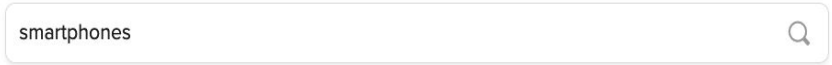
Vector Databases and ANN algorithm

Keyword search vs Semantic search



exact term matching

“Top smartphones on the market…”

“Smartphone industry struggles…”

synonyms and other similar/related terms

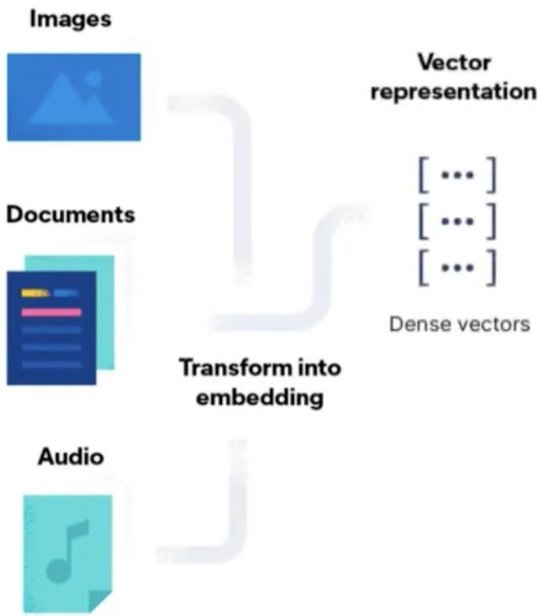
“Using a cell phone in Spain…”

“Mobile device usage on the rise…”

