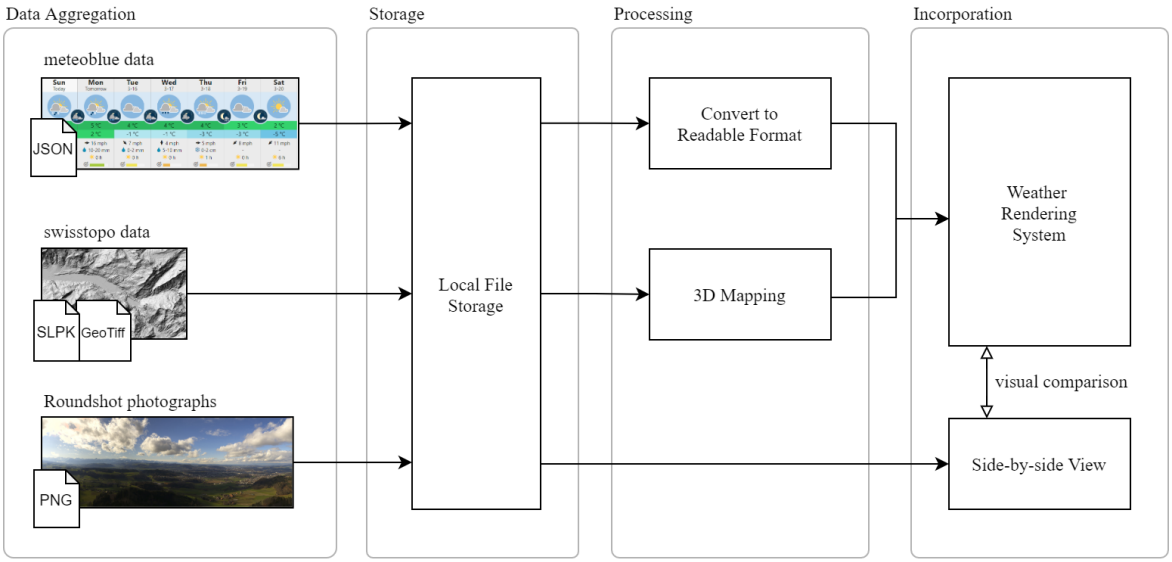
Real-time Weather Rendering System

Project documentation



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Abstract

Clouds contribute a great deal to the overall ambience in games and can be the cherry on top by filling the sky with life. To get as close as possible to real clouds, this project engages in researching and prototyping a procedural, volumetric cloud shader.
In order to achieve volumetric rendering, the document dives into the concept of ray marching, a group of methods used to render a 3D data set inside a container box to make it appear volumetric. Several variants of it are expanded on, like constant step, traditional, and sphere-traced ray marching. Additionally, to account for perception of depth, the volume can be shaded with the aid of surface normal estimation.
In the second part, 2D and 3D noise generation algorithms like Perlin's noise and the Voronoi algorithm are explained in detail. With fractal Brownian motion, the different layers of noise are then merged into one highly detailed noise texture.
At last, the goal of the project was to create prototypes in Unity displaying both volumetric rendering and noise algorithms, of which all were created successfully. Prepared with the combined knowledge of the research results and prototypes, a final shader was created, able to render a completely procedural and volumetric cloudscape.
For future work, the shader could be expanded into a fully-fledged weather simulation system with meteorologically accurate formation of clouds, rain, snow and much more.

Contents

1 General

1.1 Purpose

During this project, all gathered information and knowledge about the researched algorithms and techniques are written down. All prototypes and the final results are documented and compared with real photographs of clouds.

1.2 Audience

This document is written with the intent to further expand existing knowledge about the topic, hence it requires a fundamental knowledge about computer graphics and rendering.

1.3 Revision History

Version	Date	Name	Comment
0.1	March 25, 2020	Matthias Thomann	Initial draft

2 Natural Clouds

Clouds are a substantial part of Earth's weather. They provide shade from the glistening sun on hot days and reflect the heat at night, keeping the ground warmer. For a layman, clouds are comprehensible and useful indicators for telling the weather. If they are dark and low-hanging, they bring rain. If they are puffy and scarce, they predict fair weather ahead.

2.1 Types of Clouds

In order to create a weather rendering system that is able to display many different cloudscapes, all distinct types of clouds have to be understood first. Natural clouds are typically identified by two major factors: shape and altitude.

