GEO 281
Air Photo Interpretation

Ibadan Distance Learning Centre Series

GEO 281
Air Photo Interpretation

By
Prof. A. O. Aweto
Department of Geography
University of Ibadan

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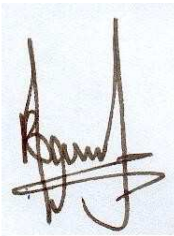
Vice-Chancellor's Message

I congratulate you on being part of the historic evolution of our Centre for External Studies into a Distance Learning Centre. The reinvigorated Centre, is building on a solid tradition of nearly twenty years of service to the Nigerian community in providing higher education to those who had hitherto been unable to benefit from it.

Distance Learning requires an environment in which learners themselves actively participate in constructing their own knowledge. They need to be able to access and interpret existing knowledge and in the process, become autonomous learners.

Consequently, our major goal is to provide full multi media mode of teaching/learning in which you will use not only print but also video, audio and electronic learning materials.

To this end, we have run two intensive workshops to produce a fresh batch of course materials in order to increase substantially the number of texts available to you. The authors made great efforts to include the latest information, knowledge and skills in the different disciplines and ensure that the materials are user-friendly. It is our hope that you will put them to the best use.



Professor Olufemi A. Bamiro, FNSE
Vice-Chancellor

Foreword

The University of Ibadan Distance Learning Programme has a vision of providing lifelong education for Nigerian citizens who for a variety of reasons have opted for the Distance Learning mode. In this way, it aims at democratizing education by ensuring access and equity.

The U.I. experience in Distance Learning dates back to 1988 when the Centre for External Studies was established to cater mainly for upgrading the knowledge and skills of NCE teachers to a Bachelors degree in Education. Since then, it has gathered considerable experience in preparing and producing course materials for its programmes. The recent expansion of the programme to cover Agriculture and the need to review the existing materials have necessitated an accelerated process of course materials production. To this end, one major workshop was held in December 2006 which have resulted in a substantial increase in the number of course materials. The writing of the courses by a team of experts and rigorous peer review have ensured the maintenance of the University's high standards. The approach is not only to emphasize cognitive knowledge but also skills and humane values which are at the core of education, even in an ICT age.

The materials have had the input of experienced editors and illustrators who have ensured that they are accurate, current and learner friendly. They are specially written with distance learners in mind, since such people can often feel isolated from the community of learners. Adequate supplementary reading materials as well as other information sources are suggested in the course materials.

The Distance Learning Centre also envisages that regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks will find these books very useful. We are therefore delighted to present these new titles to both our Distance Learning students and the University's regular students. We are confident that the books will be an invaluable resource to them.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.

Professor Francis O. Egbokhare
Director

LECTURE ONE

Aerial Photography: Background and Brief History

Introduction

Aerial photographs are not usually studied in secondary schools in this country; therefore, I assume that you are not familiar with them. This lecture seeks to introduce you to what aerial photographs are. It also presents a brief history of aerial photography.

Objectives

At the end of this lecture, you should be able to;

1. explain what air photographs are; and
2. briefly describe the history of aerial photography.

Pre-Test

List four uses of aerial photographs in geography

CONTENT

An aerial or air photograph is a photograph taken from the air. In other words, unlike conventional photographs, the air photograph is one taken at a height above the ground surface. If one climbs a tree or a tall tower and takes a photograph of the surrounding land area he will obtain an air photograph. It is obvious that only a limited area of the landscape can be seen if one takes an air photograph from a platform such as a tower or a tree top. This is because the platform is not very high above the ground surface. Hence, conventionally, aerial photographs are not usually taken from such low platforms but taken with cameras mounted on aircrafts which fly at considerable heights, usually several kilometres above the ground surface depending on the desired air photo scale. Photographs taken from such high elevations cover a much larger land area in a single photo exposure and afford one a panoramic view of the land at a glance. The air photograph therefore represents the information of an area measuring several square kilometers in a single photo print which usually measures 23cm by 23cm. In other words, the air photograph reduces the features of the landscape and thereby enlarges the area that can be seen by the researcher at a glance. The air photograph like the map, reduces the features of the landscape thereby makes them appear smaller. They are, in a sense, the opposite of a microscope which enlarges small features that cannot normally be seen by the unaided human eye.

The Air Photograph and the Topographical Map

It is obvious to you, I hope, that there are certain similarities between the map and an air photograph. Both show an aerial view of the landscape. The map however shows only those features of the landscape which are of interest to the map-maker unlike the air photograph which shows all the features of the landscape visible to the human eye at the time the photograph was taken. As a result of scale constraints, the map-maker may have been compelled to show certain features of the landscape with symbols. For instance, the map-maker may use symbols for a built-up area because he cannot show all the individual buildings. Besides, he may not be able to adequately depict certain features of the landscape such as swamps, road cuttings, embankments, vegetation types, farms, plantations-etc. in their proper perspective. This is why he is constrained to use symbols to depict these various features of the landscape. In contrast, the air photograph shows these varied features of the landscape as they appear on the ground. I should point out here, however, that on small scale photographs some salient features of land use may not readily be apparent to the photo interpreter. For instance, on photographs on scale of about 1:50,000 or smaller, it is not usually possible to distinguish individual trees. Therefore, it is not possible to measure tree density or identify individual tree species on such photographs.

In a sense, air photographs, especially those that are 'vertical' (photo-graphs taken with the camera lens facing the ground directly) are as useful or even more useful than topographical maps of comparable scale because they not only show the totality of the elements of the landscape but they also depict them in their proper perspective. This should not imply that the air photograph is always a better substitute for the topographical map. Certain features of landscape of interest to the researcher such as buildings may be obscure by other features like tree crowns. Besides, the air photograph is not usually annotated in detail as topographical maps. For instance, the names of streets, roads and settlements, rivers and hills shown on topographical maps may not be indicated on the photographs. These limitations, sometimes, make the use of air photographs in the field somewhat cumbersome to one who is not very familiar with the details of the area which is shown on the air photograph.

Brief History of Aerial Photography

The history of the development of aerial photography is closely tied with that of the invention of photography and developments in the aviation industry. Photography was invented in the 1830's but the initial development of aerial photography proper had to await the latter half of the 19th century and the beginning of the 20th century. The first known air photographs were taken in 1858 in Paris from a ballon using an ordinary camera. Subsequently, in the early decades of the 20th century special cameras were designed and mounted below the breasts of pidgeons for the purpose of taking photographs of the area over which they fly. Although, this was a major advancement in the development of aerial photography, the pidgeons cannot be piloted. Hence, it was difficult to determine the areas actually covered by individual photographs taken by cameras mounted below flying pidgeons. Besides, there was the problem of limited aerial coverage. These problems which hindered the development of aerial photography were solved with the invention of the aeroplane. Cameras which are programmed to automatically take photographs at fixed and regular time intervals are mounted below flying aeroplanes to obtain aerial photo coverage of large areas within a short period. The flying height of the aeroplane can be determined and this is used for calculating the scale of the air photograph. In most cases, the scale of the photograph is determined before hand and the pilot of the aircraft is directed to fly at a specific height so that the photographs taken would be on a specified required scale. The advent of aviation made the acquisition of air photographs over large areas possible and this facilitated the rapid aerial surveys of large areas. The air photographs obtained using aeroplanes flying along pre-determined routes are used for map compilation.

The basic principles of compiling maps from air photographs had earlier been established by Colonel Aime Lausedat and J. H. Lambert who largely laid the foundation of photogrammetry. The science of photogrammetry is concerned with making measurements on aerial photographs and compiling maps using such measurements. It should be clear to you at this juncture, that developments in aerial photography have implications for the science of cartography. Advancements in the former led to rapid progress in mapping. This issue will be discussed further in the next lecture. The First and Second World Wars led to rapid advancement of the science of aerial photography. As a direct result of both wars, there was need to study the position of enemy troops and assess their military capabilities, and to study terrain and plan routes over which troops would advance. There was the need, therefore, to rapidly reconnoiter war fronts and other areas in danger of attack from enemy troops. Aerial photography proved the most effective means of reconnoitering large areas and some of the major developments in the science of aerial photography were made in response to the emergency created by the World Wars. Since the World Wars, other advances have been made in the science of aerial photography, particularly in the areas of applications for soil and land use surveys, forest and livestock and range management.

Post-Test

The science concerned with making measurements on aerial photographs and of using such measurements for compiling maps is called:

1. aerial photography
2. cartography
3. photogrammetry
4. map compilation
5. none of the above.

Reference

Howard, J. A.: *Aerial Photo-Ecology*. Faber & Faber, London, 1970.

LECTURE TWO

Application of Aerial Photography

Introduction

I shall introduce you to some of the applications of aerial photography in this lecture with a view to highlighting the usefulness of the aerial photograph.

Objectives

After reading this lecture, you should be able to:

1. indicate specific geographic applications of aerial photography; and
2. indicate the applications of aerial photography in other fields such as agronomy, forestry, soil science and engineering.

Pre-Test

Take your pen and paper and list the possible applications of aerial photography in agriculture.

CONTENT

I shall begin this lecture by briefly indicating the geographic applications of aerial photography. The aerial photograph records and stores information about physical and cultural features of the earth's surface. It presents an aerial view of the landscape. This is why it can be used as the basis for mapmaking. Perhaps, the greatest geographic application of aerial photography has been in the fields of survey and cartography. Prior to the application of aerial photography in surveying and map-making, maps were produced from measurements made during land (ground) surveys. Such detailed land surveys are very expensive and time-consuming. Consequently, only rich countries such as the United States of America and the United Kingdom could afford to survey large areas of their territory. Land surveys are very slow compared to aerial surveys. For instance, it took several years to complete the soil and land use survey of the cocoa producing area of south western Nigeria. A complete soil and land use survey of the entire country based on aerial photo-interpretation will probably take as couple of months. Aerial photography facilitates survey and its advent gave considerable impetus to land survey in the developing countries. Detailed topographical maps were produced for most developing countries mainly after the middle of the 20th century when aerial photography became widely applied in land surveying and map production. Most of the topographical maps of this country were compiled using air photographs on scale of 1:40,000 taken by the Canadian Aero Service Limited between 1962 and1964. Maps are compiled from air photographs if adequate ground control points are established and information obtained through air photo-interpretation can be verified from a number of points or areas on the ground.

Land Use Survey and Mapping

Geographers have also employed aerial photographs in studying urban and rural land use. In urban centres, areas under different types of land use such as commercial, transportational, residential and recreational can be delimited, measured and accurately mapped. On medium scale air photographs e.g. 1:20,000 or 1: 10,000, high density and low density residential areas can be clearly distinguished from one another. In rural areas, it is usually possible to identify different types of rural settlements and to distinguish between different types of rural land use e.g. forests, plantations, farmlands, lakes, rivers, and villages. The analysis of photographs taken at different periods provides the basis for studying changes in land use over time. For instance, changes in urban land use can be studied by comparing photographs of the same town taken at different periods say at regular intervals of ten years. The phenomenon of urban sprawl can be studied by examining photographs of an urban centre especially those covering the outskirts for different periods. This clearly indicates that the analysis of the photographs of an area taken at different periods provides a basis of studying land use change over time, although the photographs themselves are static. Aerial photographs are also used for estimating urban and rural population and for delimiting enumeration areas for censuses.

Environmental Monitoring

The analysis of air photographs of an area taken at different periods could form the basis for monitoring the environment and of assessing the impact of human use of land on the environment. The rate of desert encroachment in the Sudano-Sahelian zone of West Africa can be assessed by analysing the vegetation pattern on air photographs taken at say l0-year intervals for the last 50 years, or when the earliest photographs were available. The effects of vegetation destruction on the soils, sand dune migration can also be assessed by comparing photographs of the same area before and after vegetation widespread clearance.

Resource Inventory

Geographers are interested in knowing the available resources in an area with a view to assessing its developmental potential. Assessing land quality and its developmental potential is the main subject matter of a subfield of geography known as land evaluation. In order to assess the developmental potential of areas, geographers study air photographs in order to study the terrain and the available physical resources including soils, vegetation, rocks and water.

Applications in Agronomy, Forestry and Botany

Air photographs are used in crop surveys and for estimating the amount of land under different crops or put into livestock production. In some cases, crop vigour can be estimated from air photographs and expected yields predicted. Such predictions, based on previously established crop vigour-yield relationships may not deviate significantly from the actual yield obtained at the end of the cropping season if the crops are not attacked by pests or diseases, or crop performance is drastically reduced by hazards such as drought after the prediction has been made. Crop Yield prediction from aerial photographs is based on 'previous experience' and could be subject to a wide margin of error depending on the vagaries of the weather coupled with pest and disease attack. Air photographs are also used for soil mapping. The soil cannot usually be seen on most air photographs (except those of arid regions where the vegetation cover is very sparse). This is why soil mapping from air photographs is usually based on deductions especially from the relationships between reliefs, breaks in slopes, drainage lines, and vegetation pattern on the one hand and the pattern of soil distribution on the other.