Images

Documents

Audio


Images
Documents
Audio
Transform into embedding
Vector representation
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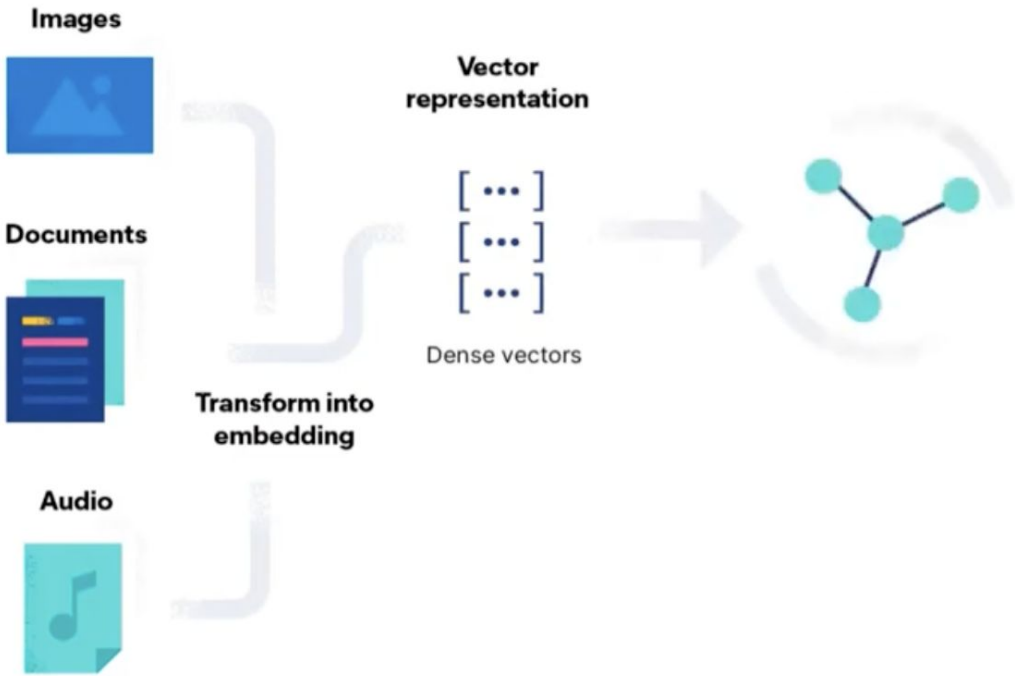
Dense vectors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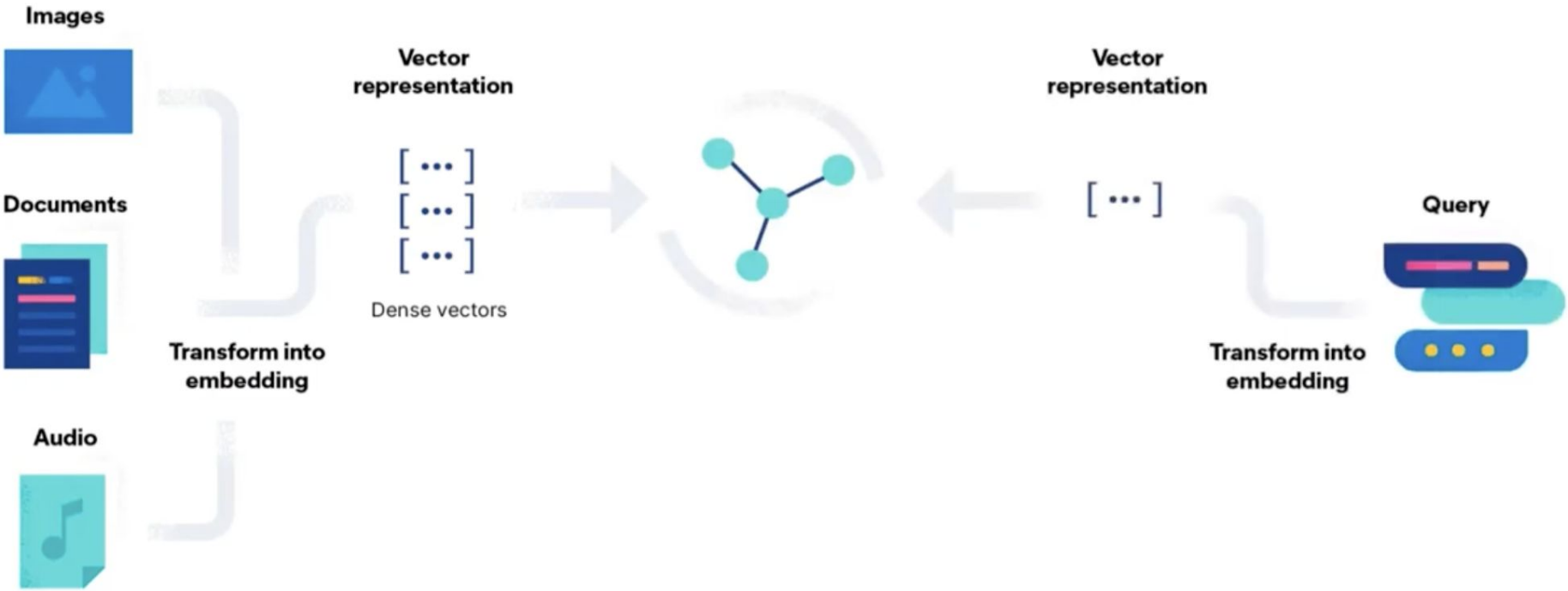
Vector representation
Dense vectors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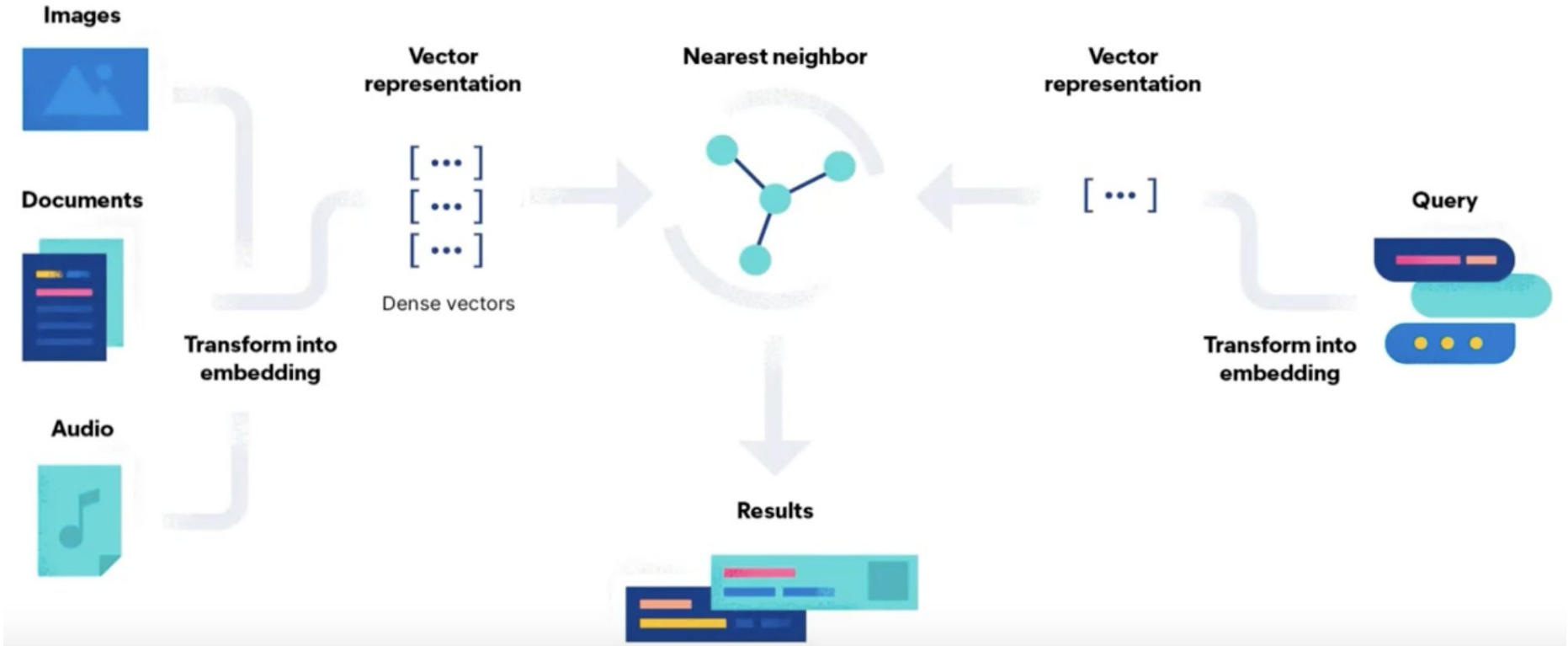
Transform into embedding
Vector representation
Dense vectors
Vector representation
Query
Transform into embedding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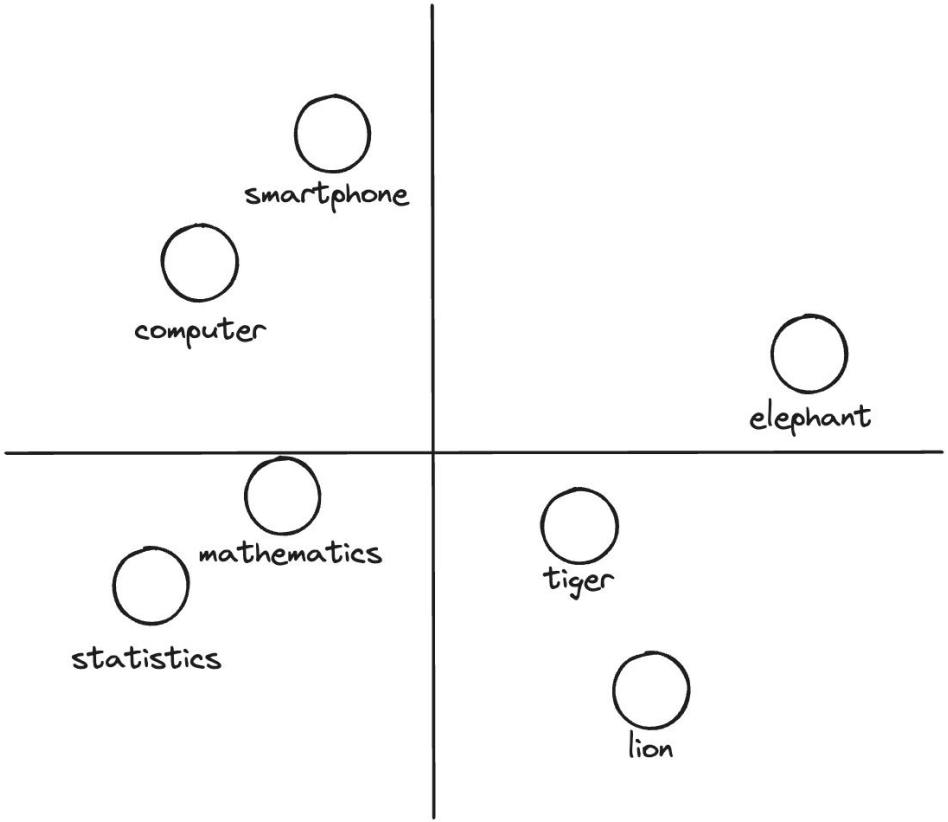
Transform into embedding
Vector representation
Dense vectors
Nearest neighbor
Results
Vector representation
Transform into embedding
Query

