# Concept and Measures of Distance

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- **Georg Friedrich Bernhard Riemann**(1826-1866) introduced ideas of fundamental importance in complex analysis, real analysis, differential geometry.
- He described the shortest path distance (Euclidean space)between geographical locations, which is relative concept.
- This concept is limited for spherical earth, where shortest path distance is not straight but it would be curvilinear.

- **Hermann Minkowski** (1864 –1909) was a German mathematician and professor. He created and developed the geometry of numbers.
- He presented the distance as four dimensional.
- Earth surface is two dimensional- where distance can be curvilinear or triangular, whose sum is more or less than 180 degree.

- **David Harvey** (1969)- ‘Geometry: The language of spatial forms’.
- According to him distance is an address system, which is helpful in the analysis of location and distribution of various points on the surface.
- Basically the concept of distance depends on the culture and experience.
- Distance has been described as absolute unit before 1950s.
- After 1950 the relative concept of distance has been introduced, which is true distance of human experience and affects according to the conditions.
- Harvey introduced following concepts of distance:
  - Physical distance
  - Social distance
  - Time distance
  - Economic distance
  - Cost distance
  - Perceptual distance

Distance depends on the relative positions of the places. It can be of two types:

1. Point to point distance
2. Distance in a group of points.

# Point to point distance

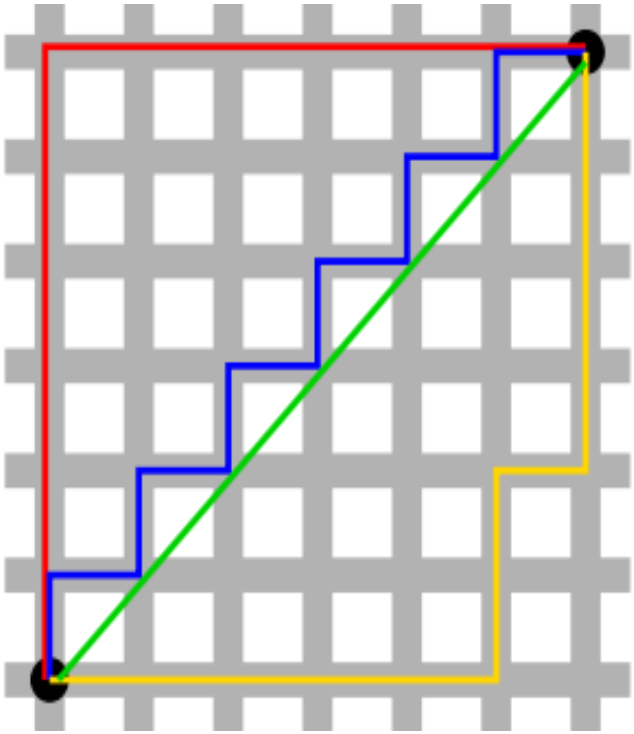
- Point to point distance can be straight or not.
- These distances are geodesic paths (A path with the minimum number of edges in a graph).
- It is shortest distance path.
- There are two types of surfaces in the case of point to point distance:
  - i) Straight-line short paths
  - Ii) Non Straight-line short paths

## i) Straight-line short paths:

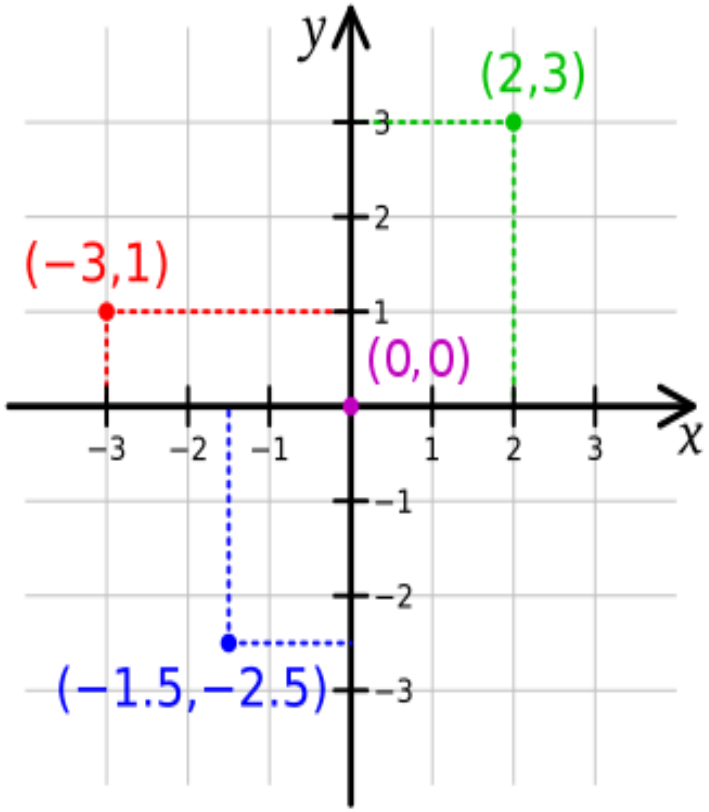
- Shortest path distance between two points.
- **Euclidean distance**. The most basic manner to represent distance as a simple function of a straight line between two locations where distance is expressed in geographical units such as kilometers. Commonly used to provide an approximation of distance, but rarely has a practical use.
- Crow fly
- Normally relative distance between a pair of nodes is constant. But it may vary accordingly. For instant one way path.

# Non Straight-line short paths

- **Manhattan s**pace geometry is a form of geometry in which the usual distance function or metric of Euclidean Geometry is replaced by a new metric in which the distance between two points is the sum of the absolute differences of their **Cartesian coordinates.**
- Manhattan geometry versus Euclidean distance:
  - In Manhattan geometry, the red, yellow, and blue paths all have the same shortest path length of 12.
  - In Euclidean geometry, the green line has length is approx 8.49 and is the unique shortest path.



