Geo Digital Documentation (GDD) for Arab and Islamic Heritage Preservation

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Abstract

The need for the digital documentation of Arab/ Islamic architecture and historical buildings, particularly mosques, churches, tombs and other heritage sites, is obvious. The recent upheaval in the Arab world, particularly in Syria, has led to the destruction of most treasured old Syrian cities such as Homs, Aleppo, Damascus as well as other historic towns and heritage sites. Even more recently in Iraq, ISIL has destroyed and razed to the ground many historic mosques, tombs and churches, along with other heritage sites belonging the Assyrian era of Iraqi history, under the banner of religious ideology. There is a pressing need for this digital documentation of the existing heritage before even more history is wiped out of existence. Such documentation will preserve the full and accurate details of these sites and buildings. These records may then be used for the efficient maintenance and preservation of these important historic buildings. More importantly, this digital documentation in addition to other historic data can be used for the full reconstruction of the heritage building/site or artefacts in the case of harm due to manmade causes, fire or natural disaster.

This paper will provide a review of modern up-to-date surveying technology and its availability and suitability, and the finance involved for the urgent digital documentations of the Arab/Islamic heritage and historical buildings, and recommend suitable technologies. These include air borne and terrestrial laser technology, Digital Photogrammetry, and Global Navigation Satellite Systems (GNSS) in addition to the traditional surveying methods. Furthermore, the paper will also explore and evaluate the use of Geographic Information Systems (GIS) and Building Information Modelling for the storage, processing management, and various applications including heritage preservation and the reconstruction of historic buildings from the collected digital documentation.

1. Introduction

The current war and the intentional destruction of heritage sites by warring parties has led to the widespread devastation of many cities and towns including Aleppo, Homs, Damascus, and others. This is not to understate the significant loss of human life and immense suffering which has been caused by such destruction. The old cities of Aleppo, Homs and many other parts of Syria's cities with their rich cultural heritage have sadly been flattened. Many of these sites are UNESCO World Heritage Sites (UNESCO, 2014). Furthermore, earlier this year ISIL (Islamic State in Iraq and Levant) managed to occupy large parts of Northern Iraq. The area under their control now extends from the Syrian/ Iraq borders through Telefer, Mosul, Tikrit and parts of Diyala Province to the Iranian borders.

ISIL has turned its attention to the destruction of ancient structures and buildings and artefacts associated with the cultural and religious heritage of Mosul and Nineveh Province to the North and West of Mosul towards Irbil. Many iconic mosques, churches, and shrines in Telefer, Mosul and other parts of Nineveh Province have been blown up by ISIL. The vandalism of such heritage necessitates an urgent review of the methods available for its protection and preservation in accordance with international conventions (Hague Convention, 1954).

Given the urgent need for the preservation and safeguarding of the remaining heritage both in Syria and Iraq, this paper explores, reviews and evaluates the technology for the Digital Documentation (GDD) of the unique, ancient cultural history and heritage of these countries. It recommends technology for assessing the damage, restoration, and reconstruction of destroyed cities and towns, and technology for the preservation of existing heritage sites for future generations.

1. Heritage from Preservation to Devastation

1.1. Syria

The so called 'Arab Spring' entering into its fourth year has turned into a nightmare of conflict, war and killings particularly in Syria, Iraq and now Libya, and to a certain extent in Egypt. The destruction in Syria of both human life and heritage is overwhelming. Over 100,000 people have been killed, and 8 million have been forced to leave their homes with 2 million refugees seeking shelter in neighbouring countries (BBC, 2014). The systematic destruction of Syria's unique cultural, architectural and historical heritage is continuing with no prospect of slow down or an end. In addition to the war and destruction of the historical cities of Syria, ideological destruction by extreme groups such as ISIL is now taking place.

In the face of the deteriorating situation inside Syria, the UNESCO Director-General, Irina Bokova, made the following statement(12 March 2014):

"The situation in Syria is deteriorating at a rapid pace with incalculable human suffering and loss. Syria's unique cultural heritage is also subject to tremendous destruction from the conflict. To date, three UNESCO World Heritage Sites -- Palmyra, the Crac des Chevaliers, and Aleppo including the Aleppo Citadel -- are being used for military purpose and this raises the risk of imminent and irreversible destruction, in addition to that which these sites have already suffered.

This presence constitutes an infringement of the rights of the Syrian people. Damage to cultural heritage is a blow against the identity and history of the Syrian people - it is a blow against the universal heritage of humanity. I appeal for the swift removal of all military presence from cultural sites, in respect of international obligations of all parties involved in the conflict". The images below show some of this devastation in Syria (UNESCO,2014).


Aleppo City


Walls of the Great Mosque


Umayyad Mosque of Aleppo


Ablution fountains


Site of Palmyra Great Mosque


Ancient statue, Palmyra

1.2. Iraq

The 2003 Iraq War caused immense suffering and thousands of deaths in addition to displacing millions of people. This war and the power vacuum in many areas of the country resulted in the destruction of many heritage listed sites as well as the systematic looting of national museums and artefacts. Since then the international community and UNESCO have managed to return some of these priceless artefacts, however the continued political instability in Iraq since 2003 has resulted in the neglect of its heritage and the inevitable damage and degradation at these sites.

