

Remote sensing assignment part 1 report_ Charlotte Knight

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Creating a new data set for a littoral zone

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Introduction

This report outlines the approach to gather a new data set for a littoral zone within a friendly urban area. Specifically, it aims to capture the topography of the area above the neap lowest astronomical tide chart datum, including local structures and accessways within 250 metres of the mean sea level, to a resolution of 15cm. Firstly, the optimal platform to collect the data must be selected. Next, the process for georeferencing the data collected to Ordnance Survey 1:1250 scale map will be identified, along with a method of transforming it into a digital terrain model.

Data Acquisition

Satellites

The geographical position of the urban area can influence the frequency and amount of satellite imagery that can be collected. If near the equator, the satellite will be in a geostationary orbit, which synchronizes with the Earth's rotation, allowing constant aerial surveillance. However, if elsewhere, the satellite will follow a polar or sun synchronous orbit, taking 1.5-2 hours to revisit the location.

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This global coverage provides diverse data but can be time-inefficient when focused observations are needed [1].

Optical sensors allow satellites to take high resolution photography from over 700km away. Commercial satellites can have a resolution of 15cm, however military grade keyhole satellites are estimated of having resolutions of 5cm, making them incredibly accurate despite being a long distance from the target area [2]. To collect the data, the satellite always points directly downwards in the Nadir projection. This limited perspective makes it difficult to determine terrain and height of structures.

The main disadvantage with satellites is their cost. Landsat 8, NASA's high resolution earth resolution satellite cost \$650 million to design and build, with costs increasing to \$1 billion after 5 years of use [3]. The research, development testing and launching of these technologies takes many years, making them slow to deploy. Once in orbit, sensors cannot be physically changed or updated without returning to Earth, reducing the versatility of this methodology. Any repairs have to be completed on Earth, adding additional launch and relaunch costs. However, they can last between 10-15 years, making them cost effective if used long term [4].

Satellites face issues with power and weight restrictions on payloads, hindering capabilities. For example, a satellite's power systems are often limited to 200-800W, constraining energy-demanding instruments such as cameras [5]. Weight constraints during launch restrict the addition of larger sensors. Combined, getting the required data at the correct resolution may be challenging and costly.

Fixed Wing Aircraft

Fixed wing aircraft can carry heavy payloads, enabling multiple technologies to be employed at once. Consequently, they are typically equipped with: optical sensors, Light Detection and Ranging (LIDAR) sensors and Synthetic Aperture Radar (SAR) to enable a range of data to be captured in a single trip.

These payloads are capable of high quality imagery, achieving 5cm resolution commercially [6]. Aircraft such as NASA's ER-2 – AFRC are capable of 5000 nautical miles range, allowing them to collect data when deployed from a distance [7].

They can cover vast geographical areas quickly, allowing for efficient surveillance and data collection. Their high altitude can provide a broader understanding of the data outside the required zone which could still be of interest, but airspace dependant they can also lower their altitude to collect higher resolution imagery.

To collect data, the aircrafts sensors often collect data in strips, meaning the aircraft has to fly over the same area multiple times to gather enough strip data to build a map. This collection technique can often cause gaps and overlaps between strips due to the pilots human error, or weather related issues [8]. Any significant altitude changes will also make it harder to create the flat 3D map, increasing the time and cost to process the data. To fly the aircraft over an area, the relevant permissions to use the airspace may be required, increasing the time taken to deploy.

Whilst collecting data, the aircraft travels at speed around 150 km/s. This can cause some the sensory data to blur, requiring further correction during data processing.

Lastly, aircraft are highly subject to weather conditions. High winds, storms and low visibility can reduce their ability to operate effectively, causing delays in the data capture [9].

Drones

A drone, also known as an Unmanned Aerial Vehicle (UAV) is an aircraft without a human pilot onboard. They can be remotely controlled by a human operator nearby or can fly autonomously using software-controlled flight plans or a combination of both. Drones are rapid to deploy, easily accessing remote regions to collect data as they require no existing infrastructure to function. Their small size and manoeuvrability allows them to get closer to areas of interest through accessways or windows, collecting focussed high resolution data from a variety of angles and orientations. Unfortunately, their small size limits their power and range capabilities. Drones such as the DJI Mavic 3 Pro quadcopter have a range of 28 km and flight time of 43 minutes, allowing a relatively short window to collect data [10].

Drones are inexpensive, typically costing between £100-£2000 [11]. They are easy to buy, fly and maintain, making them ideal for rapid data collection. They can often be purchased with a sensor suite onboard making setup straightforward and efficient. Some companies have modular designs, allowing different sensors to be added or removed with ease. However, if different sensors are required to those available, it can be difficult to integrate them into the drone's software/ hardware. Additionally, any added sensors must be light enough to be carried and have low power requirements, noting that added weight decreases the range of the drone [12].

To use a drone, a pilot with an operator and flier ID is required who adheres to the Civil Aviation Authority (CAA) code. The drone cannot be flown less than 50m away from people, which could require the littoral area to be closed to the public whilst the survey is being completed. Secondly, drones cannot be used within 150m of residential, recreational, commercial and industrial sites. This could limit where the drone could fly within the littoral area boundaries [13].

During flight, sensors themselves are subject to vibration and movement, resulting in blurry imaging and videos. This can be removed post processing but takes time to complete. Drones cannot be flown during high winds as they become uncontrollable, limiting their operation times [14].

Recommendation

Overall, drones are the most effective sensor platform. Compared to the alternatives, they are significantly more economical, offer greater resolution, and can be implemented in a much shorter time frame. This leaves drones the optimal choice for the data collection task.

