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WebGIS Design & Implementation for Pest Life-cycle & Control Simulation Management: The Case of Olive-fruit Fly

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Abstract

This work presents an integrated web geographical information system aiming at managing the simulation of the pests' life-cycle and control in a "Software as a Service" fashion. The approach adopted herein assumes that simulation processes take place in black-box functions and focuses on the management of all related information through thin clients such as common Internet browsers. In addition, in the proposed service a small framework is designed and implemented aiming at inherently handling the associated geographical data of the service in a visual manner.

Keywords: SaaS; WebGIS; Olive-fruit fly; geo-spatial data; php-framework; visual CRUD operations; pest life-cycle; simulation management

1. Introduction

A plethora of insects are considered as pests, as their actions produce harm to humans and/or their concerns [8]. Insects regarded as pests include, among other types, those that are parasitic (e.g. mosquitoes), transmit diseases (e.g. mosquitoes, flies) or destroy agricultural goods (e.g. olive-fruit fly).

The effect of pests on crops especially, can be of immense significance, as by infecting and feeding from the fruits and grains of agricultural goods pests greatly decrease the value of the industry, leading to loss of both alimentary raw material as well as invested funds [6].

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Key steps in preventing the detrimental consequences of the insects acting as pests include identifying and suppressing their life-cycle through enforcement of pest control. Thus, simulations have long been utilised [2] in order to investigate the closely related to the natural environment life-cycle and apply control on these insects.

Nevertheless, in terms of assisting collaboration and providing for flexibility and scalability of usage, software for the simulation of the life-cycle and control of pests provided as a “Software as a Service” (SaaS) is advantageous in contrast to traditional in-house hosting of standalone applications. SaaS allows organisations to enjoy the benefits of a particular business application while minimising infrastructure, implementation and maintenance costs, as well as Information Technology (IT) staffing requirements.

Moreover, and to the best of our knowledge, as far as the active scripting on the server side of the SaaS model is concerned, existing frameworks in PHP language [9] do not offer native visual Create Read Update and Delete (CRUD) handlers [5] for geographical data based on state-of-the-art WebGIS services like [4]. Such a provision would greatly support the development of WebGIS managing data and processes of the pests’ life-cycle and control simulation.

To address the aforementioned requirements, our work proposes the:

- design and implementation of an extensible WebGIS for the management of all data and processes of pests’ life-cycle and control simulation, and
- implementation of a minimalistic CRUD PHP framework for visual handling of geographical data.

The rest of the paper is organised as follows. Section 2 describes background and related work. Section 3 provides a brief account of the proposed service’s design and implementation, while the paper is concluded in Section 4.

2. Background & related research

This research is focused on the olive-fruit fly (OLF), also known as “Bactrocera oleae” and “Dacus oleae”, a phytophagous species of fruit fly belonging to the Dacinae subfamily [7]. The name of the fly is derived from the food its larvae feed from, the fruit of olive trees.

OLF is considered as the most serious pest in olive cultivation [11] as if left untreated can reach up to 100% [1] olive fruit infestation and thus a great deal of research focuses on its monitor and control.

Existing research on GIS for monitoring and controlling olive fly pest [10] has proposed a Location-Aware System that combines location sensing technologies with wireless Internet, Geographical Information Systems (GIS) and Expert Systems (ES), for monitoring and controlling olive fly pest problem in a ubiquitous precision farming environment. The approach adopted therein leads to software distributed as a traditional standalone application, thus not being able to harness the beneficial characteristics of a SaaS approach, as aforementioned.

In addition, existing frameworks, such as phpCake [3] and Yii [12], of the widely used and open-source PHP scripting language offering active scripting on the server side of the SaaS model do not offer a native handle for visual management of geographical data.

3. Service Design & Implementation

The design of the proposed service is based on the assumption that the life-cycle and control simulation process is treated as a black-box and thus only input-output knowledge is required, as shown in Figure 1. Accordingly, data are purposefully isolated from the processes in order to provide a degree of flexibility and adaptability for new simulation methods.

Input data follow the hierarchical organisation of estates ranging from cooperatives to single trees and include various measurements on pest traps and already applied pest control processes as well as geo-information on each trap (e.g. height from sea level, orientation). Output data consist of localised temporal predictions on pests’ life-cycle.

