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Long-term sci-fi vegetation  
progression simulator

Graduation work 2019-20

Digital Arts and Entertainment

Howest.be

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# Abstract

**An abstract explains the aim of the paper in very brief, (the methods, results, etc.). Maximum length 150 words**

# Introduction

**In the introduction, you write the background of your topic, explain the purpose of the paper more broadly, and explain the hypothesis, and the research question(s).**

The intent of this research is to create a system that is not only a standalone simulation, but also an expandable framework to be usable inside a complete game.

Project title:

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| Long-term sci-fi vegetation progression simulator |

Research Question:

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| How can the progression of vegetation in a contained environment, based on seeding, be accurately simulated real-time in a game engine? |

Project outline:

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| **ENVIRONMENT** - Sci-Fi; feels familiar by rooting in our nature, but adding elements that don’t exist here - Inspired by No Man's Sky    Source: reddit.com/4yuhxz  **SCOPE** - Timespan: calculations based on a day passing, can be accelerated or decelerated. If slow growing vegetation like trees are part of the possible growths, simulations will need to span many years. If not, it should give good results after just several years.  - Environment bigger than a back yard, smaller than a forest - Test case will likely be executed in 2500-10000m² - It is assumed that the environment can sustain the chosen vegetation in terms of nutrition and temperature. The only environmental element influencing vegetation growth is placement of surfaces (e.g.: some can only grow on the sides of objects, or need light to grow) - Environments do not have to be realistic (refer to image’s floating slab of ground) - Seasons remain the same as on Earth, but duration can vary  **VEGETATION** All vegetation has predefined visuals to indicate various states of progression. Most vegetation has a seasonal cycle that changes its properties. (e.g.: grasses will stop spreading during winter season, generally seeds are only produced during spring season)  **Specific properties:** Spreading: - Can either reproduce or spread through roots in or on the ground (like our grasses) - Can only spread through reproduction (fruits, seed pods)  Survival: - Relies on soil for energy - Relies on light for energy - Draws from roots of nearby vegetation for energy - Draws from tree it is located on for energy - Relies on wind for energy  Growth locations (possible options): - Can only grow on trees (or other plants) - Can grow anywhere as long as it is pointed upwards (i.e.: not on sides or bottoms) - Take root above ground and are suspended there - Can grow anywhere as long as it is not pointed upwards - Can grow anywhere with room to grow upwards (like ivy)  Progression patterns (possible options): - Seed => seedling => singular plant or tree => grow => reproduce (back to grow) => die - Seed => seedling => singular plant or tree => spread through roots => grow => possibly reproduce (back to spread) => die (when conditions are unfavorable or after lifetime end)  Seasonal patterns (possible options): - Spring reproduction => summer growth => fall stagnation => winter pause - Spring growth => summer stagnation => fall pause => winter reproduction  **PREDICTED PROCESS** - In editor, before running: Create volume, defining which vegetation is allowed to grow in this area and the amount of those plants' seeds being present in the ground before simulating. Note: if there are no plants that can grow just by having a seed in the ground (i.e.: no conditions like needing another plant nearby), nothing will grow. It is also possible to have seeds or roots enter the volume at set intervals. They come from an unknown outside area and were taken here via wind, animals...  - At start: The volume will check all objects inside of it, and spawn the amount of predetermined seeds spread out over the area.  - During running (early stage): The seeds will get a chance to grow. It is likely that most seeds will be eliminated unless the specific vegetation has seed with high chance of surviving. Some vegetation will appear.  - During running (mid stage): Progression pattern is followed; more vegetation will appear and grow bigger.  - During running (final stage): Vegetation will start dying, freeing up space for others to grow. The ones that take their place will grow and eventually die, too. This cycle is repeated indefinitely.  **INTERACTIONS**  Since vegetation won’t just sit tight until it withers, there are some situations that can spell an early end to its life. - Bigger plants might inadvertenly eliminate nearby other plants by taking away their sunlight - Some might not survive a certain season because it froze on a cold day  - Disease or predator damage (outside unknown factors), these can spread to other nearby vegetation - Vegetation cannot grow on a patch of ground another plant is already occupying (exception: vegetation of the type that grows on trees) - Withered plants enhance their soil and improve growth of vegetation that reoccupies their space  **VEGETATION GENERAL PARAMETERS**  - Resistance to disease and predators - Seed survival chance - Expected lifespan  - Growth rate (before counting factors that influence growth like sunlight)  **ENVIRONMENTAL PARAMETERS** - Disease/predator appearance rate  - Season durations - Possible vegetation and the amount of seeds present for each of those (refer to section “Process”) |

