Modeling and Implementation of a Ludic Application using Simple Reactive Agents

Hydrological Impact of High Andean Ecosystems

J. A. Villarraga Morales and L. D. Alvarado Nieto
Department of Engineering, Universidad Distrital, Bogotá D.C., Colombia

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Abstract: Intense human activity is causing drastic changes in the Colombian ecosystems. Therefore, a ludic mobile app that uses simple reactive agents was implemented to teach children about some ecosystems, that are part of the country and the role that they play for the balance of the environment. A test to determinate the app's efficacy was implemented, and the results obtained indicated that the group of children who used the app obtained a better learning curve in comparison to the group that was only taught in class.

1 INTRODUCTION

High Andean Ecosystems belong to high mountain tropical forests, according to Quijano Prieto (Quijano Prieto & al, 2015), and are fundamental in the regulation of water. Colombia owns 50% of this type of ecosystems worldwide and it has approximately 98 different types of ecosystems which make it in a natural power (Ministerio del Medio Ambiente, 2015). However, many of these environments are unknown to Colombians, as well as the functions performed by them. This ignorance the inhabitants have shown, the lack of rigor in environmental laws and the excessive actions taken by people against natural resources are generating a great environmental damage to the country. Some of these harmful effects are: erosion of soils, extinction of native species, air pollution, etc. (Güiza Suárez, 2011). Which represents an alarming scenario for living beings that depend on these environments.

Due to the difficult ecological situation that not only the country, but the whole world is facing, and given that this is a complex problem, the Complexity's Group of the District University from Bogotá Colombia has decided to take actions that contribute to the environment care. For this reason, a ludic mobile app that simulates ecosystems, specifically: a paramo, a high-Andean forest and a savannah, all of which are part of the Andean region of Colombia (Avella-M., et al., 2014), was developed. Although there are different simulations game such as Simlife, Creatures and Among Ripples, there hasn't been found an specific app focused on the simulation of the Colombian ecosystems, that allow showing the most relevant characteristics of these environments.

Basically, the main scenario of the app shows ecosystems in their natural state, then as the child interacts with the application he will be able to transform them, allowing him to cut and reforest trees, build houses and hunt animals. Simultaneously, indicators of temperature, water, oxygen and carbon dioxide levels were added, in order to visualize the changes that are generated when handling ecosystems and the effects caused by such manipulations. All this in order to demonstrate the importance of paramos for the regulation of water tributaries, and the role played by high-Andean forests as air-purifying entities and main contributors to the rains that fall in paramos (Ospina Rodríguez, 2005).

Initially, plant simulation and the role that they play in nature was the main goal. However, the simulation of animals had to be implemented too, begining with the introduction of the spectacled bear, a native specie of Colombian high-Andean forests which is currently in danger of extinction. This in order to evidence that this kind of bear is essential to the ecosystem because being that it helps to reforest its own habitat (WCS , 2011).

The modeling of the ecosystems and their components was carried out using the technique of simple-reactive agents. Subsequently, a mobile app based on those models was developed. The app's tests

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were made in a rural headquarters of the Pedro Pabón Parga school located in Carmen de Apicalá Tolima.

2 MODELING ECOSYSTEMS AND THEIR COMPONENTS

Taking into consideration that the objective of this section is the ecosystems modelling, which, being dynamic and presenting a complex behaviour, needs to be managed as such (Ritter Ortíz & Perez Espino, 2011; Ladyman, et al., 2012), it became necessary to apply complexity sciences techniques such the simple reactive agents. This technique consists in analysing an entity and identifying three factors: the sensors (parties in charge of receiving information from the environment), the decision rules (those that indicate the actions that must be taken according to the information obtained by the sensors) and the actuators (responsible for executing the actions generated through the decision rules) (Alechina, 2013).

