From a Student to Students: A Guide to the Use of Geo Referenced Images in Graphical Analysis for Architectural Design Planning

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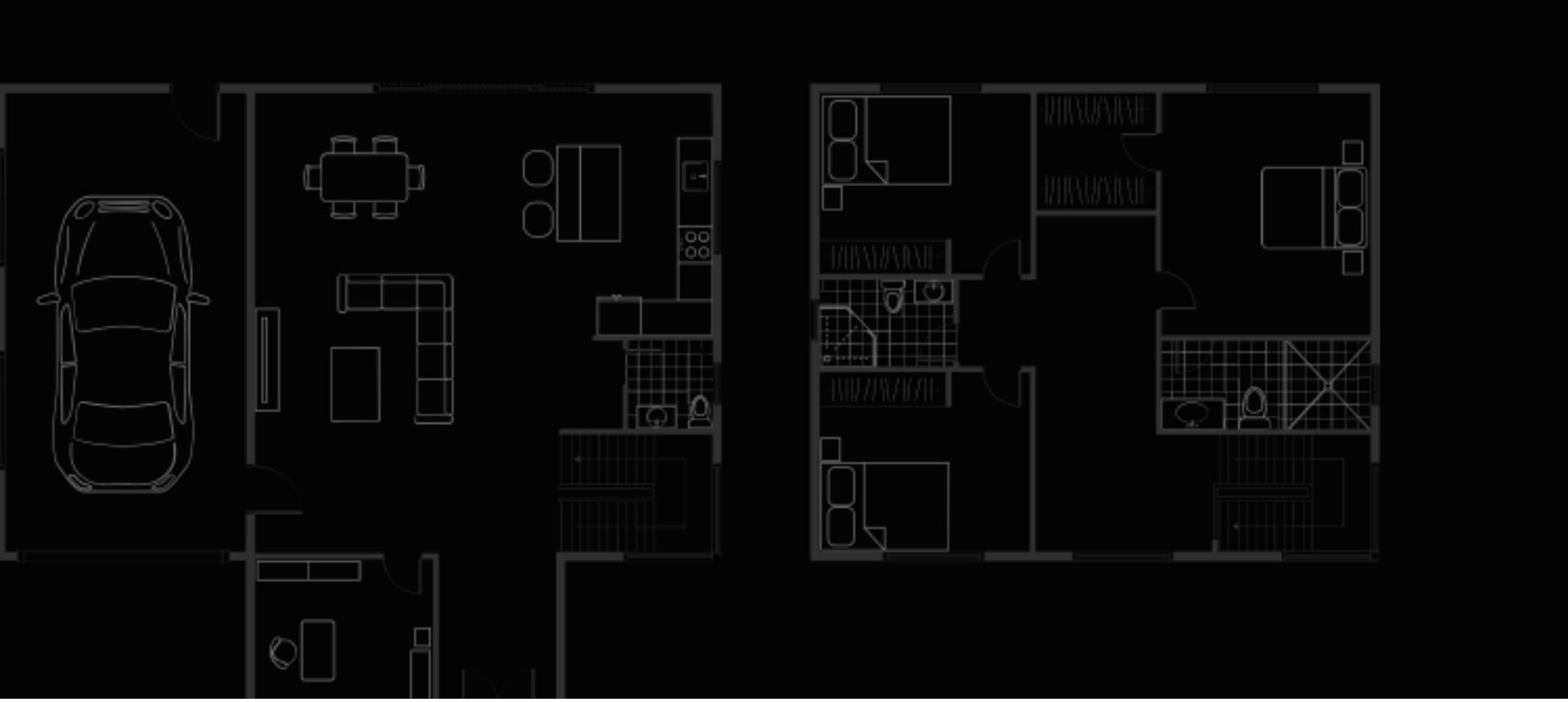


Why Geo Referenced Images in Architectural Design Planning ?

