GNG1103 – Conceptual Design for a VR Climate Change Simulation

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Abstract

This document explores concepts for a simulation that educates and immerses users in the effects of wildfires as a consequence of climate change. Ideas for potential subsystem implementations in the areas of user interface and menus, user navigation, and modes of user interaction are first devised and developed, then combined to build the structure for a set of fully functional solutions. By comparing these to existing and newly discovered design criteria, a simulation on search and rescue in a wildfire scenario was selected as the best solution.

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1 Introduction

To design a product that most optimally addresses our design criteria and problem statement, it is necessary to first ideate and analyze a wide variety of potential solutions. We begin by developing concepts for numerous subsystems, the well-delineated components that mechanically implement the story within the simulation, and couple them with a quick preliminary analysis of their merits and drawbacks. The collection of initial concepts is then refined and reworked using the aggregated information. Taking concepts from each subsystem, complete solution concepts and stories are built and graded against existing benchmarks and design criteria to converge on the best ideas. Finally, the best among these is chosen as the concept to move forward with, guiding much of the remaining planning, budgeting, and prototyping. We have chosen wildfires to be the subject of our simulation as it appears to be one of the most pressing consequences of climate change across growing regions of Canada.

1.1 Related Work

Articles on past wildfires and heat waves in Canada [1, 3, 7, 8] were used to benchmark and inform the sorts of experiences that might be delivered. Large data sets on the spread of wildfires and the consequences thereof, such as that provided by NASA [2] is also anticipated to be of value.

2 Developing Initial Concepts for Subsystems

Subsystems can be either general functionalities of the simulation or more concrete implementations, but they must be well delineated from one another and serve to carry out the story or support the function of another subsystem to justify their being. Creating these as modular concepts will make it simpler to analyze details of one in isolation of other systems or to swap out a whole system as necessary. The three areas identified for subsystems are UI and menus, user navigation, and modes of interaction. We begin the process by brainstorming any subsystems that might have a place in the simulation.

2.1 Subsystem 1 - User Interface and Menus

Any elements that do not canonically exist in the world of the simulation but facilitate the user's interaction with it are considered UI. This includes things like heads-up displays, map markers, dialogue text, or the VR laser pointers, and for our purposes also includes any form of menu. As the virtual means by which the user and the simulation interact, it must in general intuitively communicate what the user can and cannot do and consistently respond to user input. This is strongly tied to accessibility and has influence over immersion for benchmarking purposes.

2.1.1 UI Focused for Visual Effects (James)

Past the pre- and post-simulation menus, the simulation has no heads-up display to force all information to be diegetic, meaning it is conveyed solely through elements of the game world. This leans fully into the criterion for immersion and sense of presence by cutting

out any possible elements that identify it as a virtual rather than genuine reality. This allows the interface to be reserved solely for visual effects like vision tunnelling, smoke clouding, or temporary blindness. However, this risks overstepping and removing information that would be critical to the user understanding how they are supposed to interact with the world. Even if this is remedied, it still places a great burden on the visual language of the environment to guide the user, which may require more testing than we have time for.

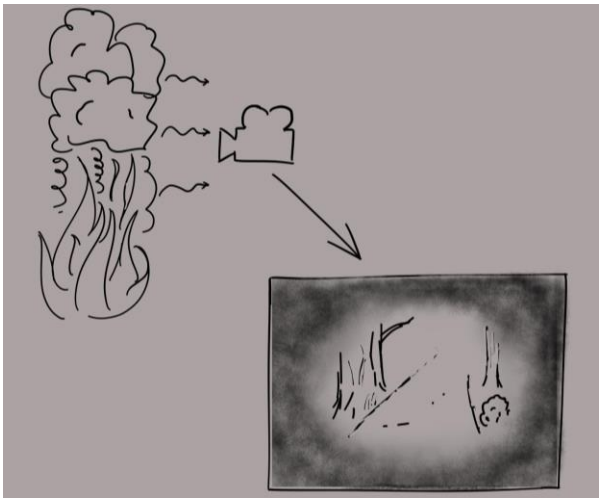


Figure 1: UI for VFX concept sketch

2.1.2 High Information HUD (James)

This approach pulls elements from many mass-market video game titles to explicitly provide the user all the information they need to efficiently navigate the simulation. This can include text and world markers overlaid on the display indicating where to go and what to interact with, an objective compass, or extra flashy effects indicating objects of interest, as well as any other environmental information that might be pertinent to their decision making. This improves accessibility for those less familiar with game design conventions by not putting information they may need behind interactions they may not think to do. The drawback is that, in having these extra UI elements designed to grab the user's attention, the user may be distracted from the environmental storytelling around them and get the impression the simulation is something to just complete rather than experience and take in, undermining the story.

Figure 2: High information HUD concept sketch

2.1.3 Diegetic HUD (Malcolm)

Diegetic design is the idea of having something that occurs in the context of the story being a part of the world it takes place in. This could be something like music playing from a radio or people watching a film in the story. A diegetic HUD is having a menu/health/notes/etc. system be a part of that game world, such as having it in a notebook/clipboard/watch/etc. All the information that the user needs could be accessed with the press of a button by having the avatar in game open up a book with little notes and/or tips written down. This method is very effective in immersing the user but unlike a traditional HUD, it's more difficult to actually have it implemented properly without having the user losing immersion.

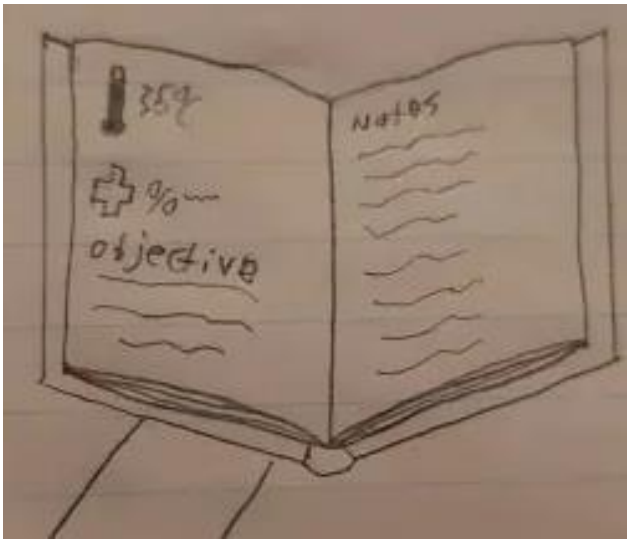


Figure 3: Diegetic HUD concept sketch

2.1.4 Gaze Pointer (Mohammad)

A highly advanced software that allows designers to implement eye-tracking software, the simulation can be accessible to a wide variety of users. This type of control does not require any fixed menu to be available on screen, it can replace menus because it only requires the user to look at the object or feature to trigger any action or dialogue. The disadvantage in such a system is accuracy, with other UI systems being controlled using a keyboard or a controller, the gaze system uses the space between the eyes as a reference point, large objects are preferable to use with gaze rather than small objects that you would not be able to accurately select.