Although, this section is widely described in a previous paper named "Paramo and High-Andean Simulation using Reactive Agents Hydrological Role of High Andean Ecosystems" (Villarraga Morales & Alvarado Nieto, 2017), It is necessary to show the modelling of a bear as a simple reactive agent, which is described below:

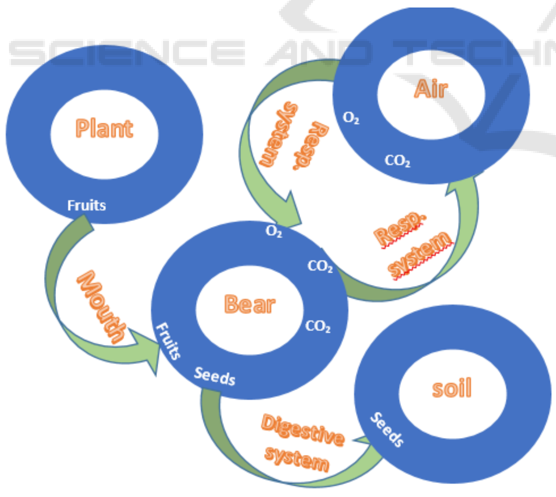

Figure 1: Model of bear using reactive agents.

Analysing the Figure 1. The bear uses two sensor elements: The respiratory system (which allows it to absorb oxygen from the air) and the mouth (used to ingest fruits of trees). And two actuators: The respiratory system (responsible for releasing carbon dioxide as a by-product of respiration) and the digestive system (used to discard the seeds of ingested fruits).

Once the bear model is specified, it is necessary to establish the control rules; therefore, the following activity diagram was created:

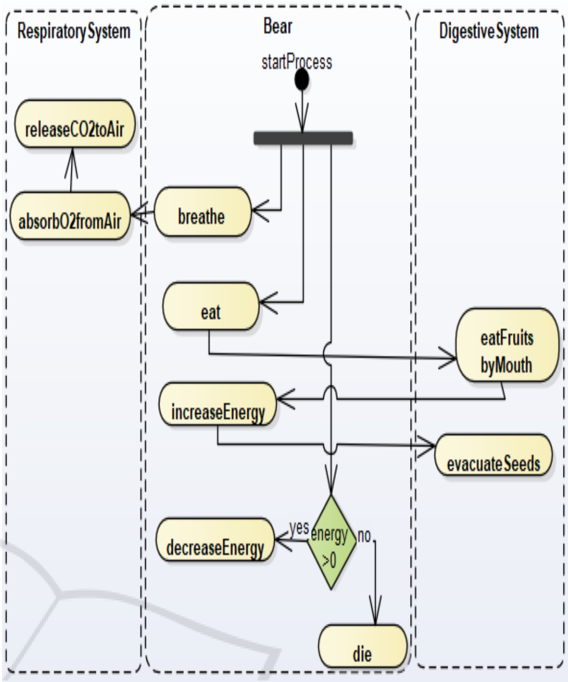

Figure 2: Bear activity diagram.

Activities performed by the bear are shown in the Figure 2. Highlighting two main processes: the breathing process and how the bear reforests the forest (the bear eats fruits, then increases its energy and later the seeds obtained after the digestive process are released into the ground).

Another important element in the simulation is the house, because it allows the user to transform natural ecosystems to artificial ecosystems. Therefore, the following model was created:

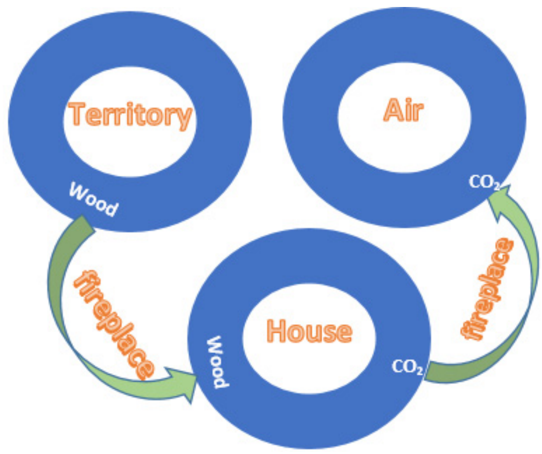

Figure 3: Model of house using reactive agents.