Semantic search is Vector search

K Nearest Neighbour

Exhaustive, brute-force approach

- Measure distance from query and all other vectors
- Sort distances
- Return top K results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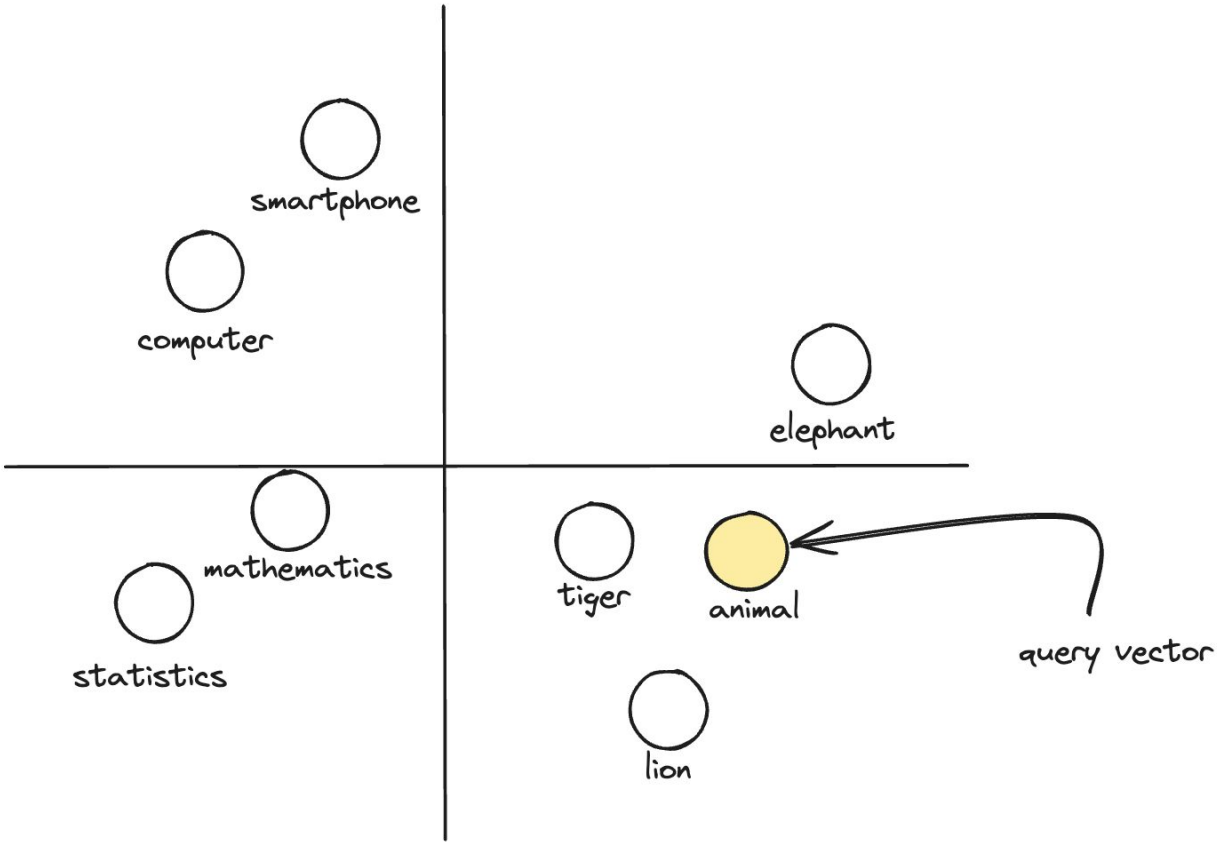
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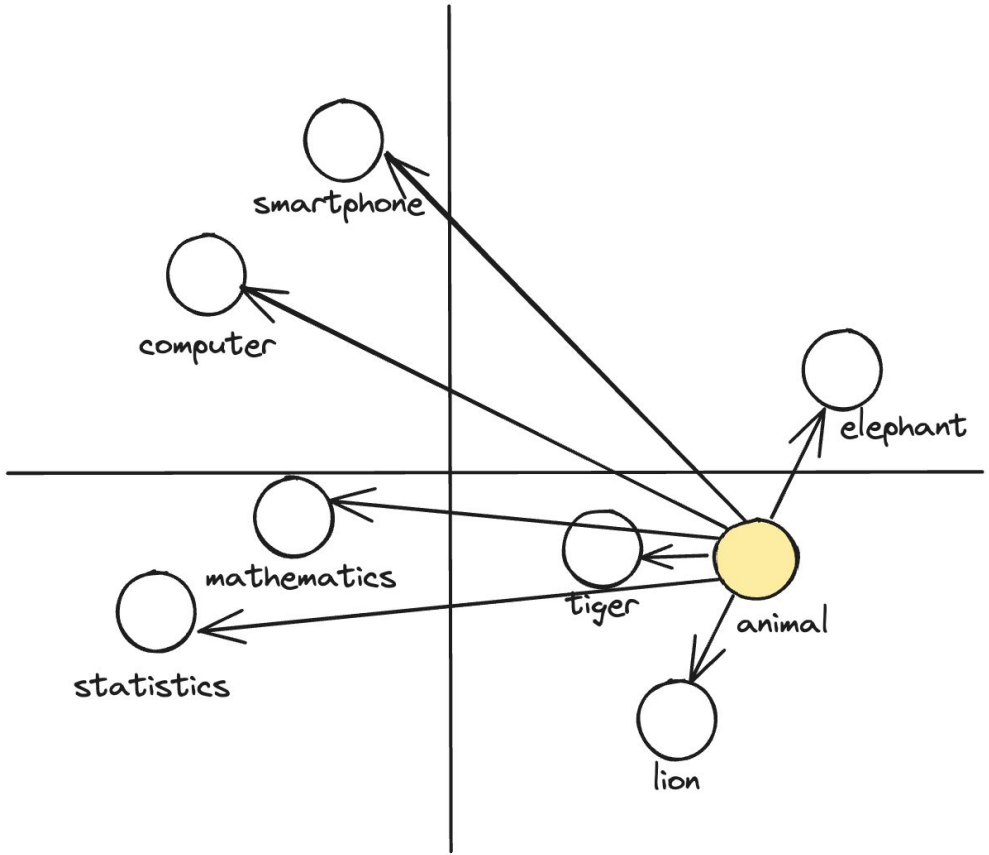
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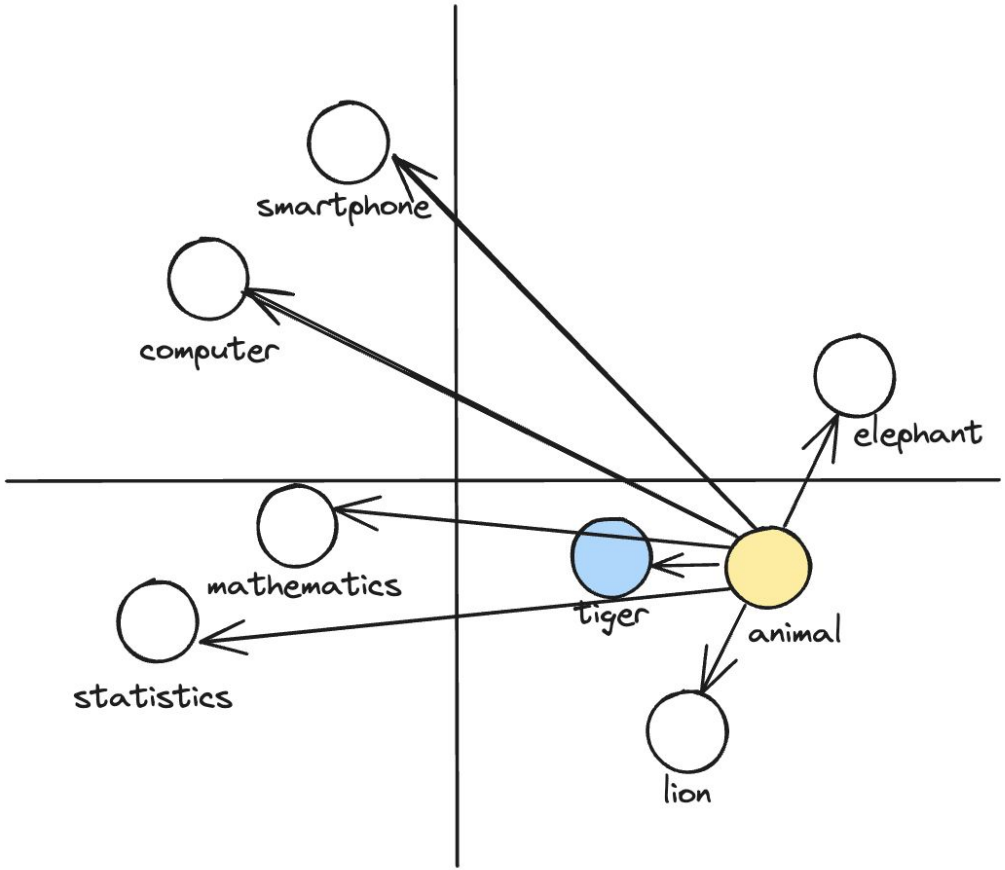
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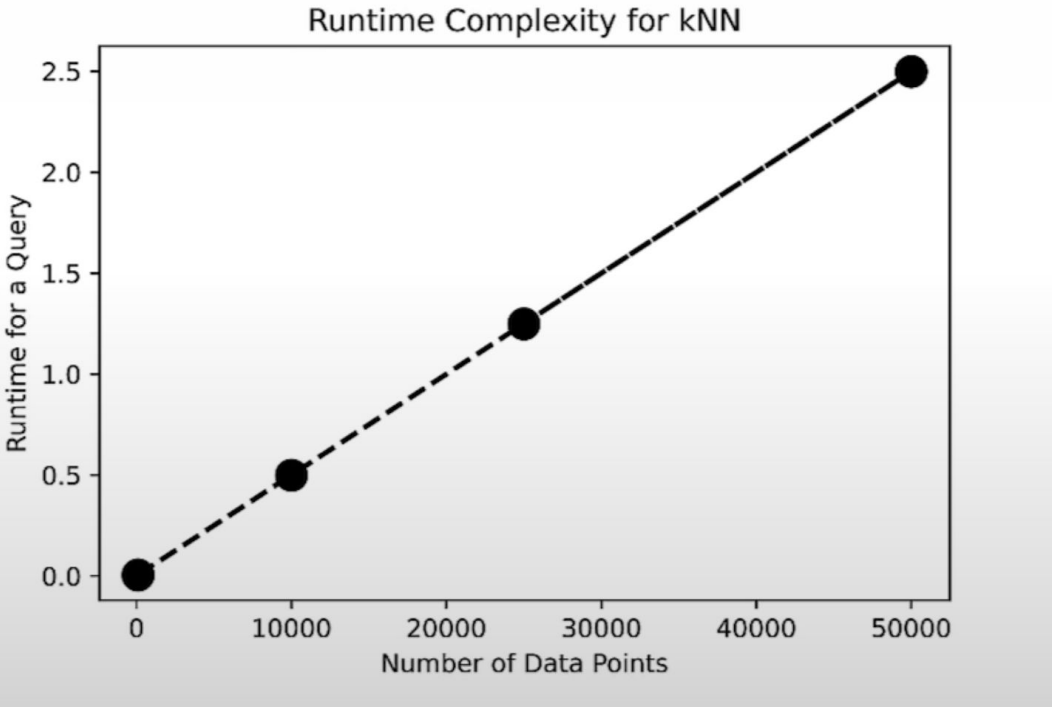
Performance