Method and approach:

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| Analyze spreading patterns of grass-likes and reproductive types (fruits, seed pods)  Figure out which model can be used to represent the vegetation Influence of light on plant growth and calculating average time spent in light for an object (over 24h)  Detection of surfaces inside a volume (for vegetation placement)  Find optimization techniques for large interactive systems intended for use in a game  Investigate real life vegetation response to seasonal changes  Weighing engine options |

Deliverables:

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| - Engine package aimed to be used in games as a means of evolving environments throughout the passing of time, without placing any vegetation beforehand  - Package has customizable parameters to influence the simulation (see project outline)  - A video showing simulation of a few years  - Videos showing partial test cases |

# Research

## Model to represent the system (agent-based model)

One model that is often used in biology is an agent-based model, of which the properties closely match up to the goals of this system. Agents – in this case the plants – define the model, meaning adding or updating plants does not warrant an overhaul of the model. Its intent is to achieve complex behaviour on a large scale while keeping the agents’ rules simple, which is equivalent to the relatively simple individual plants forming a large evolving environment of vegetation.  
  
Other considered models did not share the main goal – e.g.: the multi-agent system is more geared towards finding an optimal solution to a problem – and were thus not appropriate to use.

## Engine choice (Unity)

Since the focus lies on making a system that is useable in a game, it is only natural to pick an engine that is both widely used and accessible. This already narrowed down the choice to Unreal or Unity. Unreal has the advantage of beautifying the scene and vegetation more easily, while the strength of Unity lies in its ease of use and shorter development times – also for developers who want to expand on the system. Because of the intended style of vegetation being sci-fi, the generally less realistic style of Unity is no longer a major negative, thus triumphing over Unreal’s realism.

## Spreading and growth patterns

### Spreading patterns

Deep research was done into finding accurate patterns of which direction grasses will spread and at what pace, and the result was found to be seemingly random. Even when considering all factors including wind, soil nutrition, soil moisture… no reliable prediction of where an individual plant will appear was uncovered. The same was found to be true of reproductive type spreading. As a result, the spreading patterns in the test case will be limited to mere proximity-based randomness – unless specified otherwise by the rules of the individual plant.

### Grass-like growth

There are numerous types of grasses, sometimes having vastly different properties from each other. It is therefore more appropriate to analyse those properties individually, allowing combination at will. Ignoring non-grass specific traits – i.e.: height and lifespan – the differentiations can be limited to sod-forming versus bunching and warm versus cool season grasses. Reproductive spreading is omitted, too, due to not being exclusive to grasses.

### Sod-forming versus bunching

In nature, grasses of the sod-forming type form a large interconnected network both above ground – a connection like that is called a stolon – and below ground – called a rhizome. This manner of spreading allows new shoots – plants that are individually sustainable, but part of the network – to grow from a stolon, rhizome or even right at the ground level of another plant.

Bunching types, unlike sod-forming grasses, can only grow new plants at the soil surface of an already present plant. Grasses with this property cannot grow as closely packed as its counterpart, though the bunches themselves can be. This does increase the odds of an invasive plant appearing in the empty space between two clumps.

### Warm versus cool season

While both types employ the same method of energizing themselves through photosynthesis, the construction of their leaves is different. The deep science behind these behaviours is unimportant, but the result of it is.

Grasses meant for a cooler season are more active – growing and reproducing – during the more temperate seasons of spring and autumn, while growth is slowed down in the warmer season of summer and they might even become dormant. The warm season grasses, on the other hand, are at their peak productivity during the hot summer season. In terms of nutritional value, the cool season grasses are more densely packed.

