Appraisal

# Evaluation

How objects where met

## The objectives as set out in the analysis section

### Simulation objectives

Update objectives to exact same as ones which appear in design v2.22

1. A tool which **illustrates the concept of evolution**. This concept is summarised in Appendix B. The main ideas of the concept of evolution should all be covered:
   1. **Organisms have characteristics** which determine their species.
   2. As a result of the mutation of characteristics, **variations capable of being inherited** exist within populations of organisms.
   3. Organisms **produce more offspring than can survive**.
   4. These **offspring**, with their different inheritances, **vary in their ability to survive and reproduce**.
   5. In conditions with competition between organisms for survival and reproduction those **organisms with traits that give them an advantage over their competitors pass these advantageous traits on**, while traits that do not confer an advantage are not passed on to the next generation. As a result we have the ‘survival of the fittest’ and a gradual change in populations – they change or may even die out.
2. The simulation should be able to generate **random food placement**.
3. The simulation should be able to simulate basic **growth of food**.
4. The tool should provide a **simulation involving movement** since evolution involves dynamic change and a static tool is not appropriate.
5. The simulation must simulate the three basic types of ants
   1. The **worker ant** – Locates and collects food
   2. The **soldier ant** – Guards and attacks ant species
   3. The **queen ant** – Creates a nest
6. The simulation must **model a basic nest** capable of:
   1. Producing new ants
   2. Being attacked and eventually destroyed.
7. The ants should have variable basic characteristics Including:
   1. **Speed** the ants move
   2. The **reproduction rate**
   3. The **amount of food ants are able to carry**
   4. The ants **eyesight** i.e. the distance the ant can see
   5. The ants **antenna size** i.e. the distance the ant can smell pheromones from
8. The simulation should be able to **introduce random mutations** (so pupils can see how the ants must suited to the environment will survive).
9. The simulation must be able to **show multiple different species at the same time**, so that their fitness can be compared by the pupils.
10. The simulation should model **energy intake from food** needed for ant to survive depending on the ants characteristics. For examples ants with more favourable characteristics such as moving faster should require much more food than ants which have less favourable characteristics.
11. The simulation must be able to model **ants fighting**.
12. The simulation must model **pheromone trails** including:
    1. Their **creation** when an ant is moving
    2. Their **evaporation** due to conditions
    3. **How ants respond** to the trials
       1. Following to find food
       2. Following back to nest

### Simulation interface features objectives

1. **Pause and play buttons** to pause and play simulation.
2. **Navigation buttons** to move around the simulation.
3. **Zooming** in and out of the simulation.
4. For each species (displayed when selecting nest) statistics measuring:
   1. The **amount of food stored in the nest** of a specific species
   2. **Number of ants** in species
5. **Editable characteristics** e.g. by sliders or buttons so that the user can change the simulation in real time.
6. **Selection of different species** so that their characteristics can be compared.