Example: Renovation of a square
(Icarai) Niteroi, Brazil

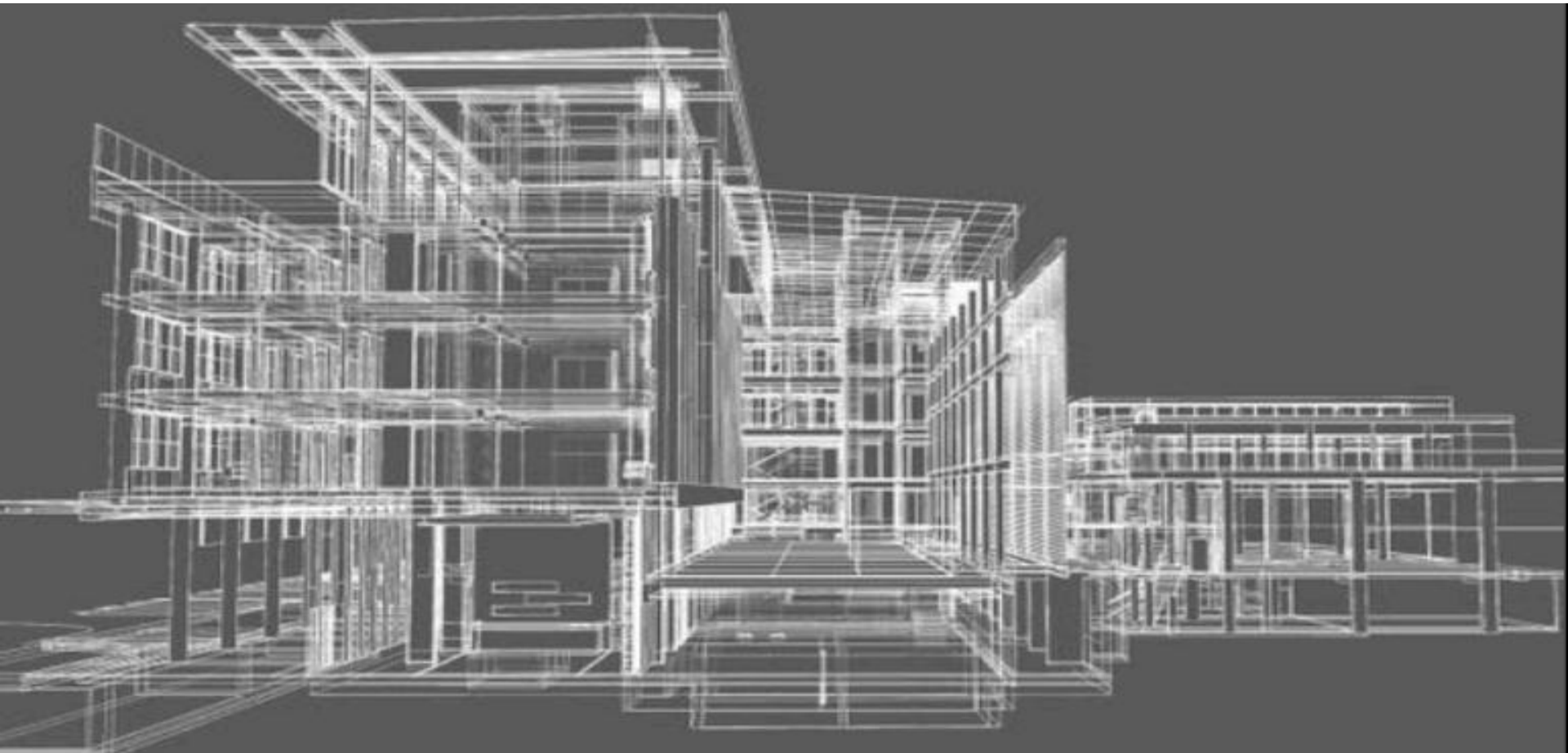
SIGeo

Sistema de Gestão de Geoinformação - **Niterói**

In urban planning it is already widely used

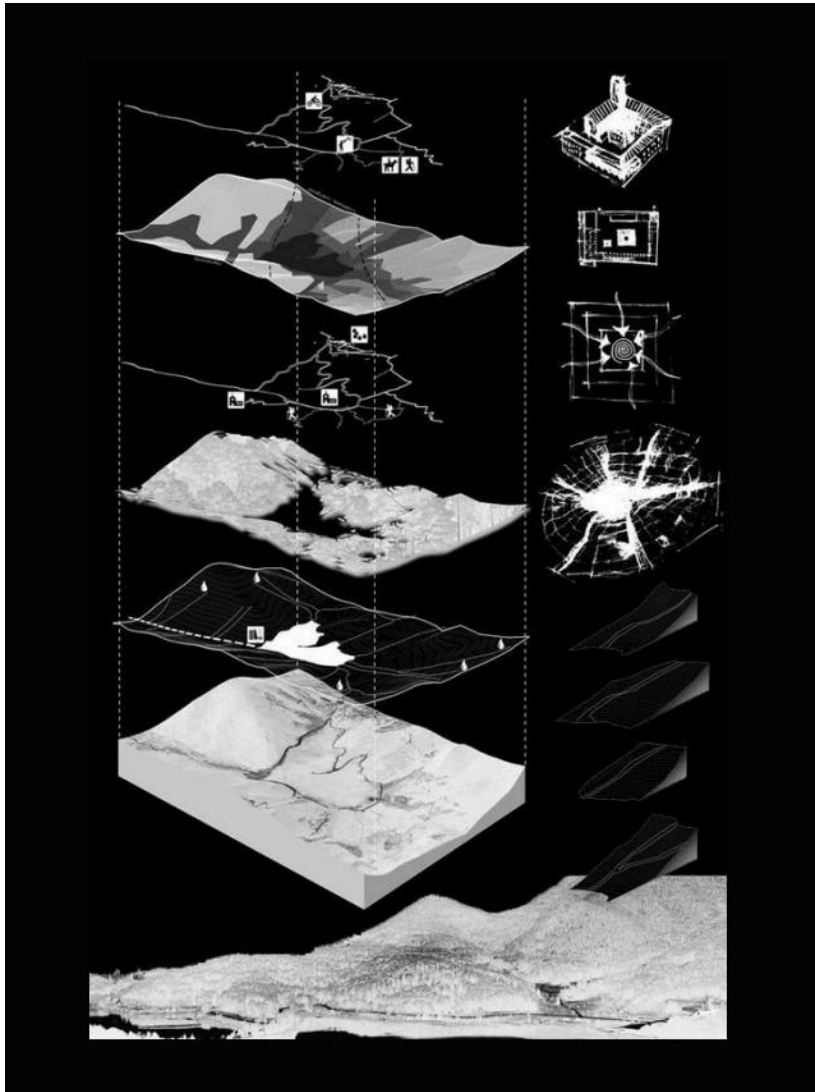
Why include **orthophotos** in design

(although **Digital imaging** is now **essential** for the creation and monitoring of urban spaces and building design) ?



Orthophoto or orthoimage:

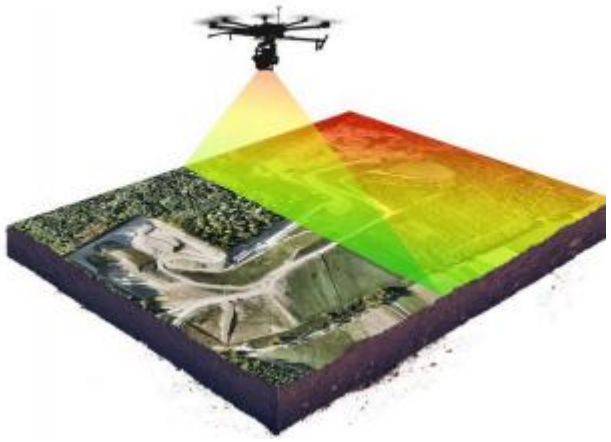
is an aerial or satellite photo that has been **geometrically corrected** to eliminate **distortions due perspective**, surface **relief** and use of **lenses**, resulting in an uniform scale throughout.



Importance:

Allow simple and precise measurements of distances, angles and areas, effectively functioning as a multi scale map.

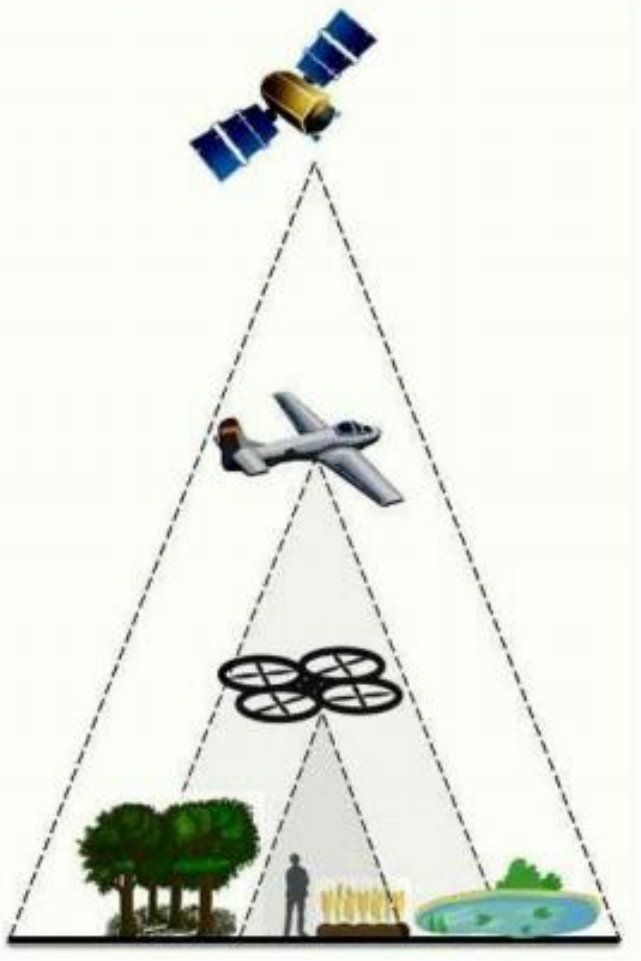
(Include Geographic Information System - GIS)



