Weather System & Day/Night Cycle Research

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Dynamic Weather Systems & Day/Night Cycles

Introduction

There are many games that strive to achieve realism. A game's environment plays a major role in immersing players into its world. Weather systems and day/night cycles are vital aspects that significantly impact gameplay experiences by making the environment feel real. The first part of this research paper aims to examine how these systems are used and how they affect the player experience.

The second part of this research paper will be focused on the Weathers System & Day/Night cycle in Red Dead Redemption 2 specifically, as I will be remaking those features.

Research questions

- In general: How do weather systems and day/night cycles contribute to the immersive player experience, and what are the things game developers must take into consideration when implementing weather systems and day/night cycles?
- Specific: How do the Weather System and Day/Night Cycle in Red Dead Redemption 2 work?

Topics

General Data on Weather Systems & Day/Night Cycles

- Weather systems & Day/Night cycles in videogames and the intended player experience
- Why do people love realistic weather systems?
- Technical implementation: Immersion
- Technical implementation: Customization

Red Dead Redemption 2: Weather System & Day/Night Cycle

- Weather in RDR2: Dynamic or Static?
- The different weather conditions in RDR2
- Day/Night cycle

- Conclusion & Takeaways
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General Data on Weather Systems & Day/Night Cycles

Weather systems & Day/Night cycles in videogames and the intended player experience

Having weather systems and day/night cycles in a game is a key component to achieve realism, which is why these systems are mostly found in games that aim to immerse the player into a realistic environment. Most commonly, those games are withing the following genres (some of these genres have some overlap):

(Open world) Survival games:

- Examples: Minecraft, The Long Dark, Rust, The Forest
- Realism and challenge: In survival games the goal is to survive the challenges that you will face in the game's world. More often than not, these games are largely inspired by real life survival and aim to recreate the challenges one would face when surviving in real life. Part of that is weather conditions and a day/night cycle, which adds realism, challenge, and variety to the game.

(Open world) Action-Adventure games

- Examples: Assassin's Creed 4>, Red Dead Redemption 2, The Witcher 3, Sea of Thieves, Zelda BOTW, Horizon Zero Dawn
- Atmosphere and Immersion, Aesthetic Appeal, storytelling, realism and challenge: Within this genre it depends on the game what the main purpose of a weather system is. In some games such as RDR2 the main purpose is realism, atmosphere and storytelling, as certain weather conditions or time of day can contribute to the mood a scene is trying to set, and weather can contribute to telling a story. In other games, such as Zelda BOTW, the weather system and day/night cycle are there primarily to create variety and/in challenge.

Simulation games

- Examples: Cities Skylines, The Sims, Rimworld, Stardew Valley
- Realistic simulation, education: Simulation games try to, of course, simulate a certain thing, whether it is piloting an airplane, owning a farm, managing colonies, managing a household, or managing a city. In these types of games, accuracy to real life is very important, and weather and time has a big impact on these things in real life. To make the simulation more interesting and accurate to real life, weather systems and day/night cycles play a significant role.

Serious racing / Sports games

- Examples: DriveClub, Forza Horizon 4, PES, FIFA, Madden NFL, DiRT Rally 2.0, Ace Combat 7, Microsoft Flight Simulator
- Realism and challenge: These games often don't have a day/night cycle because it is divided into smaller rounds rather than being a continuous game, but they do often have realistic weather systems as in real life different weather conditions have influence on for example how the steering of a car feels. Because the target audience of these games want these games to be as realistic as possible, having a weather system is important in order for the game to offer the same challenges as these sports do in real life.

Why do people love realistic weather systems?

In the previous section I mentioned how weather systems and day/night cycles can add to the variation, realism and accuracy, challenge, atmosphere, and storytelling of a game. Now I want to dive into a bit more detail on why many people love realistic weather systems specifically.

A study [2] has shown that having a simple and basic dynamic weather system with a day/night cycle can already be used to improve the gameplay experience, and that even a small-scale dynamic weather system is

an improvement to a static weather system because players like how it makes the weather and world feel more alive. The testers also preferred the weather types that felt more realistic in terms of audio and visuals. Some major reasons are that it makes a game more interesting to look at, adds a layer of complexity, and adds variety to a game, turning a static world into a world that feels more alive and believable. However, there is a bit more to it.

