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ARCHITECTURAL PHOTOGRAMMETRY

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INTRODUCTION TO ARCHITECTURAL PHOTOGRAMMETRY

Photogrammetry is the science of surveying or map making by means of measurements taken from photographs. Principles have been developed that allow photographs of ground planes, structures and landscaped areas to be accurately measured in three dimensions. The three dimensional measurements can then be transferred to two dimensional recording techniques such as architectural drawings.

The purpose of architectural documentation is to preserve the precise physical characteristics and the ambience of a structure, monument or excavation. It should be in the form of an analytical and unbiased critical report accompanied with drawings and with photographs to support it's authenticity.

The documentation must retain the aesthetic and historical value as well as unexplored traits, whose significance may not be known untill future research uncovers them and their importance.

Photogrammetry provides a practical and economical answer to recording buildings or features in their true three dimensional state. This replaces ordinnary hand measuring and drawing techniques that would prove to be too time consuming or impossible to accomplish.

Photogrammetry is ideal where an immediate documentation of a structure is required due to impending or inevitable destruction. It provides a precise and impersonal manner in which to preserve the complete original character of the building which may be lost in an restoration effort or the destruction of the building.

The expense of recording with photogrammetry techniques is related to the degree of accuracy that is required for a specific case. Recent technological advancements in equipment have produced accuracy to within 1 mm.

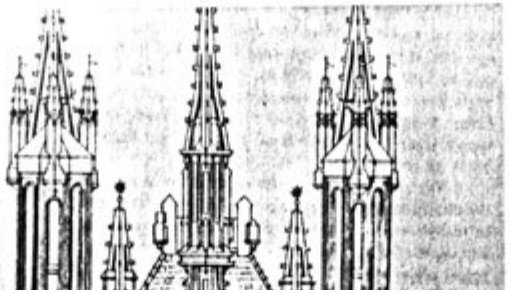
PROBLEMS SOLVED IN RESTORATION WITH PHOTOGRAMMETRY

Photogrammetry locates as well as solves many problems that arise during the study and documentation of a building. This allows the structure to be more easily restored because these problems are discovered and resolved before the restoration begins.

Obvious deformations in the structure due to sinking foundations, excessive loading,earthquakes and other minor causes must be accurately recorded in order to preserve the actual character and original state of the structure. The extent and type of deformation as well as the extent of restoration to

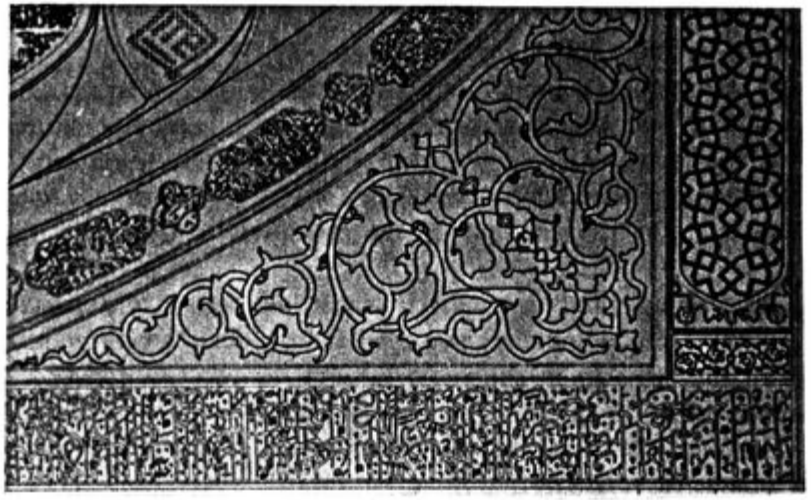
The optical refinements occur as variations of adapted normal dimensions and deviations from a straight line or plane that is supposedly horizontal or vertical. An example of this is the column entasis deviation of 17.5 mm or the corona deviation of 1/100 on the cornice of the Parthenon. Intended deviations such as these must be located in order to assure an accurate documentation and their preservation in the restoration of a building.

