

Title: Hierarchical navigable small world

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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
Erdős–Rényi

Barabási–Albert
Bianconi–Barabási
Fitness model
Watts–Strogatz
Exponential random (ERGM)
Random geometric (RGG)
Hyperbolic (HGN)
Hierarchical
Stochastic block
Blockmodeling
Maximum entropy
Soft configuration
LFR Benchmark
Boolean network
agent based
Epidemic / SIR
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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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