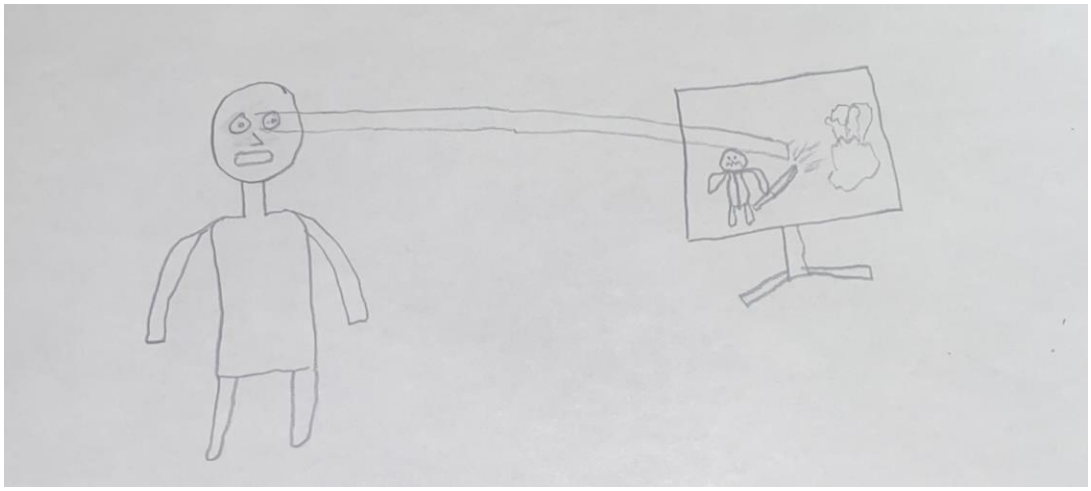


Figure 4: Gaze pointer concept sketch

2.2 Subsystem 2 - Environmental Navigation

Virtual reality can imitate real life and fantasy world settings and features; environmental navigation defines how the user is able to move and explore the settings, features and obstacles through the use of a keyboard, joystick or a controller. The designer is able to increase engagement and immersion level of the user based on their ability to manipulate the perspective, sound, lighting, weather, and environments in the simulation. The ability to freely control the point of view is a large part of what separates interactive media from films.

2.2.1 Bird's-Eye View (James)

While the medium of VR may intrinsically pull towards an on-the-ground perspective to align with what a real person would experience, the educational side of this simulation opens the avenue for a more liberated approach to navigation. The joystick controls movement in the x-y plane while two other buttons are used to traverse up and down along the z-axis, or to move the user forward and back in the direction they are facing. Unlocking the third axis of movement could allow users to get a sense of scale with how quickly wildfires can spread from above, and the fact that this method explicitly diverges from more grounded perspectives could allow it to interface more smoothly with other non-diegetic concepts. The glaring drawback of this is the threat of boundary breaking and the difficulties in trying to create an environment large and detailed enough to be worth showing from this perspective.

Figure 5: Bird's-eye view concept sketch

2.2.2 Joystick Movement (Malcolm)

Using the joystick on the VR controller, the user moves along the ground relative to their current facing. The move speed is dependent on how fast a real person might expect to be able to walk, given this method puts them on-the-ground in a realistically scaled environment, and may have to be altered to accommodate users that are likely to get motion sick. This is true also for concept 2.2.1, and motion acceleration would have to enter as a design parameter in accessibility. Grounded joystick movement is more realistic than the other methods and is quite common in many video games, which may make it more immediately intuitive to more users. This may also make it easier to implement with existing software and better to control without VR as well.

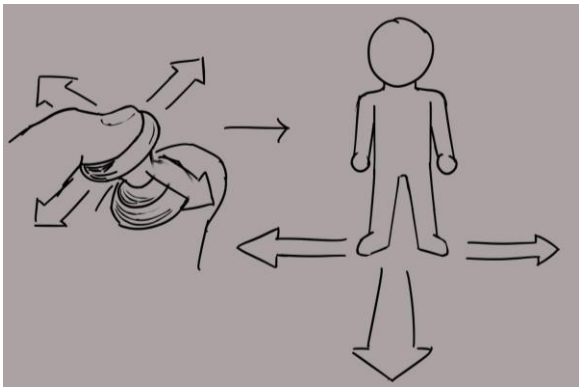


Figure 6: Joystick movement concept sketch

2.2.3 Laser Pointer Teleportation (Mohammad)

The user holds a button on the controller and a ring appears on the ground that their laser pointer is directed at, which will be green or red depending on whether or not they can teleport there. Either by releasing the button pressing another (to be determined from user testing), the user's avatar and camera will be teleported to that location if possible. This has the advantage of unambiguously communicating where the user can and cannot go in a manner that may be less frustrating than the classic invisible wall, especially since fire can act as a universally

understood no-go zone. It is also beneficial for accessibility as both studies and users have reported that it is less likely to cause motion sickness since the camera doesn't really 'move' between point A to point B. However, teleportation is not realistic and so may pull from the immersion, and the reliance on targeting the laser pointer for movement may raise accessibility concerns for users with difficulties precisely aiming it.

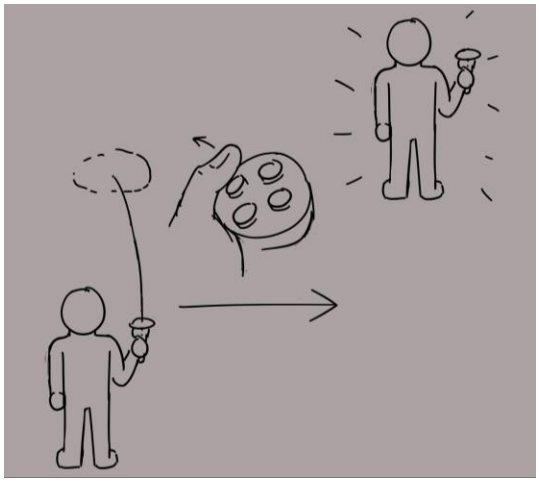


Figure 7: Laser pointer teleportation concept sketch

2.2.4 Railroading (James)

Movement is a form of interactivity but is not always necessary. By having the simulation dictate where the user's avatar is at any given time, the simulation or a section thereof can be focused around a specific point instead of having to worry about the user straying into a buggy or less polished piece of content. The camera is also not necessarily fixed in place and may move along a set path like a theme park attraction. While this allows for things to be carefully curated, restricting user control in this way diminishes the sense of presence and thus the immersive value of the simulation. Further, designing the simulation to not be explored may be counterintuitive to the full 360° provided by VR.

