Mobile Information System for Species Localization and Modelling Applied to the Amazon Forest

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Abstract. Species distribution modelling based on ecological niche uses data collected in the field by researchers which indicates whether a particular species is present or absent. However, without reliability or accuracy, the generated models are inaccurate. Because of this we propose a system which uses a smart phone and a service oriented approach to data collection. Using this, a researcher can submit data collection points for processing on remote servers which will return the distribution model after it has been previewed. It automates the collection and modelling process and allows collaboration between the researchers, but the system needs to be designed giving some considerations to the often hostile local environment in which it will operate – the Amazon Forest. This paper presents the benefits of using SOA (Service Oriented Architecture) to model this kind of system.

1 Introduction

Species distribution based on ecological niche modelling has been used in several areas of ecology. It uses mathematics techniques which are applied to weather statistics and other physical factors which can affect the geographic extension of the species in its ecological niche [1].

So with the known localization data (or absence) of occurrences of individuals species and relating them to environmental variables (such as relief, climate, humidity, etc) it is possible to predict the probability that a region will be favourable to survival of that species.

This process depends on the quality of the data collected in the field. [2] Presents research concerning the influence of errors in the collection point position. There are, however, human factors that can also influence the quality of these points.

This paper presents a mobile system which supports the collecting and modelling of data for the distribution of ecological niche. It also evaluates how mobile devices can influence the quality of data collected in terms of security, integration, storage and availability. Beyond this, it proposes a novel approach to help scientists choose an area in which to collect field data by previewing the models available to the researcher.

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2 Distribution Species Modelling

Distribution species modelling is a way of analyzing data which is applied mainly in biology which uses advanced systems of geographic information [3].

To understand what this modelling represents it is necessary to understand the concept of ecological niche: according to [4] ecological niche is defined as “a space with n-dimensional volume where each dimension represents the interval of environmental conditions or necessary sources for the species survival and reproduction”.

In [3], ecological niche is defined as a group of ecological condition in which a species is capable of maintaining population without immigration.

According to these concepts the ecological niche is nothing more than a determined region where the group of factors favours the species survival. Environmental features that influence species survival can be temperature, humidity, salinity, pH, feeding sources, luminous intensity, predatory pressure, population density, among others. Environmental factors are limited and remain relatively constant on the interval related to the timeline of these animals [5].

The ecological niche is divided between function and performance. Functional niche is defined as a group of environmental conditions necessary for a species survival without considering the influence of predators. Performance niche is where the species really occurs [6]. You can say that performance niche is a sub-group of functional one.

Predictive modelling of species distribution is mainly concerned with the ecological niche modelling. It proposes a solution based on artificial intelligence for foreseeing a probable geographic distribution of species.

The distribution modelling of ecological niche plays an important role in ecology. Among the main application are planning for environmental preservation areas [7], [8], [9]. Choosing a preservation area requires knowledge about a species ecological niche. With predictive modelling it is possible to identify statistically these areas.

Another area in which modelling is a driving force is in climate change research [10], [11] which aims to identify how living creatures are affected by global warming.

Other applications can also be found: species replacement in nature, management of species and habitat, biogeography and others [8].

3 Species Distribution Mobile System

Below we present some features of the proposed system. The case study of the system has been performed in Amazonas state in partnership with National Institute for researches of Amazon (INPA) [12].

3.1 The System Importance

The usage of mobile phones for performing data collection offers the following benefits to the collecting and modelling of ecological niche distribution:

- Collection automation: A user need only select a button in the geographic interface to identify a point of presence or absence of a species. Automatically, the system calculates geographic coordination through GPS (Global Positioning System) and stores that data. The user will not have to take notes in other sources or electronic spreadsheet. This also guarantees reliability of the collected data.
- Accompanying changes in the model: With this system it is possible to follow the mobile phone through the evolution of the model to the extent that more data can be added, including data from other field researchers.
- Better use of a researcher's distribution: With the simplification of the system more areas can be analyzed by the researchers. The researcher can work looking for species in different areas and still can transfer data for all other researchers to access.
- Convenience: The mobile device is more compact thereby reducing the number of devices necessary to conduct the research.
- Usability: A more friendly and intuitive interface will be proposed in this document. With this system the user will gain some other facilities for performing data collection such as selecting only one button on the graphic interface to identify the presence or absence of species.
- Faster GPS in regions with GSM (Global System for Mobile Communications) networks: Modern phones do not use the traditional geo positioning system, but the Assisted GPS (A-GPS). It is a system that uses a server for helping to minimize the Time To First Fix (TTFF) and improving the robustness of the positioning. The accuracy of location is less than 3.1 meters and the TTFF are less than 5 seconds, working even in situation of critical satellite signs [13]. The A-GPS uses any available networks such as the GSM network of the operator or even a wireless network in urban areas. This type of technology use case is important for the modelling of species which live in urban environments, such as rats and mosquitoes for example, when identifying possible diseases routs [14].