The problem of recording irregularities and complexities in building designs and materials can be easily solved with photogrammetry techniques. Undulating, asymmetrical and irregularly shaped facades and walls which would have consumed many man hours to measure, can now be cut to a fraction of that time.



Curved surfaces, interpenetrations of curved planes sculptures and intricate structural members are very difficult, if not impossible to measure and properly transfer into architectural drawings. The use of photogrammetry contour plotting with stereopairs of photographs will easily measure the most complicated shape to within 1mm. of accuracy.

Frescoes and mosaic designs can be easily and accurately recorded with photogrammetry to allow easy and accurate reassembly or reproduction in a restoration effort.

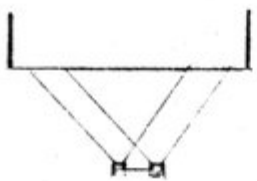


Accurately recording traces of hand hewing, dowels, lifting holes and previous restorations or remodelings on structural members can easily and accurately be

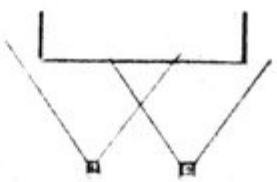
OPERATIONAL PROBLEMS WITH PHOTOGRAMMETRY

Exterior surroundings and interior spatial arrangements of a building to be documented may often impose restrictions that must be delt with. This determines the type of instruments and photogrammetry methods that will be used to obtain the desired results.

When the distance from the camera to the building is too short for a stereocamera, two widely spaced individual cameras may be used in it's place to attain the proper results.



STEREOCAMERA



INDIVIDUAL CAMERAS

The problem with this is if the cameras are placed at too great an incline from the principle axis, restrictions occur due to limitations of the equipment.

If vegetation interferes with a camera position that is perpendicular to the wall to be photographed, the camera may be relocated to a corner of the wall. This allows a clear photograph to be taken but requires the use of the more complicated analytical restitution technique in place of the analogue restitution or rectification process.

PHOTOGRAMMETRY CAMERAS

Photogrammetry requires the use of special cameras that are designed for the purpose of attaining a high degree of accuracy. The most commonly used are the stereometric and the individual camera.

The older phototheodolites are periodically used for site architectural documentation but are rarely used for building documentation.

The amateur 35 mm and 2¼ format cameras can also be used for photogrammetry but are limited in their accuracy and the type of equipment that can be used to process them.

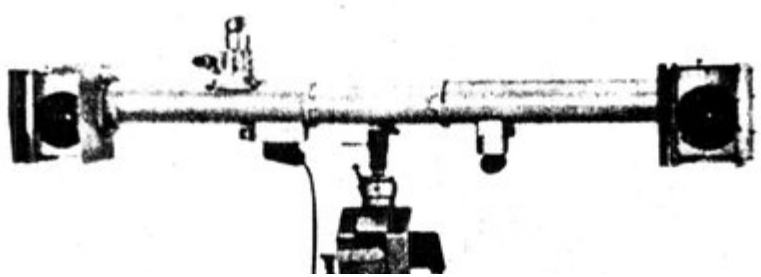
A. Phototheodilites

The phototheodolite is designed primarily for topographical surveying and is therfore usually unsuitable for building surveying. The problem with this type of camera that limits its use for

B. Stereometric Camera

The stereometric camera or stereocamera is composed of two camera bodies mounted on a tubular base of a fixed length. The fixed length and geometry of the base and camera positions set a maximum and minimum limit of operation. These limits set the range of the camera to object distance and the degree of accuracy. Operation of the camera within these limits produces highly accurate results.

The stereocamera is easier to use than the two individual cameras because there is no need to maintain a crucial measurement between the two cameras since it is already fixed.