Foresters use air photographs in mapping vegetation types and also for taking stock of forest resources. Tree heights and densities can be determined from air photographs. Foresters have therefore used air photographs for estimating the volume of merchantable timber in a stand. Botanists like foresters use air photographs in studying vegetation types and for mapping their distribution.

Applications in Geology and Archaeology

Geologists use air photographs for mapping the distribution of rock types and geological formations. The distribution of geological formations often coincides with certain landforms or vegetation types whose spatial distribution can be mapped using air photographs. Archaeologists use air photographs for detecting sites of mines of ancient settlements or other man-made features that offer clues as to the material culture of a people or past civilization.

Military and Engineering Uses

The use of aerial photographs for reconnoitering enemy territory or war fronts has been referred to. Besides, the military uses air photographs to study terrain conditions and to plan troop movements. Engineers also use air photographs for studying terrain conditions for various purposes e.g. alignment of motor and rail routes, location of dams, bridges and airports.

Summary

In this lecture, we have discussed the major uses of aerial photography. Air photographs are ready sources of information to all scientists and scholars studying the earth, its peoples and resources, and various physical processes operating on the earth.

Post-Test

Which one of the following statements is not true of air photographs?

1. they are used for environmental monitoring.
2. they are used for map compilation.
3. they have no military uses.
4. they are used for crop performance assessment.
5. they are used for evaluating land resources.

Reference

Areola, O.: The teaching of aerial photography in secondary schools, 1973. *Nigerian Geographical Journal* Vol. 16, pp. 77-89.

LECTURE THREE

The Aerial Photograph

Introduction

You already know what the aerial photograph (also referred to as air photograph) is. This lecture will introduce you to the basic types of air photographs and will also treat the main features of the vertical air photograph.

Objectives

At the end of this lecture, you should be able to:

1. distinguish between vertical and oblique photographs; and
2. describe the main features of the vertical air photograph.

Pre-Test

Check the meanings of the words 'oblique' and 'vertical' in your dictionary. Suggest how oblique air photographs differ from those that are vertical.

CONTENT

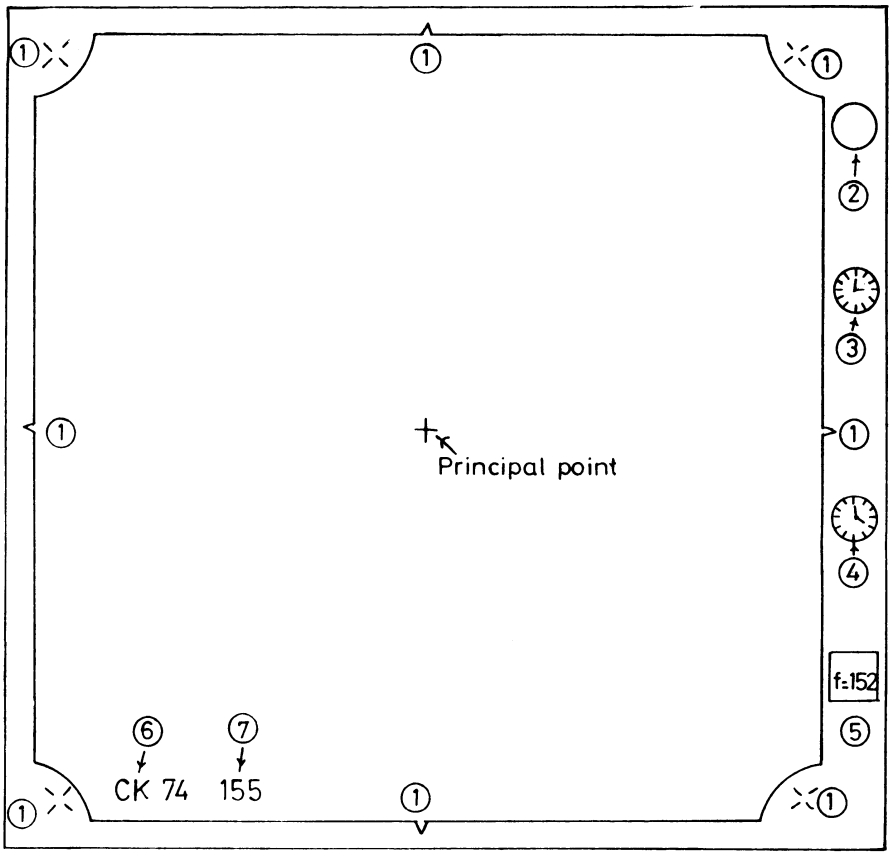
Air photographs can be classified using several criteria including scale, nature of film used and whether the photographs are 'vertical' or 'oblique.' In this lesson, we shall briefly examine the last criterion. The first two will be examined in subsequent lectures.

Vertical and Oblique Air Photographs

A vertical air photograph is one taken with a camera mounted below an aeroplane in such a way that the camera axis is at right angles to the ground surface. In other words, the aerial camera is mounted in such a way that when a line is projected from the camera lens to the ground, it would meet level ground at right angles. Oblique photographs are those taken with the camera axis inclined at an angle to the ground. This implies that a line projected from the camera lens to the ground will make an acute angle with a level ground surface. Oblique photographs are taken with the camera axis pointing downwards making an angle of less than 90° with the horizontal plane. Oblique photographs can be taken using an ordinary camera through the window of an aircraft by a passenger on board. Similarly, they can be taken from high towers provided the camera is not pointing perpendicularly downwards. The basic difference between vertical and oblique photographs is that the former are taken with the camera lens pointing perpendicularly downwards while in oblique photographs, the camera axis is tilted. This fundamental difference have implications for the type of images formed and uniformity in scale or otherwise over the surface of the same exposure of photograph. For level or nearly level areas and those without marked disparities in elevation, air photo scale is uniform over the surface of an exposure of a vertical air photograph. This is, however, not the case with the oblique photograph in which the scale becomes smaller towards the margin of the photograph farthest from the point the photograph was taken. The implication of this, is that one cannot make maps from oblique photographs without making allowance for variations in scale over the surface of the photograph. This often requires some knowledge of mathematics and photogrammetry. In contrast, it is comparatively easy compiling maps from vertical air photographs as all distance measurements made on the photo are on the same scale and hence require no mathematical correction. Consequently, the use of vertical aerial photographs is more popular and widespread than oblique photographs. In this course, we shall focus mainly on the interpretation of vertical air photographs. Large and medium scale oblique air photographs, however, have some advantages over 'vertical air photographs. Oblique photographs show the tops of features such as trees, hills, houses etc. as well as their sides unlike true vertical air photographs which show only the tops of such features. Consequently, it is much easier to identify physical and cultural features of the landscape on oblique photographs than on vertical ones.

An aircraft rarely flies along a perfect horizontal plane along the entire stretch of a flight line i.e. routes or lines aircrafts fly along when taking photographs. The aeroplane may not fly along a perfect horizontal plane when it is about to ascend to or descend from the cruising level or when it tilts sidewards. When this occurs the camera will not point perpendicularly downwards and the angle at which the photograph is taken deviates from 90°. Such a photograph originally intended to be a truly vertical photograph is said to be tilted. Many supposedly vertical air photographs contain some amount of tilt. Conventionally, a photograph is regarded as vertical if the amount of unintentional tilt does not exceed 5°.

In oblique photographs, the photographs are taken so that they contain some amount of deliberate tilt. This is usually achieved not by tilting of the aircraft but by tilting the camera axis. There are two types of oblique photographs namely: low and high oblique. In low oblique photographs, the horizon is not seen on the photograph while the high oblique photograph shows the image of the horizon.



1. Fidutial marks 2. Level bubble 3. Chronometer
4. Altimeter 5. Focal length of camera lense
6. Photo block number 7. Individual photo number.

Figure 1: Vertical air photograph and its marginal information

The Vertical Air Photograph

Each standard print of an air photograph measures 22.9cm by 22.9cm i.e. approximately, 23cm by 23cm. Each photograph has a geometric centre which can be located by drawing lines to link the opposite fiducial marks on the air photo margins. The fiducial marks are slight indentations midway along each of the four margins of the photographs. They are used for locating the geometric centre (called principal point) of the photograph. Air photographs are usually taken along strips of land. As the aircraft flies along the centre of each strip, i.e. flight line, it takes photographs. These are usually taken such that one photograph overlaps the one immediately following it. In other words, the same land area is photographed twice and so appears on two consecutive photographs on the same flight line. This type of overlap, called the *foreward overlap* or simply *endland* is usually 60% but may vary between 55% and 65% depending on the specification of the client who requires the air photographs. An adjoining pair of vertical air photographs with a common area of overlap is called the *stereopair*. It is necessary to ensure that consecutive exposures of air photographs overlap so that they can be studied with the stereoscope so as to obtain a three-dimensional impression of relief. An overlap is also required on air photographs for the purpose of plotting maps from them using the method of radial line triangulation. Corresponding photographs on adjacent flight lines also overlap. This type of overlap is called the sidelap or lateral lap and is usually 25% but may vary between 15% and 25%.

Because of the 60% overlap (endlap) between two consecutive exposures of photographs, the principal point of the previous photograph can be located and transferred to the photograph immediately following it. This can be done by careful inspection of the area of overlap noting the feature on which the principal point (Pp) appears on one photograph and identifying the same feature and the exact point on which the (pp) occurs on the next. When a pp of the previous photograph is transferred unto a present photograph, it is then called a conugate principal point (CPP). Usually, the CPP is located towards the margin of the photograph, unlike the pp which occurs at the centre. The CPP can be joined to pp and the line obtained is called the *air base or base line*.

The air base represents the distance travelled by the aircraft between one exposure and the next. The air base can be extended to the margins of the photograph to give the location of the flight line.

The vertical air photograph usually contains some marginal information to assist their users in interpreting them. These include a chronometer indicating time of the day the photograph was taken, fiducial marks photo number, focal length of camera lens, and the flying height of the aircraft. These last two pieces of information are used for calculating the scale of the photograph.

Summary

I have distinguished between vertical and oblique photographs and examined the main feature, of the vertical air photograph. The vertical air photograph, like the topographical map contains marginal information meant to assist their users in their interpretation.

Post-Test

The line joining the principal point and the conjugate principal point of vertical air Photographs is called:

1. fiducial1ine
2. air base
3. flight line
4. centra11ine
5. photo line

Reference

Areola, O.: The teaching of aerial photography in secondary schools. *Nigerian Geographical Journal* Vol. 16, Pp. 77-89, 1973.

LECTURE FOUR

Aerial Camera

Introduction

Knowledge of the aerial camera and the basic processes of photography assists the photo interpreter in making correct deductions about features of the landscape shown on aerial photographs. In this lecture, I shall briefly introduce you to the basic components of the camera and indicate their functions. I will also discuss the main types of films commonly used in aerial photography.

Objectives

At the end of this lecture, you should be able to:

1. indicate the functions of the basic components of the aerial camera; and
2. indicate the advantages and disadvantages of different types of films used in aerial photography.

Pre-Test

Name four basic components of the ordinary camera.

CONTENT

In the first part of this lecture, I will discuss the components of the aerial camera and discuss films in the last half.

Components of Aerial Camera

As with the ordinary camera used on the ground the aerial camera is essentially a light-tight box i.e. a box that light does not normally enter. It has the following basic components:

1. a light-tight box which I have just referred to that houses the other components of the camera;
2. a small opening or pin-hole at one end of the box through which light is allowed to enter the box when taking photographs of external objects. In most modern cameras the size of this hole can be enlarged or reduced by the diaphragm;
3. a lens, usually made of glass, is usually external to the pin-hole and is used for focusing rays of light from external objects on the film. The lens, therefore, assists in forming optimal images in cameras by focusing light on the film;
4. the photographic plane which is the plane surface on which light from external objects is projected. The photographic plane contains a photosensitive material (film) which records and stores images of external objects when light is allowed to enter the camera. The photographic plane occurs directly behind the pin-hole through which light enters the camera, and
5. a shutter which is a device that controls the time during which the pinhole opens temporarily (usually for less than a second) to allow light from external objects to enter the camera thereby allowing their images to be formed in the film.

Aerial cameras vary in size and with this the distance between the photographic or focal plane and the lens. The distance between the rear part of the lens and the photographic plane is called the focal length or camera lens, usually designated by the letter ***f***. Most aerial cameras have focal lengths of 152 or 304mm. The focal length of the aerial camera is usually indicated on the aerial photograph as it is used for calculating air photo scale. The focal length of camera lens and the flying height of the aircraft are the main determinants of air photo scale. By influencing air photo scale, the camera focal length partly determines the extent to which the details of features of the landscape can be recognised on air photographs i.e. ground resolution.

Films

As I have said earlier, films are light-sensitive materials that record images of external objects in the camera. Different types of films are used in taking aerial photographs. These include:

1. black and white films;
2. infra-red film; and
3. natural colour film.

