ARWeather - An Augmented Reality Weather System

Marko Heinrich†
Universitaet Koblenz-Landau

Bruce H. Thomas‡
University of South Australia

Stefan Mueller†
Universitaet Koblenz-Landau

ABSTRACT

This paper presents the design and development of an ARWeather simulation application, which can simulate various types of precipitation: rain, snow, and hail. We analysed various real occurrences of weather types and how they could be simulated in a mobile Augmented Reality system. The Tinmith system is wearable computer system for the development and deployment of the final ARWeather system that allows for autonomous and free movement for the user. The users can move freely inside the simulated weather without limitation.

Index Terms: I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality—Animation; I.6.8 [Types of Simulation]: Animation—Visual

1 INTRODUCTION

This work was inspired by the simulated rain and weather in current computer games. From the experiential viewpoint, the addition of weather adds texture and realism to the gameplay, and from a technical standpoint, the addition of weather features in believable form appeared to be quite possible. This paper explores the use of outdoor Augmented Reality (AR) to provide the impression of different forms of weather. Imagine you are in a bright sunny Australian day, and with the flick of a switch you are back in a overcast rainy day in England, see Figure 1. Users equipped with a wearable computer can be directly walk and move inside the artificial weather and visually experience rain, snow, and hail. A visual change of the real weather conditions can be used in the following application domains: as a supplement for training simulations for search and rescue teams or military training [3], in education to show people the different aspects of weather, or in entertainment like in pervasive gaming to intensify the atmosphere. To date, there have been limited investigations into the visual simulation of weather for outdoor AR.

2 BACKGROUND

Precipitation can occur in various forms, either solid or liquid depending on the temperature of the air through which it falls. If a frozen precipitation reaches ground level without melting on the way down, it can be recognised in solid form as snow or hail. If it melts while falling down, it may appear in liquid form as rain. But the raindrops can start freezing again before reaching the surface when the temperature on the ground is cold enough and results in different types of precipitation [1]. A precipitation can be defined by its type, intensity and continuity. Investigations with virtual environments dealing with the topic of weather simulation are almost exclusively performed within the domain of VR [5]. There is only a limited set of investigations that employ AR in combination with weather simulation. To our knowledge, there are no investigations concerning simulating weather in a mobile outdoor AR. There has not been any known research for simulating the precipitation in the form of hailstones, and thus information about simulating other types of precipitation has to be used for simulating falling hail in this work.

The two known AR investigations dealing with weather are made by Trembliński [6] and Gliet [2]. Andrzej Trembliński presents naturalistic methods for the visualisation of meteorological data in AR. His work concentrates on rendering clouds and sky visualization. The second investigation is Jana Gliet’s “Augmented Reality Weather Cam (AR Weather Cam)” [2], a framework for the visualisation of georeferenced weather data. It allows for the creation of a mashup of a webcam image and additional spatial and textual data.

Tinmith is a belt mounted hardware/software AR wearable computer system [4]. Batteries are fixed to the belt providing power for 2-3 hours. The helmet is connected through two cables to the backpack. Headphones are adhered inside the helmet, so ambient sounds can still be heard. The Tinmith system employs video see-through technology.

3 ARWeather

ARWeather visually simulates a change from a sunny or cloudy day to one that is raining (see Figure 1), snowing, or hailing. We are not attempting the removal of the real occurring weather condition first. For example if the weather condition shall be changed from real falling snow into augmented rain, the system would not remove the vision of the falling snow.

The particle system implemented in ARWeather is based on the Particle System API 2. The top class of the particle system ParticleSystem has methods to add and remove main emitters and build particles to be emitted. All emitters have parameters containing information about: the emitter position in world space, the size of the emitter, their precipitation type, and their number of simulated particles. The particles have various properties: size, position, velocity, pointer to their parent sub-emitter, isGrounded (for the bouncing used for hail simulation), and groundingTime (for the accumulation on the ground).

†e-mail: marko.heinrich@uni-koblenz.de
‡e-mail: bruce.thomas@unisa.edu.au
†e-mail: stefan.mueller@uni-koblenz.de

IEEE International Symposium on Mixed and Augmented Reality 2008
15-18 September, Cambridge, UK
978-1-4244-2859-5/08/$25.00 ©2008 IEEE
The density of a precipitation controls how heavy the rain, snow, or hail appears to the user. The density is dependent on the number of simulated particles and the volume the particles are simulated in. To keep the distribution and flow of the particles constant, particles that have fallen to the ground are immediately reinitialised in the emitter plane. This has also a performance advantage, because the particles are not deleted and recreated. The same behaviour happens when a particle floats outside the vertical borders of the emitter volume defined by the emitter plane and the ground level. In that case, the particle keeps its floating direction, but reinitialises on the opposite side of the emitter volume.

