

# MYSENSE-WEBGIS: A GRAPHICAL MAP LAYERING-BASED DECISION SUPPORT TOOL FOR AGRICULTURE

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## ABSTRACT

Developed focusing agriculture sustainability, mySense is a comprehensive close-range sensor-based data management environment to improve precision farming practices. It integrates discussion platforms for quick problem solving through experts support and a computational intelligence layer for multipurpose application (e.g. vine variety discrimination, plant disease detection and identification). Attending the need for keeping track of agricultural crops not only based on close-range sensing but also at a macro perspective, mySense was complemented with proper functionalities to unlock macro-monitoring features, through the implementation of a Web-based Geographical Information System (WebGIS) planned as a sidekick application that provides agriculture professionals with visual decision support tools over remote sensed data. This paper presents and discusses its specification and implementation.

**Index Terms**— WebGIS, Remote Sensing, Precision Agriculture, IoT

## 1. INTRODUCTION

Precision Agriculture (PA), Smart Farming, Internet of Things (IoT), Internet of Everything (IoE), Cloud and Fog Computing, Big Data, Data Analytics, Machine Learning, among other technological concepts, are becoming very popular when addressing the management of agricultural practices. Nowadays, for the successfully managing of crops from the economic, environmental, labour and sheer space point of view, requirements regarding the awareness of productive cycles and the spatial and temporal variabilities are very important. However, to make the production process efficient, a decision support system has to be implemented based on a huge amount of data available. It is now crucial to correlate various data sources, many of them acquired in real-time, as well as forecasting models. Even so, maximizing yields and crops' quality through sustainable practices, while reducing both the economic and environmental impacts, implies the (1) early detection of phytosanitary problems, thus reducing the implications of inputting phytopharmaceuticals; (2) sustainable and efficient irrigation management; (3) field interventions should be carried out considering the variable rate policy and acting only when and where is necessary. Developed focusing the aforementioned challenges in Agriculture, mySense is a comprehensive data management environment to improve precision farming practices. Furthermore, this platform intends to systematize the use of data acquisition equipment by employing a DIY (Do-It-Yourself) approach to quickly create solutions and scale up the use of IoT technologies in

PA. As such, mySense platform aims to take a stand as a possible solution relying on data management in PA applications [1–3].

To provide agriculture professionals with a wide range of tools for decision support towards informed interventions for crop development optimization, an integration of high-resolution aerial data obtained through sensors coupled in unmanned aerial vehicles (UAVs), namely RGB, multi/hyperspectral and thermal infrared is taking place as a complement for mySense platform, through the development of a WebGIS application. Farmers who are users of mySense platform can access their territorial data through a web interface, which is presented in the form of intuitive and easy-to-read plots. More specifically, the WebGIS application consists in a couple of layer types: raster and vector. The former is associated to a collection of geographic-based imagery, which may range from straightforward representational data (e.g. thermal, NIR, RGB), to vegetation indices (e.g. OSAVI, NDVI) post-processed over orthophoto mosaics, while the latter is more adequate to support annotation enhancements over maps. Instead of competing with other solutions commercially available, the proposed under-development WebGIS tool complements mySense, which extends an experts network support and computational intelligence services – as it already started to be delineated in [4] – capable of aiming users interpreting data and, thus, providing accurate decision support features for adequate and timely infield interventions.

In this paper, the WebGIS application developed for mySense will be presented and somehow detailed in terms of functionalities, implementation, and integration with the latter platform. Regarding organization, next section will address background, while Section 3 is reserved for mySense IoT platform contextualization. WebGIS application is addressed in Section 4, just before the final remarks, provided in Section 5.

## 2. BACKGROUND

Agriculture has been one of the areas benefiting from IoT development [5], with the goal of increasing sustainability along its value chain. In this context, several applications can be found in the existing literature addressing production line [6], distribution chain [7] and final selling points [8]. Regarding the technologies that enable infield monitoring, communication capabilities [8–10], monitoring devices [12] and image acquisition [12–14] equipment constitute an essential set of components for a PA system relying on IoT paradigm. Indeed, technological development has been enabling access to cost-effective and easy to operate small-sized UAVs with potential to fly over extensive agricultural productivity fields with a reasonable autonomy, carrying sensors capable of acquiring different types of imagery ranging from RGB to multi/hyperspectral and thermal, and whose post-processing outputs are suitable to provide decision support in what concerns to crops status at a macro

