Demo

Holo Worlds Infinite: Procedural Spatial Aware AR Content

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Abstract
We developed an Augmented Reality (AR) application that procedurally generates content which is programmatically placed on the floor. It uses its awareness of its spatial surroundings to generate and place virtual content. We created a prototype that can be used as the basis of a city simulation game that can be played on the floor of any room space, but the approach could also be used for many other applications.
CSS Concepts
• **Human-centered computing~Mixed / augmented reality** • **Computing methodologies~Mixed / augmented reality** • *Information systems~Multimedia content creation*

1. Introduction

Created to run on Microsoft HoloLens, Holo Worlds Infinite is a project that utilizes methods which procedurally generates virtual content for Augmented Reality (AR) scenes. HoloLens World Infinite addresses two important problems for AR applications; (1) rapidly generating AR content, and (2) generating AR content that dynamically fills the available real space. Procedurally generating content for AR is a challenge, as AR involves superimposing virtual objects over the real world.

We address the challenge of procedurally generating content that fits around any existing environment, without relying heavily on user input. The goal was to use a hardware device that scans any room that the user is in and then starts creating and placing virtual objects in the real environment, without users manually placing objects.

To achieve this, there are two aspects to the problem that were solved. One was procedurally creating content based on the surrounding space. This was done in the form of a procedurally generated road system for a virtual city. The second aspect was the placement of virtual objects, by filling the spaces between the roads with houses. Although demonstrated with a virtual city, our approach could be adapted to many other types of application content.

Our main contribution is combining procedural generation with spatial awareness of the surrounding space. We adapted existing procedural generation algorithms to work with depth sensed room scans, and developed a prototype of a system that turns the floor of any room into

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a game space. Figure 1 shows our procedurally generated city fitting into a room scanned by a Microsoft HoloLens. This is what the user sees when the virtual city is generated.

Figure 1: *Screenshot of the prototype showing the procedurally generated content overlaying the real world.*

Procedurally generated content for AR is uncommon, with an exception being level generators [ASG*16], which rendered everything with VR equipment instead of using a mixed reality device or AR device. This is similar to a couple of VR applications that attempt to use the real world environment to shape virtual game worlds [SX16] [SGS*16]. Instead of replacing the real world with a rendered reconstruction, either partial or complete, our prototype uses an AR headset, the Microsoft HoloLens, to view the generated content overlaying the actual environment, as demonstrated in Figure 1.

2. Prototype

To demonstrate how the procedural AR content generation worked, we built a simple virtual city simulation that could be viewed on the HoloLens. To do this, we used the Unity game engine and Microsoft's HoloToolkit Unity plugin.

We utilized the spatial capabilities of the HoloLens by using the Spatial Understanding feature of the HoloToolkit. We created a method that takes x and y values of a real location and a tile size value and determines if a tile can be placed at that location.

The procedural generation has two parts, road generation and building placement. The road generation uses a L-system [PM01]. The building generation uses the Unity engine's inbuilt Perlin noise function and a location to decide which building model belongs where. Any 2D square-grid based road generation system should work with our system. The main procedural algorithm uses a while loop that will look at a potential road and then decide whether it meets local constraints. The pseudo-code for the road generation is listed below:

```
Let P = PriorityQueue<Road>()
//Accepted roads meeting local constraints
Let S = List<Road>()
P.EnqueueAll(StartingRoads)
While (P.Count > 0)
        Let R = P.DequeueSmallest()
        Let A = CheckLocalConstraints(R)
        If (A==false) continue
        S.Add(R)
        P.EnqueueAll(GlobalGoals(R))
Return S
```

The steps are as follows:

1) We have six starting roads, two roads that span horizontally and vertically across the extents of the scanned area from where the user initially stands, and four roads that span around the edge of the scanned area.

2) We generate the rest of the roads using the while loop. The local constraints simply return true whether the road is at a minimum parallel distance to all other roads. The global goals method generates potential roads at random sizes all around the newly placed road like an L-shape. This produces a road network from which we remove any road tiles which are is not feasible.

3) Four Booleans determine which road tile model should be displayed at a given grid location. These represent if there are tiles north, south, east or west of the current tiles. The compass directions are set based on the tile's orientation within the Unity coordinate system.

Once the roads were generated, buildings were placed adjacent to them, using simple checks to see if tiles were unoccupied and if they were adjacent to roads. We kept track of the state of each tile by a set of maps (2D arrays of Booleans), one for road and another for buildings. Selecting a building model was achieved by a 2D Perlin noise function, which was part of the default Unity engine. The Perlin noise would determine the index of the building selected from an array of all the building models

The user experience at this stage is very simple. When Holo Worlds Infinite is started, it requires an initial room scan, the completion of which is determined by a gesture from user, which is one of the default HoloLens gestures, the air tap. Once the room is scanned, Holo Worlds Infinite generates a virtual city that the user can view, as shown in Figure 1. We plan to iterate on the project, to add more user functionality, as Holo Worlds Infinite is intended to be a city simulation game.

3. Conclusion

We have successfully combined AR procedural generation with the Microsoft HoloLens' depth sensing capabilities. The procedural generation algorithms, using L-systems and Perlin noise, were modified to be aware of the surrounding environments. The main benefit of our approach is that it allows procedural real-time creation of AR content that can be adapted to fit any real world environment. Our prototype has not been optimized, yet runs at an acceptable rate on a mobile, wearable computer, the HoloLens. Although we demonstrated our application with a virtual city simulation, it could be used for generating a wide range of AR content, such as virtual landscapes, forests, carpets, virtual tiles or wallpapers.

References

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