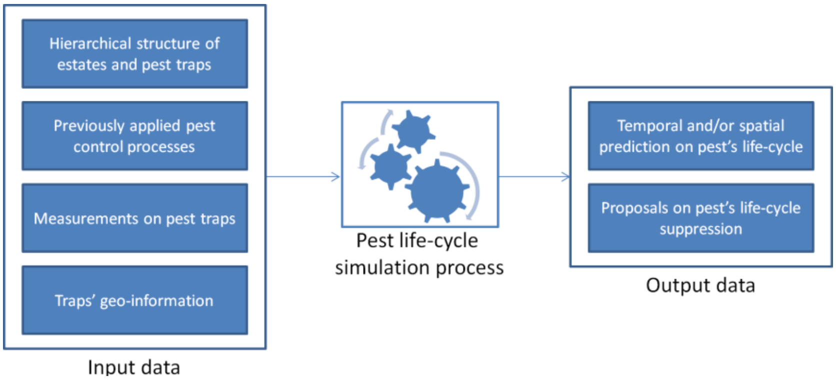

Fig. 1. The architecture of the service.

Accordingly, land-owners, potentially belonging to a farming cooperation, may have more than one estate, each of which has more than one olive tree that in turn may have a pest trap. For each of the traps, a series of measurements are performed periodically, that, coupled with already applied pest control processes information, act as input to the life-cycle and control simulation process. The results of the simulation process are highly-localised and resolutions from a few square meters to all the estates of a cooperation can be handled for each temporal unit. Moreover, should the simulation process provides for specific proposals on pest's life-cycle control, estate/cooperation administrators are given directions on pest's life-cycle control. Table 1, details the attributes of the entities stored in the database (functional attributes are clipped or aggregated).

Table 1. Entities and their attributes for the case of the Olive-fruit Fly.

Entity title	Attributes	Entity title	Attributes
Cooperative	Title	Estate	Title
	Contact details		Number of trees
Land-owner	Name		Shape (Geo-data)
	Surname	Measurement	Timestamp
	Contact details		Temperature
Trap	Location (Geo-data)		Humidity
	QR code		Altitude
Prediction	Timestamp		Verbal description
	Rectangle (Geo-data)		Number of male & female pests

The proposed service is intended to be used as a self-explanatory SaaS by non-WebGIS savvy farmers and thus the design principles also include graphical interfaces for all processes, including all actions of the administrator as well.

Measurement data can be inserted to the platform by both a web interface as well as mobile platform applications that offer a guided step-by-step submission based on either the geolocation of the device or a QR code on the trap.

The proposed PHP framework, in order to inherently handle the geographical data associated with the management of pests' life-cycle and control simulation, features a generalised approach to all CRUD actions including geographical data, as shown in Figure 2. Thus, the framework is agnostic towards the database in order to provide for a generic solution and aside common estate-based hierarchy (e.g. a tree is a child of an estate that in turn may be a child of a cooperation of estates) can be extended to arbitrary include any measurements specific to the pest life-cycle and control under examination.

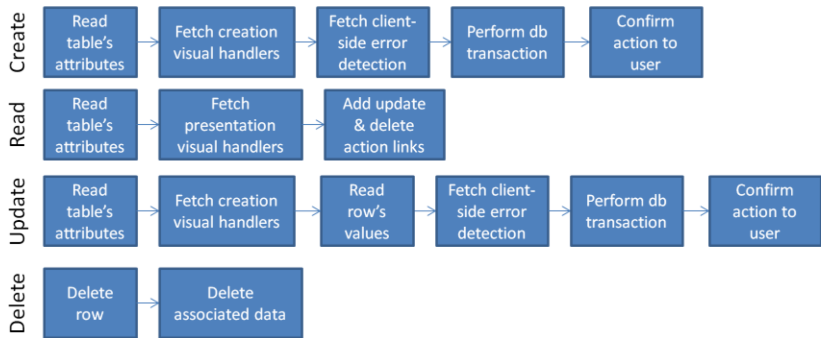

Fig. 2. The architecture of the PHP CRUD framework.

When any CRUD operation is required, a handler identifies the data type of the fields in the respective database table and fetches the appropriate CRUD handler. As the user-friendliness is paramount for the intended users, the handler invokes visual tools supported by the maps.google.com API [4] in addition to all necessary textual form fields.

Moreover, and in order to improve further the user-friendliness of the proposed service, for all fields that are necessary in each form and appropriately marked as non-null in the database, the handler also fetches client-side (i.e. at the browser) error checking based on the data type (numeric, string, date, etc.) of the database's field.

4. Conclusion

The proposed service is presented as an alternative to standalone applications supporting management of data and processes for pests' life-cycle and control simulation by adopting a "Software as a Service" approach. In addition, the service is developed as a framework handling visually geographical data natively. Future extensions will include means for automated aggregation of trap measurement data, as the current implementation requires manual insertion of the measurement data on a temporal basis dictated by the simulation's parameters. Thus, the service could easily be expanded to include a documented API that would allow networked sensors to provide measurements programmatically to the service.

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