King AbdulAziz University

Faculty of Environmental Design

Geomatics Department

Introduction to Geomatics

GEOM 101

Week 8

Introduction to Photogrammetry

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Lecture 5: Introduction to Photogrammetry

Summary

I. What is Photogrammetry

II. Principles of Human Vision

III. Branches of Photogrammetry

IV. Principles of Photogrammetry

Lecture 5: Introduction to Photogrammetry

What is Photogrammetry

Etymology

Etymologically, the term photogrammetry is composed of **three Greek roots** : '**Photo**', '**Gram**' and '**Metry**'.

* **Photos**: which means '**Light**'.
* **Graphein** : which means '**Write**' (or '**Draw**')
* **Metron** : which means '**Measure**'

Hence, we can deduce the **etymological meaning** as '**the science of measuring from photographs** '

Lecture 5: Introduction to Photogrammetry

What is Photogrammetry

ASPRS Definition

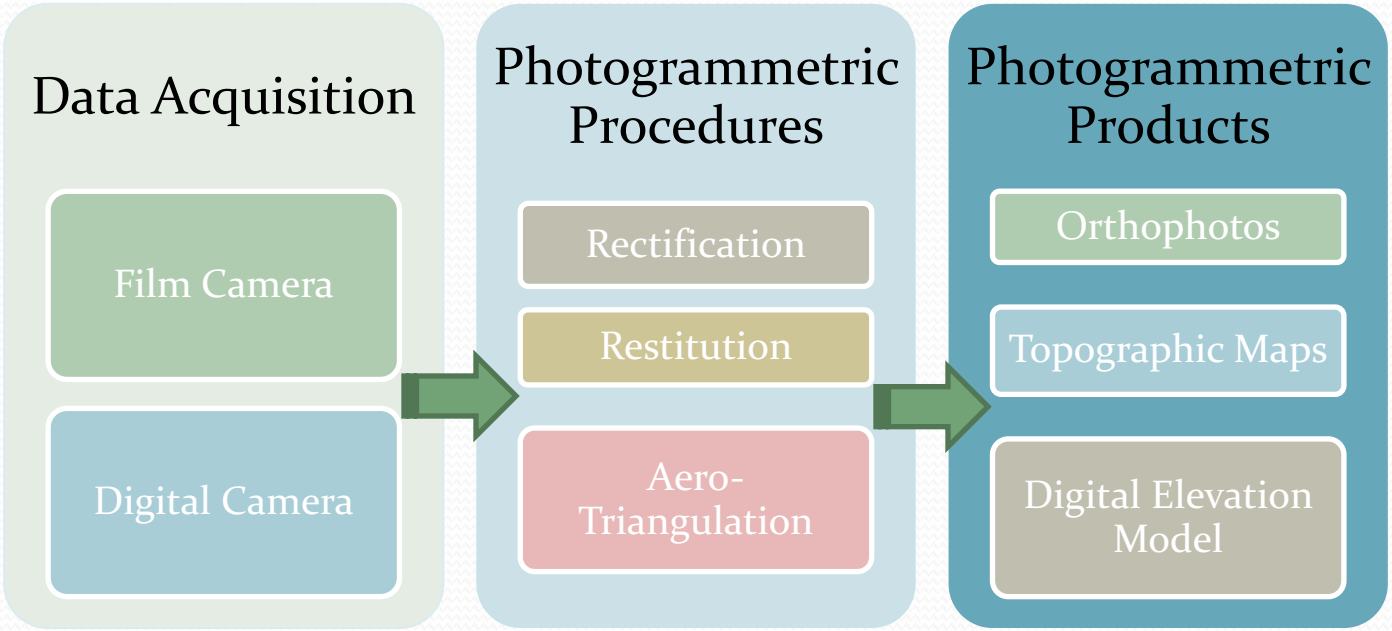
The American Society of Photogrammetry and Remote Sensing (ASPRS) defines photogrammetry as 'the **science**, **art** and **techniques** of **obtaining reliable information about physical objects and the environment**. This is done through a process of **recording**, **measuring**, and **interpreting aerial and terrestrial photographs**'.

Lecture 5: Introduction to Photogrammetry

What is Photogrammetry

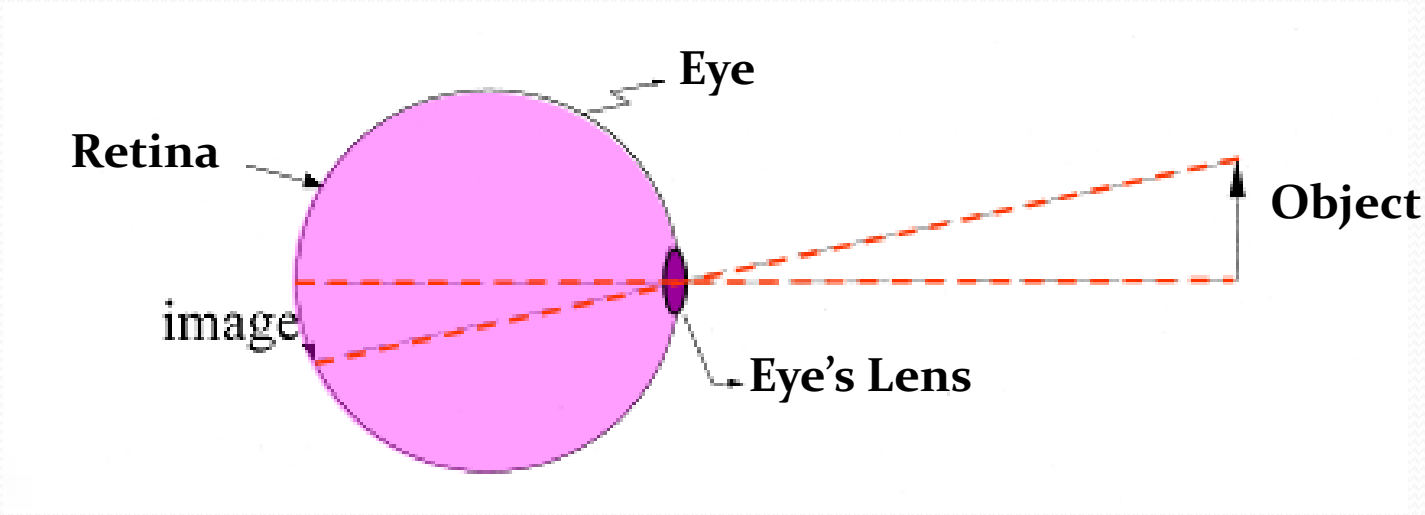
Photogrammetry Workflow

A standard **workflow of Photogrammetry** contains **three main phases** which are: 1) **Data Acquisition**, 2) **Photogrammetric Procedures** and 3) **Photogrammetric Products**.