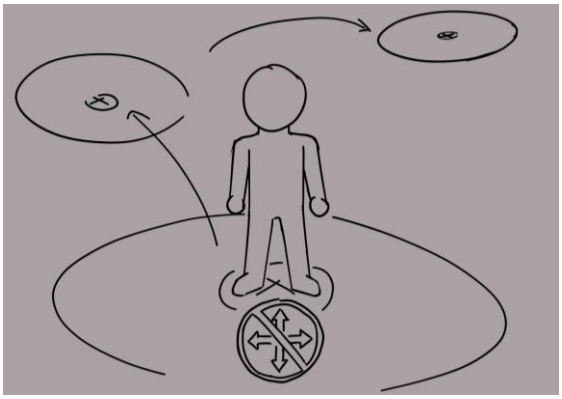


Figure 8: Railroading concept sketch

2.2.5 Proximity-Based Auto-Walking (Krithivaas)

This system makes moving around the simulation easier by letting the user walk automatically when they get close to certain areas. Instead of using a joystick or teleporting, the user just looks at or steps near a key location, and the simulation smoothly moves them forward. This can help guide users through important parts of the experience, like getting closer to a wildfire to see how it spreads or walking toward a safe zone to learn about evacuations. It's also easier to create using basic movement scripts in game engines like Unity. However, the downside is that users can't move freely wherever they want, which might feel restrictive. To make this system work well, the movement triggers need to be placed carefully so users don't feel forced into actions they don't want to take.

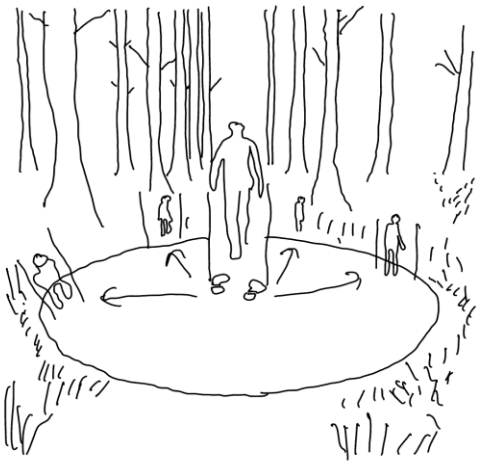


Figure 9: Proximity-based auto-walking concept sketch

2.3 Subsystem 3 - Modes of User Interaction

The modes of interaction are the methods that allow the user to engage with the simulation and influence the direction of the simulation. The different modes can shape how users navigate, make decisions, manipulate objects and open dialogues within the simulation. A well-designed interaction system can enhance the user experience and make the simulation more engaging and immersive.

2.3.1 Brush Clearing Tool (James)

As dry brush, grass, and trees are a large catalyst for wildfires, there may be educational value in showing how clearing it can slow the spread of wildfires, while leaving it can be disastrous as temperatures climb. This system provides multiple modes of interaction with a very real fire prevention scenario, but it has a number of drawbacks. As is, it is quite specific and the chain of activity for this may dominate the duration of the simulation and supposes at least two branching stories based on how much the player did. Further, while giving the player a brush clearing tool, as shown below, may make it more immersive, the

user may have their attention stolen from the story by trying to figure out what else they can swing at.

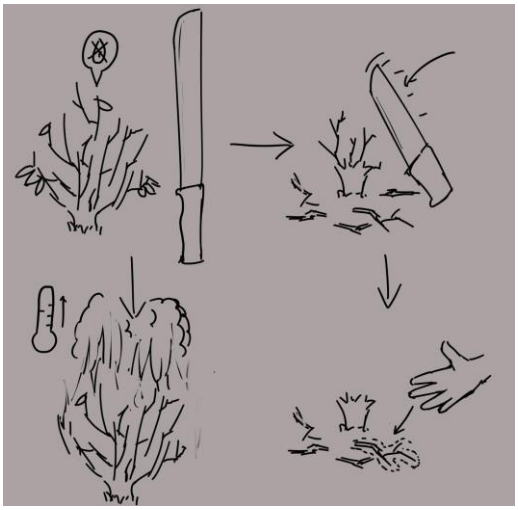


Figure 10: Brush clearing concept sketch

2.3.2 Probing Tool (James)

This tool that can be toggled to replace one of the user's VR laser pointers. Data is continuously and automatically displayed directly on the tool object based on the avatar's position and direction of the probe to diegetically show environmental information. However, this tool is not too realistic and the information it gives would have to influence how the user acts, likely by tying to another interaction mode, for this to be anything more than a distracting gimmick. This may also be bug-prone and difficult to implement as it would require fitting the whole observable environment with data sources the probe can draw from and then ensuring they do not conflict with one another.

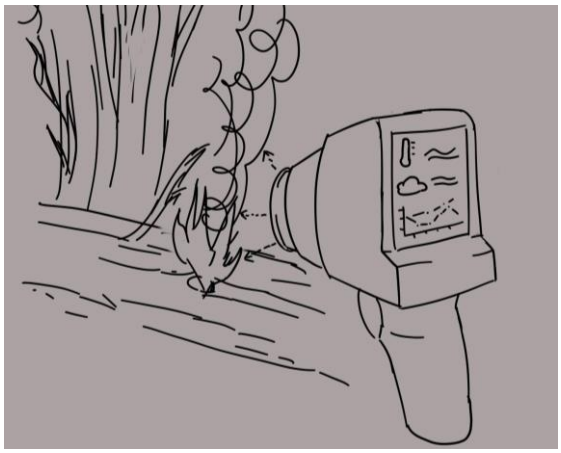


Figure 11: Probing tool HUD concept sketch

2.3.3 Quick Time Events (Malcolm)

A quick time event is a system where a user has to press a button or a series of buttons before a timer runs out. This method of interactivity can be used when you need to perform a difficult task quickly. It helps to keep the user engaged and on their feet as they need to be able to react to whatever is coming. The only problem with this kind of interaction is that it can be a bit tiresome to always have to do it as it can get old quickly. Another drawback is that it can take away from the immersion element of the simulation as having a bunch of buttons with a timer appear right in front of you can be a bit jarring.