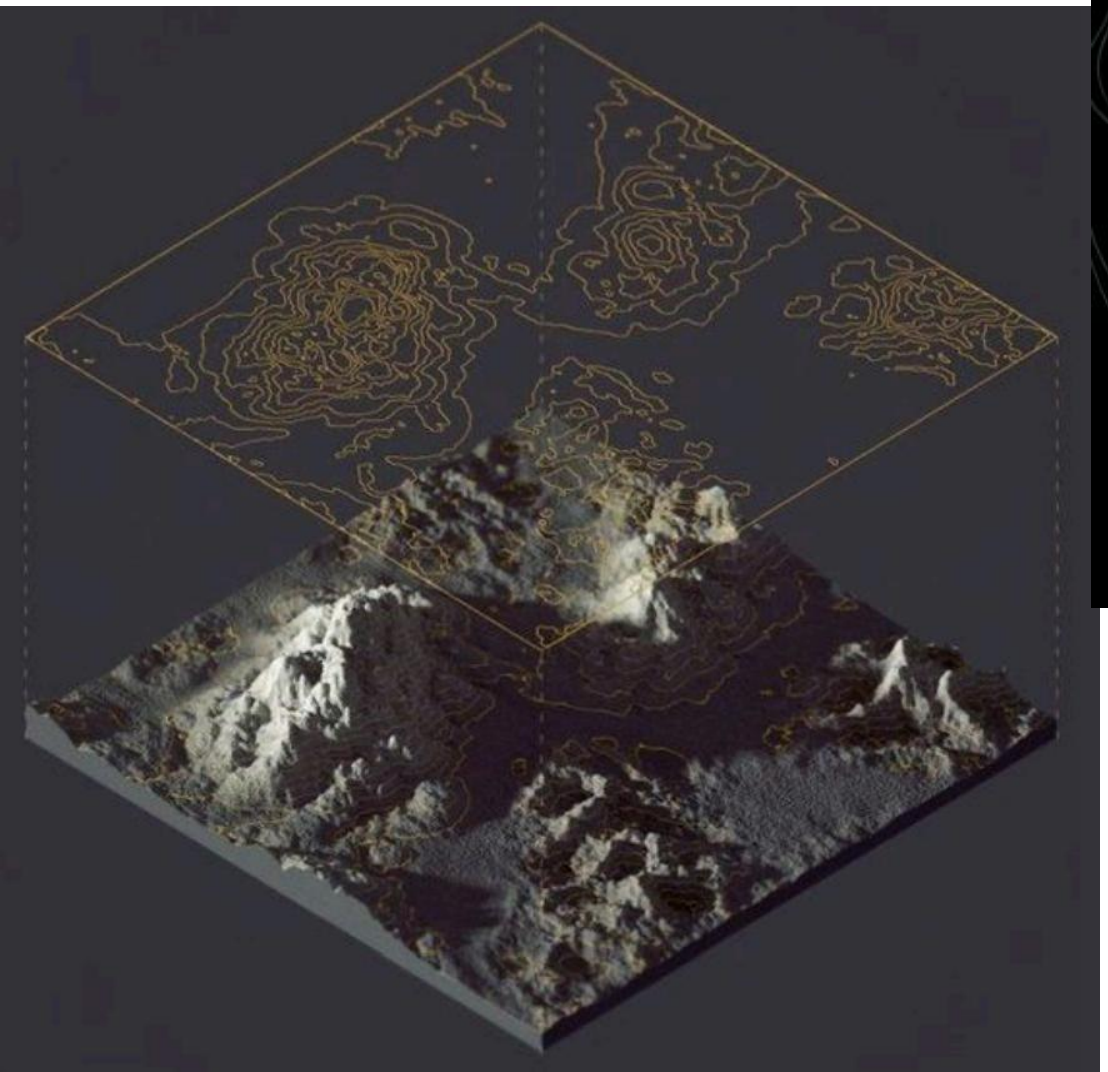
Ortophotos (OP)

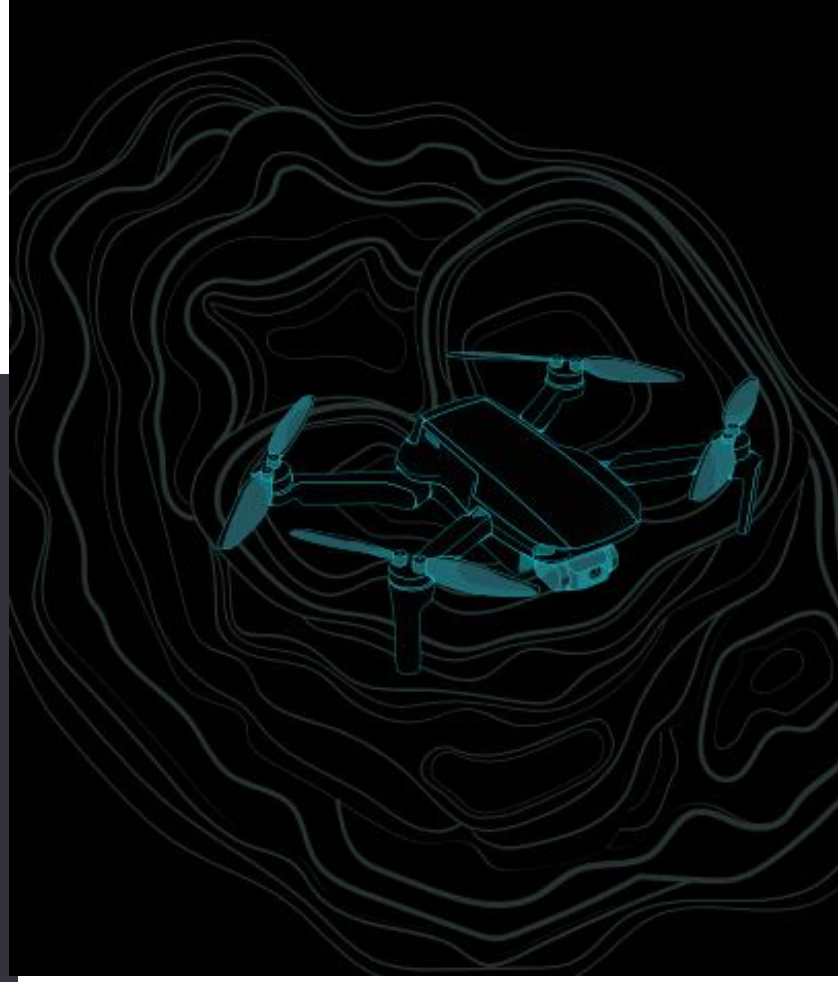
are aerial images of a region processed for use in:

- Cartography;
- Urban planning;
- Agronomy;
- Architecture;
- Etc.



But why ?





Steps of OP generation:

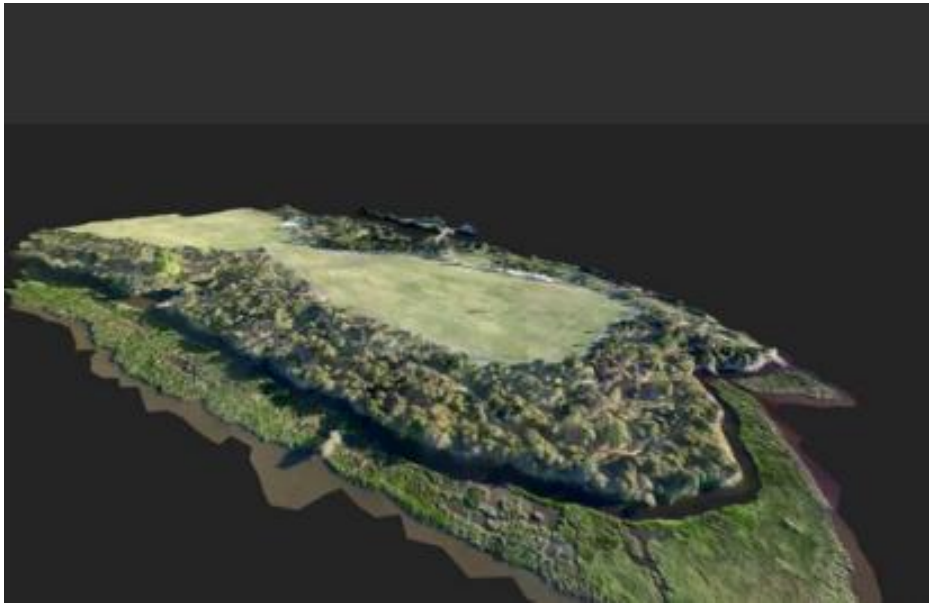
- **Image Acquisition**: Aerial photos are captured with a high degree of overlap (typically 60–80% longitudinal and lateral) using calibrated cameras mounted on drones or aircraft.

Steps of OP generation:

- **Ground Control Points (GCPs):** Points with known geographic coordinates (GPS/GNSS) are established within the surveyed area to ensure the positional accuracy of the final image.

