



Static vs dynamic weather systems in video games

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Computer Science
Bachelor's Thesis
15 ECTS
Spring 2021
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I. Introduction

Video games and virtual environments have lately advanced into the capability to reproduce real world environments [1]. Gamers [2] (video game users) set new standards with each new release, putting more pressure on the game developers to create games with an increased number of realistic attributes. The technical components have been challenged as to what and how much they can accomplish [3].

Wolfgang [4] wrote about certain objective criterias that games desire to achieve in order to potentially be good. Amongst those criterias is uniformity which means that the title, graphics and theme should give a unified impression. This is where weather comes to play. If a game has a realistic theme, a weather system could be required to give a unified impression. Gamers [2] and modders [5] have also hinted their interest in detailed and expressive weather simulations which can be seen with the amount of modifications made to the game Skyrim [6][7]. According to Roberts and Patterson, there are two different approaches when creating a weather simulation, dynamic or static [8].

Static weather simulations are fairly easy to create in comparison to dynamic weather, because dynamic weather systems are computationally heavy or time consuming [8], especially well designed ones [9]. While it is easier to create static weather, research has shown that dynamic weather is more rewarding, in regards to achieving realism [8]. But by implementing dynamic weather, it limits the options to add other resource demanding assets. In order to make effective game design decisions in relation to weather immersion, developers need to understand the implications of weather systems and its weather components.

The objective of this study is to investigate which weather components have the most impact on the player immersion, and to examine the value and implication of a dynamic weather system.

To achieve this objective, a comparison between dynamic and static weather systems are required. Each weather component in the dynamic weather system is connected to each other and continuously changing, creating an evolving weather system to imitate the real weather. The weather components in the static weather system are not connected, nor changing over time. A static weather simulation could use a picture of clouds instead of actual moving cloud objects. The relevant weather components in each weather simulation are rain, wind and clouds.

This report will reveal which weather components are most important to create an immersive gameplay which developers then can use to effectively create uniformity. Conclusions will be based on testers who evaluate the player experience based on a dynamic and static weather simulation. An experience report of the test, weather components and weather systems will be delivered.

II. Related Research

Weather simulations in video games

Weather simulations exist in different kinds of video games, from racing games to RPG games. Triple-A (AAA[10]) video games have greater possibilities to implement a weather system, mainly because of their budget, but there is a certain niche of games that have more use of a dynamic weather system than others. Some of the games that fit into that niche will now be discussed. A dynamic weather simulation has almost been perfectly simulated in Microsoft Flight Simulator [1], but the size of the weather simulations often varies. Some games prefer to have a simpler simulation, only using night and day time to add the sense of time while playing. Just Cause 4 chose to integrate the chaos of a weather simulation into the gameplay to create even more explosions with a combination of hurricanes and storms [11]. A game genre that has consistently used weather to alter the gameplay experience is driving games. They create realistic and completely physics based alterations such as rain, causing the road to be more slippery [12]. Video games created by large companies, such as AAA games, have already figured out how to implement a well functioning weather system into their games. Microsoft Flight Simulation and Just Cause 4 are evidence of that.

Smaller studios have also adapted to the wishes of more realistic experience/elements in the games and added weather simulations, but on a much smaller scale. An example of this is the game Outward, which was produced by Nine Dots Studio [13], an indie game developer located in Quebec. It features night and day time, seasonal weather change, rain, snow and much more [14]. Nine Dots Studio have also implemented weather as a mechanic, meaning the current weather affects the player in different ways. For example, cold weather requires warmer clothing and if the player is not warm enough, the character receives a movement penalty [15]. Outward is an RPG game, which genre usually has more use of a weather simulation to improve the general believability and uniformity. Several other indie games could possibly be improved on by adding a simple weather simulation. Hopefully this study can help guide indie game developers to create their own dynamic weather system.

Weather translated to the computer world

As the goal with this thesis is to create a believable weather system, the real world weather needs to be examined and analysed. The entire real weather system does not need to be completely copied, as much is invisible to the player. The weather system in the game can for that reason hide its functionality. Real weather can still be used in order to understand what parameters affect the weather and what implications they have. The virtual dynamic weather simulation will therefore include several parameters that are active in the real weather and be used to control the simulation. As the game engine Unity uses entity component systems to organize their classes, the most effective solution is to analyse what units can be found in the real weather and implement them into the simulation.