### growth stages

Vernalization requiring/vernalization not required grass types

Successful pasture management requires an understanding of physiological (internal chemical) and morphological (external structural) stages of plant development. Each stage is linked in some manner to forage quantity, quality, and plant survival. Wise managers should learn to spot the obvious and more subtle structural changes in order to predict what is happening inside the plant. This monitoring provides the basis for good management decisions. It allows a manager to know when to graze or mow in order to ensure prompt competitive regrowth and persistence of the forage plants.

One of the physiological characteristics of grasses that is important to understanding grass growth is vernalization. Some grass species, like perennial ryegrass, will hasten the development of flowers and fruit (seedhead and seeds) if they experience a period of cold weather.

Some of the morphological changes in grass plants need to be understood for proper management. Growth stages of major interest are listed below along with brief management implications.

Stages

Within a seed, when conditions are right to begin germination, specific cells within the germ tissue divide and expand, pushing the apical meristem contained in the seed out of the seed. A tube-like organ called the coleoptile protects the first leaf blade while pushing through the soil, eventually breaking through the crust of the soil. Then the first leaf unfurls.

A node (joint) at the base of the coleoptile is also pushed up towards the soil crust within a few centimeters of the soil surface by the elongation of an internode called the mesocotyl. The node that is pushed upward becomes the crown tissue from which roots and additional tillers arise.

Shortly after the coleoptile breaks through the soil crust, the first leaf unfurls. Additional leaves will quickly develop if conditions are right.

Seedling: the grass plant has just emerged from the soil as a monocotyledon (one leaf-type structure). Legumes emerge with two leaf-like structures. Grass leaves may whorl and erect a "false stem", but the true stem (culm) has not yet formed. Although relatively insensitive to management because the tissues involved in growth are nestled low and deep, enough leaf must be maintained to conduct photosynthesis for rapid growth, regrowth and root system development.

Vegetative: leaves continue to develop, emerge, unfurl, and die (senescence). The main function of the plant is photosynthesis. This stage of development yields the best livestock feed and managers should maintain this stage for as long as possible. However, climatic conditions will induce the next stage, sometimes called jointing, but it would more accurately be called internode elongation.

Jointing: the stage of grass development during which internodes commence elongation producing a true stem (culm). This elongation is preparation for seed development. The stem is producing a peduncle that will anchor the seedhead. The elongation elevates the growing point (shoot primordium including the rudimentary seed head) to a vulnerable height. Close grazing or low mowing at early jointing stage should be avoided because the elevated growing point could be removed and alternative (below-ground) regrowth mechanisms are not ready to function. However, removing the growing point in late jointing stage can be advantageous for some grasses because it stops the plant from spending so much energy on seedhead production so the plant redirects its energies to carbohydrate reserves.

Anthesis: the flowering stage during which the flowers open and shed their pollen. Grasses have perfect (sexually mature and fully differentiated) flowers and many are self pollinating. In this stage, the flowers are formed and the anthers are shedding pollen. The grass's work to produce the flower has resulted in decline of other functions, such as leaf production. The stem (culm) is more fibrous and plant palatability and digestibility declines. The grass plant is ready for harvesting seed at this stage (and before) but is not desirable for livestock feed.

### Regular type growth

Mention fruits and more…

# Case study

## Introduction

## Modelling

### Blockout



Figure 1 : MAKING OF THE HOBBIT: THE DESOLATION OF SMAUG – LAKETOWN (WETA DIGITAL, 2014)

### Zbrush

## Texturing

## Shading

## Lighting

# Conclusion

**repeat the main topics, discuss your main findings, discuss the end result.**

# References

Agent-Based Model. (n.d.). In Wikipedia. Retrieved September 30, 2019, from: <https://en.wikipedia.org/wiki/Agent-based_model>

Oregon State University. Discuss the basics of grass growth. Retrieved 1 October 2019, from the Oregon State University website: <https://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/management/growth>

# Appendices