Steps of OP generation:

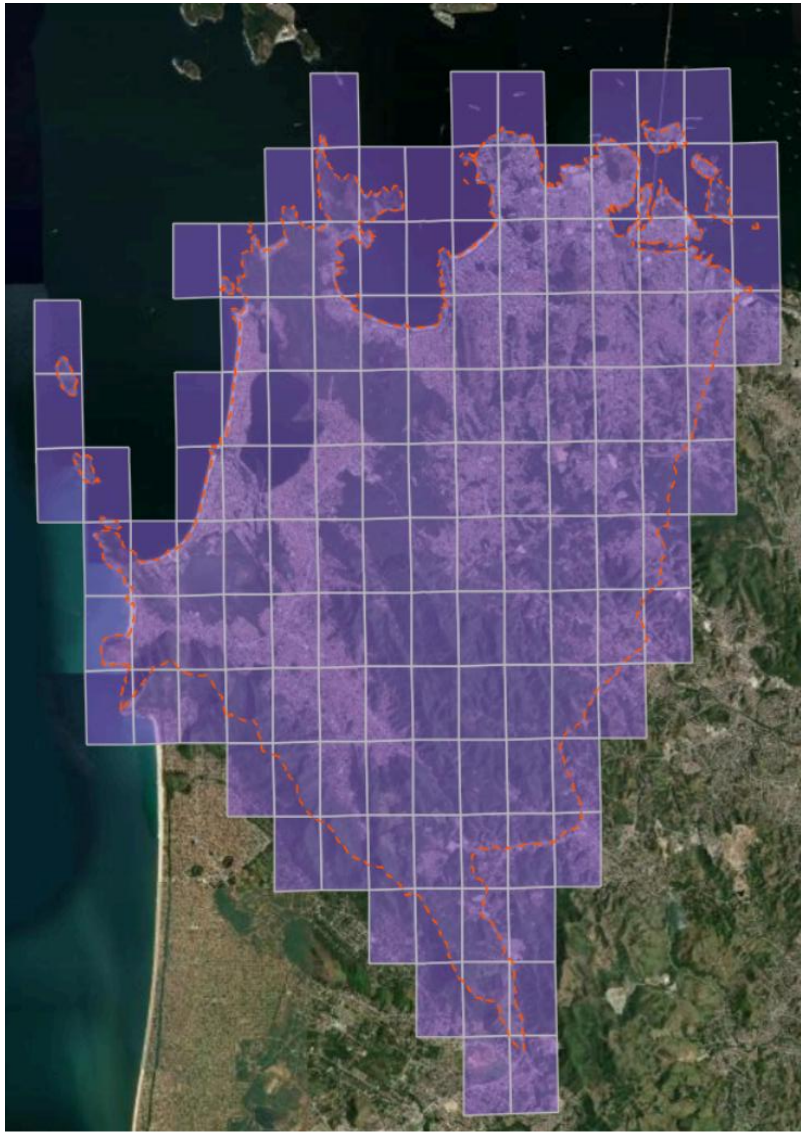
- **Ortho rectification** (Correction): Photogramme-tric apps use Digital Terrain Models (DTM) or Digital Surface Models (DSM) to "rectify" the **tilt** and "flatten" the data, **eliminating relief and perspective distortions**.



Steps of OP generation:

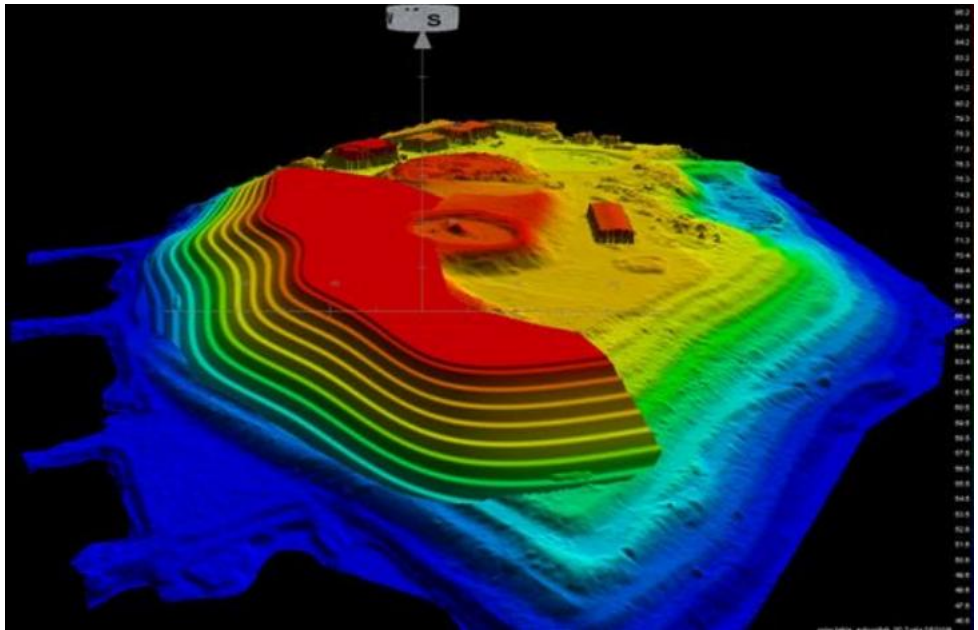
- **Mosaic:** Following correction, several images are joined into a single continuous register, known as an **ortho mosaic**.

  The main elements in its production are: **uniform scale across images** from raw aerial captures (RGB, NIR, etc.) to the vectorial data.



Steps of OP generation:

- **Digital Elevation Model (**DEM/DTM): is fundamental for correcting relief distortion; and orientation parameters, considering camera position data at the time of the click.



Ortophoto Quality is Related to:

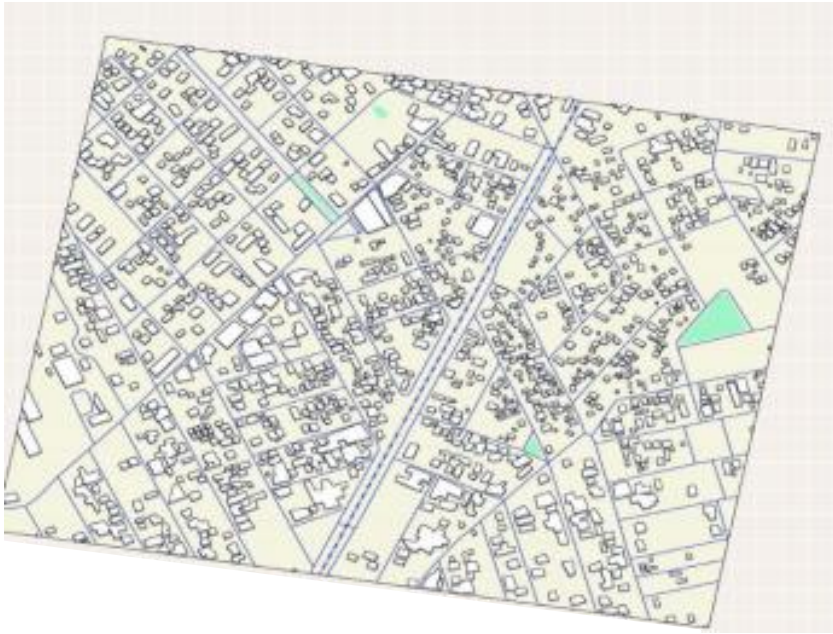
- **Photogrammetric resolution**; tonal gradation; number of spectral bands (or channels used);

  and Rectification and scale **correction process**
  - using the Digital Terrain Model (DTM);

Ortophoto quality is related to: (cont):

- Level of detail and georeferencing provided;

- Facility of : updating and use; integration with softwares; accessibility of the repository where they are stored.



