Summarizing A 3 Way Relational Data Stream

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Plan

- Problem Presentation
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  - Problematic
- Useful Tools
  - CluStream
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- Method Presentation
  - Entity Summary
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Problem Presentation

- Motivation
- Context
- Problematic
- Goal

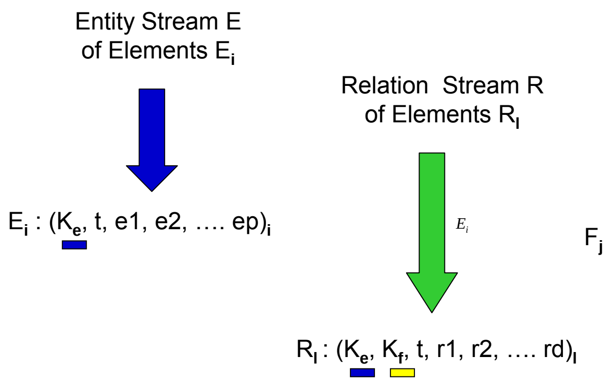
Motivations

- Data Stream processing is an ever growing preoccupation.
- For both DSMS and stream mining applications, summaries are a necessity.
- Most information is by nature, relational.

Context

- Data stream summaries generate a lot of interest.
- Static tables as well as data stream join evaluation are a popular subject as well.
- Single stream mining and single table mining are the norm.
- Relational stream mining is not a very active research area.

Problematic



- Additional Constraints :
  - All Streams are insert only.
  - R speed <<< E and F speeds.
  - All attributes are numerical.
  - References are not broken.

Goal

- Summarizing three data streams sharing a relational link with one another.
- Building separate summaries for each entity stream, and for the relation stream.
- Summarizing the information contained in the relational links between the streams.

Useful Tools

- CluStream
  - Cluster Feature Vector (CFV)
  - SnapShot System
- Bloom Filters

Cluster Feature Vector (CFV)

(BIRCH, Zhang 1996) (Aggarwal 2003)

- Structure :

  $(n, CF_1(t), CF_2(t), CF_1(a1), CF_2(a1), \ldots, CF_1(ad), CF_2(ad))$.

- With
  - $CF_1(ak) = \Sigma(i, 1, n)\ (ak_i)$
  - $CF_2(ak) = \Sigma(i, 1, n)\ (ak_i)^2$
- Remark
  - Time has the same role as any other variable.

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SnapShot System

- The state of the system is saved at regular time intervals
- The data structure is chosen in order to allow arithmetic operation between snapshots.
- The time at which snapshots are taken is chosen in accordance to the user's needs.

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Snapshot System : Distribution example : 2°

Order o	Snapshots	Step
0	69 67 65	2^1
1	70 66 62	2^2
2	68 60 52	2^3
3	56 40 24	2^4
4	48 16	2^5
5	64 32	2^6

CluStream : Data Stream Clustering Algorithm (Aggarwal 2003)

- Algorithm based on three principles :
  - Dividing processing in two parts, an on-line part and an off-line part.
  - Creating and maintaining a large population of micro clusters.
  - Storing the state of those micro clusters with a snapshot system..

CluStream (1/4) (on-line part)

- Initialization
  - Off-line initialization of the micro clusters.
- For each element
  - Locate the closest micro cluster.
  - Admission test
    - If admitted, update CFV.
    - Otherwise, create a new micro cluster, and remove an outdated one.

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CluStream (2/4) (on-line part)

- Micro cluster removal
  - Remove an old micro cluster.
    (criteria based on the arrival date of the last elements)
  - If none is available, fuse the two closest micro cluster.
    (Update the idlist of the absorbing micro cluster)

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CluStream (3/4) (partie en ligne)

- Storage
  - Snapshot system with a distribution in 2°
  - Each snapshot contains
    - The CFV of each micro cluster.
    - The id list of each micro cluster.

CluStream (4/4) (off-line part)

- Use the snapshot to rebuild the stream part to be analyzed. (as a set of micro clusters)
- Apply a classic classification algorithm to the resulting set of micro clusters.
- The resulting clusters represent the final clustering of the stream.

Bloom Filters (Bloom 1970) (1/2)

- Idea :
  Can remember whether or not it has previously seen any number of elements.

- Supports two operations :
  - Learn a new element.
  - Test if an element has been previously learned or not.

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Bloom Filters (Bloom 1970) (1/2)

- Structure :
  - A bloom filter is a simple binary word B of b bytes.
  - At initialization, all the bytes are set to 0.
- Learn a new element E :
  - Hash E to a b bytes word W_E.
  - Set all the bytes at 1 in W_E to 1 in B.
- Test a new element N :
  - Hash N to a b bytes word W_N
  - If **all** the bytes at 1 in W_N are at 1 in B, then, with high probability, N was previously learned.
  - Otherwise, N was never learned before.
- Remark :
  - Bloom filters are additive.

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Method Presentation

- System Overview
- Entity Summary
- Relation Summary
- Storage System

System Overview

Entity Stream E

Entity Summary Structure :

- N_e Micro Clusters
- N_e Bloom Filters

Relation Stream R

Relation Summary Structure :

CFV Cross Table

N_e x N_f CFV Cross Table

Entity Stream F

Entity Summary Structure :

- N_f Micro Clusters
- N_f Bloom Filters

Entity Summary

- Upon the arrival of each new element E_i (K_e, t, e1, e2, …. ep)$_i$:
  - Find the closest micro cluster.
  - Test for admission
    - If admitted :
      - Update the micro cluster CFV information.
      - Learn K_e with the bloom filter attached to the micro cluster.
    - If not admitted :
      - Create a new micro cluster with E_i as its seed.
      - Make room for it by fusing the two closest micro clusters. (this implies adding their two Bloom filters as well)

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Relation Summary

- Upon the arrival of each new element R_l (K_e, K_f, t, r1, r2, …. rd)$_l$:
  - Check all the Bloom filters for E to locate the one containing K_e. Mark its associated micro cluster C_i.
  - Check all the Bloom filters for F to locate the one containing K_f. Mark its associated micro cluster C_j.
  - If the couple (i,j) is unique, add the element R_l to the CFV of indices (i,j) in the CFV cross table if the couple .

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Storage Management

- The storage system used is the same one as the one described in CluStream.
- All three streams are considered to share the same system clock.
- The information saved in each snapshot is :
  - For each entity :
    - The CFV and IdList of each micro cluster.
  - For the relation :
    - All the CFV matrix.

Work in Progress

- A Prototype of the algorithm already exists.
- Algorithm Testing :
  - Exploring suitable real datasets :
    - Telecommunication (services/usage/client)
    - Peer 2 Peer (documents/requests/users)
    - Airline Companies (flight/reservations/passengers)
  - Constructing an artificial dataset :
    - What kind of distribution should be used (Zipf?)
    - What kind of clusters, and what evolution for them.
  - Finding an appropriate evaluation criteria and evaluation scheme.

Conclusions and Perspectives

- This work is still in progress despite a working prototype.
- Perspectives include :
  - Extensive evaluation with real and artificial data.
  - Studying the summary querying mechanisms.
  - Extending the method to more complex data schemes (star first, then any relational type).
  - Adapting the method to deal with deletions in the streams processed.

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