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RESEARCH OF THE POSSIBILITIES OF GENERATION OF NATURAL LANDSCAPES BASED ON PERLIN NOISE

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ABSTRACT. Description of the Perlin noise algorithm for creating game landscapes. Learn how these enhancements create more authentic landscapes in game add-ons. Perlin's noise enhancements enable developers to create immersive environments with increased realism.

Introduction. In the world of modern video game development, the use of Perlin noise to generate unique and interesting game environments has proven to be extremely important. Perlin noise, developed by the American scientist Ken Perlin in 1983, has become a key tool for realizing life-like and detailed landscapes in video games. The use of noise for generation in modern games is of great importance as it allows not only to create a variety of immersive landscapes, but also provides players with a unique gaming experience.

The goal of the work. Researching the possibilities of generating natural landscapes based on Perlin noise to increase their realism according to the gamer preferences.

The main part of the work. *Minecraft, Terraria* and *No Man's Sky* are just a few games that implement procedural generation of landscapes. Various noises are used for this generation: Perlin noise, simplex noise, fractal noise, numerical noise, etc. In this work, we will consider the use of Perlin noise, as it is one of the most powerful and popular. The Perlin noise algorithm consists of 3 steps:

1. Creating a grid of nodes: First, a grid of nodes is created in n-dimensional space where each node is a point with certain coordinates.
2. Random vector generation: For each grid node, a random vector is generated, which is a pseudo-random gradient. These vectors are usually pre-generated and stored in a table to ensure repeatability of the noise.
3. Interpolation of values: For each point in space it is determined which nodes it is closest to. Interpolation between the random vectors associated with the nearest nodes is then used to obtain the noise value at that point.

Perlin noise has a more organic appearance than white noise because it creates a naturally ordered ("smooth") sequence of pseudorandom numbers that resembles mountain peaks, valleys, and sea lows. An example of the differences between white noise (Figure 1.1) and Perlin noise (Figure 1.2) is given below:

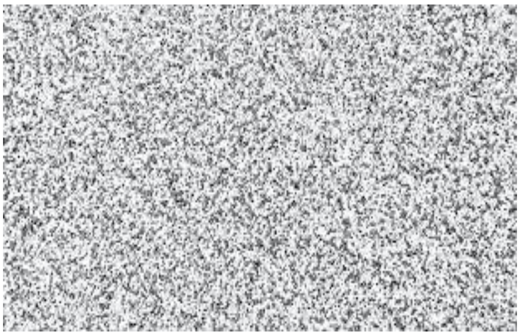

Figure 1.1 - white noise

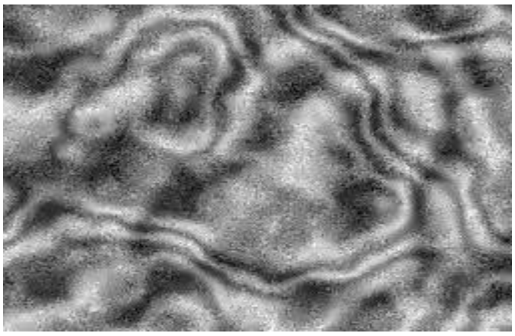

Figure 1.2 - Perlin noise

The point is that the Perlin function generates quite simple and fairly uniform noises. To obtain more heterogeneous noises, which in three-dimensional space are more reminiscent of rivers, mountains and lowlands, usually several noises of different frequency and amplitude. Noise levels with different amplitude and frequency values are called octaves. The more octaves the more heterogeneous and realistic the final surface becomes.