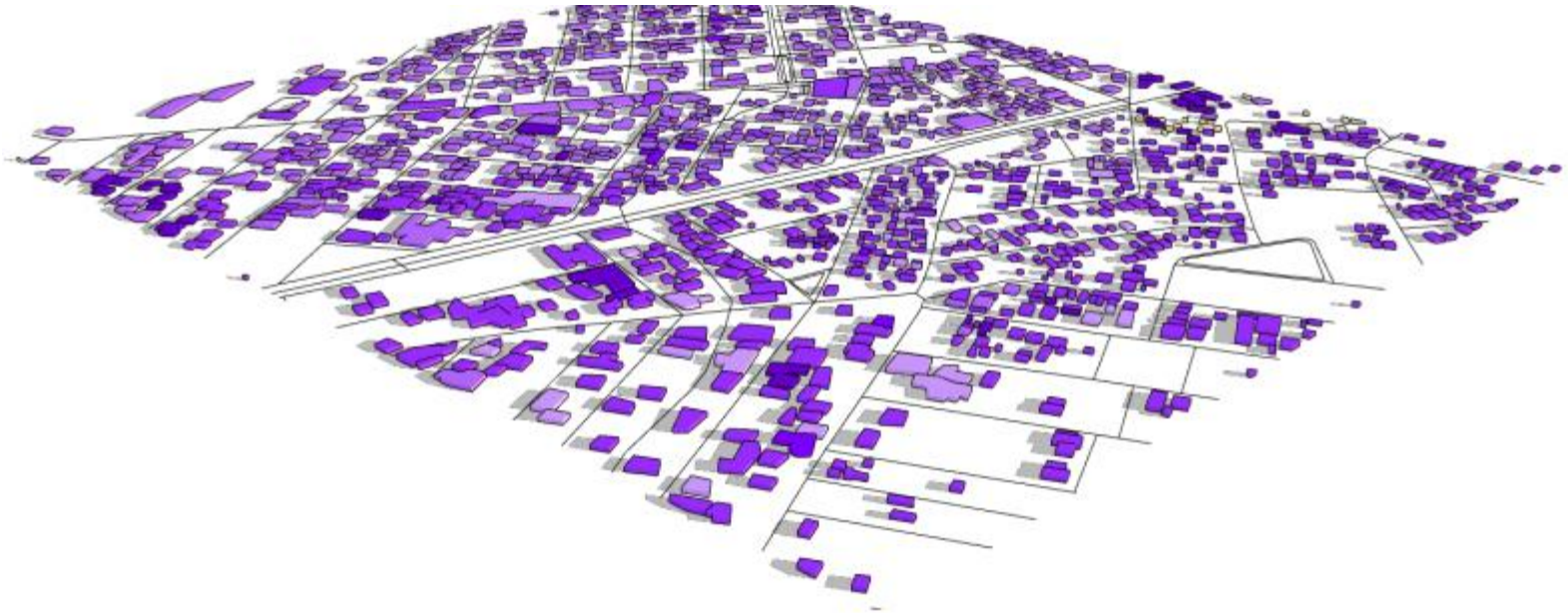
Photogrammetric Image Resolutions:

Spatial Resolution,

Radiometric Resolution,

Spectral Resolution.

Temporal Resolution



Orthophotomap vs. traditional vector cartography

- Spatial Resolution –

The **ground area** corresponding to an image **pixel** in a cartographic representation.

It refers to the ability to distinguish objects as small as the sensor allows, representing the **actual size each pixel** corresponds on ground.

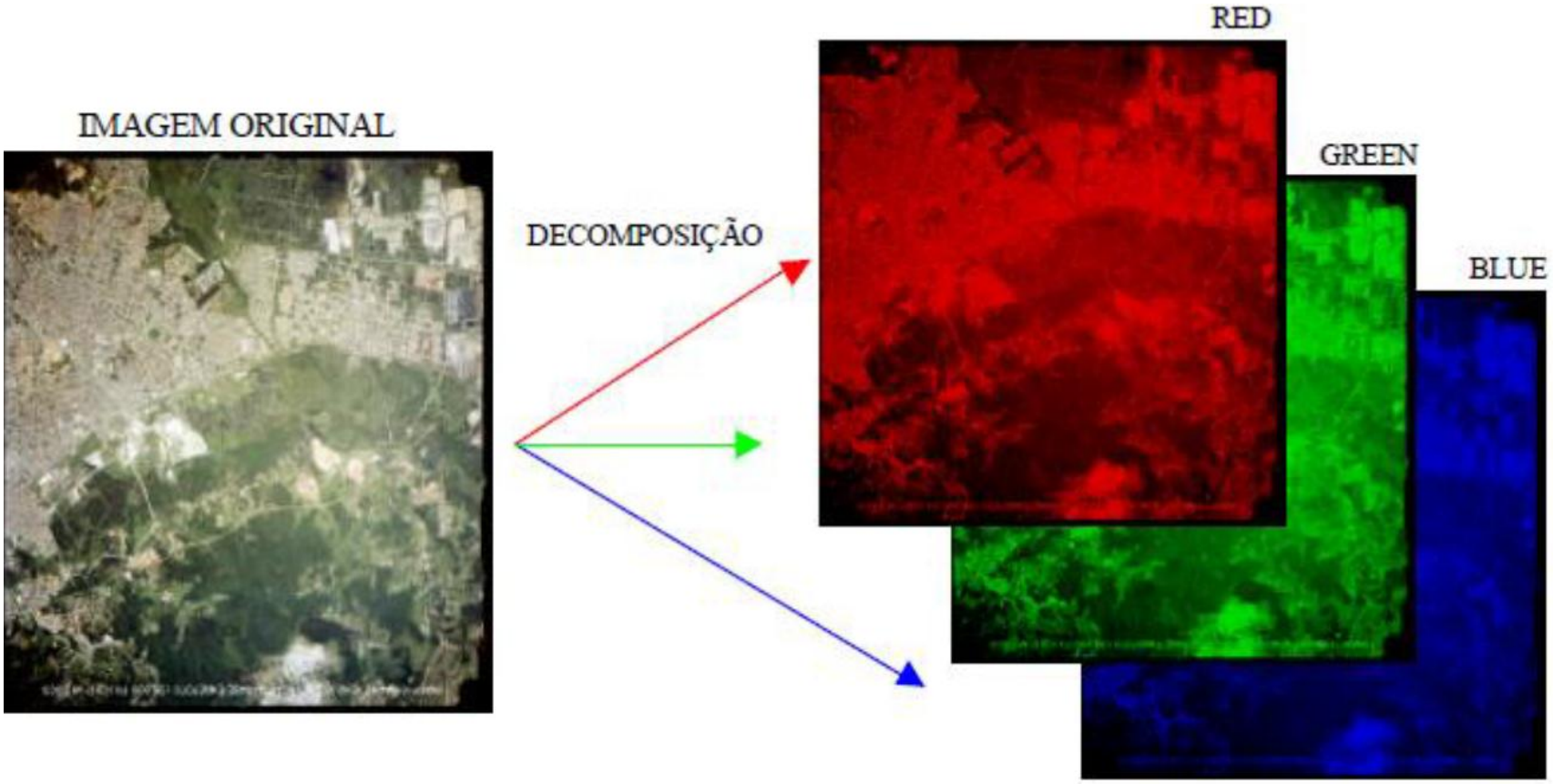
- Spectral Resolution –

Number of spectral **bands** that make up an image.

The 4 most common ones:

Band 1 (blue): exhibits significant penetration into bodies of water, making it particularly useful for **mapping water boundaries**; however, it can lead to errors in the presence of smoke from fires or industrial activity;

-Spectral Resolution–



- Spectral Resolution – cont.

Band 2 (green) is highly sensitive to the presence of suspended **sediments** in the water and is useful for **vegetation mapping** and detecting areas affected by human activity (anthropogenic impact).

Band 3 (red): good contrast between areas covered by vegetation and **exposed soil.** It is the band generally used to **delineate urban areas** and the **road network.** It is also suitable for creating **land-use maps.**

- Spectral Resolution – cont.