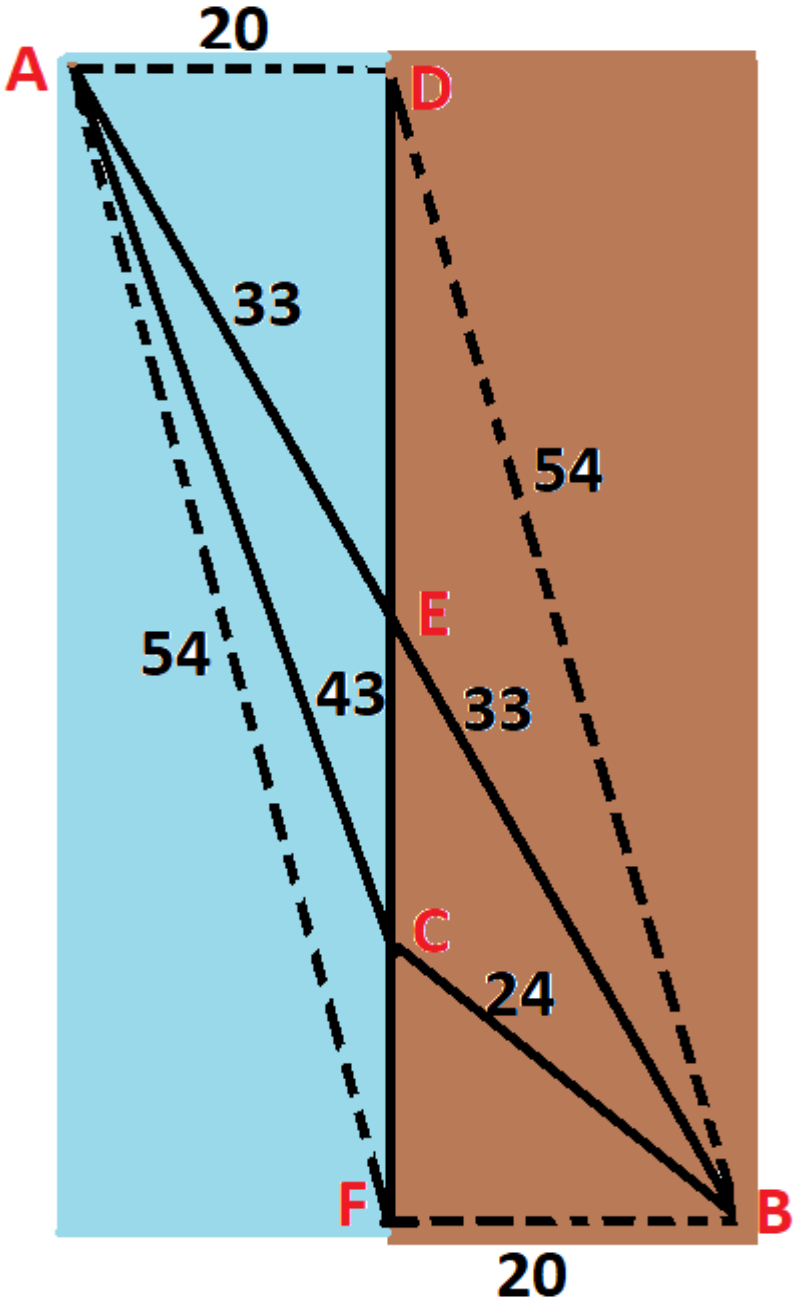
A Cartesian coordinate system is a coordinate system that specifies each point uniquely in a plane by a set of numerical coordinates, which are the signed distances to the point from two fixed perpendicular.



- Nobdeck  explained the distance between two settlements (nodes). According to him in short distances- rectangular distances and stair type distance is greater than non straight line short paths distance.
- Rectangular distances are 1.43 times more than actual distance.
- This ratio became lower as the distances increases.

- In 1967 Mr. Timer compared the distances of airways and roadways in Mid England.
- He found the difference of 1.17 times.
- There is a difference between straight and non straight paths.
- Sometimes non straight paths having low transportation cost. (in seas)

- For minimum transportation cost there is a following example:
- Where:
  - Equal distance on land and sea: AEB
  - Minimum distance on sea and maximum on land: ADB
  - Minimum distance on land and maximum on sea: AFB
  - Condition: Transportation cost would be 1Rs per km on sea and 2 Rs. Per km on land



The transportation cost on various paths are following:

1. **Equal distance on sea and land: AEB**

= 33 X 1(Sea) + 33 X 2 (Land) = 33 + 66 = 99 Rs.

2. **Minimum distance on sea and maximum on land: ADB**

= 20 X 1(Sea) + 54 X 2(Land) = 20 + 108 = 128 Rs.

**3. Maximum distance on sea and minimum on land: AFB**

= 54 X 1(Sea) + 20 X 2(Land) = 54 + 40 = 94 Rs.

**4. Geodesic Path: ACB**

= 43 X 1(Sea) + 24 X 2(Land) = 43 + 48 = 91 Rs.

In above case **ADB** is most expensive route (Rs.128), while **ACB** is least expensive route (Rs. 91).

# Distance in a group of points

- There are more than one center or node in a region.
- Total distance between all these points or centers are not abstracted, while it is average of all distances.
- These are calculated by various mathematical formulas.

# Measures of Distances

- Physical Measures
- Time Measures
- Economic Measures
- Perceptual Measures

# THANK YOU

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