Real world weather can be defined into six main units that, when combined, explain the current weather status. The six units are the following: temperature, atmospheric pressure, wind, humidity, precipitation and cloudiness, which are described in more detail below [16].

The atmospheric pressure can either be high or low and is measured by millibars where the normal value is around 1013 millibars. A high pressure indicates clear skies and cool weather while a low pressure indicates warm weather but also cloudy and a risk of storm. The atmospheric pressure is lower on higher altitudes, descending down to 40% of the normal pressure.

Wind is the movement of air which is affected by nearby regions. Wind usually blows from high pressure areas to low pressure areas which creates movement and directional winds. Winds can be cool or hot, which in turn changes the temperature over that area. Temperature defines how hot or cold the weather is and is measured with celsius. It changes depending on multiple factors such as cloudiness, the sun's position and season.

Humidity refers to the amount of water vapor in the air. Water vapor contributes to making clouds, rain and snow. Humidity is expressed as the percentage of what the maximum amount of water the air can hold. The air is saturated at 100% which means that the air can not hold any more water. Excess water will fall as precipitation. Precipitation occurs when air cools below its saturation point which happens when warm humid air cools as it rises.

Unity is a component based system which simplifies the process of creating the mentioned artifact. Each weather unit will act as a weather component inside the Unity Game Engine.

Context-aware weather

Gustafsson and Vallett [17] examines context-aware (CA) procedural content generation (PCG) with player modelling and its functionality in a mobile action role playing game. Specifically, they use real time weather to control the environment and enemies inside the game. Weather components, such as the sun's position, temperature and windiness, are tied to their corresponding component inside the game. For example, the brightness of the game is controlled by the sun's position.

Gustafsson and Vallett complete their thesis by conducting interviews with 11 playtesters to explore their reflections after playing their game. Results show that the utilization of a context-aware PCG is reflected positively on. One participant answered "I really enjoyed the aesthetic differences between game sessions as they made the world more interesting". In conclusion, changing the environment over time had a positive response from the test participants. The results that Gustafsson and Vallett collected from their interviews can be applied to dynamic weather systems. Because a dynamic weather system changes over time just as Gustafsson and Valletts weather system, it is predictable that test participants from this study will produce equivalent answers.

III. Research questions

By creating two versions of a weather system, one dynamic and one static, and using a test panel we can answer a few sets of questions.

- **How does dynamic and static weather contribute to the player experience in terms of overall satisfaction?**
- **Which weather components create the most enjoyment?**
- **What are the technical requirements of a dynamic weather system?**

Satisfaction according to Merriam-Webster [18] is a state where the subject is satisfied. The questionnaire that will be completed by each participant asks if they preferred the dynamic or static weather simulation the most. This is connected to their satisfaction, participants will reveal during which simulation they were most satisfied.

IV. Method

Design science at its core is about solving a design problem. In this case, the problem is the research questions. Understanding of the problem and its solution is gained by creating an artifact [19]. It is reasonable to say that this thesis will be improved by the use of the design science methodology because of the similarities. Design science incorporates the use of an artifact which is already needed to complete this thesis.

Design science

Design science is a methodology that gives researchers a medium to perform the task at hand. It revolves around the idea that an artifact can be used as evidence, material or solution. The development of the artifact should be a process that draws knowledge from previous work which gives a solution to the defined problem [20]. Peffers et al. discusses how design science can be applied to information system research, furthermore that it should be a valid methodology. As of today, design science has been built upon and is more common within research of information systems than it was when the aforementioned article was written. Peffers et al. developed six steps on how to perform design science research [19]. The steps can change order to fit the project of the researcher and the process can also be iterated. Each step will now be described.

- (1) *Problem identification and motivation.* The researcher should define the problem in order to understand what solution the artifact should provide.
- (2) *Define the objectives for a solution.* The objective should specify what the solution is and what it accomplishes.
- (3) *Design and development.* At this stage, the artifact should be developed. It can be in the form of models, methods or instantiations. What type of artifact depends on what the problem and solution is.
- (4) *Demonstration.* Demonstrate the artifact and its use to solve a portion or the entire problem.
- (5) *Evaluation.* Evaluate and measure the artifact how well it supports a solution. In order to perform this step, the researcher needs to compare the demonstration and the objectives to understand if it is successful or not.
- (6) *Communication.* Communicate the utility of the artifact and its importance. This is usually done in the process of writing a paper.