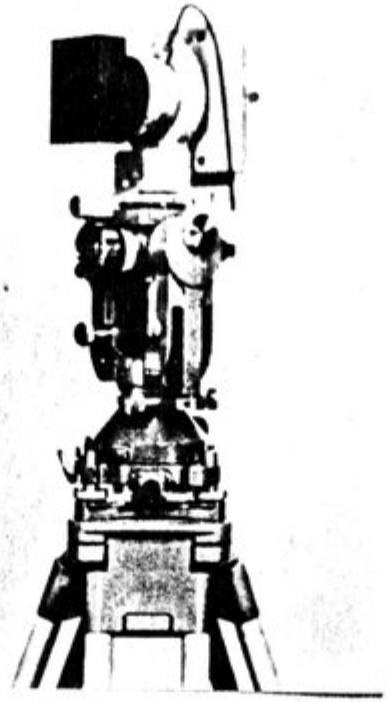
A drawback to the stereocamera with a normal field of view is that it must be placed far enough away from the subject to allow the entire facade or wall to be photographed at once.

Recent developments in stereocameras has produced a wide angle lens with a short principal distance that reduces the required distance to the object . This greatly reduces one of the camera's biggest drawbacks.

Glass plates are the most widely used type of photographic vehicle. This is due to the fact that they produce a reliably flatter image than roll or cut film. Film may have air pockets between it and the film support or deformations due to tension from the film transport mechanism.

C. Individual Metric Camera

The small format individual camera can be used to photograph an object from two different positions or two cameras can be used at two different



The advantages of this camera over the stereo-camera (standard model) are the ease with which it can be handled and set up, it's short principle distance and wide field of view.

The camera uses roll or cut film as well as the highly accurate glass plates.

Most late model cameras have the ability to

Recent developments in the manufacture of these cameras has lead to larger focal lengths while still retaining a large field of view. This improvement has greatly expanded the use and versatility of the camera and was accommplished with the following methods;

1. adjustable displacement of the lenses by spiral or translatory movement.
2. rings of different thicknessess placed between the lens and the camera body.
3. additional lenses attached to the front of the primary camera lens.
4. interchangable lenses.

SINGLE IMAGE RECTIFICATION

Documentation or surveys of objects on a single plane such as a flat or nearly flat facade can be accomplished with a single photograph. This is referred to as single image photogrammetry and is the most commonly used technique for simple elevations and objects having low surface depth such as mosaics and frescos.

A photograph of a building that was taken on an upward incline results in parallatic distortion of the building image. The distorted image must be corrected to present a physically and visually correct image that can be accurately measured.

The photographical process expands the uses of single image photogrammetry as well as saves time and expense. Examples of this are the streetscape photographs and the supplementing of architectural drawings with rectified photographs.

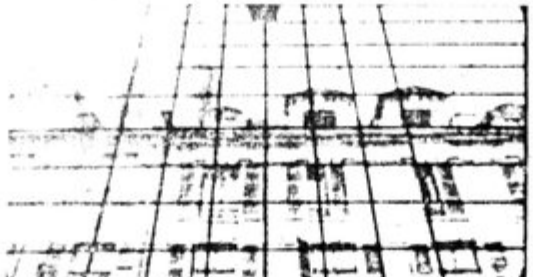
Individual photographs of a street facade can be rectified to correct the building images and then assembled into a photomosaic.

The correction process is called rectification and can be produced either graphically, optically, photographically or analytically.

A. Graphical Rectification

The graphical rectification process is the earliest of the rectification techniques and was the most extensively used in the early days of photogrammetry. It was used until the end of World War II, at which time the photographical method replaced it. The process was very time consuming and proved to not be highly accurate.

The process consisted of drawing perspective lines on the photograph and then converting them to a graphically correct image of the facade.



B. Optical Rectification

Optical aids are used in this process to convert the distorted image into a corrected form. Due to its poor degree of accuracy and the specially trained personnel required it is generally used only to complete details on a already corrected image. The end product of this process is the same as that which is derived from the graphical rectification.

C. Photographical Rectification

The photographical rectification process is more accurate then the previously discribed processes but has to deal with equipment limitations.

This rectification process reverses the effect that caused the distortion in the first place. This is accomplished by placing the photograph of the distorted image on a tilted table within the rectifier and then rephotographing it. A newely distorted photograph of the originally distorted photograph produces a corrected image of the building.