Figure 12: Quick time events concept sketch

2.3.4 Text Bubbles (Mohammad)

Text bubbles will be available for the user to allow for the user to perform the desired action such as interacting with a non-playable character or traveling towards a different setting. There will be a specified button on the VR controller that will allow for the user to select the desired option. This will allow for dialogues to be played and storyline to progress. The disadvantage of such a system is that it lacks immersion as it is only a single/multi option interaction method leading to a limited number of choices to be made. Different methods allow the user to freely manipulate and affect objects in the simulation, which leads the user to be more engaged with it.

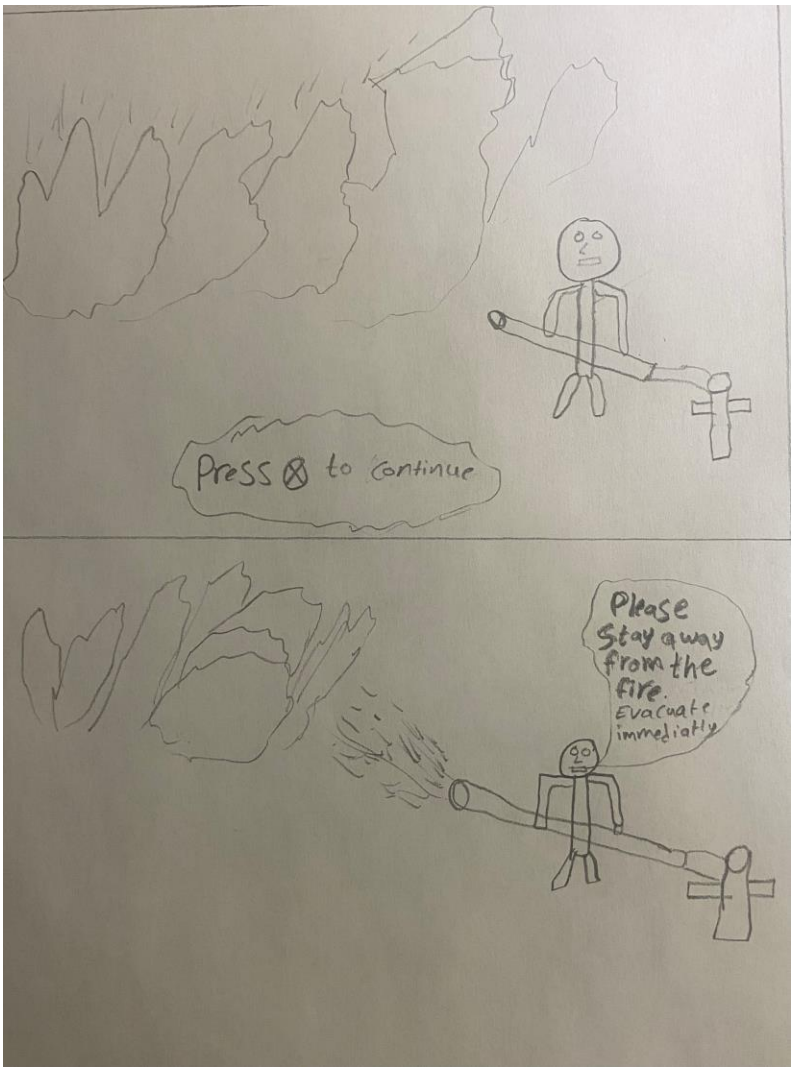


Figure 13: Text bubbles concept sketch

2.3.5 Haptic Feedback Integration (Krithivaas)

This approach introduces a simple form of haptic feedback to enhance user immersion without relying on complex mechanics. By using basic controller vibrations, the simulation can provide subtle cues to help the player sense environmental hazards. For example, as the user moves closer to a fire, the controller could start vibrating lightly and intensify as they get nearer. Entering a smoke-filled area could trigger short pulses to indicate discomfort or danger, reinforcing the need to find a safer location. Additionally, when interacting with objects like fire extinguishers or tools, a small vibration could confirm selection, making the interaction feel more responsive.

Figure 14: Haptic feedback on Oculus controllers concept sketch

2.3.6 Extinguishing Tool (James)

A tool object that toggles to replace one of the user's laser pointers. Pointing this object at a fire and using the interact button, with the guidance of the laser pointer, will gradually put out the fire, shown by the removal of fire textures and particle effects from the flame. This extinguishing tool could be modeled as a hose, a fire extinguisher, or even a bucket of sand or water, depending on the story context. Including such a mechanic would encourage the player to get up close to the fire, if even just once for curiosity. One difficulty of this is that if the player is shown they can put out fires, there is an expectation that that tool will work on any fire by principle of continuity, which could conflict with the use of fire as non-interactive set dressing or as a boundary setting tool. Further, making fire that extinguishes in a believable manner would require additional work with the material textures that could take an undue amount of development time.

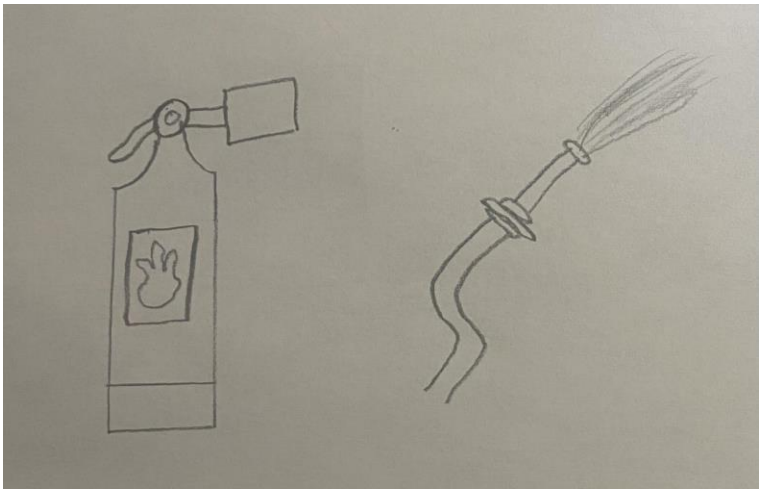


Figure 15: Extinguishing tool concept sketch

3 Refining Subsystem Concepts

We next consider how these concepts may be altered or merged in any way to produce new and improved subsystems. Concepts not listed here from section 2.1 may have been combined with another, wholly remade into one requiring a new identity, or left as-is for lack of a new idea for that concept.

