Sketch2Tooncity:Sketch-based City Generation Using Neurosymbolic Model

Junya Kanda, Yi He, Haoran Xie, Kazunori Miyata
Japan Advanced Institute of Science and Technology, Ishikawa, Japan

***Abstract*—To generate a large-scale city under user's design intention is an interesting and important issue in various applications in computer graphics and entertainment productions. However, modeling the buildings individually in a large city is labor intensive and impractical for real productions. In this study, we propose an efficient city-generation method based on user sketches. The proposed framework combines Conditional Generative Adversarial Networks(cGAN) and procedural modelling, which we call the Neurosymbolic Model. For the data training, we randomly generated three-dimensional cities from Perlin noise. The contours of the cities were extracted by the morphological transformation approach. The paired sketch extracted by morphological transformation and heightmap data generated from control parameters is used in the training stage. Users can generate diverse and satisfied cities from free-hand drawn sketches.**

***Index Terms*—city generation, GAN, procedural model**

I. Introduction

The common approach in urban design is to use procedural modeling. Benes et al. [1] developed Urban Brush, which can interactively and consistently change the layout of a city. In a paper on city formation using GAN, Kim et al. [2] introduced a method to generate a 3D virtual model of an imaginary city from a single street view image. However, it is difficult for the designers or common users to design the generated city models in their design intentions. To address the above issues, we propose a sketch-based city generation framework with grammar-based procedural model. Especially, we adopted the procedural modeling tool of Townscaper.

II. Proposed Methods

First, a height map for a city model is generated from the control parameters. The viewpoint of the height map is fixed and the user is assumed to be looking from above.

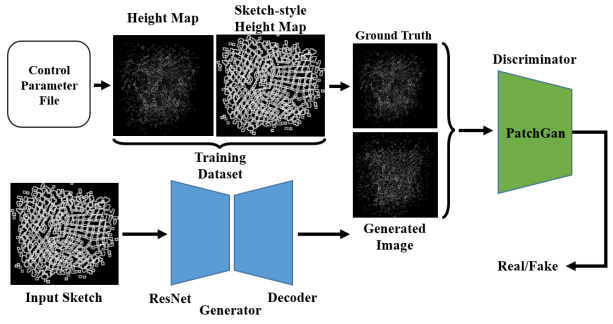

Fig. 1. Overview of the proposed system.

The generated height maps were converted into sketch-style height maps, which were used as the training dataset for deep learning. The height maps used as input to the discriminator. cGAN structure was used to generate height maps based on the sketches and the control parameters corresponding to the sketch were obtained.

To obtain the training dataset, morphological transformations are applied to the height maps generated from the control parameters. This process allows to extract the contours of the squares of the control parameters. The extracted contours surround the squares were used as hand-drawn sketches.

For implementation details, we used Perlin noise for random control parameters. We applied 9 blocks of ResNet for the generator, and the PatchGAN for the discriminator. L1 loss is added to the discriminator loss function that the generated results are close to the ground truth height distribution.

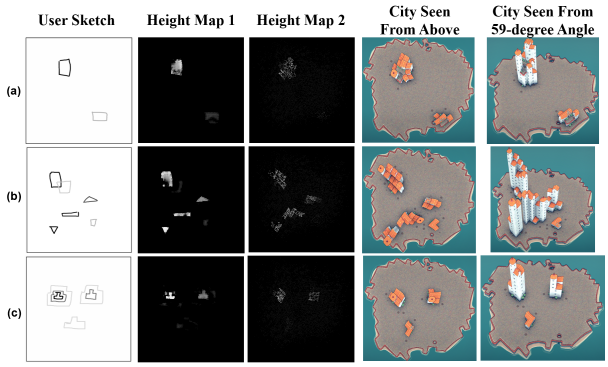

Fig. 2. City generated from user sketches. Height Map 1 is generated from user sketch. Height Map 2 is the height information using the control parameters. (a) Simple sketch. (b) Complex sketch. (c) Layered sketch.

III. Result

The 3D city models generated by the proposed system are shown in Figure 2. A black line indicates a high building and a bright line indicates a low building. We conducted System Usability Scale (SUS) study, and verified that the proposed system has good usability.

References

[1] B. Benes, X. Zhou, P. Chang, and M.-P. R. Cani, "Urban brush: Intuitive and controllable urban layout editing," in *The 34th Annual ACM Symposium on User Interface Software and Technology*, 2021, pp. 796–814.

[2] S. Kim, D. Kim, and S. Choi, "Citycraft: 3d virtual city creation from a single image," *The Visual Computer*, vol. 36, no. 5, pp. 911–924, 2020.