Black and White Films

These produce images of features in varying shades of grey colour ranging from white to grey. These films, also called panchromatic films, are sensitive only to the visible light region of the electromagnetic spectrum i.e. 0.36 to 0.72 microns. The panchromatic film is the cheapest film and is the type most commonly used in aerial photography. However, it has the following limitations:

1. it does not show the natural colour of the features of the landscape and this sometimes make their recognition difficult,
2. the human eye cannot always discern subtle differences between different shades of grey colour shown on air photographs (i.e. tones) which usually depict different environmental conditions. In other words, the photo interpreter may not discern subtle differences in environmental conditions where such differences are not strongly reflected in changes in shades of grey colour. In this respect, the inexperienced photo interpreter is at a strong disadvantage as panchromatic black and white films are incapable of showing the natural colours of contrasting features, and
3. on panchromatic black and white photographs, the same feature of the landscape may appear in different tones depending amongst other things on the time of the day the photograph was taken and the angle of reflectance from the object. This issue will be treated further in a subsequent lesson.

Infrared Films

Most infrared films are sensitive to visible light and reflected infrared energy. They are usually sensitive to energy of the wavelength 0.36 to 0.9 microns. Infrared film is less sensitive than panchromatic film to the green portion of the electromagnetic spectrum but its range of sensitivity extends into the infrared red region. Infrared films are of two main types:

1. the black and white and
2. the colour infrared type.

Generally, infrared films are more suitable than panchromatic black and white air photos for studying terrain conditions. They are particularly useful for detecting differences in ground drainage, vegetation types, relief, and soil moisture conditions. Colour infrared films are useful for detecting differences between diseased and healthy broad-leaved plants. Consequently, they have been widely used by foresters and agriculturists for detecting diseased plants, even before the symptoms of such diseases become visible to the human eye.

The disadvantage of black and white infrared films is that they do not show the natural colour of features and this makes their identification somewhat difficult to the inexperienced photo interpreter. Colour infrared photographs which largely overcome this limitation are expensive to procure. Besides, colour infra-red films and photographs are difficult to store over long periods. They tend to deteriorate and lose their colour balance due to high humidity, fungal attack and improper storage. Another limitation of colour infra-red films is that they may not show the true colours of the features photographed. This is why they are also called false colour films. For instance, vegetation on well drained sites may appear red on photographs taken using colour infrared films.

Natural Colour Films

These have advantage over panchromatic black and white films and also over infrared films in that they show the true and natural colour of features of the landscape thereby facilitating their identification. They however suffer the limitation of high costs of acquisition, difficulties of storing film and photographs. Besides, colour photographs are easily spoilt by hazy conditions. As haze tends to increase with elevation, good quality coloured aerial photographs can be taken only at comparatively low elevations.

Summary

In this lecture, I have discussed the basic components of the aerial camera and their functions. I have also examined the main types of films used in aerial photography, indicating their advantages and limitations. As I have tried to point out to you, the various films have different advantages. This is why the mm used for any aerial survey will largely depend on the purpose of the survey and the amount of money available for the purpose.

Post-Test

The distance between the rear of the lens and the photographic plane is called?

1. diaphragm
2. photographic plane
3. shutter
4. focal length of camera lens
5. film.

LECTURE FIVE

Elements of Air Photo- Interpretation

Introduction

In this lecture I shall introduce you to certain criteria used in air photo-interpretation. Some of these criteria include certain features of the photo-graphic images themselves including shape, size and pattern. In some cases, attributes of certain features of the landscape shown on air photographs are inferred.

Objectives

At the end of this lecture, you should be able to:

1. the basic process of photo-interpretation; and
2. certain characteristics of photographic images shown on air photographs notably tone, contrast, texture, pattern and shape used in interpreting air photographs.

Pre-Test

In what tone (i.e. shade of grey colour ranging from white through grey to black) will the following features appear on panchromatic black and white air photographs?

1. grassy lawn
2. bare ground with white sand such as occurs in sandy beaches.

CONTENT

In the first part of this lecture, I shall define air photo interpretation and briefly indicate the processes involved. In the latter part of the lecture, I shall discuss the characteristics of photographic images (tone, contrast, pattern, shape and size) and their significance in air photo interpretation.

Air Photo Interpretation

One may define air photo interpretation as the study of images shown on air photographs with a view to identifying them and making deductions about landscape character and processes. Photo-interpretation enables geographers to analyse spatial patterns and to make deductions about the processes that produce the observed spatial patterns and distributions on the landscape.

Air photo interpretation involves two basic processes, namely:

1. the direct identification of recognisable features of the landscape on the basis of shape and appearance; and
2. making inferences and deductions about others that cannot be seen directly or those that cannot be readily identified on account of scale. The direct identification of features of the landscape on the basis of their appearance is called photo reading. On large scale air photographs e.g. those on scale 1:10,000 or larger, it is possible to identify trees, buildings, roads and sports fields. It may even be possible to recognise certain tree species such as the oil palm at scale of 1:10,000 or large because of their characteristic shape.

Even on large scale photographs such as those on scale 1:500, the soil is usually covered by other features of the landscape. Even in desert regions, where the soil surface is exposed, one cannot determine soil nutrient status directly from the photograph. In such a case, one has to make deductions about the nature of the soils and their spatial distribution from other elements of the physical environment such as drainage lines, breaks in slopes and vegetation patterns.

From what I have said so far, it should be clear to you that the study of air photographs necessarily involves direct identification of certain features of the landscape and making deductions about others.

You should bear in mind that air photo interpretation is not a substitute for fieldwork in geography. For each feature or land use type identified on the air photograph, one has to visit at least one area or site on the ground to check the accuracy of air photo interpretation.

Characteristics of Photographic Images

The characteristics of images of features of the landscape as depicted on air photographs reflect their natural attributes such as size, pattern, shape, reflection and solar energy. The characteristics of photographic images such as tone, shape, size, and pattern can be used in identifying such features or in making deductions about them. I will now briefly discuss some of these characteristics of photographic images.

Tone

Different features of the landscape have different reflection coefficients. In other words, the proportion of the amount of light energy falling on them that they reflect varies. It is the amount of light energy reflected from an object or a scene that the camera records. The relative amount of light energy reflected from an object or scene as recorded on black and white photographs is called tone. In panchromatic black and white photographs tone is usually represented in varying shades of grey colour ranging from white to black. If an object reflects a lot of the incident t light energy, it will appear light in tone e.g. shiny new roofs made of aluminium or white sand on beaches. On the other hand, if the feature absorbs most of the incident light energy, it will appear dark grey or even black in extreme cases. Tone, therefore, reflects the reflection characteristics of the feature. In general, vegetated surfaces such as grassy lawns and forests have darker tones (usually greyish) than recently cleared land which is usually characterised by light (sometimes whitish) tones.

Factors other than the attributes of the objects photographed can affect the tone of features imaged on air photographs. Such factors include:

1. time of the day the photograph was taken and hence the degree of illumination,
2. non-uniformity in printing conditions; and
3. changes in angle of reflectance from the scene or object relative to the position of the aerial camera.

As a result of these factors, the same feature may exhibit different tones on different photo prints. For instance, water bodies may exhibit tones that range from white through grew to black. The implication of this is that tone is not always a reliable clue for indentifying objects. Hence, tone should always be used with other attributes of photographic images (e.g. shape, size and pattern) in identifying them.

Contrast

This is a measure of the distinctiveness of photographic tones. Contrast is affected by density which is a measure of the darkness of a negative. If the developed film has contrasting areas of varying degrees of darkness or density, the photograph will have distinctive tones. Contrast is poor when the shades of grey colour are not distinctive and are hardly distinguishable from one another. Poor contrast reduces the worth of the photograph for photo interpretation. Sharp or good contrast enhances photo interpretation.

Texture

This refers to the general appearance of an area as seen on the air photograph and is an aggregate or an overall expression of shape, size, pattern and tone. In a general sense, texture is an expression of the aggregate arrangement of minute images that constitute the whole. I shall now try to explain this further. A forest, for instance, consists of several trees growing together in an area. When the forest is photographed from above, the crowns of the individual trees will merge in the photograph (provided that the trees are not widely scattered) to form an 'aggregate pattern' i.e. a pattern formed by the aggregation of the images of the individual trees. Such an aggregate pattern is called texture. Texture is described as smooth or rough. It is smooth when it is homogeneous but rough if it is heterogeneous. Texture usually reflects structure. Featureless plains are usually characterised by a smooth texture and areas of rugged relief by rough texture. Similarly plantations consisting of trees of uniform height have a smooth texture while rainforests with several layers of trees, with some trees towering well above the others, have a rough texture.

Pattern

This is essentially the arrangement of geographic features in space. The pattern of distribution of rivers, settlements, vegetation and other types of land use offer a clue as to the predominant landscape processes and the impact of man on the physical environment.

Shape

This refers to the general appearance or form of an object or feature. Various features of the landscape such as buildings, farmlands, roads and rivers can be identified on the basis of shape. The shape of features such as hills and valleys cannot be readily appreciated by the photo interpreter except with the aid of a stereoscope.

Size

In order to appreciate size of objects shown on air photographs, the person interpreting the photograph should be familiar with the photo scale. One can distinguish between a pond and a lake, a hill and hillock, and commercial buildings from residences on the basis of size.

Summary

In this lecture, I have discussed the main processes in air photo interpretation. I have also treated the characteristics of images of features shown on air photographs, noting their relevance to photo interpretation. In some cases, site attributes are deduced from the presence of other elements of the physical environment with which they are associated. For instance the occurrence of swampy or waterlogged soils is usually associated with valley bottom sites.

Post-Test

Tone is a measure of:

1. shape and pattern
2. absolute amount of light reflected by an object as recorded by the camera.
3. relative amount of light reflected by an object as recorded on black and white air photographs.
4. photo colour.
5. distinctiveness of the varying shades of grey colour shown on black and white air photographs.

References

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LECTURE SIX

Air Photo Scale

Introduction

As with topographical maps, aerial photographs are much smaller than the actual land area they represent. All linear distances on the air photograph are only a tiny fraction of the actual ground distances. In order to convert distances measured on air photographs to the actual ground distances and to compile maps from air photographs, one should know the air photo scale. In this lecture, I will discuss how to calculate air photo scale.

Objectives

At the end of this lecture, you should be able to:

1. calculate air photo scale given the foca11ength of camera, lens and flying height of aeroplane; and
2. calculate air photo scale using a topographical map that covers the same area as the air photograph.

Pre-Test

1. One photograph is on a scale of 1:10,000 and the other 1:100,000. Which is on a larger scale?
2. How many centimetres will represent one kilometre on an air photo with the scale of 1:10,000?

CONTENT

You know that topographical maps contain valuable marginal information including the scale which is expressed as a statement, representative fraction and more commonly as a line or linear scale. Air photographs do not usually contain linear scale but have valuable marginal information that can be used for calculating their scale. Two vital bits of marginal information shown on air photographs used for calculating their scale are:

1. the focal length of the camera lens (f); and
2. flying height of the aircraft (H).

The focal length of the camera lens is usually clearly indicated on most air photographs. The flying height of the aircraft can usually be read from altimeter of the aeroplane (this is usually shown as one of the pieces of marginal information on most aerial photographs) or may be written clearly on some air photographs.

One can calculate air photo scale from the focal length of camera lens and the flying heights of the air-craft using the formula below:

$$S = \frac{f}{H}$$

where S - is air photo scale
f - is focal length of camera lens
H - is the flying height of the aircraft.

I will now work an example to clarify the procedure for calculating air photo scale using focal length of camera lens and the flying height of aircraft.

Example 1

Calculate the scale of the air photograph given the following:

a. focal length of camera lens = 152mm
b. aircraft flying height = 5000 metres.

$$S = \frac{f}{H}$$

F = 152mm,

H = 5000 metres.

$$S = \frac{152\text{mm}}{5000\text{ metres}}$$

Now, convert the denominator of the fraction to the same units as the numerator i.e. converts 5000 metres into millimetres

$$S = \frac{152}{5000 \times 1000}$$

I am multiplying the denominator i.e. 5000 by 1000 because there are 1000 millimetres in a metre.

$$S = \frac{152}{50{,}000{,}000}$$

$$= \frac{1}{32{,}894.7}$$

The scale of the map, on approximation to the nearest whole number, becomes 1:32,895 or $\frac{1}{32{,}894.7}$

Calculating Air Photo Scale from Topographical Maps

Occasionally, one comes across air photographs without suitable marginal information for calculating photo scale. In some cases, the altimeter reading indicating aircraft flying height, as shown on the margin of the photograph is not legible. When one is working with such air photographs, one has to determine the scale by comparing distances between any two known points on the air photo with the actual distance between the same points on the ground or on a topographical map. One can now state the formula for calculating air photo scale from the topographical map as follows:

$$\text{Air photo scale} = \frac{\text{Air photo distance}}{\text{map distance} \times \text{map scale factor}}$$

Note that the denominator of the above formula is the same thing as the actual ground distance between the two known points identified on both the air photograph and the topographical map.

Before working an actual example, I shall briefly describe the procedure for calculating air photo scale from air photographs step by step.