Principles of Human Vision

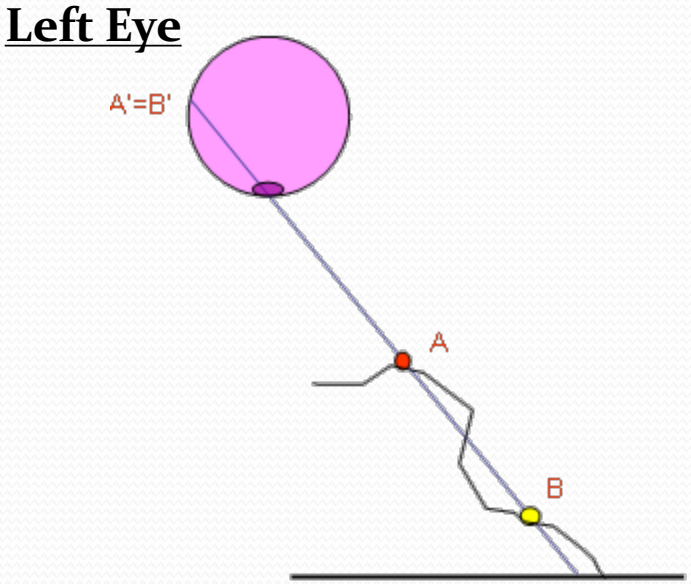
The **principles of Photogrammetry** come from the **understanding of how Human eyes work**. In fact, **the lens of the eyes act like a convex lens** that produces **an image of the object on the retina**. The produced image, which **has an inversed orientation**, is then transmitted to the brain through the optic nerve in order to be interpreted.



Principles of Human Vision

Monoscopy

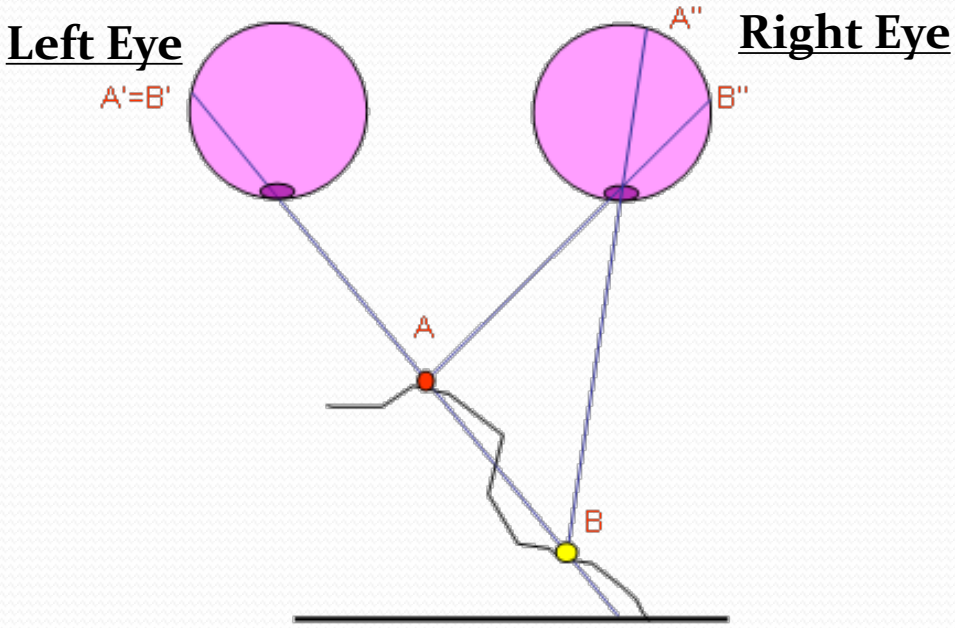
The **monoscopy** is the process of vision **that involves only a single eye**. Although the image formed **on the retina contains a huge amount of information**, the **monoscopy provides only a two dimensional representation of the scene** (the perception **doesn't contain any information about the depth** of the scene).



Principles of Human Vision

Stereoscopy

The **Stereoscopy** is the process of vision **that involves the two eyes** at the same time. The **Stereoscopy allows perceiving the third dimension of the scene,** through the brain interpretation of the two images that are formed on the left and right retinas.

