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Online Project Mapping with Researcher Community Input

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Abstract: This article introduces open access Web mapping services as an efficient tool for disseminating research information and delivering Extension services. Two potential functionalities for Web mapping application are demonstrated. The first function represents a new community-driven data collection process where Web maps are at the heart of the process. The other function is a typical Web search application for Extension services. A practical evaluation of the introduced services to input and disseminate spatially georeferenced information is demonstrated. Issues such as user authentication, community definition, implementation, and user interface design are discussed.

Introduction

The research mission of the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) is to discover new scientific knowledge, encourage innovative study, and create applications based on sound science. UF/IFAS conducts a substantial number of research projects throughout the state of Florida. These projects constitute an integral part of the UF/IFAS mission and are of interest to many groups in the state and throughout the country. Information about past and current UF/IFAS research projects and their distribution throughout the state is very important to Floridians and to Extension specialists in particular. Researchers along with Extension specialists are eager to reach a broad audience with their research results and conclusions.

The need to stimulate the channels between research and Extension was indicated by the National Research Council (1996). A national survey was conducted by Gould and Ham (2002) to investigate the status of research and Extension integration within the land-grant system. Eighty-six (86%) of the surveyed participants indicated a concern at their universities for the enhancement of collaborative efforts between research and Extension.

Communication between research and Extension is a basic element in such collaboration. Being able to find and access the updated information and to form scientific alliances and communities could be a major factor in the success of the transfer of knowledge and solutions in an Extension program. Since Carrascal, Pau, and Reiner (1995) suggested the Internet as a tool for agricultural knowledge and information transfer, the Internet has increasingly dominated this field motivated by the fast and impressive advances in information and communication technology.

The Internet offers an optimal solution not only for knowledge transfer, but also as a powerful tool to form and involve communities. In many cases, feedback from participating community members represents a new addition that moves an Extension program forward. Recently, a new trend in Web-based community-driven data collection has started to evolve. Education and training programs, supplied by experts, assist the general public in gathering useful information about their environment from a small-scale disadvantaged neighborhood to large-scale groups (Elwood, 2007). Such information can be analyzed to measure the impact of the training programs. Additionally, the same information can be used to feed research efforts and form a continuously growing cycle of knowledge development.

Current advances in Internet map services and the availability of high-resolution aerial and satellite images add a spatial dimension to the knowledge exchange process (Goodchild, 2007; Rattray, 2006). Internet mapping services such as Google Maps <http://maps.google.com/> provide an easy interface for disseminating geographically referenced information. These map services can be embedded into customized Web applications to promote knowledge exchange.

In this article, we present a new method for gathering and disseminating geo-referenced research information conducted by UF/IFAS researchers. The developed method is implemented through a Web-based application that utilizes a Google Maps at its central core. The IFAS Research Projects Mapping (IFAS RPM) application interface is designed so that an Extension specialist can query the database using information such as project keywords, researcher name, and project county. The search results are presented on a Google Maps with an option to get detailed tabular report. The application allows researchers to interactively add information about their projects, including project locations. The locations are entered through the Google Maps control embedded in the application.

Apart from the research information dissemination goal of the application, the technique introduced in this article can be looked at as a template for a geographically centered community-based interaction that can significantly enhance Extension services. Geo-referenced information has been deeply, if not completely, integrated into most modern planning and decision-making processes. Such information is becoming "the mainstay of our interconnected world at almost every level" (Bell, Cope, & Catt, 2007). It is similarly finding mass-market appeal in consumer-level functionality through what is described as the Geoweb (Maguire, 2006). This effort of collecting and disseminating information in a Web-based geo-referenced interface is a primary foundation for the evolution of presenting, manipulating, and innovatively collecting geospatial data for a broader user base.

Application Development

Functional Requirement

The first step in developing the IFAS RPM application was to identify its functional requirements. These were identified iteratively through meetings between the developing team and stakeholders represented by research and Extension faculty in addition to UF/IFAS research administration as the project sponsors. Through these meetings the following primary functional requirements were identified.

- The application should be completely Web-based and include basic information about UF/IFAS research projects.
- The application should be scalable and adapt to bandwidth constraints. (Different users have different Internet connection speeds.) The application design should be simple and intuitive.
- The application map control should be built on an open access and user-friendly interface (e.g., Google Maps™ or Microsoft®Virtual Earth™).
- The university email authentication system should be adopted for the data entry interface.
- Authentication should be cascaded from faculty members to other researchers.
- The locations of queried (searched) projects should be displayed on the map interface with clickable links.
- Researchers should be able to navigate through the map interface and interactively click their project locations.
- Researchers should have the option to hide sensitive project locations.