Most recently, the unexpected invasion by extreme groups (ISIL) into great swathes of Iraqi territory has led to the killing of thousands of people and the displacement of over 2 million people, mainly Turkmen, Shabaks, Christians, Yizidis as well as others. Moreover, Iraqi Assyrian, Akkadian and other priceless artefacts have been looted and sold on the black market on behalf of ISIL(UNESCO,2014). The Hatra historical site has been completely destroyed by explosives. More recently, ISIL has raised to the ground the most iconic Mosul mosque of the Prophet Jonas (Nabi Younis). The cultural vandalism includes the demolition of the mosques of the Prophets George and Sheet wiping out for ever thousands of years of Mosul's history and culture to the dismay and horror of both local people and the international community. Historical churches have been looted and destroyed as well as ancient Christian manuscripts both in Mosul city and now the surrounding Christian areas in Karaqosh, Karamlaise , Bartela, and other religious sites. ISIS also systematically destroyed any historic and religious buildings belonging to minorities such as the Yazidis. Nineveh Province which was occupied by Turkmens, Christians, Shabaks and Yizidis is now completely empty of its original inhabitants. Thousands of years of a diverse, rich cultural and architectural heritage has been lost for all time.

For this reason the author strongly considers that a full digital documentation of the remaining heritage sites should be carried out as soon as possible. This obviously will not stop the further destruction of such heritage, but at least there will be a full documentation available for reconstruction of the destroyed heritage, when the so-called 'Arab Spring' is over!

Quba (Turkmen town near Mosul)
blown up by ISIL, July 2014

Prophet Jonas Mosque, Mosul
blown up by ISIL, July 2014

On 26 July 2014, the UNESCO Director-General, Irina Bokova, called for an immediate halt to the intentional destruction of the religious and cultural heritage in Iraq.

"I am appalled by these brutal attacks on places of cultural and religious heritage," said Irina Bokova. "The destruction of the shrine of Prophet Jonas is a new blow against the rich diversity of Iraq's heritage, cultural and social fabric. Such acts must be stopped immediately. Every layer of Iraq's unique culture, including its religious heritage, must be protected", said the Director-General -- reminding all that the intentional destruction of cultural heritage represents a war crime.

“The diversity of Iraq’s cultural heritage bears witness to centuries of peaceful coexistence among all communities making up the society of the country”, said the Director-General, reiterating her appeal on June 17 for all Iraqis to stand united for the protection of their cultural heritage”.

UNESCO, in consultation with Iraqi and international experts, agreed on an Emergency Response Action Plan to safeguard Iraq’s cultural heritage. The Emergency Response Action Plan defines priority interventions to mitigate heightened risks of destruction and damage, looting and illicit trafficking affecting Iraq’s cultural heritage sites and monuments, museums and their collections, as well as archives in the current situation of renewed violence.

2. Aim of this Paper

The aim of this paper is to highlight the plight of Iraqi and Syrian historic heritage sites, many of which are listed by UNESCO as World Heritage Sites and should be protected by the Hague Convention. This paper will show the urgent need for the digital documentation of remaining ancient sites, particularly in Syria and Iraq. For these reasons this paper will review and evaluate modern Geomatic technology to measure, process and manage Geo Digital Documentation (GDD) for the remaining heritage sites in the Arab world. GDD will help in the preservation, maintenance and reconstruction, in case of their destruction. Furthermore, this paper will also recommend suitable technology for the GDD of existing heritage sites and for the assessment of scale and type of damage due to conflict and intentional destruction.

3. Space Borne Sensors

3.1. Multispectral and Hyperspectral images

Currently there are a number of remote sensing satellites providing images with resolution suitable for heritage and archaeology applications (English Heritage), such as IKONOS, Quickbird, WorldView, GeoEye. GoogleEarth and Bing maps. They provide suitable online imagery to a worldwide audience.

Multispectral imaging using remote sensing satellites was originally used for military reconnaissance purposes (NASA, 2014, Lu,G , Fei,2013). The multispectral image is captured using different wavelengths of the electromagnetic spectrum by dividing the spectrum into bands (NASA, 2014, Lu,G , Fei,2013). The recorded wavelengths are either separated by filters or the instruments (radiometers) and are capable of differentiating between different signals. Multispectral images extend beyond the visible light to such as the near infra-red and infra-red light.

Typically a remote sensing satellite will have on board three or more radiometers (Landsat has seven). Each radiometer will record one digital image known as ‘scene’. The multispectral range is from 0.4µm to 10µm for the visible spectra and from 0.4µm to 0.7 µm or more with a total of seven bands. Thermal imaging may also be captured through remote sensing images (NRC, 2014).These images are captured by thermal sensors from earth emitted infrared energy within 5 to 15 µm. The images may be captured during the day or at night as it is emitted heat not reflected energy. It has a variety of applications including natural or manmade disasters, military and heat loss and pollution monitoring (NRC, 2014). The heat loss monitoring application is a useful tool for monitoring the carbon footprint of cities, towns, residential, commercial and historical buildings (BlueSky, 2014). The images are processed and the interpretation is carried out using special image processing software The hyperspectral images gather and processes data from a wide range of the electromagnetic spectrum with finer resolutions for better object positioning and identification (Gideon Coltof, 2012). This is achieved by obtaining the whole (most) spectrum for each pixel of the scene. Objects are classified with their unique 'fingerprints' known as spectral signatures (Sascha Grusch, 2014). Data from various satellites has been extensively researched for use in many applications such as agriculture, forestry, engineering, geology and soil science, cartography, reconnaissance applications (military), criminology, and others. However, the utilisation of this technology in the heritage field is not fully appreciated (English heritage,2011).This may be partly due to the availability of other technology, or higher resolution such as photogrammetry, space borne Lidar(Light Detection and Ranging) and more recently Terrestrial Laser Scanning with centimetre locational and dimensional accuracy of the surveyed object. It may also be partly due to information technology's practical capability.

