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Final Project Writeup – Kitty Kourier!

I. Abstract

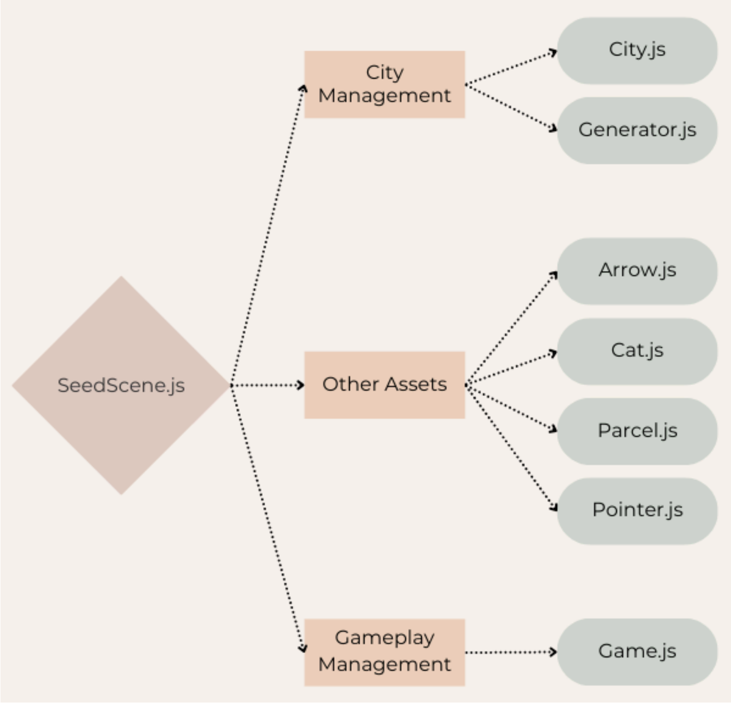
Kitty Kourier! is an endless runner style game, based in JavaScript under the Three.JS framework, in which the player controls a cat, named Bridget, who delivers parcels across a procedurally generated town. Players navigate sidewalks filled with various objects (e.g., foliage and street decor) and roads filled with speeding cars in order to pick up and deliver packages. This project uses the scaffolding code made available by Dr. Adam Finkelstein. Core contributions encompass a chunk-based terrain generation system, a character controller, character animations and animation slicing, audio management, collision detection, a robust game loop, and user interface elements.

II. Related Work

Kitty Kourier! combines elements of several games across varying genres. The project is inspired by endless runner games that I played growing up, like Subway Surfers and Temple Run. The game is also motivated by adventure games involving a cat protagonist navigating cities and obstacles, such as Stray and Little Kitty Big City. Combining the components of a cat protagonist, a town with obstacles, and an endless runner, I present Kitty Kourier!

III. Approach and Methodology

Figure 1. Kitty Kourier!'s game architecture.



The `SeedScene` class serves as the root of this game, as it initializes many necessary assets: the cat model, the lights, the audio manager, a city asset manager, a terrain generator, a texture loader for the game's background image, and a game manager responsible for most elements contributing to the infinite gameplay loop (i.e., spawning parcel and delivery destinations, vehicle management and crash handling, score tracking, and game-over conditions). The class manages the game's audio using Three.JS' `Audio`, `AudioListener` and `AudioLoader` libraries, and it also provides a mechanism for muting and unmuting all audio. The world's background image is set using Three.JS' `TextureLoader`. The world's background image and every audio file used for this game has been downloaded from Pixabay; links to original sources are provided in the bibliography, with specific attributions listed in the `readme` of my Git repository. The main update loop also exists within this class, as it manages the game over state and calls the update functionality for all objects that depend on this class (i.e., the cat, the terrain generator, and the game loop).