Database Design

A database conceptual design was developed by identifying the database basic attributes and relationships. In this design, we clearly identified five basic entities (or themes) in our database: Projects, Researchers, Locations, Sites, and Affiliations. Sample queries were discussed with the stakeholders in order to define the attributes for each of the entities and to efficiently model the relationships between these entities. For example, we identified project title, start-date, and end-date as necessary attributes for each project. Other attributes include project status and keywords.

We also identified the cardinality of the relationships between different database entities. For instance, the relationship between the "Projects" and the "Researchers" entities was identified to be a many-to-many relationship. This means that a single researcher might participate in multiple projects and a single project may be conducted by several researchers. For the purpose of this article, we cannot provide a full description of all attributes and relationships between entities in the database.

Development Strategy and Platform Architecture

The purpose of the IFAS RPM application is to examine the wider context and feasibility of a community-driven data collection and dissemination portal where our community is composed of researchers and Extension specialists. A community-driven Web application can use a variety of enabling technologies, user interfaces, and database schemas. These technologies are primarily enabled by emerging paradigms in Web development.

In particular, the maturation of Web-based applications with non-linear user interfaces is opening new opportunities for user interaction. Facilitating this paradigm is a variety of programming techniques and technologies that allow asynchronous communication between the client and server. As a result, a user can work within a single Webpage with minimal client-side computing resources and interact with centrally located data that is shared in real-time with the distributed user base. Effectively, most of the computer processes, data access, and data storage is occurring on a remote computer server and not on the users' person computers. Google Maps is one of many examples of this technology and is the platform on which this application was built.

Design Considerations

Graphical User Interface

We designed our application to provide the user with comprehensive query functionality supported with interactive map browsing. The query fields offer diverse searching capabilities while targeting aspects within the scope of the academic research environment. The Google Maps platform is familiar to most and easy to navigate for new users. All parameters of the interface respond quickly and flow naturally from step to step. The home page displays a map screen and query fields without needing to scroll. This design element is crucial for ease of navigation. Figure 1 shows a screen snapshot of the application query page.

Figure 1.
Application Query Page

The researcher interface provides the gateway for collecting UF/IFAS research project information. Researchers login to this interface using their UF credentials. Once logged in, they get a list of their project with options to edit existing projects or add new ones. This set-up also flows well from one step to the next in a three-step workflow providing an efficient but effective research information data entry portal. Figures 2, 3, and 4 show screen snapshots of the steps of the research project entry workflow.

Within the data entry workflow, the researchers can input their research project locations interactively by digitizing (clicking on a location to add a reference point) directly from the existing Google Maps imagery. This represents an extremely efficient model for georeferencing logical information. Multiple project locations can be referenced to the same location on the map to prevent cluttering the map interface and to optimize storage requirement. Researchers also have the option of adding project locations using coordinates (e.g. GPS latitudes and longitudes) or using street addresses (i.e., geocoding).

Figure 2.
Research Projects Entry: Step 1

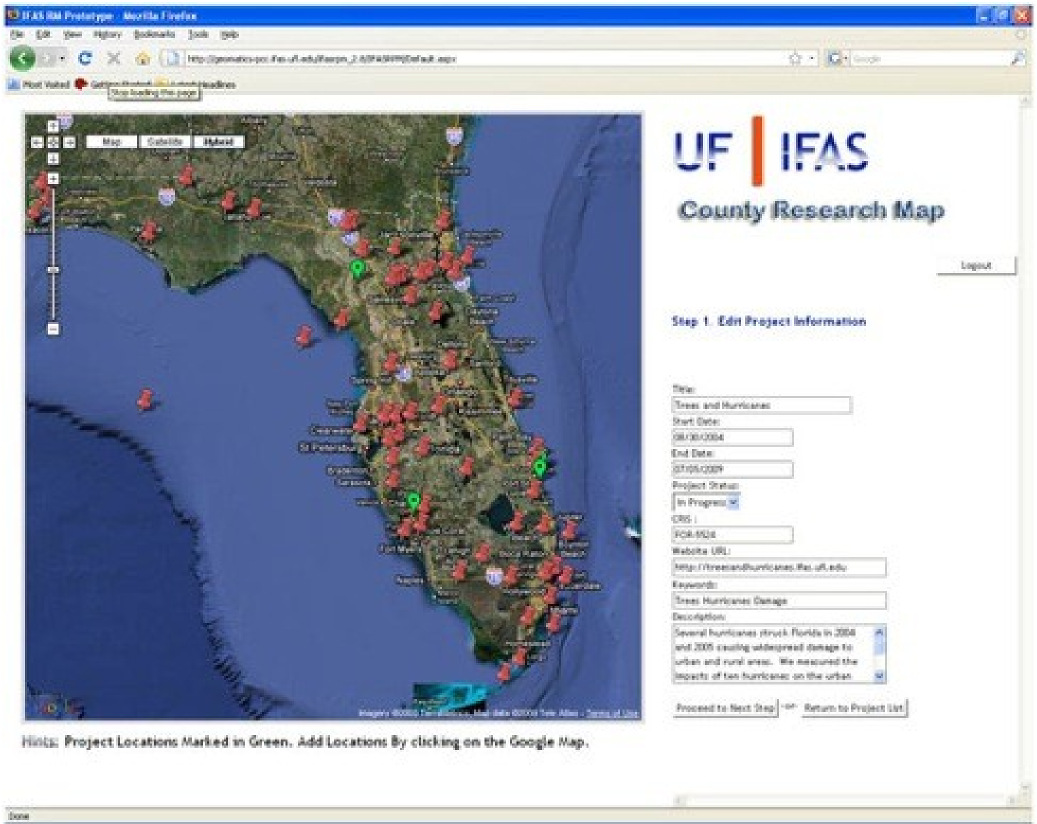


Figure 3.
Research Projects Entry: Step 2

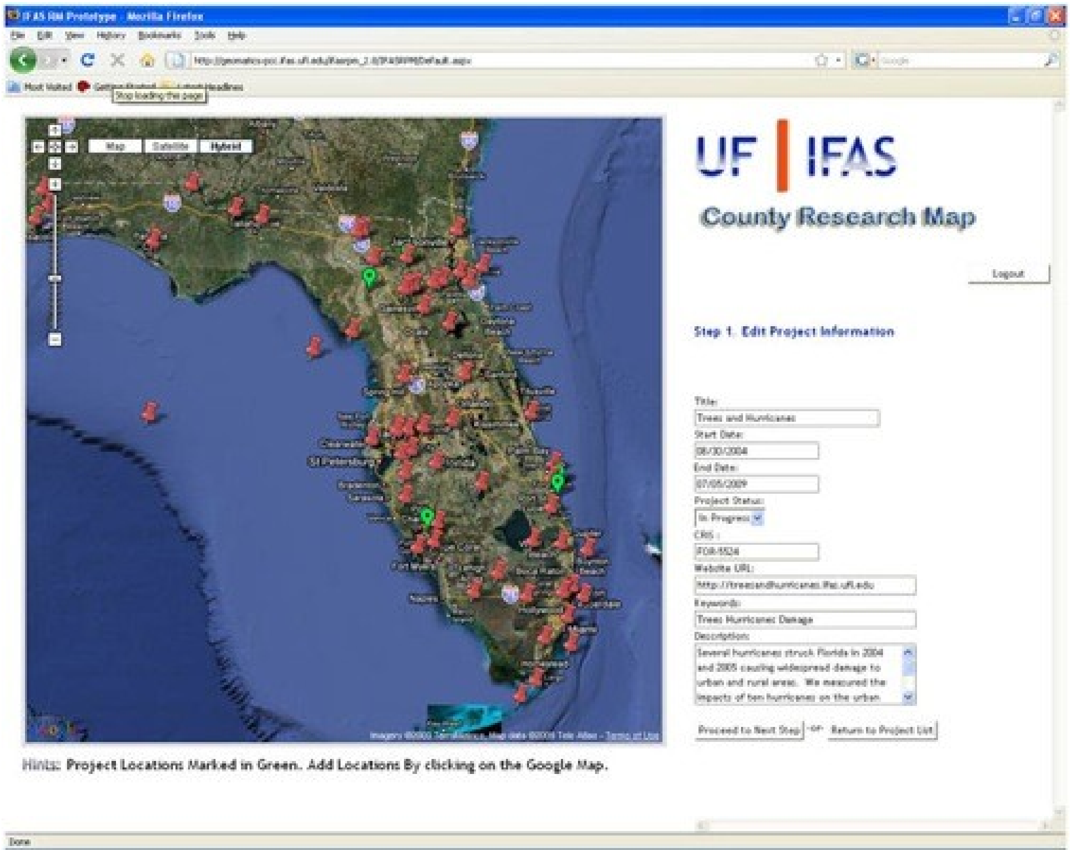
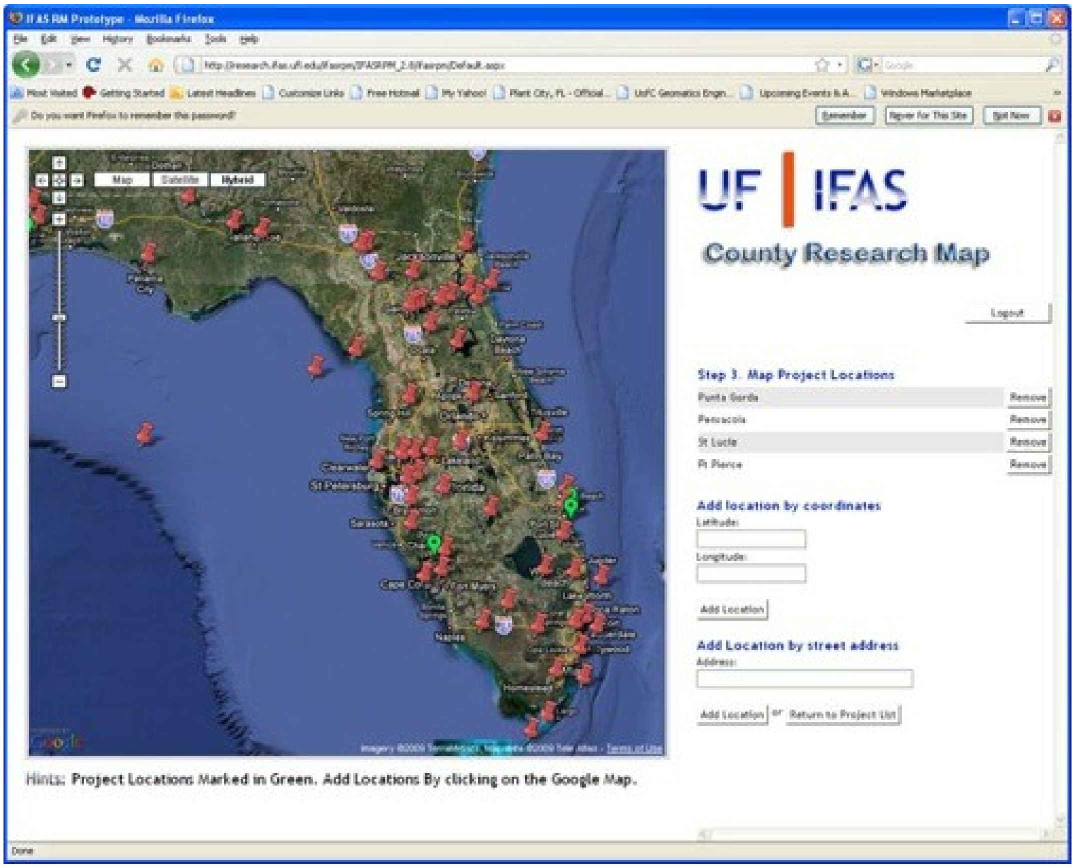


Figure 4.
Research Projects Entry: Step 3



Intuitive Functionality

The IFAS RPM implementation comprises a segmented target audience demanding multiple levels of functional requirements. For example, it accommodates UF/IFAS researchers' needs to input their project data, which differs from the needs of Extension specialists who wish to know about UF/IFAS projects in general as well as specifically within their respective counties. This created an internally adaptive resource while preserving an externally presentable portfolio of data. As the application developed, these needs were customized to suit the entire audience. Apart from the simple workflow design and the utilization of field domain constraints, special interest was devoted to the map interface.

The Google Maps API (Application Programming Interface) functionalities were extended using custom JavaScript routines to add intelligence and intuitivism. For example, when a user adds a location to the map either by point clicking or coordinates/address entry, a function is triggered to identify the county in which the user clicked. It also searches within a predefined range for other project locations or UF/IFAS Research and Education Centers. If nearby pre-existing locations are found, the researcher is prompted to affiliate the clicked location with existing ones to help optimize the database on the storage and logical level.

Although UF/IFAS centers are hard coded into the database, it is expected that with enough research project locations entered, clusters of point locations or locations with a high number of associated projects can form a new definition for highly active research sites. At the administrative level, this could prompt adjusting resource allocations and making informed recruitment decisions.

Performance and Scalability

Performance and scalability are increasingly trivial issues if appropriate application design and implementation are followed. In our IFAS RPM implementation, we depended on Google Maps for the entry and presentation of the spatial data, which we cannot consider optimal in today's technology measures. For example, a Google Maps service of third-party spatial data is still relatively slow. The spatial layers need to run through a Web-based Google service to be mashed up and rendered. To optimize performance, we decided to generalize the county boundary layer and display individual counties resulting from the search rather than displaying all the state counties and highlighting the search results.

To improve performance, a client-side cache was implemented to store previously retrieved data. Accordingly, for a single user session, only project information that was not queried before by the user is retrieved from the server. Once a query is executed, newly retrieved projects are added to the cached project information on the client side, which results in less network traffic and bandwidth optimization by reducing redundant data transfers.

Some of the developed algorithms can be implemented on either the client side or the server side. In many cases, performance and bandwidth issues were the determining factors in making the decision. For example, the algorithm utilized for identifying the county in which the user selects a project can be implemented on the client side by downloading the Florida counties layer to the client side. This may be inefficient, especially because the same algorithm can be implemented on national or international levels. Therefore, a decision was made to have the spatial search algorithm on the server side. Again, this helped to improve performance and save network bandwidth.

Understanding Community

Although the basic objective of our efforts was to disseminate IFAS research project information in order to assist Extension efforts, we consider our application a template for new community-based data integration schemes that employ Web-based mapping services to assist, facilitate, and evaluate Extension activities. Perhaps the most challenging aspect of modeling community participation is to understand the effect of the amorphous "community." The very idea of a community-driven database implies a heterogeneous source of data with inconsistent accuracy and scope of knowledge. The makeup of the user base, which will supply the data, has a great deal of influence on the mechanisms for transferring that information, type, quality, and reliability of data. Community definition and characterization dictates the type of training and education required to achieve any stated objective.

Authentication

Due to the nature of the information utilized in the IFAS RPM application, we implemented multiple layers of user authentication, while maintaining a privilege delegation scheme to facilitate the data entry. In order to be able to login to the system and add research project information, the researcher needs to have a valid university-assigned username and password in addition to being an IFAS faculty member or listed in the IFAS RPM database. The UF Lightweight Directory Access Protocol (LDAP) system was used to verify the IFAS faculty status. Once privileged researchers are added to the system, they can use their UF credentials to login to the system and edit and maintain project information.

Implementation

A proof-of-concept preliminarily application was developed and presented to the stakeholders. Several enhancements were made to the application until a final prototype version was approved. Faculty members were asked to voluntarily enter their project information. Out of 40 faculty members in the department, 22 have input at least one project. The total number of projects input into the system was 79, with 354 locations worldwide.

This prototype implementation revealed two software problems that our team was able to fix. It also resulted in an improved authentication protocol for logging to the system. We added the University Lightweight Directory Access Protocol (LDAP) to allow every faculty member to access the system. This eliminated the preliminarily work needed to register all faculty members in the database. The final step is a full version implementation for all IFAS departments was planned for mid 2009. Currently, the application and the database are being migrated from the development environment to IFAS official production environment.

Lessons Learned

The IFAS RPM effort proved the feasibility of utilizing Web-based mapping services to assist Extension efforts in collecting and querying research information. Many of the evolving communityâ™ based data collection techniques can find tremendous support through the implementation of such technology. On the other hand, the IFAS RPM application demonstrated the need for continuous improvement and simplification. As applications develop, many times the purpose and requirements evolve. This encourages dynamic planning platforms and alternative process suggestions early on. Over time, other elements such as query fields, map display parameters, and even the title required revision. Fortunately, due diligence was followed to tackle these adjustments as early as possible and ultimately helped to make the application better than it was when it began.

A key factor in stabilizing the development process was to provide enough time to understand the application audience. Understanding the communities that feed the data and those who use such data was essential in making a robust and reliable application design. Navigating through rarely exploited information technology territories with human resources that are mainly composed of a few computer science graduate students, we had to do significant testing and proof of concepts, in addition to bandwidth management. This type of experience accumulation improved the application performance and enabled the addition of many intuitive features that made the application appealing. This was evidenced by the number of faculty members who voluntarily started to utilize the system and input their project information.

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