Each step will be followed and not altered to preserve the aspect of design science research. All steps will be iterated over time and evaluated to make sure the definitions are correct and represent the updates.

Performing the method

In the following paragraphs, each step will be performed as they were described above.

(1) Problem identification and motivation

Creating an entire weather simulation of the real weather is a both a technical and artistic challenge [9]. If the weather simulation has underdeveloped features, such as bad textures for rain drops, the believability of the weather system will be in question. Weather systems in general have artistic requirements that need to be met in order to not break the immersion [8]. Dynamic weather systems have additional technical requirements, such as transitions that need to be smooth to, once again, not break immersion. The quality of the artifact is important because the test participants might base their opinion on quality instead of simply experiencing the different weather simulations.

(2) Define the objectives for a solution

Two weather simulations need to be made, one dynamic and one static. The dynamic weather requires a simple yet effective function to determine the behaviour of the dynamic weather components. The simulation needs to be set in a test environment where the test participant can look around and experience the weather simulation. Both simulations need to be set in the exact same test environment to ensure that the only difference between the simulations are in fact whether it is a dynamic or static weather simulation.

Additionally, they need to be inside the simulation for an extended time to let the dynamic weather change over time. Participants will therefore be asked to perform a task, specifically find a red cube and deliver it to a specified location. Controls and objectives inside the simulation need to be intuitive to simplify the process for inexperienced test participants.

(3) Design and development

The artifact will be built to solve the problem area. Development of the artifact will consistently be iterated, as agile development sustains creativity and productivity [21].

The weather simulations will be built within the game engine Unity and use the different components available within the engine, such as the terrain tool which enables the creation of the test environment. The dynamic weather system will be built with different weather components that have similarities with the real weather. Each component will be divided into separate classes with public variables since every component is dependent on each other. The rain effect will be created by the Particle Engine component in Unity. Each raindrop will spawn a texture to mimic a splash effect on impact. Clouds will be created by shaders with two different layers, one above the other, with the intention to shape depth. Wind will be created by the Wind Handler class within Unity, which requires the use of Tree Creator which is also available in Unity. The wind component will interact with leaves and grass,

making them sway back and forth. Furthermore, the sound of the wind blowing will be added.

With all the built-in components inside Unity, a lot of groundwork has already been done. After each component has been completed, it will be tested to make sure it works. This will be an easy process with the first weather effect but as more components are added, it will require more testing as the variables will be plenty. Additionally, a day and night cycle will be implemented into the dynamic weather system. It improves the overall gameplay experience by making it feel like the time goes by.

(4) Demonstration

After the artifact is built, it will be tested against the problem. Two tests will be performed to validate the quality of the artifact. The first part will be done internally to check that the weather simulation is in fact dynamic and realistic enough to be implemented into a video game. It is important that the weather effects are not terrible because the test persons might then prefer the static only because the dynamic weather was bothering them [8]. Although this might be the case, it is important to be avoided to some cost.

The second test will be conducted shortly after by asking rank-based questions, as proposed before, involving the different weather components. A total of 26 participants will test the simulations separately and then answer a rank-based questionnaire. This will be conducted online with google forms. A file containing the installation program, installing instructions and questionnaire will be distributed via social media platforms such as Facebook, Instagram and Discord. Some will also receive the file via email. Participants will be asked to install the game, play the two weather simulations and then answer the questions on the questionnaire. Additional communication might be necessary to help with the installation process.

Rank-based testing

To achieve the purpose of this study, it is important to oversee the questionnaire and how the test persons answers will provide useful information. The questionnaire will examine which component has the greatest impact on the gameplay experience. It has therefore been chosen to use rank-based testing.

Yannakakis and Martinez [22] discuss the pros and cons of using rating-based tests to evaluate a product. As this thesis will include an evaluation of the artifact, it is necessary to formally explain the decision making. Rating-based questionnaires are forms where the tester can explain their experience of the test by rating it [22]. An example of this is where the tester rates the ease of use of a product where the highest rating is “extremely easy” and the lowest rating is “extremely hard”.