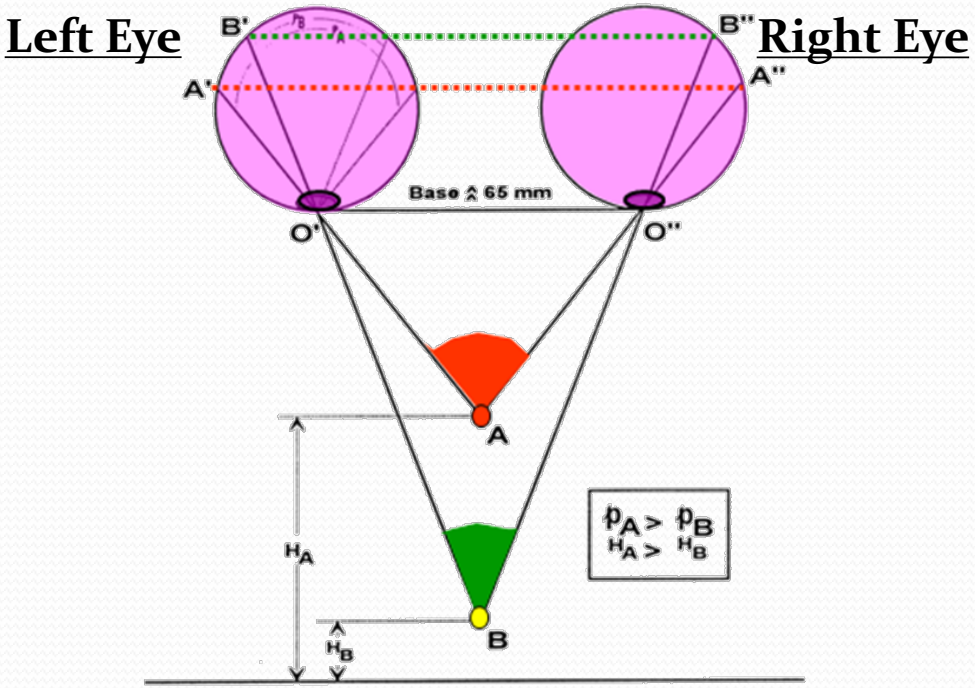


Principles of Human Vision

Parallactic Angle

The **Human brain does not make any 'graphical' report** of the **rays** that come from the scene. It **analyses the angle between the two light beams** (that come from one object) which are perceived by each eye. This angle is called '**Parallactic Angle**'.

A point which **is closer to the human eyes** has a **large parallactic angle**, and **point which is farther** has a **smaller parallactic angle**.



Branches of Photogrammetry

There are **many methods used in photogrammetry** in order to extract information from photos. However, Photogrammetry may be divided into **two main groups**: 1) **Aerial Photogrammetry** and 2) **Close range (or Terrestrial) Photogrammetry**.

In addition, **Aerial Photogrammetry** may also be classified into three categories:

1- **Analog Photogrammetry**,
2- **Analytical Photogrammetry**,
3- **Digital Photogrammetry**,

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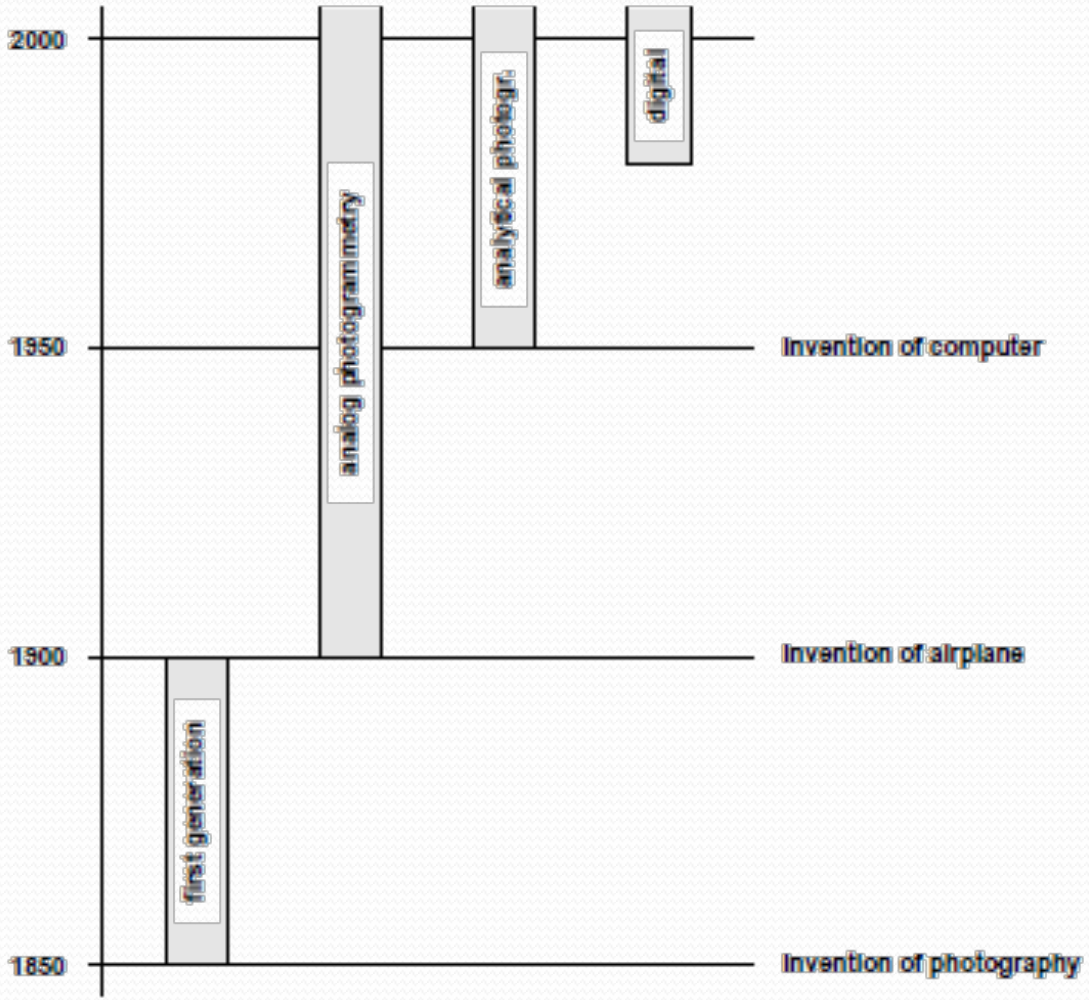
Branches of Photogrammetry

The development of **branches of Photogrammetry** depends on the **advancement and innovation** related to the **used technologies** (**photography, airplanes, computers and electronics**).



Branches of Photogrammetry

Analog Photogrammetry

Analog Photogrammetry is the branch of Photogrammetry that includes **all methods and techniques** to extract information from **analog photos** based on **mechanical and optical methods or their combination**.

The **Principle of Analog Photogrammetry** is **to produce in the laboratory**, **and on a smaller scale**, the **configuration of the camera when taking pictures in two positions**. This **configuration is reconstructed** by using **optical and mechanical instruments**.

