CS496 Software Project:
VR Puzzle Game

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1 Client Information

By sharing this client information and the rest of this document, you are stating that this client has provided this project as something they want (not something you created and asked if they wanted), and that they are interested in having you complete this project for your capstone.

- Client name: Hoang Bui
- Client title: Associate Professor
- Client email address: hdbui@loyola.edu
- Client employer: Loyola University Maryland
- How you know the client: We had him as a professor, have work with him, and he is our Competitive Programming Coach

2 Project Description

2.1 Overview

The goal of this project is to create a virtual reality (VR) puzzle game that can be played using the Meta Quest headset. This app will allow the user to take pictures of real-life objects, and then the app will generate a puzzle by breaking down the real-life object into pieces. The pieces could either be normal jigsaw puzzle shaped pieces or different shapes of the user's choosing. The user should also be able to adjust the difficulty of the puzzle by choosing the number of pieces. Finally, the user can import the puzzle into the VR world and attempt to solve it by fitting the pieces together by using their hand motions.

The problem that this project is trying to solve is that the issue with real jigsaw puzzles is that you must buy another one every time you want to solve a new one. This is impractical for Dr. Bui because he enjoys solving puzzles but does not have the time to keep going out and buying new ones. He wants to be able to generate new puzzles quickly and then solve them using his Quest headset. This app will solve this issue because Dr. Bui can take a picture of any real object of his choosing, and then the app will generate a puzzle for him.

Another issue with real life puzzles is that they become less interesting if you are to do them a second time because you already know the solution. Since the app can generate new puzzles on the fly, it will keep Dr. Bui engaged by giving him a new challenge.

2.2 Key Features

- Scan picture of real object into puzzle, Solve the puzzle in VR world
- Ability to choose the number and shape of the puzzle pieces

- Since the puzzles may be challenging and take some time, Dr. Bui wants to be able to keep track of his progress on a puzzle so he can come back to it later
- Keep track of how long it takes to solve a particular puzzle. This allows for competition as you can challenge someone else to solve the same puzzle
- Leaderboard displaying the best solving times for a particular puzzle
- Providing hints for where the pieces fit
- Additionally, Dr. Bui wanted to have the ability to be able to take a picture of a real puzzle and then import it into the VR world. This would still use the same pieces, so essentially just solving the same puzzle but it is instead while being in the VR world.
- This app would also have to figure out how to solve the real puzzle in order to provide hints. Giving hints for the real life objects is much easier as you know the solution before you break it into a puzzle.

2.3 Why this Project is Interesting

This project is interesting because it is unique compared to many other senior capstone projects. There is also learning to be done to figure out how to make this app work, which we are excited about as we have never done a project related to VR. Additionally, it seems there is not much existing support for scanning real life objects and converting them into puzzles. Most mainstream puzzle apps use premade objects (such as the one linked below). Some of them did have an uploading feature, but it was a 2D image rather than taking a picture of a 3D object in real life.

Existing Puzzle Game Link: `https://www.meta.com/experiences/art-puzzle/5920812271341547/`

2.4 Areas of CS required

- Human Computer Interaction
- Game Development
- Algorithms
- Computer Vision

2.5 Potential Concerns and Questions

We think this project should fit the requirement of a senior capstone as there are several different areas of CS involved and the project will certainly be a lot of work. The only concern we would have for ourselves is that a lot of this will be new to us. We are not sure yet about how to use the hardware to accomplish all of this. Despite this, we are good at learning new technologies and ideas, so we should be able to manage well.

2.6 Summary of Efforts to Find a Project

We talked to Dr. Bui in person about this project, and he gave us the requirements and explained why he wanted this project. We have another project that we are currently considering, which is a SWE project for Blue Raven. We are currently a little concerned that the Blue Raven project may not have enough to do for a senior capstone which is why we are continuing to pursue multiple projects in parallel.

2.7 Comparison to Draft

This is not the same project that either of us proposed. We had concerns about the original project that we were trying to do because it seemed that it might be too basic. The original project was the one with Blue Raven. We have had struggles with getting in contact with the people who would help us refine the requirements of the project. This project definitely seems to be more promising. We decided to pursue both a completely different project and client due to the same concerns above. We were considering asking for a new project, but we were afraid of having the same issues of communication with them.

3 Requirements

3.1 Non-Functional Requirements

[Non-functional requirements are just as important as functional requirements. Dont forget to specify them.]

