SRS
Digital Twin Forest

Yichen Jiang, Bowen Zhang, Jiacheng Wu, Junhong Chen, Tingyu Shi
Team 8

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Table 1: Revision History

Date	**Developer(s)**	**Change**
Sept 24, 2022	All team members	Initial Document

This document follows Volere Template. The following are some modifications that we made to the original template

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1 Project Drivers

1.1 The purpose of the Project

1.1.1 The User Business or Background of the Project Effect

A digital twin is a virtual representation of the real world, including physical objects, processes, relationships, and behaviors. Elements of a digital twin include data capture and integration, visualization, advanced analysis including AI, automation, and information sharing and collaboration. This project can be beneficial for two groups of users. The first group of users is forest owners. This project can help them to manage the forest. The second group of users is climate change researchers. This project can help them to study climate change.

1.1.2 Goals of the Project

- Implement the virtual forest, which corresponds to the target natural forest. The model of a single tree is obtained by LiDAR scanning on the field. The final project combines previous models and lab statistics to give a virtual view of the forest.
- Provide basic representation of data, such as age, height, and plant density.

1.2 Stakeholders

1.2.1 The client

- Dr. Alemu Gonsamo from School of Earth, Environment and Society McMaster University. (Dr. Gonsamo is the supervisor of this project.)
- Dr. Spencer Smith from Computing and Software Department, McMaster University. (Dr. Smith is the professor of capstone course, he will give assessments of this project.)

1.2.2 The Customer

- Forest Owners(The final project can be helpful for forest owners to better manage the forest and make decisions)
- Climate change researchers(The final product can be helpful for researchers to study climate change)

1.2.3 Other Stakeholders

- Dr. Gosamo's lab members(Graduate students from the lab will provide suggestions and data needed to assist this project)

1.2.4 The Hands-On Users of the Product

The hands-on users of this product are the same as customers mentioned in section 1.2.2. Users' responsibilities are also mentioned in section 1.2.2. For subject matter experience, these users are master. For both forest owners and climate change researchers, they are definitely familiar with the real forest and our product can help them better doing their jobs. For the point of technology, we assume that they have little experience of AR or VR(Comfirm Later) technologies.

1.2.5 Personas

Dr. Gonsam is an assistant professor from School Earth, Environment & Society. His research interests include Remote Sensing of Vegetation, Phenology, Global Change Ecology, Terrestrial Carbon Cycle, Climate Change Impact. For more information, you can check his school official website here.

1.2.6 Priorities Assigned to Users

- Key Users: Dr. Gonsamo, Forest owners, Climate change researchers
- Secondary Users: Dr. Smith, Lab members

1.2.7 User Participation

- Dr. Smith: Dr. Smith will provide suggestions about project management, project documents and project technologies like git.
- Dr. Gonsamo: Dr. Gonsamo will provide business knowledge(forest data), interface prototyping and usability requirements for this project. Since Dr. Gonsamo is a climate researcher, he can also provide suggestions for climate researchers.
- Lab members: Lab members will help this project by providing some business knowledge about the forest.
- Forest Owners: Forest owners can provide commercial data about the forest. Commercial data include tree cutting data, annual profits, etc.

1.2.8 Maintenance Users and Service Technicians

The project members will be responsible for maintaining and changing the product.

2 Project Constraints

2.1 Mandated Constraints

2.1.1 Solution Constraints

- Scanning Technology: Our team will use Light Detection and Ranging(LiDAR) method to scan physical objects in the forest. This is a kind of Laser Scanning technology. We determined to use this technology for three reasons. The first reason is that LiDAR sensors are accessible because they are common among Apple devices like iPhone or iPad. The second reason is that LiDAR sensors can provide accurate scanning. The third reason is that LiDAR allows to scan large areas within a short period of time.
- Modeling Technology: Our team will use Unity for modeling task. Unity version will be 2021.3. Our team members use different platforms(Windows or MacOS). Unity is suitable for our team because it is a cross-platform software. Also, Unity has some existing AR/VR tool boxes, which can speed up our modelling process.

- Project Documents Technology: Our team will use LaTeXfor our documents.
- Project Cooperation Technology: Our team will use GitHub to cooperate.
- Code Testing Technology: VS2019 will be used for the unit test. The team will create a unit test project (.NET Framework) that contains MSTest unit tests.
- Code Coverage Testing Technology: The JetBrains dotCover is a code coverage tool that integrates with VS2019. It can execute and run coverage analysis for unit tests in Visual Studio.