The normal rectifier can produce results only from a photograph that is taken at no more than 15 degrees upward incline. The equipment must be modified to accommadate photographs that are taken above 15 degrees, with a maximum of 30 degrees.

TWO IMAGE STEREORESTITUTION

The two image method is not limited to a single plane or nearly flat object but can be used for the restitution of three dimensional objects.

The principle is based on the intersection of two corresponding rays from two photographic images. The coordination and measurements of these rays are processed by one of the following methods;

A. Graphical restitution

B. Stereoscopical restitution

C. Stereophotogrammical restitution

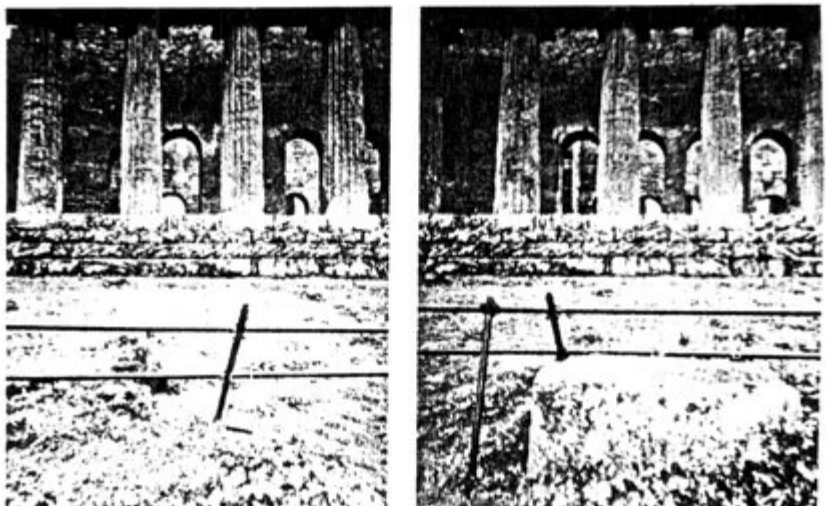
The above methods usually require only two measurements to be taken on the object, one horizontally and one vertically. Additional measurements will give a higher degree of accuracy.

The type of restitution to be used is based upon the restrictions of the object and it's surroundings, the nature of the problem and the desired final output.

The principle is similar to the single image method of graphical rectification where two converging rays are located and measured by optical and graphical means.

B. Stereoscopic restitution

The stereoscopic plotter uses photographs of an object that are taken at slightly different angles and then projects them on a tracing table that produces a three dimensional model of the object that is then studied stereoscopically.



The stereoscopic technique is generally used for small and simple structure.

The principle drawback to this method is the limited availibility of camera positions that can be used to attain desired results. The photographs that are to be used in this technique usually must be taken paralell and perpendicular to the desired wall plane with a maximum variation of 10 degrees. The limited variation of 10 degrees can be easily accommodated by normal restitution equipment. Modifications to the instruments are required to process photographs taken at 30 Or 60 degrees.

The exact restitution instrument to be used depends on the accuracy required and the position from which the photograph was taken.

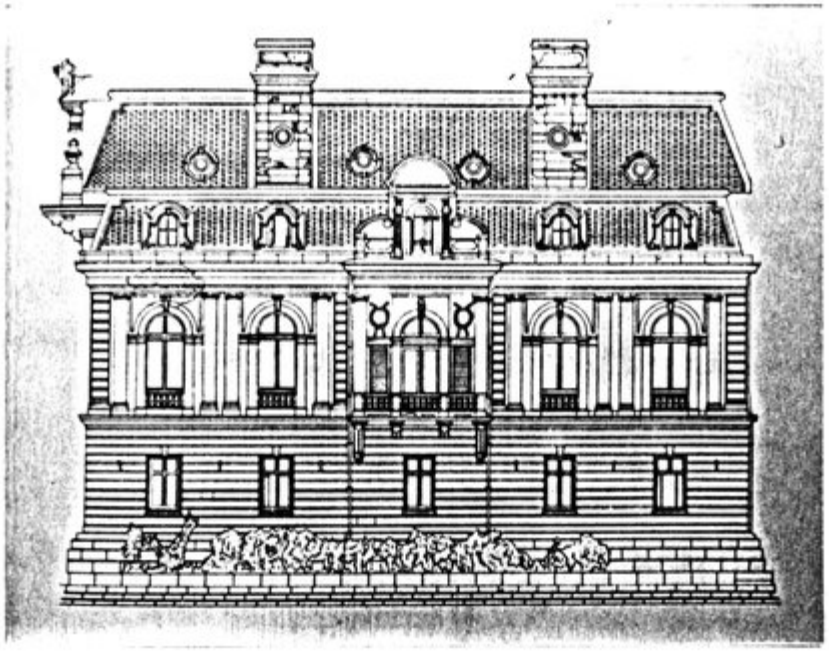
The output of most stereoscopic equipment is in the graphical form.