The area where the precipitation will be simulated needs to be limited due to the performance requirements that the weather should be simulated in real-time. We use a grid system for the simulated area that is divided into smaller sub-areas. The user stands in the centre sub-area of the simulated field (see Figure 2 position 1, left diagram). If the user moves across a border of the centre sub-area (see Figure 2 position 2, right diagram), the appropriate row and/or a column of the sub-areas is moved from the back to the front of the user. The user thus always stands in the centre of the simulated area. When in operation, the grid system’s position determined by the GPS system is compared with the borders of the centre emitter. The position is adjusted if required. With the grid system the user has the possibility to walk around freely without ever reaching the border of the simulated area, and the user experiences a fully 3D impression with real particle movement in horizontal and vertical directions.

The snowflakes and hailstones in ARWeather are rendered with a partly transparent texture mapped onto an OpenGL GL_QUAD in combination with spherical billboarding. The rain is rendered with a line and the line colour fading from partially transparent to fully transparent. The result of the rendered rain can be seen in Figure 1. The collision detection for the particle system in the AR-Weather simulation is done with the ground. Ground accumulation for hail only is simulated by using particles that stay on the ground for 2 seconds. This period ensures that there is always recognisable hail accumulating on the ground, but at the same time there is still enough particles in the air to simulate higher densities. A problem with simulating the particles occurs because of the GPS system produces tracking errors (jitter) in the position information. This is not a large problem when simulating fast movements or large objects. When smooth and slow movements like falling snow are simulated, these errors cause visual anomalies in the animation. The largest relocations are recognisable with snowflakes when they are very close to the user’s viewpoint. This problem of uncontrollable jittering is compensated by reducing the maximum values for changing the position of a particle between two frames. Thus smaller coordinate system relocations are less recognisable and the impression is still realistic.

To improve the lighting conditions to a more realistic illumination when precipitation is falling, the natural lighting of the environment is altered. Before the video stream for the AR is displayed to the user, every frame is processed with a fragment shader. The frame processing of ARWeather is performed in three steps: 1) The brightness is reduced by subtracting a certain amount from the colour of each fragment. 2) The contrast is reduced by using a threshold and multiplied with a contrast value. 3) The amount of blue saturation for some fragments is reduced. The advantage of this conversion into the HSV colour space is the easy detection of blue areas (sky) in a frame (hue angle between 160 and 290 degrees).

Sound plays a very important role when creating the impression of immersion in weather. Hearing precipitation falling is also a relevant element of an ARWeather simulation, as it is part of the whole impression. We support the sound of the impact of falling precipitation like rain and hail on the ground. Falling snow reaches the ground surface with a very low speed and the flakes have a low weight that no audible sound is created. The sound of wind blowing is supplied while precipitation is falling (impact sound can be combined with a wind sound). Because sounds occurring during precipitation have no easily defined source, all simulated sounds are ambient. During heavy rain lightning strikes cause a thunderclap a few second later.

4 Conclusion

In this work, a method for visually simulating three different kinds of weather in mobile outdoor AR was presented. The Tinmith system was used as the wearable AR platform for the development of the ARWeather system. A custom particle system based on a reconfigurable grid system provided an excellent solution to simulate the large quantity of precipitation particles in three dimensions. This produces a realistic impression for the user. We were able to simulate three different types of precipitation (snow, rain, and hail) in an unbounded outdoor area.

One focus in the future for improving the weather simulation is the enhancement of the accumulation simulation on the ground. It is important to find a balance between the additional calculation effort and the quality of the accumulation. A second visual improvement would be the effect of motion blur for rendering hail, which occurs because of the fast falling speed of hailstones.

Acknowledgements

The authors wish to thank the men and women of the Wearable Computer Lab in the University of South Australia for all there support and help on this project. In particular we would like to thank Dr. Wayne Pietkarski, Benjamin Avery, and Ross Smith for their knowledge and help with the Tinmith system.

References