Analysing the Figure 3. The house element has the same sensor and actuator (fireplace), because the wood obtained from the territory is deposited in the chimney and later, as it's being burnt, carbon dioxide is released by this element into the air.

3 IMPLEMENTATION OF THE LUDIC APPLICATION

Continuing with the development process, the next step was to integrate the modelling performed in the previous section, as a mobile app, where every model of ecosystems and its components was implemented. The resulting interface is shown in this section.

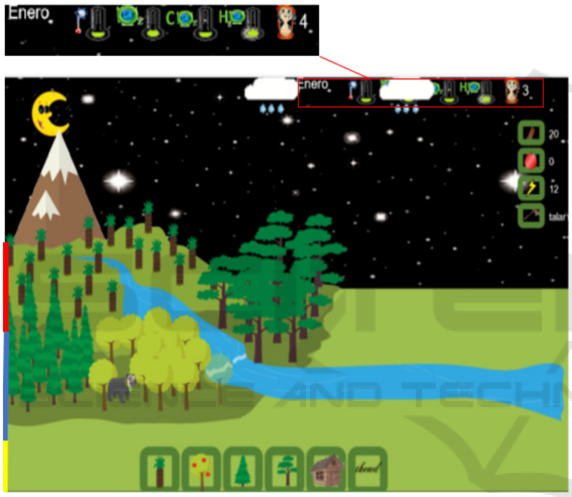

Figure 4: Territory interface.

Visualizing the Figure 4. It can be seen that all the ecosystems that were proposed to be represented, are implemented: a paramo (on the right side of the red line), a high-Andean forest (on the right side of the blue line) and a savannah (on the right side of the yellow line). Additionally, at the top of this figure the elements of the air (temperature, O_2, CO_2, H_2O) represented by icons, can also be seen, allowing the user to identify if some change has altered the natural balance of the territory.

Another aspect to detail is the button bar located in the lower part of the application, that gives the user the option to create trees or houses, allowing him to perform functions of reforestation and transformation of natural ecosystems.

3.1 Implementation of the Functionalities of Ecosystems Components

Focusing in the main activities performed by trees, the buttons described in the following figure were generated, in order to implement processes such as felling and harvesting trees.

3.1.1 Functions of Trees

Implementing activities such as felling and harvesting trees, the buttons described in the following figure were generated.

Figure 5: Buttons and icons of trees.

Analysing the Figure 5. It's shown that when a tree is selected from the simulated territory, immediately in the upper right corner of interface, icons that show the amount of wood, fruit and energy that such tree has, appear. Similarly, the fruits are harvested when the icon referring to the fruit is selected, and the axe icon is used to cut a tree.

3.1.2 Functions of the Bear

Another biotic organism characterized in the simulated territory is the spectacled bear. Consequently, interactions represented in the Figure 2, were implemented in the present app. Obtaining as result the next icons:

Figure 6: Icons of bear.

Identifying the icons shown in the right side of the Figure 6, that only appear when the bear is selected, it shows that the first icon represents the bear's energy, while the second one allows the user to feed it but only if there are harvested fruits in the territory. Finally, the third icon allows hunting the bear.

3.1.3 Functions of House

Although this reactive agent (house) only has an activity (turn on the fireplace), it was important to implement it, since that way, the simulated ecosystems could be transformed to an artificial environment. Analysing the next figure (Figure 7). As the savannah is being transformed into an agro-ecosystem, is shown that the user is manipulating that environment. Additionally, the smoke coming out from the chimney indicates that the wood, that had to be previously collected by felling trees, is being burnt. The final phase of this process is generated when CO2 is released into the air.

