Visualisation of domestic unmanned aerial vehicle usage by geolocation

UP714581, UP683095
UP714581@myport.ac.uk, UP683095@myport.ac.uk

School of Computing, University of Portsmouth, Buckingham Building, Lion Terrace, PO1 3HE

1. Abstract

Unmanned aerial vehicles are becoming more prevalent in society and their usage potentially has a number of dangers. This report aims to visualize areas in which higher volumes of drone activity occur to help further understand the risks of this emerging technology. It also gives insight into the use of YouTube as a source of information for analysis and the challenges of utilising open Google technologies.

2. Introduction

Domestic drone, or unmanned aerial vehicle (UAV), ownership has been increasing in recent years. Currently there is very little regulation on their usage, with permissions only needed if it is for commercial use or has a camera equipped near congested areas (Caa.co.uk, 2015). A number of issues surround the emergence of this technology. Drones are either equipped or could be equipped with camera equipment, giving illegal surveillance capabilities to members of the public. Equally they could be fitted with weaponry such as guns or tasers. Their usage could also could be a danger to aircraft if a collision were to occur.

With the increasing prevalence of public drone usage, many users are taking to sharing their footage online. In the last week “about 1,800” videos were uploaded to YouTube alone (Youtube.com, 2015). Visualising this data shared from users worldwide on a map can be analysed to determine areas that have higher UAV activity.

3. System Architecture

To visualize UAV footage on a map, the model-view-controller architecture paradigm was chosen. The model is a dataset of the locations of UAV activity. The view is the HTML output of a map that gives the user access and allows interaction. The controller is the Javascript that accesses the dataset and generates the map. Javascript was chosen to ensure cross platform compatibility.

4. Manual data collection

To produce a visualization of UAV locations information was taken exclusively from YouTube. YouTube is not the only video sharing website, however it is the largest, therefore it is the largest source of data in one location. Manually extracting this data proved to be a time consuming endeavor, for this reason it was restricted to London. To produce a dataset to visualize the search term “London drone footage” was used. The dataset comprised of the videos ID, title and description. Using the information provided in the title and the description the geolocation could be ascertained using a google search.

5. Issues in utilising this data

Relying on data provided by the public in this way raises a number of issues. There is no set format for the titles and descriptions of the videos. Many videos contain no information on what their location is, this means many videos will need to be excluded from the dataset. Using the country of the uploads origin can not overcome this as the uploader is not necessarily from the location of the footage and would not be specific enough to give an accurate representation. Many videos provide in the title or description some information related to its location, commonly just the name of the city or a street address.

Video editing is also an issue that may reduce the quality of the visualization. Commonly the videos uploaded to YouTube are compilations of UAV footage from a number of different locations. These videos will be represented in the dataset, but only at the first location specified, resulting in some data being lost.

6. Heat mapping of collected data

The Google Maps Javascript API provides open heat mapping technology (Google Developers, 2015). Although countless alternatives exist, the Google maps format is widely recognised and used by the potential users of this system, ensuring it is usable without instruction. There are no restrictions on the amount of data that can be shown in the heat map, although greater volumes of data will impede performance (Google Developers, 2015).

This mapping of the information will unfortunately not give a true visualization of the locations. This is because of the vagueness of the information that can be pulled from YouTube. The videos will often just give “London” as the location, rather than the full address. This issue leads to a poor visualization of the area, with the center of London having such a high concentration of results that other areas with less than 5 videos became very hard to see. Excluding results that were geocoded to London increased the usability of the map but reduced the sample size from 155 to 106.

7. Results of heat mapping

After entering the sample data retrieved from YouTube into the template Google Maps Javascript heat map (Google Developers, 2015) figure 1 was returned. The blue represents the areas of activity, with darker blue showing increased density.

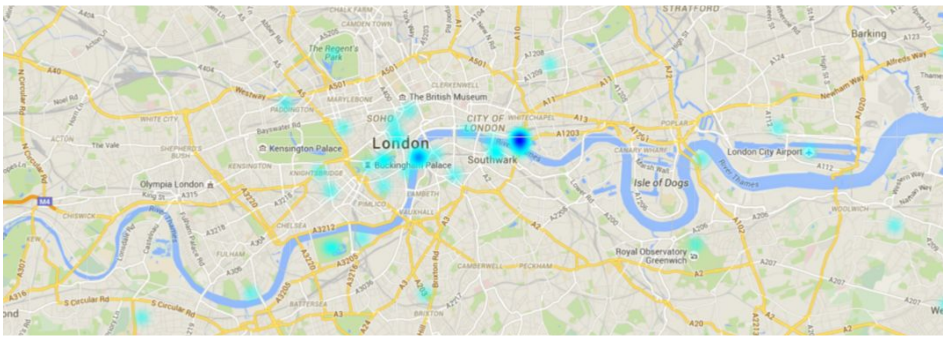

Figure 1 - Heat map of London UAV activity shared on YouTube

The heat mapping uncovered a few areas of higher UAV usage, most prominent of which are the Tower of London and the London Eye. This is not unexpected as both are points of interest or landmarks.