3.2 Technical Restrictions

There are two main technical restrictions for the proposed system. They are:

- Network availability: One of the biggest challenges this project faces is the issue of communication between the cellular and the service provider. Most use cases for a system such as this involve communication networks with intermittent network access so the system shall work most of the time in off-line mode. The main objective of the application is in automating the data collected and its sending to the server. However it is not intended that data collection occurs at the point of collection but as soon as there is an available network. Working in off-line mode the application will be able to store the current coordinates, show saved models and analyze these models.
- Processing power of the devices: The predictive modelling of the species distribution requires high performance computing [14] the generation of a model can take between hours and days to prepare.

3.3 Business Restriction

This type of research in Brazil needs to comply to some rules concerning the transfer of biodiversity data. This data needs, in many cases, to be kept secret. These measures are necessary for environmental property protection.

This kind of concern is important for Brazil once which has 20% of the total number of species on the planet. In august of 2009 the Ministry of Science and Technology published 'the concierge 693' which standardizes the manipulation and distribution of research data about biodiversity. This concierge makes the following observations:

- The management and authorship of data must be published.
- The usage condition and the access to data must be protected in the database.

3.4 Usability

The system needs to have easy browsing, be intuitive and have few steps necessary for performing tasks. The kind of device that is being proposed for use is a *Smart phone*, which has a limited screen size. That means that the icons need to be arranged in such to be very easy to use. Fig. 1 shows the screen of the main menu of this tool in a mobile device.

Fig. 1. Main Menu in a mobile device demonstrating the usability with the thumbs.

This interface shows how efficient it is for small devices that have touch screens. Usage of the thumbs allows for a more comfortable experience. Fig. 2 shows the flowchart of initial activities with skeleton of the screens.

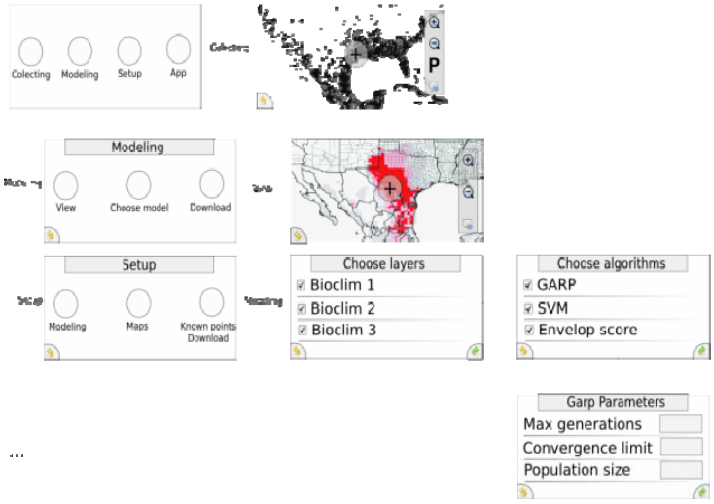

Fig. 2. Flowchart for some screens of the system.

4 SOA to Mobile Species Distribution Modelling

SOA was chosen as the distribution mechanism due to the challenge of having access to a distribution model via mobile phones. Using this system the following use cases were identified as services and offered by the providers:

- Environmental data provider;
- Maps provider;
- Species data provider;
- Modeling algorithms provider;
- Pre-modeling algorithms provider;
- Post-analysis algorithms provider.

At Fig. 3 is shown the architecture proposed by this paper.

Basically, an infra-structure with a set of servers is used. Each of the offered services can be available in different servers. The mobile devices will have access to these services at the moment they are in regions with Internet access, having Wi-fi, GSM or any other kind of connection. Most of the collected data happen in remote regions, without this kind of infra-structure. For this reason, the system runs in two working modes: connection with or connectionless. The connection with mode is used for transferring data between the mobile devices and the service providers. While the connectionless mode is used mainly while the researcher in field looking for points of species presences or absences. In this mode the data persists on the device.

Before the data can be transferred, the information is first checked by an active service on the device itself, this service aims to perform a pre-processing of information in order to ensure the integrity of data being made available to other modules. If the information is not corrupted, it is transmitted through a provider of