ID	NFR Title	Category	Description
NFR1	Puzzle Generation	Performance	Puzzle should quickly in less than 2-3 seconds
NFR2	Framerate	Performance	Game should run at at least 72fps (equal to minimum refresh rate) on the meta quest headset
NFR3	Cheating Prevention	Security	Prevent users or at least make it extremely difficult to uploading a false time
NFR4	Understandable Menus	Usability	Good UI/UX for menus, easy to understand what menus are for
NFR5	Understandable Interactions	Usability	Pieces are easy to interact with and interactions are intuitive
NFR6	Game Server	Reliability	Server should be almost always up so that users can attempt uploaded puzzles and view the leaderboards at any time

Table 1: Non-Functional requirements

3.2 Functional Requirements (User Stories)

ID	Story Title	Points	Description
U0	Piece Movement	1	As a user I want to be able to pick up and move around puzzle pieces using my real hand motions so that I can figure out how to solve the puzzle.
U1	Piece Connection	5	As a user, I want to be able to connect puzzle pieces together so that I can make progress towards solving the overall puzzle.
U2	2D Picture Upload	1	As a user, I want to be able to upload a picture file contains a 2D object so that I can solve a puzzle consisting of pieces of that object.
U3	Piece Generation	5	As a user, I want to be able to generate puzzle pieces out of an object so that I can enjoy reconstructing the object by fitting the pieces back together.
U4	Local Puzzle Creation	2	As a user I want to be able to create a puzzle locally so that I can solve it on my headset.
U5	Local Puzzle Delete	1	As a user I want to be able to remove a locally created puzzle so that I can get rid of puzzle that I don't want to play anymore.
U6	Move Puzzle	2	As a user I want to be able to pick up my partially solved puzzle and move it so that I can reorganize my workspace while solving the puzzle.
U7	Choose Piece Count	1	As a user I want to be able to choose the number of pieces in the puzzle so that I can adjust the difficulty to my preference.
U8	Choose Piece Shape	3	As a user I want to be able to choose the shape of the pieces in the puzzle so that I can solve a puzzle consisting of my favorite shapes.
U9	Solve Time	2	As a user I want to be able to see how long it takes me to solve a puzzle so that I can put my puzzle solving skills to the test and challenge my friends.
U10	Puzzle Upload	2	As a user I want to be able to upload puzzles that I create so that other people can also attempt to solve them.
U11	Uploaded Puzzle Deletion	1	As a user I want to be able to delete puzzles that I uploaded so that I change my mind about which of my puzzles I want publicly available.
U12	View Other Puzzle Uploads	1	As a user I want to be able to view puzzles created by other people so that I can decide which ones I want to try to solve.
U13	Download Puzzles	1	As a user I want to be able to download puzzles created by other people so that I can solve them myself.
U14	Save Progress	2	As a user I want to be able to save my current progress on a puzzle so that I can come back and finish it later.
U15	Provide Piece Hint	2	As a user I want to be able to receive a hint as to where one of the pieces that I have not yet connected fits into the puzzle so that I can get help when I am stuck.
U16	3D Object Upload	1	As a user I want to be able to import a 3D object file into the game so that I can solve a 3D puzzle out of that object.
U17	Leader Board Creation	2	As a user I want to have a leader board generated after I upload a puzzle so that I can see who is the best at solving my puzzle.
U18	View Puzzle Leader Board	2	As a user I want to be able to view the leader boards of uploaded puzzles so that I can see where my time ranks compared to others.
U19	Leader Board Update	2	As a user I want the leader board to update my I or someone else solves the puzzle so that I can see the most up to date standings.
U20	Take Picture with Headset	2	As a user I want to be able to take a picture of an object using the headset so that I can generate a puzzle from that image to solve.
U21	Crop Image on Headset	2	As a user I want to be able to crop an image that I take with the headset so that I can generate the puzzle out of only parts of the image I want to keep.

Table 2: Functional requirements as User Stories.

4 System Design

4.1 Architecture

[Which type of software architecture are you team following? Layered architecture, MVC, other? What are the main modules for your software?]

4.2 Diagrams

[CS482, on sprints/iterations 2-3, you need to create and update a diagram (check the assignment for which type of diagram). On CS496, since before sprint/iteration 1 you should have a class diagram and keep it up-to-date.]

4.3 Technology

[Which technologies are you going to use to implement your project? This should include the chosen programming language, main frameworks/libraries, and database or data storage. Testing framework is essential here as well.]

