4 Design

4.1 Design Context

4.1.1 Broader Context

Our challenge in detail is reverse engineering the brain. Medical and technical personnel around the world are working towards solutions that will have applications in artificial intelligence, medical treatments, and prosthetics. The knowledge of this challenge is crucial to garnering public support and increased funding. Our goal is to inform and gain the interest of the general public and potential engineers through an interactive art exhibit to display on Iowa State University's campus.

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	Our project could lead or be improved upon in areas that can help map the human brain. Or assist with reading brain activity to certain situations. And also help people become aware of the possibilities of virtual reality.	Increasing exposure to Engineering Art. Maybe a stepping ladder for other fields, like mapping the brain. And a cheaper way to read brain activity.
Global, cultural, and social	Our project should educate the general public about why Reverse Engineering the brain is an important topic.	The development of our project is supposed to target groups that are interested in engineering. And both positively and negatively affect the global, cultural, and social areas we live in.
Environmental	Our project ideation that we are leaning towards would cause us to use silicone to make our device. Which if mass produced could lead to a silicone-deficit.	Most of our pieces needed to engineer are product use silicone.
Economic	With the project we have and the idea we are going with reverse engineering the brain using VR, it will be difficult to create our product within the $500 budget. Because a lot of the pieces we need can well over be past that budget.	The computer we need to run our software needs to have a gaming engine, in order for our simulation to run with no problems or hiccups.

4.1.2 Prior Work/Solutions

A lot of initial research has been done for this project including:

1. Roysam, B., Shain, W. & Ascoli, G.A. The Central Role of Neuroinformatics in the National Academy of Engineering's Grandest Challenge: Reverse Engineer the Brain. *Neuroinform* 7, 1–5 (2009). https://doi.org/10.1007/s12021-008-9043-9
2. https://physiology.med.cornell.edu/faculty/nirenberg/lab/papers/PNAS-2012-Nirenberg-1207035109.pdf (will do full citation in future)

3. https://www.youtube.com/watch?v=Ey7VokgpZZ4&list=PLJ8uEbBRJZKf878RK5gjmDvSciU4AUNmY&index=29
4. https://science.mit.edu/future-of-artificial-intelligence/
5. https://neuroscience.stanford.edu/news/can-we-reverse-engineer-brain-computer
6. https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1005268
7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2726926/
8. https://link.springer.com/chapter/10.1007/978-3-642-38556-8_9
9. https://www.santafe.edu/what-is-complex-systems-science
10. http://eztuir.ztu.edu.ua/bitstream/handle/123456789/6479/142.pdf?sequence=1&i
11. https://link.springer.com/book/10.1007/978-94-017-7239-6
12. S. Adee, "Reverse engineering the brain," in IEEE Spectrum, vol. 45, no. 6, pp. 51-53, June 2008, doi: 10.1109/MSPEC.2008.4531462. https://ieeexplore.ieee.org/document/4531462
13. https://www.sciencedirect.com/science/article/pii/S0006899319306365
14. https://www.worldscientific.com/doi/abs/10.1142/S1793843010000448
15. https://lifesciences.ieee.org/article-archive/reverse-engineering-animal-vision-with-virtual-reality-and-genetics/
16. https://ieeexplore.ieee.org/abstract/document/6861928
17. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6354552/
18. https://www.sciencedaily.com/releases/2014/11/141124162926.htm

The research done is in reference to reverse engineering the brain, and specifically around how this research helps improve AI.

There's plenty of interactive exhibits for example see

- https://blooloop.com/technology/in-depth/immersive-art-experiences/
- https://desmoinesartcenter.org/art/exhibitions/immersive/
- https://www.tiqets.com/blog/interactive-museum/

We're not following any previous work as we are building a new interactive exhibit, but we are not the first people to build an interactive exhibit. There are specific benefits that interactive exhibits give such as ability to gain more interest and keep users engaged, but with drawbacks such as complexity. These were pros and cons that were balanced before we started the project and decided as part of the requirements given to us.

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. Assuming we develop for the **Microsoft Hololens 2** or another **AR** platform, there is an inherent complexity involved with mapping and scaling your software to a real world location, possibly ones we can't plan for.
2. Assuming our project makes use of the **multimedia wall** in Coover, we will have to do some reverse engineering of our own and figure out how it operates, what type of software it runs, and how to deploy it.

3. Assuming our project **analyzes users actions** and **makes predictions based on this**, we will need to implement a decently robust prediction algorithm or neural network.
4. So many **assumptions.** This is because our project was given to us in an extremely **open-ended** form. We have many important decisions to make about how best to represent our chosen engineering challenge, many of which will have far-reaching effects on the rest of our project.
5. Our project will be **installed** somewhere and must be able to function without an expert on hand, possibly without any supervision whatsoever.
6. Requires a sufficient understanding of **reverse-engineering the brain/AI** and their inherent challenges in order to present the challenge accurately.
7. Our project must strike a **balance**. While it does need to be well-researched, well-informed, and accurate to the engineering challenge it represents, it also should not be too technical. The average person should be able to understand it and learn something.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

Previous Decisions:

1. **Focusing on 21st-Century Challenges:** To begin our project, we had the options of innovations in the ECpE department at Iowa State and the 21st-Century Engineering Challenges proposed by the National Academy of Engineering. Selecting the 21st Century Challenges has narrowed our deeper topics down to the fourteen listed rather than the full history of ECpe developments at Iowa State. It also highlighted the importance of outside research and expert opinions--examining the ECpE department would involve almost entirely on-campus outreach.
2. **Focusing on Reverse Engineering the Brain:** Of the fourteen challenges, reverse engineering the brain had the strongest interest from our team and the greatest potential for an interactive exhibit. Again, this influences the future of our project greatly--we know that we should continue research and expert interviews with a focus on neuroscience and biology, in addition to engineering in the field.
3. **Focusing on Applications in Artificial Intelligence:** To further narrow our focus, we decided to focus on the applications of reverse engineering the brain in artificial intelligence. We know to ask questions in upcoming interviews related specifically to artificial intelligence--this will help us make the most efficient use of our time with experts and prevent our topic from growing outside the scope of the project and timeline.