## How the objectives where achieved

### Simulation objectives

1. Evolution is simulated in the following ways
   1. This objective was fully met in the final solution. All ants have characteristics e.g. antenna size. The unique combination of these characteristics does determine their species.
   2. When queens are created there is a chance of mutation of a species characteristics. If a mutation occurs a new species is created which has this altered characteristic within it. This new species will then be inherited by all ants which are born from the nest the queen creates. Thus there is a variation between ants born from the original nest and ants born from the nest with the new species.
   3. From multiple runs of the simulation it is clear that not all ants born will survive. Only the ants which are lucky enough to find food will survive for a reasonable amount of time. Thus it can be said that the nests do produce more offspring than can survive.
   4. This is certainly true, not all species flourish in the simulation and in fact many die quickly after being started due to poor mutations in characteristics such as 0 speed which results in ants not being able to move and thus not being able to collect food.
   5. Species in the simulation which have more favourable characteristics will survive for longer than those with poor characteristics due to mutation. The species which survive for longer often produce more queen ants then those which do not survive for as long. As these queen ants will either belong to the same species or belong to a mutate version of the species, the favourable characteristics will be passed onto ants born from the nests these ants make. And from the comment in d it is clear that ants with more advantageous characteristics will survive for longer creating a survival of the fittest simulation.
2. At the start or restart of every simulation food is randomly placed throughout the map with random densities. This shows that this objective has been completed.
3. Over time, food will slowly regrow in the simulation (unless it has all been eaten).
4. The simulation allows ants to move on the screen and is certainly not static.
5. The simulation does model simplified versions of the worker, queen and soldier ants. The worker ant can search, collect and deposit food back to the nest. A queen ant can find a location and create a nest. A soldier ant can guard the nest, food and pheromones as well as attack ants from other species. These are sufficient models of the basic ant’s functions.
6. The simulation does model a simple version of an ants nest, the nest in the simulation is effectively a static ant. The nest in the simulation performs the functions of producing new ants and allowing ants to deposit food at it. This is a very simple model of how real ant nests work and could potentially be improved to make the simulation more realistic (*Note*: See suggestions and improvements section for more details).
7. The finished simulation has 21 editable characteristics which all affect the behaviour of the ants in the simulation for example and ant’s eyesight characteristic affects the distance the ant can see in front of it. All characteristics mentioned are impended as well as a number of other characteristics. This objective has been completed beyond expectation.
8. Whenever a queen ant is created in a nest, there is a chance of a single characteristic of the queen’s species to be mutated to a random value. The mutation rate is set high enough for it be quite likely that a queen ant will undergo mutation. This means that there will be a large variation in characteristics from the original characteristics in the simulation thus allowing the user to see which mutations aid ants to survive and which thwart the survival of ants.
9. This objective is complete as multipe differnt species can be shown, and due to each species having a differnt colour it is obvious to see which species are fitter than others by the way which they move and by looking at their information in the data panel.
10. Energy intake from food is modelled by the relationship between food and health within the simulation. A single piece of food is worth a certain amount of health. Health is spent by ants in different ways. In all ants health is decreased over time thus creating a reliance on food for survival. Nests have a unique use for health. When an ant is created part of the nests health goes into the ant, this is the amount of health the ant starts with when it is born. However some of the health is wasted/lost to the characteristics of the species i.e. species with more favourable characteristics will require more health then less favourable characterises making it fair. Therefore there is sufficient evidence to accept that that objective has been met in the simulation.
11. Soldier ants in the simulation can attack other ants. However only other solider ants can fight back and attack the other soldier ants back. This could be potentially improved by allowing worker and queen ants the ability to fight back or deploy some form of defensive mechanism to stop the soldier ants from attacking *Note*: See the *Improvements* section for more details. However the fighting mechanism is implemented and therefore the objective has been achived.
12. Phereomones are implmented in the simulation.
    1. Worker ants create pheromone trials when they are returning with food back to their nest thus showing that pheromone trials can be created by moving ants. So this objective has been achived.
    2. All pheromones in the simulation evaporate at a constant rate i.e. their concentration decreases as time continues until they are gone. The rate can be set in the configuration options and is part of the enviromental setup.
    3. All ants except queen ants in the simulation use pheromone trials to navigate. Worker ants will follow pheromone trials in order to either find a source of food, or to find their way back to the nest. Soldier ants also use pheromones trials when they are tasked with guarding pheromone trials, or when they are looking for food to guard.