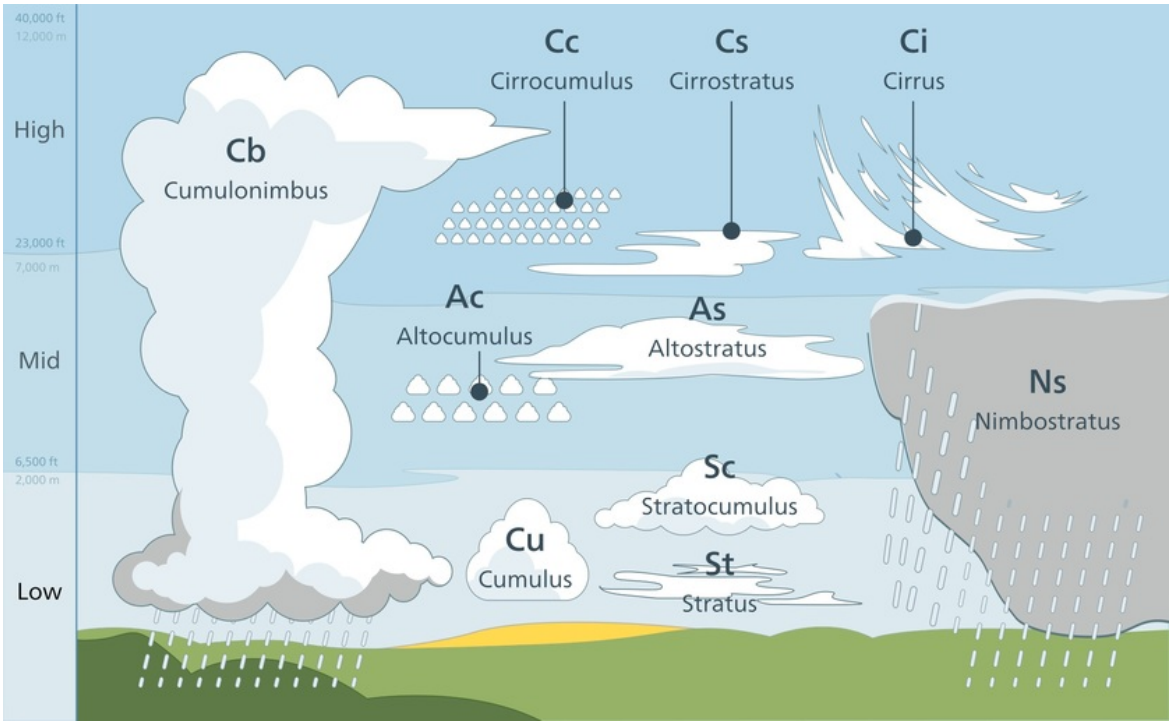

Figure 1: Different categorizations of cloudshapes [1].

This graphic from *sciencelearn* provides and excellent overview of all distinct cloud types. Each type is depicted in its signature shape and marked with the scientific name and abbreviation.

2.1.1 Classification of Altitude

The altitude, which is the distance from sea level to the cloud, is further split into three categories "low", "mid" and "high".

2.1.2 Classification of Shape

Glossary

Altitude A vertical distance measurement, in this context specifically the distance from sea level to the given object. 2

Fractal Brownian motion Different iterations of continuously more detailed noise layered on top of each other. i

Noise A randomly generated pattern, referring to procedural pattern generation. i

Procedural Created solely with algorithms and independant of any prerequisites. i, 3

Ray marching Ray marching is a type of method to approximate the surface distance of a volumetric object, where a ray is cast into the volume and stepped forward until the surface is reached. i

Surface normal A *surface normal* or *normal* is a vector which is perpendicular to a given geometry, like a triangle or polygon. i

Volumetric This describes a technique which takes a 3D volume of data and projects it to 2D. It is mostly used for transparent effects stored as a 3D image. i

Weather rendering system The Unity application that is implemented during this project. It takes in live data from a weather service and uses topological elevation models to create a weather simulation, which is then rendered and up for comparison with live photographs. 2

References

[1] *Observing clouds and weather - cloud types*, [Online; accessed April 07, 2021], 2014. [Online]. Available: https://www.sciencelearn.org.nz/resources/628-observing-clouds-and-weather.

List of Figures

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