3.1.1 UI and Menus - Dynamic HUD as a Visual Effect (James)

Drawing from concepts 2.1.1 and 2.1.2, this approach alters the state of the user interface depending on the avatar's surroundings to treat it as a representation of the state of the avatar rather than a purely functional item for the user. This can be used either as a method of tutorialization by giving the user a chance to become familiar with one element before introducing more, or to intentionally elicit confusion in the user for part of the story. For instance, if the user is taught early to rely on navigational aids to get through the story, then removing them when a fire flares or smoke billows over the avatar can disorient the user to better convey a sense of panic. By extension, showing that these elements can be recovered in safe areas may serve to steer the user without interrupting the user's agency. Creating these sorts of dynamics, though, would demand more development resources than either solution alone, both for graphically designing a self-altering UI and for figuring out where and how the interactions for it will occur.

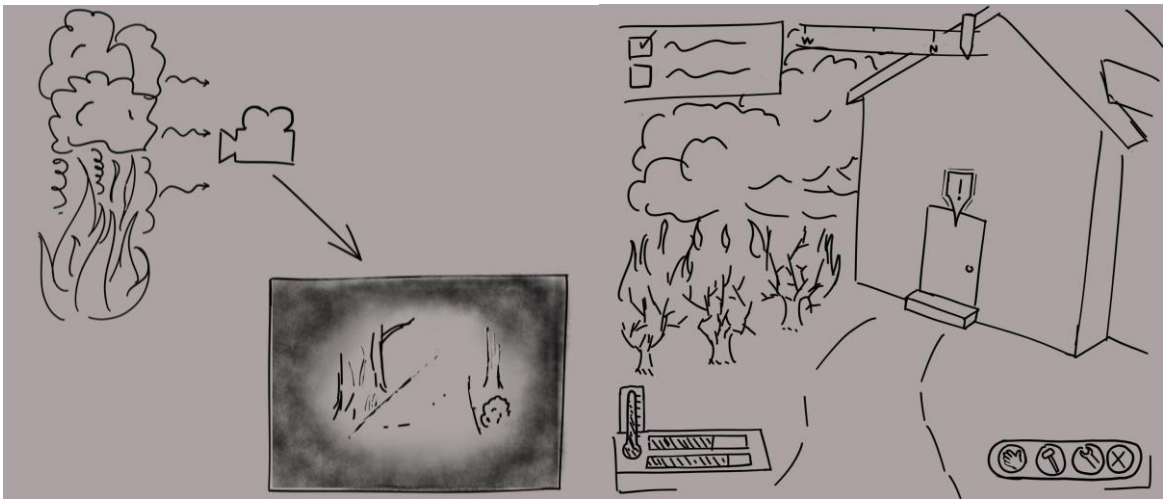


Figure 16: VFX High information HUD fusion concept sketch

3.1.2 Environmental navigation- Proximity based auto-walking-Joystick Movement

Using Concepts 2.2.2 and 2.2.5, combining joystick movement navigation and proximity-based auto-walking, this combination allows the user to move freely in a certain space in the direction they are facing, however, if the user were to step into dialogue or action-based area, the scenario would be activated automatically. Initially, the proximity navigation would be very restricting in terms of user movement as it does not allow the user to explore their surrounding environment, this would undoubtedly decrease user immersion as it would be similar to a film playing out.

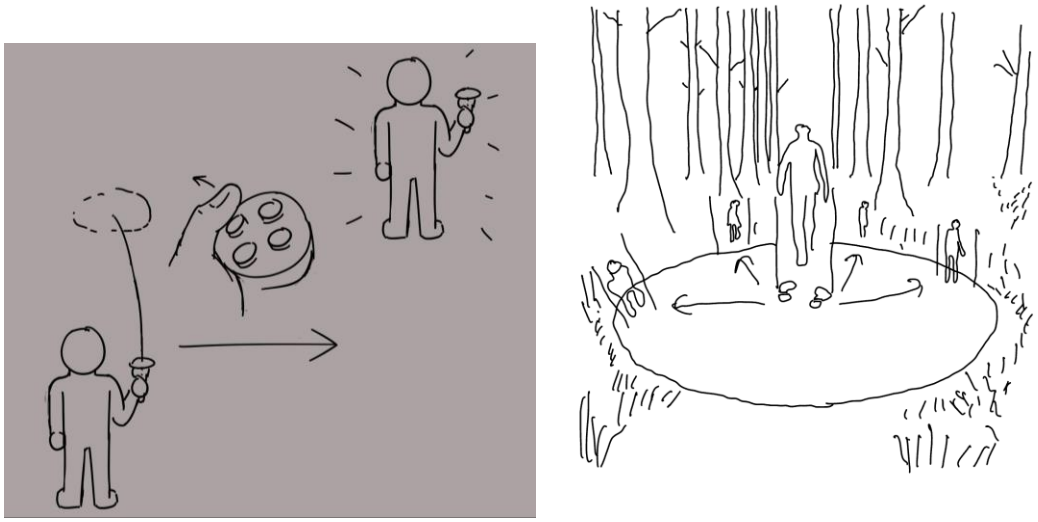


Figure 17: Teleportation and proximity-based auto-walking fusion concept sketch

3.1.3 Modes of User Interaction – Comprehensive Firefighting and Prevention

All concepts for user interaction (2.3.1 to 2.3.6) are all possible functional modes of interactivity within the simulation. Some of these concepts will be integrated into a set of inventory tools or mission related items that could be distributed and used throughout the simulation at appropriate times. The probing tool, clearing brush and fire extinguisher operate based on replacing one of the laser pointers of the joystick, meaning only one can be used at a time, requiring the user to specify which tool they will be using. Quick time events are an in-game event that activates based on a specific scenario. They are a way for the user to increase their immersion by feeling the intensity of a situation through a time constraint of a specific sequence of events. The Haptic feedback system affects the user in real life as it sends out vibrations through the controller/joystick to provide subtle cues to help the player sense environmental hazards. The purpose of these tools and modes is to increase user engagement and immersion in the simulation.