Band 4 (near-infrared) shows good contrast between soil and water. It is also sensitive to terrain morphology and is used for geological mapping. It allows for the **discrimination of various vegetation types** and is used by agricultural agencies (for crop types) and for the creation of **land-use maps**.

Radiometric Resolution

Each sensor has a limit on the **values** it can capture and store; this **range** is measured in bits or bytes.

$$\begin{bmatrix} 128 & 192 & 128 \\ 192 & 255 & 192 \\ 192 & 0 & 128 \end{bmatrix}$$

radiometric componet of each pixel

Radiometric Resolution

Number of **perceptible levels** in an image.

It depends on the number of bits per pixel.

A bit corresponds to a binary digit, which can take one of two values: 0 or 1.

A sequence of bits can represent many more values.

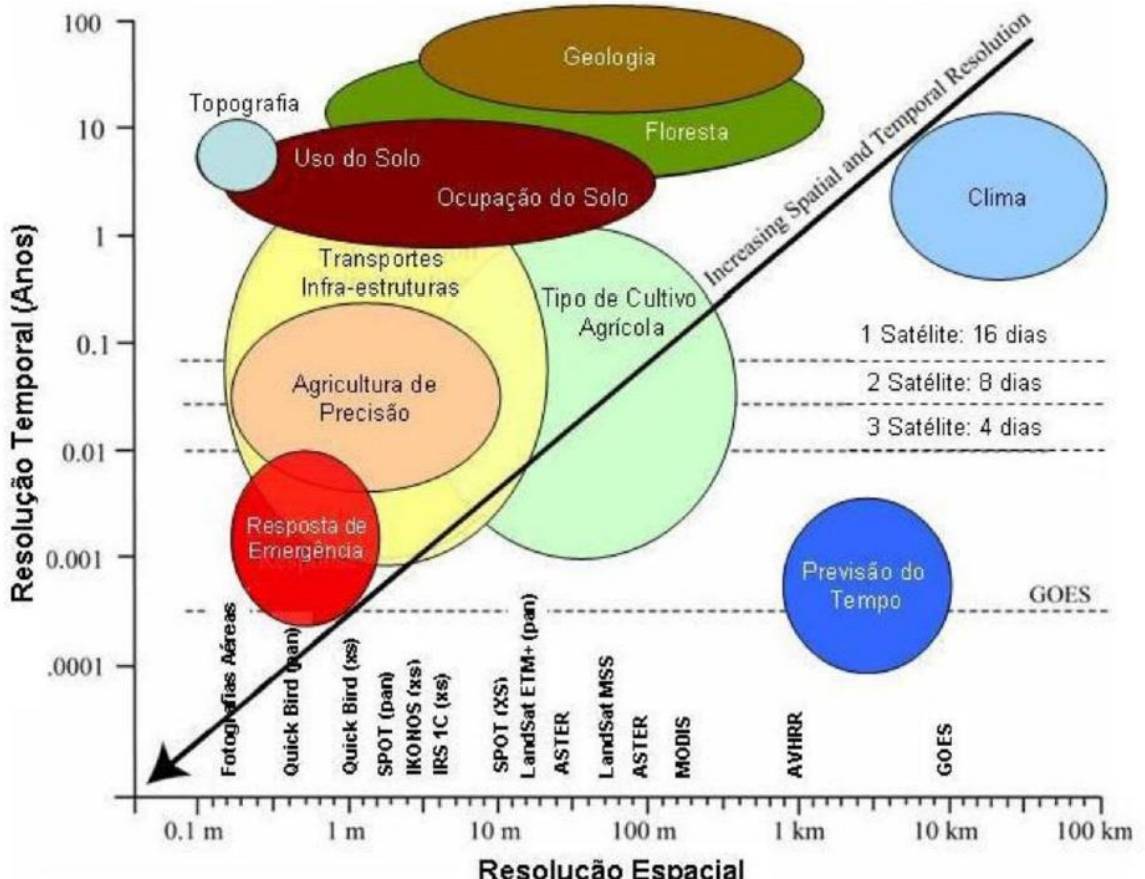
If ***n=*** is bits numbers

Bits and values : 2^n

1 bit	2^1	2
2 bits	2^2	4
8 bits (1 byte)	2^8	256
16 bits	2^{16}	65.356
24 bits	2^{24}	16.777.216

Temporal Resolution

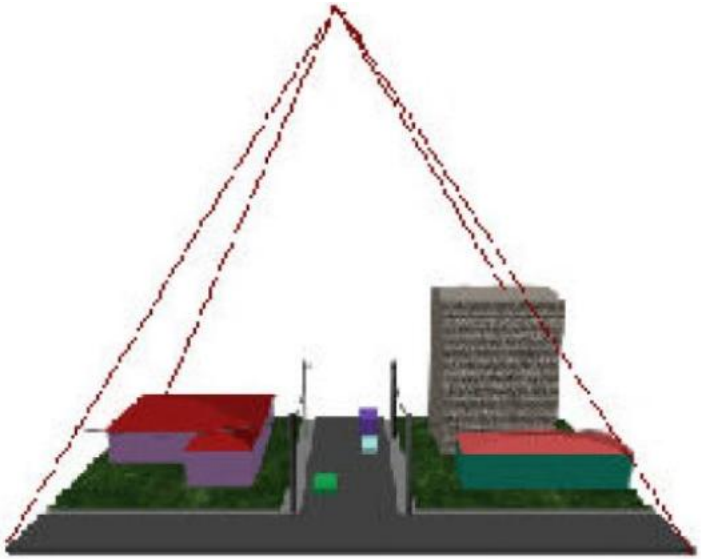
Time interval (in year) images are acquired in the place . It depends on the OP application.

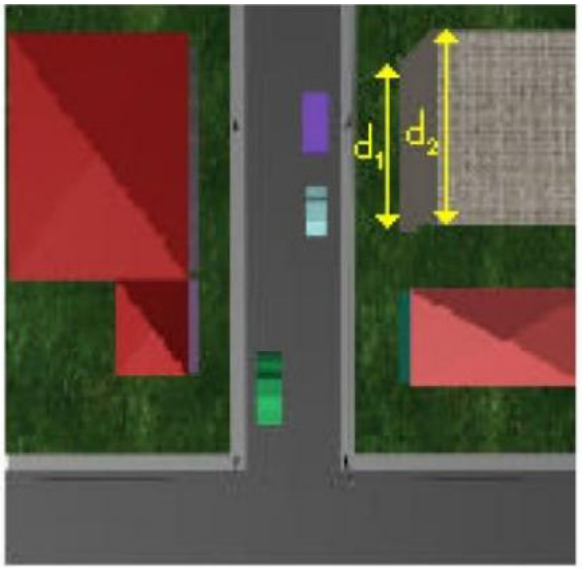


From an Imagem to an Orthophoto

An image in perspective **cannot** provide geometrically **rigorous information**; it contains **errors inherent to perspective.**

For example, the difference between the **side of a building** measured from the **base** and at the **top** (but they are, in reality, equal).



