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Yoram Rubin
University of California at Berkeley, yoram.rubin@webh2o.net

Christopher Michaelis
WebH2O, LLC., chris.michaelis@webh2o.net

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myObservatory—An Information Management System for Supporting Multi-Stakeholder Partnerships

Software Introduction

Yoram Rubin¹*, Christopher Michaelis²

¹WebH₂O, LLC, University of California at Berkeley
²WebH₂O, LLC

*Corresponding Author: yoram.rubin@berkeley.edu

ABSTRACT

This paper provides an overview of myObservatory (myO), a free (for non-profit use) web-based information management system that specializes in multi-stakeholder, geospatial projects. myO important features include rich graphic and interactive data display, multiple data entry modes, user-access control tools, project-management tools, built-in and user-defined quality assurance tools, maintaining the integrity of the database, and flexibility in customization the system (e.g., by embedding user-defined algorithms) to meet special project needs.

Keywords
environmental information management systems, EIMS, data management, citizen science

1.0 Motivation and Overarching Themes

This paper presents myObservatory. The primary motivation for developing myO is the need to provide a no-cost, advanced data acquisition and data management and community resource for environmental science-focused non-profits. None of the biggest-name competitors offer a totally free solution for nonprofit use. Another driver is the need to provide an easy-to-use, easily accessible and low maintenance tool. To support the science focus, we introduced several elements that are unique to myO, including:

(a) Flexibility in embedding science modules (embedded functionality)
(b) Compliance with Federal data repository guidelines
(c) Desktop-smartphone seamless connectivity
(d) Easy-to-introduce quality-assurance (QA) measures
(e) Broad latitude in establishind data acquisition protocols such as creating forms and designing of field sampling campaigns.
(f) Easy link with external, public data providers (i.e., Federal and State agencies and research organizations such as CUAHSI),
(g) Advanced querying solutions for data exploration
(h) Built-in enterprise structure to support multi-organizational partnerships
(i) Compliance with standards to provide open and accessible data
The common themes to all these features include providing users with the flexibility to modify the platform to meet their particular need, and creating a modular platform that can be easily modified to meet any other needs. A detailed discussion on how all this was managed is provided below.

2.0 Schematic Representation of the Platform

myObservatory is web-based, geospatial information management system, providing users with tools for data acquisition, storage, sharing, and analysis. myObservatory, or myO in short, evolved over time, learning from experiences gained through project applications. myO is available for free for non-profit use. myO serves a diverse range of users (see myobservatory.org and myobservatoryblog.blogspot.com). It is built to address the challenges facing a diverse community of data collectors, data users, and data managers working together. Communities could vary in number of users, number of organizational partners, and types of membership allowed. A community may include a few cattle farmers in Argentina, or it could scale up all the way to national organizations of citizen scientists, like the ASPEA organization in Portugal (as discussed here), which monitors the health of the national river network with tens of thousands of kilometers and thousands of volunteers. A community can even be a global organization with multiple hubs covering several continents, like Savory Global, with common-core activities plus hub-specific activities. How can we make a community of users work efficiently? There are several factors that are important to consider, which became the guiding principles for myO. Such a platform must (1) provide the community with flexibility in defining and accommodating a wide range of user roles; (2) it must accommodate multiple and diverse modes of data entry; (3) it should be able to maintain the credibility and integrity of the data collected; (4) it should allow users to generate meaningful and exciting content, and (5) it should be scalable and customizable.

Figure 1 shows how data in myO is organized into datasets and stations. A dataset is like a cabinet, whereas a station is like a drawer that could possibly contain many folders. For example, a dataset could be devoted for an experimental site and the stations to various activities taking place at the site. Information can enter myO in multiple ways: manual data entry, spreadsheets, import from a variety of data formats, graphical representation via established data sharing protocols like WMS (Web Map Service), via connected sensors, and many other means. Information can be submitted through the internet using an API (Application Programming Interface). Legacy data can be imported through built-in functions. Information can be in many different forms: numeric, spreadsheets, text records, documents, or pictures.

