Application note

pestMapper—A internet-based software tool for reporting and mapping biological invasions and other geographical and temporal events

Yulu Xia [a,*], Shalini Guru [b], James VanKirk [a]

[a] *NSF Center for Integrated Pest Management, Campus Box 7553, North Carolina State University, Raleigh, NC, USA*
[b] *Department of Computer Sciences, North Carolina State University, Raleigh, NC, USA*

ARTICLE INFO

ABSTRACT

An internet-based Google® Maps application, pestMapper, is developed for sharing biological events such as invasive species and pest distribution over large geographical areas. This data gathering and mapping tool facilitates reporting, viewing, and providing alerts about important pest occurrences and research activities both regionally and globally.

This Google® application provides reported events dynamically to a Google® Maps interface with detailed information displayed for each event. Users can make use of various built-in options such as region, event, pest, country, or time to display the map selectively. Alerts can be automatically sent to interested parties when system-specified types of events, such as pest outbreaks, occur. The system also generates web-based alerts for certain pre-defined events. A time slider is available for users to view temporal distributions of a biological event.

Data are entered using an online data report component. The software can be modified for many other applications, such as species regional or global distribution mapping.

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1. Introduction

Introduced species (we will use non-native species and invasive species interchangeably hereafter) cause enormous economic and environmental damage. Invasive species are responsible for a large portion of the estimated $130 billion in US crop losses each year due to pest damage (Carruthers, 2003). It is estimated that invasive species cause worldwide impacts up to US $1.4 trillion annually or almost 5 percent of the global Gross Domestic Product (The Global Invasive Species Programme, 2007). Studies indicate that invasive species often devastate native species and biodiversity (D'Antonio and Vitousek, 1992).

The impact of non-native species to developing countries is significant. These countries generally lack the resources and technology to tackle the issue. The ecosystems in these countries are often fragile. Introducing foreign species can cause a series of environmental consequences (The Global Invasive Species Programme, 2006).

These problems demand a coordinated effort to share information about these pest distributions and outbreaks. pestMapper, an internet-based data and information gathering, reporting, alerting, and mapping application, was developed to facilitate this effort.

This project was initially developed as an internal application in a project funded by the United States Agency for International Development, through the Integrated Pest Management Collaborative Research and Support Program (IPM CRSP). The goal of the project is to develop a tool that automates the process of gathering global data about invasive species occurrences and maps their distribution interactively. This version is a case-specific application which takes data from an internal data reporting component and queries other pest information databases.

2. Procedures

The Google® Maps API, CFAjax® (Ajax for ColdFusion), and ColdFusion® programming language were used to develop this mapping application. Further information regarding the Google® Maps API can be found at http://code.Google(.com/apis/maps/. Ajax (Asynchronous Java and XML) is a software programming package for dynamic web information manipulation. CFAjax is a ColdFusion version of Ajax. CFAjax can update a map event without refreshing the full web page. Further description of CFAjax can be found at http://www.indiankey.com/CFAjax/. ColdFusion is a tag-based programming language for creating dynamic, database driven web pages (http://www.fusionauthority.com/cfintro.cfm).

The system has three conceptual components: user interface, server-side programming scripts, and the database. The interaction of these three components is illustrated in Fig. 1.

* Corresponding author. Tel.: +1 919 513 8187; fax: +1 919 513 1114.
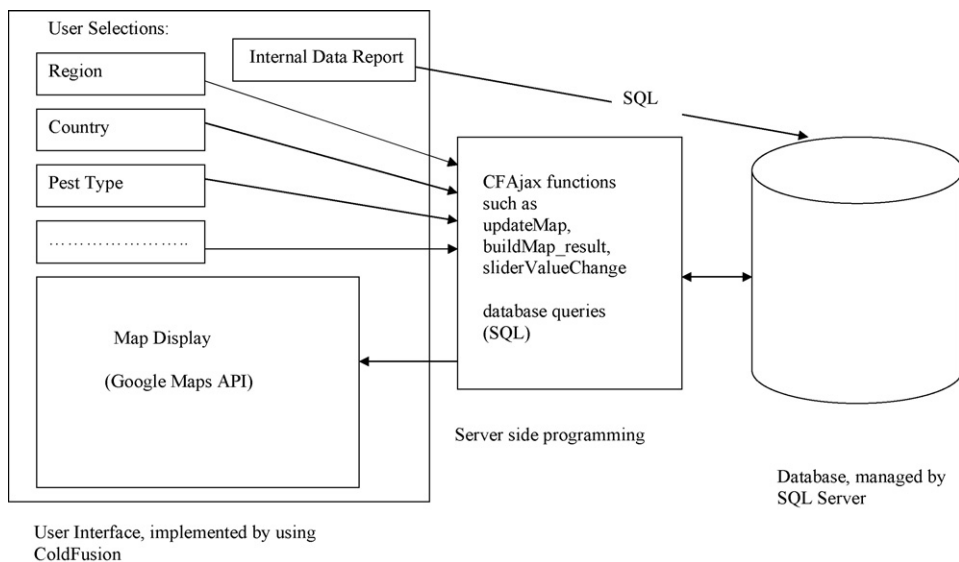 *E-mail address:* yulu_xia@ncsu.edu (Y. Xia).

