Self Fullfield Prophecies

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# 1 Introduction

## Keywords: Sixth Mass Extinction; Conservation; Machine Learning; Artificial Intelligence

In the past two decades human activities were responsible for the lost of 10% of the wilderness. This lost was the result of bad planning and human errors, but can yet be undone if the humankind accept to be part of nature instead of being apart of nature.

## 1.1 Background

We are at the year 2020, scientists have been warning for the dangerous results of humankind actions for 30 years and they had been ignored once and once again.[1] Planet Earth is currently experiencing an extinction crisis, entire ecosystems are collapsing mainly due to the exploitation of the planet by humans, unfortunately we are at the beginning of the sixth mass extinction, which means by definition of mass extinction that three quarters of the existent species will be soon wiped out from our planet.

The planet is being sacrificed for a small amount of people can continue to make a large amount of money.

In fact, some studies show that the interacting conditions experienced today, such as accelerated climate change, changing atmospheric composition caused by human industry, and abnormal ecological stresses arising from human resources consumption, define a perfect storm for extinctions.

Human kind has not yet failed, but it will if it doesn’t act right now. Now is the time to stop being smart and start to be wise as the *Homo sapiens* words suggest. The solution is however so simple, *Homo Sapiens* needs to rewild the world, without nature we will most certainly fail.

The primary goal of this investigation is to create artificial organisms and ecosystem that imitate and simulate the natural and original world. This goal is exactly what artificial life, or ALife, is by definition, the study of synthetic systems that simulate characteristics and behaviors of natural living systems by create ”life-like” behaviors with machines. [Overview of AI][Langton]

## 1.2 Motivation/Justification

The goal for this research is to build a artificial system that allows to study a species in its natural ecosystem, in order to understand how human exploitation influence the species development.

Despite the enormous potential of artificial system in simulate ecosystems, there are not many examples of insects simulation, therefore the chosen species was the Chocolate Midge scientifically known as *Forcipomyia Squamipennis*.

It will be possible to simulate thousands of generations and also to understand how human exploitation influences the natural course of this midge population and that will happen to the ecosystem itself.

## 1.3 Study Objectives

Through the simulation should be possible to analyse and predict when the species will be extinct and why in order to understand what can be done to stop this extinction.

In order to achieve the goal, the following intermediate objectives were defined:

1. Define the main ecosystems characteristics.
2. Define the species genetic characteristics.
3. Define how the species will reproduce.
4. Define how the species will move in the environment.
5. Simulate the species behaviour and ecosystem through the years.
6. Take the conclusions.

# 2 Literature Review

In this section it will be described all the concepts and the species features necessary to build the artificial ecosystem as well as the specie itself.

## 2.1 Artificial Life

[1 paragraph - section objective]

### 2.1.1 Concept

Some authors also define ALife as ”life-as-is-could-be” instead of ”life-aswe-know-it” saying this is how ALife com contribute to theoretical biology. Actually, the year of 1989 was first time this term was defined by Christopher Langton, who defined ALife as ”the study of natural life where nature is understood to include rather than exclude human beings and their artifacts”. [Langton]

An important property of ALife is that the system’s behavior is represented indirectly and develops out of interactions of individuals with each other.

In this artificial system, the artificial life will be the chocolate midges, the tree species and the midges predators, all these living organisms will be described in detail later.

### 2.1.2 Evolutionary Algorithms

Given a population of individuals within some environment that has limited resources the competition for those resources causes natural selection, this constant survival of the fittest origins the evolutionary algorithm. [Intro to evolutionary comp]

### Genetic Algorithm

A genetic algorithm, or GA, is a method to generate offspring from a parent population, which the principal concern is to produce variants that have a high probability of surviving in the environment, this survival process is also known as natural selection and leads the population to evolution. [Langton]

The GA generates variants by applying genetic operators to genotype of the most successful fenotype in the population, this genetic operations are, crossover, inversion and mutation.

The genotype is the set of genetic characteristics encoded in a DNA’s organism. The fenotype, is the physical organism, the set of physical characteristics that are visible to the eye as result of the interpretation of the genotype in the context of the environment where the organism lives. [Langton]

### 2.1.2 Artificial Neural Networks

An artificial neural network is a mathematical model inspired in the network activity of brain cells. Neural networks are composed by nodes or units connected by links, just like a graph.

A link from the node *i* to the node *j* is meant to propagate the activation *ai* from *i* to *j*. Each link has also a numeric weight associated that determines the strength and sign of the connection.

### 2.1.3 Artificial Ecosystems

Biologists define natural ecosystem as the physical place where species interact with each other and compete for resources in order to survive and reproduce. As expected, an artificial ecosystem is a natural ecosystem but artificially constructed with computer simulation behind it where artificial life, the agents, adapt their behavior to best fit their environment, the ecosystem. [Artificial

Ecosystems for Creative Discovery]

An artificial ecosystem has two main components, agents and environment.[Ants] In this ecosystem the agents are the chocolate midges, the predators and the trees, each of these will be represented as a class in the program and also have different characteristics that need to be pointed out later, also the dominant agent in the ecosystem is the chocolate midge. A life cycle of an agent include the birth, interaction with a dynamic environment, mating or reproduction and death. The goal of the main agent is to survive in the ecosystem, meaning to produce offspring.