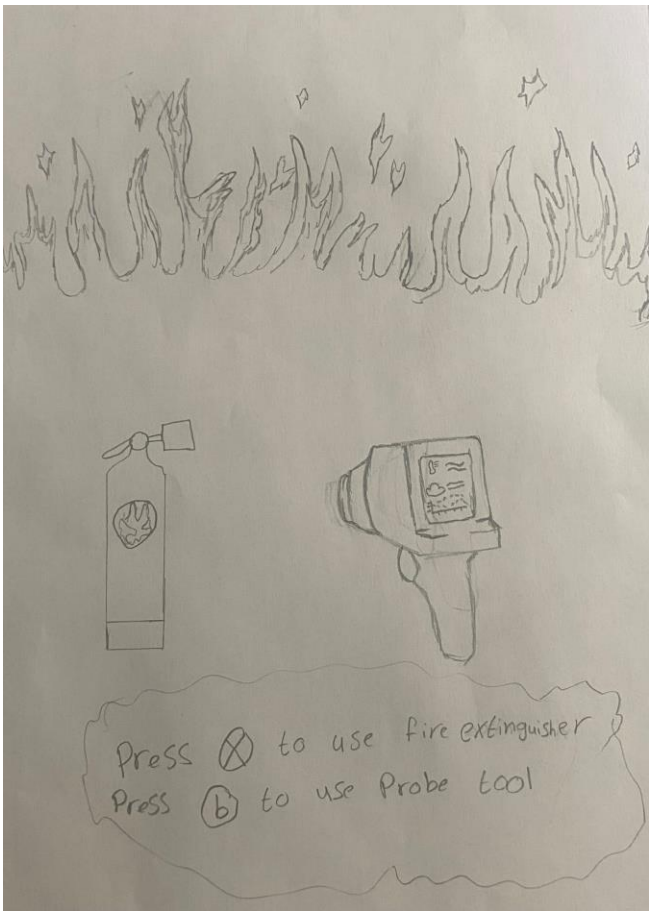


Figure 18: Comprehensive firefighting and prevention concept sketch

4 Developing Solutions

Using these subsystem ideas, we consider how they can be combined to support each other and work to collectively deliver a compelling and informative short story. From these synthesized solutions, we use a selection matrix to benchmark their qualities and converge on the best concept for the solution.

4.1 Generating Solution Concepts

4.1.1 Story Solution 1 - Lytton Evacuation

The user is a resident of Lytton, sitting at home and given a brief time (~30 seconds) to explore it, pick things up, see the neighbourhood, etc. Soon after, someone in another house starts shouting and an alarm sounds on the character's phone; an evacuation call for the fires. Sound picks up in the background, drawing the user's attention to the fire sweeping down into the town. They are given one objective: grab only what you need and get to the car to escape. The introduction should have given them some familiarity with the house and some endearment to the things in it, sending them to run around and pick up items as the fire grows louder and closer. After picking up a few items, the player is told they cannot hold anything more, and fires start to rise at the windows. They are forced to choose whether to try dumping things in their

car and coming back for more, or leaving things behind and leaving while they can. If they stay too long or escape, it fades to black, and information fades in on the reality of the Lytton fires. This will be mixed with some inner monologue about how the character feels and how the wildfire was only attributed to a railway accident [1]. This solution leans into the pure-VFX style of UI but would use button prompts for intractable items and include dialogue text. Environmental navigation would take the joystick controls, favouring its realism and the fact that it would be easy to curb the user's movement speed as a form of immersive feedback. Picking up objects to center them in the user's view and interacting with doors and cupboards would be the primary means of interaction, but including haptic feedback could be used to make picked up objects feel more realistic or to convey the shakiness of the panicking character.

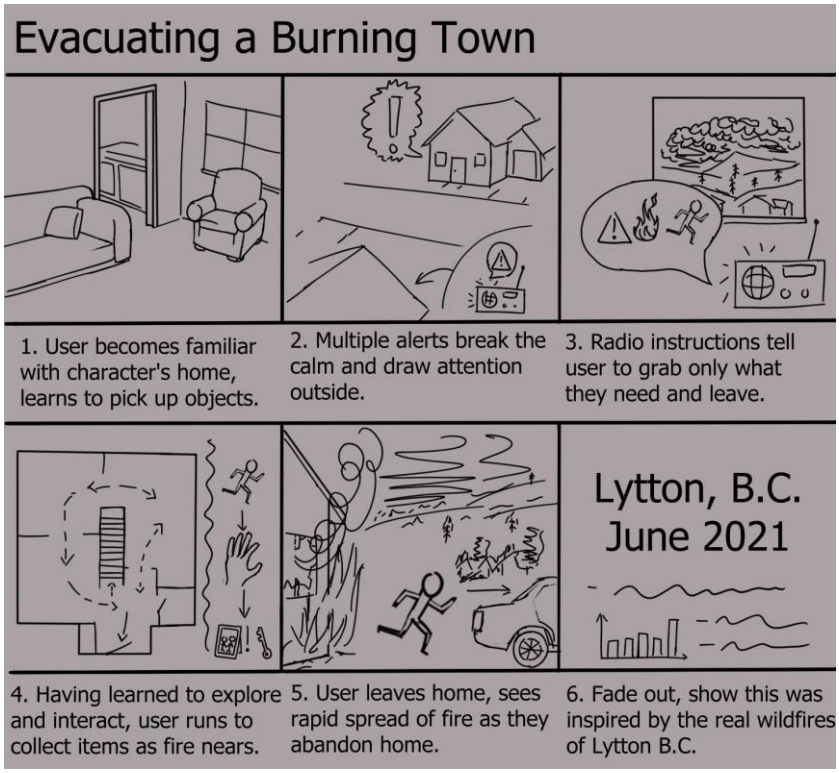
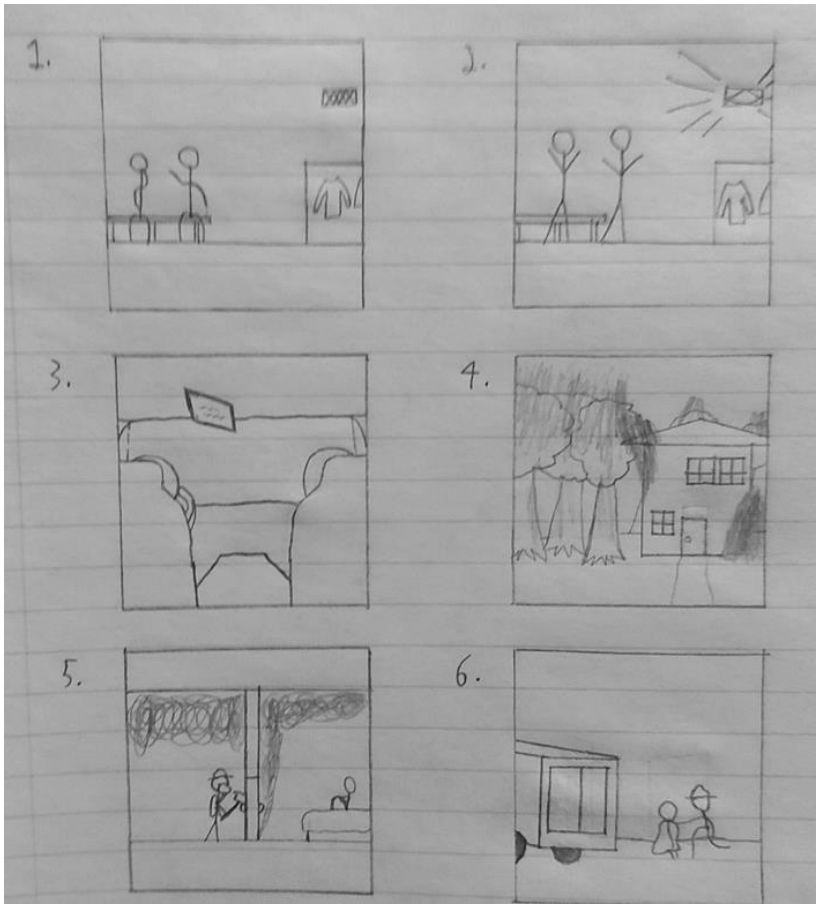


