Assignment 3
Satellite/Aerial Image Retrieval

CS 513 Geospatial Vision/Visualization

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At A Glance

Approach - 1.1
Understanding Map Projection

The earth is a sphere like 3D object, while a map a 2D object. That way, projection is a must when making a map. An usual method employed in most and this one map system is Mercator projection. This method project the object on the earth to a cylinder. Distortion happens on high altitude areas, while most of the population live on low altitude areas.

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQdsm
He8xE9sqeN0sk0S-DfvXNlHFa6th8MVnHK1Oj47YSnLEGY6A
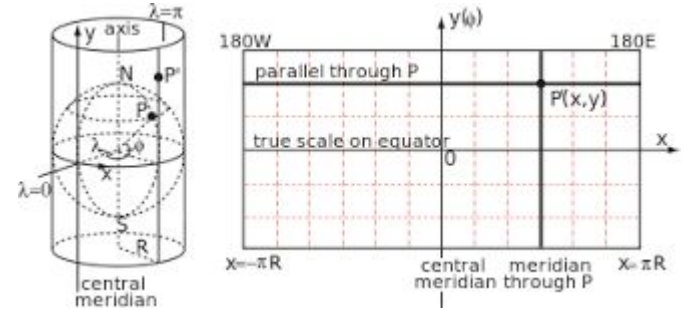
A relation between the Mercator projection and the true size of each country.
https://upload.wikimedia.org/wikipedia/commons/thum
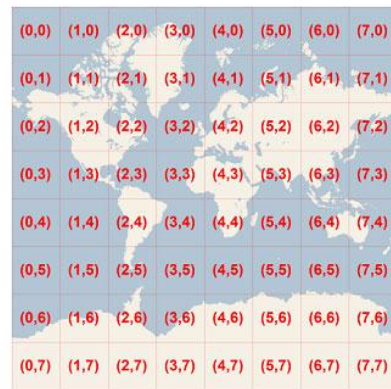b/e/ee/Worlds_animate.gif/220px-Worlds_animate.gif

Approach - 1.2
Understanding Tile System

Bing Maps provides maps at many different levels of detail, and to cut each map into tiles for quick retrieval and display. For each level of map, resolution differs.

$$map\ width = map\ height = 256 * 2^{level} pixels$$

Level of Detail	Map Width and Height (pixels)	Ground Resolution (meters / pixel)	Map Scale (at 96 dpi)
1	512	78,271.5170	1 : 295,829,355.45
2	1,024	39,135.7585	1 : 147,914,677.73
3	2,048	19,567.8792	1 : 73,957,338.86
⋮	⋮	⋮	⋮
22	1,073,741,824	0.0373	1 : 141.06
23	2,147,483,648	0.0187	1 : 70.53

https://docs.microsoft.com/en-us/bingmaps/articles/media/209e5af1-34c1-45f6-ba24-41df3e1a1b10.jpg
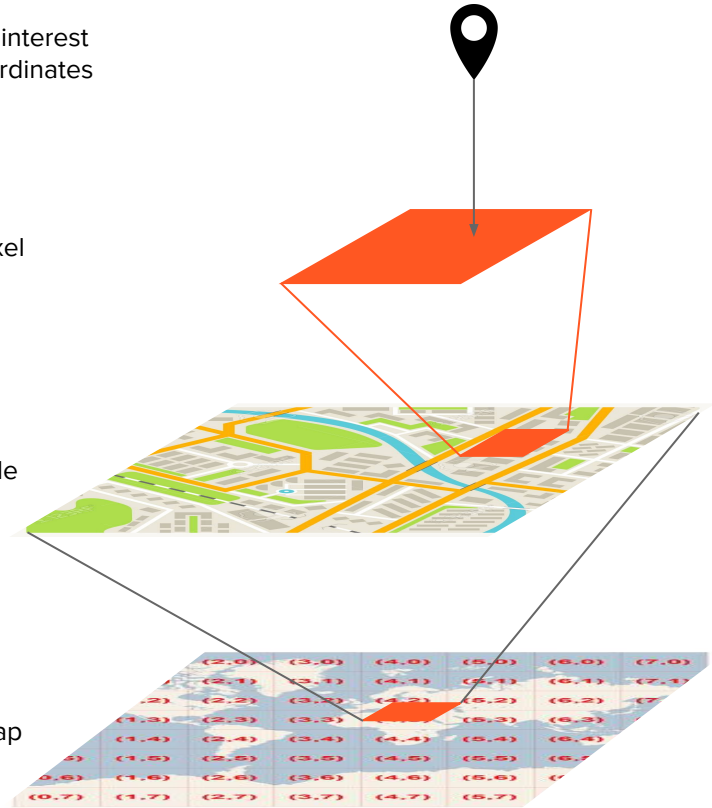
Approach - 1.2
Understanding Tile System