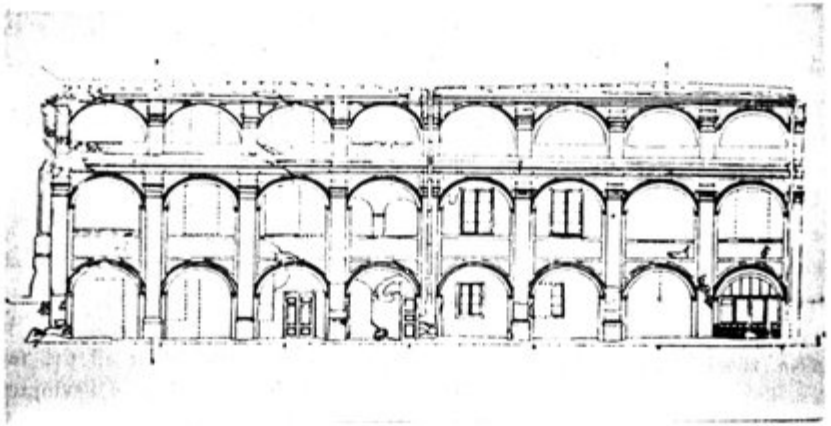
C. Stereophotogrammical restitution

The stereophotogrammetry or analytical restitution is generally used for large complicated structures, rugged terrain and streetscapes that require a high degree of accuracy. Analytical restitution is based on a perspective relationship between the true object and it's photographed image. Mathematical expressions of this relationship enable measurements to be taken on a particular plane. By establishing a number of different measured planes the object can then be accurately surveyed.

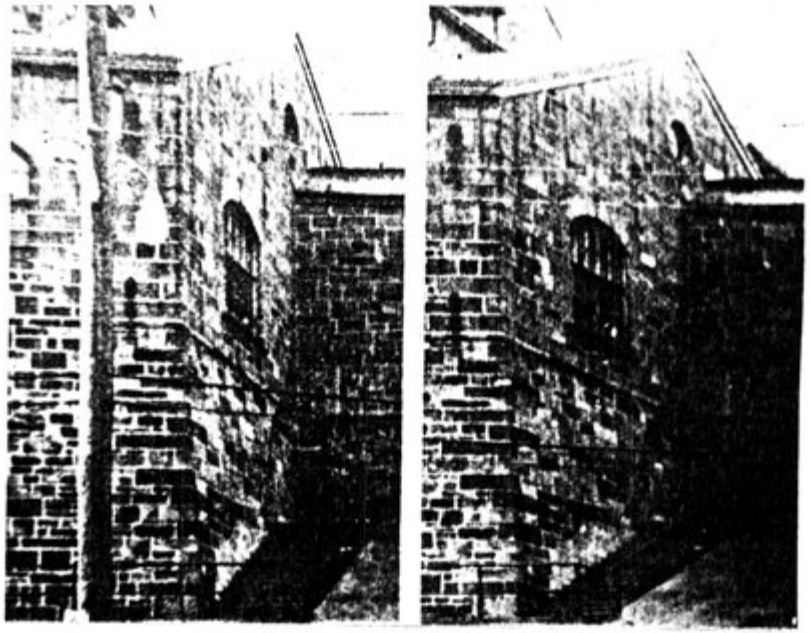
The technique is more versatile and accurate than stereoscopic or graphical restitution and has the following advantages;

