

Procedural Content Generation

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1 Introduction

As part of this project, a structure generator has been developed to generate randomized content in Minecraft (v1.19.2) procedurally. The program has been developed using the Generative Design in Minecraft Challenge python package which communicates with the game using HTTP requests. For the development and testing of the generative script, Minecraft single-player mode was used with specific mods to allow procedural content generation.

2 Design

The design of the structures that can be generated using the developed python script is based on typical apartment buildings that can be seen in the city centre of Amsterdam. The generated houses are most often built from bricks, however, other materials are also used to randomize the outlook of the homes. Since these houses are rarely standing on their own if the terrain allows it the buildings are generated tightly next to each other like it is in Amsterdam. Furthermore, a part of a canal is also generated as part of the script with a sycamore tree standing next to it to better imitate the real-life features of the city.

The interior design of the houses consists of four rooms:

- Livingroom - This room has a large sofa with bookshelves and a fireplace.
- Bedroom - There is a bed with bedside tables in this room as well as a desk.
- Kitchen - The dining table is in the middle of the room and the kitchen is on the side in an L-shape.
- Study - Bookshelf at the entrance and two desks at the other end of the room.

3 Environment & Placement

As well as many other aspects of the house, the width can also vary, for this reason, the algorithm first chooses the size of the next house randomly and then scans the build area for suitable places. An area is suitable for generating a house when it does not have more than 3 blocks of difference in the minimum and the maximum elevation of the terrain. The bounds of the area are always 9 blocks in front of the house, 14 blocks for the length of the house and 3 blocks after the building while the width changes randomly from 5 to 9. The 9 blocks in front of the house are needed for the 3 blocks of pavement in front of the porch and an additional 4 blocks of water for the canal, the canal is 2 blocks deep and all blocks from in front of the house are cleared. The house is automatically adjusted to the terrain by using a foundation 1, 2 or 3 blocks high based on the differences in the terrain under the house. When building the foundation dirt and other already existing blocks are not replaced or removed apart from the ones in front of the house. This is necessary for houses to be accessible, also for aesthetic reasons.

4 Randomnes & Variation

The house is built out of several different components to ease the generation of variable results. Firstly the size of the house is randomly selected based on the following random distribution:

- 40% chance that the house will be 7 blocks wide
- 20% chance that the house will be 6 or 8 blocks wide (each)
- 10% chance that the house will be 5 or 9 blocks wide (each)

As the base of the house is built the underlying block and pavement are places where the house will be built. The canal in front of the house is also generated as part of this stage. Next to the canal, a sycamore tree is also generated with randomized sizes. The trunk and the foliage both are randomized in height independently from each other, with the following probability:

- 30% chance that the trunk will be 8 and the foliage 5 blocks high
- 25% chance that the trunk will be 7 or 9 and the foliage 4 or 6 blocks high (each)
- 10% chance that the trunk will be 8 or 10 and the foliage 3 or 7 blocks high (each)

After the area has been selected and prepared the foundation and porch are built using stone_bricks. As it is mentioned in the previous section the height of the foundation is based on the previously existing terrain within the building area.

The next step in the generation is building the house floor by floor, the building always has at least two floors and the maximum number of floors is 6. The number of floors is also determined by random distribution as follows:

- 40% chance that the house will have 4 floors
- 20% chance that the house will have 3 or 5 floors (each)
- 40% chance that the house will have 2 or 6 floors (each)

As mentioned in previous sections the houses can be built from different materials, just as in real life. To randomize the outlook of the buildings a number of building block has been selected to give variation by introducing different colours to the generated structures. The list of possible blocks with the probability distribution is in the list below:

- There is a 25% chance that the walls will be made out of regular bricks
- mud_brick, stone_brick and smooth_quatz all have an equal 15% chance each to be selected
- end_stone_bricks, deepslate_bricks and red_nether_bricks have a slightly lower chance with 10% probability to be selected

Furthermore, the rooms within the house are also randomly varied. There are two options for both the front and the back of the house.

- Living room and Kitchen can be in the front part of the house with equal chances to be selected
- Bedroom and Study room are both generated in the back part of the house with 50-50% chance also for each to be selected

5 Limitations & Future Improvements

The generated structure was able to generate correctly in most flat terrains. With varying altitudes or large oceans, it may not find places to generate, however, this is intentional as we expect the build area to be similarly flat as the real-life placement of Amsterdam. With hills or mountains, this generator would only work if we would allow it to drastically reshape the surface of the world.

In a few instances, the canal may flow out of the canal bed where the elevation of the blocks in front of the house has a lower elevation than most of the area of the house. This may be handled simply in the future by generating extra blocks at the other side of the canal, however, in most cases, this is not the case. On the sides of the canal, however, it is more difficult to place extra blocks as houses generated in the future usually form a longer canal together.

The interiors of the house could also be improved in the future, by randomizing the colours of carpets and beds. Also by placing paintings on the wall, the rooms can be made more appealing, however, paintings and item frames do not behave as blocks and are not supported by the python package. During development item frames in the kitchen were placed by running raw Minecraft commands using the following utility function:

```
def placeEntity(point, name, states):
    options = json.dumps(states)
    coordinates = "{x} {y} {z}".format(x=point.x, y=point.y, z=point.z)
    editor.runCommand(f"summon {name} {coordinates} {options}")
```

6 Appendix: Screenshots







