Functional Specification

Artificial Life Simulation

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Functional Specification Contents

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1. Introduction

1.1 Overview

The purpose of this system is to create a visual 2D simulation of simple single celled organisms that reproduce and pass on their most beneficial traits via implementation of a genetic algorithm, some of those traits being co-operative and competitive behaviours based on game theory. Co-operative behaviour will take the form of single celled organisms joining together to become larger, resource sharing multicellular organisms and competitive behaviour will include competition for resources and consuming other organisms. The user will be free to edit the variables of the simulation. This project will be executable via web browser.

1.2 Glossary

Genetic Algorithm:
An algorithm generally used for solving optimization problems that is based on natural selection. It does this by repeatedly modifying a population of individual(usually mostly random) solutions and selecting the most fit of those solutions to as a basis produce the children of the next generation.

Individuals/organisms:
Individual is used to refer to a single entity in the population of a Genetic Algorithm. In the case of the Simulation the individuals are expressed as organisms.

DNA/Genotype:
In the context of this project DNA and Genotype refer to the set of variables that determine the traits of the organisms.

Generations:
A generation is a set of individuals, the DNA of the most successful individuals in a generation is used to produce the next generation.

Game Theory:
The study of mathematical models of strategic interaction between rational decision makers.

Cooperative:
In the context of game theory Cooperative refers to the formation of coalitions and the resulting payoff between members of a group.

Competitive:
In the context of game theory focuses on predicting individuals' actions and payoffs, generally at the expense of others.

2. General Description

2.1 Product / System Functions

The product will be a HTML Page or small website containing a Javascript program. The product will be hosted on a domain and contain the following components:

An implementation of a Genetic Algorithm with individuals(a class) whose DNA will contain traits for their phenotype and their behaviour; the genotype will include methods of energy production(converting light to energy and consuming other organisms), a hierarchy of task priorities, proclivity to exhibit cooperative or competitive behaviour as well as other traits yet to be decided. The individuals of this simulation will also have an indicator of health, rate nutrient generation, age and other variables.

A “world” which will be a 2D array representing XY coordinates and contain information about the position of light(used by organisms to produce energy) and other objects in the world. The world will also map the individuals of the Genetic Algorithm onto itself and feed information back to the Algorithm about the positions of the individuals relative to everything else in the world. It will take input from the algorithm to update the coordinates of the individuals which will represent movement.

The visual representation of the map will be made using HTML5 Canvas. It will take a feed of information from the world and the Genetic Algorithm to visually display the simulation to the user.

Menus for the user to start, stop, resume, change speed and edit the variables of the simulation will be made using HTML and CSS in the form of input fields and drop down menus. The user will be able to switch the game theory element of the simulation off.

2.2 User Characteristics and Objectives

Users of this product will be individuals in fields that study genetic algorithms and game theory(Computer Applications, Mathematics, Economics, Business). Teachers and students will be able to use the simulation to gain a better understanding of genetic algorithms and how they behave when applied to game theory, and visa versa. Users will have at minimum an intermediate experience in using a web browser; those from a Computer Science background will be able to read the Javascript code and see exactly how everything is implemented. Users will want as much control as possible over the algorithm such as control of the weights in the genetic algorithm and the game theory implementation and the ability to control which traits exist in the simulation.

2.3 Operational Scenarios

User edits variables of the simulation(dropdown):
The user should be able to load the web page. They should be able to click any of the drop down menus and edit the drop down variables by clicking the desired option.

User edits variable of the simulation(text field):
The user should be able to load the web page. They should be able to click any of the text fields and enter new values for the variables using their keyboard.

User runs simulation:
After loading the web page and (optionally) editing variables the user should be able to run the simulation by pressing the “Run” button. The simulation should run according to the settings specified in the menu.

User stops the simulation:
After running the simulation the user should be able to press the “Stop” button with their mouse to pause the simulation.

User resumes the simulation:
After stopping the simulation the user should be able to press the “Resume” button with their mouse to resume the simulation.

