Aerial / Satellite Imagery Retrieval

Assignment 3 | Geospatial Vision and Visualization | Spring 20

Chirag Khandhar | A20434926

Akshay Kulkarni | A20448255

Megha Tatti | A20427027

The Bing Map Tile System

- We are using Bing Map Tile System, that provides a pre-render World Map at multiple levels of details.
- We provide a lat/lon bounding box and level of detail to cut each map into tiles for quick retrieval.
- To make the map seamless, and to ensure that aerial images from different sources line up properly, we have to use a single projection for the entire world.
- We chose to use the Mercator Projection, which looks like the picture shown aside.

Ground Resolution and Map Scale

- In addition to the projection, the ground resolution or map scale must be specified in order to render a map.
  - Lowest Level (Level 1) = map size = 512 x 512 px
  - Level 2 = map size = 1024 x 1024 px and so on.
  - Thus, the map width and height grow by a factor of 2.
- In general, we calculate the width and height of the map in pixels as follows:

$$\text{Map width} = \text{Map Height} = 256 \text{ x } 2^{\text{level}} \text{ pixels}$$

- The Ground Resolution indicates the distance on the ground that’s represented by a single pixel in the map

Ground Resolution and Map Scale (cont.)

- The Ground Resolution indicates the distance on the ground that's represented by a single pixel in the map.
- It varies depending on the level of detail and the latitude at which it's measured.
- Thus, by using Earth Radius = 6378137 m the Ground Resolution in m/px can be calculated as follows:

$$Ground\ Resolution = \cos\left(\frac{latitude \ \times \ \pi}{180}\right) \times \frac{Earth\ Circumference}{Map\ Width}$$

$$Ground\ Resolution = \cos\left(\frac{latitude \ \times \ \pi}{180}\right) \times \frac{2 \times \pi \times 6378137}{(256 \ \times \ 2^{level}\ px)}$$

Ground Resolution and Map Scale (cont.)

- The Map Scale indicates the ratio between map distance and ground distance, when measured in the same units.
- It varies depending on the level of detail and the latitude at which it’s measured.
- It can be calculated from the ground resolution as follows, given the screen resolution in dots per inch, typically 96 dpi:

$$Map\ Scale = 1 : Ground\ Resolution \times \frac{Screen\ dpi}{0.0254\ m/in}$$

$$Map\ Scale = 1 : \left[\frac{\cos\left(\frac{latitude \times \pi}{180}\right) \times 2 \times \pi \times 6378137 \times screen\ dpi}{256 \times 2^{level} \times 0.0254}\right]$$

Pixel Coordinates

- Now after calculating the above quantities, we now convert the Geographic Coordinates into Pixel Coordinates.
- We consider the following conventions:
    - Pixel at upper-left corner = (0, 0)
    - Pixel at lower-right corner = (width – 1, height – 1) = (256 x 2^{level} – 1, 256 x 2^{level} – 1)
- Given latitude and longitude in degrees, and the level of detail, the pixel XY coordinates can be calculated as follows:

sinLatitude = sin(latitude x pi/180)