- Number of dimension ~1000
- Number of vectors ~millions
- Typical query latency ~seconds

Trade off accuracy for performance

Approximate Nearest Neighbour

- Preprocess data into efficient index
- Speed up search using index

Approximate Nearest Neighbour

- Tree-based algorithm (ANNOY)
- Locality sensitive hashing
- Product Quantization
- Inverted File Index
- **Proximity Graph (Hierarchical Navigable Small World)**

Navigable Small World

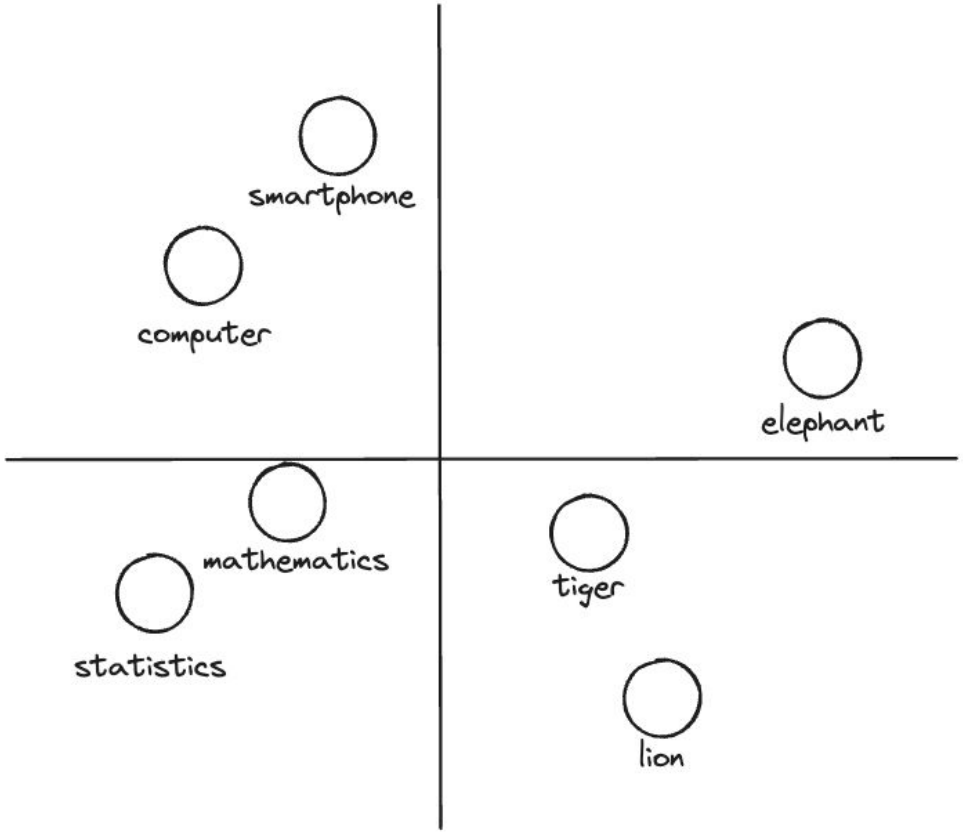
- Six degrees of separation
- Hungarian novelist – Karinthy Frigyes – 1929

- Better communication tech and travel
- Migrations and increasing connectivity
- "Shrinking" modern world