With the advance of information technology, the capacity of modern computers to handle vast amounts of data at practical speeds, and the application of MS imaging in assessing natural disasters (volcanoes, floods, earthquakes, wind damage etc.) and man-made disasters such as war, is becoming increasingly important (Wang, F.T. et al, 2011). This is particularly the case in assessing war devastated Syrian cities and heritage sites and the intentional devastation of Iraqi heritage. The importance of this technology in the assessment and evaluation of the damage caused by war and intentional destruction is twofold. Firstly, the data from various satellites is readily available for the war area, day or night, both during and after the war is over. Secondly, the international community, UNESCO and other heritage Arab/Islamic organisations should then do what they can to stop further destruction of the heritage. Once the war is over, the process of damage assessment and limitation will help to speed up the reconstruction of the damaged and destroyed heritage. Digital documentation for the existing heritage should be produced using the full range of data available.

3.2. Global Navigation Satellite System (GNSS)

Most of us are now familiar with the civilian use of GPS (Global Positioning System) operated by the US department of defence through everyday use such as directions to find a place in a city using a mobile phone GPS or a car GPS, in addition to many other technical uses including Air Navigation, Sea Navigation, Surveying and

Mapping, Built Environment, Heritage Surveys and Preservation (Leica Geosystems,2014).

In addition to the GPS (US), there are other satellite constellations that also provide free 24 hour signals. The Russians developed a similar GPS system at the same time as the US. For political and economic reasons the Russian constellation did not have a constellation for full coverage of the earth. However, the Russian Government showed a full commitment to completing the GLONNASS system of satellites *(English Heritage, 2011).* Most modern GPS receivers can receive and process both systems. In addition, Europe is also testing its own navigation system called GALILEO. This is a civilian controlled constellation of satellite system compared to the GPS or GLONASS defence systems. An Indian system (Indian Regional Navigation Satellite System) and Chinese Compass Navigation System are also planned. The GNSS system has been extensively used in field surveys of Heritage sites and historical buildings (English Heritage, 2014,Historic Scotland,2014). GNSS is integrated into Aerial and Terrestrial Photogrammetry for heritage and many other applications in addition to Airborne Lidar and Terrestrial Laser Scanning (leica Geosystems, 2014).GNSS/GIS data collection systems are an efficient but limited way to gather heritage mapping data.

4. Airborne Sensors

4.1. Photogrammetry

This is the science of precise measurements from photography (Wolf, 2000). The photographs may be aerial, using specially adapted aircraft and metric cameras, or terrestrially obtained on the ground surface. Low level aerial photographs are used for precise 3D measurements for many applications, including topographic mapping, man-made and natural features, urban planning maps for cities and towns, engineering and construction, archaeology, heritage documentation and preservation (Wolf,2000, English Heritage,2011). Traditionally, stereo metric aerial cameras are used to produce stereo models of the site. Precise 3D data is measured from these models after photogrammetric restitution using stereo plotters. The density and the accuracy of this data(X, Y and Z) will depend on the flying height of the aerial photography, topography, features measured, and the processing techniques. The cost of flying an area using survey aircraft is relatively high as compared to other available modern technology (English Heritage, 2011). Although this is superseded by various digital photogrammetric techniques, large scale aerial photographs are an important source for many heritage sites, and building information. City and municipal authorities still hold large stocks of aerial photography taken over time. These could be the only remaining source of information about cities and towns devastated in the war in Iraq and Syria. In addition to photographs, maps, plans, elevations, building material, descriptive and historic information provide valuable data to be added to the digital documentation for after-war reconstruction, rebuilding and preservation of heritage.

4.2. Digital Photogrammetry

More recently, with the availability of high definition digital images from both metric and non-metric cameras, digital photogrammetry is becoming an important source of the 3D data and virtual reality (Alshawabkeh et al, 2002) of the photographed scene. The direct acquisition of digital images has a number of advantages in photogrammetric applications such as direct data flow and quality control, high potential for automation, and good geometric characteristic(GMV, 2014). The high-resolution digital cameras used in digital photogrammetry applications provide better image quality with high resolution images based on the Charge Coupled Devices Sensor (CCD), replacing the film images from the digital interchangeable Single Lens Reflex camera (SLR).

The methods used in digital photogrammetric software systems vary according to the specific needs or characteristics of the cultural heritage object. The methods are based on digital image rectification, monoscopic multi-image evaluation, stereo digital photogrammetry, and ortho-images(English Heritage,2014).The large scale images provide precise 3D information for producing various heritage building and site information including site DTM's, DSM, plans, elevations, sections and other details at competitive cost. Digital photogrammetry combined with laser scanning and other technology is extensively used by both English Heritage and Historic Scotland.