1. Identify two points on the air photograph. Preferably the points should be on a straight stretch of a river or road to reduce measurement errors. The two points chosen may be settlements.
2. Identify the two same points on the topographical map.
3. Measure the distance between the two points on both the topographical map and air photograph.
4. Use the formular given above to calculate the air photo scale.

I shall now work a concrete example to make the procedure clear to you.

Example 2

Two points are 10cm. apart on an air photograph. The same points are 8cm. apart on a topographical map on scale of 1:50,000. Calculate the scale of the air photograph.

Air photo scale = $\dfrac{\text{Air photo distance}}{\text{map distance} \times \text{map scale factor}}$

air photo distance = l0cm.

map distance = 8cm.

map scale factor (denominator) = 50,000.

$$\text{Scale} = \frac{10}{8 \times 50{,}000}$$

$$= \frac{10}{400{,}000}$$

$$= \frac{10}{40{,}000}$$

Air photo scale is 1:40,000 or $\dfrac{10}{40{,}000}$

Summary

In this lecture, I have briefly outlined the importance of air photo scale and described two procedures for calculating air photo scale using:

1. focal length of camera lens and aircraft flying height; and
2. topographical maps.

Determining the scale of air photographs is vital to quantitative air photo analysis. The student of aerial photo interpretation should therefore be conversant with procedures for calculating air photo scale.

Post-Test

Calculate the scale of an air photograph given the focal length of camera lens of 152mm and an aircraft flying height of 4.5 kilometres.

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LECTURE SEVEN

The Study of Vertical Air photographs: 1
The Use of the Stereoscope

Introduction

We are now moving into a more practical aspect of the study of aerial photographs. In this lecture, I shall introduce you to the stereoscope and tell you how to use it in studying air photographs.

Objectives

At the end of this lecture, you should be able to:

1. discuss the use of stereoscopes to study vertical air photographs; and
2. the procedure for using the stereoscope for studying vertical air photographs.

Pre-Test

Take out your dictionary and check the meaning of stereoscope. Why is the instrument used in studying vertical air photographs?

CONTENT

I shall begin this lecture by explaining why it is necessary to use the stereoscope to study vertical air photographs. Before doing this, I shall try to answer a question you may have been wondering about. 'What is a stereoscope? It is an instrument, usually with two lenses, used for viewing stereopairs of vertical air photographs so as to appreciate relief. This implies that when one uses the stereoscope to study the area of overlap in two adjoining exposures of vertical air photographs, one will have a mental impression of a three-dimensional model of the landscape.

In other words, the hills and ridges will appear upstanding while the valleys will appear as if they are actual troughs or elongated depressions in the land fringed by higher land on either side. Although, the surface of the photograph is flat, when the stereoscope is used to study a stereopair of photographs the relief stands out clearly and one will be able to appreciate the third dimension of objects or features of the landscape relating to the extent of their vertical development i.e. height and depth. By using the stereoscope to study a stereopair of vertical air photographs, one would be able to distinguish between hills and valleys. This is quite important in the geographical study of air photographs. A stereopair of air photographs, you will recall, is a set of two adjoining photographs both of which have a common area of overlap. The science of stereoscopy is very basic to aerial photo interpretation and I intend to discuss it a little further here.

Stereoscopy

Stereoscopy has been defined by Howard (1970) as 'the science and art of viewing two different perspectives of an object, recorded on photographs taken from nearby camera stations, so as to obtain the mental impression of a three-dimensional model of the object'. One can appreciate length and breadth of objects on vertical air photographs but one needs to use the stereoscope to study them to appreciate height or depth. The science of stereoscopy is essentially concerned with obtaining the three dimensional model of objects from stereopairs of vertical air photographs. You will recall that a photograph and that immediately following it on the flight line have 60% end lap. This ensures that any portion of the landscape is photographed at least twice and so appears on two consecutive exposures of photographs. Each photograph, therefore, represents a different perspective of the land with respect to the area of overlap.

In the nineteenth century, Wheatstone demonstrated that when two photographs of the same image are placed in front of the eyes such that each eye views a similar image, the two images will appear to fuse to form a single image and the eye will be able to appreciate relief of objects in the photograph. This is the essence and basis of stereoscopy. The use of the stereoscope in studying aerial photographs is supposed to facilitate stereoscopic vision. The ability of the eyes to fuse two separate images of the same object to form a single image, giving a impression of relief is physiologically determined. Using stereoscopes to study air photographs does not therefore automatically guarantee stereoscopic vision. Due to eye defects, some individuals cannot see stereoscopic vision. Due to eye defects, some individuals cannot see stereoscopically. Stereoscopic vision is hampered by poor lighting conditions and tiredness.

Stereoscopic Viewing of Vertical Air Photographs

Only consecutive exposures of vertical photographs with a common area of overlap should be examined using a stereoscope. Any two consecutive exposures can be examined. Before describing the procedures for stereoscopic examination of air photographs, I shall talk briefly about stereoscopes. The pocket or lens stereoscope (also caned hand stereoscope) is very commonly used because it is very handy and can be easily carried about in the field and also because it is very cheap compared with the mirror stereoscope. The pocket stereoscope consists of two lenses that are connected by an adjustable bridge (bar) whose length can be adjusted by unscrewing a knob. The two tenses with the connecting bar are mounted on two sets of collapsible legs that can be folded. Before using the pocket stereoscope for studying a stereopair of photographs, the distance between the two lenses should be adjusted to correspond with the eve base or the interpupillary distance of the viewer. The eye base is simply the distance from the centre of one eye (i.e. the pupil) across the nose bridge to the pupil of the other eye. For most people, the eye base varies between 60 and 75mm with an average of about 65mm. I wish to emphasize here that the stereoscope should be used for studying only the area of overlap. The major limitation of using the pocket stereoscope is that only a narrow strip of the stereopair of photographs can be studied at a time. A much wider area can be studied using a mirror stereoscope. Besides, when using a pocket stereoscope, it is necessary to bring the two images of the same object appearing on the two photographs very close to one another (usually about 60mm apart) and this may necessitate flipping the side of one of the photographs.

Before examining consecutive pairs of photographs with the stereoscope, they should be properly oriented. This implies they should be aligned in such a way that each photograph occupies the same position it occupied at the time of exposure relative to the other photograph. This is usually done by locating the principal point of each photograph on it and also the transferred (conjugate) principal point. The two photographs are then aligned in such a way that the principal point and the conjugate principal point of one photograph are in line with those of the other photograph. Having aligned the photographs as described above, the procedure described below is followed in their stereoscopic examination

1. The area of overlap of each photograph is placed under each lens of the pocket stereoscope.
2. A suitable image of the same object appearing in both photographs is identified.
3. Place one image of the object appearing on one photograph under the right lens of the stereoscope.
4. Place the image of the same object appearing in the other photograph under the left lens.
5. Move the two photographs gradually towards one another while looking through the lens of the stereoscope (the right eye viewing the right lens and the left eye the left lens) until the two images are seen to fuse to form a single image under the lens of the stereoscope.
6. Keep the photographs firmly in place and scan through the area of overlap using the stereoscope.

Summary

A single photograph should not be examined using the stereoscope except to enlarge small images to facilitate their identification. Stereoscopic examination of a single photograph usually gives a wrong impression of relief. The most appropriate spacing; of images of the same object when studying photographs using a pocket stereoscope is usually about 6-10mm less than the eye base of the viewer. The lines of drainage offer a clue as to the pattern of relief on the photograph. The narrow strip of land immediately bordering streams should be seen as valleys and not as hills.

Post-Test

Which of the following is the most appropriate definition of stereoscopy?

1. the science of air photo analysis.
2. the use of stereoscope to study vertical air photographs.
3. the use of stereoscope to study oblique air photographs.
4. the art of viewing two different perspectives of the same object recorded on a stereopair of vertical air photographs so as to appreciate relief.
5. the art and science of recording different perspectives of images of objects on vertical air photographs.

References

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LECTURE EIGHT

The Study of Vertical Air Photographs: II Urban Land Use Analysis

Introduction

In this lecture, I shall introduce you to the study of urban land use types on vertical air photographs. I shall concentrate mainly on the identification and characteristics of different types of urban land use. We shall also examine land use patterns on a vertical air photograph and make deductions about human spatial interaction and distribution of people belonging to different socio-economic classes (low income versus high income earners) from the pattern and characteristics of housing density and types. Note that what we shall do in the latter part of this lecture involves inferring the distribution of people of different socio-economic classes from housing density. Making deductions about spatial relationships and spatial processes from patterns observed on photographs is an essential and perhaps, the most significant part of aerial photo interpretation. The categorisation of images on air photographs into distinct classes (e.g. of land use types) is called air-photo analysis and is usually a step prior to the making of deductions from air photographs.

Objectives

At the end of this lecture, you should be able to:

1. identify different types of urban land use; and
2. describe their basic characteristics.

Pre-Test

Name three types of land use characteristic of urban areas.

CONTENT

Urban Land Use Types

Buildings which are clustered together generally dominate the urban land-scape. Buildings possess regular outlines and can be readily recognised on vertical air photographs by their light (white) tones. The agglomeration of discrete rectangular structu.res with light tones usually suggests the presence of a settlement on air photographs. Usually, only the roofs of buildings are seen on vertical air photographs and their very light tones suggest a high reflection of solar energy.

Usually the following types of land use can be identified in urban/areas:

1. residential land use;
2. commercial/industrial land use;
3. recreational land use; and
4. transportational land use.

Residential Land Use

This is usually characterised by buildings which are generally much smaller than those used for commercial and industrial purposes. Residential land use is usually the dominant type of land use in an urban centre. Two distinct types of residential land use can be recognised in most cities namely:

1. the high density; and
2. the low density residential land use.

The former is characterised by small, closely packed buildings with no gardens or shade trees near or around the buildings. The high density residential zone usually houses the low income earners (the urban poor) and it is characterised by narrow streets. The low density residential zone, in contrast, is characterised by larger buildings, wider streets and the presence of grassy lawns/gardens and shade trees around or near the buildings. The number of houses per unit area is lower than in the high density zone. The low density zone usually houses the elite and people of high socio-economic status such as top insurance and bank personnel especially those belonging to the managerial cadre.

Commercial/Industrial Land Use

This is characterised by very large buildings that are sometimes arranged in rows. A single building in this land use category may be up to five times the size of an ordinary residential building. This land use category can therefore be easily recognised because of the unusually large size of the buildings.

Recreational Land Use

This is usually made up of sports grounds and other grassy lawns. In some cases, the presence of a recreational land use on a photograph is unmistakable, the presence of an oblong running track being diagnostic. The running tracks are usually characterised by a light tone. Grassy lawns, usually with grey tones, also indicate recreational land use. Such grassy lawns stand out clearly from roofs of buildings which are characterised by lighter (usually white) tones.

Transportational Land Use

Roads are an important land use type in urban areas. Roads and railways are characterised by a constant width and dark tone. Tarred roads generally have a low degree of light reflection and so appear dark in tone on black and white air photographs. Generally, roads and railway lines stand out clearly on air photographs because they are linear and have a constant width.

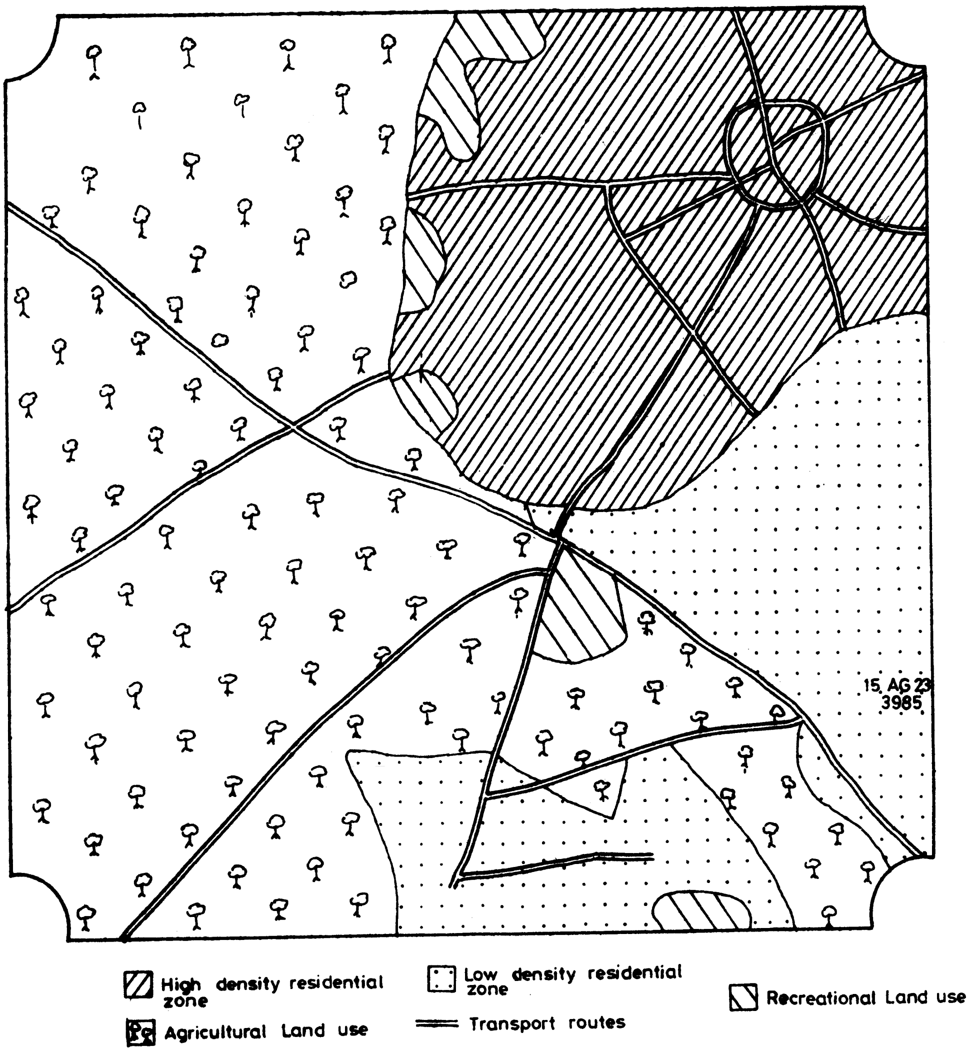

Figure 2: Land Use pattern on air photo 15 AG 23 3985

Analysis of Land Use Pattern on Air Photo No 5AG23 3985

An actual example of land use analysis in an urban setting will now be considered here. The air photograph shows a part of an urban centre and the adjoining rural countryside where farming is an important human pursuit.