### Challenges and Opportunities

The main challenge to build the artificial ecosystem will be the design of environment namely all the rules associated with it and the interaction between the different species as well as the design of these species.

This kind of system directed to midges was never built before, it will be possible to know how the species deals with minor and major changes in the environment as well as when and why the species will be wiped out of the planet.

**2.1.4 Artificial Ecosystem Construction**

**Key Definitions & Parameters**

### An agent is anything that recognize the environment through sensors and acts upon this environment thought actuators. An actuator is simply what causes that agent to operate. [AIMA]

The agent function is a mathematical abstract that describes the agent behavior.

This function is implemented by an agent program which is a concrete implementation that runs within the program. [AIMA]

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| --- | --- | --- |
| Parameter | **´Description** | **Variables** |
| Environment | Model with specific rules on interactions between the elements of the environment. [Artificial Ecosystems for Creative Discovery] | 2D Size (m x n) |
| Species | Collection of individuals or agents. [Artificial Ecosystems for Creative Discovery] | Initial number of the population |
|  |  |  |
| Agent Health | Scalar measure of an agent success in surviving in its environment. If this variable is zero the agent is dead, therefore is removed from the environment.[Artificial Ecosystems for Creative Discovery | Energy |
| Agent Life-cycle | The time since an agent is born until it dies. [Artificial Ecosystems for Creative Discovery] | Number of generations |
| Rational Agent and Performance measure | A rational agent is an agent that does the ”right thing”. This notion of the ”right thing” is measured with a variable called performance measure that evaluates anything given a environment state, therefore a rational agent selects every action that maximizes this variable. Usually, it is better to define the performance measure according to the goals in the environment, rather than according to how the agent should behave. [AIMA | performance measure |

**Strategies to build the ecosystem**

## 2.2 *Forcipomyia squamipennis*, The Chocolate Midge

All around the world there are diverse *Theobroma cacao*, also known as Cocoa tree, pollinators species, living in different temperatures and regions, but *Forcipomyia squamipennis*, informally, the chocolate midge is known for being the most important of all, due the constant food, reproduction and development near these trees. [artigo mal´asia][artigo dynamics of insect pollinators][kaufmann]

Before starting to describe this species it is important to notice that as every insect this midge is ectotherm and poikilotherm. It means the species internal temperature varies considerably and also the main heat source comes from the external environment.

Therefore, the development of this midge such as reproduction, longevity, mortality rate and population characteristics depends directly on external environment temperatures.

### 2.2.1 Biological Characteristics

This species has a life span of 22 − 29 days and its life cycle can be split into four stages: eggs, larvae, pupae and adult. These four will be described next in detail.

Although *Forcipomyia squamipennis* is abundant and reproduce through the entire year [kaufmann] the population drift seasonally, the largest populations occur in the rainy season and the high midge numbers recorded were from June to November declining sharply in February and March. [artigo biology][artigo dynamics of insect pollination]

### Eggs

Usually the eggs are laid in humid places like rotten wood, hallow dead trees roots, old trees cracks, decayed cocoa husks or even moss. The eggs take around 2 − 3 days until hatch at temperatures of 20 − 25°C. Scientists believe that each female can produce about 200 eggs in a single life time.[kaufmann][biology] About 5 − 6% of the eggs pupated and become adults.[kaufmann]

### Larvae

This stage is often seen during the rainy season, but also exists during the dry season, which can be seen in places that did not dry out. Therefore, as expected, larvaes live in a dark and humid environment without any love for light. The midge lives in this stage during 10 − 15 days at temperatures of 20 − 25°C and then pupate into the next one.[biology]

It feeds on cocoa husks, decayed wood, banana stems and other vegetables. Some scientists say larvaes feed on fungi, mould, yeasts, bacteria and algaes rather that plants organisms. The larvae starts to be semi-transparent and as accumulate fat in its body the larvae gets white.[biology]

### Pupae

The pupae is yellow, it can be found in dry places and does not feed during the entire stage. Although it seems a delicate phase, the pupae is able to defend itself when under attack.[kaufmann] This period takes around 2 − 3 days at temperatures of 20 − 25°C until pupae achieve imago.[biology]

### Adults

The midge body in this stage is black and yellow and previous investigations revealed adult stage last 8 − 16 days [biology][kaufmann], the species produces at least 12 generations per year.[biology] The midges can live 24 hours without food or water and were never observed preying upon other insects or animals.

[kaufmann]

Adults feed and pollinate on the cocoa flowers and usually this event occurs in the morning, depending always on weather forecast, clear and sunny days are preferable to rainy days. Therefore, rainfall in the morning eliminates pollination for the rest of the day. [artigo mal´asia]

Usually males outnumber females when spotted on cocoa flowers depending on the cocoa plantation with a ratio 4 : 1 and also during reproduction with a ratio 2 : 1 where the ration means male:female. Mating pairs are formed during swarming and a male often mates with 2−3 females during one swarming. This swarming event will be described in detail in the next section.[biology]

After the mate the female either remain in the resting place or go elsewhere to lay the eggs.