As Yannakakis and Martinez explains, rating-based questions are subject to interpersonal differences, meaning that people inherently perceive the ratings differently and therefore the results are misleading. The rating is commonly used as an integer but the reality is different. Rating-based answers are usually analyzed by adding the numbers together as the difference between all numbers are the same, but the truth is that the extreme ends of the rating scale are less picked only because they are the extreme and therefore the distance between the extreme and less extreme is larger than normal and just above normal.

With all the problems that occur with rating-based questionnaires, rank-based has proven to be more effective as each answer is not compromised by subjective elements [22]. Conclusively, rank-based questions will be asked to the participants.

(5) Evaluation

Like the first demonstration, the first evaluation will be done internally. Each simulation will be heavily tested to find bugs within the test environment and the weather simulations. The questionnaire, both simulations and instructions will also be evaluated together with a pilot test participant to make sure the questions are understood well.

After the demonstration and when every participant has answered the questionnaire, each answer will be reviewed. As a result of using google forms, all the answers given on the questionnaire will be shown in a statistical graph. This simplifies the process and the data shown can more easily be reviewed. Lastly, the quantitative questions will be further reviewed to find connections. Everything that is concluded in the evaluation will be shown under "Results" and furthermore discussed beneath "Discussion".

(6) Communication

This document will serve as the last methodology step, communication. It will give indication of which weather elements have the largest impact on player experience but its transparency will show how the artifact was built and how the tests were conducted.

Method Discussion

Once the research questions were concluded, different alternatives of methods were explored. The lack of technical information about how dynamic weather systems are made, the better choice was to create a new dynamic weather simulation, inside Unity. To accomplish the research question, the methodology design science by Peffers et al. [19] was chosen. Two different choices were present when trying to answer the research questions regarding how to gather data. Either a quantitative or qualitative research. A proposed strategy was to conduct interviews but there are multiple concerns. Primarily, test participants have to be hand picked to make sure they had previous experience of video games. Whether the weather is static or dynamic is a very small detail that most inexperienced players wouldn't notice or care for. This makes it complicated to conduct interviews as the results wouldn't speak for a big

variation of people who play or will play video games. Secondly, the research questions were not complicated and did not require an interview to get the response needed. Quantitative research would better suit this thesis.

V. Static and dynamic weather simulation

Simulating weather

To implement the weather system into a simulation, each component needs to share variables to be affected by each other. Following components were implemented into both versions of the artifact; clouds, wind effect and rain.

As described previously, millibars indicate whether it is low or high pressure, which in turn changes the different weather components. The solution was therefore to connect each component to a float called millibar.

To simulate the change of weather, a random number was generated between -100 and +100 each 0.2 second. If it was positive, the float millibar would increase and the opposite would happen if it returned a negative number. When a number was generated, it would remove one possible instance from the other side. For example, if a positive number was generated, the lowest possible number generated would change from -100 to -99. The intention was to increase the chances of generating the same negative or positive value to force the weather to evolve in one direction.

Millibar would also increase or decrease depending on how high or low the generated number was. Each 0.2 second that millibar changed, the corresponding function would be called to change the weather accordingly. When the highest or lowest available generated number reached a certain threshold, it would reset back to the default -100 and +100. This was to make the weather not too extreme, but in practice it would also make the weather bounce back. The result is an ever changing weather simulation that reaches both clear skies and heavy storms over time.

Weather Components

The existing weather components in the test environment are the following: wind, clouds and rain. Almost all components share public variables and are dependent on the everchanging variable millibar.

Wind is affecting the movement of objects within the test environment. This includes leaves on the trees and grass. When millibar is changed, the amount of sway and the speed at which objects move are changed.

Clouds have several inputs and is a shader put on an object. The object is a circular object that covers the entire sky and is divided into two sections, lower and upper clouds to create an

illusion of depth. The clouds can change color, transparency, speed and density. All cloud inputs are dependent on the value millibar.