pixelX = ((longitude + 180) / 360) x 256 x 2 level

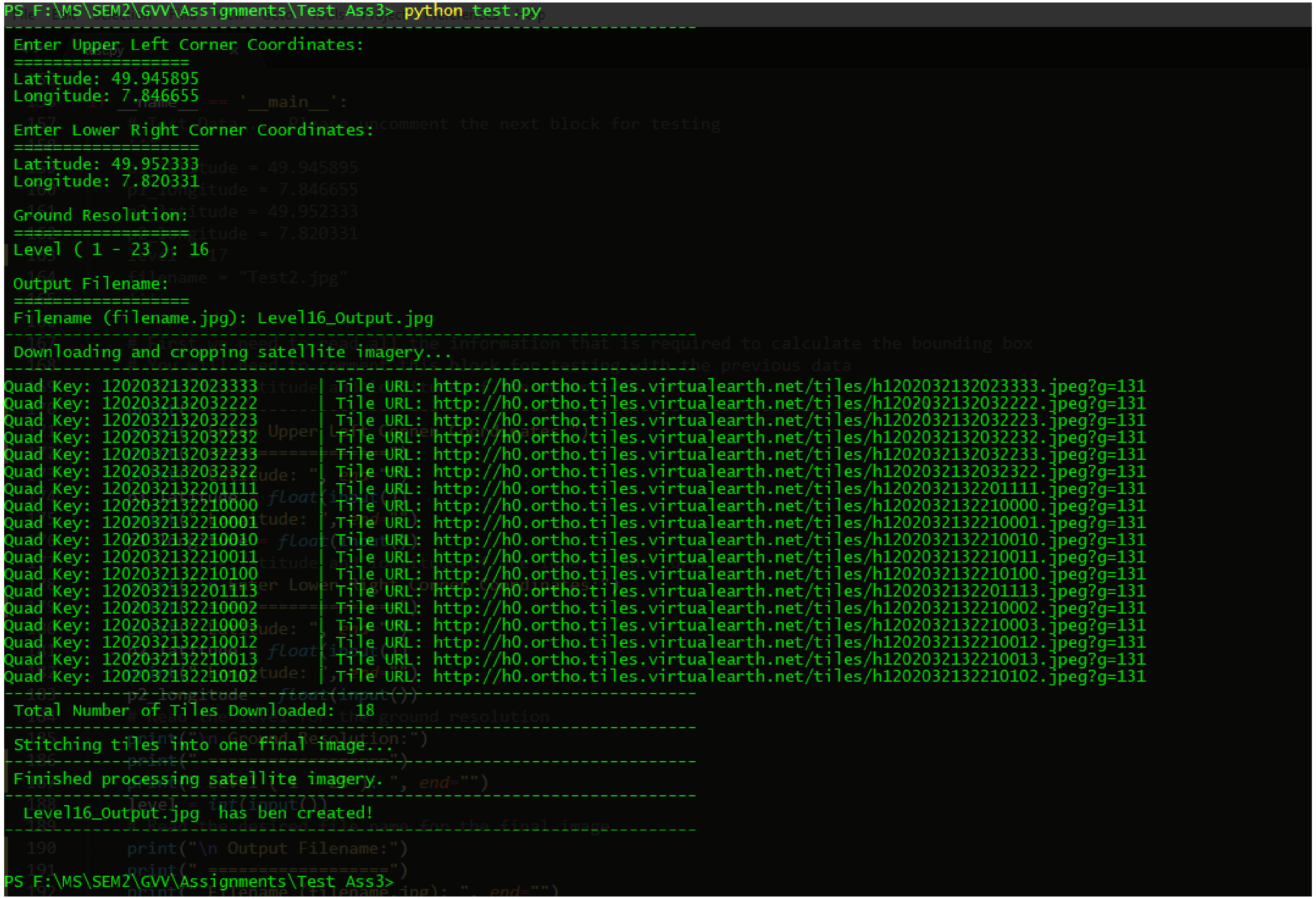
pixelY = (0.5 – log((1 + sinLatitude) / (1 – sinLatitude)) / (4π)) x 256 x 2 level

Tile Coordinates and Quadkeys

- To optimize the performance of map retrieval and display, the rendered map is cut into tiles of 256 x 256 pixels each.
- Each tile is given XY coordinates from upper left to lower right corner.
- Thus, given a pair of pixel XY coordinate we can easily determine the tile XY coordinates of the tile containing that pixel.
    - tileX = floor(pixelX / 256)
    - tileY = floor (pixelY / 256)
- The quad key is a integer value with base 4 that is accepted by the Bing map.
- Parameters for Quadkey:
    - Tile Position: A tuple of tile coordinates x and y.
    - Level: The level of detail of the map ranging from 1 to 23 that was used to calculate the pixel position.

Results

P1_latitude = 49.945895
P1_longitude = 7.846655
P2_latitude = 49.952333
P2_longitude = 7.820331
Level = 16
Filename =
Level16_Output.jpg



```
PS F:\MS\SEM2\GVV\Assignments\Test Ass3> python test.py
---------------------------------------------------------------------------------
 Enter Upper Left Corner Coordinates:
 ==================
 Latitude: 49.945895
 Longitude: 7.846655

 Enter Lower Right Corner Coordinates:
 ==================
 Latitude: 49.952333
 Longitude: 7.820331

 Ground Resolution:
 ==================
 Level ( 1 - 23 ): 16

 Output Filename:
 ==================
 Filename (filename.jpg): Level16_Output.jpg
---------------------------------------------------------------------------------
 Downloading and cropping satellite imagery...
---------------------------------------------------------------------------------
Quad Key: 1202032132023333 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132023333.jpeg?g=131
Quad Key: 1202032132032222 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132032222.jpeg?g=131
Quad Key: 1202032132032223 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132032223.jpeg?g=131
Quad Key: 1202032132032232 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132032232.jpeg?g=131
Quad Key: 1202032132032233 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132032233.jpeg?g=131
Quad Key: 1202032132032322 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132032322.jpeg?g=131
Quad Key: 1202032132201111 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132201111.jpeg?g=131
Quad Key: 1202032132210000 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210000.jpeg?g=131
Quad Key: 1202032132210001 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210001.jpeg?g=131
Quad Key: 1202032132210010 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210010.jpeg?g=131
Quad Key: 1202032132210011 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210011.jpeg?g=131
Quad Key: 1202032132210100 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210100.jpeg?g=131
Quad Key: 1202032132201113 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132201113.jpeg?g=131
Quad Key: 1202032132210002 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210002.jpeg?g=131
Quad Key: 1202032132210003 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210003.jpeg?g=131
Quad Key: 1202032132210012 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210012.jpeg?g=131
Quad Key: 1202032132210013 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210013.jpeg?g=131
Quad Key: 1202032132210102 | Tile URL: http://h0.ortho.tiles.virtualearth.net/tiles/h1202032132210102.jpeg?g=131
---------------------------------------------------------------------------------
 Total Number of Tiles Downloaded:  18
---------------------------------------------------------------------------------
 Stitching tiles into one final image...
---------------------------------------------------------------------------------
 Finished processing satellite imagery.
---------------------------------------------------------------------------------
  Level16_Output.jpg  has ben created!
---------------------------------------------------------------------------------

PS F:\MS\SEM2\GVV\Assignments\Test Ass3>
```

