OpenAerialMap: Empowering Disaster Response and Preparedness Communities with Aerial Imagery

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Abstract:

Small unmanned aerial systems (sUAS) and nanosatellites are revolutionizing earth observation and democratizing remote sensing. Increasing amounts of aerial imagery are now being acquired both from these novel systems and from traditional satellite and aircraft platforms. Earth observation and remote sensing research and activities have the potential to gain from this increase in amount and quality of data. But the use of this data is still limited because of the difficulty of access. OpenAerialMap (OAM) seeks to solve this problem by providing a simple open way to search and retrieve open imagery. OAM is both a set of tools and community built on open source and open standards. OAM launched in the summer of 2015 in support of humanitarian response and development mapping projects through the Humanitarian OpenStreetMap Team (HOT). OAM is growing the community of contributors; currently there are thousands of images freely available for use.

Keywords:

open data, satellite imagery, humanitarian mapping, sUAS

Full paper:

1. Introduction

Small unmanned aerial systems (sUAS) and nanosatellites are revolutionizing earth observation and democratizing remote sensing (Ball, 2013 and Colomina, 2014). Increasing amounts of aerial imagery are now being acquired both from these novel systems and from traditional satellite and aircraft platforms. Earth observation and remote sensing research and activities have the potential to gain from this increase in amount and quality of data. While most imagery produced is sold commercially, providers very often donate free imagery for humanitarian causes, research and education (Digitalglobe, 2015). Imagery procured by government agencies and shared by individual UAV mappers is also usually offered to anyone for free (UN-SPIDER 2015). Unfortunately, it is often difficult to determine what is shared publicly and how to access it. Satellite and aerial imagery are also normally recorded in

large raster digital file formats which are more expensive to store and transfer than other vector-based geographic data. This poses additional challenges for both providers and end users when technological capacity is constrained during emergency response situations.

This paper reviews aerial imagery use in humanitarian mapping and why is it important, discusses progress of the OpenAerialMap project, how it responds to the needs of difficult access of imagery, and provides an outline for growth of the tools and community.

A Brief History

The idea of creating a digital online commons for openly licensed imagery has been around since 2006. With more and more satellite imagery providers releasing their data freely for humanitarian and research applications, it became evident that a comprehensive catalog was needed to easily find what imagery was made available. Following the 2010 earthquake in Haiti, an unprecedented amount of satellite and aerial imagery was offered to support disaster response and recovery operations. It was the first time in history that imagery was available publicly in such amounts and temporal frequency. Unfortunately most of this imagery was provided in ancillary format and as large digital files, difficult to manage and share. This required a substantial effort by specialized remote sensing experts, in order to make imagery available in a suitable format to the response community. In the following years, after typhoon Haiyan hit the Philippines in November 2013 and a strong earthquake shook Nepal in April 2015, aerial images were again offered by a variety of providers, including traditional satellite corporations as well as individual drone mappers. Unfortunately all these valuable datasets still were not indexed in a centralized catalog, and it was difficult to understand exactly what their coverage and their characteristics were. Despite several efforts to build OpenAerialMap over the years, only in 2014 the Humanitarian OpenStreetMap Team (HOT) received funding from the Humanitarian Innovation Fund (HIF) to start its development. With less than 10 months from design to delivery, OAM is now a functional online system that humanitarian organizations can use for sharing and finding open imagery.

Aerial imagery background in humanitarian response

The use of aerial imagery in humanitarian situations dates back to 1906 (Baker, 1989). Large humanitarian organizations, as well as, civil and military response organizations have been using aerial imagery for information gathering and damage assessment purposes in the immediate aftermath of an event. Historically these organizations have used large, manned aircraft to capture imagery. As technical capabilities have increased, the size of aerial platforms required to collect imagery have decreased. With the decrease in size, and reduced need to rely on human pilots (which includes less risks), the use of aerial vehicles to capture imagery requires less manpower and is less costly. This has given rise to an increased potential of using unmanned aerial vehicles to capture imagery.

Collected imagery has been used in a number of ways in humanitarian responses: information gathering for immediate relief operations, analytical assessments for response and recovery planning, and for pre-disaster preparedness activities. Imagery continues to be a major source of information for major disaster relief operations. Major natural disasters in the last several years, for example Vanuatu, Nepal, and the Philippines, have all included an international response that have used UAVs during the response (Meier 2015).

Why is open imagery important?