Branches of Photogrammetry

Analog Photogrammetry

Example of an analog instrument for Photogrammetry

Branches of Photogrammetry

Analytical Photogrammetry

Analytical Photogrammetry is also based on the **reconstruction of camera's positions** during the flight mission. However, the **reconstruction is not performed mechanically**.

Although the **used photos are analog**, the principle of Analytical Photogrammetry is to **reconstruct mathematically the configuration of cameras** during the flight **using computers**.

Branches of Photogrammetry

Analytical Photogrammetry

Example of an analytical instrument for Photogrammetry

Branches of Photogrammetry

Digital Photogrammetry

Digital Photogrammetry uses the **same mathematical principles as Analytical Photogrammetry**. However, **Digital Photogrammetry** (in contrast to **Analytical Photogrammetry**) uses **Digital Photos**.

Digital Photos may come either from **scanning existing Analog Photos**, or directly acquired from **Digital camera** (see picture below).

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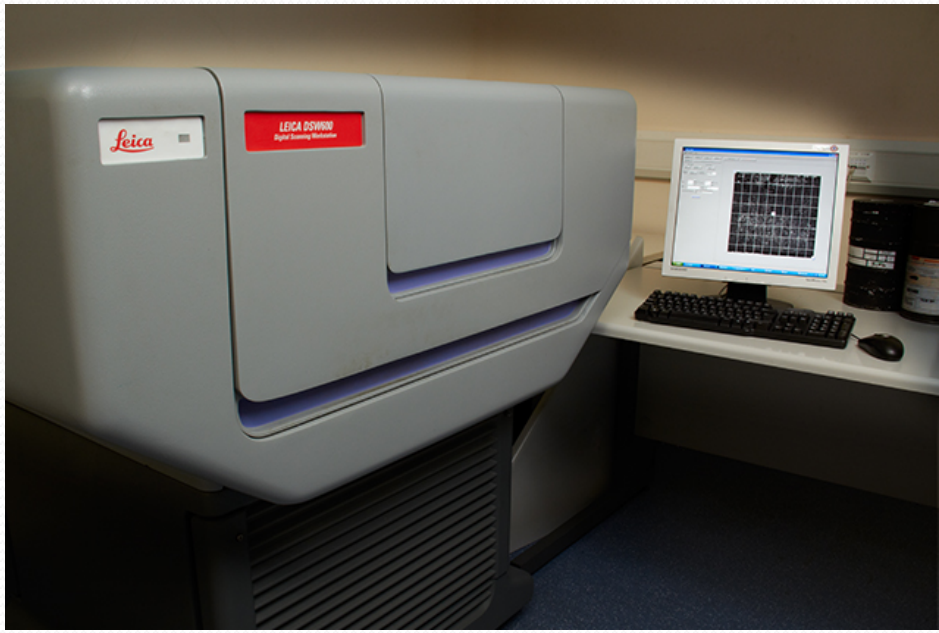
Branches of Photogrammetry

Digital Photogrammetry

Example of an Digital instrument for Photogrammetry

Leica Photogrammetric High Resolution Scanner



Branches of Photogrammetry

Close –range (Terrestrial) Photogrammetry

Close-range (or Terrestrial) Photogrammetry uses the **same theoretical basis as Aerial Photogrammetry**. In the case, the photos are taken from a **very-close distance** from the **object to be photographed**.

Principles of Photogrammetry

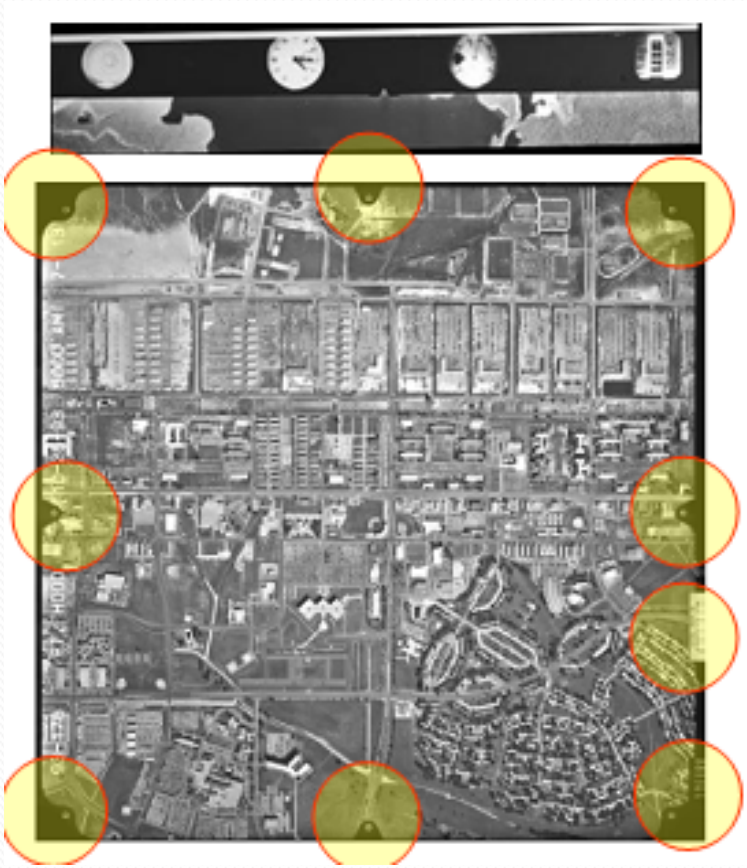
Characteristics aerial photography

Marginal data of aerial photography

Fiducial marks: small registration marks exposed on the edges of a photograph. The distances between fiducial marks are precisely measured when a camera is calibrated.

Roll and Photo Numbers: each aerial photo is assigned **a** unique index number according to the photo's roll and frame.

Geographic location, time and date, etc.