The following main types of land use can be identified on the photograph:

1. high density residential zone;
2. low density residential zone;
3. recreational land use;
4. agricultural land use; and
5. transport routes.

Note: The number on the sketch map is inserted in the same approximate position as on the photograph. Use the number for orienting the photo and sketch map so that their features correspond with one another.

A. High Density Residential Zone

This consists of small, closely packed buildings. With the exception of the main transport routes, the streets are very narrow. You will notice that most of the roofs have dark tones instead of light (white) tones. This is because the roofs are made of mud. The city shown on the photograph is in the drier near-extreme northern part of our country where the rainfall is low. It is traditional to use mud for making roofs in such areas of the country. Note also that trees (indicated by black dots or patches) are very few in the low density zone. You will also notice the presence of white patches, some of which are tending towards dark grey, here and there. They are pools of water, some of which are used as dying pits. You will notice that roads in the low density zone converge at its centre which is presumably its nuc1eaus and focus of vehicular traffic. If you observe closely, you will notice that the buildings in the central region of the low density residential zone are very large in relation to the typical buildings in that zone. The buildings which are very long are most likely to be commercial buildings housing central place activities such as banks, insurance, wholesaling and retailing activities. One can, therefore, infer that the central region of the low density zone is some sort of a Central Business District (CBD).

B. Low Density Residential Zone

The buildings here are larger and less closely packed than those in the high density zone. The presence of trees (indicated by black spots some which merge with one another) is very evident. The streets are wider and some of them are lined with trees. The roofs of buildings in the low density zone are light (white) in tone suggesting that the roofs are not made of mud but of materials such as corrugated iron sheets which reflect a lot of the incident light energy.

C. Recreational Land Use

The presence of the oblong running tracks with light (white) tones clearly indicates recreational land use. Some grassy lawns, presumably used for recreational purposes -also occur near the outskirts of the high density residential zone and also in the low density zone.

D. Agricultural Land Use

This occurs in the areas not characterised by buildings. The boundaries of the individual farm holdings are visible and the entire land divided up into farms. Most of the farms are a bit light in tone suggesting that they have been cleared recently. The black dots are trees standing on the farms.

Summary

In this lecture, we have examined the characteristics of urban land use types and briefly outlined their main features on black and white air photographs. The pattern of urban land use in an air photograph was also analysed.

Post-Test

Which of the following types of land use is not usually characteristic of urban are as?

1. agricultural land use
2. residential land use
3. industrial land use
4. recreational and use
5. transportational land use.

LECTURE NINE

The Study of Vertical Air Photographs: III Rural Land Use Analysis

Introduction

In this lecture, I shall introduce you to the analysis of rural land use on vertical air photographs. I shall focus on the characteristics of rura11and use and provide guidelines on how to identify different types of rural land use on vertical air photographs using the characteristics of photographic images. In the latter part of this lecture, we shall examine the pattern of rural land use on a vertical air photograph.

Objectives

At the end of this lecture, you should be able to:

1. identify different types of rural1and use on vertical air photographs; and
2. describe the basic characteristics of rural land use as depicted by photographic images.

Pre-Test

What is the predominant type of rural land use? What features on the vertical black and white air photograph would suggest to you that rotational bush fallowing is the system of arable farming in an area?

CONTENT

I shall begin this lecture by describing the different types of rural land use and indicate their characteristics.

Rural Land Use Types

Unlike in urban areas where houses are the dominant elements of the landscape, houses generally do not feature prominently in rural areas. Usually, agricultural land use is the predominant land use accounting for the greatest proportion of the total land area of the countryside. The character of agricultural land use varies with the system of farming. In the photographs we examined in the last lecture, the agricultura11and near the urban centre consists of different farm holdings which are contiguous with partitions between them. The landscape is open and virtually the whole land is divided up into individual farm holdings. This is usually the case around some urban centres in the northern part of this country around which permanent and continuous systems of cultivation have evolved. This is not usually the case in most of the rural areas of this country where rotational bush fallowing is practised. Where rotational bush fallowing is practised, the landscape consists of scattered clearings separated by intervening bushes which are left uncultivated by the farmer at a particular point in time. At some future date, the bush will be cleared for cultivation and the farmland allowed to revert to fallow. The scattered clearings usually have a light tone, tending towards white, if the sites are recently cleared and bear very little vegetal cover. The older clearings which contain a dense cover of crops have a darker tone but a distinct whitish tone is still discernible. The recently cleared patches of farmland look superficially similar to roofs of buildings because of their very light tones. They can however be distinguished from the latter in that they (the farmlands) are more irregular in shape than roofs of buildings. Besides, on medium scale photographs on scale of 1:20,000 or larger the parting at the middle roofs can be seen clearly and their characteristic shape resembling an inverted letter V (i.e. $\wedge$is readily apparent.

In parts of southern Nigeria, secondary regrowth vegetation and in some areas, forest vegetation are important features of rural land use. The former is characterised by grey tone and sometimes a smooth texture. In old secondary regrowth vegetation with some trees towering above the general canopy level, the texture is usually rough. Generally vegetated surfaces reflect less incident solar radiation than bare ground surfaces. Hence, vegetated surfaces are generally characterised by darker tones than cleared land. Mature rain forest with tall emergent trees towering above the general level of the vegetation usually has a rough texture and dark grey tones. Forest plantations consisting of a single tree species of about the same height are usually characterised by a smooth texture.

Settlements are usually an important element of the rural landscape although the actual land area occupied by them is small in relation to land under arable farming/uncultivated bush. Settlements are readily identified by the very light (white) tones and the regular structure (mostly rectangular) of the individual buildings. Settlements are usually strung along transport routes, especially the main roads.

Rivers are important features of the natural landscape in many rural areas. Rivers are linear like transport routes. They can be distinguished from roads by careful stereoscopic examination. It will be observed that rivers occur in trough-like depressions characteristic of valleys unlike roads. Besides, rivers usually have more pronounced curves than roads. In general, roads tend to be straighter over longer stretches than rivers. Additional features of rivers which clearly distinguish them from roads on air photographs include varying width and braiding. Water is somewhat transparent and therefore generally reflects less incident solar energy than road surfaces: Hence, rivers tend to appear in darker tones than transport routes on panchromatic black and white air photographs.

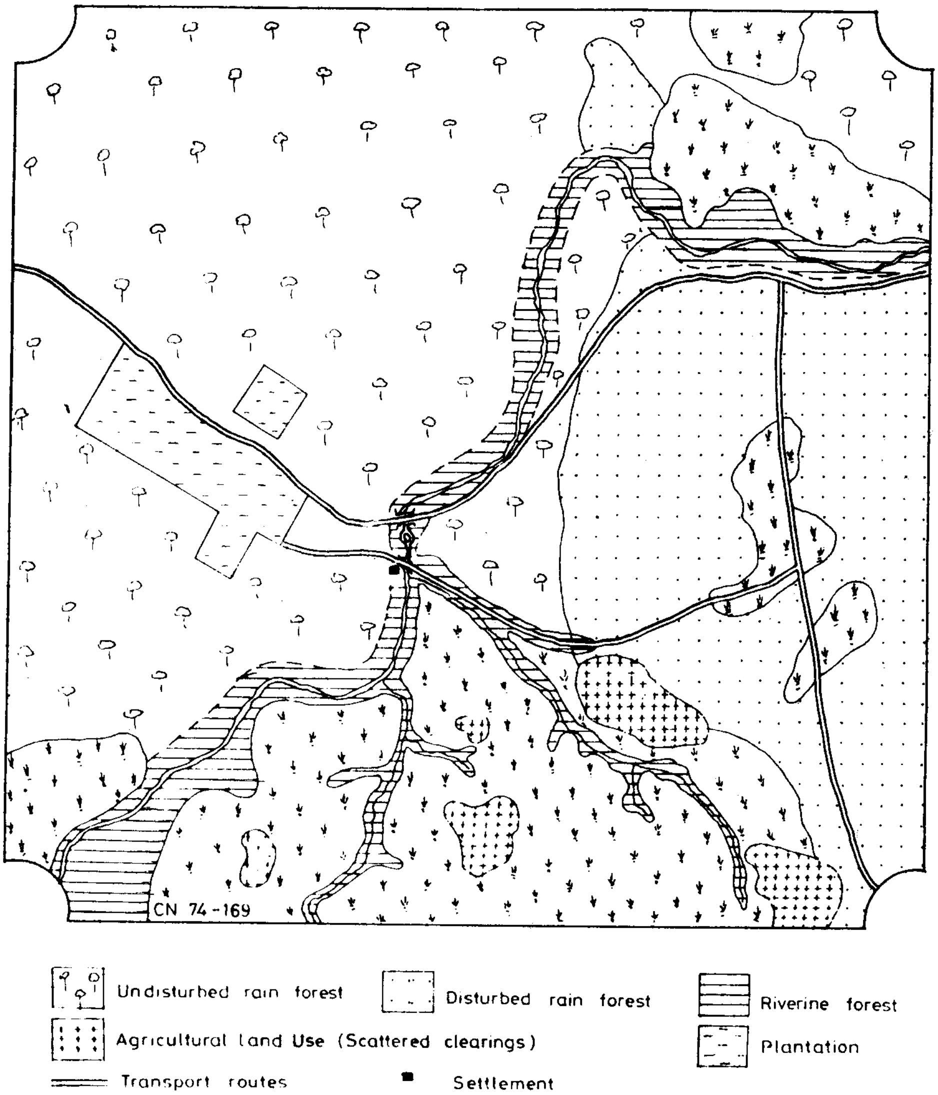

Figure 3: land use pattern on air photo C -N 74 169

Analysis of Rural Land Use on Air Photo C - N 74 169

The air photograph shows rural land use in a part of the rain forest zone of south-western Nigeria. The following types of land use can be identified on the photograph:

a. Undisturbed rain forest.
b. Disturbed rain forest.
c. Plantation.
d. River and riverine.
e. Agricultural land use.
f. Settlement.
g. Transport routes.

Note: The number on the sketch map is inserted in approximately the same position as on the photograph. Use the number for orienting the photo and sketch map so that their features correspond with one another.

A. Undisturbed Rain Forest

This occupies much of the air photograph (see sketch map). It is readily recognised because of its dark grey tone and its rough texture, the latter characteristic is mainly due to the tendency of tree crowns to overlie one another. This land use type occupies much of the left half of the photograph.

B. Disturbed Rain Forest

This is mature rain forest but has areas of lighter tones here and there indicating recently cleared sites.

C. Plantation

This is characterised by a grey tone similar to that of rain forest but the texture is smoother. It appears to be divided into a number of strips.

D. River and Riverine Forest

The main river channel has a black tone which makes it stand out dearly from other features of the photograph. The river is fringed on either side by riverine forests although the riverine forest is hardly distinguishable from the adjoining undisturbed rain forest along the main river channel. The riverine forest is more clearly seen along the tributary streams. It is characterised by a grey tone with specks of white here and there and a rough texture.

E. Agricultural Land Use

This consists of areas of light tone scattered in a matrix of areas of dark tone. The scattered patches of light tone are recent clearings (farmlands) while the areas of dark tone are bushes not currently used for cultivation. This pattern of agricultural land use suggests that rotational bush fallowing rather than continuous cultivation is the system of arable crop production.

F. Settlements

Only one settlement on the bank of the main river channel can be seen.

G. Transport

A number of roads traverse the area covered by the air photograph. The transport route that is most clearly visible on the air photo is a railway line.

Post-Test

What type of land use is typified by scattered patches of light tone in a matrix of darker tones on panchromatic black and white air photographs?