Figure 1. Data in myO is stored in datasets and stations.
How can we turn all this information, neatly stored in datasets and stations, into an efficient community resource? This is covered in the next two sections. Section 3 discusses data acquisition and community management tools, and Section 4 discusses data exploration tools. Section 5 discusses software availability and coordinates of a demo site.

3.0 The myO Platform – Managing a Community of Users

Managing a community needs to consider the complex interactions between users and partners. It needs to address questions about access privileges; it needs to maintain the integrity of the database; it needs to recognize common-core activities as well as activities that are specific to any of the partners; and it requires strict QA measures. In this section we focus on the operational aspects of managing a community. This section is devoted to various aspects of management, including keeping track of activities, and managing users and their access. All functions described below come with online Guided Help (see the Green tab on the right-hand side of the screen in Figure 2, and center screen in Figure 4a).

3.1. The Dashboard

myO’s control panel is designed to provide users and managers with quick access to management tools, going beyond providing access to the various functions. Shown in Figure 2, authorized users (“authorized” is defined in Section 2.3) could see the most recent additions to the database (in this case, in the form of pictures, see top left box); follow recent activities filtered by user and type (lower left box); recent announcements from managers (upper right box); plan a project with milestones that can be shared by designated users (middle right), and manage an event calendar (lower right).

myO enables multi-stakeholder collaboration by embracing flexibility in management strategies for the workspace. A workspace is defined by datasets and stations, and managing the workspace means identifying who can do what (view, edit, delete, etc), where (which datasets and stations) and when. Administrators can designate space for common-core activities, pursued by all or a large subset of the user community, while at the same time enabling each of the partners to pursue independent programs that reside outside of the common core space, defined by limited-access datasets and stations, and accessible to a designated subset of the membership. The myO functionality is accessible to all, but specific the datasets and stations can be restricted as needed and are

Figure 2. myO welcome dashboard.
by default shared only with their creators. The independent and common-core spaces are firewalled, but can be bridged for any type of sharing, if so desired.

Using myO, project administrators can manage projects by disseminating instructional material and guidelines; assimilating data into the common core areas and analyze it using statistical and graphical tools; setting standards for all common activities starting from field methods all the way to data labeling; creating and sharing forms; monitoring compliance of partners with set project guidelines; devising and implementing quality assurance measures; generating reports; analyzing trends and setting alerts, as well as managing compliance with data management guidelines mandated by funding agencies. Identical functionality is provided to the managers of the independent programs. Crossovers are allowed on an as-needed basis.

3.3 Defining User Roles.

myO accommodates a wide range of roles such as administrators, technicians, consultants, citizen scientists, analysts, observers, regulators, and occasional (non-member) contributors. User roles are defined by data access (read/write) and management privileges, and are assigned by administrators. A user role defines a set of authorizations on what the user can do: what data they are allowed to see, and what they can do with that data. These authorizations or data access rules can be defined at a high level, such as dataset-wide, or a low-level such as on stations (see Figure 1 covering datasets and stations). Contributions from occasional members could include, for example, reporting hazards or any other special event that could be of interest to the organization, via a data collection form accessible to the public with an optional password. Users with smartphones could easily become conduits for actionable information. User could take, for example, pictures of environmental hazards using a smartphone, which, geotagged and dated, are immediately transmitted and automatically become a part of the database, widely shared and displayed, and possibly generating some sort of response. This accessibility empowers communities to take charge over their environment, and could keep the entire group energized and motivated. We will present such a case study in detail in Section 3.

3.4 Quality Assurance (QA)

Quality Assurance (QA) is at the heart of any project, and is particularly challenging when serving a diversified user community with flexible data organization options. myO scans the data for several types of errors: grammatical errors, physical plausibility errors, and trend-defying out-of-range errors. Grammatical errors mean, for example, writing 1.0a3 instead of 1.03. QA means catching this error and alerting the parties entering the data and those managing it, and providing quick tools for correcting the errors. Physical plausibility errors are data points lying outside of the range of physically-acceptable values. This could mean, for example, entering 17 for pH or a negative value for rainfall intensity. Out-of-range errors are those data points that defy trends and norms: myO identifies trends in data and detects data entries that could be potentially out of range, but could also be real and accurate. myO provides users with the discretion on how to handle these data points.

A trickle of data entry errors could easily become an avalanche, so it must be controlled at the source. myO has built-in automated QA analytical tools that would flag questionable data as soon as it is entered, based on the customizable data type defined for the station. This has significant cost savings: you do not want an army of data checkers poring over data just days before a major report is due, scrambling to come up with corrections.

3.5 Maintaining Integrity of the Database

myO provides project managers with tools for managing chain of custody issues for each data point and for reversal of errors and unwarranted edits. Comprehensive logging monitors who is interacting with data and making changes. The technical team handles other aspects like data backups and server integrity, freeing project participants to focus on their work.

3.6 Project Management Tools

Figure 3(a,b) is an example of customized project management tools taken from a project in Portugal. Figure 3a shows a form template developed by the project managers using myO's form design tools. This form template is available to all project participants on their smartphones. Figure 3b provides an overview of progress in the various project segments.

3.7 Automatic Language Translations
myO includes the ability to present the user interface in a variety of written languages, currently including Afrikaans, Arabic, Chinese, French, German, Italian, Portuguese, Russian, Spanish, and Turkish (Figure 4). Most languages are automatically translated using a powerful statistical translation engine, though contributors have also customized several languages to improve translations further.

4.0 Exploring Data and Creating Knowledge

myO allows users to analyze the data as it flows in, plot charts and generate statistics, identify trends, generate and receive alerts, perform comparative analyses, communicate with stakeholders, identify data needs, and manage the data acquisition process, all by clicking on icons on the user interface. To make this happen, myO is built around analytical tools that are open-source and widely recognized. Recognizing that different organizations have different needs, myO provides an option for implementing project-specific and proprietary tools as well.

4.1 Visualization

Three of the options that we have in myO are reviewed in this subsection. They all aim to provide users with easy-to-use, carefully-documented (through the interactive Guided Help function, see Figure 5a for example) graphical display capabilities.
Figure 4. The myO interface can be presented in a variety of written languages.

Figure 5a. GIS-enabled data display on myO.
Figure 5b. This panel demonstrates how users can review data from the hand-drawn shape marked by the red arrow as shown in Figure 5a.
myO allows users to explore their data on a map. Clicking on any location reveals the data in the flexibly-defined vicinity of that location. For example, clicking on a hand-drawn shape reveals a list of all the data associated with that shape. A follow-up click would allow the user to generate charts and analyze the data using statistical tools. An example is shown in Figure 5(a,b). The blue areas are hand-drawn shapes representing parcels/blocks/paddocks of particular interest. Each of these shapes acts as a container for all related data. This could include pictures (dated and geo-tagged), reports, notes, sensor data, lab reports, etc. The red arrow in Figure 5a is pointing to one of the hand-drawn shapes (which could represent an experimental plot, for example).
The box on the left-hand side (shown also in Figure 5b) lists the data collected at the area defined by the shape. myO provides seamless connectivity between desktop and smartphones. For example, pictures can be taken using smartphones, and these pictures are automatically uploaded into the myObservatory platform and automatically linked to the coordinate where it was taken. Data could be imported from external data providers for added insight, or data can be fed in by third parties (e.g. from partnered labs offering soil analysis lab services). Once data has been loaded or collected, it may be analyzed with statistical analysis and charting tools, geospatial analysis tools, or shared with selected stakeholders.

Users can only view data they are authorized to view. The box on the left shows all the data available for the hand-drawn shape marked by the red arrow. Users can quickly skim through the data (as shown in Figure 5b). The center box provides interactive (guided) help for the various functions associated with this map display. The menu box on the right allows user to select what data is actively displayed in the map. With multiple pictures at a given location, a time-lapse viewer allows the user to review all the pictures one by one or animated, as shown in Figure 6. This could be a useful tool when monitoring the evolution of landscapes, for example.

4.1.2 Timeline

This function provides users with an option for visually exploring multiple data streams. Users need to click on the relevant datasets and stations, which are then translated into parallel timelines, as shown in Figure 7.

4.1.3 Story View

This function allows users to turn an ensemble of pictures and documents into a story. A Story is a document built around pictures, text and maps, as shown below in Figure 8. Users can build stories around multiple themes. For example, seasonal
summaries of invading species, or document a field experiment or a river restoration project. Users only need to identify the datasets and stations forming the story: Story Viewer will then assemble the information into an ensemble of pictures and documents and maps shown together with their respective locations.

4.2 Mobility and Embedded Functionality

myO provides users with the capability to implement new functions, designated to meet special project needs, on top of what’s included in the standard myO platform. New and existing technologies, whether developed in-house or imported, could be easily incorporated into myO.

4.2.1 Embedded Functions Case Study: Natuf

Smartphones are particularly useful for connecting myO with a large number of users in real time. In myO, we view the smartphone as a vital component, and to accommodate it, we created seamless connectivity between smartphones and desktops. Our smartphone technology allows quick and seamless assimilation of data. Data transmitted via smartphones includes pictures, notes, and filled-in forms. Data becomes actionable as soon as it is transmitted and displayed, which could take a fraction of a second.

In this project (Natuf), users record information on new environmental hazards by filling in specially-designated forms and taking notes and pictures. This information is transmitted by cellular or wi-fi, and as soon as it is received it updates a hazard map in real-time (see Figure 9). This map is then processed together with a vulnerability map using a built-in algo-

**Figure 8.** Story Viewer. The picture on the upper left is matched with its location map (on the right). The strip below allows user to scroll quickly across the pictures and maps. These pictures were collected using the myObservatory mobile app (iOS and Android compatible).
rithm, producing an up-to-date risk map. This process is demonstrated in the figure below. The vulnerability map represents local conditions (soil, vegetation, water resources, land use, depth to groundwater, and others). The map at the center represents recorded hazards, and it updates daily. Once new hazards are introduced or hazards removed, the risk map updates.

The multicolored icons in the Hazards map (Figure 9) mark the locations where risks were reported. These icons, once clicked, reveal all the relevant information, including filled-in forms and pictures.

4.2.2 Embedded Functions Case Study: Sonoma

A technology platform that is commonly used opens the door for negotiating favorable arrangements with external suppliers, anywhere from purchasing sensors to developing solutions for managing legacy data. An example is the Sonoma Creek Groundwater Basin project which focused on sustainable management issues. The list of stakeholders on this project includes state and local water agencies, as well as private well-owners and volunteers. For this, myO was expanded to provide snapshots of groundwater levels and flow directions (see Figure 10). This map was generated in real-time from data provided by all the stakeholders. The green dots represent groundwater state-owned monitoring wells. The blue lines represent groundwater levels and the red arrows mark flow directions. Looking at consecutive snapshots like this, users could draw conclusions about trends. Well owners are particularly worried about the water level falling

Figure 9. Natuf Risk Mapping process. The procedure for calculating the risk is embedded in the project’s myO platform. The left and center maps represent intermediate output maps, generated by interpolation from point sources of hazard and risk data. These two maps are then processed to produce the risk map, shown on the right. The risk map updates daily (or as needed). It is a vital tool for maintaining the sustainability of the underlying aquifer. This entire process is executed using scientific modules embedded in myO. The complete user-smartphone-desktop process is shown and discussed here.
below critical elevations required for proper operation of their pumps. Addressing this and similar concerns could be very useful in encouraging participation.