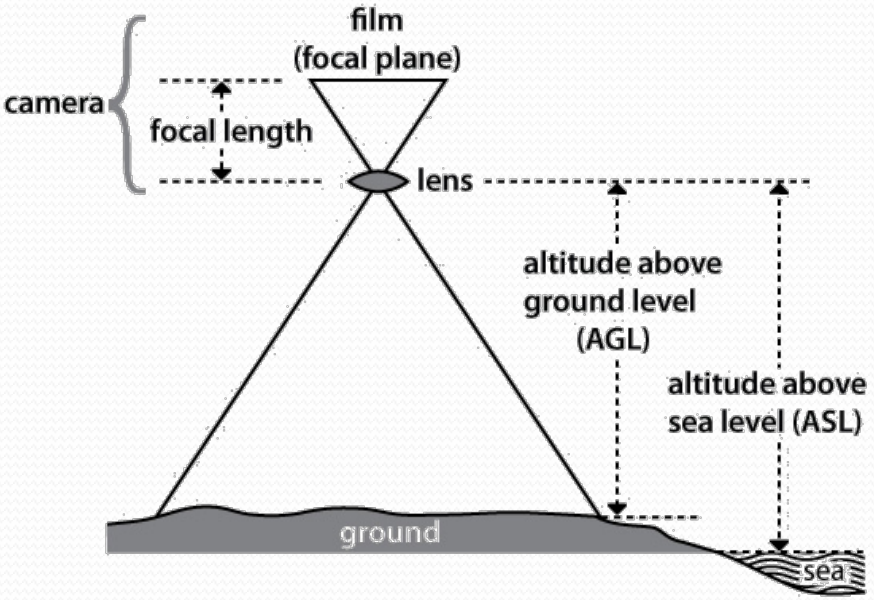
Principles of Photogrammetry

Characteristics aerial photography

Focal and Scale

Focal length: the distance from the **middle of the camera lens** to the **focal plane** (i.e. the film). **The focal length is precisely measured when the camera is calibrated**.

Scale: the **ratio of the distance** between **two points on a photo** to the actual distance between **the same two points on the ground**.



$$\frac{\text{PHOTO DISTANCE}}{\text{GROUND DISTANCE}} = \frac{4\text{ cm}}{2\text{ km}} = \frac{4\text{ cm}}{200\,000\text{ cm}} = \frac{1}{50\,000} \quad \text{SCALE: 1/50 000}$$

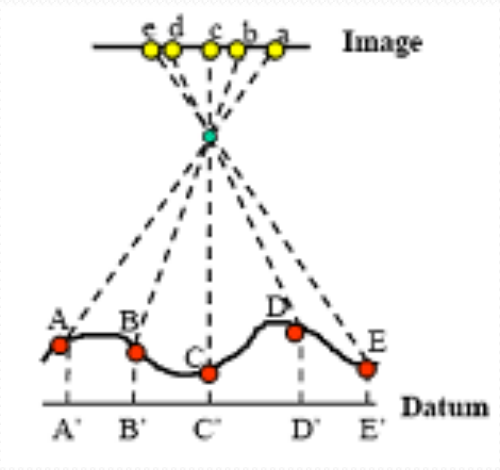
$$\frac{\text{FOCAL LENGTH}}{\text{ALTITUDE (AGL)}} = \frac{152\text{ mm}}{7\,600\text{ m}} = \frac{152\text{ mm}}{7\,600\,000\text{ mm}} = \frac{1}{50\,000} \quad \text{SCALE: 1/50 000}$$

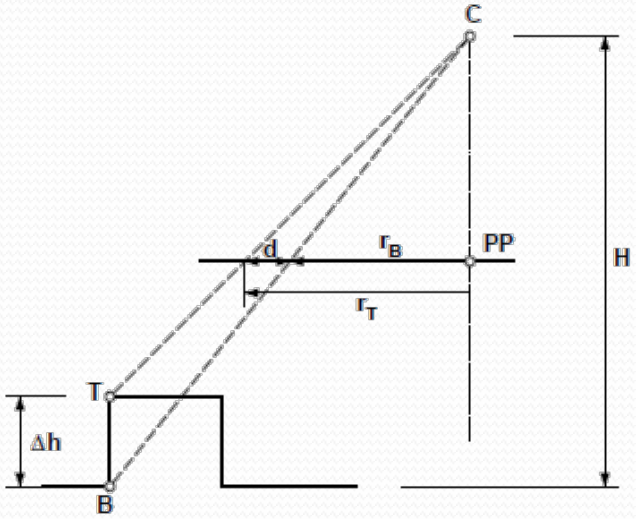
Principles of Photogrammetry

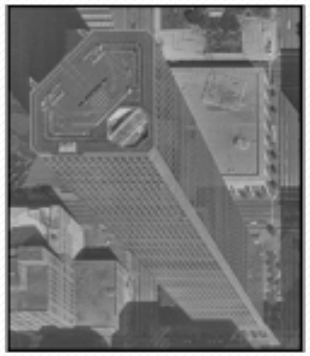
Characteristics aerial photography

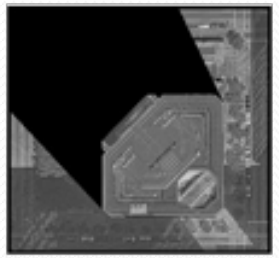
Distortion on aerial photography

The projection of a photography is a **perspective (or central) projection**, because all the rays **should pass through a point called the center of perspective**. This type of projection **causes an important distortions especially** for **taller object** on the scene.