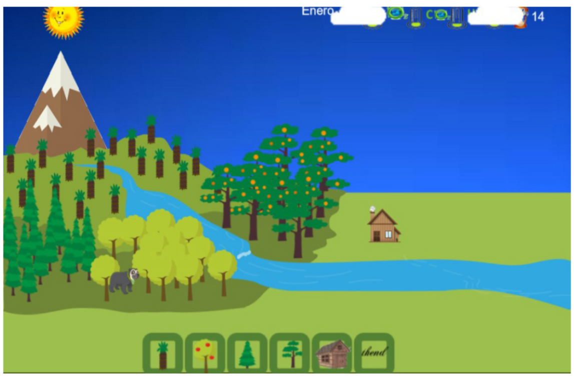

Figure 7: House implemented in the simulation.

4 APPLICATION TEST

Although the previous section indicates that the modelling of the ecosystems and their components carried out in phase 2 was implemented in the development of the app, it's important to verify that the results obtained in the paper, entitled "Paramo and High-Andean Simulation using Reactive Agents Hydrological Role of High Andean Ecosystems" (Villarraga Morales & Alvarado Nieto, 2017) are evidenced. Additionally, due to the fact that the developed app is made to have a ludic nature, tests that validate the pedagogical effectiveness of the developed tool were necessary.

4.1 Functionality Tests

Tests about changes in the ecosystem's behaviour when strongly modified or affected, were applied. The first part was to destroy most of the high Andean forest. The next figure shows that changes:

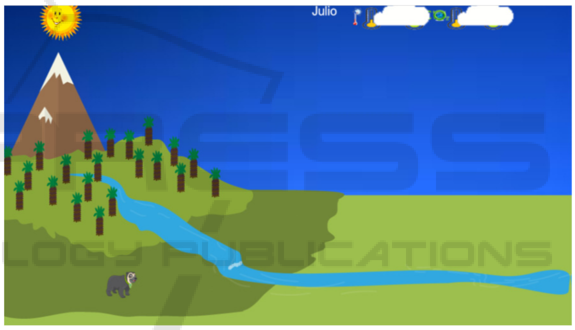

Figure 8: The high Andean forest is destroyed.

Visualising the effects shown in the Figure 8. The thawing of the mountain and the reduction of river flow are the main changes highlighted. However, the increase in temperature and CO2 levels are also denoted. This because these kinds of ecosystems do not only play the role of purifying agents, but they also provide most of rainwater that falls in paramos (Díaz-Granados Ortiz, et al., 2005).

Continuing with the test process, the next step was to identify what happens when the paramo is destroyed. The figure above (Figure 9) represents that scenario. Analysing such figure, a great effect is denoted, the river flow changes drastically in different periods of time: the river flow decrease severely in January (which is a month of dry season) but in July (a rainy month) this one increases disproportionately. Effect that is caused being that the paramo is a hydric regulator (Jacobsen & Dangles, 2017).

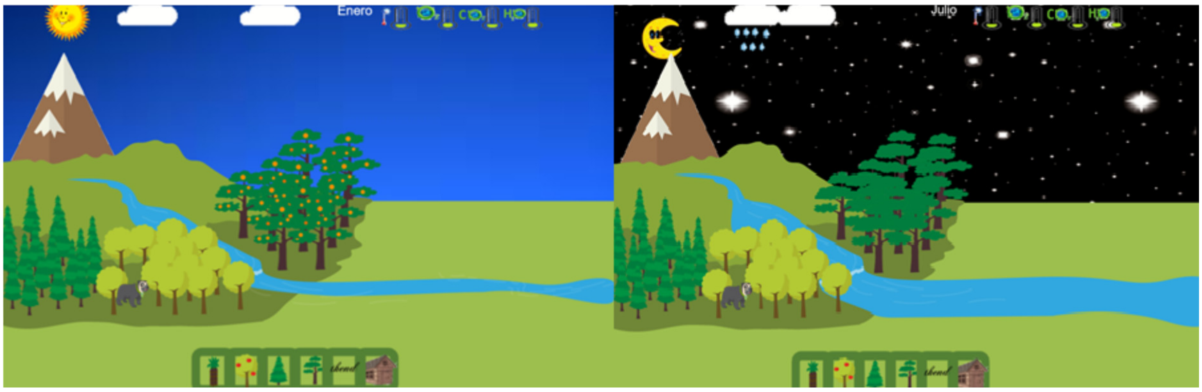

Figure 9: scenario when the paramo is destroyed.