4.4 Coding Standards

[Are your team going to follow any coding standards? For example, using a naming convention for Database tables (like only singular lowercase names). Another example, only allowing code with unit tests and above 60% coverage to be committed (good convention since testing is going to be evaluated). If you need inspiration to define your coding standards, the Extreme Programming approach has a set of coding, design, and test rules.]

4.5 Data

[What is the main structure of your data? In SQL-like databases, this would be the planning of the main tables, their attributes, and interactions with other tables (basically an ER diagram). In NoSQL databases, this would be the main collections and general attributes of the JSON you will store in each collection.]

4.6 UI Mocks

[Define and draw/sketch/code the main UIs your user will interact with in your software. Add your UI mocks here and a short caption about it. Do not forget about the main forms and CRUD UIs.]

5 Iterations

5.1 Iteration Planning

Iteration	Dates	Stories	Points
1	01/27 - 02/10	U0 Piece Movement (1), U1 Piece Connection (5), U2 2D Picture Upload (1)	7
2	02/10 - 02/24	U3 Piece Generation (5), U4 Local Puzzle Creation (2), U5 Local Puzzle Delete (1)	8
3	02/24 - 03/17	U6 Move Puzzle (2), U7 Choose Piece Count (1), U8 Choose Piece Shape (3), U9 Solve Time (2)	8
4	03/17 - 03/31	U10 Puzzle Upload (2), U11 Uploaded Puzzle Deletion (1), U12 View Other Puzzle Uploads (1), U13 Download Puzzles (1), U14 Save Progress (2), U15 Provide Piece Hint (2)	9
5	03/31 - 04/14	U16 3D Object Upload (1), U17 Leader Board Creation (2), U18 View Puzzle Leader Board (2), U19 Leader Board Update (2), U20 Take Picture with Headset (2), U21 Crop Image on Headset (2)	11
		Total:	43

Table 3: Iteration Planning for Incremental Deliveries

5.2 Iteration/Sprint 1

5.2.1 Planning

Team Member	Story	Story Description	Points
Joe	U1	Piece Connection (Pair Programming)	2.5
	U2	2D Picture Upload	1
		Joe Total	**3.5**
Kyle	U0	Piece Movement	1
	U1	Piece Connection (Pair Programming)	2.5
		Kyle Total	**3.5**
		Total	**7**

Table 4: Iteration 1 Planning

5.2.2 Work Done

[Which stories did you complete in this iteration/sprint. Which ones did you partially complete? Who worked on which story? You may elaborate in paragraph(s) to add more detail about the work done.]

5.2.3 Testing Coverage

[Testing is very important. Show your coverage here. Is this coverage good enough? Explain why you think so. Is it not good enough? Explain a plan to increase the coverage. You may also elaborate on why some artifacts do not undergo much testing. If the testing changed from the last iteration, explain the reasons.]

5.2.4 Retroespective & Reflection

[What were the pitfalls, challenges, and issues you had in this iteration? How can you address them to improve the process in the next iteration? Did anything not go according to plan? Why so and how to avoid the same mistake? Write a personal reflection on what you learned in this iteration (even if a small technical thing like Database storage).]

5.3 Iteration/Sprint 2

5.3.1 Planning

Team Member	Story	Story Description	Points
Joe	U3	Piece Generation (Pair Programming)	2.5
	U4	Local Puzzle Creation (Pair Programming)	1
	U5	Local Puzzle Delete (Pair Programming)	0.5
		Joe Total	**4**
Kyle	U3	Piece Generation (Pair Programming)	2.5
	U4	Local Puzzle Creation (Pair Programming)	1
	U5	Local Puzzle Delete (Pair Programming)	0.5
		Kyle Total	**4**
		Total	**8**

Table 5: Iteration 2 Planning

5.3.2 Work Done

[Which stories did you complete in this iteration/sprint. Which ones did you partially complete? Who worked on which story? You may elaborate in paragraph(s) to add more detail about the work done.]

5.3.3 Testing Coverage

[Testing is very important. Show your coverage here. Is this coverage good enough? Explain why you think so. Is it not good enough? Explain a plan to increase the coverage. You may also elaborate on why some artifacts do not undergo much testing. If the testing changed from the last iteration, explain the reasons.]

5.3.4 Retroespective & Reflection

[What were the pitfalls, challenges, and issues you had in this iteration? How can you address them to improve the process in the next iteration? Did anything not go according to plan? Why so and how to avoid the same mistake? Write a personal reflection on what you learned in this iteration (even if a small technical thing like Database storage).]