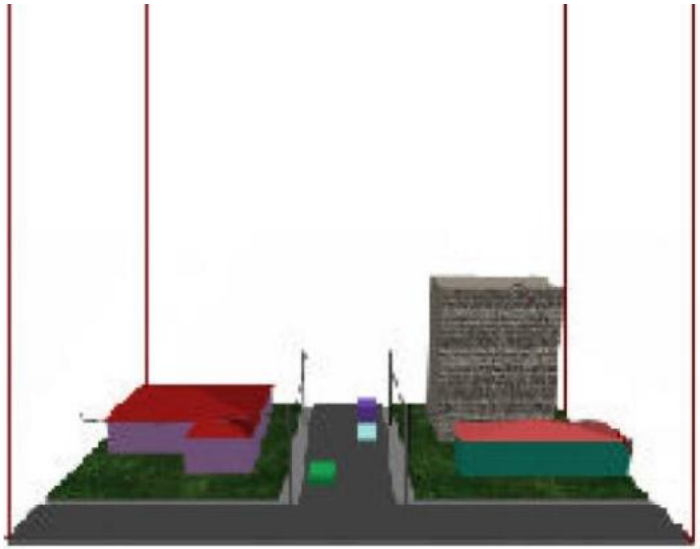


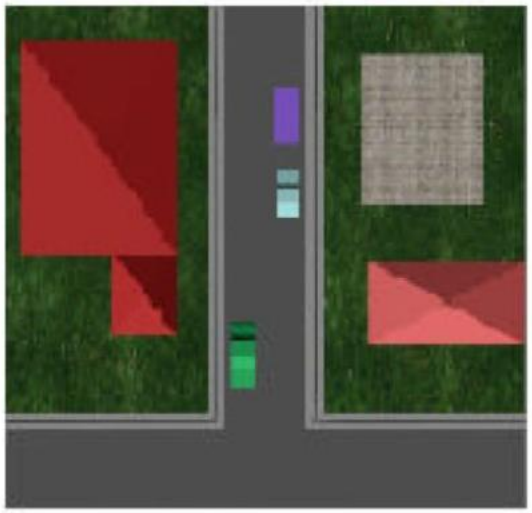
Orthogonal projection :

- **Orthogonal rays** are projected from the captured image. These rays never converge, and the resulting image is **free of distortions**, allowing it to be treated **as a cartographic product**.
- **Orthogonal perspective** is an artificial phenomenon resulting from a transformation applied to a perspective image.
- This process is known as **orthorectification or orthocorrection.**

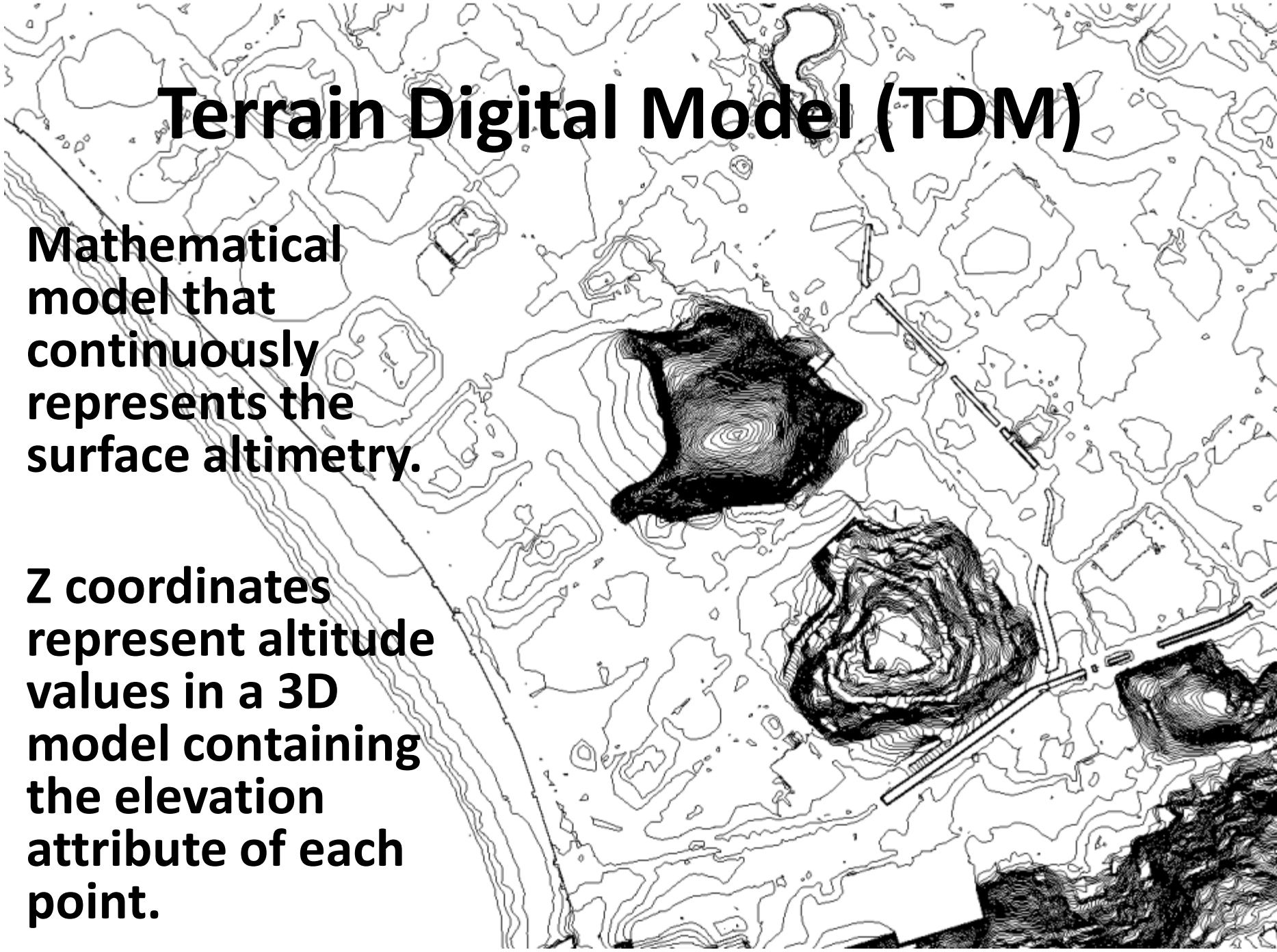
Orthorrectification

A process that uses aerial photos and the terrain's Terrain Digital Model (TDM) as input data, aiming to generate **images with measurable carthographic characteristics.**





Terrain Digital Model (TDM)



Mathematical model that continuously represents the surface altimetry.

Z coordinates represent altitude values in a 3D model containing the elevation attribute of each point.

Processing steps:

