AREAS OF APPLICATIONS OF CLOSE-RANGE PHOTOGRAMMETRY

(web.itu.edu.tr/~seker/files/Application-Areas.doc)

The ever-expanding areas of application of close-range photogrammetry can be grouped into three major areas: architectural photogrammetry, biomedical and bioengineering photogrammetry (biostereometrics) and industrial photogrammetry.

ARCHITECTURE

It is noteworthy that the very first measurements ever made by photogrammetry (in the middle of the 19th century) had to do with monuments. It is also a fact that an architect introduced the term "photogrammetry",

Albrecht Meydenbauer, who made his first photogrammetric surveys in 1867. For over century, photogrammetric methods and equipment have continued to evolve. More recently, the field of architectural application of photogrammetry has undergone considerable expansion both in scope and diversity.

SURVEYS OF HISTORICAL MONUMENTS

Photogrammetric surveys of historic monuments can be grouped in three major categories: rapid and relatively simple surveys, accurate and complete surveys, and very accurate surveys.

a) Rapid And Relatively Simple Surveys

These are used in preliminary studies for restoration and improvement, in inventory work, and in the study of the history of art. Stereometric cameras and other small format photogrammetric cameras are used extensively, together with "normal case stereo plotters". Plotting is generally at a scale of 1:100. To simplify the operations, inclined photography is taken at standard angles and slope calculators are used.

b) Accurate and Complete Surveys

These are used for systematic documentation of architectural heritage. Plotting scale is generally 1:50, while the details are mapped at 1:20 or 1:10. Large-format metric cameras with long focal lengths are preferred in this type of work in view of the accuracy requirements and the sizes of buildings surveyed. The recently developed wide-angle cameras having local lengths ranging between 100 mm to 150 mm are particularly suitable for this class of photogrammetric surveys.

Accurate surveys are used to document the technical history of the construction of the monument and its evolution as time passes, also to analyse its structural lines and to document its condition and its need for conservation and restoration. This is why one needs high accuracy and precision and as detailed a survey as possible. The use of "first order" stereo plotters is, therefore, essential. Furthermore, normal case photography is often not possible due to the difficult conditions frequently encountered. In some countries, precision photogrammetric surveys have been made for "technical monuments" such as ancient bridges and viaducts of artistic value.

A special case of accurate photogrammetric surveys is the survey of building exteriors (facades). Such surveys are carried out, particularly in central Europe, for the systematic documentation of harmonious architectural groups formed by series of houses in a street or on a square in ancient urban centers in towns and villages. Because of space limitations, facade photography is often taken at an upward inclination (e.g. 30^g or 70^g) or from an elevatable platform on a special truck.

A second special case of accurate photogrammetric survey is the partial detailed survey of particular parts of monuments. Such surveys are conducted in conjunction with restoration and consolidation projects. The highest possible accuracy is needed for these purposes. Depending on the needs, the final outputs of the survey can be in the form of plans, cross-section s, elevations, profiles (for arches), contours (for vaults and cupolas), and/or numerical data giving accurate dimensions between the main elements of the building or distances between these elements.

The photogrammetric surveys conducted in the framework of UNESCO campaigns to salvage prestigious monuments such as About Simbel, Philae, Petra, Borobudur, are good examples of accurate and complete photogrammetric survey.

c) Very Accurate Photogrammetric Surveys

These are needed for highly refined studies. Accuracy requirement is generally in the order of 1 mm and in some cases 0.1 mm. The study of sculptures in monuments and the assessment of the evolution in the surface of defaced stones (in support of chemical and physical investigations into the “disease of the stone”) require this very high accuracy. The principal difficulty in such cases is encountered in photography. Metric cameras permitting short object distances (e.g. by having variable principal distance or through the use of additional lenses) are of great help in this type of work.

OPERATIONAL PROCEDURES

Procedures for all of the above-discussed types of photogrammetric surveys are well established and documented. Independent stereopairs of photographs are taken either horizontally, vertically or at some inclination using the camera(s) most suitable for the individual project. Base-to-distance ratio is kept rather small (1/5 to 1/15). External controls are kept as simple as possible (such as number of distances and checks on the levelling bubbles of the camera). In case of complex object, however, a network of reference points is necessary. Camera stations are normally located on the ground, on scaffoldings, on nearby buildings, on a hydraulic lift truck or even in helicopters, which are sometimes used to take horizontal photographs of the upper portions of tall buildings.

The photographs are catalogued and stored in “photogrammetric archives” and are plotted only when the need arises. Plotting is mostly done using analogue instruments.

In some photogrammetric surveys, rectifying and assembling a ground of photographs produce photo-plans. This technique is particularly suitable for plane surface of murals, for mosaics, for windows and for facades, particularly when the streets are narrow. In this case, photography is systematically taken at a given inclination and rectified in simple instruments. This approach is appealing both from the technical and economical view.

Orthophotography has recently been experimentally applied in Italy on photography of interiors of cupolas and in Germany and Poland for decorated surfaces with some relief.

Some architectural surveys are made by analytical photogrammetry. In this approach, a certain number of points are accurately determined and then connected by architectural lines. Such a method is not applicable to complex and important monuments because it often involves too many assumptions on the course of the lines to be drawn between points thus giving a theoretical rather than a real representation. On the other hand, analytical methods can be advantageously applied in schematically treating groups of simple constructions, as has been done in Scandinavian countries.