5.4 Iteration/Sprint 3

5.4.1 Planning

Team Member	Story	Story Description	Points
Joe	U7	Choose Piece Count	1
	U8	Choose Piece Shape	3
		Joe Total	**4**
Kyle	U6	Move Puzzle	2
	U9	Solve Time	2
		Kyle Total	**4**
		Total	**8**

Table 6: Iteration 3 Planning

5.4.2 Work Done

[Which stories did you complete in this iteration/sprint. Which ones did you partially complete? Who worked on which story? You may elaborate in paragraph(s) to add more detail about the work done.]

5.4.3 Testing Coverage

[Testing is very important. Show your coverage here. Is this coverage good enough? Explain why you think so. Is it not good enough? Explain a plan to increase the coverage. You may also elaborate on why some artifacts do not undergo much testing. If the testing changed from the last iteration, explain the reasons.]

5.4.4 Retroespective & Reflection

[What were the pitfalls, challenges, and issues you had in this iteration? How can you address them to improve the process in the next iteration? Did anything not go according to plan? Why so and how to avoid the same mistake? Write a personal reflection on what you learned in this iteration (even if a small technical thing like Database storage).]

5.5 Iteration/Sprint 4

[CS496 has 5 sprints. CS482 only has only 3 sprints (remove Iterations 4 and 5 from this doc if you are writing a doc for 482]

5.5.1 Planning

Team Member	Story	Story Description	Points
Joe	U10	Puzzle Upload	2
	U11	Uploaded Puzzle Deletion	1
	U15	Provide Piece Hint	2
		Joe Total	**5**
Kyle	U12	View Other Puzzle Uploads	1
	U13	Download Puzzles	1
	U14	Save Progress	2
		Kyle Total	**4**
		Total	**9**

Table 7: Iteration 4 Planning

5.5.2 Work Done

[Which stories did you complete in this iteration/sprint. Which ones did you partially complete? Who worked on which story? You may elaborate in paragraph(s) to add more detail about the work done.]

5.5.3 Testing Coverage

[Testing is very important. Show your coverage here. Is this coverage good enough? Explain why you think so. Is it not good enough? Explain a plan to increase the coverage. You may also elaborate on why some artifacts do not undergo much testing. If the testing changed from the last iteration, explain the reasons.]

5.5.4 Retroespective & Reflection

[What were the pitfalls, challenges, and issues you had in this iteration? How can you address them to improve the process in the next iteration? Did anything not go according to plan? Why so and how to avoid the same mistake? Write a personal reflection on what you learned in this iteration (even if a small technical thing like Database storage).]

5.6 Iteration/Sprint 5

5.6.1 Planning

Team Member	Story	Story Description	Points
Joe	U17	Leader Board Creation (Pair Programming)	1
	U18	View Puzzle Leader Board (Pair Programming)	1
	U19	Leader Board Update (Pair Programming)	1
	U21	Crop Image on Headset	2
		Joe Total	**5**
Kyle	U16	3D Object Upload	1
	U17	Leader Board Creation (Pair Programming)	1
	U18	View Puzzle Leader Board (Pair Programming)	1
	U19	Leader Board Update (Pair Programming)	1
	U20	Take Picture with Headset	2
		Kyle Total	**6**
		Total	**11**

Table 8: Iteration 5 Planning

5.6.2 Work Done

[Which stories did you complete in this iteration/sprint. Which ones did you partially complete? Who worked on which story? You may elaborate in paragraph(s) to add more detail about the work done.]

5.6.3 Testing Coverage

[Testing is very important. Show your coverage here. Is this coverage good enough? Explain why you think so. Is it not good enough? Explain a plan to increase the coverage. You may also elaborate on why some artifacts do not undergo much testing. If the testing changed from the last iteration, explain the reasons.]

5.6.4 Retroespective & Reflection

[What were the pitfalls, challenges, and issues you had in this iteration? How can you address them to improve the process in the next iteration? Did anything not go according to plan? Why so and how to avoid the same mistake? Write a personal reflection on what you learned in this iteration (even if a small technical thing like Database storage).]

6 Final Remarks

6.1 Overall Progress

[Have you completed everything? If so, present evidence on how you brought value to your client, and the overall client satisfaction. Otherwise, estimate how much progress you done and how long it would take to finish this project.]

6.2 Project Reflection

[Your personal reflection on the project. What lessons did you learned. What would you have done differently. How can you do better work in future projects? You may write this as a team or per person (or both)]

Appendix

[Appendix section if needed]