4.3. UAV (Unmanned Aerial Vehicles)

Other alternative methods of flying an area are the use of Unmanned Aerial Vehicles (UAV's). Recently a number of UAV's have been developed and used for a variety of applications including heritage preservation (AOC, 2013). High resolution digital cameras are mounted on these vehicles. The overlapping photographs may be processed and converted into scaled photographs (Ortho Photos) using suitable computer programmes based on the photogrammetric principles. The result is a 3D data set of the area including man-made features such as the heritage site and buildings. This may be presented as a footprint for the site or as a Digital Terrain Model (DTM) plus a Digital Surface Model (DSM) of the site showing the various details for the heritage site. Depending on the scale of detail and the information required for the heritage site, this may be a cost effective way of heritage documentation. There are two systems worth discussing for heritage preservation, damage assessment and reconstruction as in the case of Syria and Iraq. The Trimble UX5 is mounted with a large sensor digital camera of 16.1MP and its custom- made optics capable of capturing data to 2.4cm resolution(Trimble, 2014,Korec,2014).The access imaging software is loaded onto the Trimble tablet which automatically checks, monitors and controls the flight of UX5 at 80 kph(Trimble,2014).This is supported by extensive office software that covers all aspects of the photogrammetric processes including real colour clouds, Ortho mosaics, Digital Terrain Models(DTM),GNSS processing/management and Digital

Surface Models(DSM) in addition to supporting non -Trimble UAV platforms(Trimble, 2014).

XactMap Surveys has developed a compact and light UAV (Octocopter) with a Lidar sensor on board which does not need GPS tracking (XactMap,2014). The XactMaps octocopter uses intelligent software instead of heavy hardware and the system can be used both inside and outside of buildings (XactMap,2014). XactMaps Lidar octocopter can viewed in flight at https://www.vimeo.com/86810214.

The UAV surveys are cost effective technology with high resolution that can be used for various heritage applications (Digital Surveys, 2014).

(http://xactmaps.com/the-lidarcopter/,2014)

(http://uas.trimble.com/ux5, 2014)

5. Terrestrial Sensors

5.1. Terrestrial Laser Scanning

The data for heritage application and documentation may be presented in a variety of ways such as 2D/3D data, plans, elevations, sections, aerial or terrestrial photographs and digital images. However with the availability of IT technology, both software and hardware, the need for presenting data as 3D digital information is increasing hyperbolically (Tao, 2004). With advances in technology, a wide variety of techniques in addition to traditional surveying are available for heritage documentation and preservation.

The figure below summarises these techniques in terms of scale and object compared to air borne or even satellite, techniques. Laser scanning, from the air or from the ground, is one of those technical developments that enable a large quantity of three-dimensional measurements to be collected in a short space of time (*English Heritage, 2011*). This document presents advice and guidance on the various survey technologies available to heritage and built environment professionals, so that they can choose the most suitable techniques and technology within their budget and time constraints.

The term “laser scanner” applies to a range of instruments that operate on differing principles, in different environments and with different levels of accuracy. A generic definition of a laser scanner, taken from Böheler and Marbs (2004) is:

"Any device that collects 3D co-ordinates of a given region of an object's surface automatically and in a systematic pattern at a high rate (hundreds or thousands of points per second) achieving the results (i.e. three-dimensional co-ordinates) in (near) real time."

Traditional surveying techniques and technology such as EDM's (Electromagnetic Distance Measurement) and tapes have been extensively used to survey and digitize a natural surface or a man-made structure such as a building. The limitation of these techniques is twofold: a limited number of points will be measured due to time, and the labour constraints of these techniques. In addition to direct survey techniques terrestrial photogrammetry has also been used successfully (English Heritage, 2014). To alleviate these difficulties 3D laser scanning is becoming a popular method for measuring heritage buildings and the built environment at various stages of design, construction, maintenance and decommissioning or preservation

Three dimensional terrestrial laser scanning may be defined as the process of producing a Real Time 3D Digital Surface Model (RTDSM) of the structure (object) by subjecting the surface to a low powered laser light generated by a scanner. A typical laser scanner will use lasers, sensors, computer software and hardware. The scanning results are stored in a large set of digital data which is called the "Point Cloud" for various scans. The scans are imported and a registration is created according to the established control points, and the registered point clouds will be unified into one file to form the RTDSM of the scanned structure using the scanner's relevant software. RTDSM's may also be converted into digital ortho-photos using software such as Point Tools (Bentley Point Tools 2013). The Real Time Digital Surface Model of the structure is represented by 3D space coordinates(X, Y and Z) relative to the instrument station. The relative positional accuracy of the collected data is 5-10mm, depending largely on the scanned surface distance from the scanner and the reflective nature of the surface together with lighting conditions. The data also contains the passive colour (primary) of the material, as different surfaces reflect different laser light intensity. This yields a number of applications in addition to building surveys and building conservation.

The world's largest Laser scanning project (Jacobs, 2010) modelled Istanbul. It is the world's fifth largest city with a population of over 12 million, rich in architecture, and heritage monuments and sites. In 2003 UNESCO designated significant parts of the old city as World Heritage protected sites. Following this, all new developments in this area were banned by the Municipality of Istanbul until 3D models were available for the planners. This project was carried out by Istanbul Metropolitan Municipality's (IMP-BiMTAS) Directory for the Protection of Historical Environment. The project involved the scanning and creation of highly accurate 3D models (5-30mm) of 48,000 buildings, 1500 hectares, 5.5 million $m^2$of façade, and 400 km of busy city streets. The scanning models were supplemented by digital photogrammetric data for key historical buildings and monuments.