Fig. 1. System design.

The User interface allows users to both view the map and report data. It is made of three parts (1) Google® Maps, (2) drop down and selections, and (3) the internal data report.

Google® Maps. The appropriate Google® Maps API script was downloaded from Google®. A site-specific Google® Maps application key was requested and inserted into the code. The interactive and dynamic map is achieved by using a series of Google® Maps. A global variable was used throughout for map manipulation.

Drop down and selections. This is a series of menu options that allow users to map an event selectively. These menu options were programmed using ColdFusion. Once an option is selected, one or more CFAjax function(s) (see Server-side programming for more detail) is/are called to change the map display with results from a query of the events database.

Internal data reporting. This password-controlled ColdFusion form allows authorized users to enter data for the map display. A web-service is used to find the geo-coordinate information automatically. The report data are entered into the events database by using ColdFusion embedded SQL (Standard Query Language).

Server-side programming. CFAjax is used to communicate between the user interface, the database, and Google® Maps API functions. A series of CFAjax functions are used here. These functions change the map display immediately after the user makes a selection on one or more of the selections such as pest type, crop type, or country. A Yahoo API was used for programming the global date slider. The total span of the slider is defined as the range of dates from the first event occurrence in the database to the current date. The actual pixel position of the slider bar is used to calculate the relative position from the start of the slider bar. The start of the slider bar indicates the first event date. The relative position is mapped to a date in an event date range.

Events database. A relational database is used for managing the data. The database consists of nine tables. These tables are used to record the relevant biological and geographical information. These tables and their content are

- tbl_crop: crop or host plant names
- tbl_event: reported events
- tbl_types: a list of event type such as first report and new host
- tbl_geoCoordination: latitude and longitude data
- tbl_pest: pest names
- tbl_pestTypes: a list of pest type such as insect pest, weed and plant disease

- Tbl_region: a list of region names
- Tbl_users: user login information

The database is managed by using MS SQL Server 2000.

3. Results and discussion

Fig. 2 shows the pestMapper web interface. It provides the user with two main services:

Mapping and alerts. A Google® Map displays the pest distribution, occurrences, outbreak, or other type of events on an interactive map. Alert messages appear on the bottom of the web site. Icons that represent insect pests, plant diseases, weeds, or other pests display the reported information in detail when the mouse moves over them.

By default, all reported pest events are displayed on the map when a user first opens the site. However, users can display the following via built-in menus (drop downs and selections):

Region. The user can view a map of (1) the World (default), (2) Africa, (3) Asia, (4) Australia and Oceania, (5) Europe, (6) North America, and (7) South America.

Event type. Users can choose an event type: (1) All (default), (2) Distribution, (3) Native, (4) First Report, (5) Outbreak, (6) Research Interest, (7) Eradication, and New Host. These event types can be changed to accommodate the need of each application.

Pest type. There are five choices: (1) All (default), (2) Insect Pest, (3) Plant Disease, (4) Weed, and (5) Other.

Time. This feature allows the user to view pest events based on the time at which the event was reported. Users can select: (1) All (default), (2) One Week, (3) One Month, (4) Six Months, (5) One Year, (6) Five Years, (7) >Five Years.

Country. By default, the map lists all countries where pest information has been reported. The user can view the reported pest events in a particular country.

Pest. This map shows all reported pest events. The user can choose to view one or more species.

Crop. This displays pest events associated with a specific crop. A reported event may not be associated with any crop in some cases.

Additionally, users can use the time slider on the bottom of the map to select other event time periods.

Alert messages will be generated if the reported pest information is either in a new location or an outbreak. The application