1. forest plantation
2. secondary forest
3. permanent cultivation
4. rotational bush fallowing
5. pastures/ranches

Reference

Dickinson, G. C.; *Maps and Air Photographs*, Edward Arnold, London, 1979.

LECTURE TEN

Radial Displacement

Introduction

You may have observed that relief is poorly represented on vertical air photographs. The vertical air photographs can adequately represent dimensions (length and breadth) but not the third dimension relating to the extent of vertical development as the surface of the photograph is flat. When a standing tree is imaged near the margin of a photograph of about 1:10,000 or larger, it will be seen as if it were lying on its side. In other words, the top of the tree has been displaced away from its base. Similarly, the tops of features such as telegraphic poles and even hills are displaced away from their bases. The displacement of images of objects may also be due to the effects of tilt. In this lecture, I shall introduce you to the basic types of image displacement (radial displacement) on vertical air photographs and their main causes.

Objectives

At the end of this lecture, you should be able to:

1. define radial displacement; and
2. describe the main causes of radial displacement on vertical air photographs.

Pre-Test

What is a datum plane?

CONTENT

Radial displacement can be defined as an error or a shift in the location of an object relative to the principal point (geometric centre) of the photograph. On the ground, the top of a tree or telegraphic pole is directly above its base. In other words, it is standing vertically upright. On suitable air photographs, such upstanding features such as telegraphic poles and trees will be seen as if they are lying on their sides when they appear towards the periphery of the photography. (Note that at the centre of the photograph, i.e. the principal point, only the tops of features such as trees and poles will be seen on vertical air photographs).

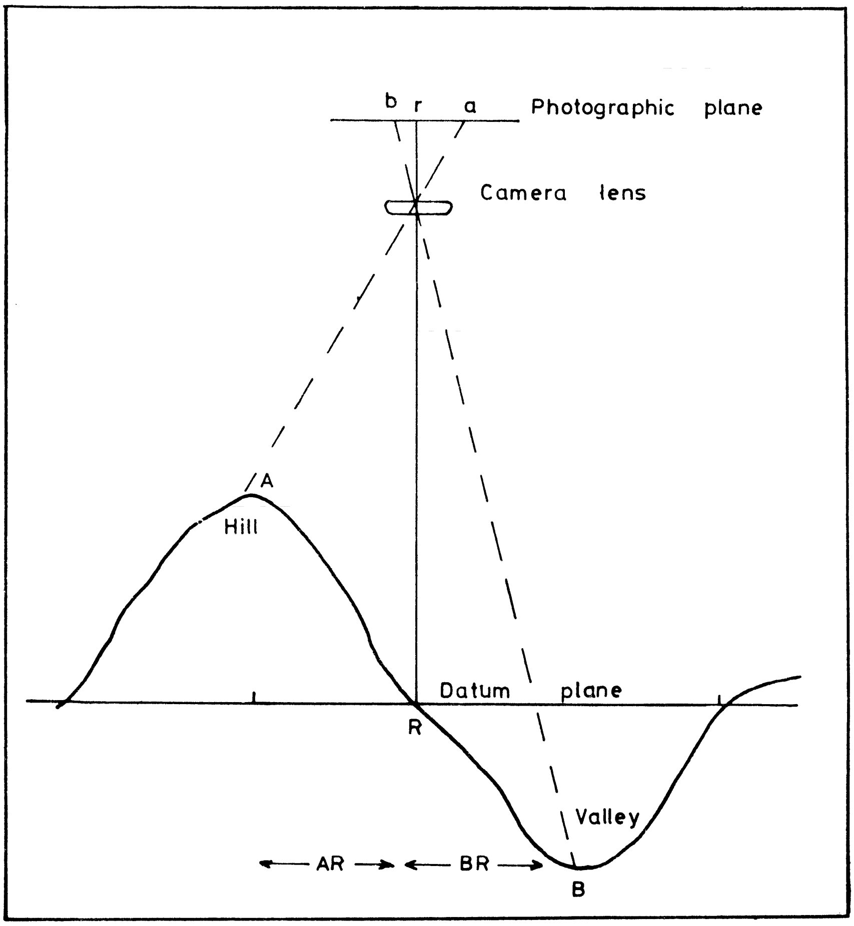

Figure 4: Effect of relief on radial displacement on a vertical air photograph

The images of trees which appear on vertical air photographs as lying on their side suggest that the top of the tree has been displaced away from its foot. This type of radial displacement is essentially due to height or elevation of upstanding features above the ground or the datum plane. Radial displacement due to height or changes in elevation is not confined to features of such telegraphic poles and trees. It may also be due to changes in elevation, relative to the datum plane, over the ground surface being photographed. 'This type of radial displacement resulting from variations in relief is called relief or topographic displacement. In general, there is no relief displacement on flat or nearly flat featureless plains where differences in elevation are not marked. In contrast, relief displacement is considerable in areas of rugged relief with marked differences in altitude.

Radial displacement may also be due to the effects of tilt. As a result of tilting of the aircraft, the camera may not be pointing perpendicularly downwards. In such a case, the point on the ground directly below the camera lens (nadir) would not correspond with the principal point of the photograph as it should theoretically. The tilting of aircraft with the attendant inclination of the camera axis at angle of less than 90° to the horizontal plane results in a shift in the location of points on the photograph relative to the principal point.

Because radial displacement results in a lateral shift in the location of points on vertical air photographs, it is important to determine the true location of points on them before compiling maps from them.

Topographic Displacement

Figure 4 illustrates the effects of relief on radial displacement on a vertical air photograph. R is the point below the camera lens; it is the nadir on a truly vertical air photograph. A is located on a hill top and B is the valley bottom. Both points are located at the same radial distance from R. This implies that if the area were to be flat, the two points will be equidistant from R i.e. AR= BR. The projections of the points A, R and B to the photographic film of the camera are shown in Fig. 4. The points b, r, and a, represent the positions on the camera film of points B, R and A on the ground respectively. It can be observed that point A on the hill top is displaced away from the principal point of the photograph (r) than point B in the valley bottom. As a result of topographic displacement point "a" on the photograph is further away from "r" than "b" in the valley bottom. This is because point A on a hill top is nearer the camera lens than point B in the valley bottom which is farther away from the camera lens. In general, objects which are above the datum plane are displaced radially outwards while those below are displaced radially inwards. The datum plane is a plane surface or level from which heights and depths are measured e.g. the mean sea level. As a result of radial displacement, the distance br is not equal to ar on the photograph as it should have been if the ground were flat.

Height Displacement

The phenomenon of height displacement on vertical air photographs is essentially similar to that of topographic displacement I described above. Trees of the same height may occur at different elevations on the landscape and so exhibit varying degrees of radial displacement on vertical air photographs. The amount of radial displacement due to a tree of 100 metres tall in a valley bottom will be less than that due to another tree of the same height occurring on the summit of a hill which is 300 metres higher than the valley. For this reason, some people regard height displacement as different and distinct from topographic displacement. The basic principles of radial displacement due to topography and height of trees, telegraphic poles etc. are however the same. The tops of features such as trees and telegraphic poles are displaced radially outwards relative to the principal point of vertical air photographs while their bases are displaced radially inwards.

Summary

I have discussed the radial displacement on vertical air photographs as resulting primarily from a shift in the location of points relative to the principal point of the photograph. Radial displacement on vertical air photographs is commonly due to aircraft tilt or variations in ground elevation relative to the datum place. Upstanding features of the landscape such as trees and telegraphic poles also exhibit radial displacement on vertical air photographs. Their bases are usually displaced away from their tops. The basic principle of radial displacement is that points above the datum plane are displaced radially outwards in relation to the principal point while those below are displaced radially inwards.

Post-Test

A shift in the location of points, relative to the principal point on vertical air photographs is called?

1. point migration
2. height displacement
3. lateral displacement
4. topographic displacement
5. radial displacement.

Reference

Howard, J. A.: *Aerial Photo-Ecology*. Faber & Faber, London, 1970.

LECTURE ELEVEN

Radial Line Triangulation

Introduction

In the last lecture, I introduced you to radial displacement on vertical air photographs. You will recall that radial displacement is a lateral shift in the location of a point relative to the principal point of the photograph. This error or shift of location of points on vertical air photographs results from tilt of the aircraft and variations in elevation over the ground surface photographed. Because vertical air photographs contain locational errors resulting from radial displacement, it is important to determine the true location of points on air photographs when making measurements and when compiling maps from vertical air photographs. The technique of radial line triangulation is used for this purpose. In this lecture, I will introduce you to the technique of radial line triangulation.

Objectives

At the end of this lecture, you should be able to:

1. distinguish between two-dimensional and three dimensional radial line triangulation; and
2. apply the technique of two dimensional radial line triangulation to determine the true location of points on vertical air photographs.

Pre-Test

Check the meaning of the word 'triangulation' in your dictionary. In what field other than aerial photo analysis is the principle of triangulation commonly applied?

CONTENT

To triangulate means to divide an area up into triangles as is commonly done when surveying land. The principle of triangulation is also employed when compiling maps from vertical aerial photographs. Essentially, triangulation is used to fix the true locations of points on vertical air photographs. Usually, the triangles are drawn using the air base or baseline of the photograph (the line joining the principal point and the conjugate principal point) as the base of the triangles. The other two sides of the triangles are used for fixing the true location of any point imaged towards the periphery of the photograph. I shall return to this point later when I shall describe the technique of two dimensional radial line triangulation.

There are two main types of radial triangulation techniques namely; (two dimensional radial line triangulation and (2) three dimensional radial line triangulation. The latter involves complex mathematical computations and plotting of the true map position of points from stereoscopic images. It is a lot more complex than two dimensional radial line triangulation. Developments in and applications of electronic computers have enhanced the application of three dimensional radial line triangulation. In this lecture, we shall focus primarily on two dimensional radial line triangulation because of its simplicity and ease of application. Two dimensional radial line triangulation merely involves using triangles founded on the baselines of vertical air photographs to locate points imaged towards the periphery of the photograph without resort to plotting from stereoscopic images. This obviously implies that the application of the technique of two dimensional radial line triangulation does not involve stereoscopic viewing of images and plotting from the three dimensional model of the landscape so obtained.

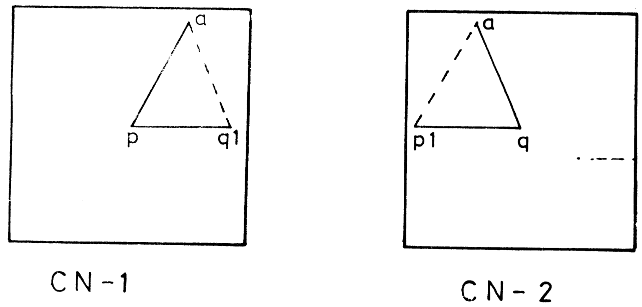

Figure 5: A method for determining the true position of an object using two dimensional radial line triangulations

Principle of Two Dimensional Radial Line Triangulation

I have made the point in the previous lecture that there is usually no radial displacement at the centre of the vertical air photographs. Only the tops of upstanding features such as hills, trees, poles; and buildings will be seen when such features are imaged at the centre of the photograph. The assumption that there is no radial displacement at the centre of a vertical photograph (subject to the condition that tilt is negligible or non-existent) is, therefore, a reasonable one to make. Granted that there is no radial displacement at the centre of the photograph, one can, therefore, use the principal point of the photograph as centre from which rays or radial lines can be drawn at constant and true angles to the images of objects whose true location are to be determined. You are aware of the fact, I hope, that the location of a feature on the ground can be fixed by observing it from two geographically separate points and projecting lines from the two points to the object. The two lines, one originating from the first point of observation and the other from the second will intersect at the location of the feature one wants to fix.

The simple principle I have just described can be applied in air photo analysis to locate the true location of points imaged towards the periphery of the photograph. The principal point and the conjugate principal point can be used as the two points from which radial lines (rays) are drawn to the images of objects. The intersection of the two rays drawn from the principal point and the conjugate principal point defines the true location of the object one is interested in fixing. If the area is not characterised by marked differences in relief, it may well be that the true location of the point coincides with its actual location on the air photo. I shall now discuss the application of the principle I have just described to make a theoretical discussion appear more real.

Application of the Technique of Two Dimensional Radial Line Triangulation

The technique of two dimensional radial line triangulation is used for locating the true location of points imaged in the area of overlap on consecutive air photo exposures. The principal point and conjugate principal point are used as the centre points from which radial lines are drawn to the points whose true locations are to be determined. The procedure of two dimensional radial line triangulation is illustrated in Figure 5. CN-1 and CN-2 are stereopairs of vertical air photographs with a common area of overlap. The point, a, whose true location is to be determined occurs in the area of overlap and so can be located on both photographs. Each photograph is annotated as illustrated in Figure 5. The principal point of CN-1 is p and that of CN-2 is q. Their respective conjugate principal points are q1 and p l. On each photograph, the base line is drawn and a line (a ray) drawn from the principal point to the point a, whose true location is to be determined. The true location of the point is determined by making the two rays (one drawn from the principal point of CN-1 and the other from the principal point of CN-2) to intersect. This can be done in two ways. The first method is to measure the angle apq l on CN-l and measure the same angle at point p1 on CN-2 and use the angle for fixing the transferred ray which is shown in broken line. The second method forms the basis of the overlay method which I shall describe in some detail in the next lecture. A tracing point is placed over air photo - CN-1 and the base line pq l and the ray from p to a traced on it. The tracing paper is then placed on the second photograph (CN-2). It is correctly oriented such that the base line pq l on the tracing paper lies directly above p1q on photo CN-2. Then the line p 1a is drawn on the tracing paper and the intersection of the two rays determined.