Any coordinate pairs in actual world will be projected to a map. The point of interest resides on a pixel. No matter what the resolution is, the pixel may be as big as a city or as small as a card on the ground, the point will on a particular pixel. The pixel resides on a tile, the tile is a part of this map.


Point of interest with coordinates

Pixel

Tile

Map

https://previews.123rf.com/images/ssstocker/ssstocker1701/ssstocker170100361/70481994-city-map-colored-illustration-for-navigation-program-or-mobile-app-city-layout-map-vector-illustrati.jpg

https://docs.microsoft.com/en-us/bing maps/articles/media/209e5af1-34c1-45f6-ba24-41df3e1a1b10.jpg

Approach - 1.3
## Understanding Tile Queries - Quadkey

In level one, the map is cut into four pieces, or four tiles. From then on, each level cut every tile that last level has into four tiles. The initial tiles in level one is assigned as 1 to 4. Then the descendant was assigned an extra digit behind.
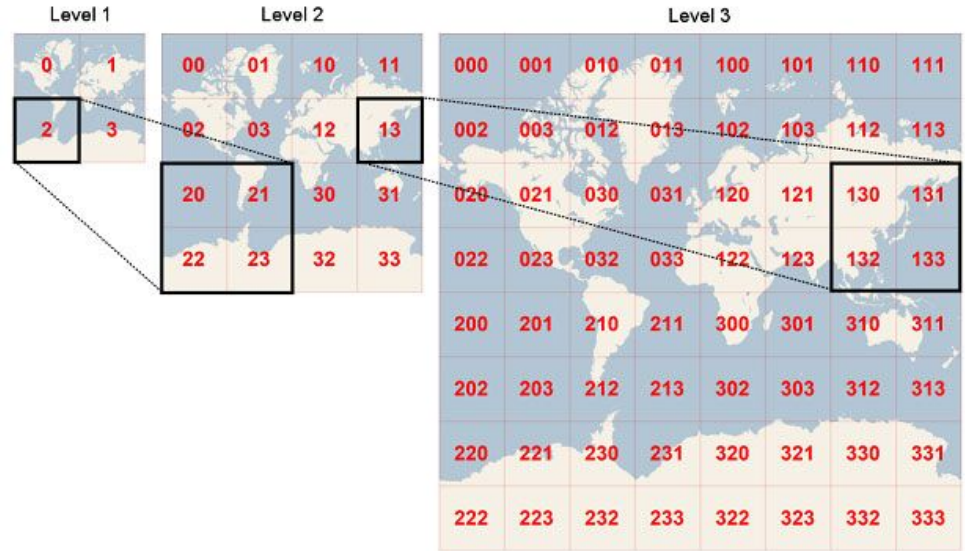
Approach - 1.4
Facts About Bing Map