The global satellite imaging market was sized at US $1.6 billion in 2014 (The Tauri Group 2015) and it is predicted to reach $5 billions by 2019. Commercial satellite imagery providers have been adopting very detailed End User License Agreements (EULAs) for their product, in order to protect valuable intellectual property as well to

maximize sales profit. On the other hand, government sponsored programs such as the recent Landsat Data Continuity Mission, have granted open access to their image products as part of federal open data policies. Open access in most cases indicates that the end user if free to utilize the imagery for any scope, from commercial, to environmental monitoring applications. While humanitarian mapping projects rely on both commercial and government acquired imagery, a critical requirement is that such imagery can be freely and efficiently shared among partners. This is particularly important for initiatives such as OpenStreetMap (OSM) where thousands of volunteers trace satellite and aerial imagery to create basemaps of areas affected by disasters. Because the OSM project adopts the Open Database License (ODbL) which allows for free and efficient sharing of data, it is imperative that imagery from which data is derived must be used under a compatible license. The types of licenses often adopted for sharing imagery to be used in OSM are Creative Commons public domain (CC-0) and Creative Commons Attribution (CC-BY). The latter also requires explicit permission to be used in OSM through an additional ad-hoc clause. All imagery data in OAM is currently available under one of these two licenses. While openly licensed imagery is imperative for projects such as OSM, other traditional licensing arrangements often prevent sharing imagery between different response partners or sometimes even between personnel within the same organization. Imagery, in fact, could be licensed "per device" and available for display on only one computer at a disaster response coordination crisis room. This factor can potentially limit processes of collaborative decision making or rapid damage assessment. In order to avoid these issues and guarantee the most effective use of imagery for response operations, several commercial imagery providers are now offering event related imagery free of charge and under an open license.

2. OpenAerialMap

OpenAerialMap (OAM) was built to solve the problem of access and meaningfully improve rapid access to aerial imagery for disaster mapping and humanitarian response. Lives are lost during a disaster because detailed situational information is not available to responders in a timely manner for response coordination, evaluation, and logistical planning. It is often difficult to get a detailed picture of how a natural disaster impacts people and property over a large geographic area and detailed, up to date base map data is often not available. OpenAerialMap provides a simple open way to search and retrieve open imagery by creating a common catalog for digital humanitarians to find available imagery.

OAM is both a set of tools and a community built on open source and open standards. At the core is the OAM platform to search, publish, and download imagery. Because hosting imagery and file transfer bandwidth are still very expensive and cannot be afforded by a single centralized entity, the data itself is not stored in OAM, but instead on distributed nodes of the Open Imagery Network (OIN). OIN is a network of distributed highly available and standardized public file stores. Imagery within these stores is publicly available and licensed under a CC-BY (Creative Commons Attribution 4.0 License) open license. OAM provides a visual browser and tools for search and discovery ("What is OIN?", 2015). A key requirement for all OIN nodes is their high availability which is achieved by hosting on cloud services such as Amazon S3 (AWS, 2015). This allows for efficient search and retrieval of imagery in OAM and on-demand creation of Web map tile services. OAM is built on top of OIN and provides a visual browser and tools for search and discovery ("What is OIN?", 2015).