The analytical approach is particularly suitable in studying the structure of monuments and in checking on their stability through the use of digital models. By forming digital models encompassing the monument's fundamental points and the skeleton of its structure, one can study the proportions, define the volumes, compare the form etc. By repeating these operations at intervals of time, one can follow and measure eventual deformations in the building and thus check on its stability. By targeting the points involved in the analytical increases the precision of the observations and the accuracy of the solution.

Both the analogue and the analytical approach lead to numerical data, which is used to determine architectural forms. Using a computer, one can determine the curve of surface that best fits the group of points measured, according to the method of least squares.

(Archaeological surveys, surveys on historic sites)

BIOSTEREOMETRICS (BIOMEDICAL AND BIOENGINNERING APPLICATIONS OF PHOTOGRAMMETRY)

The study of biological form is one of the most engaging subjects in the history of human thought, which is hardly surprising considering the immense variety of living things. As new measurement techniques and experimental strategies have appeared, new fields of inquiry have been launched and more minds have become absorbed with the riddle of biological form. Discovery of the microscope and X-rays prompted the development of microbiology and radiology, respectively. More recently advances in electronics; photo optics, computers and related technologies have helped to expand the frontiers of morphological research. Growing interest in the stereometric analysis of biological form typifies this trend.

Measurements of biological form and function were made from stereophotographs in the middle of the 19^{th} century, shortly after the invention of photography. Why has it taken so long to establish a real place for photogrammetry in the biomedical world? Limited Space does not permit a detailed discussion of this questions: suffice it to say that the problem of bringing photogrammetrist and biomedical specialist together is a bit like trying to unite two tribes who speak different languages and are separated by uncharted territory. In this metaphorical setting, biostereometrics can provide the interpreter-guides needed to negotiate the no-mans land and make more durable connections than those, which have occurred by serendipity alone.

Over the years, contacts between photogrammetrists and biomedical specialists have been quite numerous but most of the contacts involved trying to tie photogrammetry to a particular biomedical speciality. Unfortunately, these efforts generated surprisingly little sustained interaction. Recently, the more wide-ranging approach of systematically relating stereometric analysis to biology and medicine in general has proved to be a more fruitful strategy.

If biological structures were regular geometric shapes, there would be no great problem measuring them because simple lengths, breadths, and circumferences would be entirely adequate. But as well all known, organism have irregular three-dimensional components and linear “atomistic” measures such as are produced by tapes and callipers cannot give an unambiguous, comprehensive spatial qualification of a part of an organism as a whole.

Biologist and medical specialists are showing renewed interests in the stereometric analysis of biological form. Recent advances in computer technology and a growing range of stereometric sensing techniques have helped to expose the potential of biostereometrics. As a result, the use of photogrammetry is growing in such fields as: aerospace medicine, anthropometry, child growth and development, dentistry, marine biology, neurology, orthodontics, orthopedics, pediatrics, physiology, prosthetics, radiology, and zoology, to mention a few.

The need for biostereometrics stems for from the fact that linear tape and calliper measurements of inherently irregular three-dimensional biological structures are inadequate for many purposes. When stereometric data are used to fill this information gap the potentials for achieving more realistic models and making a more thorough analysis of biological form and function are far reaching. However, the best tools in the world confer no advantages unless they are used wisely. A petroleum geologist is expected to have the necessary training to select promising sites for oil exploration. Similarly, training in biostereometrics can be helpful in making decisions about “when” and “where” to use photogrammetry in biomedical research and clinical practise.

As the potentials of stereometric analysis in biology and medicine become more widely recognized, the role of biostereometrics in helping to unravel the complexities of organic form and function should continue to grow. Already, several photogrammetrists have chosen careers in biology and medicine and this number is expected to increase over the next few years.

INDUSTRIAL PHOTOGRAMMETRY

Photogrammetry has been applied in numerous industrial fields and the potentially for further expansion and growth is seemingly limitless. Industrial photogrammetry has been described as “application of photogrammetry in building construction, civil engineering, mining, vehicle and machine construction, metallurgy, ship building and traffic, with their fundamentals and border subjects, including the phases of research, planning, production engineering, manufacture testing, monitoring, repair and reconstruction. Objects measured by photogrammetric techniques may be solid, liquid or gaseous bodies or physical phenomena, whether stationary or moving, that allow of being photographed" by Meyer (1973).

The experiences in the fields of architectural photogrammetry and biostereometrics clearly indicate the effectiveness of this strategy. The consistent use of term "industrial photogrammetry" should be instrumental in drawing the attention of photogrammetrist and equipment manufacturers to this fertile field of application, and should be helpful in bringing the capabilities of photogrammetry to the attention of the various industries. Tis way, it is hoped that more and more industrial concerns would make full use of the economical and technical advantage of photogrammetry.

Economic benefits of derived from photogrammetric approach has been stated as;

Measurement time on the object is reduced by %90 - %95,
Saving in manpower,
Reduce machine and time for blade machining through optimisation of the metal removal rate,
Reduced material expenditure in the propeller casting manufacture through optimised molds,
A cut in recycling time for non-ferrous metals,
Shorter production time for propeller manufacture.

Photogrammetric technique is equally suited for other industries where work-pieces of a complex surface configuration are to be manufactured, which would be very time consuming to measure with conventional measuring tools. A review of selected application in metal working industry has confirmed that photogrammetric techniques can be both practical and economically feasible for industrial measurements inspection tasks. The development of a systematic approach to implementing such application is necessary to investigate the reduction of start-up costs, operating costs and equipment costs.

Examples of Industrial Applications

- Automobile Construction
- Mining Engineer
- Machine Constructions
- Objects in Motion
- Shipbuilding
- Structures and Buildings
- Traffic Engineering