The rain is built upon a particle system. It was first designed to start raining after a certain threshold and then continue to increase the amount of particles, but Unity changed the particle system during this thesis, making it much more difficult to achieve the same results. Instead, there are two rain particle systems, one which has more particles than the other, making it seem to rain even more. Each component is connected to the millibar meaning with a low air pressure, the wind gets stronger, clouds get darker and more dense, and after a certain point it will start to rain. At a high air pressure, the wind is weaker, the clouds are more transparent and some bird sounds are added to simulate a nice summer day.

Another component implemented is the day and night cycle, although it is not necessarily part of a weather system. However, day and night cycles could change the temperature which in turn affects the weather, but that is not implemented into this system. The day and night cycle is fixed to the sun's position which works as a global light source. Simply put, when the sun is beneath the horizon it becomes dark.

Test environments

The test environments are divided into two aesthetically identical simulations. Participants are not aware of what the intentions of the test are. They only know that it is a weather simulation but they do not know the difference between part one and part two. They both have the same goal, find a red cube and place it near a specified red cylinder. The only difference to the games are where the player starts, where the red cube is located, where they can find the red cylinder and lastly that part one is static and part two is dynamic.

A simple game, such as retrieving a cube, was necessary to keep the players somewhat focused on a task without making it too difficult. The purpose of having the exact same game is to isolate the weather components and remove unwarranted factors. By having the same tasks in both versions, we can know for a fact that it did not influence the player's opinion.

The major difference between the two versions is the weather. Part one is the static weather and part two is the dynamic weather. Dynamic weather changes over time, for example the clouds are changing shape, color, speed and transparency while also affecting the humidity, meaning it will only rain when the clouds are dark enough. It is all connected.

While the static also has rain, it is on a timer. The static weather does not evolve as the dynamic one does, instead the clouds are still and does not change color. This means in practice that it could rain even though the clouds indicate it wouldn't, challenging the player's imagination to see if they can spot the difference.



Figure 1.0: In-game picture of the test environment during rainy weather



Figure 1.1: In-game picture of the test environment during sunny weather

VI. Result

The weather simulation was published and shared to different media platforms for people to take part of the test. A total of 26 people answered the questionnaire. The age of the test persons varied, from 12 years old to 62 years old. Some were used to video games and some were not. The variation of people who took part in the test validates the results as a lot of different people play video games today.

Results are divided up into two different sections, one qualitative and one quantitative. The results published below are the answers from the questionnaire that each test person had answered. Showing statistical answers is possible because participants had to rank them in compliance to the rank-based questions. These are the following results from rank-based questions:

Q.1:

Which of the two games did you prefer the most?
26 svar

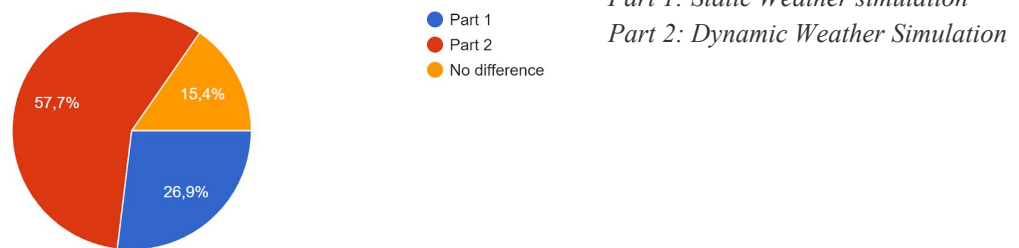


Figure 2.0: Results from question 1

Q.3:

Which weather effect did you enjoy the most?
26 svar

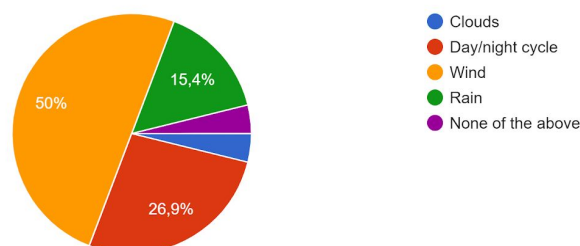


Figure 2.1: Results from question 2

Q.5:

Which game element did you enjoy the most?

