

# Module 20: Distance Calculations - Complete Notes

## What You'll Learn

Master **distance metrics** — measuring how far apart two points are. Essential for similarity calculations, clustering, and nearest-neighbor algorithms.

## Concept Explained

### Types of Distance

Point A: (1, 1)      Point B: (4, 5)

MANHATTAN (City blocks):

$$|4-1| + |5-1| = 3 + 4 = 7$$

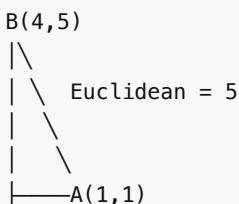
(Can only move horizontally/vertically)

EUCLIDEAN (Straight line):

$$\sqrt{(4-1)^2 + (5-1)^2} = \sqrt{9 + 16} = \sqrt{25} = 5$$

(As the crow flies)

### Visual



Manhattan =  $3 + 4 = 7$  (go right 3, up 4)

## Programming Connection

### Code Examples

```
# Example 1: Manhattan Distance

def manhattan_distance(p1, p2):
    """Sum of absolute differences (L1)"""
    return abs(p1[0] - p2[0]) + abs(p1[1] - p2[1])

print(manhattan_distance((1, 1), (4, 5))) # 7
```

```
# Example 2: Euclidean Distance
```

```
import math
```

```

def euclidean_distance(p1, p2):
    """Straight line distance (L2)"""
    return math.sqrt((p2[0] - p1[0])**2 + (p2[1] - p1[1])**2)

print(euclidean_distance((0, 0), (3, 4))) # 5.0 (3-4-5 triangle!)

```

```

# Example 3: Find Nearest

def find_nearest(target, points):
    """Find point closest to target"""
    return min(points, key=lambda p: euclidean_distance(target, p))

points = [(0, 0), (5, 5), (2, 1)]
print(find_nearest((3, 3), points)) # (2, 1)

```

```

# Example 4: N-dimensional Distance (for embeddings!)

def distance_nd(p1, p2):
    """Euclidean distance for any dimension"""
    return math.sqrt(sum((a - b)**2 for a, b in zip(p1, p2)))

# 3D points
a = (1, 2, 3)
b = (4, 5, 6)
print(distance_nd(a, b)) # 5.196

```

## SDET/Testing Application

```

# SDET Scenario: Find Similar Embeddings

def find_similar(query_embedding, embeddings, top_k=3):
    """Find most similar embeddings by distance"""
    distances = [(i, distance_nd(query_embedding, emb))
                 for i, emb in enumerate(embeddings)]
    distances.sort(key=lambda x: x[1])
    return distances[:top_k]

# Smaller distance = more similar

```

## Key Takeaways

- Manhattan** — Grid movement ( $|dx| + |dy|$ )
- Euclidean** — Straight line ( $\sqrt{(dx^2 + dy^2)}$ )
- Smaller distance = More similar**

 Save as: *Module\_20\_Distance\_Calculations.md*