Summary

The technique of radial line triangulation described above can be used for compiling maps from air photographs. This is the theme of the next lecture.

Post-Test

Two dimensional radial line triangulation is?

1. fixing- true location of points on vertical air photographs from plots of stereoscopic images.
2. dividing air photographs into triangles in order to determine their areas.
3. determining the true locations of points on vertical stereopairs of photographs based on the intersections of rays drawn from their principal points and conjugated principal points.
4. drawing radial lines from the geometric centre to points at the periphery of a vertical air photograph.

References

Areola, O.: *An Introduction to Aerial Photo-Interpretation in the African Environment*. Evans, Ibadan, 1987.

Howard, J. A.: *Aerial Photo-Ecology*. Faber & Faber, London, 1970.

LECTURE TWELVE

Planimetric Mapping

Introduction

The technique of radial line triangulation forms the basis of line-plotting methods used for compiling maps from vertical air photographs. In the last lecture, I have introduced you to the technique of radial line triangulation. In this lecture, I shall build upon what I taught you in the last lecture and describe the procedures of compiling planimetric maps from vertical air photographs.

Objectives

At the end of this lecture, you should be able to:

1. define planimetric maps and distinguish between them and topographical maps;
2. indicate the usefulness of planimetric maps; and
3. describe the overlay and template methods of compiling planimetric maps from vertical air photographs.

Pre-Test

Name two types of planimetric maps.

CONTENT

I suppose that you are not very familiar with the term "planimetric map." I shall, therefore, begin this lecture by attempting its definition. A planimetric map is one which shows the lengths and breadths of features of the landscape as recorded on the vertical air photograph. An important distinction between planimetric and topographic maps is that the former do not usually adequately characterise differences in ground elevation quantitatively as topographical maps do. Topographical maps show differences in ground elevation by means of contour lines and it is possible to quantitatively assess the difference in elevation between any two points on topographical maps. This is not usually possible on planimentric maps which lack contour lines and which at best give an indication of the lengths and breadths of features such as hills and ridges. Since air photographs contain radial displacement, the planimetric map is not a direct tracing of ground features from the photograph. Rather, it is an accurate drawing of the features of the landscape to scale and in their proper spatial relationships to one another. This means that the vertical air photograph has to be corrected for radial displacement when compiling planimetric maps of mountainous areas which will most likely contain substantial amount of topographic displacement. The technique of radial line triangulation described in the previous lesson is used for correcting vertical air photographs for topographic displacement.

Use of Planimetric Maps

Planimetric maps can be put into a variety of uses such as showing boundaries between soil and vegetation types, forest types, boundaries of landed property, and land use types generally. Many soil, vegetation, land use and cadastral maps are produced directly from vertical air photographs and are examples of planimetric maps. It is clear to you, I hope, that planimetric maps can serve different purposes including land management and conservation, taking inventory of forest resources; and taxation purposes in case of cadastral maps. The last mentioned type of planimetric maps (cadastral maps) show boundaries of individual land holdings.

Although some planimetric maps show some details of terrain conditions (e.g. occurrence of swamps, forests, lakes, and ridges etc.), they are not a substitute for topographical maps as they (planimetric maps) are generally deficient in quantitative representation of relief.

Methods of Planimetric Mapping

I shall describe two methods of compiling planimetric maps from air photographs here. The two methods (the overlay method and the hand template method) are based on the principle of the two dimensional radial line triangulation.

Overlay Method

I introduced the overlay method in the last lecture. It is suitable for compiling planimetric maps when the photographs are few. Ideally, the overlay method should be used for compiling planimetric maps when the number of flight lines does not exceed three with only a few numbers of photographs per flight line.

The overlay method was described in the previous lecture. It is a simple method of compiling planimetric maps from vertical air photographs. Each photograph is annotated using China graph pencils or other suitable materials such as coloured pencils. Do not use ordinary pencils or ball pens for annotating air photographs. If you do, you will deface and spoil them. The annotations on each photograph include the principal point, the conjugate principal point, the base-line, and the rays from the principal point to the various points to be fixed. Note that when trying to fix a feature such as a road or. a river, one needs to use a few strategic points especially those marking changes in direction of flow or orientation. In other words, one needs to mark those points along the road or river where distinct bends occur and ignore the straight portions of the road or river. Once the points marking the bends along the road or river have been fixed on the planimetric map, the straight stretches can be sketched in between the points by interpolation. When trying to fix areas which are square in outline or possess other regular outlines, only their corners need be marked on the photograph. Once the points marking the corners of such features have been fixed on the planimetric map, their approximate outlines can easily be plotted by drawing lines to connect the points.

After annotating the photographs as described above, the first photograph in the first flight line is inserted under a suitable transparent drawing material as described in the last lesson. The baseline and the rays to the various points to be fixed (e.g. river bends) are traced on the tracing paper. The first photograph is then removed and the second in the flight line inserted under the tracing paper following the procedure described in the last lecture. After properly aligning the flight line, rays are drawn from the principal point of the second photograph to the same features; rays were drawn to when working with the first photograph. The rays are extended until they intersect with those drawn when working with the first photograph, thereby fixing of the location points on the map being drawn. The second photograph is then removed from below the tracing paper and the third one in the flight line inserted. The base line formed by the conjugate principal point of the second photograph and the principal point of the third photograph is then traced on the tracing paper. Note that the base line of the first and second photographs is extended to the third as the flight line is in fact continuous. Using the principal point of the third photograph as the centre point, one traces rays drawn on the third photograph on the tracing paper. In short, the procedure used for locating the correct location of points when working on the area of overlap between first and second photographs is repeated for the area of overlap between first and second photographs is repeated for the area of overlap between the second and third photograph and the rays made to intersect. The overlay method requires working with a single large piece of tracing paper. Hence, it is more convenient to work with one to three flights, each having a few numbers of photographs.

Template Method

Templates are thin transparent sheets cut to the size of each photograph. These are used for fixing the location of the desired points instead of using the actual photographs for this purpose. As with the previous method, each photograph is annotated with the principal point, rays from the principal point to the points to be fixed and the base line clearly shown. A template is placed on each photograph and the annotations on the photograph traced on the template. The base line of the second template is placed on the first template of the flight line to determine radial ray intersections for fixing the location of points to be fixed. This procedure is repeated for all adjoining templates to fix all desired points.

Summary

In this lecture, I have described two line-plotting methods for compiling planimetric maps from vertical air photographs. It is tedious to compile maps from air-photographs manually using the two procedures. There are a number of mechanical-graphic aids such as the sketchmaster and lineplotters which aid the compilation of maps from air-photographs.

Post-Test

Which of the following statements is true of planimetric maps?

1. they show the horizontal positions of features of the landscape but not their height.
2. they are similar to topographical maps.
3. they show terrain conditions only.
4. they show cultural but not the physical features of the landscape.
5. they are maps produced using the sketchmaster only.

LECTURE THIRTEEN

Planning Aerial Photograph -1: Preliminary Considerations

Introduction

In this lecture, I will discuss some important factors which must be borne in mind when planning to acquire aerial photographs for an area. The acquisition of aerial photographs for any purpose usually involves aerial survey which is expensive. Unless careful thought is given to the planning of such an aerial survey, good quality air photographs will not be obtained and the purpose of acquiring aerial photo coverage for the area will be defeated or at best, partially fulfilled. In this lecture, I shall discuss the preliminary considerations which must be borne in mind by the client before he gives the contract of taking air photographs over a given area to a firm of aerosurveys. To avoid any doubt, I shall not discuss the purchase of already taken air photographs from a government department such as the Federal Surveys. The assumption in this lecture is that you are a client who will award a contract of an aerial survey to an aerosurvey firm.

Objectives

The main objective of this lecture is to acquaint you with the initial factors that should be taken into consideration when planning to obtain aerial photo coverage of an area. At the end of this lecture, you should be able to:

1. determine the most appropriate time for flying an aircraft to take photographs; and
2. decide on the appropriate scale of photographs bearing in mind the purpose of survey.

Pre-Test

What season of the year is best for taking air photographs in Nigeria?

CONTENT

Important factors to be taken into consideration at the planning stage of an aerial survey include:

1. the purpose of the survey;
2. scale of photograph;
3. cost of survey;
4. time of flying; and
5. preparation of the flight plan.

The last mentioned item will be discussed in the next lecture and will not be treated further here.

Purpose of Acquiring Air Photographs

The purpose of acquiring air photographs varies from one client to another. Aerial surveys can be carried out for various purposes including soil and vegetation mapping, forest inventory and management, urban land use analysis etc. The purpose of the survey will determine the scale of the photographs, the type of mm to be used and the time of flying the aircraft to take the photographs. For the purpose of compiling topographical maps and vegetation mapping over fairly large areas, black and white air photographs on scale of 1:40,000 or 1:50,000 are adequate. However, such photographs are inadequate for detailed inventory of forest resources of an area or for distinguishing between diseased and healthy trees in a plantation. For detailed assessment of the merchantable timber in a forest or to identify major associations of plant communities in a stand, large scale air photographs on scale of about 1:5000 or larger would be required. In order to distinguish between diseased plants and healthy ones, it would be necessary to use infrared false colour mms rather than panchromatic black and white film. What is apparent from the foregoing is that the purpose for which aerial photographs are being acquired not only determine the scale of the photograph but also the type of film to be used for taking the photographs. As we shall soon see, when aerial photographs are being acquired for livestock surveys, the photographs have to be taken at certain times of the day. For very detailed ecological and land use studies such as those involving identifying major plants species, it is necessary to use air photographs on very large scale (e.g. 1:5000 or larger) taken preferable with coloured mms. The need of taking large scale air photographs with coloured film has to be reconciled with the cost of the survey, bearing in mind the amount of money available for the project.

Scale of Photograph

The scale of photograph factor was discussed in the last subsection. Generally, large scale air photographs are required for detailed land use, agricultural, and entomological studies. Given, the focal length of camera lens, the scale of the photograph determines the flying height of the aircraft. The type of aircraft largely determines the maximum safe flying height and this should be borne in mind when deciding on the scale of the photograph. Given the maximum flying height of the aircraft, one has to use an aerial camera with an appropriate focal length to obtain a required scale. In deciding on the scale, especially when a very large scale of about 1:1000 or larger is required, one has to consider the minimum safe flying height of the aircraft to be used for the aerial survey. Many aeroplanes have a 'bumpy' flight below an elevation of below 1500 metres and this has to be taken into consideration when deciding on the scale of the photograph. When very large scale air photographs are required, it may be necessary to use a helicopter for taking the photographs.

Cost of Survey

The cost of acquiring a total air photo coverage for the area in question is an important consideration when planning aerial photography. As the scale of the photograph increases, the area covered for each photo exposure diminishes. This substantially increases the cost of the survey. It is the responsibility of the client to ensure that he has enough funds for a complete aerial photo coverage bearing in mind the scale of the photograph. When money is a serious constraint in the client's budget, he may have to settle for medium scale photographs although ideally large scale air photographs are required. Howard (1970) has reported that it was possible to use tone, texture and pattern in conjunction with local knowledge, to identify areas under rice, maize and groundnuts on medium scale air photos of Tabora, Tanzania. Identifying the three annual crops is ideally better achieved on large scale photographs but can be done also on air photos on medium scale of about 1:30,000 if the photo interpreter is familiar with the area.

The cost of acquiring air photographs also has to be considered when deciding on the type of the mm to be used. As pointed out in a previous lecture, panchromatic black and white aerial films are cheaper than infrared and coloured films.

Time of Flying

Time of the day and season of the year the photographs are taken affect their quality and ease of interpretation. Ideally, photographs should not be taken early in the morning or late in the evenings due to poor lighting conditions which would result in poor tonal contrast. Ideally, photographs should be taken between about 10.00a.m in the morning and about 3.00p.m provided that the day is not cloudy. This would ensure maximum natural illumination of the scene being photographed. For the purpose of livestock and wildlife enumeration, it would be necessary to take photographs when the sun is at low angle of-about 10 to 300. This is because animals tend to lie in the open when the sun is low in the sky. In contrast, when the sun is high up in the sky, temperatures are very high and the animals tend to hide under shade of trees. Besides, when the sun is at low angle, the shadows of the animals are distinct and this facilitates their identification.

