0

1019   31:20/0 = 0

1020   32:20/0 = 0

1021   33:20/0 = 0

1022   34:20/0 = 0

1023   35:20/0 = 0

1024   36:20/0 = 0

1025   37:20/0 = 0

1026   38:20/0 = 0
```

```
1027    39:20/0 = 0
1028    40:20/0 = 0
1029    41:20/0 = 0
1030    42:20/0 = 0
1031    43:20/0 = 0
1032    44:20/0 = 0
1033    45:20/0 = 0
1034    46:20/0 = 0
1035    47:20/0 = 0
1036    48:20/0 = 0
1037    0:21/0 = 0
1038    1:21/0 = 0
1039    2:21/0 = 0
1040    3:21/0 = 0
1041    4:21/0 = 0
1042    5:21/0 = 0
1043    6:21/0 = 0
1044    7:21/0 = 0
1045    8:21/0 = 0
1046    9:21/0 = 0
1047    10:21/0 = 0
1048    11:21/0 = 0
1049    12:21/0 = 0
1050    13:21/0 = 0
1051    14:21/0 = 0
1052    15:21/0 = 0
1053    16:21/0 = 0
1054    17:21/0 = 0
1055    18:21/0 = 0
1056    19:21/0 = 0
1057    20:21/0 = 0
1058    21:21/0 = 0
1059    22:21/0 = 0
```

```
1060    23:21/0 = 0

1061    24:21/0 = 0

1062    25:21/0 = 0

1063    26:21/0 = 0

1064    27:21/0 = 0

1065    28:21/0 = 0

1066    29:21/0 = 0

1067    30:21/0 = 0

1068    31:21/0 = 0

1069    32:21/0 = 0

1070    33:21/0 = 0

1071    34:21/0 = 0

1072    35:21/0 = 0

1073    36:21/0 = 0

1074    37:21/0 = 0

1075    38:21/0 = 0

1076    39:21/0 = 0

1077    40:21/0 = 0

1078    41:21/0 = 0

1079    42:21/0 = 0

1080    43:21/0 = 0

1081    44:21/0 = 0

1082    45:21/0 = 0

1083    46:21/0 = 0

1084    47:21/0 = 0

1085    48:21/0 = 0

1086

1087    [sub_resource type="TileSet" id="TileSet_8pb5m"]

1088    sources/0 = SubResource("TileSetAtlasSource_j4usm")

1089

1090    [node name="TileMap" type="TileMap"]

1091    tile_set = SubResource("TileSet_8pb5m")

1092    format = 2
```

```
1093    script = ExtResource("2_iyhvf")
```

C.5.5 tile_map.gd

```gdscript
1    extends TileMap
2
3    var cell_points: Array[Vector2]
4    @export var point_radius: float = 1.0
5    @export var region_size: Vector2 = Vector2.ONE
6    @export var rejection_samples: int = 30
7
8    var x_tile_range: int = ProjectSettings.get_setting("display/window
         /size/viewport_width") / tile_set.tile_size.x
9    var y_tile_range: int = ProjectSettings.get_setting("display/window
         /size/viewport_height") / tile_set.tile_size.y
10
11    # Called when the node enters the scene tree for the first time.
12    func _ready():
13        randomize()
14        for x in range(-50, x_tile_range + 50):
15            for y in range(-50, y_tile_range + 50):
16                set_cell(0, Vector2(x, y), 0, Vector2(0, 0))
17        cell_points = generate_points(point_radius, region_size,
             rejection_samples)
18
19    func generate_points(radius: float, sample_region_size: Vector2,
         number_of_samples_before_rejection: int = 30) -> Array[Vector2
         ]:
20        var cell_size: float = radius / sqrt(2)
21        var grid: Array[Array] = []
22        var points: Array[Vector2] = []
23        var spawn_points: Array[Vector2] = []
```