In one country, or one continent, the best available resolution level is the same. For example, lower US states has level 21 available, while in China, only level 19 is available. So there will be no scenario that tiles have different levels in one query, unless you are querying too big, which will lead to memory exceeded.
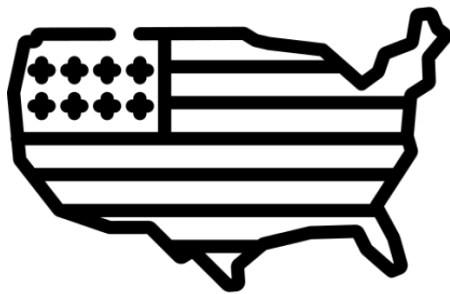
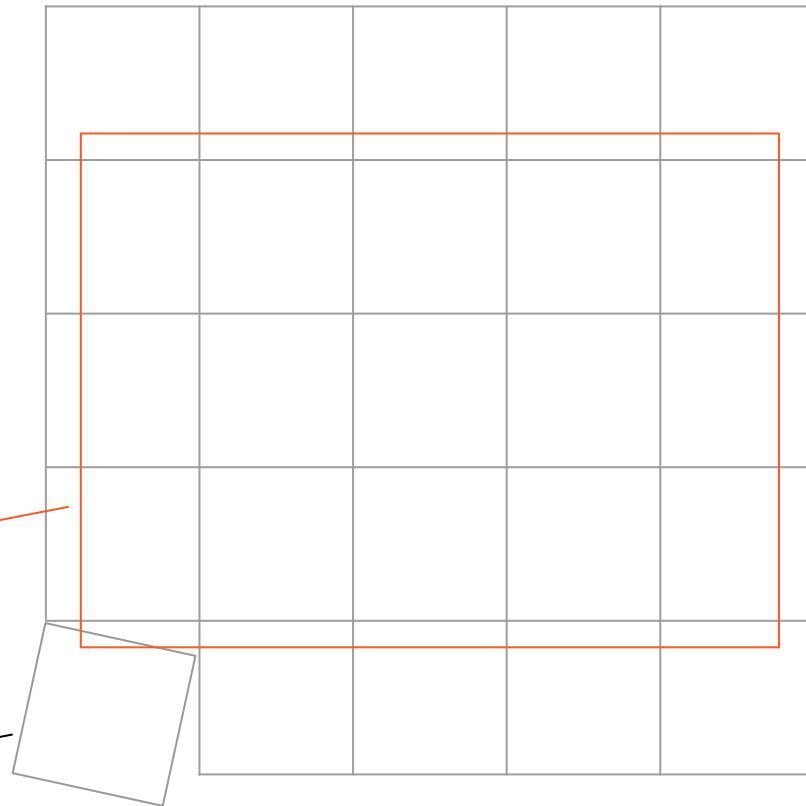Best Tile Level 21

Best Tile Level 19

Approach - 1.5
Image Stitching

Stitching is an easy job in this part. After downloading all the tiles needed and put them together. Then crop the area we need.

Query area

A tile

Materialization - 2.1
Making Queries

There are steps to make it happen:

1. Determine which pixel the point lies.
2. Determine which tile the pixel lies.
3. Generate the quadkey from the coordinates of the tile.
4. Download the tile, using quadkey.

These are results of those steps:

0. Point of interest if the intersection of 35th Street and South State Street. (41.834680, -87.626601)
1. Pixel coordinates (68878598, 99813477) in level 20.
2. Tile coordinates (269057, 389896) in level 20.
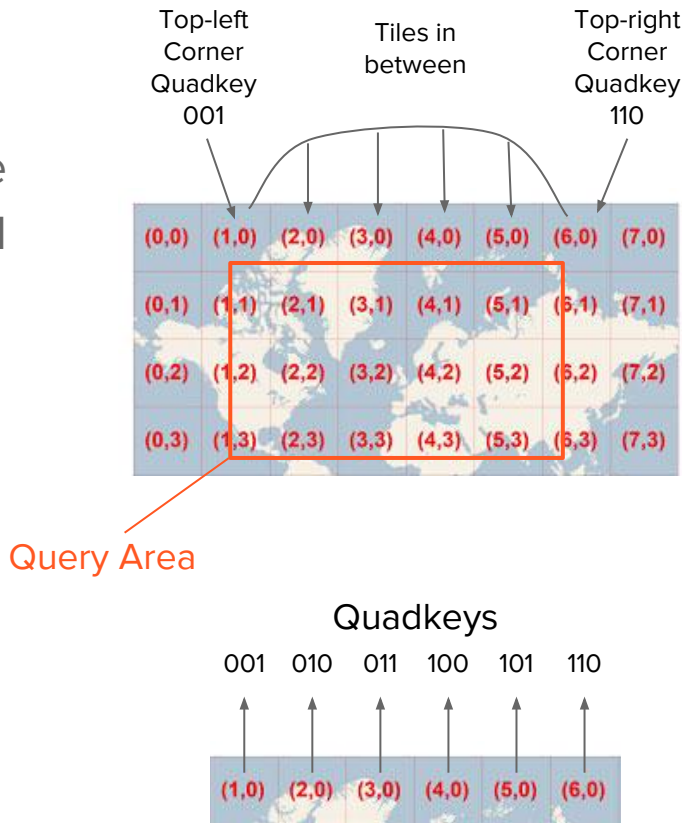3. Quadkey 03022223103300002001
4. Nailed it! Generate URL.

