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DIGITAL BUILDING SURVEYS

THE USE OF DIGITAL SURVEYING TECHNOLOGY IN MODERN DAY
SURVEYING

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1.INTRODUCTION

Surveying pre-dates today's modern skyscraper and yesterday's first multi-storey building. In fact, surveying methods trace back to the earliest civilisations. The continuous use and development of surveying throughout time is a testimony to its on-going importance in construction.

Nowadays, it is utilised to determine the scope of works prior and during construction, evaluating the progress, and identifying problems (*Smith and Gorse 2021*). Advancement within technology has provided useful instruments to monitor the performance of buildings during its use; not limited to its structural behaviour but now more than ever, its environmental efficiency also.

The scope that surveys present are extensive, and technology has surcharged the capabilities. They certify structural positioning of components and land boundaries, expedite valuations, even create geographical maps of the earth and ocean floors. Simply, technology like hydrographic surveys and remote sensing has enabled humans to survey terrain that otherwise was be impossible to observe.

The emerging technology has lead *Thompson and Walker (2017)* to publish a report on behalf of RICS (*Royal Institute of Chartered Surveyors*) highlighting that the 17 identified surveying professions are all experiencing technological growth. Although this report addresses the concerns of increased technological presence, it acknowledges the positive contributions that technology offers the industries.

This assignment will focus on the role of digital surveying technology within house surveys. The report will focus on three types of digital surveying technology, a desktop survey, thermal imagery, and aerial drone surveys.

2. SURVEY OBJECTIVES & SCOPE

Establishing clear objectives of a survey is paramount in maximising its effectiveness (*Hoxley 2002*), in return the survey should then ascertain a further scope of work to be implemented or the progress of current construction (*Smith and Gorse 2021*).

The scope of this survey derives from the perspective of a semi-detached house in Landore, Swansea, built in the 1930s using traditional brick and block construction.

Firstly, a preliminary study will formulate an appreciation of the house and its surroundings. Following this the surveyor will examine the thermal performance of the property through thermology cameras and unmanned aerial vehicles (UAVs). The survey will focus on the thermal performance of the roof, windows, external walls, and external doors.

3. Digital Surveying Equipment

3.1 Remote Desktop Survey

A remote desktop survey is a surveying technique that is conducted by any individual with access to the internet. Coined '*The Internet of Things (IoT)*' and discussed by *Thompson and Walker (2017)* it provides a digital archive of data that can be obtained to assist in surveying operations.

Google Earth or Google Maps provide mapping and topographical data, including the eastings and northings, and roaming tools to view in 3D and first person. These enable an individual to remotely survey a site simplistically. Furthermore, geological risks have been surveyed and mapped by *Natural Resources Wales (NRW)* for online access to assess the flood risk and ground conditions, as well as Dwr Cymru providing online maps of underground drainage systems.

It is also possible to view previous or potential planning decisions for the local area including any discharging conditions to the planning application. These contain information regarding site restrictions or potential environmental considerations needed before development which can be suggestive to local hazards.

These resources may cost a small fee, however they are digital tools enabling access to previous surveys which can save time and money. They develop a remote appreciation, that will guide the planning and preparation of a physical survey. Nevertheless, secondary data may be outdated or unreliable, therefore all collected data is provisional until verified on-site or by an authorised body.

3.2 Thermal Imagery

Thermal performance is an essential component to buildings within the UK. Thermal properties are measured with modern technologies (*Smith and Gorse 2021*), usually a thermal camera capable of capturing infrared radiation. The ‘thermogram’ within the camera transposes the infrared radiation to a visible colour to analyse the quantity of emitted radiation (*Hart 1990*) (*Figure 3.1*). The collected data will indicate insulation defects, air leaks, dampness and even the safety of heating and electrical equipment.



Figure 3.1 Infrared image capturing radiation emissions and transposing the data to visible light, referencing to the colour scale on the right

Importantly there are parameters that will affect the infrared readings, such as surrounding air and object temperature, humidity, sunshine, shade, reflective surfaces, stored heat, and drafts (*Pearson 2017*). These conditions must be understood before conducting a survey to avoid misrepresentation of infrared emittance. Good practise is to ensure that there is at least a 10°C internal to external temperature difference, close all windows and doors, turn off heating and cooling appliances, and avoid direct sunlight.

Such thermal influences have a lasting and varying effect on materials, therefore adequate time should be allowed for objects to return to their natural temperature.