2.1.2 Implementation Environment of the Current System

Discuss the technological and physical environment in which the product is to be installed.
Computer System or AR/VR(Confirm Later)

2.1.3 Partner or Collaborative Applications

N/A(Our product is an independent product)

2.1.4 Off-the-Shelf Software

- LiDAR sensors: LiDAR sensors should be used to scan the forest and collect forest data for modelling.
- Unity: Unity should be used for modelling.

2.1.5 Anticipated Workplace Environment

This part discusses the workplace in which the users are to work and use the product.
Computer System or AR/VR(Confirm Later)

2.1.6 Schedule Constraints

Please check our project schedule here. The following are deadlines for demonstrations:

- Proof of Concept Demonstration: 2022, Nov, 14
- Final Demonstration: 2023, Mar, 20

2.1.7 Budget Constraints

Total expenses should be exceed $750.

2.1.8 Enterprise Constraints

N/A This project is not invested by any enterprise.

2.2 Naming Conventions and Definitions

- LiDAR: Light Detection and Ranging(Scanning Technology)
- Plot: A square shaped area in the forest. There are 13 plots in total.
- Target Forest: Confrim Later

2.3 Relevant Facts and Assumptions

2.3.1 Relevant Facts

The following attributes can be used to describe a forest:

- Leaf Area Index:

2.3.2 Business Rules

2.3.3 Assumptions

Fact: The project will use AR foundation

Assumption:

- The scanning devices are available.
- Team members are ready to develop and meet on time.
- The running device supports Unity.

3 Functional Requirements

3.1 The Scope of the Work

3.2 Business Data Model & Data Dictionary

3.3 The Scope of the Product

Nowadays, with digitization of many objects, our world is getting dramatically easier. Many countries are focusing on simulate cities. Digitization is absolutely a new trend. This project intends to simulate a forest with data collected from forest from real world. With a successful project, people are able to anticipate the consequence by collecting data from cutting, firing and climate changes. The project can have commercial benefits such as helping farm owner make decisions and scientific benefits like studying the climate change. The project will be scanned with LiDAR in iPad pro and will be implemented with C Sharp and Unity. The project will be deployed on phones.

3.4 Functional Requirements

FR1 The project must simulate models of forest based on data collected from real forest.

FR2 The project must display the data of the tree which the user specifies by giving inputs.

FR3

4 Nonfunctional Requirements

4.1 Look and Feel Requirements

4.1.1 Appearance Requirements

LF1.1 The product shall be easy to use.

LF1.2 The product shall have a goal that each of the 13 plots adheres to.

LF1.3 The goal of the product shall be display a lifelike forest to the users.

4.1.2 Style Requirements

LF2.1 The product shall appear authoritative based on the real forest.

LF2.2 The product shall appear professional.

4.2 Usability and Humanity Requirements

4.2.1 Easy of Use Requirements

UH1.1 The instructions of the product shall be easy to understand.

4.2.2 Personalization and Internationalization Requirements

UH2.1 The product shall be English only.

4.2.3 Learning Requirements

UH3.1 The instruction of the product shall be displayed at the homepage.

UH3.2 The users shall be able to use the product with no longer than 5-minute training.

4.2.4 Understandability and Politeness Requirements

UH4.1 The product shall use symbols to highlight core functions.

UH4.2 The product shall use icons that are appealing to all ages.

4.2.5 Accessibility Requirements

UH5.1 The product shall be usable by people who are able to tap the screen.

UH5.2 The product's user interface should be easy to learn.

4.3 Performance Requirements

4.3.1 Speed and Latency Requirements

PR1.1 The product shall respond to user actions within 1 second.

PR1.2 The product shall run at no less than 30 frames per second.

PR1.3 The product shall take no more than 5 seconds to load the models.

4.3.2 Safety-Critical Requirements

N/A

4.3.3 Precision or Accuracy Requirements

PR3.1 Data displayed on the screen shall be rounded to two decimal places.

PR3.2 The relative error of each model shall be less than 10%.

4.3.4 Reliability and Availability Requirements

PR4.1 The product shall be available whenever the users access to it.

PR4.2 The product shall not crash while running.

4.3.5 Robustness or Fault-Tolerance Requirements

PR5.1 The product shall be able to run locally.

4.3.6 Capacity Requirements

PR6.1 The app size shall be less than 5GB.

4.3.7 Scalability or Extensibility Requirements

PR7.1 The product shall cover all 13 plots of the forest.