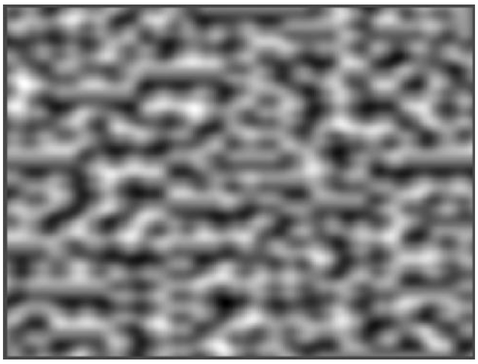

Figure 1.3 - Perlin noise with 1 octave

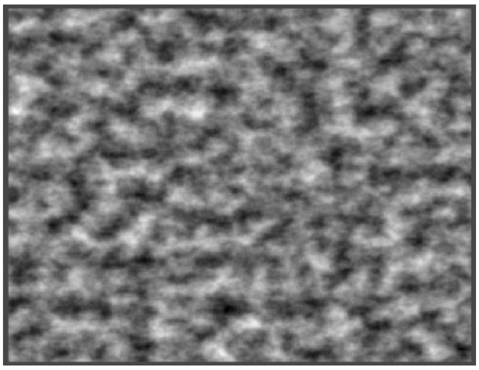

Figure 1.4 - Perlin noise with 4 octaves

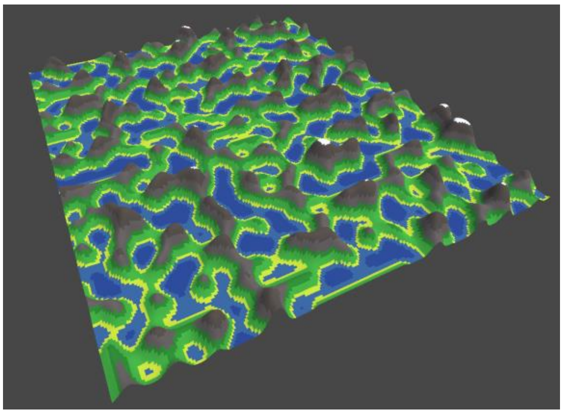

Figure 1.5 - Landscape generated by noise Pearl with 1 octave

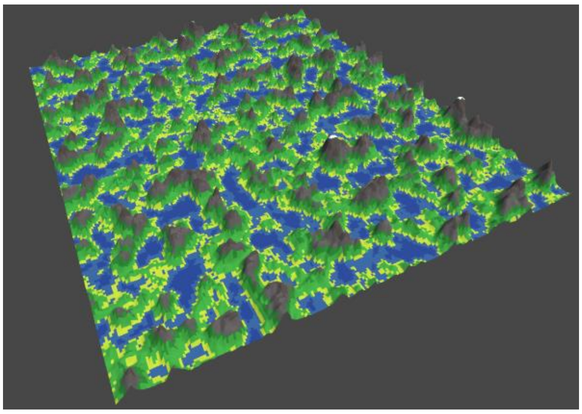

Figure 1.6 - Landscape generated by noise Pearl with 4 octaves

In addition to octaves, it is worth noting how the following factors affect noise generation:

1. Frequency determines how fast the noise changes per unit distance. Larger values result in larger fractal structures.
2. The amplitude value determines how much each octave affects the result. Large amplitude values make low-frequency noise components more pronounced.
3. Repeatability indicates how far apart the noise starts to repeat. This helps create smoother transitions between noise values.
4. Seed is the initial value used to generate the noise. Allows you to create the same noise every time you run the program with the same seed.

But why can't this algorithm be the only basis for games based on procedural generation? Table 1 lists several advantages and disadvantages.

Table 1 - Advantages and disadvantages of Perlin noise

Advantages	Disadvantages
The algorithm makes it possible to generate endless maps with a large number of different landscapes	Procedural generation becomes fairly homogeneous. Landscapes and "biomes" begin to repeat themselves.
Generation cannot be predicted. It is not known which landscape will be generated next.	Sometimes even game developers cannot foresee some situations that can lead to incidents.

Saving memory. When locations are created by a human, each object is stored separately, while procedurally generated objects are stored as separate maps and save space.	Sometimes the generation can be wrong and give confusing and even funny results. Due to the impossibility of predicting all possible combinations, there is a chance of an unsuccessful outcome.

Conclusions. Based on the research done, it can be concluded that the use of the Perlin noise algorithm to create game landscapes is an important and even fundamental element of modern video game development. This method allows developers to create more realistic and attractive game environments, providing players with a unique immersive experience. Research into the possibilities of generating natural landscapes using Perlin noise is aimed at increasing the realism and immersiveness of game environments, which is important to meet the needs of users in modern video games.

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