```gdscript
24
25        spawn_points.append(sample_region_size/2)
26
27        while spawn_points.size() > 0:
28            var spawn_index: int = randi_range(0, spawn_points.size() -
                  1)
29            var spawn_centre: Vector2 = spawn_points[spawn_index]
30            var candidate_accepted: bool = false
31
32            for i in range(number_of_samples_before_rejection):
33                var angle: float = randf_range(0.0, 1.0) * TAU # TAU = PI
                      * 2
34                var direction: Vector2 = Vector2(sin(angle), cos(angle))
35                var candidate: Vector2 = spawn_centre + direction *
                      randf_range(radius, 2 * radius)
36                if is_valid(candidate, sample_region_size, cell_size,
                      radius, points, grid):
37                    points.append(candidate)
38                    spawn_points.append(candidate)
39                    grid[int(candidate.x/cell_size)][int(candidate.y/
                          cell_size)] = len(points)
40                    candidate_accepted = true
41                    break
42
43            if not candidate_accepted:
44                spawn_points.remove_at(spawn_index)
45
46        return points
47
48    func is_valid(candidate: Vector2, sample_region_size: Vector2,
          cell_size: float, radius: float, points: Array[Vector2], grid:
          Array[Array]):
49        if candidate.x >= 0 and candidate.x < sample_region_size.x and
```

```
          candidate.y >= 0 and candidate.y < sample_region_size.y:
50            var cell_x: int = candidate.x / cell_size
51            var cell_y: int = candidate.y / cell_size
52            var search_start_x: int = max(0, cell_x - 2)
53            var search_end_x: int = min(cell_x + 2, x_tile_range - 1)
54            var search_start_y: int = max(0, cell_y - 2)
55            var search_end_y: int = min(cell_y + 2, y_tile_range - 1)
56            for x in range(search_start_x, search_end_x):
57                for y in range(search_start_y, search_end_y):
58                    var point_index: int = grid[x][y]
59                    if point_index != -1:
60                        var distance: float = (candidate - points[
                                point_index]).length()
61                        if distance < radius:
62                            return false
63            return true
64        return false
```

C.5.6 icon.svg.import

```
1   [remap]
2
3   importer="texture"
4   type="CompressedTexture2D"
5   uid="uid://uotfe6soknht"
6   path="res://.godot/imported/icon.svg-218
        a8f2b3041327d8a5756f3a245f83b.ctex"
7   metadata={
8   "vram_texture": false
9   }
10
11  [deps]
```

```
12
13   source_file="res://icon.svg"
14   dest_files=["res://.godot/imported/icon.svg-218
         a8f2b3041327d8a5756f3a245f83b.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
22   compress/normal_map=0
23   compress/channel_pack=0
24   mipmaps/generate=false
25   mipmaps/limit=-1
26   roughness/mode=0
27   roughness/src_normal=""
28   process/fix_alpha_border=true
29   process/premult_alpha=false
30   process/normal_map_invert_y=false
31   process/hdr_as_srgb=false
32   process/hdr_clamp_exposure=false
33   process/size_limit=0
34   detect_3d/compress_to=1
35   svg/scale=1.0
36   editor/scale_with_editor_scale=false
37   editor/convert_colors_with_editor_theme=false
```

C.5.7   monochrome_packed.png.import

```
1   [remap]
2
```

```
 3   importer="texture"
 4   type="CompressedTexture2D"
 5   uid="uid://c3bpsm4r8t504"
 6   path="res://.godot/imported/monochrome_packed.png-6
          b9bd1c64dd50f72acd3afd14d1ac34f.ctex"
 7   metadata={
 8   "vram_texture": false
 9   }
10
11   [deps]
12
13   source_file="res://monochrome_packed.png"
14   dest_files=["res://.godot/imported/monochrome_packed.png-6
          b9bd1c64dd50f72acd3afd14d1ac34f.ctex"]
15
16   [params]
17
18   compress/mode=0
19   compress/high_quality=false
20   compress/lossy_quality=0.7
21   compress/hdr_compression=1
22   compress/normal_map=0
23   compress/channel_pack=0
24   mipmaps/generate=false
25   mipmaps/limit=-1
26   roughness/mode=0
27   roughness/src_normal=""
28   process/fix_alpha_border=true
29   process/premult_alpha=false
30   process/normal_map_invert_y=false
31   process/hdr_as_srgb=false
32   process/hdr_clamp_exposure=false
33   process/size_limit=0
```

34   `detect_3d/compress_to=1`