The procedural generation of the game environment is made possible by the `City` and `Generator` class. The `City` class loads the .glb file containing all city assets (e.g., buildings, vehicles, and street decor, etcetera) and organizes them into categories. For instance, a model of a coffee shop goes into the 'building' category. Our categories of interest are: buildings, vehicles, decor (e.g., foliage and street items), roads, and a fence that I use to act as a soft world barrier. The `City` class also consists of getter methods to retrieve a random object from each relevant category: (e.g., getRandomBuilding() and getRandomVehicle()). Note, all 3D models used for this project have been downloaded from Sketchfab as .glb files; links to original sources are provided in the bibliography, with specific attributions listed in the `readme` of my Git repository. The city assets .glb file organizes everything as a scene graph, so the class traverses it using Three.JS' GLTFLoader in order to retrieve each object. Each parent object consists of smaller, child objects, so we ensure we store objects by their parent reference by looking out for these references by their set name in the scene graph during graph traversal.

The `Generator` class then utilizes these categorized assets to create strips of terrain along the z-axis as the cat moves forward. Overall, I model the world as a series of 44.7 by 44.7 unit chunks aligned along the z-axis. In order to model the world as this grid of chunks, I implement this process: (1) calculate the current chunk (index) the cat is in by taking the cat's position along the z-axis and dividing it by the size of a chunk (44.7), flooring it, (2) for a given chunk index, compute the chunk's position in the world, (3) using the chunk's calculated world coordinates, populate the world with a symmetric layout: a road running down the middle, grass tiles extending from the road towards the edges of the map along the x-axis, a random building placed on each sidewalk, randomized road decor to act as obstacles for when the cat is navigating towards a point of interest (POI) (i.e., to pick up or deliver a package), and fences running through the edges of the map to form a soft world boundary. Each chunk varies slightly in appearance since the buildings and street decor are randomly indexed from the categorized list of city assets. The position of the street decor on the sidewalks are also randomly positioned along the x-axis, and there is a 0.8% chance street decor may not spawn for that chunk (specifically, street decor has a chance of spawning three times within a chunk, at different positions along the z-axis within that chunk, each with a 20% probability). The class also tracks all objects it creates to act as a repository the cat controller can access to check for collisions. In the main update loop, the class updates the current chunk the player is in, generates terrain for all chunks in view distance (for chunks not already populated with terrain), and it removes chunks behind the cat, outside of view distance to save memory.

The `Cat` class implements the player's avatar, Bridget the kitty. The class loads the .glb file containing the model and its associated animations: idle, walk, and run. The class manages the cat's animations using Three.JS' `AnimationMixer`. The source file stores all motions in a single animation clip, so the class slices the clip into explicit time ranges, updating the animation mixer's time accordingly when switching states; animations are also infinitely looped. The `Cat` class implements movement by listening for keyboard events and subsequently associating actions with specific keyboard events. `W` and `S` control forward and backwards movement, respectively, along the direction the cat is currently facing. `A` and `D` rotate the cat in place. And, holding `Shift` while moving forward makes the cat run (i.e., move at a faster speed). Animations are played accordingly for the cat's current action (e.g., if a cat is sprinting, the run animation is played). Lastly, the `Cat` class implements collision detection with objects along the sidewalks using axis-aligned bounding boxes. I implement collision detection predictively. To specify, I associate hit boxes with the cat's potential new position, check whether that hit box collides with any buildings or street decor, and only move the cat if there is no collision.

The `Game` class orchestrates all gameplay loop mechanics. The class manages package and delivery destination spawns; these POIs randomly spawn 60-90 units ahead of the cat. I ensure POIs spawn in locations where other street decor is not present by iteratively testing whether the POI object collides with any existing assets in the intended spawn location using axis-aligned bounding boxes in a similar manner as described earlier; if a collision is detected, I slightly move the POI object along the z-axis and repeat the testing procedure until a valid spawn location is found. The sidewalk that parcels spawn on is always random, but the delivery destination will always spawn on the sidewalk opposite to the parcel, forcing the player to cross the street every delivery cycle. The player automatically interacts with a POI (i.e., picks up or delivers their current package) as long as they are within a specific radius of it (in particular, 8 units). There is also a red arrow that follows the cat, guiding the player in the direction of a POI. The `Arrow`, `Parcel`, and `Pointer` classes load the directional arrow, parcel, and delivery location pointer, respectively. The `Game` class also spawns vehicles at randomized intervals (every 1–4 seconds) at the front edge of the map along the z-axis, where they move towards the cat; the speed of each vehicle is also random (3-5 units per update). Also, there can only be a maximum of 15 vehicles present in the world at a time to not overwhelm the player attempting to cross the road; vehicles that have travelled too far past the cat are removed to ensure new vehicles can consistently spawn as a result and for memory management. Vehicle collisions with the cat are also managed used axis-aligned bounding boxes in a similar manner as described earlier. If a car collides with the cat, the cat turns sideways, and the game ends.