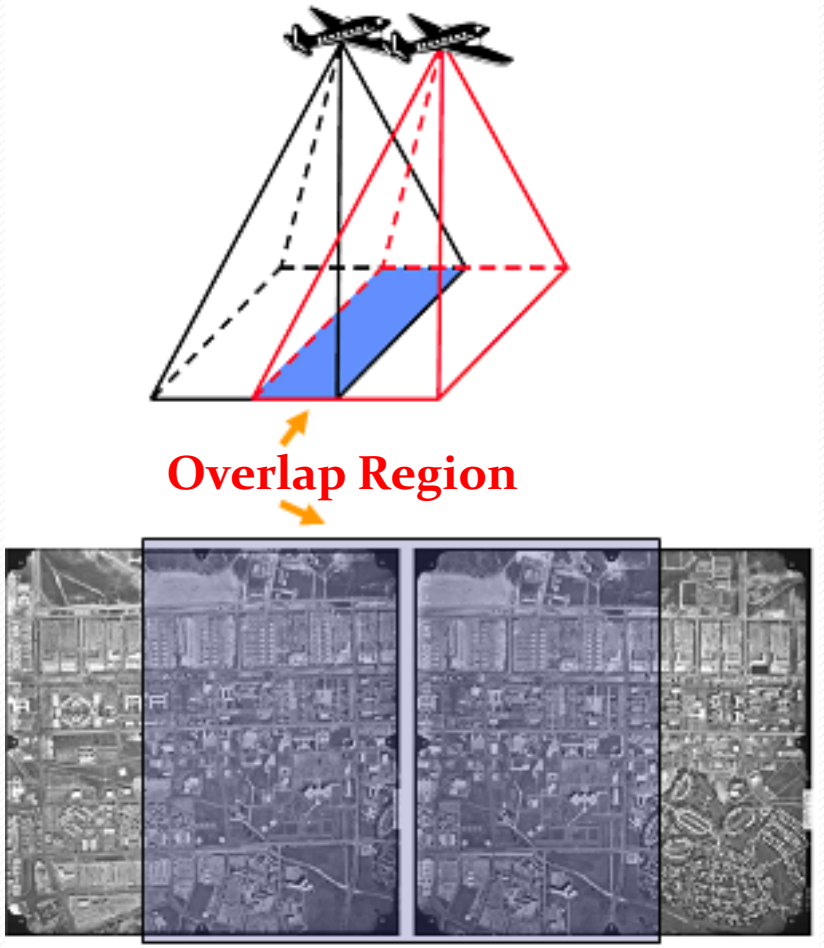

Perspective Projection


Orthogonal Projection

Principles of Photogrammetry

Stereoscopic coverage

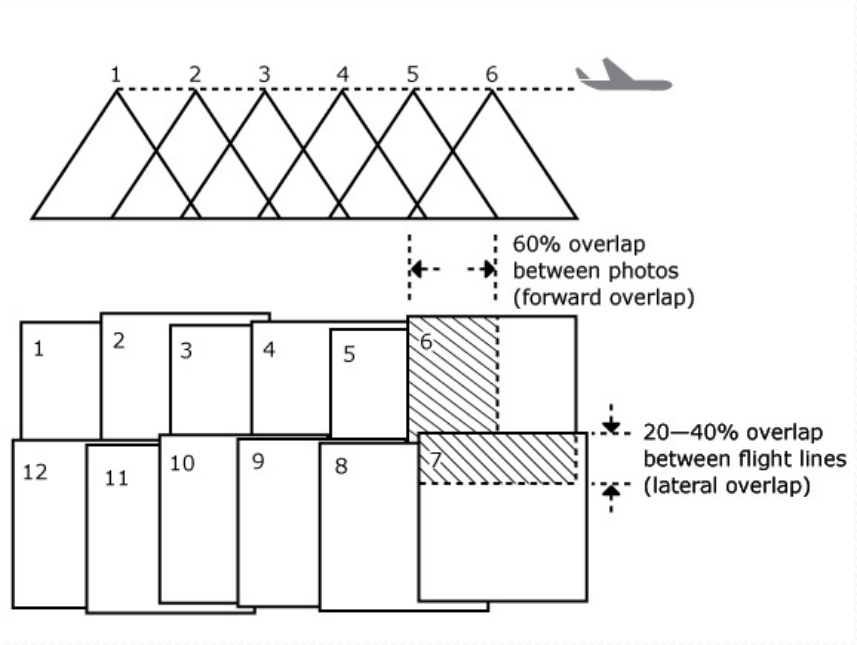
The concept of **Stereoscopy in photogrammetry** is one of the **most important notions**. It uses the **same principle of human vision** in order to **extract the elevation** of an object in a scene. To retrieve the elevation from a scene it has **to be necessary photographed from to different perspectives** (**Overlap region**).



Principles of Photogrammetry

Stereoscopic coverage

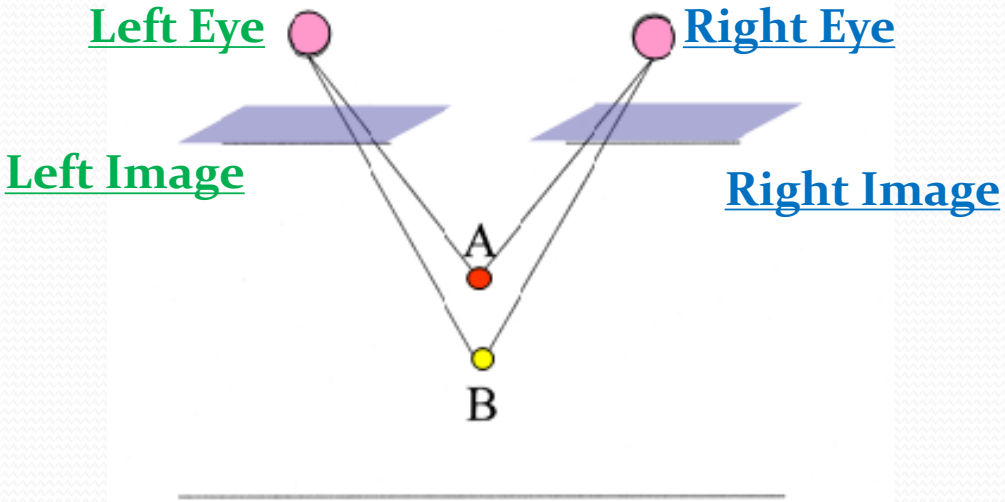
Overlap: is the amount by which one photograph **includes the area covered by another** photograph, and is expressed as a **percentage**. The photo survey is designed to acquire **60 per cent forward overlap** (between photos along the same flight line) and **30 per cent lateral overlap** (between photos on adjacent flight lines).