It is well known that weather has an impact on a person's mentality [6]. The severity of this depends on the person. For example, some suffer from Seasonal Affective Disorder (SAD), which is a type of depression that occurs during certain seasons, usually in winter when there's less sunlight, and it gets better in spring and summer when there's more sunlight. People who suffer from this might find a connection or relief in weather systems depicted in games. For example, games with sunny, cheerful weather might offer comfort or a mood boost to people with Seasonal Affective Disorder, especially during gloomier seasons like winter, potentially providing a form of mental escape or temporary relief.

There are also many people who don't suffer from SAD, who still find comfort in, for example, rain. Weather in games allow people to experience and enjoy certain weather types without having to fear for actual negative consequences, such as having to fear that lightning may strike during a thunderstorm, or having to fear that the roads will be slippery when it's snowing. This way, games make it possible to even storm chase without risking your life [7].

All in all, this makes players feel more connected to the environment, contributing to a deeper sense of immersion within the game.

Technical implementation: Immersion

It is very important that immersion is not broken. For that, the following requirements must be met:

- Smooth transitions between weather conditions, as to not break immersion
- Good quality textures that fit the aesthetic of the game. This does not necessarily mean that the textures should be very realistic. Realistic textures work for games like RDR2 in which all the visuals are realistic, but in a more cartoony game such as Animal Crossing: New Horizons, this would not work. Therefore, it is important that the textures match the aesthetic of the game.
- Realistic audio that matches the visuals well and blends in well with other audio.
- Consistency: The weather changes and day/night transitions must be consistent with the game's setting and world logic
- Lighting that matches the weather and time of day

The points are mandatory, as immersion will be broken without these, defeating the purpose of a weather system and day/night cycle in the first place. Of course, there are additional features a developer might want to add to increase immersion. Think of the following:

- Impact on environment: Puddles forming during rain, snow coverage, lightning striking trees, etc.
- Impact on gameplay: For example, rain causing surfaces to be slippery, snow altering movement, lightning striking the player, NPC behaving differently in certain weather conditions or at certain times, monsters spawning at nighttime, different temperatures, etc.
- Story Integration: Integrate weather and time changes into the narrative or quests as aligning weather events or specific times with story moments can make them more impactful and immersive.

Technical implementation: Customization

In the previous section I mentioned how it is important that the visuals fit the aesthetic of the game. For this, it is important that the weather & day/night cycle system offer enough customization options, giving developers a lot of freedom for them to change the look of these systems.

Day/Night cycle:

- General Settings:
    - Cycle length (how many minutes it takes for a full 24-hour cycle to complete)
    - Time of the day (for testing purposes)
    - Time when the sun rises and when the sun goes down
    - Time at which the game starts
    - Positions of sun/moon (horizontal rotation)
- Day Settings:
    - Sunlight intensity, temperature, and color
    - Sun scale, rotation, brightness, color/tint, texture
- Night Settings:
    - Moonlight intensity, temperature, and color
    - Moon scale, rotation, brightness, color/tint, texture
    - Stars visibility, texture, brightness, tiling, size, and masked noise speed

Weather System:

- Individual weather types:
    - Textures and particle effects
    - SFX
    - Weather intensity
    - Lighting intensity & Temperature
    - Cloud formations
    - Wind strength
- Dynamic weather:
    - What weather types should be in the dynamic weather system
    - Option to toggle dynamic weather on and off
    - The duration of weather conditions
    - Speed in which weather transitions to another weather type
    - The frequency in which a weather type occurs / Probability of a weather type occurring
    - The option to define specific zones or regions where certain weather types have a different probability to occur
- Static weather:
    - Option to turn static weather on/off
    - The option to define specific zones or regions where there should be static weather
    - Triggers tied to events (for example, some mission may require a certain type of weather)

Red Dead Redemption 2: Weather System & Day/Night Cycle

Weather in RDR2: Dynamic or Static?

Red Dead Redemption 2 has both static and dynamic weather.

Dynamic Weather: The game incorporates dynamic weather, meaning that weather conditions change dynamically and unpredictably over time with seamless transitions. Dynamic weather impacts the environment, gameplay mechanics, and the overall atmosphere, creating a more immersive experience with more variation. The probability in which a weather type can occur can vary depending on the area. The weather system is also integrated with the day/night cycle. Certain weather conditions may be more likely to occur at specific times of day.