Future Decisions:

1. **Technological Implementation of the Project:** While we have had some initial brainstorming regarding the implementation and nature of our interactive art exhibit, the method and chosen technology are choices we'll have to make as we continue working on solution ideation. Once we

have an intended method, we will be able to conduct further research, if necessary, and begin work on the actual solution itself.

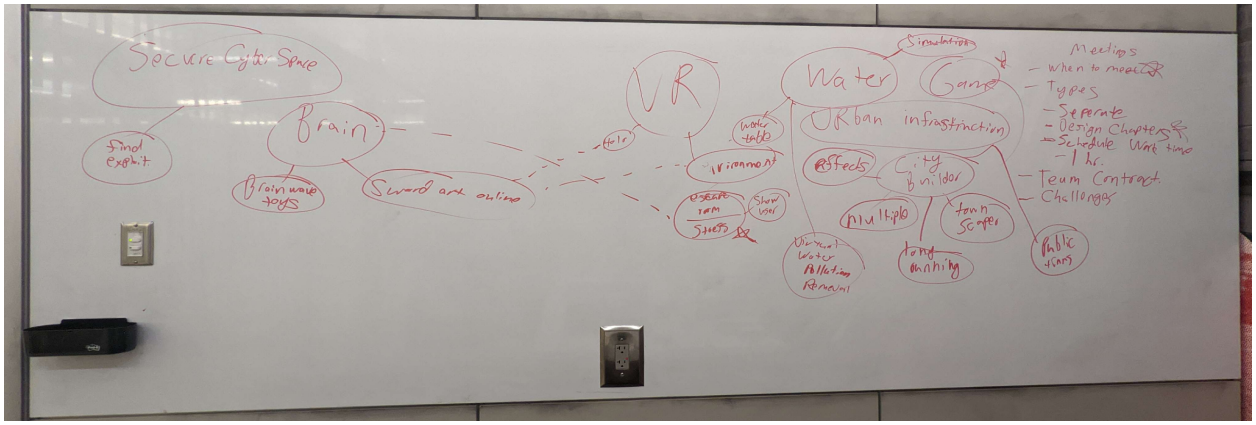
2. **Location of the Project:** Depending on where our project is displayed, we may face additional limitations and constraints on what we are able to do. If it's outside, we need to account for variable weather conditions and general wear-and-tear. If it's inside, square footage will have a stronger influence. We will likely need to consider internet connectivity, electricity availability, and security, regardless of the specific location.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

Deciding our Project Topic

When we first gathered our team to decide our project's topic from one of the 14 Engineering Grand Challenges, we all came to our meeting with our own individual thoughts and eventually took votes and narrowed down the topics. Our chosen method for this decision was to draw a mindmap on a whiteboard with each suggested topic challenge as their own center node to their personal mini-mind map. Here are the five challenges that we decided between after completing the first draft of our mindmap: "Enhance Virtual Reality," "Reverse Engineer the Brain," "Restore and Improve Urban Infrastructure," "Secure CyberSpace," and "Provide Access to Clean Water." From these topic nodes, we connected project ideas to them that related to each given topic node. We then voted out certain topics from the decision pool based on how difficult it was to come up with an art installation for that topic. The first topics to go were "Secure CyberSpace" and "Provide Access to Clean Water" because we couldn't come up with very many ideas for them and our whole group seemed to be more enthusiastic about the other remaining topics. By comparing the ideas that we had generated, ity had become very clear that our group was interested in VR, but ultimately we decided that we could use VR as a potential platform for our installation without us having to make our topic become "Enhance Virtual Reality." Thus, we took that challenge out of the decision pool as well. This left us between "Reverse Engineer the Brain" and "Provide Access to Clean Water" and our group chose "Reverse Engineer the Brain" by majority vote. Ultimately we feel that we strongly enjoyed multiple project ideas that we had come up with for "Reverse Engineer the Brain" and we thought that it could lead to a very interesting VR experience if we decided to still use VR as our platform.



4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish to include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

Option 1: Restore and Improve Urban Infrastructure - City builder

Option 2: Reverse Engineering the Brain - Brain wave toy

Option 3: Secure CyberSpace - Find and show local wireless communications

Option 4: Provide Access to Clean Water - VR Water Pollution Removal

Option 5: Reverse Engineering the Brain - VR Decision Based Game(e.g. Escape Room)

Criteria	Weighting	Option 1	Option 2	Option 3	Option 4	Option 5
Hardware Complexity	4	20	32	32	20	20
Software Complexity	4	24	20	16	20	24
Affordability	5	15	15	20	25	25
Correlation to Challenge	7	49	42	49	35	49
Fun Factor for Users	4	28	24	8	20	32
Team Knowledge of Tools	4	20	12	20	20	20
(Higher is better)	Total	156	145	145	140	170

Tentatively we have chosen Option 5: Reverse Engineering the Brain, a VR Decision Based Game such as an escape room. This is the idea that our team has the most excitement about. Option 5 also scores the highest on the weighted decision matrix. The highest weighted criteria is correlation to the challenge outlined in the 21st Century Engineering Challenges, in which option 5 scored as one of the highest. Overall we feel as though this option will result in the best and most practical interactive art installation to show the Importance of the engineering challenge.