26 svar

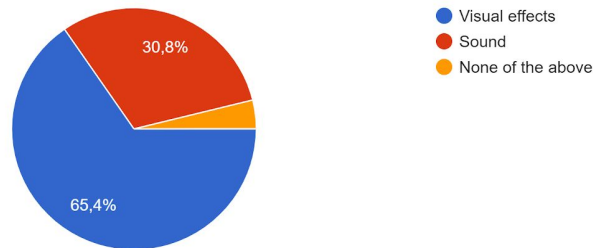


Figure 2.3: Results from question 3

The majority preferred part 2, which was the dynamic weather simulation. They also enjoyed the wind effect the most and thought that the visual effects were more enjoyable than the sound effects. Participants were then asked to motivate their answers on question one and three. Results from the qualitative questions, question two and four, will be examined in the following section.

- The majority who preferred part one did so because it was easier to find the cube in part one rather than in part two.
- The majority who preferred part two did so because the weather was more alive in part two rather than in part one.

Participants were asked, in question 3, which weather effect they enjoyed the most. As shown in the figure above, 50% of them chose wind effect, 26.9% chose day/night cycle and 15.4% chose rain effect. The least enjoyable weather component was clouds.

- The majority who enjoyed the wind effect did so because it made the player almost feel it.
- The majority who enjoyed the day/night cycle did so because it was changing the lighting.
- The majority who enjoyed the rain effect did so because it improved the atmosphere.

VII. Analysis

Part two was the most preferable game of the two versions. Most people found it more enjoyable because it felt more dynamic. There were also some people who preferred part one, mainly because it was harder to find the cube in part two. There could be several reasons for this, which there is no data of. A probable reason is because of the day and night cycle and rain effect, which made the scene a lot darker and therefore also harder to find the cube. Hindering the test persons from finding the cube was an unintended feature. Nevertheless, the majority still preferred part two over part one.

Because participants were not aware of the difference between part one and part two, answers from question 2 were varied. Some saw the difference while others enjoyed the result, for example test person number 22 answered “it was more fun playing part two”. It is therefore important to mention that it is better to rely on statistical data because test persons were unaware of why they enjoyed part two over part one, making some answers detached from the survey.

But participants did not have to be aware of the weather difference to make an eligible choice. The reason why some answers mentioned the weather, while others did not, could be because of their previous experience around digital games. By playing video games you have a more experienced eye to notice small details. A person who is not used to video games were instead focused on accomplishing the game, rather than looking around at the details. In those cases, the test person might motivate their answer as test person number 22 who said it was more fun. They might not know why it is more fun but they still preferred part two over part one.

Each answer on question number 4 relates to immersion. For example, test person number 8 explained that the wind gave a chilling effect. The results showed that wind was the most enjoyable one, meaning wind effects are something video game developers should focus on as well. Some answers revealed that they were unsatisfied with the rain effect, which was expected, but when done on a larger scale with more resources, this should be avoidable.

In question 4, that relates to which weather effect was the most enjoyable, some answers indicated that it was the combination of sound and the visual display of moving leaves that made wind the most enjoyable one. This indicates a need that each weather component is fully developed, in the sense of sound and visuals, to give a better player experience. Question 5 asked which game element, sound or visual effects, that they enjoyed the most. The majority answered visual effects. This does not mean that visual effects is the only component that should be developed but possibly have priority over the other.

This study has also shown how a simple and basic weather system can be used to improve the gameplay experience. Because the majority chose part 2, we can draw the conclusion that even small scale dynamic weather simulations are an improvement to static. It shows the importance of having a dynamic weather system and also that it does not require a AAA budget to create one. Indie developers can use this data to further improve their game with a simple dynamic weather system. Furthermore, developers can also gain the knowledge on how to create a dynamic weather simulator and which components are the most important. It does not require a full scale weather system, even on a small scale it can make improvements.

VIII. Discussion

Because participants do not know the difference between part one and part two, some answers on question 2 were not corresponding with the actual gameplay. An example of this is test person number 3, who preferred part two but the reason behind it was because it had more grass and trees, which was not the case. Additionally, test person number 4 preferred part one and their motivation was because the cube got stuck in a tree during part 2.

As expected, some answers are more difficult to analyze and it is therefore simpler to rely on statistical data rather than qualitative data. The only difference between part 1 and part 2 was the weather simulation and therefore that should be the deciding factor even if participants did not mention it.