User resets the simulation:
The user should be able to reset the simulation at any point by clicking the “Reset” button on the menu with their mouse. Values previously changed in the menu should reset to their default values.

2.4 Constraints

Device Compatibility:
This system will be designed to work with most popular web browsers(Chrome, Chromium, Firefox, Safari) but will not designed to be specifically compatible with mobile browsers.

Speed:
The simulation will have to run at an appropriate speed so that users can observe substantial development in the population in a reasonable time.

Hardware Requirements:
The system must run on lab computers with reasonable ease.

3. Functional Requirements

ID	**1**
Description	The system needs to be able to display a 2D simulation in real time.
Criticality	High. If the simulation does not display in real time it's utility in demonstrating Genetic Algorithms is greatly reduced.
Technical Issues	The front end will need to be updated in rapidly and in sync with the backend calculations.
Dependencies	Both front and back end must be developed to a testable level.

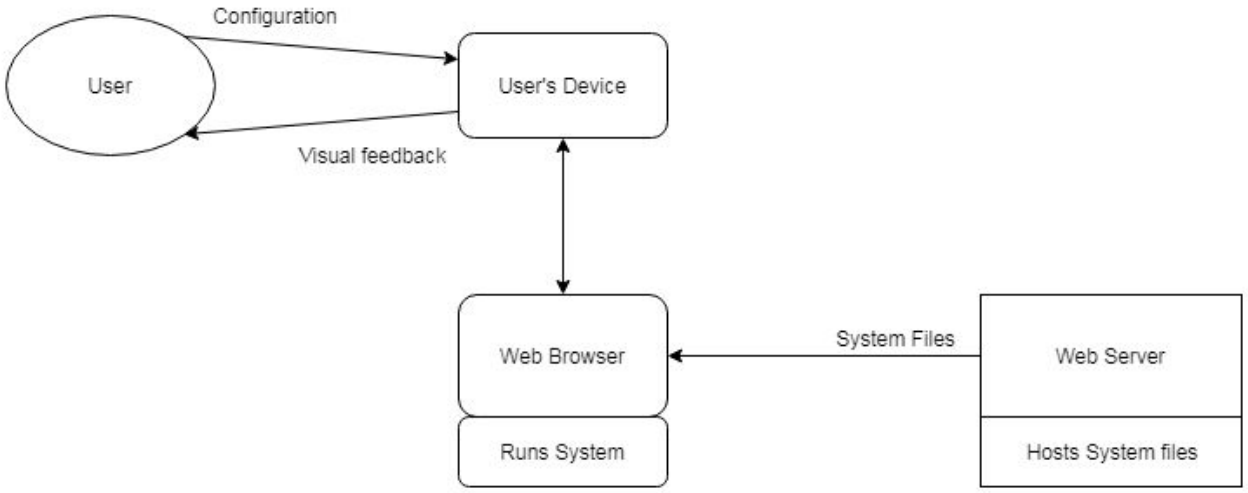
ID	**2**
Description	The system must be secure.
Criticality	High. The system is going to be stored on a server and so it must be ensured that there is no vulnerability that allows individuals to tamper with the server or other the data of others.
Technical Issues	More knowledge of common network vulnerabilities is required than I already have.
Dependencies	Website needs to be hosted on a server before I can test for vulnerabilities and ensure security.

ID	3
Description	The user needs to be able to edit variables of the simulation.
Criticality	High. The system needs to be configurable so that users can learn how changing different parts of the simulation affects its outcome.
Technical Issues	Ensuring user interface is of a high standard and enables the user to use the interface in an intuitive manner.
Dependencies	N/A

ID	4
Description	The system needs to be entirely runnable within their browser.
Criticality	Medium. Although it is not an absolute necessity I believe my product will have significantly more users if it does not need to be installed.
Technical Issues	None, except the project must be developed only in browser runnable languages.
Dependencies	N/A

ID	5
Description	The system needs to be entirely runnable client side.
Criticality	Low. Ideally the user would be able to run the whole system but it's possible that later features may require computation from the server.
Technical Issues	Restricts the use of server side software.
Dependencies	N/A