Principles of Photogrammetry

Stereoscopic restitution

The **Stereoscopic restitution** consists of **reconstructing a stereoscopic model** (**which will be seen by the operator**) from **two images** that were taken **from different angles**. To do so, **each eye has to see only the corresponding image** (left or right), and the human brain will **automatically perceive the three-dimension**.

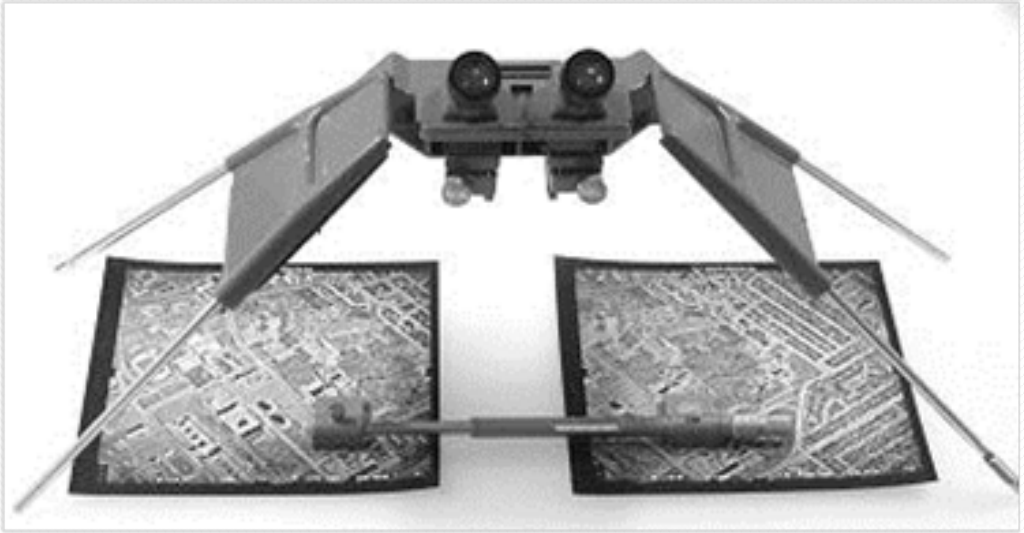


Principles of Photogrammetry

Stereoscopic restitution

There many methods used **to display the corresponding image for each eye**. The most used methods are: 1) **Optical Stereoscope**, 2) **Anaglyph** (with complementary colors) and 3) **Polarization** (polarized filters).

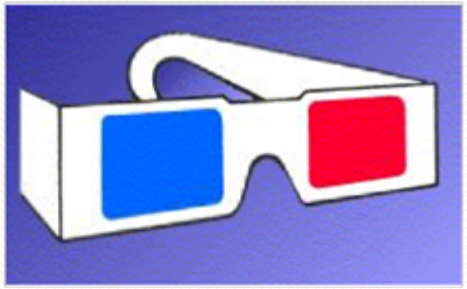
Example of Optical Stereoscope



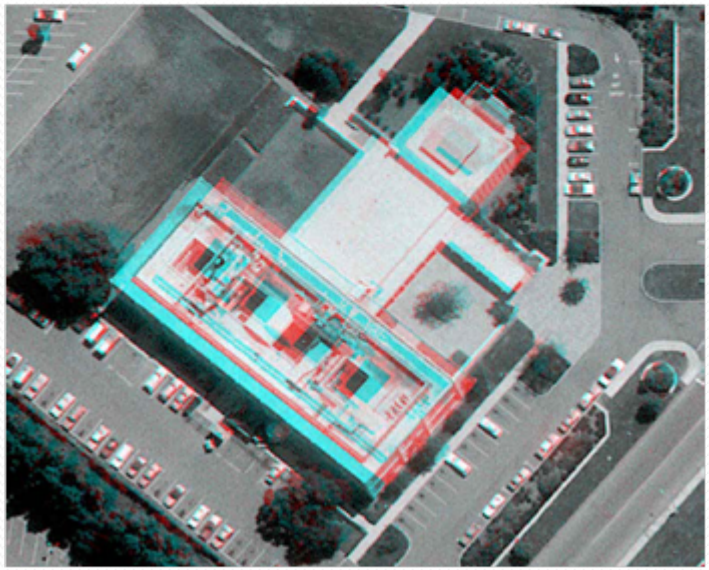
Principles of Photogrammetry

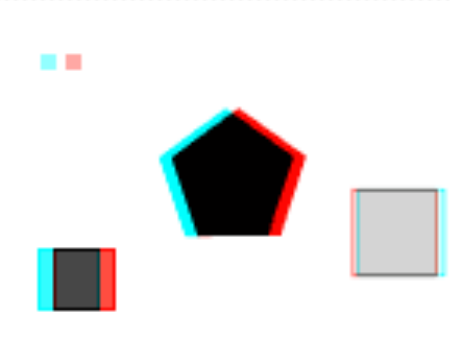
Stereoscopic restitution

Example of Anaglyph



To display the two images, **we use a special glass with two complementary colors** (**cyan and Red for example**). **Hence, each eye will see only one of the two images.**





Principles of Photogrammetry

Stereoscopic restitution

Example of Polarization

To display the two images, **we use a special glass with two different polarization** (**Horizontal and Vertical for example**). **Hence, each eye will see only one of the two images.**

Principles of Photogrammetry

Stereoscopic restitution

In order to **construct a Stereo Model**, it is necessary to **reconfigure the position of the two images** as their **initial positions during the flight mission**.

