Theory

Graph

Complex network

Contagion

Small-world

Scale-free

Community structure

Percolation

Evolution

Controllability

Graph drawing

Social capital

Link analysis

Optimization

Reciprocity

Closure

Homophily

Transitivity

Preferential attachment

Balance theory

Network effect

Social influence

Informational (computing)

Telecommunication

Transport

Social

Scientific collaboration

Biological

Artificial neural

Interdependent

Semantic

Spatial

Dependency

Flow

on-Chip

Clique

Component

Cut

Cycle

Data structure

Edge

Loop

Neighborhood

Path

Vertex

Adjacency list / matrix

Incidence list / matrix

Bipartite

Complete

Directed

Hyper

Labeled

Multi

Random

Weighted

Metrics

Algorithms

Centrality

Degree

Motif

Clustering

Degree distribution

Assortativity

Distance

Modularity

Efficiency

Random graph

Erd■s–Rényi

The Hierarchical navigable small world (HNSW) algorithm is a graph -based approximate nearest neighbor search technique used in many vector databases . Nearest neighbor search without an index involves computing the distance from the query to each point in the database, which for large datasets is computationally prohibitive. For high-dimensional data, tree-based exact vector search techniques such as the k-d tree and R-tree do not perform well enough because of the curse of dimensionality . To remedy this, approximate k-nearest neighbor searches have been proposed, such as locality-sensitive hashing (LSH) and product quantization (PQ) that trade performance for accuracy. The HNSW graph offers an approximate k-nearest neighbor search which scales logarithmically even in high-dimensional data.

It is an extension of the earlier work on navigable small world graphs presented at the Similarity Search and Applications (SISAP) conference in 2012 with an additional hierarchical navigation to find entry points to the main graph faster. HNSW-based libraries are among the best performers in the approximate nearest neighbors benchmark.

A related technique is IVFFlat.

Use in vector databases

HNSW is a key method for approximate nearest neighbor search in high-dimensional vector databases , for example in the context of embeddings from neural networks in large language models. Databases that use HNSW as search index include:

SingleStore

Apache Lucene Vector Search

Chroma

Qdrant

Redis

Vespa

Vearch Gamma

Weaviate

pgvector

MariaDB

MongoDB Atlas

ClickHouse

Milvus

DuckDB

Kuzu

Cozo

TiDB

Several of these use either the hnswlib library provided by the original authors, or the FAISS library. libvictor is another high-performance library that implements HNSW and other indexing structures, designed for flexibility and integration in custom vector database solutions.

References

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