4.2.3 Embedded Functionality Case Study: The Utility of myO as a Package

This case study follows the report by Schima et al. (2016) (see http://myobservatoryblog.blogspot.com/2016/02/open-source-based-monitoring-of-urban.html). The system developed by Schima et al. (2016), see Figure 11, includes a monitoring system consisting of mobile sensor devices which can be controlled and managed by a smart phone app. The system is able to acquire temperature and humidity in space (GPS) and time (real-time clock) as a built-in function. Larger system functionality can be accomplished by adding further sensors for the detection of e.g. fine dust, methane or dissolved organic com-

Figure 10. Sonoma Creek Groundwater Aquifer in California. The information on the map, including contours and arrows, was generated by myO-embedded functions.
pounds. The smartphone is used for initial data processing, data provisioning and data visualization. The smartphone app provides an interface to myObservatory. Here, the user has full access to all the data managing and analytical tools provided by myObservatory.

A demonstration of the output (recorded in real-time in Leipzig) is provided in Figure 12. Data was recorded in real-time using a bike-mounted sensor. The data was transmitted in real-time to myO and immediately displayed on the map and posted in stations.

4.2.4 Embedded Functions: Importing Legacy Data

Importing legacy data is another important part of any data management system. myO provides several import tools for bringing in data; often the easiest is CSV (Comma-Separated Value) format, though ESRI Shapefiles and many other data formats are supported. Custom data importers may easily be built and embedded to satisfy any legacy data import need.

4.2.5 Support for CUAHSI Catalog Publication

myObservatory offers users the ability to publish data to the CUAHSI data catalog (Consortium of Universities for the Advancedment of Hydrologic Science, Inc., www.cuahsi.org), for use by others.

4.2.6 Open Source Standards

In support of open and accessible data, myObservatory was built in compliance with several open standards, including ESRI’s shapefile specification and GeoTIFF. myObservatory is also compatible with open web standards such as Open Geospatial Consortium (OGC)’s Web Map Service (WMS).
Figure 12. Urban Monitoring by bike. Evaluation of urban heat conditions based on the mobile sensor integration platform. The flower icons represent locations with multiple data. The color background is generated by myO's interpolator, on top of a myO provided map.

Figure 13. This screenshot from myO shows the user-interactive sampling campaign design tool. The user needs to create or click a shape file, and to specify the method of selecting locations.
4.2.7 Orient+ for Designing Field Sampling Campaigns

Orient+ is an embedded function intended to facilitate the design and execution of field sampling campaigns. It allows users to design the campaign on desktop or on smartphone. This includes selecting sampling locations either manually or automatically (based on one of several alternative criteria). The design is shown on a map (see Figure 13). The plan is accessible throughout the smartphone. The user can then navigate over the field site, aided by built-in navigational tools (see Figure 14). Orient+ on the smartphone provides the users with guidance on how to reach the sampling location, and it also marks those locations already sampled. Once on location, the user can take notes and a picture of the sampled location (See Figure 15).

5.0 Software Availability

As a web application, there is no software specifically to download and install; hardware and software requirements are any desktop or laptop computer with internet access and a modern web browser. We recommend Google Chrome for the best experience. Any user can sign up for free at www.my-observatory.com; the service is free for nonprofit use, and for commercial use a thirty-day free trial is automatically
applied for all new users. A demonstration account is also available: sign in (at https://dallas.my-observatory.com/site/myobservatory/ci/welcome/login) using “demo” for both the username and password.

6.0 Summary

myObservatory is a web-based, geospatially-enabled information management system and community support tool. It addresses the challenges of serving diverse communities of users by providing project management tools, flexible data organization strategies, strict user access control and quality assurance tools, multi-source data assimilation and analytical tools, as well as seamless desktop-smartphone connectivity.

References