viewpoint [15]. For an effective visualization and interaction with such data, WebGIS applications have been proposed for different purposes. Focusing agriculture and related areas, several studies can be found in literature, for example, to monitor and forecast pest and disease in crops [16], to assess heavy metal pollution in farmland soils [17], to prevent and control crop threatening insects infestations [18], to monitor waterlogging events [19] and to keep track of crop production [20]. This paper results from an effort to integrate an IoT system (mySense) with a WebGIS application to open the range of available data for providing enhanced decision support capabilities for professionals performing activities within agricultural area.

### 3. MYSENSE PLATFORM CONTEXTUALIZATION

mySense is a cloud-based infrastructure that integrates proprietary and off-the-shelf static, mobile and proximity sensor-based solutions to provide critical data to support the most diverse agroforestry practices. Simultaneously, computational learning algorithms can be used on data generated from these sources, aiming at the implementation of decision support tools. Devices associated with the mySense platform produce data that may be numeric and/or images and may also be geographically referenced, which allows association with a location context. Such data is indexed to the domain of each user or group considering respective contexts, while ensuring isolation based on data privacy. Additionally, mySense users are provided with the freedom to make their own agricultural/forestry/meteorological data available to the community, in order to contribute to a richer and stronger knowledge base. In short, mySense platform relies on knowledge acquisition characterizing the development of agricultural or forestry crops, which includes certification, phytosanitary assessment and prediction of disease and pest occurrence.

To enhance mySense's functionalities with large-range data acquisition features, a web-based geographic information tool that enables uploading remote sensed data (UAV, satellite, etc.) was developed to provide interaction with digital browsable map layers for the visual assessment of crops status/characteristics. Such WebGIS tool will be presented in the next section.

### 4. MYSENSE-WEBGIS

This section addresses the WebGIS system overview, as well as implementation details and integration with mySense platform through webservices.

#### 4.1. Specification

While mySense covers the infield short-range monitoring mainly resorting to a wide diversity of sensing devices, the need for keeping track of agricultural crops at a macro perspective was identified. To address this need and complement mySense with proper functionalities to unlock macro-monitoring features, a WebGIS platform was planned as a sidekick application that supports the upload of high-resolution aerial imagery and trades data with mySense to cook user context-aware maps, while ensuring map queries privacy (i.e., a user can only consult data regarding his fields).

A task to highlight WebGIS backend and frontend requirements was carried out. The following were identified for the frontend interface:

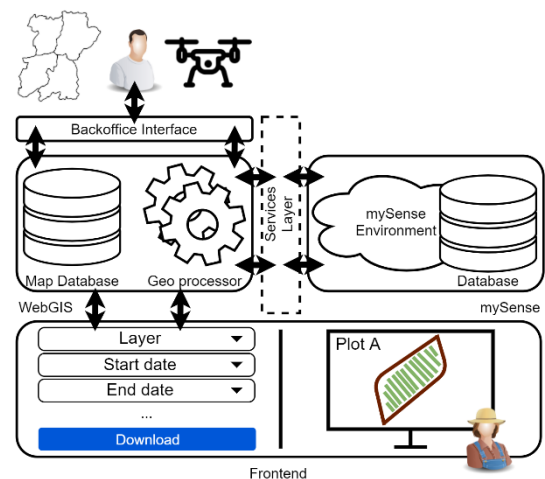
- Access through mySense user-based authentication;

- Map cooking relying on map layers intersected with land portions owned by authenticated users;
- Map interaction features (zoom, drag, etc.);
- Navigability through a menu that enables to select range of dates and map layer type.

Regarding back-end management operations, the following requirements were defined:

- Support to UAV-based data uploading.
- Specification of mission name, description, acquisition data, type of layer (raster or vector);
- Within raster layer type, support either straightforward representational data (DSM, CIR composite, NIR reflectance and RGB composite) or vegetation indices.

To comply with the established requirements, an architecture for mySense-WebGIS was designed to orient further implementation (Fig. 1). It relies on the following main components: WebGIS platform for orthophoto mosaics warehouse and geoprocessing, backoffice interface for data uploading, and frontend interface to provide WebGIS data visualization for mySense users, to their respective cropland areas stored in mySense, so it uses a service layer for data requesting purposes. By intersecting the maps of surveyed areas with user delimited croplands provided by mySense, WebGIS ensures proper data access and privacy.