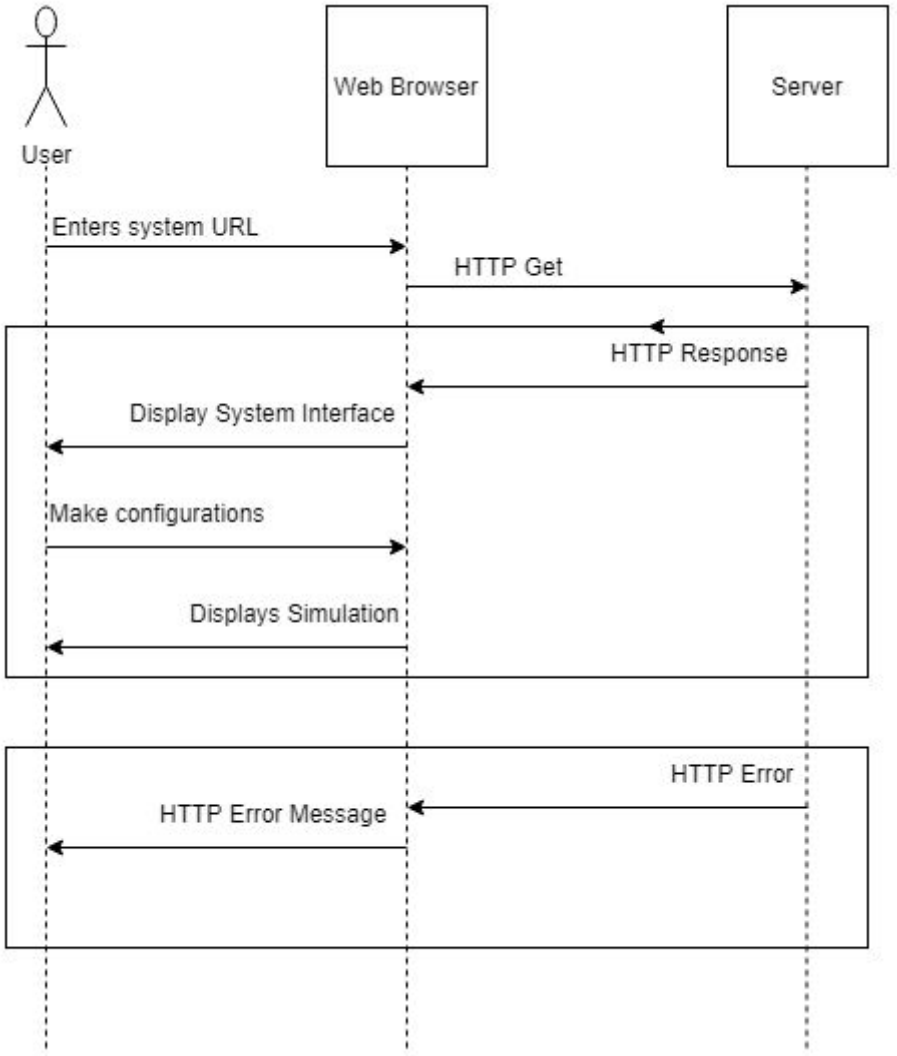
4. System Architecture



The simulation will be a Javascript program that will be hosted on a server and cached and run in a web browser. The user will input configuration changes via the browser and receive visual feedback in the menu. The simulation will also be displayed on their device.