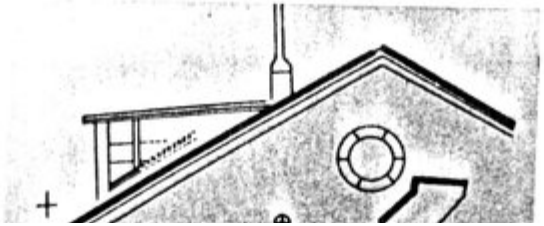
1. it is not limited by any camera angle
2. the plotter can use a photograph taken by non-photogrammical cameras and still maintain a reasonably high degree of accuracy.





The biggest advantage of the stereophotogram - mical plotter is it's ability to use photographs that are taken from a corner angle. The corner photograph possesses much more information than a frontal phtotgraph.



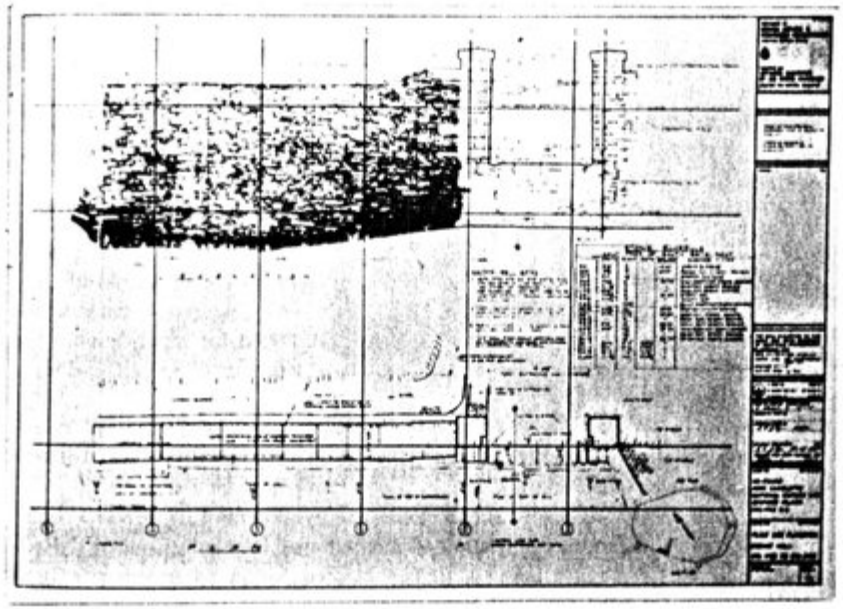


A drawback to stereogrammical restitution is that the movement of the measuring point is not correlated with the field coordinated measuring system. This does not allow specific points to be read on a particular horizontal or vertical cross section. It is therfore only possible to record profile points that are naturally visible on a building such as downspouts or brick courses.

Another disadvantage is it's inability to produce a output of continous lines unless computer plotting is employed.