Lastly, there are minimal graphical user interfaces within the game. Injecting HTML into `App.js` and using a CSS sheet, I made a start screen, an instruction screen, a score counter, an audio toggle button, and a game over screen. The icons used for the audio toggle button come from Iconify; links to the original sources are provided in the bibliography, with specific attributions listed in the `readme` of my Git repository.

IV. Results, Limitations, and Future Work

The resulting game implements a full loop of picking up packages, crossing the street, and delivering packages, all wrapped in an environment that infinitely extends as the player progresses. The cat's movement is also quite smooth and visually intuitive due to its animations, and the proximity-based parcel pickup/delivery mechanism keeps interactions simple. Also, the procedural generation of the environment supports this indefinite generation and ensures that each chunk varies in appearance slightly.

However, there exists some limitations. The use of simple hit boxes for collisions results in asymmetrical objects having blocking volumes larger than intended, causing the cat to collide with ‘empty’ space. For instance, a tree blocks a lot of space due to its crown despite the cat only being able to collide with its trunk. Moreover, object movement is currently tied to frame rate instead of a fixed time step, so the game feels faster on displays with a higher refresh rate. Lastly, game difficulty is static; there is no adaptive scaling as the player’s score increases.

Future work can address these limitations. For example, we can integrate a physics engine to handle the complex collisions associated with the use of many asymmetrical objects in this game. We can also implement a strict, delta time-based update mechanism so that timing does not hinge on frame rate. Additionally, we can adaptively scale the game difficulty in various ways as players increase their score; we could increase the vehicle spawn rate, have vehicles begin spawning in both lanes, and/or have packages spawn in the road, etcetera.

V. Ethical Concerns

One ethical concern that arises in the design of Kitty Kourier! is accessibility for players with color-vision deficiencies (e.g., red-green and blue-yellow color blindness), corresponding to ACM guidelines 1.2 avoid harm and 1.4 be fair and take action not to discriminate. The game mainly utilizes 3D assets with a low-contrast, pastel color palette. Thus, important gameplay elements, such as the package, delivery, and guidance markers, could be difficult to perceive for a player who is colorblind, thereby excluding them from having a fair experience with the game. To mitigate this concern, I can modify the aesthetics of Kitty Kourier! by adjusting contrast between assets, incorporating non-color cues (e.g., distinct shapes) on essential pointers, and/or offering selectable visual themes curated for common color-vision deficiencies, etcetera.

An ethical concern that arises in the gameplay of Kitty Kourier! relates to the depiction of fictional animal harm, corresponding to ACM guidelines 1.1 contribute to society and to human well-being, acknowledging that all people are stakeholders in computing and 1.2 avoid harm. Currently, the game only ends when the cat experiences a collision with a car. Upon collision, a sound of a cat meowing plays, the cat flips onto its side, and the game ends with a message stating, “Game over! Bridget got hit by a car... :(But do not worry! She's a super cat who got up, unharmed, and went home safely.” Even though all models are highly cartoon-esque, and there is reassurance that Bridget is okay, some players could find this representation of a car crash involving a common household pet upsetting. Thus, to mitigate emotional harm to players, I can adjust the fail-state of the game to be more ‘neutral.’ For example, on collision, I could incorporate an animation of the cat getting startled and retreating instead of being hit. I could also include a content warning on the instruction screen informing players of the vehicle hazards within the game.

This report represents my own work in accordance with University regulations.

/s/ Anha Khan

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