Navigable Small World

- every node can be reached with small number of hops from any other node

- Build a graph
- Every node has M connection to closest nodes (proximity list, “friend list”)
- Random entry node
- Greedy search, move to closest node
- Stop condition, no closer node in friend list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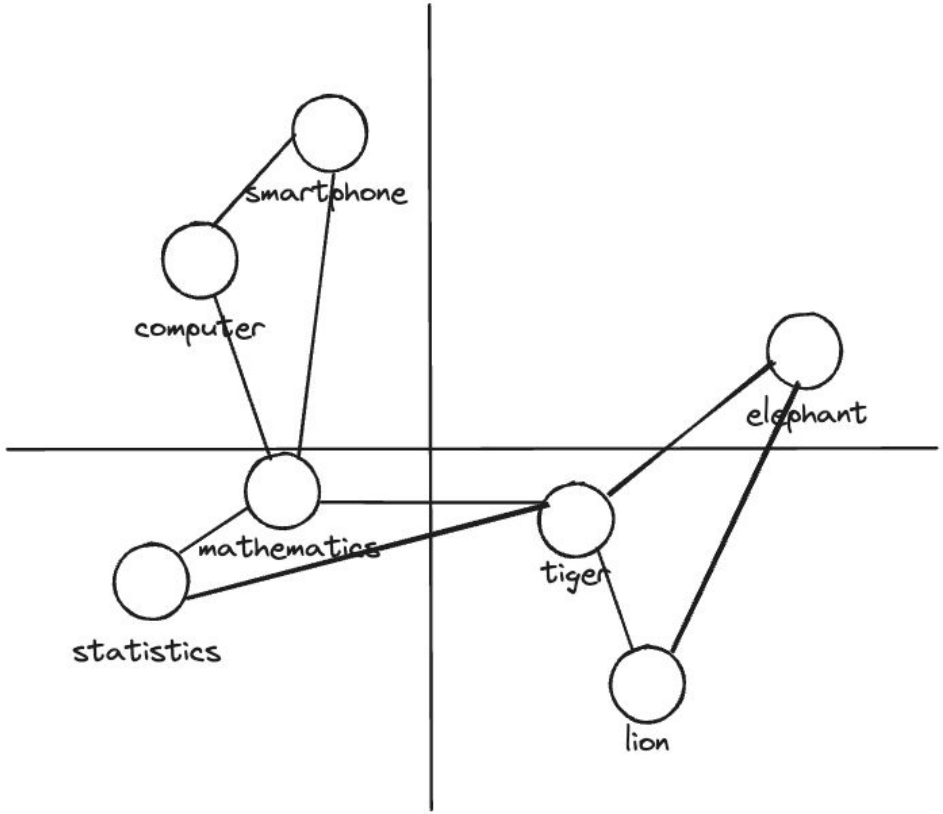
