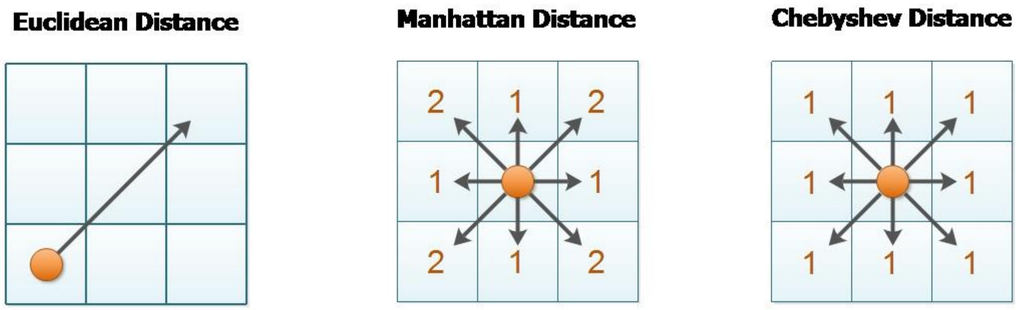
Euclidian Vs Manhattan Vs Chebyshev Distance

Euclidean, **Manhattan**, and **Chebyshev** distances are all metrics used to measure the distance between two points, but they are preferred in different real-life scenarios based on the nature of the data and the problem. The choice depends on whether a straight-line path, a grid-like path, or movement limited by a single dimension is more appropriate.



$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$ $|x_1 - x_2| + |y_1 - y_2|$ $\max(|x_1 - x_2|, |y_1 - y_2|)$

Euclidean Distance

Euclidean distance is the most common distance metric and represents the shortest straight-line path between two points. It is the preferred choice when diagonal movement is possible and meaningful.

- **Real-Life Usecase:** Navigation and robotics where movement is unrestricted. For example, a drone flying from one point to another will follow the most direct, straight-line path. In a machine learning context, it's often used in algorithms like **K-Means clustering** and **K-Nearest Neighbors (K-NN)** for datasets where features are independent and the overall magnitude of the difference matters more than the individual components.
- **Why it's Preferred:** It accurately reflects the actual physical distance in a continuous space. Its formula, the square root of the sum of the squared differences, gives equal weight to each dimension.

Manhattan Distance

Manhattan distance, also known as the taxicab or L1 distance, measures the distance between two points by summing the absolute differences of their coordinates. It is the preferred choice when movement is restricted to a grid, such as in a city with a street grid.

- **Real-Life Usecase:** Urban planning and warehouse logistics. A delivery driver in Manhattan, for instance, can't travel through buildings, so the shortest path is the sum of the horizontal and vertical distances. In machine learning, it's often used when dealing with high-dimensional data or when the features are not independent, as it is more robust to outliers than Euclidean distance.
- **Why it's Preferred:** It accurately reflects the cost of movement in a grid-like environment, where diagonal shortcuts are not possible. Its formula focuses on the sum of the individual changes in each dimension.

Chebyshev Distance

Chebyshev distance, also known as the chessboard or L-infinity distance, is the maximum distance of any single dimension between two points. It is the preferred choice when movement is limited by the largest single step.

- **Real-Life Usecase:** Robotics and game theory. In chess, the minimum number of moves a king needs to get from one square to another is calculated using Chebyshev distance, as a king can move one square in any direction (horizontally, vertically, or diagonally). In robotics, it can be used for pathfinding where a robot's movement speed is limited by the slowest of its axes.
- **Why it's Preferred:** It captures the maximum change in any single dimension, making it suitable for situations where the bottleneck or limiting factor is a single coordinate, rather than the cumulative change.