4.2 Efficacy Tests

Knowing that the purpose of this app was for children to keep in their minds knowledge that, although is very important, sometimes is taught in a tedious way. The next step was to perform tests that allowed identifying if the app did help to ease the learning of topics related to ecology. Therefore, a group of 18 children (who represented approximately 60% of the total school children) of third, fourth and fifth grade of a rural school located in the Carmen de Apicalá (Tolima) were chosen. The next figure shows a classroom where the tests were made:

Figure 10: Children learning ecology.

The total group was divided in two. The first day both groups were evaluated using a written test composed by 10 questions about the High Andean ecosystems and the greenhouse effect, this in order to determine their degree of previous knowledge. The next day, the first group (named group A) was taught using the ludic application as a support tool while the other group (group B) was taught using the classic method. Finally, a new written test was applied to both groups.
The results obtained are shown in the following graph:

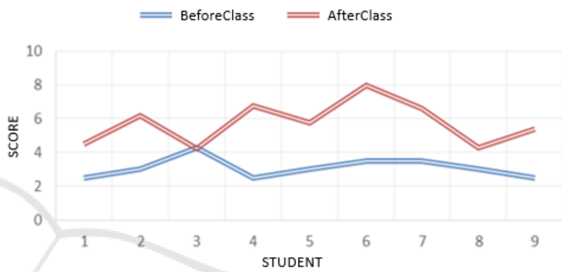

Figure 11: Score obtained by students of group A.

The improvement in the score of the children after explaining the topics using the app is evident. In the Figure 11 is analysis it's shown that 100% of the group members improved their marks or in the worst, case maintain them.

On the other hand, the second group (named group B), which was taught without the ludic app, kept a low score. The following figure represents their results:

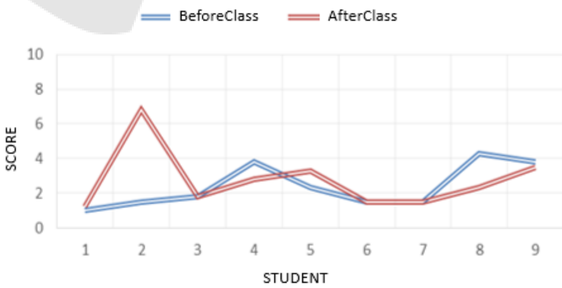

Figure 12: Score obtained by students of group B.

Certainly, the results presented in the Figure 12, are much lower than the results of group A. showing that for group B: 22.5% of children improved their score, while another 22.5% worsened the score and the remaining 55% maintained their level of qualification.

5 CONCLUSIONS

Analysing the results obtained in the implementation section, it's evident that the technique of simple reactive agents is an adequate tool for the simulation of ecosystems. Because, not only allows to visualize the characteristics of the agent, but also to define the way in which the interaction with the environment is generated.

The functional tests verify that the role played by paramos and high Andean forests for the balance of the environment is essential. Similarly, a strong dependence between these ecosystems was denoted. This agrees with the results obtained by studies such as those of Antoine M. Cleef (Cleef, 2015) and Thomas Van der Hammen (Estévez, 2009)

The characterization of simulated ecosystems as complex systems was clearly demonstrated. Because, even though each of its elements present simple behaviours, the elements interaction generates complex behaviours (such as the change in the flow of the rivers or the melting of the snow). That is, unscheduled actions emerge.

Children in rural areas are those who are in direct contact with paramos and high Andean forests. Therefore, they are the ones who should have the best knowledge, about the importance and care of these environments. Due to that, this work was focused in the ludic learning of those children.

Finally, the importance of the results obtained when the app was used to teach fundamental topics such as ecology, is highlighted. Being that the learning curve of the children who used the application was much higher than the group that was oriented with the conventional method, showing that this kind of knowledge can be imparted to children in a fun and ludic way, without losing the final objective "that the topic explained is engraved in the mind of the child and not just in a notebook".

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