This map of UAV locations can be compared to restricted airspace over London (figure 2). It shows that many results fall within danger zones, represented in red, and most within controlled airspaces, shown in blue (No Fly Drones, 2015).

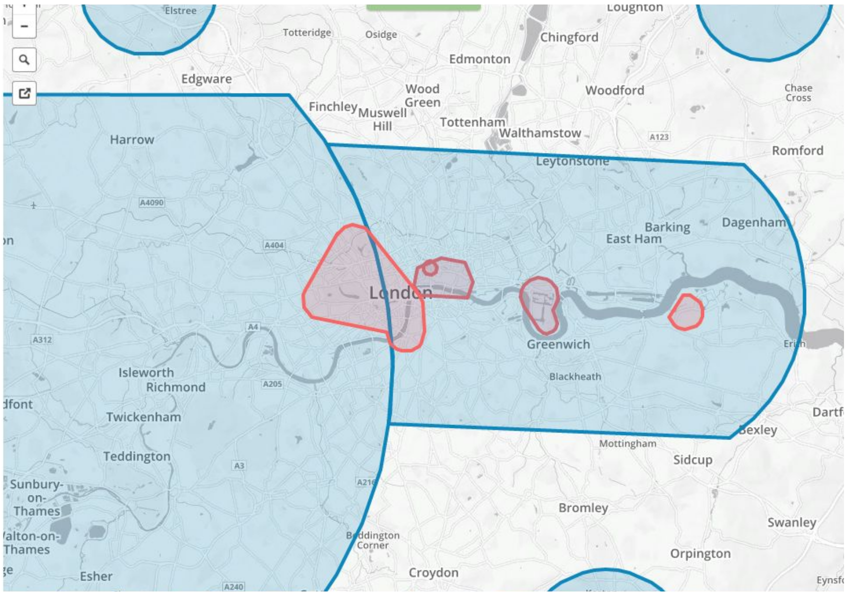

Figure 2 - Map of restricted airspace over London (No Fly Drones, 2015)

This indicates that much of the UAV activity in London is potentially dangerous. Users are piloting UAVs in areas in which air traffic is common or areas that are controlled by the military.

8. Automated data collection

YouTube provides an API to facilitate the extraction of information in programmatic ways. The YouTube Data API v3 retrieves requests, such as search results, in the JSON format (2. Google Developers, 2015). This can be achieved using search.js, which is provided by Google. This can be used to make a list of all the videos uploaded that match the search term “drone footage”, giving their titles, descriptions, URL, country of origin and comments. Similar information could be collected from other sharing sites using either their API’s or RSS feeds.

9. YouTube Data API restrictions

“The YouTube Data API uses a quota to ensure that developers use the service as intended and do not create applications that unfairly reduce service quality or limit access for others” (Google Developers, 2015). This means the access to YouTube data is restricted to how much you can use. They allow 50,000,000 “units” per day, one unit equating to the retrieval of one video ID. Retrieving the ID, title and description will result in the use of 3 units per search result and is specified in the search function of search.js. There are currently “about 1,700,000” videos matching the search “drone footage” on YouTube (Youtube.com, 2015), this falls within the limits of the quotas. However, if this data is accessed each time the page is used this quota will be quickly depleted.

10. Automated data collection and utilisation solutions

To avoid reaching the YouTube Data API restrictions the search results need to be stored as opposed to being accessed from YouTube every time the page is used. Retrieving all the relevant footage can be achieved in one instance, giving a list of video IDs with the titles and descriptions. Saving this data as local storage is not sufficient as each user will still use the quota, instead it would require storage in the server. This will also allow the data to be used much quicker than retrieving the data from YouTube in each instance. This information store could be kept updated with daily searches for videos uploaded within the last day.

The information compiled from YouTube needs to be converted into its geographical location in order to be represented on visually on a map. Google provides the facility to do this in their Google Maps API. Using this the description of the location, taken from the video, can be converted into its map location (Google Developers, 2015). This approach is not without its complications. The video's information can be programmatically accessed, giving a string of the title and description. This requires analysis of each word individually and combinations of words to ascertain the correct location. The words and combinations of words can be passed to the Google geocoder, which will return "failed" if no map location exists matching the input. Combinations of words have been given higher priority. This way videos of "London, England" are not shown on the map over the center of England.

This is not without its problems. Entries such as "London Eye drone footage" will result in three possible geocodes; one on the center of london and either on the London Eye or in Las Vegas where there is a map location called the London Eye. American locations often cause this problem, Portsmouth, Hampshire and Portsmouth, New Hampshire are programmatically hard to distinguish between. For this reason, when geocoding the location, the word "new" needs to be the priority result, ensuring American results remain American.