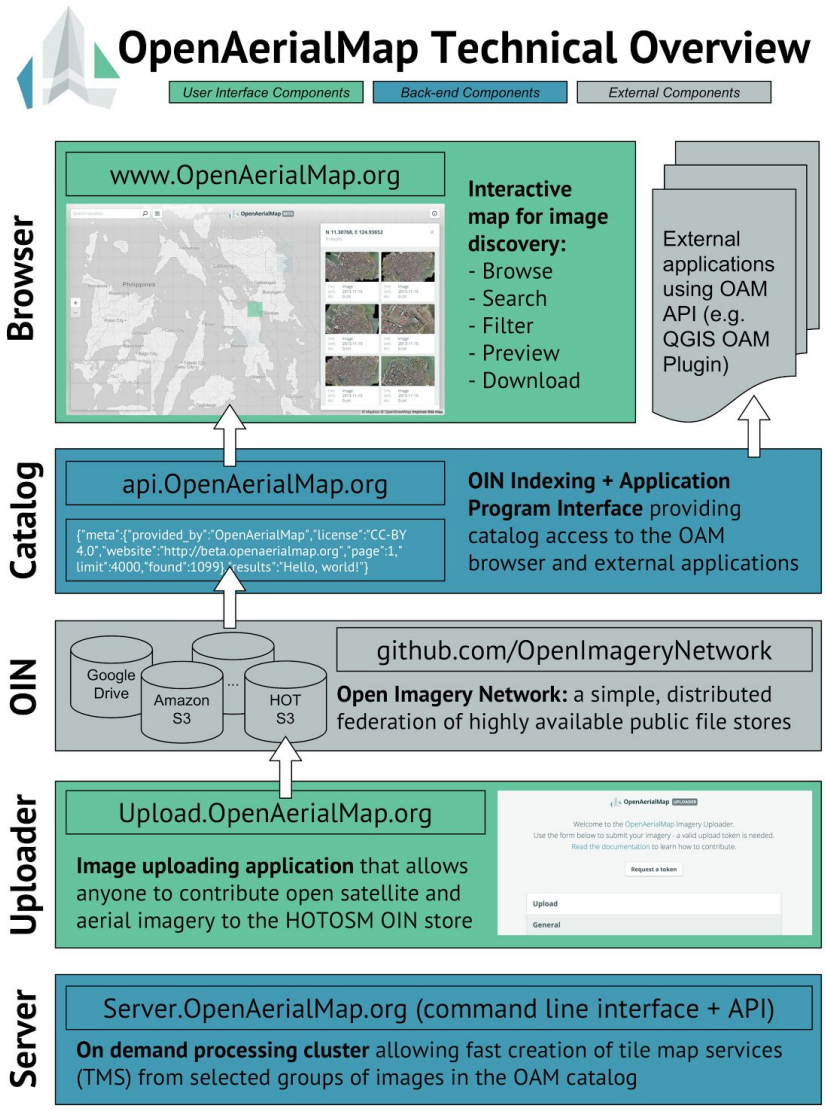

Figure 1. Overview of OpenAerialMap technical components.

Four core functions form the OAM platform - imagery storage, searching for imagery, downloading or using available imagery, and publishing new imagery (Figure 1). Humanitarian responder and mappers coming to OAM, can interactively browse the catalog and set specific search criteria to identify available imagery for their specific area of interest. Files can then be downloaded for use in desktop GIS software from highly reliable sources in the OIN or alternatively used through Web mapping services. Tools such as the online iD OpenStreetMap editor, for example, allow to easily display OAM imagery overlaid with other map data without having to download large raster files (Figure 2). On the other hand, providers who want to contribute and share imagery on OAM, are offered with an interactive form and application programming interface (API) to upload image files to OIN.

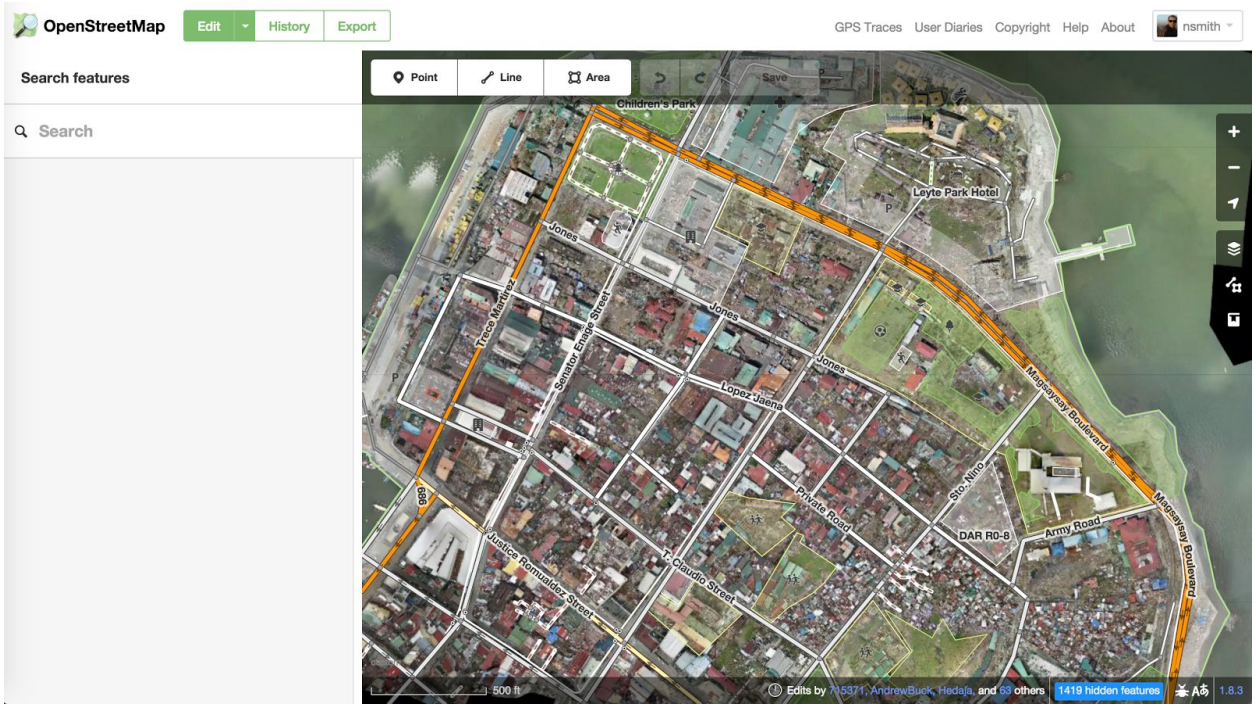

Figure 2. OpenAerialMap imagery used within the iD OpenStreetMap editor.