A few participants answered that they preferred part one, or part two, because the cube was bigger in the other part. The cube had the same size in both versions, consequently this feedback is interesting to review further. An explanation might be that this is an extreme case where the participant was too focused on actually completing the game and did not notice any difference between part 1 and part 2. Even though they stated they prefer part two, it could possibly be changed to no difference. The question might even have implied that there was a difference and the test person never noticed one but felt forced to come up with an answer, alas they mentioned the cube size. So in conclusion, if a participant motivated their answer with a statement that did not correspond with the actual gameplay, it gives an indication that their answer on the first question could be revised and perhaps moved to “No difference” depending on its severity. Questioning participants' answers should be avoided though as their intentions are unknown.

The purpose of the artifact was to provide a medium for test participants to gain an opinion, in which it has succeeded. It also managed to display two sets of weather systems, one dynamic and one static. Each weather component in the simulations were based on the real weather as described before. However, the dynamic weather simulation did not use the same values or variables as the real weather [16]. The dynamic weather was based on generating a random number while the real weather has multiple factors in play to determine, for example, the color of the clouds. When developing larger weather simulations it could possibly be important to include for example temperature but for a simulation as basic as this one, it was not needed.

The quality of the weather simulations will always be in question since there is no confirmed method on how to create dynamic weather systems. Some games, especially RDR2 [23] have managed to create very realistic weather, but because this artifact was on a much smaller scale, the quality is expected to be reduced. If the quality was too low or some components are underdeveloped, it could possibly change the opinion of the participants. It is therefore

important that each component is on the same level of quality. Whether or not the components are on the same level is difficult to measure, but it could possibly be seen in the results. An example of this are the clouds, which was expected to be rated higher, but the quality of the clouds was maybe too poor. In conclusion, results were probably affected by the quality of each weather component but not too much to completely alter the data.

As results from the study made by Gustafsson and Vallett [17] showed that test participants enjoyed the aesthetic look, regarding visual effects, so did this study. Roughly 66% enjoyed visual effects over sound effects. However, the quality of the visual effects and sound effects could alter the results. Conducting more research regarding visual effects vs sound effects in weather simulations would be needed to draw any larger conclusions.

How weather can affect the virtual physics, game world and game design can be seen in Just Cause 4 [11] and Need for Speed Heat [12]. The artifact in use in this thesis does not experiment with changes of the game design. However, it is aesthetically similar to Outwards, developed by Nine Dots Studio [13], which is an indie developer studio. Results from the questionnaire can help indie studios, such as Nine Dots Studio, to focus their development on certain weather components or in the development of a dynamic weather system.

Another topic that is subject to questioning is whether test participants should be or not be aware of the goal of the test. Participants were not informed of the goal nor the difference in the two versions, except for the name of the application they downloaded which was called Weather Simulation. Because the only difference between the two versions was the weather, each answer should reflect if a dynamic weather impacts the player experience. In practice, that did not work out as intended. If participants were informed of the difference, they would also pay more attention to the weather but this could possibly skew the results. With the current setup, that participants were not informed, we also receive information if a dynamic weather gets recognized and whether or not it improves the player experience.

IX. Summary

This thesis examines the technical and player experience differences between static and dynamic weather systems. It investigates peoples opinion when comparing dynamic and static weather simulations, and their reason behind their opinion. Two weather simulations were made, where the difference was which weather system they used. Part one used static weather and part two used dynamic weather. 26 people were asked a few questions after they played both parts, investigating which part they preferred. 57.7% preferred part two, 26.9% preferred part one and 15.4% saw no difference. This indicates that dynamic weather systems are preferred over static ones, regarding overall satisfaction.

The test persons were also asked which weather component they enjoyed the most, revealing that 50% chose wind, 26.9% chose day/night cycle and 15.4% chose rain. Indicating that the wind component was most impactful on the player experience.

Lastly, test persons were asked if they preferred the visual effects or sound effects. 65.4% chose visual effects and 30.8% chose sound. The provided results give game developers a better understanding of what a dynamic weather system can provide. They also gain the knowledge of which weather effect had the most impact on the player experience, indicating what game developers should focus on.

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Questionnaire:

Q.1: Which of the two games did you prefer the most?

Q.2: Why?

Q.3: Which weather effect did you enjoy the most?

Q.4: Why?

Q.5: Which game element did you enjoy the most?