Laser scanning like any other surveying technology has limitations. The scanning process yields large amounts of digital data as point cloud. The post processing of this data may a take relatively long time to deliver the final product. This technology is suitable for producing DSM's of the scanned surface and is not capable of penetrating surfaces to deliver subsurface information. Special care should be taken when there is a break in the surface and where there is dense vegetation cover (airborne laser). Instruments' range limitation should also be noted before embarking on scanning. Depending on the scale and constrains of the project the initial cost of this technology is relatively high as compared to digital photogrammetry. In addition, digital cameras provide instantaneous digital images which can be processed into digital data, thus saving time and cost.

5.2. Handheld Scanners

The recent advances in laser scanning and information technology led to improving the efficiency, accuracy, economy and practicality of instrumentation. One of the devices that does not follow the traditional methods is the handheld laser scanner Zeb1 (weighting less than 0.7kg) developed by CSIRO scientist Dr Elliot Duff and his team(Zeebee).The scanner is mounted on a flexible neck(spring) which enables it to measure in confined spaces such caves, gorges, and buildings(Digital Surveys,2014). The device does not need a GPS unit for tracking and referencing. The scanner is operated by software that requires only basic training. Zeb1 uses image recognition software and inertial device for a full scene point clouds. The Director of the Australian Museum, Frank Howarth said "Their quick and easy scanning is a revolution for bio-physical measurement of cultural heritage sites and tracking of environmental changes—no other technology comes close,"(Digital Surveys, 2014). The scanned site data will be uploaded onto the company's site for processing. The cost of the service is based on the size (m3) of scanned space but at a relatively competitive price. This could a useful device for scanning partially damaged buildings or heritage sites such as the ones in war torn Syria and Iraq in addition to the existing buildings and other heritage sites for damage assessment, reconstruction and preservation.

6. Multi-Sensor Systems

With the rapid advance of computers and IT, Geomatic Systems are at the forefront of the application of this technology. Recently, a number of multi-sensor systems have been used in surveying cities, towns and infrastructure in addition to heritage sites and buildings. For example, streetMapper360 of 3D laser Mapping Ltd and IGI, Paguses of Leica Geosystems and Google Street View and Google Earth.

6.1. StreetMapper

StreetMapper was developed as a joint venture between 3D Laser Scanning(UK) and IGI(Germany), specialists in guidance and navigation systems for accurate collection of laser scanning data from a moving vehicle. The two companies worked closely for the development and worldwide distribution of laser technology solutions. The on board navigation systems are GPS, a gyro based inertial system(IMU), and the recent Direct Inertial Aiding(DIA) systems to help with GPS signals' cutting off 's, with 360 degree field view and a capacity of 300000 points per second per sensor. StreetMapper 360 offers an efficient, practical, large scale laser scanning data capturing system with sub-centimetre positional accuracy at lower cost than the static laser systems (3D Laser Scanning Ltd, 2014). A high resolution DSLR camera may also be added to the system to capture still or video recording of the surveyed area. The new compact scanning pod of StreetMapper 360 includes two scanners and three digital cameras. The system has been used successfully on a number of infrastructure projects including highway maintenance and improvement, city mapping, public safety, and European and international projects. The national mapping agency of UK, the Ordnance Survey, used the StreetMapper in combination with other laser scanning systems to produce a full 3D digital survey of the English resort city of Bournemouth. The survey contained over 700 million 3D points of the city (3D Laser Scanning Ltd, 2014).Glen Hart, Head of Research OS,UK, "This combination of technology, including the contribution from StreetMapper, could change the way we map the country and also have a massive impact on things like personal navigation, tourism, the planning processes and town centre management as well as aiding architects and the emergency and security services."

6.2. Leica Geosystem Pegasus

The newly marketed Leica Geosystem's Pegasus two is another multi-sensor system similar but different to StreetMapper 360. Pegasus two has just superseded Lieca's Pegasus one .Pegasus two is a digital mapping that is vehicle independent, economical, multi-sensorplatform (Leica Geosystem,2014). The system provides all software and hardware including high resolution DSLR cameras, laser scanners, GNSS and inertial measurement unit as a complete mapping station which can be loaded on vehicles, aircraft and other moving bases. With 360 spherical field view the system provides digital imaging, and Lidar data as point clouds for many practical application including city surveys and heritage digital documentation at various scales. The system software enables access ESRI ArcGIS for desktop.