Architecture

The foundation of OAM is built upon OIN. OIN contributors can expose their imagery through any type of highly available public file stores - Amazon S3, Google Cloud Storage, and Microsoft Azure are all examples of public file stores that can be used within the OIN. The Catalog and API consists of two functions: an indexing function that collects the metadata of imagery within the system; and, an API that provides programmatic access to the indexed metadata. The underlying database to the API uses MongoDB, an open source NoSQL document-oriented database. MongoDB provides a flexible and fast database schema that is used by the Catalog API.

The Browser provides a web-based imagery search function (Figure 3). It is a front-end web application that uses the Catalog API to expose what imagery is available in the system. It provides an intuitive interface that is accessed through a web browser to enable searching by date, location, and other metadata properties. The Browser is a javascript-driven frontend application - meaning that it does not have a database backend - and it only relies on the API. This gives the Browser easy portability and enables the application to run offline in conjunction with the API.

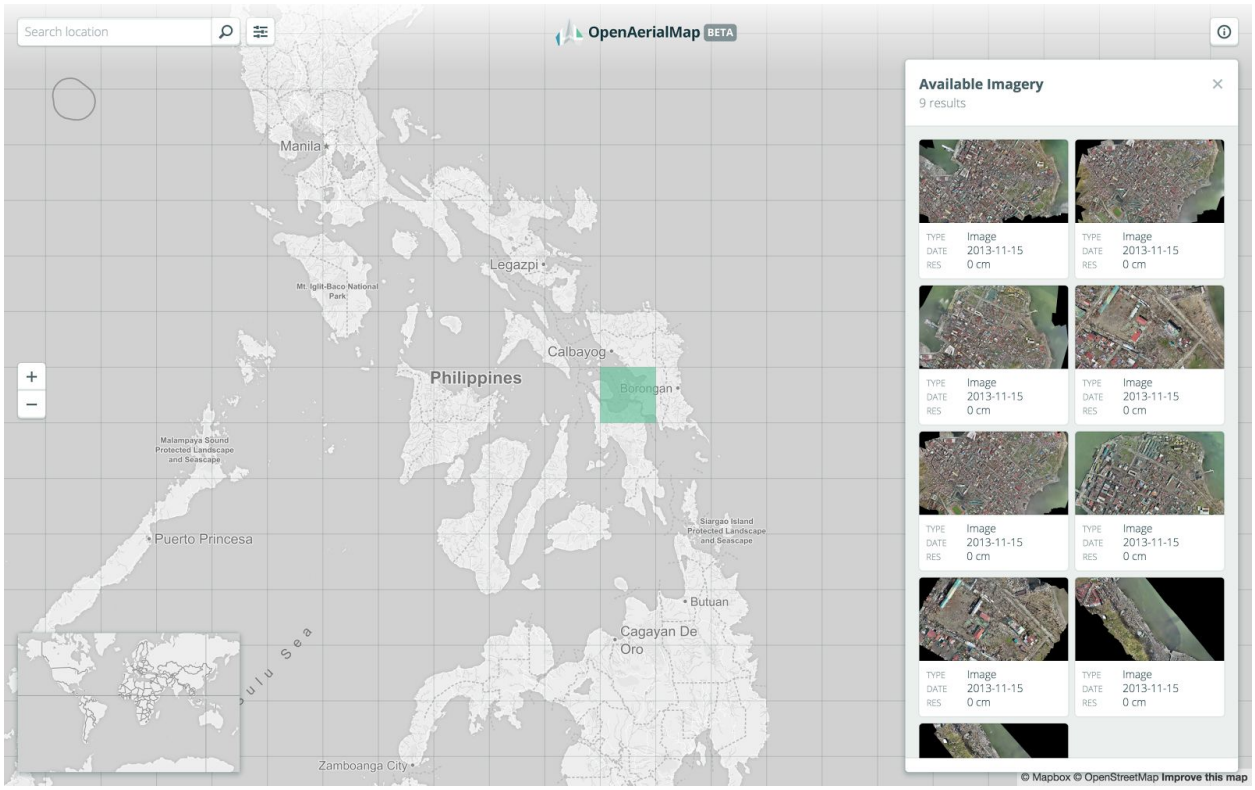

Figure 3. OpenAerialMap imagery browser.