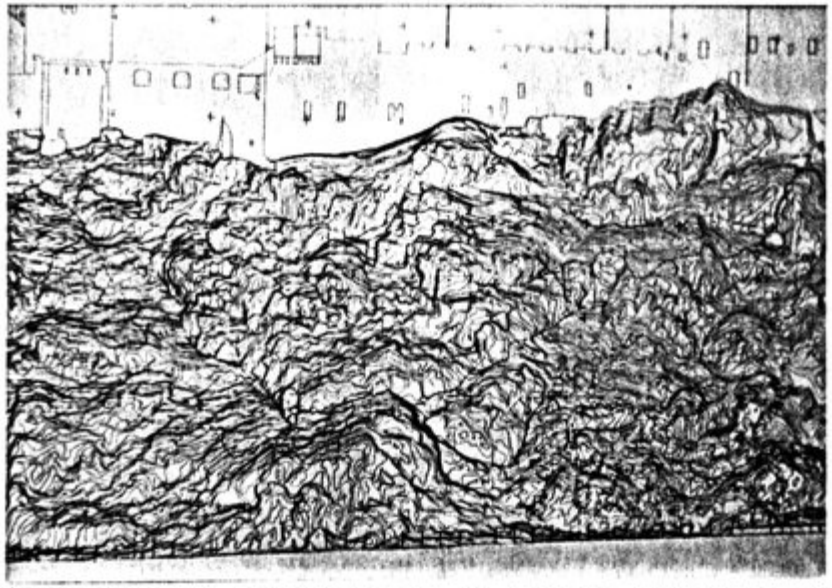
SPECIAL PHOTOGRAMMETRY APPLICATIONS

A valuable special use for rectified photographs is to use them in conjunction with hand drawings. Details of the wall surface and building materials can easily and accurately be recorded.

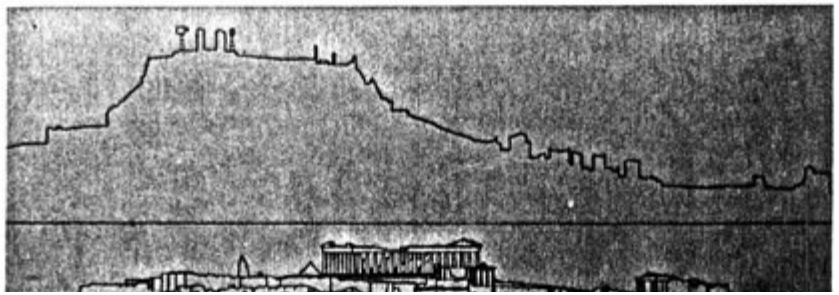


Entire sites can easily be surveyed and documented from the air in a fraction of the time required to do it by hand.

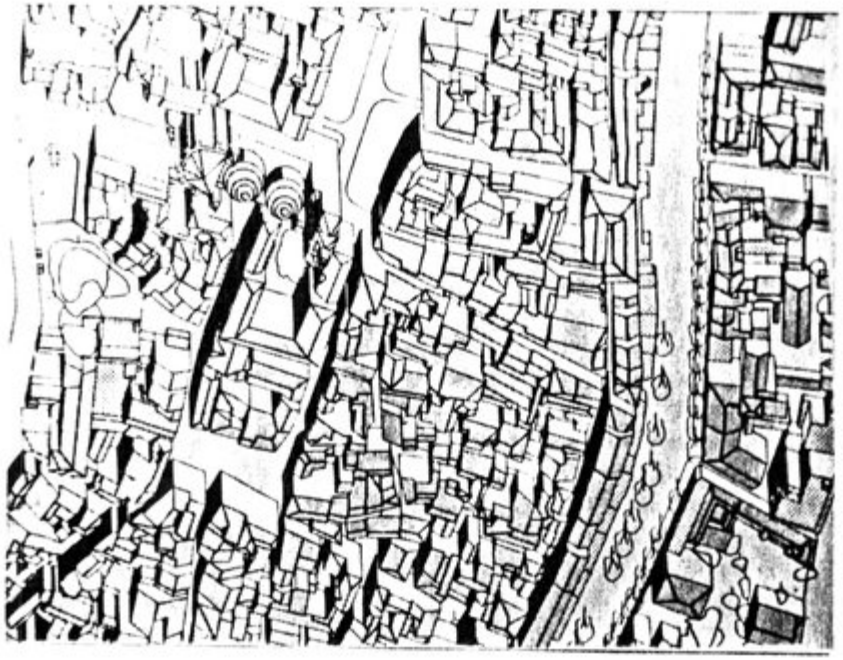
Horizontal as well as vertical contour lines can be easily plotted to reproduce the character of the terrain surrounding the surveyed object.



Profiles and projections of entire portions of a city with vertical sections at desired points.



Photogrammetrically produced perspectives in the form of axonometric perspective projections. This gives an even three dimensional relationship over the entire area to be studied with the scale the same over the entire output sheet.



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