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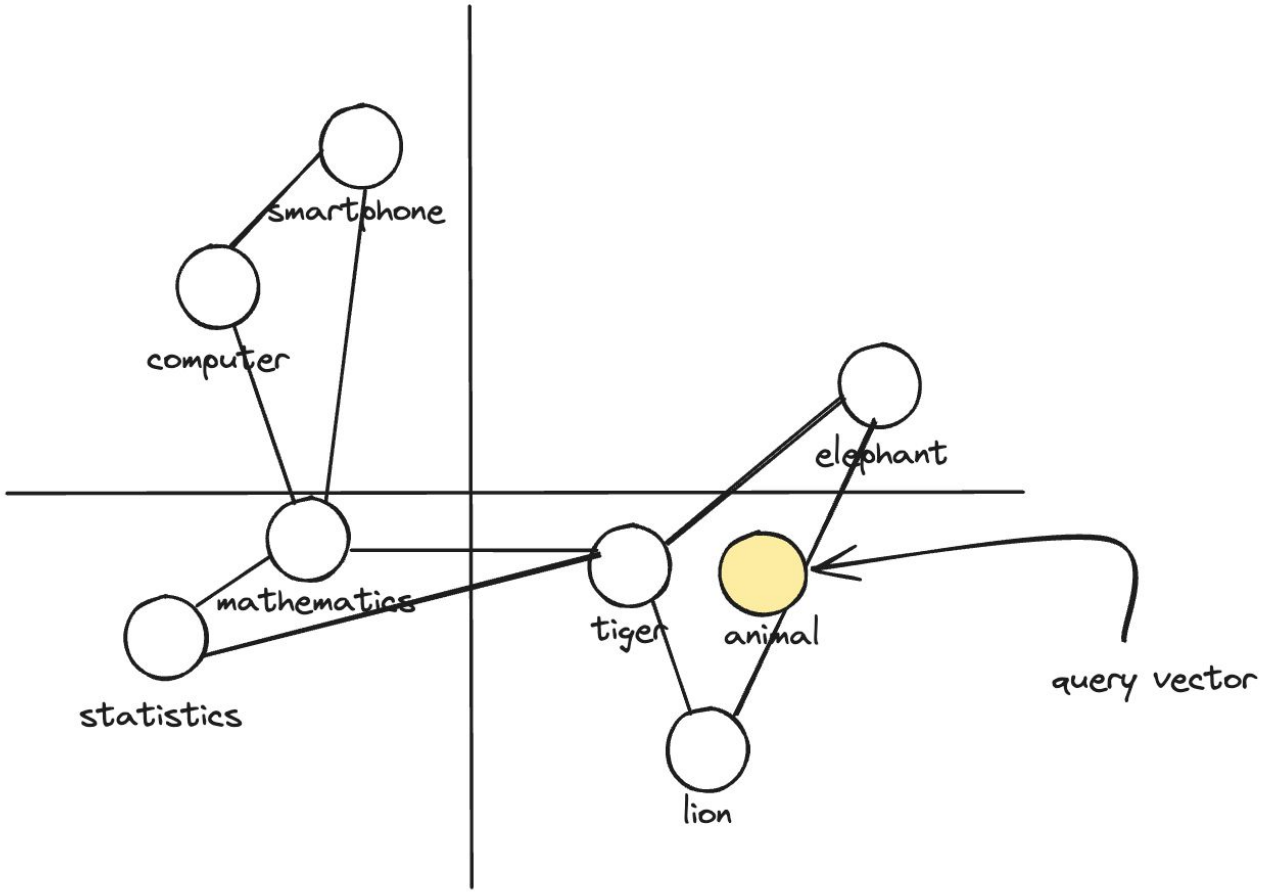
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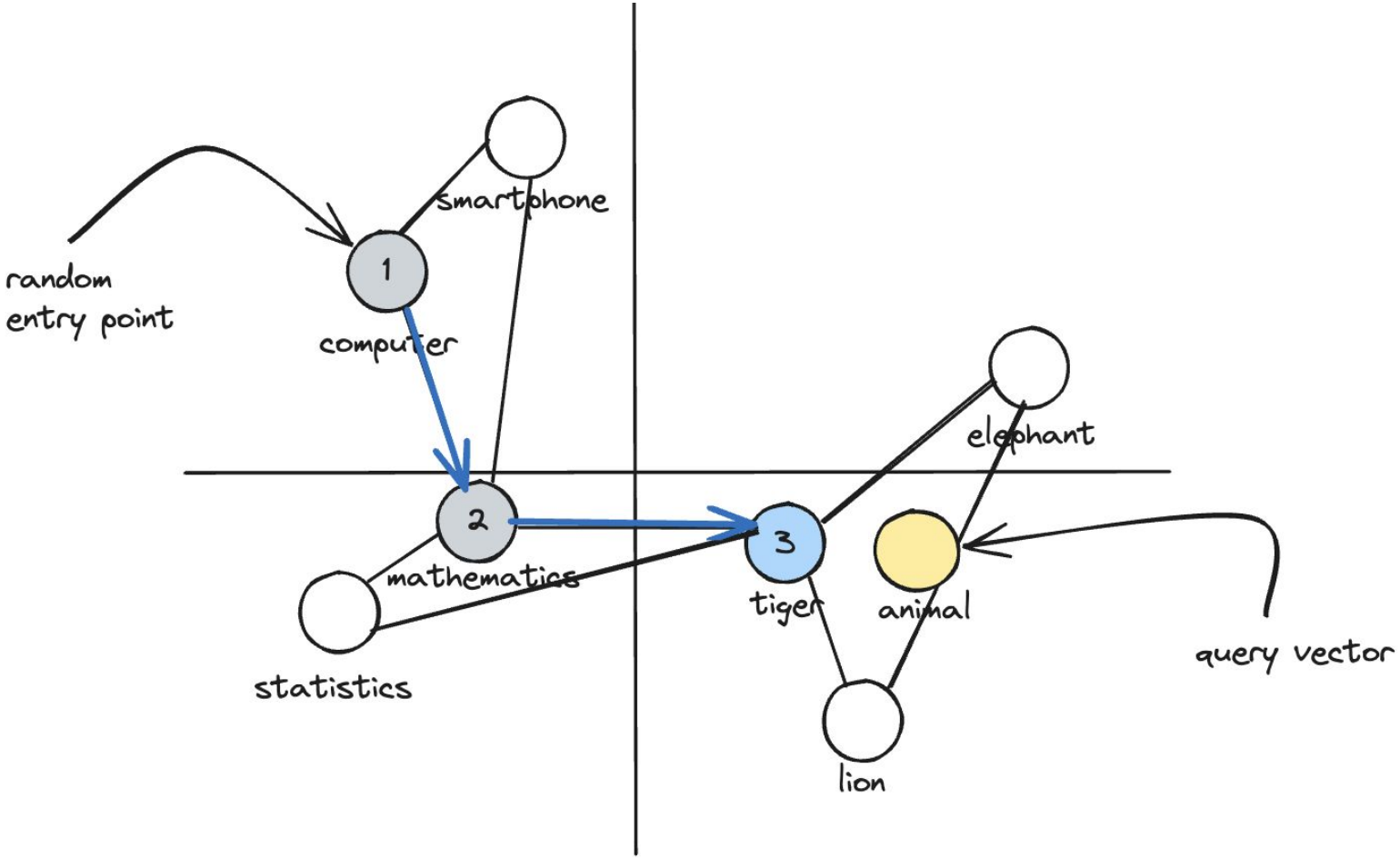
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smartphone
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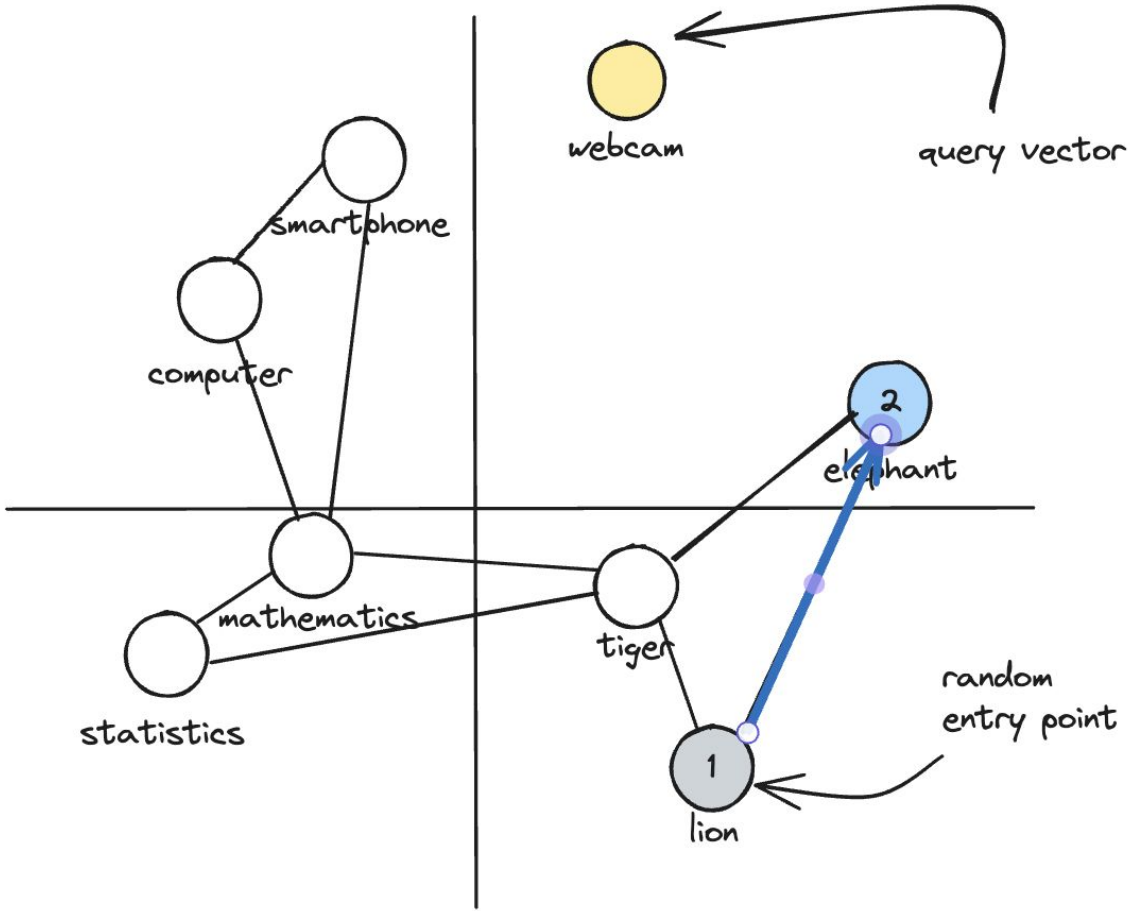
Drawbacks