Static Weather: There are also certain static or predetermined weather conditions that occur during specific story missions or in particular regions of the game. These weather conditions might be static to fit the region in

order to keep it realistic (ex. Only clear weather in the desert), to create specific atmospheres or to enhance the narrative during certain key moments in the game, adding depth to the narrative and immersing players further into the game's environment.

The different weather conditions in RDR2

Weather Condition	When and Where	Visuals	Audio	Environmental change & Impact on gameplay
Clear/Sunny	Dynamic: Has a random chance of occurring in regions without static weather (Most frequent type of weather)	Few clouds in the sky, bright lighting	X	X
Cloudy/Overcast	Dynamic: Has a random chance of occurring in regions without static weather, is primarily encountered in swampy regions and mountain regions	Roof of clouds, dark/gloomy lighting	X	X
Wind (not explicitly classified as a separate weather type, but is an environmental factor)	Dynamic: Has a random chance of occurring in regions without static weather	Blowing dust, leaves/grass flying across screen	Wind SFX	Stronger movement/swaying in trees, grass, and other environmental elements.
Fog/Mist	Dynamic: Has a random chance of occurring in regions without static weather, has a higher chance of occurring in the morning and evening in swamp regions or near bodies of water.	Limits visibility making it more difficult to see objects in the distance, gloomy lighting	X	X
Rain	Dynamic: Has a random chance of occurring in regions without static weather (One of the most common types of weather)	Raindrops falling from sky creating ripples on water surfaces, limits visibility, roof of grey clouds, darker lighting	Rain hitting surface SFX, Rain pattering on roof SFX, Rain hitting liquid SFX	Causes mud and puddles to form, affecting movement and horse handling. It can also lead to decreased visibility and slippery surfaces.
Thunderstorm (dry)	Dynamic: Has a random chance of occurring in regions without static weather (Very common in certain regions, not common in others)	Roof of clouds, darker lighting, lightning in clouds, occasional lightning strikes that brighten the sky, chance to be accompanied by rain	Thunder rumbling SFX Lightning Strike SFX (Wind SFX) (Rain SFX)	Lightning may strike the surface, trees, and structures. Lightning may even strike the player, resulting in instant death
Thunderstorm (rain)				
Snowstorm	Static: Only in snowy mountain region	Snowflakes falling from sky, limits visibility, roof of clouds(?), white lighting	Wind SFX, Snow crunching SFX from walking through snow	Snow coverage (varying in thickness) Footprints / Trails being left in the snow Player moves slower in a thick layer of snow
Dust/Sandstorm	Static: Only in desert region	large amounts of sand/dust flying across screen, limits visibility, little to no clouds	Wind SFX	

Figure 2 - Clear Weather

Figure 3 - Snow

Figure 1 - Rain and Thunderstorm

Figure 4 - Fog

Day/Night cycle

In Red Dead Redemption 2, the day/night cycle functions in a way that is supposed to simulate a realistic passage of time within the game world.

The game follows a real-time clock system where time passes at a certain rate. A full in-game day typically lasts around 48 minutes in real-time, with around 30 minutes for daytime and 18 minutes for nighttime. However, this cycle can be adjusted in the settings, certain game modes, or certain situations.

The game's lighting and visuals change dynamically as time progresses. The transition from day to night and vice versa affects the environment, with different lighting conditions, hues, and atmospheric effects.

Besides visuals, the day/night cycle also has an impact on gameplay and AI. Different activities, events, and behaviors of characters and animals can vary depending on the time of day. For example:

- Wildlife might behave differently, with certain animals being more active during specific times.
- Characters/NPCs behave differently depending on the time of day
- Some side missions, encounters, or events might only occur during certain times of the day or night.
- Shops and businesses may have different operating hours, affecting when players can access certain services or goods.

Like in many other games, there is an option to advance time more quickly. This can be done by sleeping, which allows players to choose the specific time they want to wake up, allowing for control over the day/night cycle to some extent

The day/night cycle adds depth and realism to the game, impacting gameplay, visuals, and the overall experience by creating a dynamic environment that changes as time passes.

Conclusions

How do weather systems and day/night cycles contribute to the immersive player experience, and what are the things game developers must take into consideration when implementing weather systems and day/night cycles?