The process of **Stereoscopic restitution** consists of **three main phases**:

1- **Interior** orientation
2- **Relative** orientation
3- **Absolute** orientation

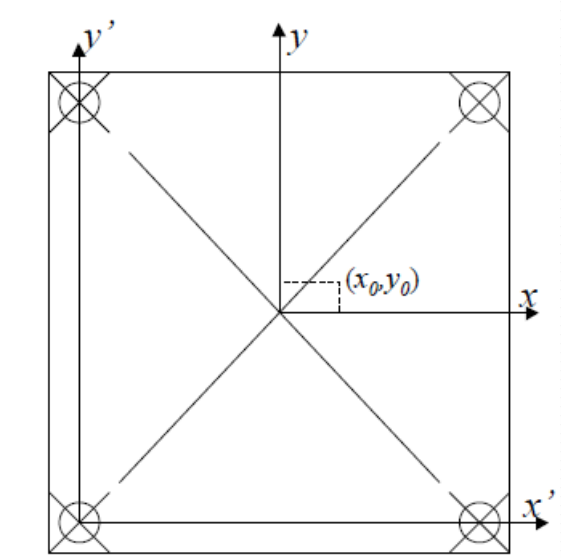
Sometimes, **relative and absolute orientation** may be combined in one step called **Exterior orientation**.

Principles of Photogrammetry

Stereoscopic restitution

Interior Orientation

The aim of **Interior orientation** is to **define a Photo coordinate system** for each Photography. This is very important **in order to reconstruct the Perspective Projection** of each image. To do so, we use the **fiducial marks** for each photography.

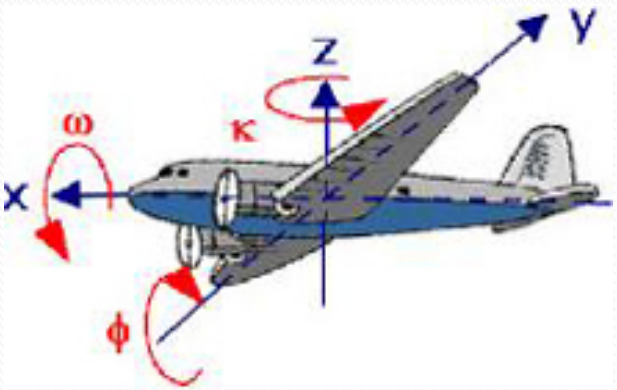


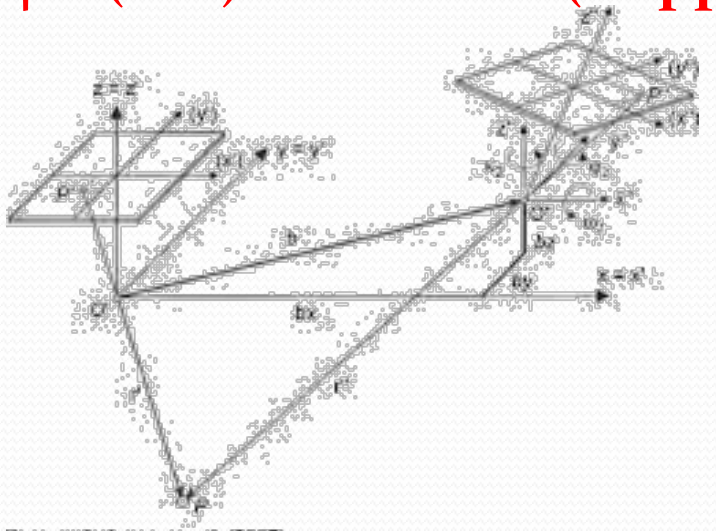
Principles of Photogrammetry

Stereoscopic restitution

Relative Orientation

The aim of **Relative orientation** is to **the relative position of two photographs, or a relation to another**. To do so, an image is fixed and we 'drag and rotate' the other **until finding the relative position as the flight mission**. **"Drag and rotate" means to move the image around the axis ω (Omega), ϕ (Phi) and K (Kappa), corresponding to X, Y and Z.**





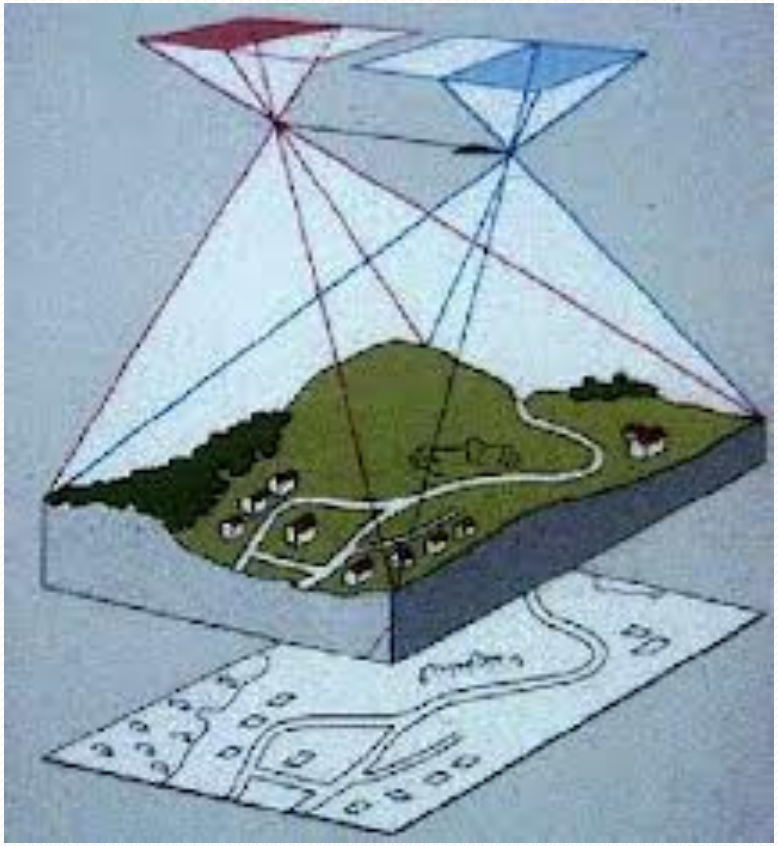
Source: Lohmann et al. (2007)

Principles of Photogrammetry

Stereoscopic restitution

Absolute Orientation

The **Absolute orientation** aims to bring **the relative stereo-model** constructed in the previous phase **to the ground Scale, Orientation and Level**. When we complete this phase, the **measurement on the stereo-model** will be the **same as if we were on the real field**.



QUESTIONS ?

Next Lecture

Introduction to Geomatics

GEOM 101

Week 9

Introduction to GPS

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