- Can get stuck in local minimum
- Polylogarithmic complexity, not performant at scale
  - Searches for multiple nodes, multiple times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entry point
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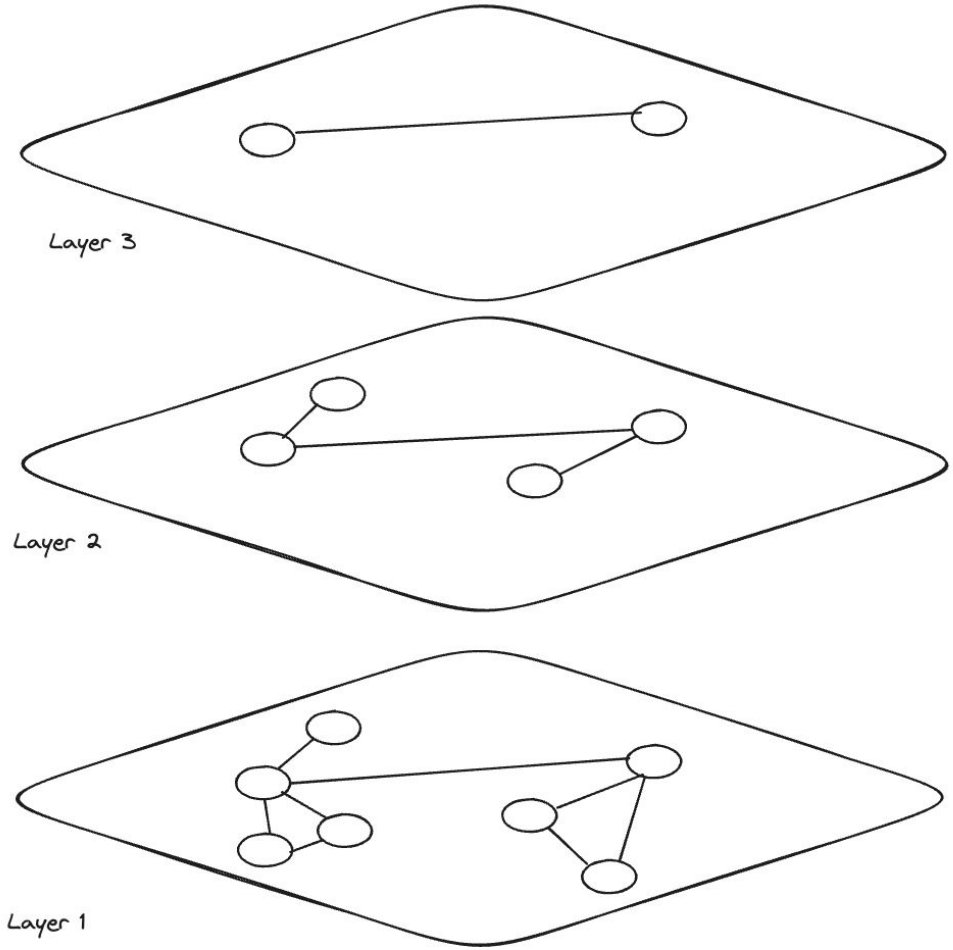
lion