The main advantage with using drones is their rapid deployment capabilities. Off the shelf drones can be purchased at minimal cost, and can contain in-built sensors, reducing the time spent searching for standalone sensing systems. They can then be launched from almost any location globally, so require no existing infrastructure within the littoral zone. When deployed, they can easily be manoeuvred around the scene to collect information. This contrasts with satellites, which can take years to develop at great expense, with any launches requiring scheduling with launch pads. Once launched, there is only a small window of data collection opportunity before it has passed overhead. Fixed wing platforms are reliant on airports being near the littoral area, and require advance planning before work can commence. Once in the air, data gathering can become time intensive, as data can only be collected in strips, requiring the plane to circle back and forth over the same location. This method can incur significant costs, considering the expenses associated with the aircraft, pilot services, airfield fees, and fuel.

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As they can fly very close to the ground, drones offer much better resolution, and thus data accuracy, compared to the other platform. They also allow the user to fly closer to objects of interest, gathering further information. Planes are capable of reducing their altitude, however are limited by the Civil Aviation Authority (CAA) on how far they can drop. Satellites cannot decrease their orbit, so therefore offer the worse resolution of the three platforms. With the exception of spy satellites, it is unfeasible for a satellite to collect the quality of information required by the brief.

Data Processing

Data collected using the techniques above is only significant if put into perspective of the area surrounding it. To enable seamless integration of remotely sensed data into Ordnance Survey (OS) map data, a series of steps must be followed to align and process the information accurately. The following description outlines the key processes involved in achieving this integration:

Raw data processing

Data collected must be processed to correct sensor specific issues, including radiometric and geometric corrections. An example of this is reducing image blur or the effects of sun glint. This step ensures the image quality is as high as possible, and accurately reflects the Earth's surface [15].

Coordinate System Alignment

The remotely sensed data must use the same coordinate system as its corresponding 1:1250 scale OS map. Therefore, all raw data coordinates must be converted to match the projection, datum, and coordinate units of this map.

Selecting Control Points

Control points are areas of a map which can be confidently assigned latitude and longitude coordinates. In order for the remotely sensed data to be georeferenced to the OS map, multiple control points must be selected and easily identified in both datasets. They must also cover the entire study area [16].

Georeferencing

Raster data is a spatial data representation consisting of pixels that each correspond to geographical information such as temperature. In order to georeference the two maps, the control points found using the process above will be used to transform the raster data to match the spatial reference of the OS map, allowing the maps to be integrated and thus for analysis to occur [17].

Resampling

As the two raster data sets contain different spatial resolutions, the data needs to be resampled to align to the required 1:1250 scale of the OS map. Resampling involves adjusting cell data in order to obtain images at a consistent resolution. This ensures compatibility between the raster datasets and the target map scale.

There are 4 common resampling techniques:

1. Nearest neighbour- As demonstrated in figure 1, this takes the cell centre from the input raster data set to determine the closest cell centre of the output raster. It is the fastest technique, and is ideal for discrete data such as soil types.

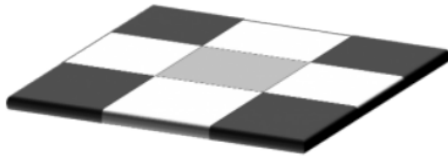


Figure 1- An example of the nearest neighbour resampling technique

2. Bilinear Interpolation- This technique calculates values of a grid location based on four nearby grid cells, as seen in figure 2. The output cell value is assigned by taking the weighted average of the four neighbouring cells in an image to generate new values.

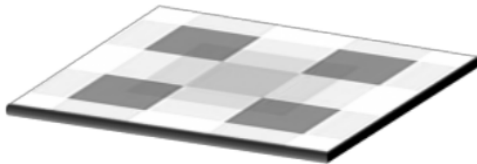


Figure 2- The bilinear interpolation technique

3. Cubic Convolution- This method takes the average of the 16 nearest cells to the centre. This increases the processing time, however is incredibly useful in reducing noise as it smooths data from the input raster grid

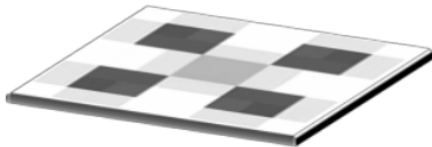


Figure 3- The cubic convolution resampling method

4. Majority sampling- In this, the value of each output cell is determined by the most common values of the cells surrounding it . It is used in situations where categorical data representation is essential [18].

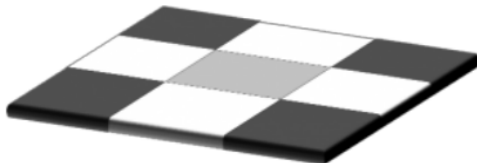


Figure 4- The majority sampling technique

Digital Terrain Model (DTM) Generation

To create a continuous elevation surface for the DTM, the gaps between the resampled raster data need to be filled in. This can be done using interpolation techniques such as Inverse Distance Weighting (IDW), kriging, or spline interpolation. Afterwards, the scale of the completed DTM must be

compared against the 1:1250 scale of the OS map. If different, spatial resolution adjustments need to be made by modifying the raster cell size in the DTM grid to align with the correct scale [19].

Geographical Information Software (GIS) should then be used to visualise the completed DTM, aiding in the identification of terrain features, patterns, and anomalies. To increase accuracy, the completed model should be compared against the ground control points to verify that the raster data has been successfully transferred across. Here, additional smoothing algorithms may be employed to reduce noise.

Conclusion

Overall, the drone was the optimal remote sensing platform as it was the most economical option. It was easy to use, implement and collect data from. Additionally, the process of creating georeferenced Ordnance Survey 1:1250 scale data has been explained using a series of simple steps. The methodology in creating a DTM has also been included.

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GRADEMARK REPORT

FINAL GRADE

75/100

GENERAL COMMENTS

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