Emerging Technologies - Smart systems: Final project

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Abstract

This project focuses on developing an **interactive coconut shy game** using Unity3D with both conventional and augmented reality interaction modes. The AR mode integrates Vuforia to track real-world image targets.

1 Introduction

The aim of this project was to create an **interactive game** where players can throw a ball to knock down a pyramid of six cans. It was built using Unity (version 2022.3) and includes:

- a **non-AR game** standard variant, controlled via keyboard and mouse;
- an **AR game** variant, utilizing the Vuforia AR package for real-world interaction.

The ball is launched using a transparent arrow, with a certain direction and velocity managed by the user. Additionally, a scoring system has been implemented to track game progress.
To enhance gameplay, three difficulty levels were introduced:

- **Easy**, the basic version of the game, without additional environmental effects;
- **Medium**, which includes two static obstacles (a leafy tree and a leaning bare tree);
- **Hard**, which introduces wind effects and a 30 seconds countdown timer, in addition to the obstacles from the Medium level.

For the AR version, two image targets, *Astronaut* and *Fissure*, were added. The first one anchors the game's floor, while the second one places one of the two decorative trees around the cans. These trees serve only as background elements and are not related to the obstacles used in the difficulty levels.

2 Materials and Methods

The game developed in **Unity3D** following these steps:

2.1 Game Set and Objects

A Unity scene (*SampleScene*) was created, featuring a ground plane (floor) and a pyramid of cans arranged in a 3-2-1 structure. The cans were implemented as **cylinder objects**, each equipped with a *Box Collider* and *Rigidbody* component to enable realistic physics interactions and collisions with the ball. Regarding the ball, it was created using a **sphere object** with a *Sphere Collider*. To ensure proper gameplay dynamics, a *physics material* was assigned to it, providing moderate friction and low bounciness to prevent excessive rebounds. Finally, to pass from a level to another one in both the game versions, a double click on the correspondent level button is sufficient to have a restarted set.

2.2 User Interaction

The two modalities of interaction are:

- **Keyboard-mouse**: the ball is controlled using a transparent arrow, whose orientation is adjusted via a Joystick on the left, allowing players to set the throwing direction smoothly. The launch is triggered by a Joybutton on the right that, when pressed, releases the ball. Moreover, a slider enables players to adjust the throwing velocity before launching.
- **AR mode**: the game is anchored to the two image targets mentioned in previous section, using Vuforia. The interaction mechanics remain unchanged, utilizing the same Joystick, Joybutton, and slider as in the non-AR version.

Finally, the current ball force and score are dynamically displayed and updated in real time.

3 Results and Discussion

The final implementation resulted in a fully functional interactive game with a forest setting. To enhance immersion, the scene was designed to resemble a natural outdoor environment, reinforcing the classic concept of a tin-can shooting game typically played in rural or forested areas:

- the floor was textured with grass and small flowers from *Stylized Nature Textures package* ([Sto23c]);
- the cans were made of light-colored soil to blend with the natural theme;
- rocks, sourced from *Rock Package* ([Sto23b]), were scattered around to enrich the scenery;
- the two trees of decoration (one above Fossil image target), were sourced from the *Free Trees package* ([Sto23a]) in the Unity Asset Store.

Moreover, the choice of building the two trees of Medium and Hard levels using the Tree tool of 3D Object, was made to allow for better control over their shape and placement, ensuring they increased difficulty without excessive visual obstruction or occlusion. Larger and denser trees from external assets, in fact, would have hindered visibility and disrupted game balance. Regarding the wind introduced as an additional challenge in Hard level,

this effect was communicated to the user through a text notification displayed on the screen. It was avoided to add Unity's basic particle effects that were visually confusing and unrealistic.
These results contributed to an engaging gameplay experience, with realistic physics and natural interactions. In AR mode, however, some difficulties were encountered when restarting the scene between levels (specifically in Hard level the cans were not appearing again in their initial position). The experiment was conducted using the *Iriun Webcam* to stream video between an iPhone and a Windows laptop connected to the same Wi-Fi network. Therefore, the issues might have stemmed from an unstable connection or the computational load of the scene itself.
Finally, the use of both standard and AR modalities demonstrated the versatility of the system, but the second one resulted to be more immersive and stimulating for the user, thanks to the direct interaction with printed target and the real world.

4 Conclusion

This project successfully demonstrated the feasibility of integrating AR elements into a Unity3D physics-based game. Moreover, the inclusion of difficulty levels added depth to the game challenging players, along with an enrichment of the scene through nature objects. The principal challenge was encountered particularly in aligning AR objects with real-world physics. For a future expansion of the project, it would be interesting to add gesture recognition commands and multiplayer functionality, or new levels with other scene set.

References

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[Sto23c] Unity Asset Store. *Stylized Nature Textures - Unity Asset Store*. 2023. URL: https://assetstore.unity.com/packages/2d/textures-materials/stylized-nature-textures-228680.

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