PR7.2 The functions of the product shall be modularized.

PR7.3 New components shall be easily added to the product in the future version.

4.3.8 Longevity Requirements

PR8.1 The product shall be expected to operate within the maximum maintenance budget for a minimum of one year.

4.4 Operational and Environmental Requirements

4.4.1 Expected Physical Requirements

OE1.1 TBD

4.4.2 Requirements for Interfacing with Adjacent Systems

OE2.1 The product shall be used on mobile devices with photogrammetry technology.

OE2.2 The product shall be able to run on the majority of mobile phones with Android 10.0 or latest or IOS 11.0 or latest.

4.4.3 Productization Requirements

OE3.1 The product shall be distributed as an application to be installed on mobile devices.

4.4.4 Release Requirements

OE4.1 The maintenance releases will be offered to end users weekly for at least one year.

OE4.2 Each release shall not cause previous features to fail.

OE4.3 Each release shall include latest modelling.

4.5 Maintainability and Support Requirements

4.5.1 Maintenance Requirements

MS1.1 Documentation of this product shall be kept up to date.

MS1.2 All functions shall be clearly documented.

MS1.3 Any detected bug in the product shall be fixed within three days.

4.5.2 Supportability Requirements

MS2.1 The development of the product shall collect feedback from the users to improve usability.

4.5.3 Adaptability Requirements

MS3.1 TBD

4.6 Security Requirements

4.6.1 Access Requirements

SR1.1 The product shall only be accessed by users who download the product on their mobile devices.

4.6.2 Integrity Requirements

SR2.1 The system shall not propagate errors throughout the user's devices in case of failure.

4.6.3 Privacy Requirements

SR3.1 The product shall not change the data of the virtual forest.

SR3.2 The product shall not ask the users to provide personal information.

SR3.3 The product shall not send emails to the users.

4.6.4 Audit Requirements

SR4.1 N/A

4.6.5 Immunity Requirements

SR5.1 N/A

4.7 Cultural and Political Requirements

4.7.1 Cultural Requirements

CP1.1 The product shall not have elements that offend the users of the environment in which the system is deployed in.

4.7.2 Political Requirements

CP2.1 The product shall not include elements which may be interpreted as a political statement.

4.8 Legal Requirements

4.8.1 Compliance Requirements

LR1.1 N/A

4.8.2 Standards Requirements

LR2.1 The product shall abide by all Canadian laws and regulations.

LR2.2 The product shall be facing to the users of all ages.

5 Project Issues

5.1 Open Issues

The process of collecting data, building models and eventually generating a product takes a long time. During this process, real-world data may have changed due to environmental factors and human factors. Environmental factors such as thunderstorms, conflagrations, earthquakes, floods and the natural growth of plants and human factors such as cutting and planting might change the data of trees and the structure and density of the forest. When we are modelling the actual forests, The data that we use is non-real-time, which will lead to the data shown in the virtual forest that we model being different from the actual data in the real world. This might cause inaccuracy in the actual use of the product.

5.2 Off-the-Shelf Solutions

There are many unity tutorials online. We get data and solution from Dr.Gonsamo's lab members. We referred to a paper to design our project.

5.3 New Problems

TBD

5.4 Tasks

5.4.1 Project Planning

The project is planned to be done before February 2, 2023.

5.4.2 Planning of the Development Phases

There are five development phases of this project:

- design feature
- measure
- implement
- test
- apply

5.5 Migration to the new Product

N/A

5.6 Risks

1. Bad weather when field modelling may result in inadequate modelling.
2. Budget might not cover the cost.
3. Excessive schedule pressure.
4. The mobile devices may not provide sufficient computing capacities to test the models.
5. The trees might be too high to scan all aspects of the trees or result in a poor precision.
6. The project might occupy too much memory of the devices.
7. The natural forest continuously changes, which brings high maintenance cost to update related information.

5.7 Costs

The cost of this project will not exceed 750 Canadian dollars.

5.8 User Documentation and Training

User manuals with a few lines of instructions.

5.9 Waiting Room

1. The product shall represent the overall data of forests, such as amount of logging, the situation of growth, etc.
2. The product shall record significant data for later use.

5.10 Ideas for Solutions

The representation of overall data of the forest might be realized in a separate module. And same for the recorded significant data. Our current project is designed to run locally on a certain device, while a possible solution could be, to design an online mode for the users to access to the latest information. The users might click a certain button to browse the overall data of the forest and its historical versions.