### Simulation interface features objectives

1. This objective has been fully met. The simulation can be stopped and started with either a button or a keyboard input. Futhermore a step button has been added which allows the user to step and single tick in the simulation.
2. Navigation has been implemented however its impmentation has changed slightly since the design. Instead of buttons overlaying the simulation instead mouse input is used to navigate and also keyboard input from the arrow keys is used. This implementation is sufficient to say that this objective has been met.
3. Zooming has also been implmented into the interface through either a keyboard or mouse input and thus this objective has been met.
4. As well as both statistics mentioned further statistics have been added such as the number of nests which allow the user to more easily see a overview of a species. This objective has been met.
5. In the interface it is easy for the user to change the characteristics of a species. Sliders have been used rather than buttons to reduce the amount of validation the inputs would have to go through. An update mechanism has been designed to stop the user from accidently changing characteristics, this means that the changes to the simulation are not instantanious as the user must first press a button however this design decision was made for the better and so the objective has been completed.
6. This has been implemented fully.

To summarise all objectives have been fully met, with some objectives being achived above and beyond they initial ideas stated. Some other objectives although fully implmented could be improved to make the application as a whole better.

# User feedback

# Analysis of feedback

# Suggestions and improvements

### Ants

The simulation could be improved by adding a firmer model of an ant i.e. the current simulation models an ant which borrows features primarily off leaf cutter and Pharaoh ants but has features which do not appear naturally as they are simplifications of much more complex processes such as queens becoming nests. A firmer model would mean that a specific type of ant would be fully implemented rather than a mismatch of multiple types of ants. This would make the simulation easier to conceptualize as it could be more easily compared to real life ants. And this would make the learning process easier to understand for the pupils.This could be done by re anaylsing how ants work and operate and then modifying the current ant, worker, soldier and queen classes.

Another improvement would be the development of the nest idea in the simulation. Currently the nest is an entity on the map, it acts like a static ant. This is done to reduce the complexity of the simulation. However in reality the nest is a series of tunnels where ants live and work. Expanding the idea of the nest into a location where the queen lives and is tended to by other ants i.e. bringing the queen food, would improve the realism of the simulation. Being able to expand the nest would also be a dramatic improvement and even being able to interconnect multiple nests to create larger nests. This could be achived by adding the ability for nests to grow over time.

Finally ants in the simulation are born into adulthood, this is a good simplification of the real process however with more time this could be improved on by giving the ants a life cycle i.e. having an infancy stage and then having the ants slowly grow up. The purpose of this would be to improve the realism of the simulation again making its message easier to understand by the pupils as it is more comparable with real ants. This would not be difficult to achive, it would require ants to have an age property and certain goals/tasks resticted to certain age ranges.

### Pheromones

Only a single pheromone is used in the simulation, the trial pheromone. Most ants in nature have multiple types of pheromones such as attractive pheromones, repulsive pheromones and alert pheromones. A much more real model of the ants search and retrieval of food could be made by integrating these pheromones into the simulation. Due to the abstract nature of the pheromones in the simulation this woulf be easy to integrate and would involve new pheromone sub classes being created and some logic changes to ants when they smell certain pheromones.

### Species

Of course the number of characteristics in the simulation can always be improved upon. This would make the ants more and more real. This links in with the improvement of a firmer model of the ant. The application has been desinged to make it very easy to add and change characteristics. Once added to the CHARS varible an input would be automatically added to the interface. Then they would only need to be added to the species class.

### Faster and larger map

In terms of the technical solution. A faster update cycle would allow for a larger map to be used which would improve the scope of the simulation. It is possible currently to overcrowd the map very quickly by introducing multiple queens very quickly. A larger map would slow down the time it takes for the map to become overcrowded. It would also allow the possibility of more realistic distances between nests. To implement a faster update cycle the code would have to run faster. From current anylisis of CPU profiles 25% of the time each tick is spent on the fillRect operation, this is part of the canvas API and can be easily speeded up by doing batch draws rather than drawing individual ants.

### Food

Food in the simulation could be improved upon by adding different types of food which require different characteristics e.g. stomach type, which could allow for carnivores and herbivores which would add another dynamic to the simulation. Food could come in different shapes, this would make it more interesting to watch. This could be done by implmenting an algorithm to make randomly shaped food sources perhaps a repurposed map generatoin algorithm such as the perlin noise algorithm.