### 2.2.2 Ecosystem

In order to built the artificial ecosystem it is crucial to describe in detail the habitat where the midge population live. This research was based on investigations made at Ghana, where there are two main seasons, wet and dry season.

It was observed by scientists in the past that adult midges can be found in the shades of large trees, in crack in the trees, in decayed wood, in hollow rotten trunks and also in cocoa husk piles.

Over all, previous investigations on the midge biology reveled that the perfect habitat is a place where exists a great amount of shade and a high level of humidity.

Apart from these important conditions, the habitat includes the Cocoa tree, *Theobroma cacao*, but also other types of trees that contribute for the large shades mentioned before, such as:

* Odahoma, *Piptadeniastrum africanum*,
* Odum, *Chlorophora excelsa*,
* Katawani, *Pseudospondias microcarpa*,
* Okuri, *Bosqueia angolensis*
* Silk cotton, *Ceiba pentandrd*.

There are some important aspects to notice about the Cocoa tree. The cocoa flowers are available from August to November, also, the *Theobroma cacao* grow up mainly in the south of Ghana, where the rainy season goes from April until mid-November. [artigo dynamics of insect pollinators]

As every species, the midge population has predators other insects like mites, ants, springtails, dermapterans and centipedes. The last three usually feed on larvae and pupae and the springtails only feed when there is no resistance, however, the worst of the predators is the mite that feed on eggs and sometimes on adult midges.

### 2.2.3 Behavior

There are some important species behaviours that need to take into account when building the artificial ecosystem like how does it moves, reproduce, feed or even lay eggs. Every behaviour that will be described next is valid for both sexes.

To begin with, it is important to notice how *Forcipomyia squamipennis* moves around its ecosystem. It was observed before by scientists that the midge has a zigzag flight which means that it can only move diagonally always in different directions. Also, the normal flight range is between 5 − 6 meters which means the moves are limited unless they stop between flights.

It’s known that this species feed on cocoa flower therefore they visit the flowers a lot, but no more that 2−5 midges at a time in each flower.[kaufmann] They also have resting places where they spend most of the day. These midges do not tolerate sun therefore it is very unlikely to observe midges flying to on cocoa pod to another, they are usually spotted to fly around when the sky is cloudy.[biology]

Another frequent behavior is called swarming and dispersal, some scientist split this behavior into two categories, normal and mating swarm.[kaufmann] Swarming occur at any time of the day in or around the resting places and dispersal takes place early in the morning and late in the afternoon. Previous observations shown that around 11% of the swarming results in mating, therefore reproduction [biology], this event occurs in the air with males seeking females. [kaufmann] After the swarming the midges disperse, but, no dispersal occurs in presence of rain or strong wind.

To sum up, the principal behaviours of adult midges are move, feed, swarm, reproduction and lay eggs.

**3 Method**

# 4 Model

## 4.1 Assumptions

Before advance to a detailed description of how this system will work it is necessary to define some important concept that will be useful in the model.

**Chocolate Midge as egg**

**Chocolate Midge as larvae**

**Chocolate Midge as pupae**

### Chocolate Midge as adult

Since the moment it is born until it dies the midge makes thousands of decisions like eat, swarm, move or rest. These actions are all chosen at random except the eat action. An agent only eat if the energy variable, that decreases throughout time, is close to zero, by other words, when the agent is hungry. Also in order to eat the midge need to moves to the closest food tree, in this case the cocoa tree. Every action has costs, these costs are subtracted in the energy variable, every time an agent feeds this variable reaches is maximum value. [it is necessary to define the costs]

If an agent decides to rest then doesn’t do anything, remains only in the place where there is.

If the action to move is chosen an artificial neural network takes over, the possibles outputs to this action are back, front, right and left.

If a midges meets a predators in the environment, it dies.

The swarm action can randomly end in mate or not. If mating occurs a GA takes over to ensure either evolution as offspring.

This stage can learn from the environment.

There is no communication between individuals of this species.

It’s expected that the species evolves through natural selection, and to understand the conditions favorable to its evolution.

objective function: Maximize the reproduction?

### The Genetic Algorithm

Usually a genetic algorithm is used to search for good solutions in optimization problems, in this particular case traditional genetic algorithms will not do. A genetic algorithm involves a population of strings, chromosomes, by giving to each one a score, the fitness value, based on the quality of the solution. [intro to GA]

**Predators**

–¿ Which stage do they feed on

### Trees

It will be 3 types of tree in the environment –¿ is it a tree to eat, to mate or to rest?

**4.2 Ecosystem Architecture 4.3 Ecosystem Implementation 4.4 Validation**

**5 Conclusions**

# References

[1] JD Majer. The ant mosaic in ghana cocoa farms. *Bulletin of Entomological Research*, 62(2):151–160, 1972.