Results (cont.)

tile0.jpg

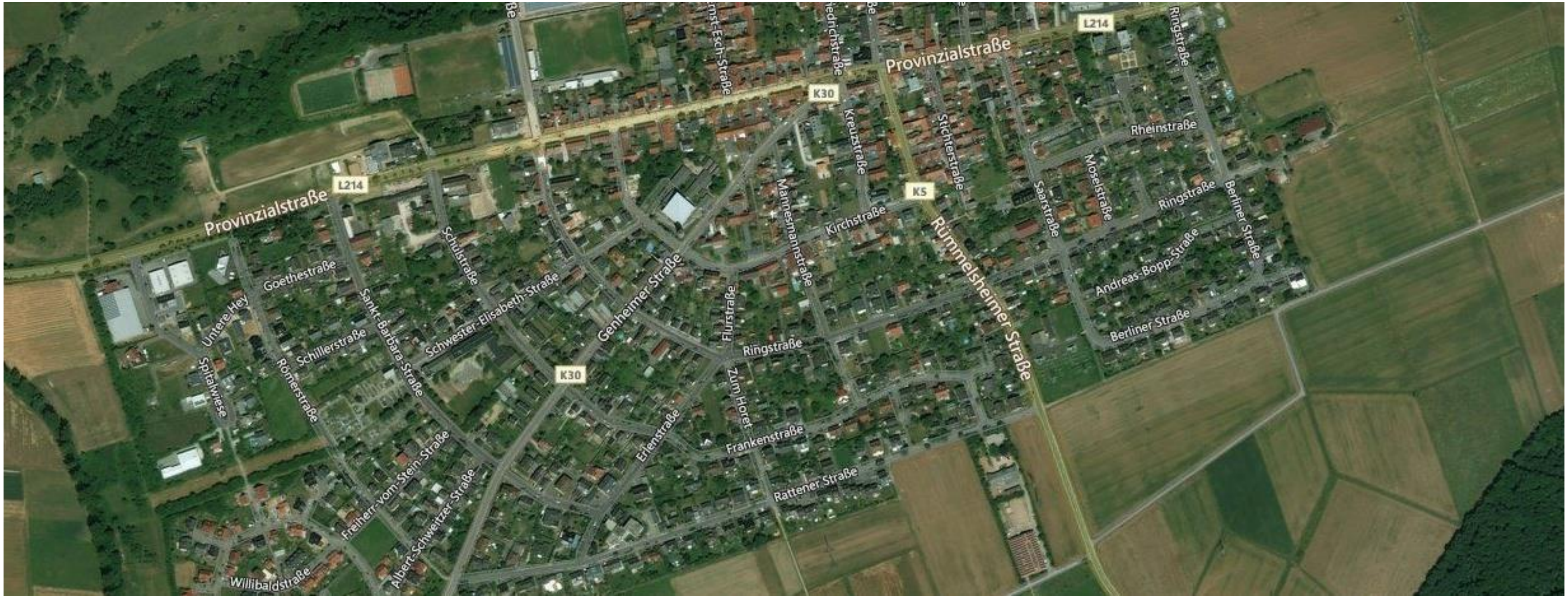
tile1.jpg

...

tile17.jpg

Intermediate Tiles

Results (cont.)



Level16_Output.jpg

Conclusion

- We are thus accepting the bounding box coordinates and level of detail.
- Then converting geographical coordinates to pixel coordinates.
- Then we are calculating the tile position.
- Then we are validating the input.
- If we have the valid input then we are downloading the tiles.
    - Downloading tiles is done by generating the QuadKey.
    - QuadKey is then appended to the URL.
- Ultimately, we are stitching all the tiles into one Image.

Source Code is Available at:

https://github.com/chiragkhandhar/Aerial-Satellite-Imagery-Retrieval

Thank You.