Conditions prevailing at certain seasons of the year are not conducive for taking air photographs. The cloudy and rainy conditions prevalent during the wet season not only impair visibility but also make it impossible for the aerial camera to record features of the landscape. Although the harmattan period is generally dry, it is not suitable for taking air photographs because of widespread haze which reduces visibility and makes it difficult for aerial cameras to record features of the landscape. About the best time for taking air photographs in this country is the dry season before the onset of harmattan and the latter part of the dry season after the harmattan.

Summary

In this lecture, I have discussed some preliminary considerations for procuring air photographs of an area through an actual aerial survey. These factors should be viewed together and decisions taken on the basis of all factors to ensure that the aerial photographs are of good quality and the purpose of the aerial survey met.

Post-Test

When carrying out an aerial survey for livestock enumeration the photographs should be taken when:

1. the sun is at zenith
2. the sun is near zenith
3. the sun is at low angle
4. the rays of the sun strike the earth perpendicularly
5. very late in the evening.

Reference

Howard, J. A.: *Aerial Photo-Ecology*. Faber & Faber, London, 1970.

LECTURE FOURTEEN

Planning Aerial Photograph - II
Calculating the Parameters for Drawing the Flight Plan

Introduction

A flight plan should be drawn up before the plane flies over the area for the purpose of taking air photographs. The flight plan guides the pilot in taking the photographs. Specific information needed for drawing up the flight plan include the following:

1. air photoscale;
2. size of air photograph and the amount of overlap;
3. the number of flight lines;
4. number of photographs to be taken per flight line;
5. the speed of the aeroplane; and
6. the exposure, interval i.e. the time interval between when one photograph was taken before taking the next photograph on the same flight line.

Objectives

At the end of this lecture, you should be able to calculate the following:

1. the total number of photographs required to cover an area given the amount of overlap and air photo scale;
2. the number of flight lines and the number of photographs per flight line given the size of area and air photo scale; and
3. the exposure interval given the speed of the aeroplane.

Pre-Test

What is a flight plan?

CONTENT

As said earlier, our primary objective in this lecture is to calculate the parameters for drawing up the flight plan. I will therefore devote the remaining part of this lecture to working a concrete example to clarify the procedure for calculating the required parameters.

Example

An ecological survey of a forest is to be carried out. An aerial photographic coverage of the entire forest measuring 200km × 50km is required for this purpose. Calculate the parameters for drawing up the flight plan given the following basic information:

a. scale of air photograph = 1:20,000;
b. focal length of camera lens = 152mm;
c. speed of aeroplane. 500km/hr;
d. average land elevation = 200 metres above sea level; and
e. each photo print measures 23 × 23cm with 60% end-lap and 25% side lap.

1. Flying Height of Aircraft

We need to tell the pilot the required flying height that would yield a scale of 1:20,000 given the focal length of camera lens of 152mm.

$$S = \frac{f}{H}$$

where S = air photo scale
f = focal length of camera lens
H = aircraft flying height

$$\frac{1}{20{,}000} = \frac{152}{H}$$

$$H = 152 \times 20{,}000$$
$$= 3{,}040{,}000\text{mm}$$

We divide this figure by 1000 to convert mm into metres

$$H = \frac{3,040,000}{1000}$$

$$= 3040 \text{ metres.}$$

The aircraft has to fly 3040 metres above the ground.

The altimeter of the aircraft indicates height above mean sea level. Therefore we need to convert height above the ground into height above mean sea level.

For the aircraft to fly 3040 metres above the ground it must fly 3040 metres + 200 metres (mean land elevation above sea level).

= 3240 metres a.s.l

2. Number of Photographs along Each F1ight Line

Note that the longer axis of the area is usually used as the flight line.

With 60% end-lap, net gain is 40%.

Now we shall calculate what distance the 40% of the photograph represents on the ground:

$$\frac{40}{100} \times \frac{23\text{cm}}{1} \times \frac{20,000}{1}$$

(Note that 20,000 is the map scale factor)

$= 0.4 \times 23 \times 20,000$cm.

= 184,000cm.

= 1840 metres

= 1.84km.

Divide the length of the area by 1.84km. to get number of photographs.

$$\frac{200}{1.84} = 108.69 = 109$$

This figure actually represents the number of spaces between the individual photographs. To get the actual number of photographs add one to this figure i.e. 109 + 1 = 110 photos.

3. Number of Flight Lines

With 25% side lap, net gain is 75%. Calculate the distance 75% represents on the ground using the dimension and scale of the photograph:

$$\frac{75}{100} \times 23\text{cm} \times 20{,}000$$

= 345,000cm.

= 3.45km.

Now divide the width of the area by 3.45km.

$$\frac{50}{3.45} = 14.49$$

= 15

As with case of photographs on each flight line, add one to this figure.

Number of flight lines =15 + 1

= 16.

4. Total Number of Photographs

This is obtained by multiplying the number of flight lines by the number of photographs on each flight line i.e.

$110 \times 16 = 1760$ photographs.

5. Exposure Interval

This is obtained by calculating how long it takes the aeroplane to cover the distance between one exposure and the next.

Distance travelled by aircraft between one exposure and the next = 1.84km.

Aircraft speed = 500km. per hour.

Exposure interval is

$1.8 \times 60 \times 60$

500

= 13.248 seconds.

= 13.2 seconds.

Post-Test

Given a mean land elevation of 200 metres at what height above mean sea level should an aircraft fly to yield a scale of 1:40,000 given a camera lens focal length of 152mm.

1. 6080 metres above sea level
2. 8080 metres above sea level
3. 4080 metres above sea11evel
4. 2000 metres above sea level
5. none of the above.

Reference

Areola, O.: *An Introduction to Aerial Photo-Interpretation in the African Environment*. Evans, Ibadan, 1987.

LECTURE FIFTEEN

Aerial Photography and Remote Sensing

Introduction

In this lecture, I shall introduce you to the science of remote sensing. You may be wondering whether there is any relationship between aerial photo interpretation and the science of remote sensing. Aerial photography and air photo interpretation are a part of the much broader discipline of remote sensing. Hence, it would not be totally irrelevant at this juncture to introduce you to remote sensing. I also intend to evaluate photographic sensors and indicate their major limitations.

Objectives

At the end of this lecture, you should be able to:

1. distinguish between photographic and non-photographic sensors; and
2. describe the main limitations of the aerial camera as a photographic sensor.

Pre-Test

Check the word 'sensor' in your dictionary and give an example each of a mechanical (non-biological) sensor and an organic remote sensor.

CONTENT

I shall begin this lecture by explaining what remote sensors are. Remote sensors are devices or organs that collect record and/or store information about a scene or object with which they are not in direct contact. Three examples of organic remote sensors in the human body - the eye, ear and nose - readily come to mind. The eye can observe and collect information about distant scenes and objects without coming in direct contact with them. Similarly, the nose can perceive the smell of distant objects while the ear can pick vibrations from them. When we are talking about the science of remote sensing, we are not strictly concerned about human sensory organs such as the eye, ear and nose. We are mainly concerned about mechanical devices such as the aerial camera and non-photographic sensors which are used for collecting and storing information about the earth, its resources and the various physical, chemical and 'cultural' processes taking place on it. The science of remote sensing is therefore essentially concerned with collecting, storing and retrieving information about the earth using various mechanical devices which are usually borne by aeroplanes, spaceships and orbiting satellites.

There are two main types of remote sensors namely:

1. photographic; and
2. non-photographic sensors.

Photographic sensors 'perceive' a scene and collect information about it using light energy. The aerial camera is a photographic remote sensor. The information collected by the aerial camera is usually stored as a photograph. Non-photographic sensors do not utilise light energy for sensing a scene. They may however produce a photo-like image of a scene. Since they do not perceive using light energy, the photo like image they produce are not photographs. Examples of non-photographic sensors include the radar, the thermal infra-red scanner and micro-wave radiometers.

Advantages and Disadvantages of Photographic Sensors

I shall briefly outline the advantages and disadvantages of photographic sensors before treating non-photographic sensors. Photographic sensors have the following advantages:

1. information is collected and stored as a photograph. Provided the scale is large enough, the features of the landscape can be easily identified and interpreted. Features of the landscape such as vegetation types, roads, settlements and rivers can be easily recognised, sometimes by people who are not familiar with air photographs;
2. Aerial photographs are comparatively cheap and easy to procure

compared to nonphotographic sensors; and

3. the interpretation of air photographs does not require heavy and expensive equipment.

The aerial camera as a photographic sensor has some disadvantages including the following:

1. it depends on light energy (sunlight) and cannot normally be used at night,
2. it requires clear weather for its operation. It cannot be used when it is rainy or when fog and mists reduce visibility, and
3. it is sensitive to only the visible portion of the electromagnetic spectrum.

Although aerial cameras equipped with infra-red films can have their range of sensitivity extended beyond the visible light region, their spectral sensitivity is limited compared to non-photographic sensors.

Non-Photographic Sensors

I shall treat three non-photographic sensors here namely: radar, thermal infra-red scanners, and micro-wave radiometers. The term radar is an acronym formed from Radio Detection and Ranging. You are probably familiar with military uses of radar in detecting the approach of enemy planes or ship. Radar also has peaceful applications in collecting data on the earth's resources. Radar does not use light energy but sends a burst of energy over the scene being sensed. The components of the scene send back signals to the radar and these are used for producing a photo-like image of the scene being sensed. Radar imageries are more difficult to interpret than air photographs. However, radars can be used at both night and day as they do not utilize light energy. A further advantage of radar sensors over photographic sensors is that the former can penetrate clouds and thick forests and are consequently particularly useful for studying terrain conditions.

Thermal scanners produce imageries of a scene on the basis of the relative temperature differences between the components of the scene. Most thermal scanners sense infra-red radiation emitted by various objects in a scene. Since the various objects have different temperatures, they emit radiation of different wavelengths. The emitted radiation is sensed by thermal scanners and used for producing a photo-like imagery of the scene. Thermal infra-red scanners are useful for studying thermal pollution, urban heat islands and the population of night-roaming animals.

Microwave radiometers are similar to thermal scanners in that they sense the energy of longer wavelengths than thermal infra-red scanners. They have been used in studying sub-surface conditions and soil moisture status. As with other non-photographic sensors, the images obtained using microwave radiometers are not easily interpreted as those produced by photographic sensors.

Summary

In this concluding lecture, I have discussed the advantages and disadvantages of photographic sensors vis-à-vis non-photographic sensors. I have also tried to describe the main types of non-photographic sensors. It is apparent to you that aerial photography and aerial photo interpretation are only a small part of the science of remote sensing.

Post-Test

Which of the following remote sensors is ideal for studying terrain conditions?

1. aerial camera
2. thermal infra-red scanner
3. microwave radiometer
4. radar
5. aerial camera equipped with infra-red film.

Reference

National Academy of Sciences: *Remote Sensing*. Washington D.C., 1970.

Answers to Pre-Tests and Post-Tests

Lecture 1

Pre-Test

Land surveying, map compilation, rural and urban land use analysis and vegetation mapping

Post-Test

C

Lecture 2

Pre-Test

Soil mapping, livestock enumeration, crop and land use survey, crop performance evaluation and prediction of crop yield; land productivity assessment.

Post-Test

C

Lecture 3

Pre-Test

Vertical air photographs are taken with camera axis and lens pointing perpendicularly downwards while oblique photographs are taken with the camera axis inclined at an acute angle to the ground surface. Scale is usually uniform over the surface of a vertical air photograph but varies over an oblique photograph.

Post-Test

B

Lecture 4

Pre-Test

A light-tight box, lens, film and shutter.

Post-Test

D

Lecture 5

Pre-Test

Grassy lawn will appear grey while bare ground with white sand will appear white.

Post-Test

C

Lecture 6

Pre-Test

1. The photograph on a scale of 1:10,000 is on a larger scale.
2. 10cm.

Post-Test

1:29,605

Lecture 7

Pre-Test

Stereoscopes are used in studying vertical air photographs so as to appreciate relief.

Post-Test

D

Lecture 8

Pre-Test

Residential, commercial, industrial, recreational and transportational

Post-Test

A

Lecture 9

Pre-Test

Agricultural land use. Shifting cultivation is usually indicated on black and white air photographs by scattered patches of light/whitish tones in a background of darker tones.

Post-Test

D

Lecture 10

Pre-Test

A datum plane is a plane or surface from which heights and depths are measured e.g. mean sea level.

Post-Test

E

Lecture 11

Pre-Test

Land surveying

Post- Test

D

Lecture 12

Pre-Test

Cadastral and soil maps compiled from air photographs.

Post-Test

A

Lecture 13

Pre-Test

The dry season with the exception of the harmattan period

Post-Test

C

Lecture 14

Pre-Test

A flight plan is a map of the area to be covered by aerial photographs showing the routes (lines) along which the aircraft will fly while taking aerial photographs and the location of the starting and finishing photographs on each line in relation to important ground objects that can be seen by the pilot from the air.

Post-Test

B

Lecture 15

Pre-Test

Examples of mechanical remote sensors include the aerial camera, radar, microwave radiometers and thermal infrared scanners, organic remote sensors include the eye, ear and nose.

Post-Test

D