6.3. Google Street View

The Google street Mapper is a multi-sensor system car mounted that captures 360 degrees panoramic(stitched images) views of the scene with a sixteen lens camera(mail online,2014).The camera uses 5 megapixel CMOS sensors with low flare lenses plus a fisheye lens to capture taller buildings(GSV,2010). The exposure station(camera) positioning of Google view is done by Global Positioning System integrated into the camera hub and Inertial Measurement Unit(IMU), wheel speed sensor together with laser scanners capable of measuring point clouds up to 50m from the camera position(GSV,2014). Feature positioning is done by intersection and resection techniques from known camera positions using the overlapping panoramic views. The root mean squared errors of predetermined point positions are of ±0.522m, ±1.230m, and ±5.779m for intersection and ±0.142m, ±1.558m, and ±5.733m for resection in X, Y, and h (elevation), respectively(Victor J. D. et al ,2012). The hardware is supported by data capturing, ArcGIS and post processing software. Google Earth is satellite imagery of worldwide coverage and is an audience web based open access system. Every day millions of people view their own area and street using Google Street View and Google Earth. It should be mentioned that in some areas the Google Street View and Google Earth images may not match correctly (Curtis et al, 2013). It should also be noticed that Google Street View (GSV) is not designed for precise geospatial applications. Nonetheless the richness and ease of access of worldwide GSV data through the web can be an important source for many built environment and heritage applications. One of the interesting applications of this enormous source of geospatial data is the production of 3D cities (Mail online, 2014). The data could be of great benefit for Heritage applications. This is particularly useful in the war damage assessment of cities and heritage sites in Syria, Iraq and other parts of the world. Combining the street views(if available) with Google Earth satellite images before and after war destruction of the conflict areas together with the historical data of the site would help in the reconstruction, restoration and preservation of heritage structures.

(Digital Surveys, 2014)

(Leica Geosystems, 2014)

(Google Mapper, 2014)

7. Data Management Systems

7.1. Geographical Information Systems (GIS)

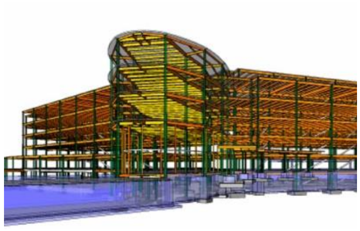
As the information for heritage projects may consist of both metric and non-metric data such as maps, plans, sections, photographs, site information and historical data, Geographical Information Systems(GIS) is a technology medium for organising and managing this data. GIS is an IT system which allows the entry, storage, analysis, interrogation and visualisation of the digital data. The system stores and manages metric and non-metric data sets in layers interlinked to spatial geo-referenced location through the GIS database (Petrescu, 2007). This is a multi-directional editable system that allows the creation of specific application GIS. The system relates the various data through a geographical location index in a similar fashion to that of relational data bases which use a common index to relate different data sets. For example, in the case of heritage buildings the geographic data stored as X Y and Z coordinates may contain other data such as date, time, and address of the building, construction materials, building methods, structural conditions, historical importance etcetera. This is a very useful facility for archaeologists, conservationists, architects, engineers and other heritage professionals. Heritage GIS (HerGIS) can be interrogated for specified information. The heritage professional may then analyse, interpret the data and make the appropriate informed decision. There are a number of GIS commercial desktop systems on the market such as ArcGIS, MapInfo, Intergraph, Smallworld etcetera, but the most useful may be those that are open source and offer free online access: GIS systems GRASS GIS, MapWindow GIS, Capware etcetera. GIS data collection using GNSS and management are an efficient and relatively cost effective method for archaeological and heritage data procurement (English Heritage, 2014, Historic Scotland, 2014). There are a number of GNSS/GIS data collectors available commercially including Leica Geosystems and Topcon, Trimble and others.

7.2. Building Information Modelling (BIM)

Building Information Modelling (BIM) may be defined as the process of creating and managing building data from the conceptual design stages through to demolition. BIM is a digital three-dimensional, real-time, dynamic building management system in which you can increase productivity and improve quality throughout building design, construction, use, maintenance, demolition or preservation as heritage building. The system inter-connects the spatial building data to all construction materials, processes, uses and maintenance throughout its functional life to demolition, which can be shared by all parties.

The UK Government Construction Strategy was published by the Cabinet Office (May 2011). A report announced the intention to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016. In July 2011, the Government/Industry BIM programme commenced a four year programme for sector modernisation with the key objective of reducing capital cost and the carbon burden from the construction and operation of the built environment by 20%.This depends on a simple assumption that there would be a considerable saving in cost, time, value and carbon emissions by making project data available as open source sharable data between various stake holders. A collaborative approach is at the heart of BIM. This will encourage the adoption of most efficient techniques, technologies and processes and share best practices. The BIM task group is helping to spread the objectives of the Government’s Construction Strategy to support and strengthen public sectors institutions and all central government departments in the adoption and implementation of a collaborative BIM level 2 by year 2016 (BIM, Task Group,2013).


(Amvic, 2014)


(Cadalyst, 2007)

7.3. Heritage BIM (HerBIM)

BIM is designed for new built environment projects with novel software (Fai et al, 2011). This allows 3D visualisations with an extensive multifaceted parametric data base that facilitates an integrative and collaborative approach between the stake holders (Russell, P. and Elger, D, 2008). BIM may also be used for the 3D digital documentation of heritage buildings. BIM can accommodate heritage data which consists of various data including manual surveys, nonmetric and metric photography, maps and plans, aerial and terrestrial photogrammetry, ortho-photos and images, laser scanning, topographical, municipal and historical data of cultural importance. BIM is an ideal IT technology that allows the integration of this data into one 3D system. The software also facilitates the archaeological and cultural studies, and planning of maintenance and preservation work for heritage buildings. BIM software also allows for the integration of construction materials and methods for such buildings (Autodesk Revit,2013). For heritage building preservation, this data combined with geographical locations both inside and outside of the building provides an efficient tool for the study of the building and design remedies. It also provides a better understanding of the materials and the construction methods used for the cost effective and efficient maintenance of heritage buildings. A good example of HerBIM is the Batawa project (Fei, S. et al, 2011) located northeast of Toronto, Canada which consists of one hundred houses, two unused factories, three commercial buildings and two municipal facilities (Fei et al, 2011) established in 1939.The context of this was the development of 600 hectares of land that includes the town and its rich history. Various parametric and metric data were included in the HerBIM model (including the historical data) and then processed using AutoCAD, Revit, Civil 3D, SketchUp. The model also includes a point cloud generated from Terrestrial Laser Scanning.