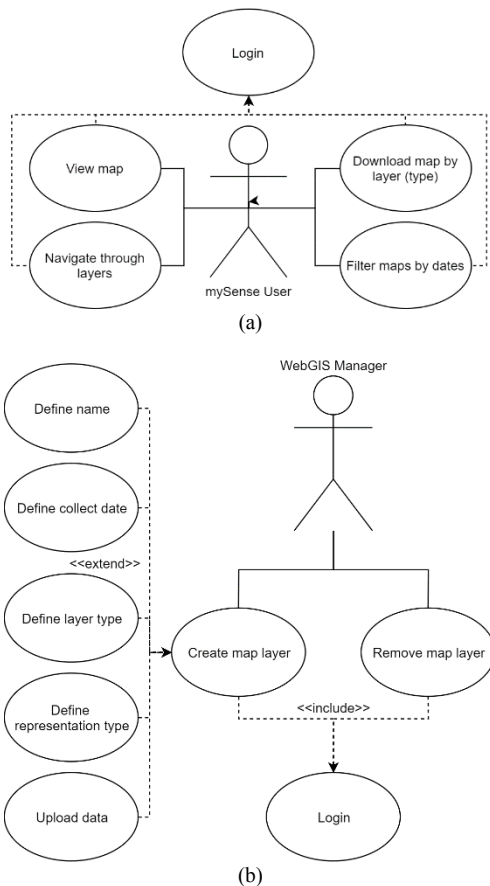


**Fig. 1.** mySense-WebGIS architecture proposal, composed by WebGIS and respective interfaces, i.e., backoffice (maps' data uploading) and frontend (mySense users querying and consultation). WebGIS relies on users' data and respective owned cropland areas stored in mySense, so it uses a service layer for data requesting purposes. By intersecting the maps of surveyed areas with user delimited croplands provided by mySense, WebGIS ensures proper data access and privacy.

WebGIS encompasses data storage and geo-processing, wherein users experienced in both UAV flight campaigns, and photogrammetric processing are responsible for submitting orthophoto mosaics to a hosted database set up for this purpose, using the backoffice interface. Moreover, it cooks, on demand, user context-aware decision support-oriented maps, using mySense's data regarding users and geographic delimitations of their respective croplands. The communication point between WebGIS and mySense is provided through a service layer specifying protocols for data trading. In terms of computation, when a mySense user queries WebGIS, a processing unit intersects user's cropland areas with the available imagery previously submitted, by map layer type, ensuring not only user context-awareness but also data privacy (private data

of other users is kept hidden). Filtering capabilities are also supported to provide a selected map layer within a range of dates. WebGIS computed results can be displayed in a frontend component for visualization, that enables user context-aware map layers' analysis and provides a simple form for filtering data requests, both within a web-based application interface. It is noteworthy that the filtering form of the frontend component only represents an interaction point to request parameterized data to WebGIS.

In terms of users, there are two main roles defined for mySense-WebGIS: manager and mySense user. The former is responsible for uploading the processed mosaics resulted from UAV-based surveys that will be made available by WebGIS as map-layers. To attend the previously specified requirements, a manager can create a map layer, which includes defining a name, collection date, layer type (raster or vector) and representation type (depending on layer type), as well as uploading orthophoto-mosaics resulting from previously processed UAV-based imagery. This user role can also delete/disable existing map layers. On the other hand, mySense users can consult maps intersected with their respective cropland areas, by layer type, date range, as well as download their data. Respective use-case diagrams are depicted in Fig. 2.



**Fig. 2.** Use-case diagrams for mySense-WebGIS: a) depicts mySense users' functionalities set (map querying and viewing features); b) presents the actions that may be performed by a WebGIS manager (map uploading and characterization features). This specification includes already implemented features, only.

WebGIS implementation took place considering this specification, as it will be presented next.

