

# Augmented Reality Project Proposal

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Our proposed project is an interactive AR (Augmented Reality) tower defence mobile game where the player can draw a level on paper following certain rules. Then, using a phone, the application will take the drawing and render the game scene. Elements of the map such as the towers and path can be drawn and rendered in real-time. The goal of the project is to investigate the potential of interactive real-time AR technologies in making novel and creative gaming experiences. Pen-and-paper is a particularly under-explored form of interaction in real-time applications, and this project aims to examine the possibilities at hand. This may reveal a new and interesting approach to game design and AR app development. By implementing this approach, we aspire to contribute to the advancement of the field and foster further exploration of novel approaches to real-time AR interaction.

## 1 INTRODUCTION

We propose an AR game that showcases the interplay between the real and virtual worlds by way of pen-and-paper, largely unexplored as a form of real-time interaction in AR. This is a timely and worthy topic to examine, as AR is a rapidly maturing technology with a wealth of untapped potential. There is a notable lack of existing work on incorporating real-time pen-and-paper interactivity. We believe this to be an interesting challenge to tackle in the realm of game design due to the ubiquity and accessibility of pen-and-paper as well as the novelty of the approach in the field of AR. This will provide an exciting challenge for us to tackle and hopefully contribute to the field of AR game design.

The project aims to showcase the potential of pen-and-paper as a medium of real-time interaction between the real and virtual worlds in AR. We shall do so by delivering a tower defence mobile game where the player draws a tower defence level following an appropriate set of restrictions. The computer attempts to defeat the level while the player can interact with and change certain elements such as towers, while the rendered game scene reflects all valid changes on the sheet of paper.

Regarding existing works, there are tabletop AR games like Mirrorscape [4] and Comino [2], and AR ports of known pen-and-paper games like Pictionary Air [3]. Research has also been done on VR pen control, as in Flashpen [8]. However, these all either require the use of specialised/proprietary equipment or are limited exclusively to digital interactivity, lacking real-world interaction.

Closer related to our proposed work are research works like Q\*bird [5] and Art of Defence [1]. These works demonstrate AR video game level-building using pre-fabricated tiles/cards, either real in the case of Art of Defence or virtual in the case of Q\*bird. Despite operating in real-time, neither of these demonstrates drawing on paper as a mode of interaction.

The most relevant works that we could find are AR Bridge Builder [6], which demonstrates the vectorisation of drawn lines on a whiteboard for an AR application, and Mario Sketchbook Android [9], an AR mobile game app that captures a photo of a simple drawing and makes it into a playable Mario-style 2D platformer level.

Both demonstrate the use of the pen-and-paper medium in AR, but neither delivers a real-time experience.

We plan to implement the project largely using Unity [10] as it is a cross-platform, powerful, and extensible game engine. We have also used it in labs previously and thus have some experience with it. Furthermore, we are strongly considering using Vuforia Engine [7] to complement Unity's built-in AR support and assist us in creating a modern application that allows us to complete our objective of exploring the possibilities of pen-and-paper in AR. We shall also make use of additional freely available packages/libraries as we work through the project, if necessary.

We are looking for a minimum of approximately 24 frames per second, and ideally a consistent framerate of 30 or higher. We will deploy to one or more Android mobile devices for testing and will use profiling tools, such as those found in Unity, to record and objectively evaluate the final app's performance. It is worth noting that since Unity is cross-platform, we expect it to be perfectly possible to deploy to a variety of other AR-compatible platforms such as iOS devices and MR (Mixed Reality) headsets; though doing so is beyond the scope of this project, we nonetheless consider this to be another advantage of choosing Unity as our development framework.

We shall endeavour to divide the workload equally and fairly amongst ourselves as we work on the project. We have organised our team in a dedicated Discord server to facilitate communication and teamwork, and have prepared a GitHub repository for source control and collaboration.

## REFERENCES

- [1] Duy-Nguyen Ta Huynh, Karthik Raveendran, Yan Xu, Kimberly Spreen, and Blair MacIntyre. 2009. Art of defense: a collaborative handheld augmented reality board game. In *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games* (New Orleans, Louisiana) (*Sandbox '09*). Association for Computing Machinery, New York, NY, USA, 135–142. <https://doi.org/10.1145/1581073.1581095>
- [2] Jakob Leitner, Christina Hochleitner, and Michael Haller. 2008. Bridging the gap between real and virtual objects for tabletop games. *International Journal of Virtual Reality* 7 (01 2008), 33–40. <https://api.semanticscholar.org/CorpusID:14285738>
- [3] Mattel. 2019. *Pictionary Air*. Mattel, Inc. <https://shop.mattel.com/products/pictionary-air-gjx13>
- [4] Mirrorscape. 2022. *Mirrorscape*. Mirrorscape, Inc. <https://www.mirrorscape.com/>
- [5] Aline Normoyle and Yifei Cheng. 2019. The Q\*bird Level Designer: User-assisted procedural level design in augmented reality. In *Proceedings of the 12th ACM SIGGRAPH Conference on Motion, Interaction and Games* (Newcastle upon Tyne, United Kingdom) (*MIG '19*). Association for Computing Machinery, New York, NY, USA, Article 46, 2 pages. <https://doi.org/10.1145/3359566.3364686>
- [6] Frank Petzold, Jonas Pfeil, Christian Riechert, and Richard Green. 2007. AR Bridge Builder: Real-Time Vectorisation of Freehand Sketched Structures for an AR Application. 6. <https://api.semanticscholar.org/CorpusID:110846497>
- [7] PTC. 2024. *Vuforia Engine*. PTC, Inc. <https://www.ptc.com/en/products/vuforia>
- [8] Hugo Romat, Andreas Rene Fender, Manuel Meier, and Christian Holz. 2021. Demonstration of Flashpen: A high-fidelity and high-precision multi-surface pen for Virtual Reality (*CHI EA '21*). Association for Computing Machinery, New York, NY, USA, Article 195, 4 pages. <https://doi.org/10.1145/3411763.3451550>
- [9] Cal Stephens, Jake Waldner, and Nate Thompson. 2017. *Mario Sketchbook Android*. Helluva Engineers, Georgia Institute of Technology. <https://github.com/helluva/Mario-Sketchbook-android>
- [10] Unity Technologies. 2024. *Unity3D*. Unity Technologies, Inc. <https://unity.com/>