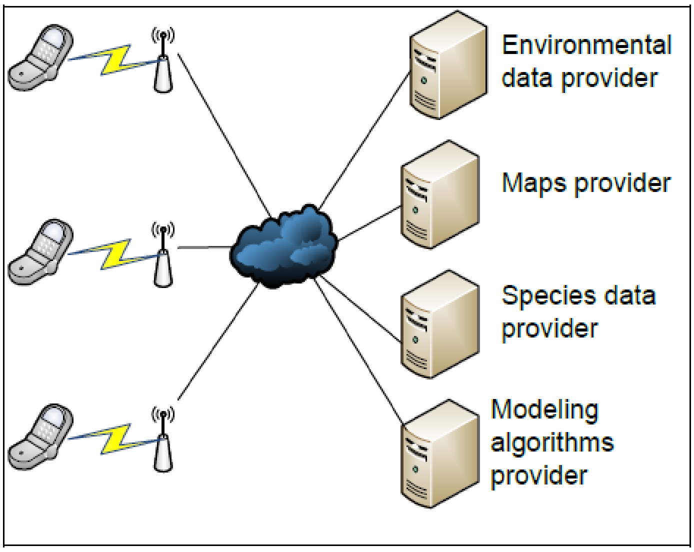

Fig. 3. Services used for species distribution modelling.

communication services to an intermediate server. If the device is operating off-line this information is stored on the device itself, until it has access to any network. To receive the information collected by the device, the intermediary service provider is engaged to provide this content to a number of providers of services, each with a separate responsibility within the architecture, so that at the end of execution this data can be made available to a service provider responsible for ensuring the persistence of information processed in a server database.

Through the use of services, the SOA model provided the project a coherent distribution of resources in infrastructure. Despite the technical constraints (section 3.2) the use of the Internet has provided an efficient way to transfer the data collected with the service providers in a quick and dynamic manner.

This service oriented architecture allowed us to solve the following issues:

- High performance computation on a mobile phone: Although mobile phones do not have enough capabilities to perform distribution modelling, it was possible to show a model on the device due to the use of services.
- 6yReuse of existing services to composition of many solutions: Some services used on this project are from the Openmodeller project and others from SpeciesLink. They obtain from the services models and data concerning the presence or absence of a species.
- Use of web services to provide fast software updates: With this approach each research team is able to get the current data that all other teams have collected. Without this system the update can only be done after the team come back to the base. Another feature of this project is the ability to do upgrades on the software.

5 Conclusions

The system proposed in this paper allows a user to preview the distribution models of ecological niche using a low computational power mobile device. It was verified that mobile devices are powerful enough to make previewing the model possible, given the service orientated system architecture. It was even possible using communication with remote servers.

We also show that an opportunity exists for data collection given a crowd sourcing approach

The automation of data collecting through a mobile device is important as it reduces human intervention in a system. Further research is necessary to measure the quantity and quality of the collected data with this system.

The service oriented architecture shows that it is efficient in this type of project. Modelling species distribution in a distributed manner through the use of services in different servers is an interesting use case for Service Oriented Computing.

References

1. Soberón, J. & Peterson, A.T., 2005. Interpretation of models of fundamental ecological niches and species' distributional areas. p.10.
2. Iwashita, F., 2008. Sensibilidade de modelos de distribuição de espécies a erros de posicionamento de dados de coleta. Instituto Nacional de pesquisas espaciais.
3. Peterson, A.T., 2001. Predicting species geographic distributions based on ecological niche modeling. Cooper Ornithological Society.
4. Hutchinson, G.E., 1957. Concluding remarks. Cold Spring Harbor Symposia on Quantitative Biology, pp.415-27.
5. Bazzaz, F.A., 1998. Plants in changing environments: Linking physiological population, am community ecology. Am community ecology.
6. Malanson, G.P., Westman, W.E. & Yan, Y.-L., 1992. Realized versus fundamental niche functions in a model of chaparral response to climatic change. Ecological Modelling, pp.261-77.
7. Austin, M.P., 2002. Spatial prediction of species distribuition: an interface between ecological theory and statistical modelling. Ecological modelling Elsevier, pp.101-18.
8. Guisan, A. & Zimmermann, N.E., 2000. Predictive habitat distribution models in ecology. Ecological modeling, pp.147-86.
9. Sohn, N., 2009. Distribuição provável, uso de hábitat e estimativas populacionais do galo-da-serra (Rupicola rupicola) com recomendações para sua conservação. Universidade Federal do Amazonas.
10. Peterson, A.T. et al., 2001. Effects of global climage change on geographic distributions of Mexican Cracidae. Ecological modelling, pp.21-30.
11. Canhos, V. et al., 2005. A framework for species distribution modeling. Research project. São Paulo: Reference Center in Ambiental Informatics, USP Polytechnic School, National Institute of Spacial Research.
12. INPA, (2010). Instituto Nacional de Pesquisas da Amazônia. Retrieved September 1, 2009, from http://www.inpa.gov.br.
13. SCHREINER, K., 2007. Where We At? Mobile Phones Bring GPS to the Masses. IEEE Computer Graphics and Applications, 27, pp.6-11.
14. Santana, F.S., Siqueira, M.F., Saraiva, A.M. & Correa, P.L.P., 2008. A reference business process for ecological niche modelling. Ecological informatics 3, pp.75-86.