8. Conclusions and Recommendations

Innovation and advances in the fields of science and Information Technology have led to parallel innovation and development in fields of geo-informatics and, in particular, laser technology and high resolution DSLR cameras. There exists a wide range of geospatial sensors including space, airborne, terrestrial and multi-sensors. The hardware is supported with an extensive range of data capture, processing software and computer power. However, the recent advances in laser scanning and the associated software and hardware have revolutionised methods of data capturing and processing. Space and airborne Lidar data constitute an important technology in archaeology and heritage sites preservation (English heritage, 2014). Terrestrial laser scanning combined with digital photogrammetry is a cost effective, efficient and accurate method for both inside and outside surveys of heritage sites and buildings (English Heritage, 2014, Historic Scotland, 2014).The UK recently adopted the Building Information Modelling (BIM) system for new built environment projects (BIM Task group, 2014) which could be a suitable data storage and management system for heritage applications as an alternative to GIS (Fai et al,2011). Space borne sensor such as multi-spectral satellite and Lidar data are important sources of information for the war damage assessment of cities and towns in Syria and Iraq both during and after the conflict is over. Terrestrial laser scanning and digital photogrammetry are also efficient and cost effective technology for the production of accurate large scale 3D data in the form DTM, DSM, 3D cities and plans, elevations, sections for individual buildings, monuments and other structures. The digital documentation produced combined with historical data can be used for the reconstruction of the destroyed heritage, restoration of the partially damaged structures, and preservation of the existing ones. Furthermore, due to the continuing war and expansion of extreme groups such as ISIL, this research urgently recommends the production of a full digital documentation of the remaining heritage sites and priceless historical artefacts using advanced laser technology including terrestrial static, vehicle based ,air and space borne sensors together with associated soft and hardware in Syria. This is particularly important for the preservation of the remaining Iraqi heritage.

9. References

3D Data Acquisition and Object Reconstruction for AEC/CAD - Directions Magazine. 2014.. [ONLINE] Available at: http://www.directionsmag.com/articles/3d-data-acquisition-and-object-reconstruction-for-aeccad/123668. [Accessed 07 September 2014].

3D Data Acquisition and Object Reconstruction for AEC/CAD - Directions Magazine. 2014. [ONLINE] Available at: http://www.directionsmag.com/articles/3d-data-acquisition-and-object-reconstruction-for-aeccad/123668. [Accessed 07 September 2014].

Amvic Building System Smart BIM, revit files, CAD drawings of Amvic ICF . 2014.. [ONLINE] Available at: http://www.amvicsystem.com/bim. [Accessed 07 September 2014].

Autodesk | 3D Design, Engineering & Entertainment Software. 2014.. [ONLINE] Available at: http://www.autodesk.co.uk/. [Accessed 07 September 2014].

BBC News - What is Islamic State?. 2014. BBC News - [ONLINE] Available at: http://www.bbc.co.uk/news/world-middle-east-29052144. [Accessed 07 September 2014].

Bentley Point Tools 2013. Available from: http://www.bentley.com/en-US/Promo/Pointools/pointools.htm?skid=CT_PRT_POINTOOLS_B [Accessed 07 September 2014].

BIM Task Group | A UK Government Initiative. [ONLINE] Available at: http://www.bimtaskgroup.org/. [Accessed 07 September 2014].

Bluesky aerial photography, LiDAR, Tree Mapping and GIS data. 2014. [ONLINE] Available at: http://www.bluesky-world.com/#!bluesky-maps-heat-loss-from-homes-with-n/c6g5. [Accessed 07 September 2014].

Boehler, W. and Marbs, A, 2004. 3D Scanning and Photogrammetry for heritage recording: a comparison, Geoinformatics, June 2004, Proc. 12th Int. Conf. on Geoinformatics − Geospatial Information Research: Bridging the Pacific and Atlantic University of Gävle, Sweden.

Cadalyst - The Five Fallacies of BIM, Part 1 (1-2-3 Revit Tutorial). 2014. [ONLINE] Available at: http://www.cadalyst.com/aec/the-five-fallacies-bim-part-1-1-2-3-revit-tutorial-3688. [Accessed 07 September 2014].

Cavallo, M, 2014. The Glasgow Urban Model,smart cities and exploring urban change in 3D. Geomatics World, August 2014.

CHAPTER 4 - REMOTE SENSING IN NATURAL HAZARD ASSESSMENTS. 2014.. [ONLINE] Available at: https://www.oas.org/dsd/publications/Unit/oea66e/ch04.htm. [Accessed 07 September 2014].

Curtis, J. et al, 2013. Using google street view for systematic observation of the built environment: analysis of spatio-temporal instability of imagery date. International Journal of Health Geographics.

Daniel, S and Doran, M.A, 2013. Geo Smart City: Geomatics contribution to the Smart City. ACM. June 2013.