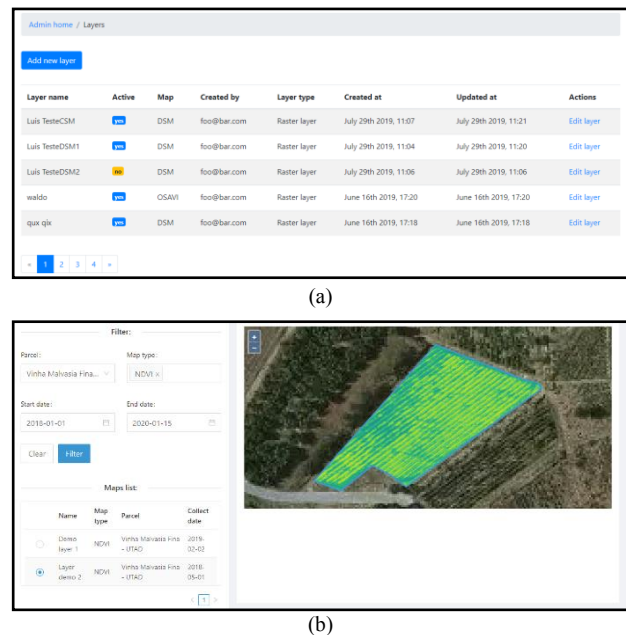
## 4.2. Implementation

The implementation of mySense-WebGIS ended up with the following components: a webserver to share geospatial data; a GeoServer, which is a repository and server of maps; a backoffice accessible through web, where an operator uploads the geospatial data; and, a web-based frontend map application for end-users, that allows them to interact with the geospatial data previously uploaded by operators.

A set of API services were implemented to integrate the aforementioned components: Geoserver API services integrate with GeoServer by uploading data and managing maps and layers; integration with mySense platform is done through webservices that, among other aspects, allow to fetch map types in the platform, user accounts and permissions, as well as related cropland areas information. The following set of webservices was implanted for mySense-WebGIS integration purposes:

- `USR_login_through_password`: allows authentication in mySense and retrieves a token for further operations;
- `USR_logout`: logs out from mySense, cleaning ative token;
- `getGroupParcelsByGroupID`: retrieves parcels – i.e., cropland areas – owned by group within users influence;
- `getGroupParcelsByOwnerID`: retrieves parcels owned by a user;
- `getMapasSubscrByOwnerID`: retrieves active subscriptions to filter access according to a time range;
- `getMapTypes`: returns a set of supported map types.

In what concern to technologies employment, the APIs are based on HTTP REST developed in Node.js and backed by PostgreSQL database with PostGIS extensions. Both the backoffice and end-user map application were developed with React.js and OpenLayers mapping library. Some results of mySense-WebGIS integration are depicted in Fig. 3.



**Fig. 3.** mySense-WebGIS platform: a) shows a screenshot of WebGIS backoffice, wherein imagery can be uploaded as map layers; b) presents the frontend part, with a graphical user interface to filter parameters that, in turn, are used to query WebGIS (left section) and visualize map layers such as NDVI (right section).

## 5. FINAL REMARKS

mySense is a sensor/cloud-based infrastructure that relies on the acquisition of data characterizing the development of agricultural or forestry crops for different application purposes including certification, phytosanitary assessment and prediction of disease and pest occurrence. In this paper, an under-development prototype of a web-based geographic information tool that enables uploading remote sensed data was developed and presented to complement mySense with proper functionalities to unlock macro-monitoring features and provide farmers with decision-support tools over their croplands. Several types of data derived from photogrammetric processing – currently, using third-parties applications, but having in mind the future integration of this photogrammetric processing pipeline, using custom developed resources and/or freely available application programming interfaces – covering large areas can be uploaded (e.g. DSM, NDVI) to be intersected with croplands data of mySense’s subscribing farmers, providing visualization over the general state of plants, in terms of phytosanitary conditions, phenology, etc. As such, agricultural professionals can take advantage of timely insights to sustainably manage important tasks such as irrigation, plant protection products administration, plant treatment and healing interventions, among others.

The proposed WebGIS tool, rather than competing or outperforming other similar systems available, has the goal of being continuously improved in integration with mySense solution as a complementary module, from which will, in a near future, benefit from specialists assistance and computational intelligence layers capable of providing a robust PA-based decision support. Moreover, functionalities for maps’ histogram manipulation, semi-/fully automatic harvesting of community available remote sensing data (collected by, for example, Sentinel-2), and improvements towards UAV-based data compatibility are being planned.

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