The Upload and Processing system has two main functions: enable users to upload imagery directly to the system; and, provide processing capabilities to render tiled web maps from the imagery. The Upload server provides a method for a user to receive an authorization token and then submit the necessary metadata for each image. The application then downloads the submitted imagery, validates and checks the image, and uploads the image to the OAM node storage. The Catalog is then able to index the new imagery. The imagery processing system provides on-demand map processing capabilities. The processing server enables users to create tiled web maps from the available imagery in the system. The system uses a processing system called Elastic MapReduce from Amazon. EMR provides a managed processing system for distributing tiling tasks in parallel.

3. Open Imagery for Humanitarian Mapping

A disaster response activation by HOT is a prime example for how openly licensed and highly accessible imagery can be a valuable resource. During a HOT activation, both pre- and post-disaster imagery is needed. Pre-disaster imagery is needed for baseline mapping activities. Post-disaster imagery is needed for identifying needs and conducting assessments. Timeliness of these activities is defined by the access and use of imagery. OAM has provided timely access to imagery through its intuitive search interfaces and use of cloud services for fast processing ("OAM Adds Dynamic Filtering, Upload Tools Coming Soon" 2015).

Another prime example of the use of open imagery for humanitarian mapping comes from the Missing Maps project, an initiative to preemptively map vulnerable communities in the developing world founded by the American Red Cross, British Red Cross, the Humanitarian OpenStreetMap Team (HOT), and Medicines San Frontiers (MissingMaps 2015). The Missing Maps project coordinates remote-based volunteers to use aerial and satellite imagery to generate data in OpenStreetMap, works with local volunteers to add attributes to the data, and provides

support to humanitarian organizations to use the data in the midst of a crisis. The remote mapping component of the project needs high resolution imagery to digitize and access to openly licensed imagery has been critical for success.

In Dar es Salaam, members from a community mapping project funded by the World Bank, used openly licensed imagery in OAM to map flood-prone areas ("Task #1120" 2015). Using aerial imagery collected with small UAVs,, they were able to digitize buildings and roads within flood-prone areas. This data is being used to generate flood inundation models and evaluate areas at high risk.

4. What's Next?

OAM tools and the community launched in the summer of 2015 in support of humanitarian response and development mapping projects through the Humanitarian OpenStreetMap Team (HOT). OAM is growing the community of contributors; currently thousands of images are freely available for use. As more and more providers use OIN as the method of sharing imagery with the community of humanitarian disaster responders, OAM will become the reference catalog where critical information is shared. The ease of access to imagery means that crisis response organizations will more quickly and efficiently create products like base maps, 3D renderings, damage assessments, ultimately saving lives and providing prompt humanitarian assistance of those in needs.

As a part of the growth of OAM, the OAM community is focused on what is next. The OAM community is focused on growing the community of contributors to open imagery as well as the tools available for additional imagery analysis. Listed as one of the greatest successes in the project included raising awareness of the importance of openly licensed imagery (OpenAerialMap 2015). Open access to critical data is an extremely important principle that OAM continues to urge.

Imagery analysis tools is another area of growth within the OAM community. Online and offline tools are needed to provide additional access to the data. Raw data download and tiled map service are one way to access the data. Additional tools for automating extracting features and doing analysis on the imagery can be useful to increase access to information the data can provide.

6. Conclusions

Lives are lost during a disaster because detailed situational information is not available to responders in a timely manner for response coordination, evaluation and logistical planning. It is often difficult to get a detailed picture of how a natural disaster impacts people and property over a large geographic area and detailed, up to date base map data is often not available. Increased satellite imagery and remote sensing data availability and the advent of small unmanned aerial vehicles have significantly increased the amount, detail and timeliness of imagery data available, but the time it takes for processing after acquisition and the delivery of useful imagery to decision makers and responders is still surprisingly long. This problem was sadly illustrated during the recent Nepal earthquake. An unprecedented amount of imagery data was made available by providers, but the very limited resources of international humanitarian response organizations made it nearly impossible to sort, process and make actionable data available to responding organizations, damage assessment and crisis mapping personnel. OpenAerialMap was built in 2015 to address these challenges and make imagery readily available, discoverable and usable by humanitarian responders. The system is entirely built using open source software, making it scalable and easily extensible. Organizations such as the World Bank, the American Red Cross and Doctors without Borders are already using OAM for sharing and finding critical imagery. It is expected that more and more image providers will join the underlying Open Imagery Network federation and make their openly licensed imagery available through OAM for future crisis and humanitarian projects.

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