http://h0.ortho.tiles.virtualearth.net/tiles/h03022223103300002001.jpeg?g=131

Materialization - 2.2
Making A Batch Query

Based on last slide, we can easily find the quadkey for four corners, but we need to find all the quadkey in between:

1. Get the quadkey for four corners.
2. Transform quadkey back to tile coordinates.
3. Find all the tile coordinates in between.
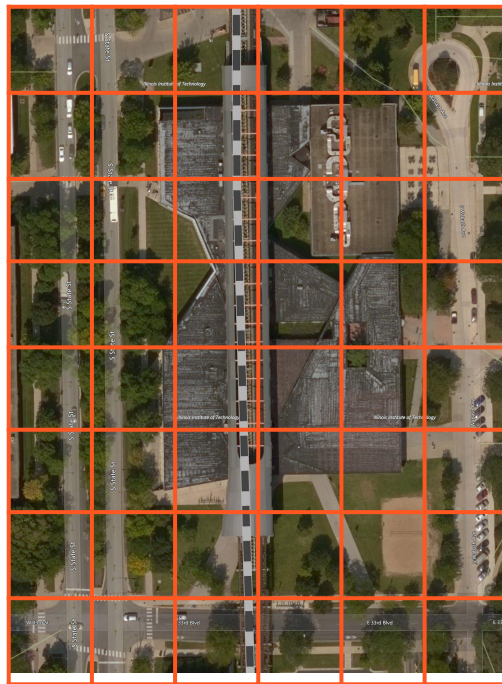4. Transform tile coordinated to quadkeys.

Top-left Corner Quadkey 001

Tiles in between

Top-right Corner Quadkey 110

Query Area

Quadkeys

001 010 011 100 101 110

Materialization - 2.3
Image Stitching

There are steps to do image stitching:

1. Create a new blank map.
2. Put tiles on the right space.
3. Crop to the area we want

Uncropped

Cropped

Materialization - 2.3
Image Stitching

Here is a massive query we have made on Forbidden City, Beijing.

Coordinates Pair 1: 39.932718, 116.373009

Coordinates Pair 2: 39.907931, 116.411487

Level: 19   Size: 24.8 Mb

(This is not the original image. It's a screenshot, because the Google Slides does not support such big image. The original image can be accessed via our GitHub repo)

Thank you.

Github repository:

https://github.com/HaoHowZhan/Geospatial_Vision_Visualizatio

Reference:
1. Schwartz, Joe. "Bing Maps Tile System - Bing Maps." Bing Maps | Microsoft Docs, 27 Feb. 2018, docs.microsoft.com/en-us/bingmaps/articles/bing-maps-tile-system.
2. Microsoft. "Bing Maps Geographic Coverage - Bing Maps." Microsoft.Com, 28 Feb. 2018, docs.microsoft.com/en-us/bingmaps/coverage/geographic-coverage.
3. Bing Map Scale - Level below 18 and 19. community.esri.com/thread/28918.