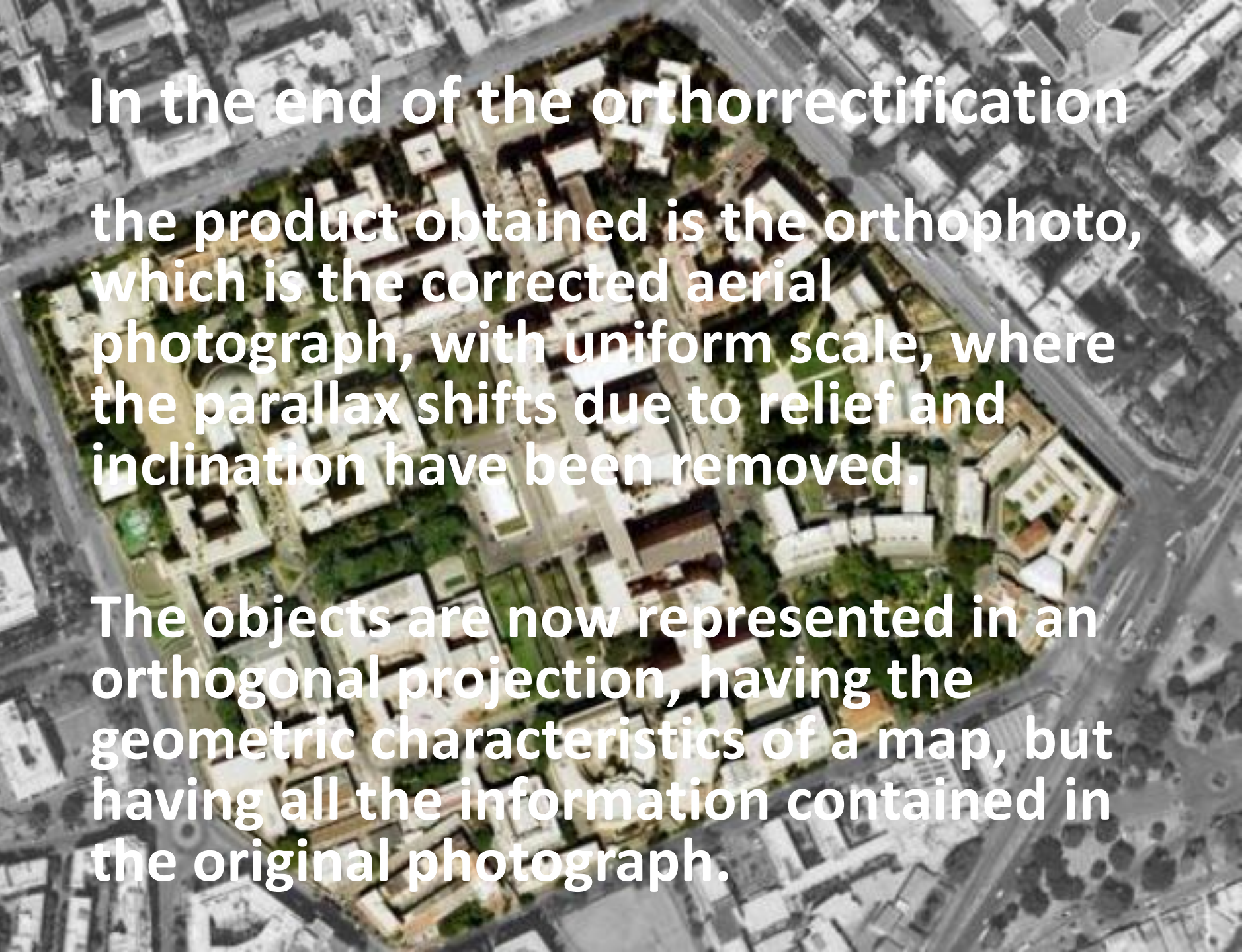
1- Organization of **various images** obtained covering a specific region;

2- **Rectification** to correct capture-related issues (lenses, position, etc.) and terrain-induced distortions;

3- Standardization of **measurements and angles**;

4- Georeferencing;

5- Organization into **data repositories**.



In the end of the orthorrectification

the product obtained is the orthophoto, which is the corrected aerial photograph, with uniform scale, where the parallax shifts due to relief and inclination have been removed.

The objects are now represented in an orthogonal projection, having the geometric characteristics of a map, but having all the information contained in the original photograph.

Ortho rectification

Correction of geometry, perspective and landscape **distortions** in aerial or satellite photographs, **making them geometrically equivalent to a map**.

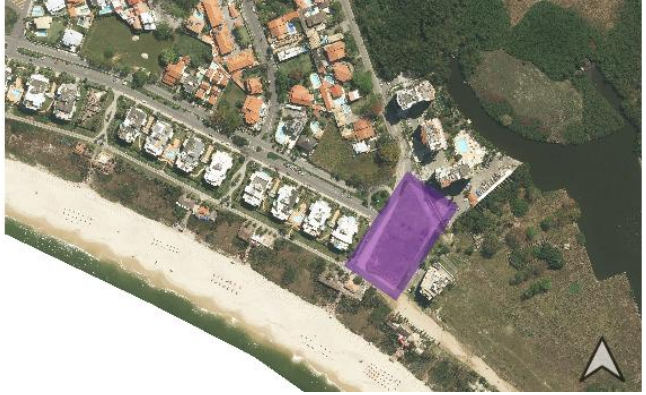
It integrates overlapping **aerial images** (captured by drones, aircraft, or satellites) with terrain **elevation data** (Digital Elevation Models - DEM) and **ground control points** (GCPs).

original photo X corrected one

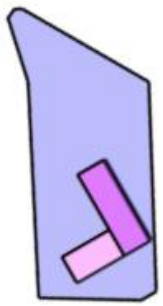
The final product is a photograph suitable for measurements at any scale and georeferenced

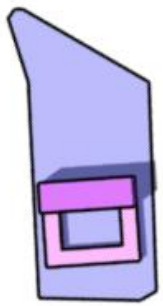
Orthomap – Orthocartographic

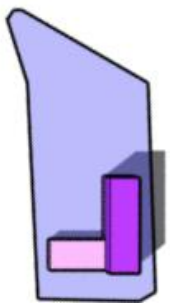
- An orthomap is a map resulting from the merging of all orthophotos necessary to fill the study area.
- The initial format, RAW, becomes Tagged Image File Format, that is, TIFF format (*.tif), with a radiometric resolution of 8 bits for each channel.
- Generally, JPEG is chosen as the compression method with a Q factor of 1, creating a set of visualization pyramids (overviews).

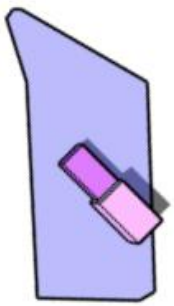


in Graphical Analysis for Architectural Design Planning it is incredible useful for meeting students' expectations regarding knowledge of new technologies.



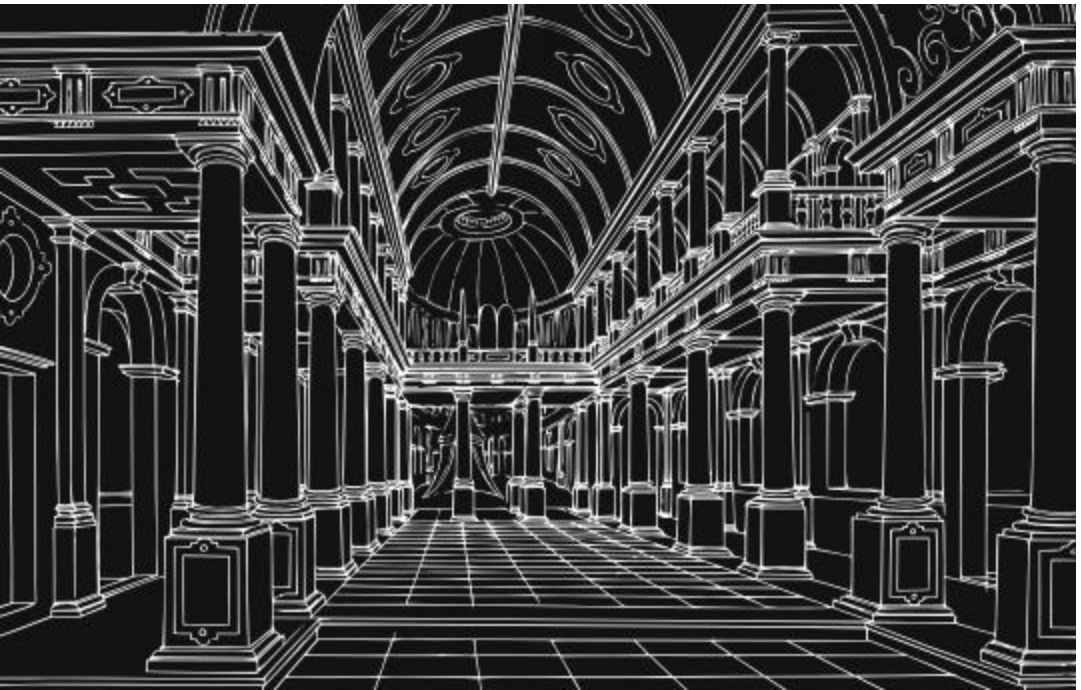






Thank you!

Questions?



Reference:
Wilfried, L. (2016) - Digital Photogram-metry, A Practical Course. Springer