4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

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

Area	Description	Examples
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization

We are only designing this project for the students of ISU. It will primarily be an educational tool and only be used in the context of learning about machine learning or a competition.

Public health, safety, and welfare: There is not much to say here. Our project will not be a public project. However, there may be some implications for safety as it pertains to the physical

DeepRacer unit. It shouldn't be a huge safety concern but designing the algorithm to keep the car within the bounds of the track should help it be safer.

Global, cultural, and social: Seeing as how we are looking to set the groundwork for a club/team at ISU, we are affecting the community here in the ISU engineering department.

Environmental: There shouldn't be an environmental impact from our project, other than the materials required to make the deep racer or the energy needed to run our algorithm.

Economic: We do need to consider the monetary cost of the deep racer. It is not a lot but if we want to integrate machine learning into CPRE 288 then we may want to consider a cheaper interface that can be bought for a whole class section to use at once.

4.1.2 Prior Work/Solutions

We are not making a product or following previous work. Using DeepRacer as a learning tool for a university appears to us as a novel idea. While possible to create a similar product using off the shelf parts, that would involve much more compatibility troubleshooting and would take away from the key elements of machine learning the goal is to teach.

4.1.3 Technical Complexity

This is a technologically complex project. Electric cars with complete and reliable machine learning algorithms onboard are not something one can go out and buy off-the-shelf. In fact, automated vehicles are still something that industry has not fully solved yet, so this is not a trivial task.

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.

1) We need to figure out what kind of sensors we are going to use. We might choose to use the proprietary sensors from Amazon or utilize the sensors from CPRE 288. These decisions will rely on their compatibility as well as their application to learning and understanding the overall concept of machine learning.
2) Speed ratings and how we will control the bots slowing and turning into corners. While this can be done fully with machine learning, it also may be possible to utilize feedback controllers to minimize the effect speed has on our model which could lead to faster training times as there will be much less time from the model spent on controlling speed and more spent analyzing the track elements.
3) Performance metrics were a large concern in determining the success of the project. We needed to determine what was important and what the cutoff for a failure is, such as driving instability, lap times, and consistency to different environments. By deciding this, we then have a proper goals and metrics to use when comparing different sensors and trained models to determine what our final product will be.

4.2.2 Ideation

With our project being much more on the conceptual side now, we didn't have much to design in terms of the design as the car comes mostly pre-assembled aside from the potential add-ons we may include. For this we have a few ideas when it comes to the software design, track layout, and visual design choices when we make such expansions:

1. Making changes to the car's design:
   a. For this approach, we will implement a waterfall model as we will have to implement, test, decide, and adjust in different stages. This will allow us to narrow down our options – even taking a longer time when adding new sensors and capabilities to our vehicles. The DeepRacer has a smooth external shell we wish to maintain aesthetically – and in addition not have the design affect the performance.
2. Software Development Practices (machine learning):
   a. With our project falling into the domain of both machine learning and embedded systems, both coincide in attempting to maintain a low-profile OS/software to allow for quick and effective computations by our equipment. For this, we will have adopted an AGILE method of design, as we continue to build onto our software – we have to ensure that the writing of the data back to the cloud and pulling of this information is effective and does not affect the performance of the vehicle in addition.
3. Software Development Practices (embedded systems):
   a. Additionally, we'll also have to implement effective OS at getting information about the vehicle's environment and processing this information is near constant O time to ensure we have the speed to write/read from the cloud in the training of this module. For this, we have decided an AGILE method would be both dynamic in developing an effective software piece – and allow us to make those quicker changes compared to the physical design of the car. And in addition to this, use a function-oriented design when building software to allow us a quick process of smaller functions combining for larger functions.
4. Track Design:
   a. The track design is a more practical and software design choices we have to implement, as this won't be performed until the end and we have the option to train our model virtually – this will take on a more of a water fall design, in which we brainstorm – build – then test, repeating this cycle to make effective environments to test out vehicle. This will be a complete top-down design as we work down the requirements for a successful track and implement the finer details as we wrap -up the process.
5. Testing:
   a. In terms of testing our software, we will implement a bottom-up approach testing nearly every variable to ensure both predictable and concise computing. Using automated test cases- we will focus on testing by function (see Ideation 3).

4.2.3 Decision-Making and Trade-Off

While there are pros and cons to all the ideated options, we decided to implement the 5 listed above in a modular sense as we must maintain different approaches with every element of our project. This project is unique in this design sense, in which there will be multiple aspects of the various portions of the project. However, to identify why we chose these – it comes down to personal experiences with the ideations. In the past, our group has participated in varying styles of organization and brainstorming – these were a collective effort in combining our personal experiences with where it would fit best.