Birch: An efficient data clustering method for very large databases

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Discussion: April

Outline

- What is data clustering
- Data clustering applications
- Previous Approaches
- Birch's Goal
- Clustering Feature
- Birch clustering algorithm
- Clustering example

What is Data Clustering?

A cluster is a closely-packed group.

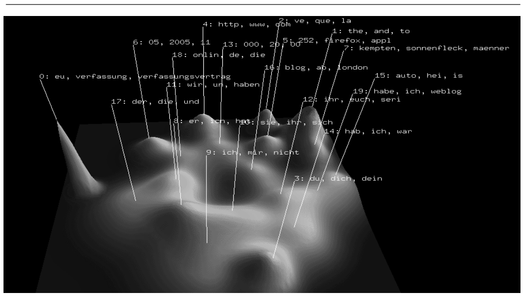
A collection of data objects that are similar to one another and treated collectively as a group.

Data Clustering is the partitioning of a dataset into clusters

Why Clustering?

- Helps understand the natural grouping or structure in a dataset
- Large set of multidimensional data
- Data space is usually not uniformly occupied
- Identify the sparse and crowded places
- Helps visualization

Example



Data Clustering – previous approaches

- Probability based (Machine learning): make wrong assumption that distributions on attributes are independent on each other
- Probability representations of clusters is expensive
- Distance based approach assumes DB scanning is not costly

Requirements for large datasets

- Not more than one scan of the database
- Should be online
- Should be suspendable, stoppable, resumable
- Can work with limited memory

Birch's goals:

- Minimize running time and data scans, thus formulating the problem for large databases
- Clustering decisions made without scanning the whole data
- Exploit the non uniformity of data – treat dense areas as one, and remove outliers (noise)

Discussion #1

- In what applications could you see data clustering being useful? In which of these applications can you imagine that it would be important that a clustering be found in a certain # of seconds? Minutes? Hours?
- Do you think the authors made the right choice in focusing their design on minimizing I/O? Why or why not? If not, do you think that some either criteria, such as efficiency, stability or immunity to abnormal data, might be a more appropriate criteria for determining if a data mining algorithm (such as BIRCH or APRIORI) is "good?"

Clustering Feature (CF)

- CF is a compact storage for data on points in a cluster
- Has enough information to calculate the intra-cluster distances
- Additivity theorem allows us to merge sub-clusters

Clustering Feature (CF)

Given N d-dimensional data points in a cluster: {X*i*} where i = 1, 2, …, N,

$CF = (N, LS, SS)$

N is the number of data points in the cluster,

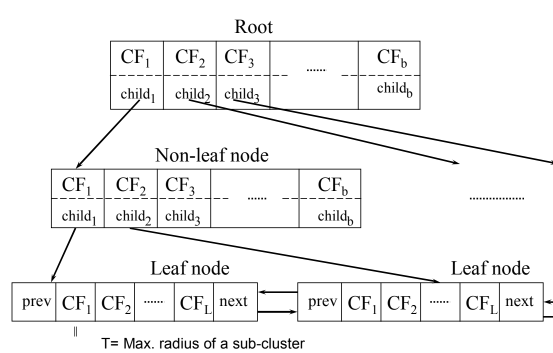
LS is the linear sum of the N data points,

SS is the square sum of the N data points.

CF Tree

B = Max. no. of CF in a non-leaf node

L = Max. no. of CF in a leaf node



CF TREE

- T is the threshold for the diameter or radius of the leaf nodes
- The tree size is a function of T. The bigger T is, the smaller the tree will be.
- The CF tree is built dynamically as data is scanned.

CF Tree Insertion

- Identifying the appropriate leaf: recursively descending the CF tree and choosing the closest child node according to a chosen distance metric
- Modifying the leaf: test whether the leaf can absorb the node without violating the threshold. If there is no room, split the node
- Modifying the path: update CF information up the path.

Birch Clustering Algorithm

- Phase 1: Scan all data and build an initial in-memory CF tree.
- Phase 2: condense into desirable length by building a smaller CF tree.
- Phase 3: Global clustering
- Phase 4: Cluster refining – this is optional, and requires more passes over the data to refine the results

Birch – Phase 1

- Start with initial threshold and insert points into the tree
- If run out of memory, increase threshold value, and rebuild a smaller tree by reinserting values from older tree and then other values
- Good initial threshold is important but hard to figure out
- Outlier removal – when rebuilding tree remove outliers

Birch - Phase 2

- Optional
- Phase 3 sometime have minimum size which performs well, so phase 2 prepares the tree for phase 3.
- Removes outliers, and grouping clusters.

Birch – Phase 3

- Problems after phase 1:
  - Input order affects results
  - Splitting triggered by node size
- Phase 3:
  - cluster all leaf nodes on the CF values according to an existing algorithm
  - Algorithm used here: agglomerative hierarchical clustering

Birch – Phase 4

- Optional
- Additional scan/s of the dataset, attaching each item to the centroids found.
- Recalculating the centroids and redistributing the items.
- Always converges

Clustering example

Pixel classification in images
From top to bottom:
- *BIRCH classification*
- *Visible wavelength band*
- *Near-infrared band*

Conclusions

- Birch performs faster than then existing algorithms on large datasets
- Scans whole data only once
- Handles outliers

So far so good

- The CF tree has to reside in the memory
- Performs poorly when clusters don't take shape of a circle
- Can handle only numeric data
- Sensitive to the order of data records

Discussion #2

- The BIRCH algorithm requires the user to specify a number of parameters (e.g., the page size, the initial threshold for cluster radius, a definition of outliers, etc).
  - Is it reasonable to expect users to specify and tune these parameters?
  - Is it possible for these decisions to be incorporated into the algorithm itself (i.e., automate parameter specification and tuning)?
  - And, would this be desirable?

Discussion #3 (time permitting)

- Both the BIRCH and APRIORI papers used synthetic data, instead of actual data, to evaluate their algorithms. Many members of the class expressed concern over this choice.
  - Why do you think the authors chose to use synthetic data?
  - Do you think that the results of their analysis would change if actual data was used instead?