Hierarchical NSW

- Multi-layered graph
  - Base layer has all nodes (dense), more connections
  - Higher layer have fewer nodes (sparse) and fewer connections

- Search starts in top layer descending towards bottom layers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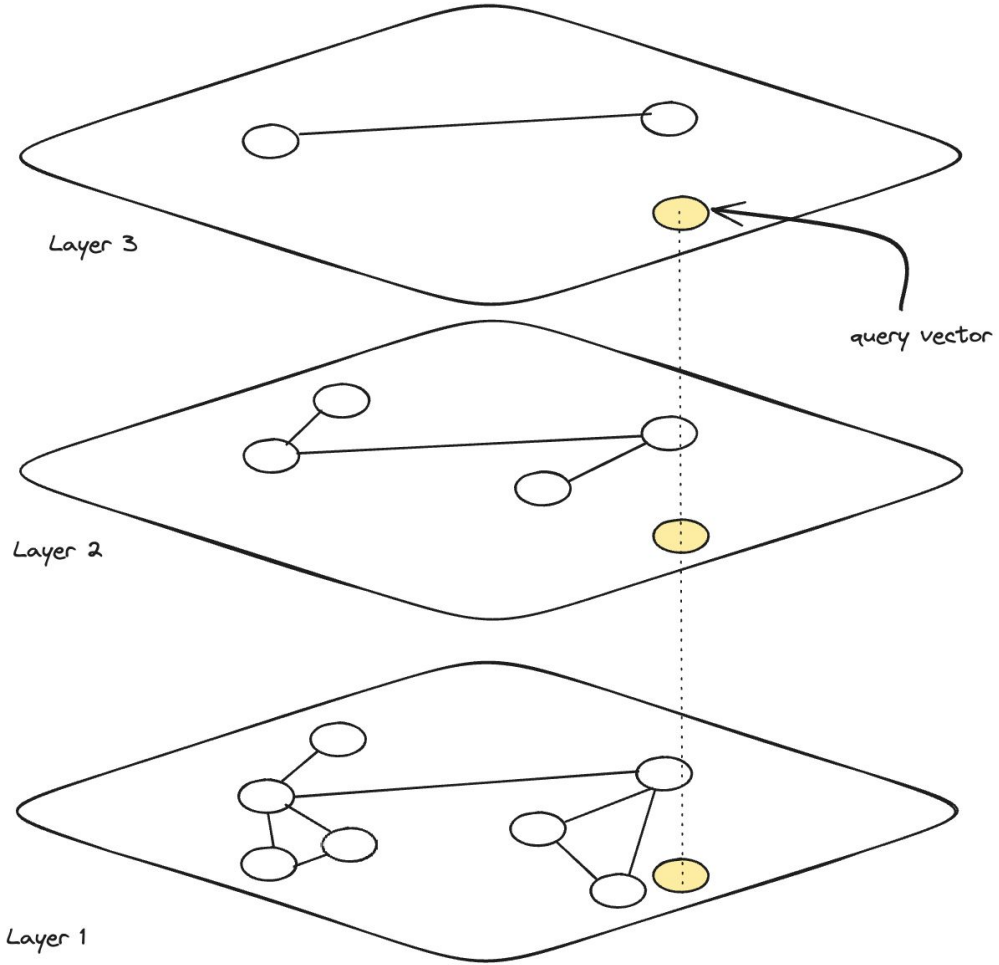
Layer 3
query vector
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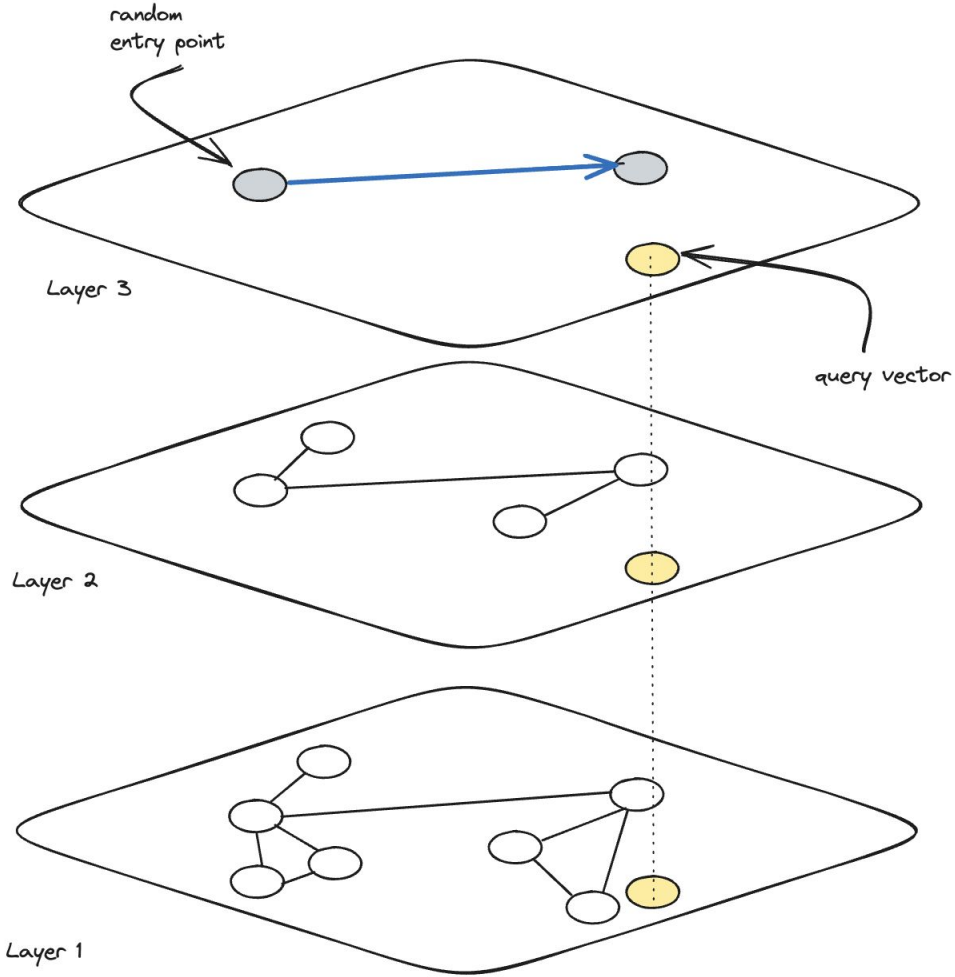
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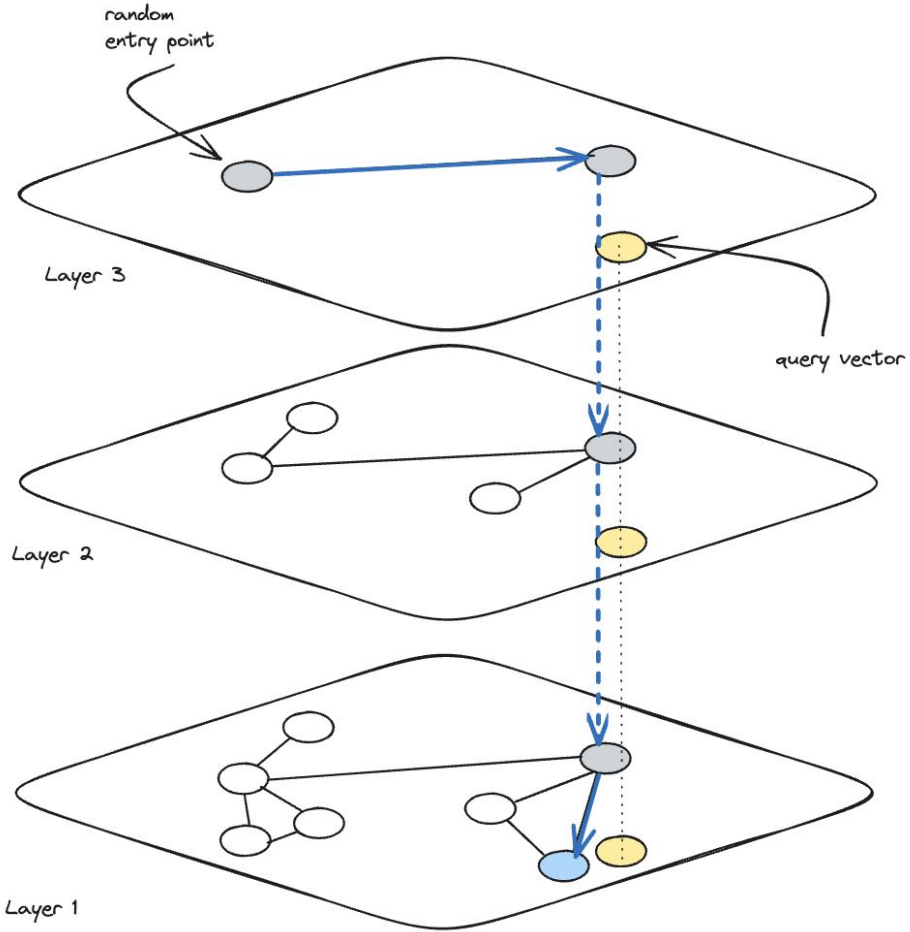
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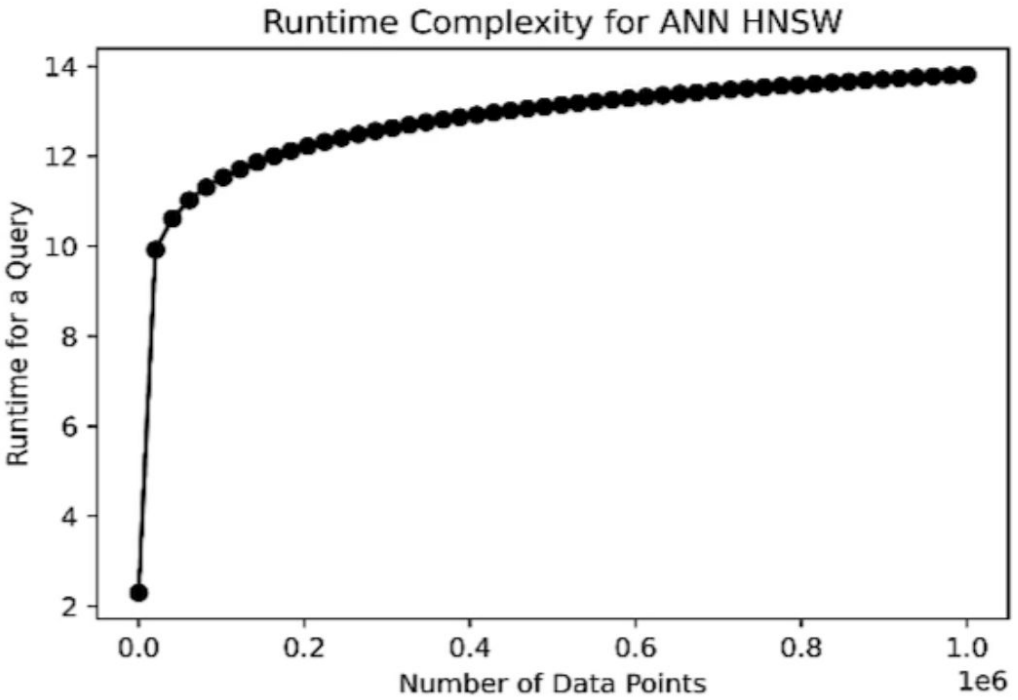
Performance



- Ensures consistent, reliable performance
- Query time increases logarithmically
- Typical query latency ~milliseconds