5. High-Level Design

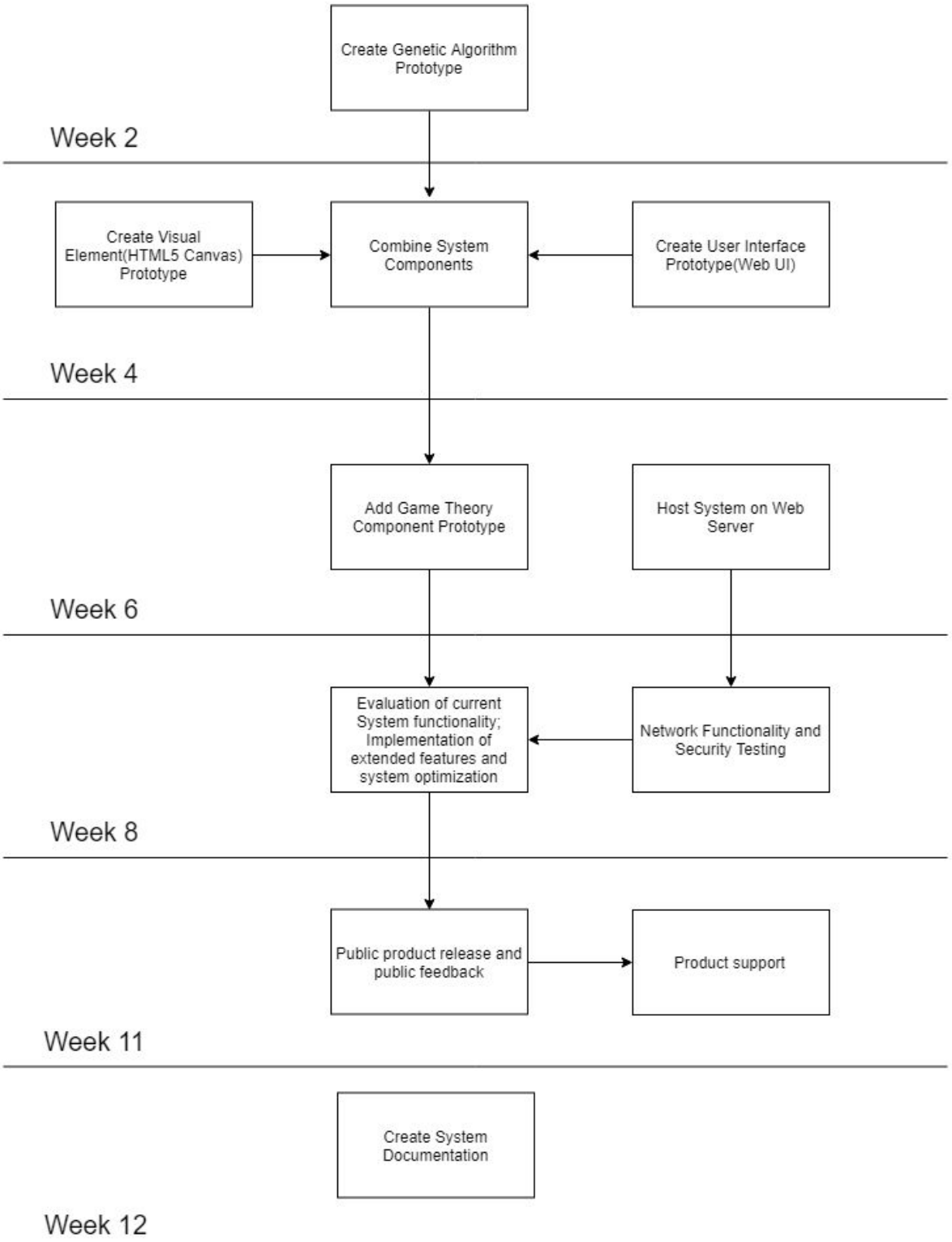
Sequence Diagram



The sequence diagram above shows the interaction between the user, their machine and the server during use of the system. In the case of a successful HTTP Response the system will be loaded onto the user's browser from the server and the user will be able to make changes to the settings before running the simulation. In the case the server cannot deliver a successful response the user will receive an error message.

6. Preliminary Schedule

PERT Chart



Above is the development cycle over a 12 week period broken into two week sprints with the exception of a three week sprint towards the end of the schedule to accommodate the final stage of the product development and it's initial release. It should be noted that testing will occur alongside each task and will be updated accordingly with the product development.

7. Appendices

A not too dissimilar combination of game theory and genetic algorithms: https://pdfs.semanticscholar.org/3b96/427b507c429c9db96fdb3de8bc5edfe190ca.pdf

https://natureofcode.com/book/chapter-9-the-evolution-of-code/