Weather systems and Day/Night Cycles significantly contribute to the immersive player experience (primarily in games where realism plays an important role), increasing realism, variation, challenge, atmosphere, storytelling, and overall gameplay. Having a weather system (and day/night cycle) makes players feel more connected to the environment, contributing to a deeper sense of immersion. Game developers must consider several key factors when implementing these systems to maintain immersion. These factors include smooth transitions between conditions, appropriate visuals and audio, consistency with the game world's logic, and alignment with the game's aesthetic. Aside from this, incorporating impacts on the environment, gameplay mechanics, and narrative integration increases the player immersion even more. If a game developer is planning on using the weather system for different projects or is planning on selling it, offering customization options for both day/night cycles and weather systems is extremely important as it provides developers with the freedom to adjust these systems to fit the game's specific requirements, aesthetics, and gameplay mechanics. Overall, these things collectively contribute to creating a more immersive/engaging player experience and makes it easier to adapt these systems to different projects.

How do the Weather System and Day/Night Cycle in Red Dead Redemption 2 work?

Red Dead Redemption 2 pays great attention to detail. This is especially noticeable in the game's weather system and day/night cycle. Not only are the textures and sounds very realistic, but these systems also have a significant impact on the gameplay and environment.

RDR2 combines both dynamic and static weather in order to simulate realistic weather patterns that affect different regions of the game's world. Dynamic weather shifts unpredictably (with the frequency of certain weather types depending on the area/region) with seamless transitions. Static weather occurs in regions where dynamic weather would not make sense (ex. Desert) or during certain moments in order to intensify storytelling and set the mood.

The day/night cycle simulates a realistic passage of time but within a 48-minute timeframe (although this is adjustable). It influences visuals, lighting, and atmospheric effects, dynamically changing the environment and impacting gameplay and AI behavior. It even affects the weather, as certain weather conditions may be more likely to occur during certain times of the day.

Takeaways

Understanding the player experience that these systems should deliver helps me figure out what to focus on. Immersion is key, which can be achieved through realism. Realism in this case does not necessarily mean realistic to the real world, but realistic to the in-game world. Therefore, I'm concentrating on making transitions smooth, getting the lighting right, and giving developers plenty of customization options so that the systems can be easily tweaked to fit the game's aesthetic.

Even though I'm just working on the systems, I can see they might be used for story integration or challenges. Realizing that the systems might be used for such things, gives me a better idea on what customization options these systems should offer so that they could support future stories or gameplay challenges.

At first I was planning to just have a dynamic weather system, but seeing how static weather can be important when it comes to story integration and realism (as certain regions can't have certain types of weather), I have realized that the option to have static weather on certain occasions or in certain areas can also be important.

Basically, I'm not just making systems; I'm making tools that can shape future stories and help players feel more connected to the environment. By tweaking these details and giving developers more options, I hope to make the experience more flexible and real.

Sources

- [1] Paper on Realism in games: https://www-cs-students.stanford.edu/~geksiong/papers/cs378/cs378paper.pdf
- [2] Paper on Dynamic and Static weather in games: https://www.diva-portal.org/smash/get/diva2:1524012/FULLTEXT02.pdf
- [3] Video about realism in games: https://www.youtube.com/watch?v=zrqwvsilA-8
- [4] Essay on weather systems in games: https://www.gamestudies.org/0801/articles/barton
- [5] Video about the importance of dynamic weather – Flight Simulator 2020: https://www.youtube.com/watch?v=hj4oRL1cJNo
- [6] Video 'How In-Game Weather Can Regulate Mental Health': https://www.youtube.com/watch?v=W7G1j4Su6bs
- [7] The Storm Chaser of Red Dead Redemption 2 - https://www.eurogamer.net/meet-the-storm-chaser-of-red-dead-redemption-2
- [8] RDR2 fan wiki – weather: https://reddead.fandom.com/wiki/Weather_in_Redemption_2#:~:text=The%20weather%20is%20controlled%20by,mountainous%20regions%20of%20Grizzlies%20West.
- [9] Video showing the weather types in RDR2: https://www.youtube.com/watch?v=-TG2uyfsspY
- [10] Timelapse of day/night cycle in RDR2: https://www.youtube.com/watch?v=EfBcSfApmAg
- [11] Video showing thunder and lightning strikes in RDR2: https://www.youtube.com/watch?v=4Y-u4Hq7af8
- [12] Video of lightning strike close by in RDR2: https://www.youtube.com/watch?v=zrjXnBowYEw