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TRINITY COLLEGE

***Exploring the use of microworlds to teach about forest management and climate change.***

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Highlights

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Abbreviations

* ABM = Agent Based Model (or Modelling)
* CO­2 = Carbon Dioxide
* EduTech = Education Technology

1. Introduction

Forests play a crucial role in mitigating climate change by absorbing around 30% of global anthropogenic emissions annually [1]. However, they are delicate ecosystems. When a significant portion of a forest is cleared, it can shift from absorbing more carbon than it emits to doing the opposite, which would have disastrous implications for our planet. Unfortunately, this is already beginning to occur and will only worsen if left unaddressed.

* 1. Motivation

Balancing the demand for forest products, primarily timber, with the need to preserve forests as carbon sinks is a complex challenge that requires deep understanding of the intricate relationship between forest ecosystems and atmospheric carbon levels. Misguided forest management strategies can easily lead to over-exploitation of these precious natural resources. Therefore, ***it is essential to prioritize widespread education and awareness*** regarding sustainable forest management and conservation to ensure a bright future.

* 1. Problem Statement

Effective education demands increased user engagement. Education technology approaches involving microworlds have proven successful at achieving this in other areas but remain underutilized in the field of forest management with there being few examples of similar projects today, and none, to the best of knowledge, aimed at educating non-expert audiences about forestry and climate change.

* 1. Research Objective

This study aims to create a digital microworld that teaches adolescents about forest management and climate change through a conceptual model. Rather than focusing on scientific accuracy and intricate details, the priority is to create a simple yet realistic model that effectively captures real-world mechanisms and supports learning objectives. Agent Based Modelling (ABM) is an effective approach to simulate systems like natural forests wherein multiple separate entities or components perform individual actions that together result in complex emergent behavior. Therefore, this work utilizes ABM to develop the digital microworld.

***Research Question:*** Can a microworld, simulating forest management scenarios using Agent Based Modelling (ABM), engage users? Can such a teaching tool change the attitude of learners regarding use of forests as a nature-based solution against rapid climate change?”

1. Background

Forests grow and change over centuries, which is slow relative to the human lifespan. This means accurate long-term data is difficult to collect due to the need for sustained temporal and financial commitment. Also, since change is slow, making observations in the real world to propel studies in forestry or amend forest management strategies, is often impractical. This is why, forest growth simulations are popular among foresters. These simulations must be as accurate as possible even under varying circumstances like rapid climate change due to greenhouse gas emissions today, for them to be a useful tool for understanding effects of forest management strategies, calculating forest yield, or understanding ecological mechanisms like nutrient cycles, photosynthesis, etc. Hence, most forest simulations are catered towards expert users like foresters, scientists, or analysts and in general come in 2 flavors; empirical models and mechanistic models. [2]

Empirical approaches such as growth and yield (G&Y) models often rely on large amounts of past data and leveraging statistical, Machine Learning (ML) or Artificial Intelligence (AI) models like Artificial Neural Networks (ANN) to predict values of quantifiable parameters of a forest. A most common use case is prediction of timber output of a forest measured in terms of tree basal area or volume. G&Y models have the advantage that they are simple and capture region-specific short-term relationships between input variables related to forest inventory (tree density, past basal area, biomass, …) and/or environmental factors (solar radiation, soil water content, soil nutrient composition, …) and a target variable (timber volume, …). However, G&Y models assume environmental conditions to remain the same and this cannot be farther away from the truth today, given rapid climate change due to global warming [2, 3].

Mechanistic approaches like succession and process models are more detailed compared to empirical ones, in that they try to capture biological behavior of a forest/ecosystem (nuanced ecological mechanisms like carbon cycle, photosynthesis, water cycle, …) in as much detail and accuracy as possible using mathematical representations. They are popular due to increased accuracy, ability to capture effects of environmental changes over time and connectedness inherent within natural systems. More than for just prediction to support decision making, mechanistic approaches are used for exploration and investigation in hopes of making new discoveries regarding latent relationships and developing a better understanding of underlying mechanisms. That said, desirable features of mechanistic models come at the cost of requiring vast amount of calibration data specific to the location of interest.

To summarize, empirical models are simple but lack accuracy, especially over changing conditions. In contrast, mechanistic models are accurate and can explain cause-effect dependencies in a natural system but are significantly more complex in terms of computations involved and data required.

Thus, there is no one best way to simulate a forest because every model is ultimately only an approximation of a natural system that is far to complex to capture in full glory. The best forest simulation models are tactful combinations of both these techniques to achieve levels of accuracy specific to the problem of interest while keeping the model and data requirements as simple as possible [2].

Complexity is the hefty price paid for accuracy. Highly complex models that require specialized data is often impractical and not generalizable. Hence, prior to designing a model for natural system simulation, it is crucial to clearly identify the purpose of the simulation and identify the required level of accuracy at which predictions are to be made as well as the type of values one is most interested in observing (i.e., quantifiable metrics like CO2 capture, or interdependencies like cause-effect ones such as effect of CO2 availability on forest growth rate).

This work ... ***to do***.

* 1. Microworlds

*Different types of education technology (EduTech). Why microworlds?*

* 1. Agent Based Modelling

*How to simulate forest growth and interdependencies between them and CO­­2 levels? Explain different simulation strategies and why ABM is best for this work.*

* 1. Similar Work

*What are existing most similar works and how is this project different from them?*

1. Proposed Teaching Tool
2. Implementation
   1. Scope
   2. Methodology

Source Data

Experiments

* 1. Limitations

1. Evaluation
2. Conclusion

*Limitations. Future work.*

Appendix

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