Figure 19: Lytton evacuation storyboard

4.1.2 Story Solution 2 - Search and Rescue

The user would be a firefighter of a small village, location can change, it's not super important. It starts off with them interacting with other workers, getting familiar with the firestation setting, when suddenly the alarm goes off. They must get to the truck (which they will most likely remember from exploring the station) quickly so that they can continue to the next part. Once they reach the burning home, they are instructed to go inside and find the person who called before the house collapses. The begging will have them forced to walk and look around the station so that they can have the knowledge of where the firetrucks are in case of an emergency as well as getting to know some of their fellow coworkers. Once the alarm sounds,

telling them to rush to the garage, the user will know where they need to go. During the short ride to the house (no more than 20 seconds) they'll get a brief rundown of what's happening and what to do once they reach the location. During the search of the house, the user will already be given an axe to break down anything in their way to reach the person in need. There will be button prompts that'll appear for when you need to break something or when helping the person leave the house. The UI would be minimal, with only few button prompts appearing when needed, but could also have the user's vision clouded when inside the burning house. The user would move around the different environments using basic joystick controls as that would be the most effective and immersive by having the story revolve around having the user find someone. Having the main form of interaction being inside the house would allow the user to feel as if the situation depends solely on them, and including haptic feedback could add weight to the user's actions when breaking down a door.



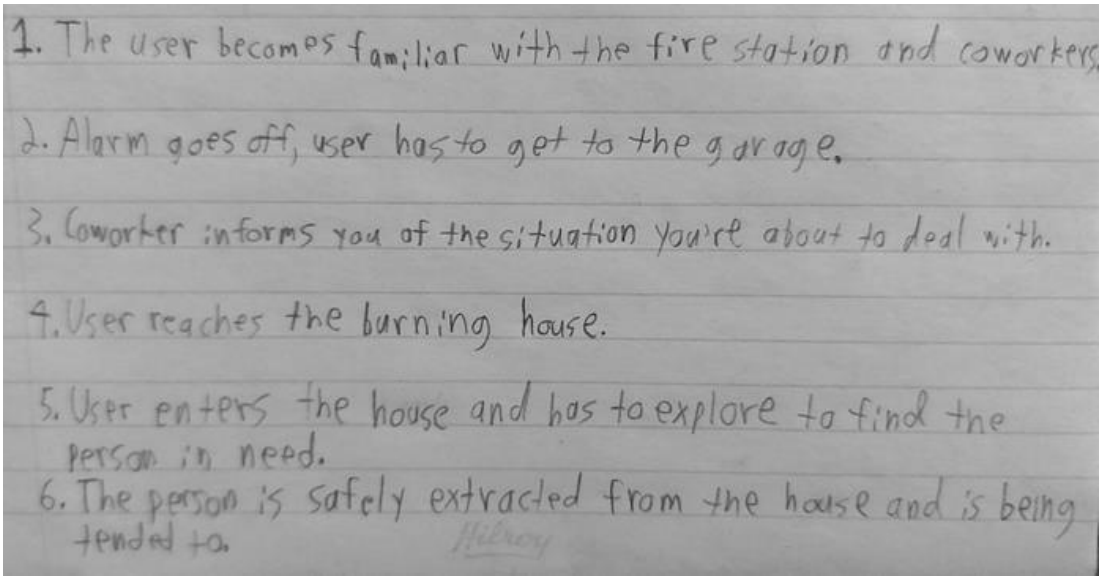


Figure 20: Search and rescue storyboard

4.1.3 Story Solution 3 - Fire Inspector

The user is a city fire inspector tasked with planning how to control an ongoing wildfire. They are teleported to a wooded area just outside a small town where many of the trees are dried out and dying, which they can inspect with their equipable probe/scanning tool. This provides data on how dry the trees are and whether they're still alive, as well as ambient conditions like wind speed and direction. Information like temperature and air quality, i.e. pollutant levels, are also passively displayed in smaller sections, with the user able to expand these to view historical values and see how they've been increasing. As the environment is explored and more data gathered, the user gains a better picture of how the climate is getting more prone to wildfires. To help convey this information, the user is accompanied by a non-descript companion who will prompt them through dialogue to think about how these conditions came to be and to comment on the state of things. This approach combines the diegetic and informational HUD concepts to more immersively deliver information while allowing the user to feel as competent as their character. As this is not meant to be a tense affair, teleportation may be a safe choice for environmental navigation as the finer control of the joystick is not required. The probe is the primary means of interaction, but there may be a short brush-cutting segment to teach the user and companion a bit about fire prevention.

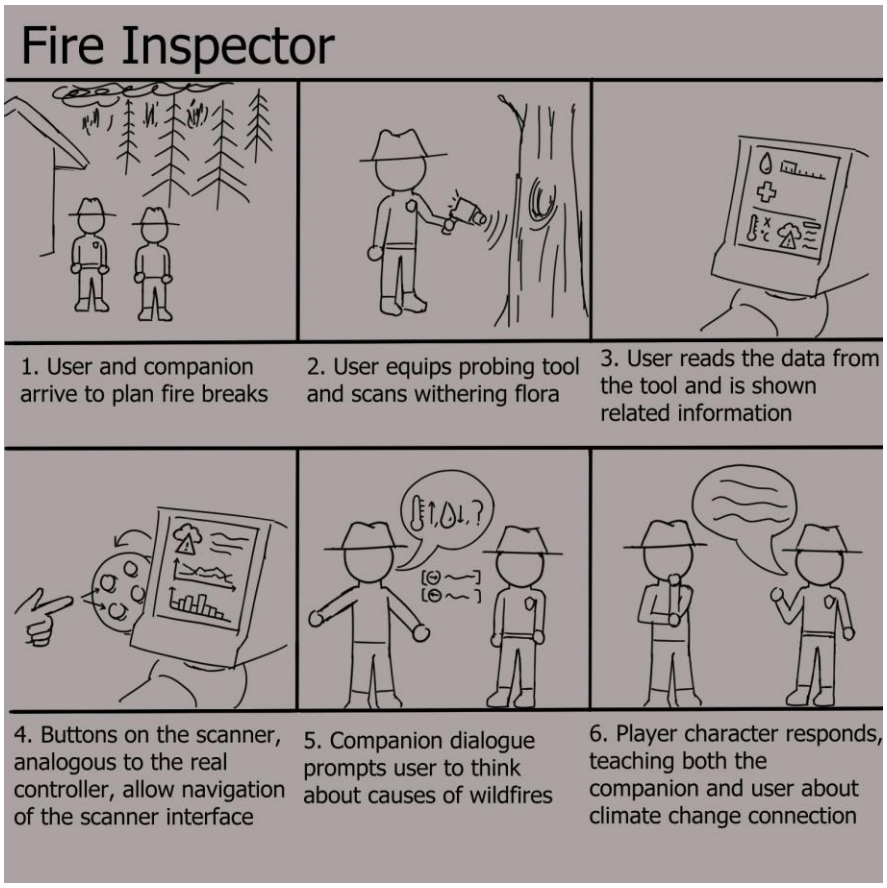


Figure 21: Fire inspector storyboard

4.2 Selection Matrix Evaluation and Analysis

The selection matrix is used to more objectively compare the solution concepts. Past benchmarking criteria are broken into more specific criteria as different subsystems may inherently target only certain parts of a broader criterion. Each is explained as follows:

- Simplicity of controls refers to the anticipated intuitivity of the controls, considering how they connect to real-world analogs or how similar they are to controls in existing games that users may already be familiar with.
- Compatibility with alternative controls evaluates how well the systems in a given solution could be used outside of VR, such as on a desktop, for accessibility.
- Direct connection to climate change is part of both immersion and education, stating how the solution shows the story and setting relate to climate change.
- Personal elements regards the expected parts of the simulation that will appeal to the user's empathy.
- Educational elements refers to what the simulation aims to teach about climate change and the sections that will focus on it. This is separate from the direct connection criterion as a given story may be informative on wildfires but fail to connect them to climate change.

- Interactivity seeks to quantify how much the user is able to interact with the simulation, measured by how much time they spend in control of the simulation and how much they can impact the simulation.
- Immersivity is how much the solution commits to making the user feel like they are really in the world they're seeing. This considers audiovisual and tactile feedback, as well as any elements that are perceived to likely be non-immersive or unrealistic.

Table 1: Criteria Benchmarking for Solution Concepts

Design Criteria	Lytton Evacuation	Search and Rescue	Fire Inspector
Simplicity of Controls	Controls required for item pickup and character navigation	Will require few button inputs for the tools and navigation	May require multiple buttons for scanner menu interactions
Compatibility with Alternative Controls	Suitable with bird-view control and teleportation	Railroading and teleportation due to minimal amount of movement in the scenario	Teleportation and scanner could easily map to mouse and keyboard.
Direct Connection to Climate Change	The real event can readily be connected to climate factors	More focused on the fires caused by climate change	More focused on the fires, climate is somewhat secondary
Personal Elements	Works to build sentimentality, fear, and sense of loss	Focuses on altruism, fear and sorrow.	Reliant on companion for personality
Educational Elements	Explicit information on the incident is only shown after the main simulation	Data will have to be shown NOT in the context of the world (i.e after the simulation)	Abundant data can be shown compactly and organically with scanner
Interactivity	Closely map to realistic actions, limited to convey proper emotions	Realistic actions like picking up objects and free movement around the station and house	Limited largely to dialogue choice and impersonal observation
Immersivity	Fully committed to immersion with limited UI and abundant environmental cues	Focused on the main character's story and the destructive scale of the wildfire disaster	Focuses on the character and info, less on being affected by the climate event

Table 2: Selection Matrix for Solution Concepts

Design Criteria	Importance	Lytton Evacuation	Search and Rescue	Fire Inspector
Simplicity of Controls	3	3	2	1
Compatibility with Alternative Controls	2	2	1	3
Direct Connection to Climate Change	5	2	2	3
Personal Elements	4	3	2	1
Educational Elements	5	1	2	3
Interactivity	4	2	3	1
Immersivity	5	2	3	1
Total	-	58	63	52

The relative importance of each criterion is rated on a 5-point scale, and the relative degree to which each solution fulfills a given criterion is rated on a 3-point scale. Immersivity, educational value, and connection to climate change were identified as the most important elements for the simulation. Personality and interactivity are important to conveying these but are not considered to be the primary objectives of the project. Qualities of the controls are nice to have but were not identified to be key elements by the client or by analysis of the problem. Based on these weightings and our interpretations of the relative merits of each complete concept, Search and Rescue (section 4.1.2) has come out as the most recommendable solution.

5 Conclusions and Recommendations

Several concepts for implementations were devised for the core subsystems of user interface and menus, environmental navigation, and modes of interactivity. From these, the previous technical benchmarks were broken down and expanded to better encompass the specific ways in which each subsystem can address the issue. Three potential solutions were built combining ideas from each subsystem, and on comparing them with one another against the revised criteria, the Search and Rescue simulation came out as the highest rated design and was thus selected as the concept to advance with, though the Lytton Evacuation remains a strong contender and will be kept as a backup plan should development go awry.

6 Future Work

As development continues, we will use this document as a reference for concise renditions of the concepts or to retrieve different concepts as back-up plans if one proves infeasible to implement during the development phase.

7 References

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