Digital Photogrammetry | Geospatial Modeling & Visualization. 2014. Digital Photogrammetry | Geospatial Modeling & Visualization. [ONLINE] Available at: http://gmv.cast.uark.edu/photogrammetry/. [Accessed 07 September 2014].

Digital Surveys For 3D Laser Scanning and LiDAR Surveying. 2014. Digital Surveys For 3D Laser Scanning and LiDAR Surveying. [ONLINE] Available at: http://www.digitalsurveys.co.uk/. [Accessed 07 September 2014].

English Heritage, 2011. 3D Laser Scanning for Heritage, English Heritage Publishing.

English Heritage Home Page | English Heritage . 2014. English Heritage Home Page | English Heritage . [ONLINE] Available at: http://www.english-heritage.org.uk/. [Accessed 07 September 2014].

Fai S. et al (2011). Building Information Modelling and Heritage Documentation. CIPA 2011 Conference Proceedings: XXIIIrd International CIPA Symposium., Prague.

Google 3D now lets users explore London's buildings using 45-degree aerial imagery. [ONLINE] Available at: http://www.dailymail.co.uk/sciencetech/article-2694769/Google-3D-lets-users-explore-Londons-buildings-using-45-degree-aerial-imagery.html. [Accessed 07 September 2014].

Google Lat Long: Meet the new Google Maps: A map for every person and place. 2014. Available at: http://google-latlong.blogspot.co.uk/2013/05/meet-new-google-maps-map-for-every.html. [Accessed 07 September 2014]

Google Street View: Capturing the World at Street Level. 2014. Google Street View: Capturing the World at Street Level. [ONLINE] Available at: http://doi.ieeecomputersociety.org/10.1109/MC.2010.170. [Accessed 07 September 2014].

Grusche, S., 2013. Basic slit spectroscope reveals three-dimensional scenes through diagonal slices of Hyperspectral cubes. Applied Optics, Volume 53 (Issue 20), pp. 4594-4603.

Historic Scotland - the official website. 2014. Historic Scotland - the official website. [ONLINE] Available at: http://www.historic-scotland.gov.uk/. [Accessed 07 September 2014].

Hussain, M. et al, 2013. Change detection from remotely sensed images: From pixel based to object based approaches. ISPRS. 2013.

Hyperspectral Techniques Explained. 2014. . [ONLINE] Available at: http://www.bodkindesign.com/wp-content/uploads/2012/09/Hyperspectral-1011.pdf. [Accessed 07 September 2014].

Hyperspectral Systems Increase Imaging Capabilities. 2014. Hyperspectral Systems Increase Imaging Capabilities. [ONLINE] Available at: http://spinoff.nasa.gov/Spinoff2010/hm_4.html. [Accessed 07 September 2014].

Jacobs, G., 2010. Modeling Istanbul: World’s Largest Scanning Project, Reporter 63,The Global Magazine of Leica Geosystems.

Home - Leica Geosystems - United Kingdom. 2014. Home - Leica Geosystems - United Kingdom. [ONLINE] Available at: http://www.leica-geosystems.co.uk/en/index.htm. [Accessed 07 September 2014].

Lu, G. and Fei, B., 2013. Medical Hyperspectral Imaging: a review. Journal of Biomedical Optics 19

Home | Mail Online. 2014. Home | Mail Online. [ONLINE] Available at: http://www.dailymail.co.uk/home/index.html. [Accessed 07 September 2014].

Mensura | Autumn 2013 - Korec. 2014. Mensura | Autumn 2013 – Korec. [ONLINE] Available at: http://www.korecgroup.com/media/MensuraAutumn2013.pdf [Accessed 07 September 2014]

Petrescu, F, (2007). The use of GIS technology in cultural heritage. In XXI International CIPA Symposium. Athens, 1-6 October.

Research and Technology Organisation (RTO), 2007. Survey of Hyperspectral and Multispectral Imaging Technologies. RTO Technical Report for NATO.

Russell, P. and Elger, D (2008). The Meaning of BIM, Architecture in Computro. Proceedings of the 26th eCAADe September 2008 Conference, Antwerp.

Thermal Imaging | Natural Resources Canada. 2014. Thermal Imaging | Natural Resources Canada. [ONLINE] Available at: http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9319. [Accessed 07 September 2014].

Tsai, V.J.D and Chang, C., 2012 Feature positioning on Google Street View panoramas. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume 14 2012.

UNESCO, 2013. Director General deplores continuing destruction of ancient Aleppo, a World Heritage site, 25 April 2013.

UNESCO. 2014. The destruction of Syria's cultural heritage must stop: joint statement by the UN Secretary-General, the UNESCO Director-General; and the UN and League of Arab States Joint Special Representative for Syria, 12 March 2014.

Wang, F.T. et al, 2011. Application and prospect of multi-spectral remote sensing in major natural disaster assessment. Guang Pu Xue Yu Guang Pu Fen Xi, pp. 577-582.

Wolf, P., Dewitt, B and Wilkinson, B., 2000. Element of Photogrammetry with Applications in GIS, New York: McGraw Hill.

Zimmerman, P., 1990. The Role of Remote Sensing in Disaster Relief in Communication When It's Needed Most: How New Technology Could Help in Sudden Disasters. Report of the International Disaster Communications Project.