Qualitative and quantitative data are collected from thermograms (*Hart 1990*). Qualitative is the simplistic and cheapest approach, capturing images for on-site analysis. Such images cannot analyse real-time changes, nor provide a detailed report. Alternatively, quantitative approaches are videos analysed off-site by a statistical computer. This can contribute to a U value report, producing real-time temperature fluxes.

A thermal camera (*Figure 3.2*) can measure temperatures within the ranges of -20°C to 600°C and provide accuracy of approximately 2°C (*Pearson 2017*). Additional features include GPS that can record the location of the captured data, the ability to forward data via Bluetooth/WIFI, lightweight, and relatively low cost. However, it is impossible to retrieve data through objects nor detect objects without a temperature difference to the surrounding atmosphere.

Considering this, thermal imagery lends itself well to a thermal dwelling investigation due to its simplicity, economical nature, and the relatively isolated environment within a property that restricts temporal influences.



Figure 3.2: Example of a thermal camera

3.3 Aerial Drone Survey

Aerial drone surveys or UAVs are modern and versatile surveying equipment used to survey aspects that would otherwise be challenging (*Figure 3.3*). UAVs are programmed by geographical referencing systems equipped with navigation and mapping technology to collect targeted information, usually in the form of visible or inferred imagery (*Armenakis, Li-Chee-Ming, Persad 2019*).



Figure 3.3: Example of a small rotary UAV

For the purposes of the roof inspection, this method of surveying is safer because it mitigates the need to work at height, reduces potential damage to the roof and associated fixings, and it can be an economical approach (*Brown and Miller 2018*). To execute a successful survey the type of UAV is critical, for a small-scale survey a small quadrotor/multicopter capable of carrying a digital and infrared camera is sufficient. An aircraft such as this can be manual or automated, agile, and effective in mapping smaller areas (*Ma and Xie 2019*).

A key indicator for points of interest (*POI*) would be to utilise the infrared lens to identify any abnormalities, these may include warm spots or any dramatic radiation variations. If

these are identified, visible images and videos can be captured at higher resolution for further assessment.

Nevertheless, this approach is not simplistic. *Brown and Miller (2019)* discuss the need for excessive photographs with 80% overlap for sufficient data to stitch imagery. Video data supplements imagery although this is not recommended for sloped roofs or stand-alone data; it is encouraged to capture static imagery for greater detail. Alternatively, a vertical method which captures large-scale images, before flying closer to divide the area into smaller photo segments is deemed to be an effective method for the pilot to identify POI (*Figure 3.4*). This method is a targeted approach, identifying POI by gradually increasing the focus on specific segments of the roof. Vertical data collection can eliminate the requirement for stitching imagery.

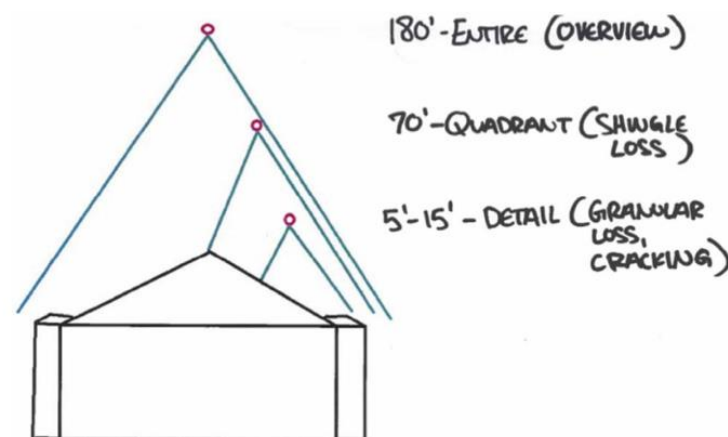


ILLUSTRATION 3.—Vertical Approach to Still Images

Figure 3. 4: Caption of the vertical approach from Brown and Miller 2019)

Although *Eisenbeiss and Sauerbier (2019)* raised concern over cheaper, smaller UAVs due to their inability to sustain heavier quality cameras resulting in the need to obtain more photos for coverage and resolution, it can be argued that this benefits the vertical approach because of its nature to capture detailed imagery as the UAV nears the target. In addition, smaller rotary powered UAVs can achieve a closer flying distance than its bulkier counterparts. *Patias (2019)* discusses a case study where a small UAV was successfully utilised to inspect the ‘*Basilica di Santa Maria di Collemaggio*’, using an optic

and infrared camera to assess the damage caused by an Earthquake in 2009; the combination of both cameras on a rotary UAV enabled close and detailed inspections in restricted areas.

4. Methodology

4.1 Data Collection, Challenges, Preparation and Planning

Before conducting a physical survey, it is critical to establish an understanding of the site. The desktop survey will accumulate secondary data from previous surveys throughout the existence of the property, providing a preliminary understanding. The method will present an overview of the property's location, geological influences, and development by utilising remote satellite software, environmental resources, official planning applications from the local authority's planning portal, and the local building regulations to provide a benchmark standard.

However, it is strictly a base point from where a planned primary survey can expand on vacant data. All secondary data is to be treated as provisional until confirmed by on-site inspection or official correspondence from a delegated authority.

Once inside the property the surveyor will collect infrared imagery and videos for quantitative computer analysis. The video footage will enable a real-time understanding of airflow behaviour, whilst thermal imagery will provide a visual appreciation. Perimeter walls, windows, and external doors will be captured for analysis, each individual component will be captured separately, and if required divided into segments to enhance the thermal breakdown analysis.

The thermal survey will take place on an overcast day to avoid direct sunlight, and the owner will be made aware of the date to ensure that heating and cooling mechanisms are deactivated, and all windows and doors are closed to avoid drafts to ensure an adequate external-internal temperature difference. All potential negative influences on thermal data shall be noted for consideration, and all parameters for assessment are factored into the analysis to establish a detailed report (*Hart 1990*). This will include a past and present weather report up to 48hrs, components that may have had direct sunlight in that

time, and the present internal and external temperature difference. All measured components should be paired with a description of its constructed material as this will also have differencing thermal properties.

Finally, a small rotary UAV will assess the roof. To conduct this survey the weather must be dry with limited wind and sunshine to avoid destabilising the UAV, resulting in poor imagery (*Eisenbeiss and Sauerbier 2019*). A safe take-off and landing location will be identified by the desktop survey and later confirmed on site; the rotary UAV enables a vertical take-off and land reducing the required space. Nevertheless, due to the vertical method the UAV is required to fly closely to the roof therefore the pilot must maintain a visual on the UAV to avoid damage or risk of collision.

The UAV will be fitted with a thermal camera and GPS system, and in this instance the thermal camera has a dual usage. Not only will it identify thermal leaks, but these thermal leaks may be caused by a defect to the roof rather than inadequate insulation. Therefore, the UAV will utilise the vertical method (*Brown and Miller 2019*) to capture the roof's thermal properties, and consequently any areas of thermal leakage will be plotted with a GPS reference point. Once all reference points are collected the drone will commence its second survey with a high-resolution digital camera, flying at proximity to the roof it will capture images of the plotted areas through the GPS navigation system to assess the defect. These images will be downloaded and assessed by qualified surveyor to detail further recommendations.

Similarly to the internal survey, all parameters past and present will be recorded and accounted in the analysis. The data collected from these thermal surveys may suggest and assist any cavity or loft surveys or identify singular components for replacement such as doors and windows.

5. CONCLUSION

Evidently surveying retains a paramount importance to the built environment today, only differentiating by the supplementation of modern technology. Nevertheless, digital surveying is not indispensable, and various parameters will influence the quality of these surveys. The range of digital equipment has become abundant, limiting this report to three methods of digital surveying.

The IoT stores unlimited information that could be used to compile a preliminary survey; however, the depth and quality of this survey is dependent existing data and if that data does not exist then it is impossible to survey. Desktop surveys are a simple digital resource comprising of many data engines to form an understanding of an existing site, however secondary data is required to be verified and should not be taken for granted.

Thermal cameras accumulate data beyond the capabilities of a human eye, translating this data on to the visible spectrum for analysis. It is a mechanism to identify thermal leakages, dampness, or electrical faults. Nevertheless, external parameters such as latent heat and temperature variations will impact results requiring planning and detailing of the potential influences.

Similarly, UAVs facilitate and accelerate a survey of larger or hard-to-reach areas. Notwithstanding the ease of survey, UAVs improve health and safety by limiting the need to work from height. However, the type of drone and cameras used will present its own unique challenges such as weight limitations and camera quality not including weather patterns that could prohibit the safe flight.

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