Birla Institute of Technology and Science-Pilani, Hyderabad Campus

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# Information Retrieval (CS F469)

# Design Document

# Assignment 2

Locality Sensitive Hashing

Rohith Saranga (2017A7PS0034H)

Kasuba Badri Vishal (2017A7PS0270H)

Rikil Gajarla (2017A7PS0202H)

JSNS Rahul (2017A7PS0262H)

Under the guidance of

Dr. Aruna Malapati

## Abstract:

This project aims to build a plagiarism detection software using a technique called Locality Sensitive Hashing. In this technique, similar items are hashed in to same buckets. Items that end up in the same bucket have high probability of being similar. This algorithm involves three steps.

1. Shingling
2. Minhashing
3. Locality Sensitive Hashing

Any substring of length k is defined as a k-shingle. The text in all documents is used to form k-shingles. Generally a shingle size of around 9 is chosen for research articles. An incidence matrix is built with these shingles and minhashing is applied on it to get a signature matrix. Minhashing compresses the document vectors to give signatures that have lesser number of rows. In the lsh part, this signature matrix is divide into bands with a certain number rows in each band. Each band is hashed into buckets so that similar documents have more probability of ending up in same bucket. Now documents in same bucket can be checked using appropriate similarity metric to find similarity.

## Architecture:

Programming Language: python

Dataset: <https://ir.shef.ac.uk/cloughie/resources/plagiarism_corpus.html>

The dataset is a set of 100 documents of which 95 documents are short answers given by 19 participants to 5 questions related to Computer Science. These answers were copy pasted from given wikipedia articles by the 19 participants. The other 5 documents are original answers.

Some of the libraries used are pandas, numpy, pickle.

Data Structures used are pandas.DataFrame for storing incidence matrix and signature matrix, python list for storing similar files to be returned to the user and python dictionary for buckets.

Modules:

The project has been divided into the following modules.

Folder structure:

└── Locality-Sensitive-Hashing

├── lsh.py

├── main.py

├── minhashing.py

├── shingling.py

└── statistics.py

1. shingling
2. minhashing
3. lsh
4. statistics
5. main

Go to this link for full documentation of all modules and functions used. [docs\\_build\html\index.html](docs/_build/html/index.html)

## Working Description:

Pre-processing:

The shingling module takes the text documents and performs preprocessing like case normalization, removal of \n, \r and other unimportant characters. Then shingles from each document are created and added to the incidence matrix. The incidence matrix is a dataframe with a shape of no of shingles x no of documents. It has 1 when a shingle is present in a document and 0 if not at the a respective position of the dataframe.

Minhashing technique:

h hash random hash functions are generated. Hashes[k] is the kth hash function.

Each hash function has return the value as **(ax+b)%c** where a and b are >0 and c is equal to number of shingles.

Signature matrix of shape (no hash functions x no of documents) is initialized to infinity.

For each shingle (row) in incidence matrix, if a document has 1 in that row then the corresponding column in signature matrix is filled with hash values of the indices only if they are less than the values already present. In this way number of rows is decreased from number of shingles to h(no of hash functions). The reason this is done is because

*The probability that the minhash function for a random permutation of rows produces the same value for two sets equals the Jaccard similarity of those sets.*

Locality Sensitive Hashing:

The signature matrix generated by minhashing is divided into b bands with r rows in each band. If m is the number of hash functions used for signature matrix.

A hash function is used to hash each band. While hashing a particular band, parts of each document are hashed into a set of buckets. For different bands different set of buckets are used. Each bucket list is a dictionary having hash values as the keys and list of document id’s as values. So, documents with exactly same signature in a band end up in the same bucket of that band. These documents are considered as candidate pairs and similarity between them is calculated using an appropriate metric.

## Results: