SIFT Implementation on Hadoop Platform

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Abstract- *Due to advanced camera capturing techniques used in medical domain efficient management and quick diagnosis of massively generated 2D/3D medical data has become challenging tasks for doctors. In this project, we propose an idea for analyzing medical images using Hadoop's MapReduce Framework. HDFS is used for storing feature library of existing medical images and parallelism in indexing; matching and retrieval processes are achieved by MapReduce. The Map function is used to match feature vector of the query image with feature vectors present in feature library, while the Reduce function is used to aggregate and sort results from all the mappers. As a result of parallelism Hadoop based medical image retrieval system will take very less time for image retrieval as compared to the traditional image retrieval systems. We are going to incorporate image analysis using Scale invariant feature transform (SIFT). SIFT matching is done for a number of 3D medical images taken from different angles because it uses depth of an image. It results in the elimination of manual processes of diagnosis and leads to automated detection and diagnosis. Hadoop-based medical image retrieval system can reduce the retrieval time. This model will definitely help doctors in real time decision making and understanding of particular stage of disease. Also real time treatment is suggested after identification of a particular type of disease.*

General Terms- Image processing, Hadoop, MapReduce.

Keywords- Scale Invariant Feature Transform, Difference of Gaussian, and Laplacian operator

I. INTRODUCTION

Now days, Cameras used in medical domain for capturing images are advance. So the diagnosis of these generated 3D images has become challenging for doctors. In medical field it is very important to analyze these images very quick for making decision in Operation Theater. The task of image retrieval and analysis framework is to identify features and providing indexing of data as well. To overcome these challenges in medical domain Mapreduce is used. With this model an application can be implemented as series of Mapreduce operation each consisting of map phase and reduce phase to process large number of 3D data. The emergence of Hadoop provides a new storage, process and analysis solution for the health big data.

Hadoop Distributed File System (HDFS) supports huge mount storage requirement and MapReduce processes the medical big data by parallel computing in cluster. There are several advantages for Hadoop to be used in health information platform. 1) High dynamic scalability without halt. In HDFS, metadata is on a Name Node server and data blocks are distributed stored on Data Node servers. When the system needs to scale, Hadoop would import the new server to cluster automatically and the distributed algorithm of HDFS would move data blocks to the new Data Node In the process, it is unnecessary to halt the system and any manual operation. 2) High reliability by automatic data detection and replication. The data is replicated to multiple copies and distributed to different Data Node servers. The HDFS automatically detects the data consistency when reading and writing and maintains the numbers of the copies on a specified level. 3) High throughput by eliminating the access bottleneck. Each data block is distributed to several Data Node servers on different racks. HDFS would compute the nearest and the least accessed server to provide user access, so the throughput is faster than traditional storage solution. 4) Low cost of storage and high performance distributed computing. HDFS may consist of hundreds or thousands of low-cost commodity devices, on which MapReduce implements parallel distributed computing by simple APIs.

Scale Invariant feature transform is an image descriptor for image based matching and recognition developed by David Lowe (1999, 2004). The SIFT descriptor is invariant to translations, scaling and rotations in image domain and robust to moderate perspective transformations and illumination variations. SIFT descriptor comprised method for detecting interest points from grey level image at which statistics of local gradient directions of image intensities were accumulated to give summarized description of local image. Later, SIFT descriptor has also been applied at dense grids which have been shown to lead to better performance for tasks such as object categorization, texture classification, image alignment and biometrics. The SIFT descriptor has also been extended from grey level to color image and from 2D spatial images to 3D spatio temporal video.

In this paper, we design a 3D medical image storage and retrieval system based on Hadoop, to efficiently store, organize and retrieve the 3D medical images, which can be helpful for doctors in real time decision making and understanding of particular stage of disease. Also real time treatment is suggested after identification of a particular type of disease. We are incorporating SIFT method for image analysis and matching images taken from different angles because it uses depth of 3D image.

The paper is organized a follows. Section II introduces the related work on Hadoop, MapReduce, and Image retrieval. In section III, we present the retrieval of 3D object with multiple views, overall architecture of the system and The design and implementation of SIFT is detailed in Section IV. At last, we summarize our present work and propose the future work.

II. Related Work

Content based image retrieval has become very active research area from since 90's. Many different image retrieval systems which may be for research purpose of may be for commercial purpose has been built.
Most of image retrieval systems support one or more of following parameters:-

1. Random Browsing
2. Search by example
3. Search by text
4. Navigation with customized image categories

Image searching is a specialized form of data searching which is used to find images. For searching of images in database user may provide query terms such as keyword, image file, or click on some image and system will return type of images to the inputted query. The similarities used for search criteria could be Meta tags, color distribution in images, region/shape attribute.

Hadoop is open source software framework for distributed storage and distributed processing of large data sets on computer clusters built from commodity hardware. Hadoop consist of storage part called as HDFS (Hadoop Distributed file System) and processing part known as Mapreduce.

Developer	: Apache software foundation
Initial release	: December 10th, 2011
Stable release	: 2.7.3/ 25th August, 2016
Written in	: Java
OS	: Cross platform

Hadoop includes some modules like Hadoop common which contains libraries needed by other Hadoop modules, YARN is a resource management platform, HDFS, and MapReduce.

HDFS is a master/slave architecture designed to run on commodity hardware. Each HDFS cluster has a single Name Node master, which manages the file system namespace and regulates access to files by customers. In addition, there are a number of Data Nodes, usually one per node in the cluster, which manage storage attached to the nodes on which they run. The Data Nodes are arranged in racks for replication purposes. Customers communicate with the Name Node, which coordinates the services from the Data Nodes.

MapReduce is an increasingly popular distributed programming paradigm used in cloud computing environments. It expedites the processing of large datasets using inexpensive cluster computers. Additional advantages include load balancing and fault tolerance. In Hadoop, the unit of computation is called a job. Customers submit jobs to Hadoop JobTracker component. Each job has two phases: Map and Reduce. The Map phase maps input key-value pairs to a set of intermediate key-value pairs. The Reduce phase reduces the set of intermediate key-value pairs that share a key to a smaller set of key-value pairs traversable by an iterator. When a job is submitted to the JobTracker, Hadoop attempts to place the Map processes near to the input data in the cluster to reduce the communication cost. Each Map process and Reduce process works independently without communication.

III. Overall Architecture

As shown in diagram user gives input image to the system. Given query image is given to Hadoop master. Master node will generate a MapReduce task to match/compare features of 3D images. After this a new MapReduce task will be generated by master to match feature vector of query image with feature vectors in feature library stored at HDFS. The result of previous MapReduce task will be given to the second MapReduce task which will retrieve required images.

For processing of 3D image data we are considering Scale Invariant Feature Transformation algorithm.

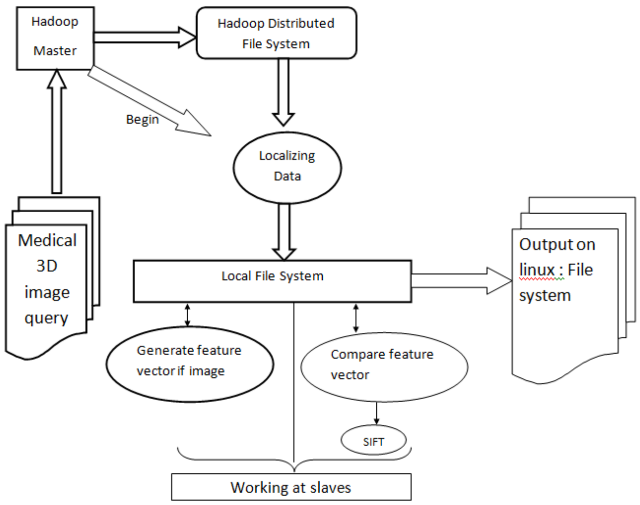

Figure 1. Overall Architecture

Retrieving of 3D object with multiple views

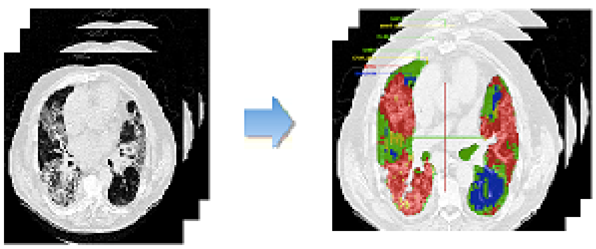

Figure 2. Image of brain tumor consisting of one or more views

We can define the view-based 3D object retrieval task as follows: Each object consists of one or more views as shown in figure 1.4, and given one query object, the objective is to find all relevant and/or similar objects from the 3D object database under the view-based representation.

Following are the steps for 3D image processing:-

1. View capture: - Views are the fundamental elements for view-based 3D object analysis. Most existing methods use a camera array that consists of a group of cameras capturing views from different directions.
2. Representative view selection: - Although a large number of views can provide rich information, they also introduce redundant and noisy data and result in high computational costs.
3. Feature extraction: - It is still difficult to extract features for multiple views because of the special characteristics of 3D data. The spatial correlation among different views should be taken into consideration, which still requires further investigation.
4. Object matching using multiple views :- Most of the existing image retrieval tasks are based on one-to-one image matching. View based 3D object retrieval, however, focuses on multiple view matching. Thus, it is challenging to determine how best to conduct many-to-many view matching and estimate the relevance among different 3D objects.

Detailed Explanation of steps in SIFT

SIFT is one of the most commonly used local features of image analysis, using gradient orientation histograms to model shape. This method of extracting the SIFT features is divided into two main parts: i) the detection of the interest points in different scales and ii) the description of the neighborhoods of these points in the appropriate scale. Key stages in SIFT are

1. Scale-invariant feature detection
2. Feature matching and indexing
3. Cluster identification by Hough transform voting
4. Model verification by linear least squares
5. Outlier detection
6. Competing methods for scale invariant object recognition under clutter / partial occlusion.

1. Scale-invariant feature detection:

Lowe's method for image feature generation transforms an image into a large collection of feature vectors, each of which is invariant to image translation, scaling, and rotation, partially invariant to illumination changes and robust to local geometric distortion. These features share similar properties with neurons in inferior temporal cortex that are used for object recognition in primate vision. Key locations are defined as maxima and minima of the result of difference of Gaussians function applied in scale space to a series of smoothed and resampled images. Low contrast candidate points and edge response points along an edge are discarded.

2. Feature matching and indexing:

The best candidate match for each keypoint is found by identifying its nearest neighbor in the database of keypoints from training images. The nearest neighbors are defined as the keypoints with minimum Euclidean distance from the given descriptor vector.

3. Cluster identification by Hough transform voting:

Hough Transform is used to cluster reliable model hypotheses to search for keys that agree upon a particular model pose. Hough transform identifies clusters of features with a consistent interpretation by using each feature to vote for all object poses that are consistent with the feature. When clusters of features are found to vote for the same pose of an object, the probability of the interpretation being correct is much higher than for any single feature.

Each of the SIFT keypoints specifies 2D location, scale, and orientation, and each matched keypoint in the database has a record of its parameters relative to the training image in which it was found. The similarity transform implied by these 4 parameters is only an approximation to the full 6 degree-of-freedom pose space for a 3D object and also does not account for any non-rigid deformations.

4. Model verification by linear least squares:

The affine transformation of a model point [x y] T to an image point [u, v] T can be written as below

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} m1 & m2 \\ m3 & m4 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} tx \\ ty \end{bmatrix}$$

Where the model translation is [tx, ty]T and the affine rotation, scale, and stretch are rep-resented by the parameters m1, m2, m3 and m4. To solve for the transformation parameters

The equation above can be rewritten to gather the unknowns into a column vector.

$$\begin{bmatrix} x & y & 0 & 0 & 1 & 0 \\ 0 & 0 & x & y & 0 & 1 \\ \ldots. & & & & & \\ \ldots. & & & & & \end{bmatrix} \begin{bmatrix} m1 \\ m2 \\ m3 \\ m4 \\ tx \\ ty \end{bmatrix} = \begin{bmatrix} u \\ v \\ . \\ . \end{bmatrix}$$

This equation shows a single match, but any number of further matches can be added, with each match contributing two more rows to the first and last matrix. At least 3 matches are needed to provide a solution. Where A is a known m-by-n matrix (usually with m ¿ n), x is an unknown n-dimensional parameter vector, and b is a known m-dimensional measurement vector. Therefore the minimizing vector is a solution of the normal equation.

5. Outlier detection:

Outliers can now be removed by checking for agreement between each image feature and the model, given the parameter solution. Given the linear least squares solution, each match is required to agree within half the error range that was used for the parameters in the Hough transform bins. As outliers are discarded, the linear least squares solution is re-solved with the remaining points, and the process iterated. If fewer than 3 points remain after discarding outliers, then the match is rejected. In addition, a top-down matching phase is used to add any further matches that agree with the projected model position, which may have been missed from the Hough transform bin due to the similarity transform approximation or other errors.

SIFT algorithm:

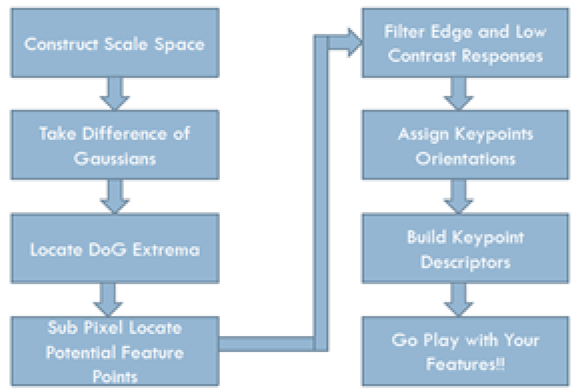

Figure 3.

Algorithm for proposed system:

1. For the set of databases images:
    a. Compute SIFT features
    b. Save descriptors to databases
2. For query image:
    a. Compute SIFT features
    b. For each descriptor find a match
        i. Verify matches using geometry and Hough transform
3. Give Output of related images.

Advantages of using SIFT

1. 1Built on strong foundations:
    – First principles (LoG and DoG)
    – Biological vision (Descriptor)
    – Empirical results
2. Many heuristic optimizations
    – –Rejection of bad points
    – Sub-pixel level fitting
    – Thresholds carefully chosen.

Cases where SIFT don’t work

1. Large illumination change
2. Non rigid deformations

VI. CONCLUSION

In this report, we have described the "SIFT Implementation on Hadoop Platform". The analysis of Big Data, Hadoop, MapReduce, and JAVA is done and based on these; the application building program has been initiated. A dedicated server operated by master node is implemented to accept query image from the user and three slave nodes to do parallel processing of the image. When user uploads the image to system, Master node will accept image and create a job. After creating the job, the slave will accept the job and will process the query. Overall the system will process the query image and will return related images. The system when implemented will be very beneficial for diagnosis at the Hospital.

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