11. Alternative visualisations

Marking the location of each video could be used instead of heat mapping. This can be achieved using the same dataset as the heat map. Using the Google Maps API, map markers can be added representing the location of the footage (Google Developers, 2015). The API allows custom markers and limited animations, which can be used to add pictures of drones that appear to fly or "bounce" on the map. An onclicklistener can be added to these markers, giving a pop up information window which can contain the embedded YouTube footage.

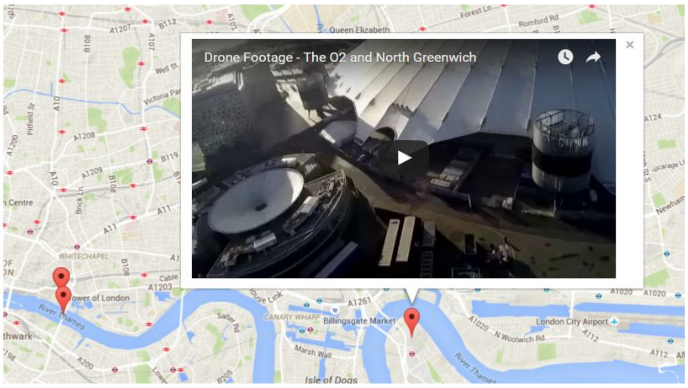

Figure 3 - Marker based visualization

12. Marker limitations and solutions

Although it is not specified by Google in their API documentation it appears that only 10 markers can be simultaneously displayed on the map. This prevents a global map of drone markers with videos being produced. To avoid marker limitations, the markers containing the drone footage will only be added to the map when it is zoomed in. Only adding markers to the map when the “zoom" property of the map is 13 or lower will restrict the number of markers that need to be added. Using the current “viewport”, the area in which the user can see, exclusively videos within this latitude and longitude can be selected. These markers can then be removed if they fall outside the current viewport and new markers added. This may not show all the videos of densely populated areas, but different videos could be shown when it is returned to. The number of markers may be increased by paying for a Google premium account.

Another limitation in the usage of the Google markers is that if two entries have the same location only the first will be displayed. The collision of markers, resulting in them not being presented on the map is avoidable, but reduces the accuracy of the visualization. Checking each marker against the list of previously added markers and slightly manipulating the latitude or longitude location will ensure all markers will be shown. An increase or decrease to the latitude or longitude of 0.000009 will give a visually distinct marker at closer ranges without greatly impacting the location. This amendment to the location must be applied differently each time to create a cluster around its true location. If the amendment was applied, increasing the latitude in each instance, it would result in a line of markers from the original location. This amendment can be achieved with a series of if and else if statements or a switch statement.

13. Improving data accuracy

The dataset of geo locations collected does give some indication of the locations of UAV activity however, it is not accurate. The accuracy could be improved by getting the recorders of the video to provide the exact starting location of the video. Alternatively users could comment this information on the video, which can be accessed using search.js. Lack of participation will largely affect this approach. A website attempting a similar visualization does exist, using user submitted information to generate its map (Travelbydrone.com, 2015). As a result of relying on submissions their data only shows 11 results across greater London, whereas our data contains 155.

A more accurate visualization could be achieved using the metadata of the recordings. Modern camera equipment will encode the video with the geolocation of the recording. From this and the visual imagery of the video the location of the UAV can be crudely established (Cooke, Whatmough, Redding & El-Mahassni, 2008). This would require access to the actual recordings through user submission as the YouTube Data API v3 does not allow access to videos metadata. This more detailed location data would allow a visualization of the flight path of the UAV rather than a mere estimation of its location. Live access to the geolocation of the UAVs current activity would be able to produce a real time mapping of the unmanned vehicles in the sky. While this may be seen as intrusive, it would be beneficial as many users fly their UAVs in restricted or dangerous areas.

14. Further uses of the system

The system when fully produced can be manipulated to map almost anything. Changing the search parameter in search.js would allow any YouTube search to be heat mapped or markers added by location. This could be used to produce similar results for GoPro footage. Combining UAV and GoPro footage in one place could create a map allowing users to see land or air footage of any part of the world.

15. Conclusion

From the limited data set collected it can be stated that domestic UAV use does occur within areas designated as dangerous. As the users have actively shared this information it seems they may be unaware of the restrictions and potential dangers.

Although the data is far from precise, it is possible to get a better estimation of the locations. It is possible to create a far more inclusive dataset by utilising the YouTube Data API v3 to collect the data and programmatically analyse the information into an estimation of its geolocation. Google's APIs provide a large amount of data collection potential but its restrictions create some additional challenges.

16. References

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