Text Classification Combining Clustering and Hierarchical Approaches

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Presentation Outline

- Search Engines Today
- Contributions
- Related Work
- Text Classification – Our Approach
- Experiments and Evaluation
- Conclusions
- Future Work

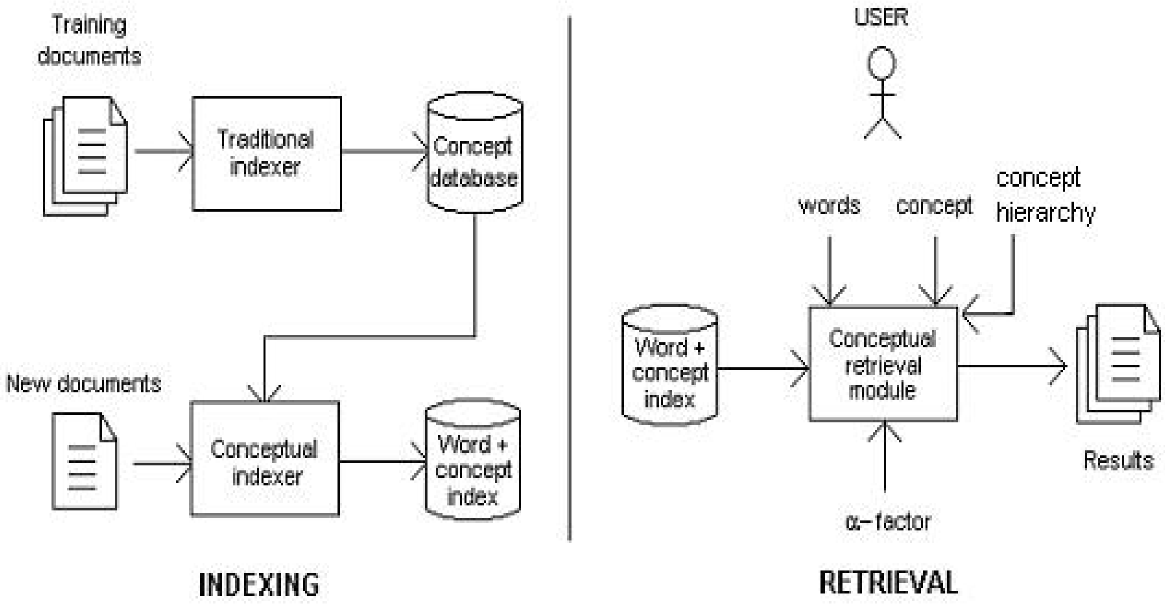
Search Engines Today

Return results based on simple key-word matches.

No regard for conceptual information.

For E.g. : If the query is “SALSA”, Is it……

KeyConcept Architecture



Contributions

- Novel approach to Text Classification by combining clustering within the concepts with hierarchical text classification
- Effect of clustering on flat classification versus hierarchical classification
- Effect of ignoring versus using concept wise distinction lower down the hierarchies

Related Work I

- **Text Classification**
  - Yang, Sebastiani: Comparison of Text classification methods - K-Nearest Neighbors, linear least square fit, Naïve Bayesian, Support Vector Machines, Decision trees
  - **Hierarchical Classification**: Proposed by Koller. Further work by – Sun, Labrou, Sasaki, Dumais, Wang

Related Work II

- Chaffee, YAHOO, Open Directory Project : **Ontology**
- Manning, Dubes, Kaufman – **Document clustering**

  Agglomerative (Guha, Karypis) vs. Divisive (Zhao)

  Lots of packages available on net – Cluto, Chameleon, Rock, Cure, DocCluster, Siftware etc.,
- Perkowitz – **Cluster Mining**

Text Classification

- Two Step Process : Training the classifier and Classification of new documents
- Training Phase:
  - Classifier is fed with documents that have been classified manually
  - Learns about the features (vocabulary) of the various categories into which new documents can be classified

Text Classification contd…

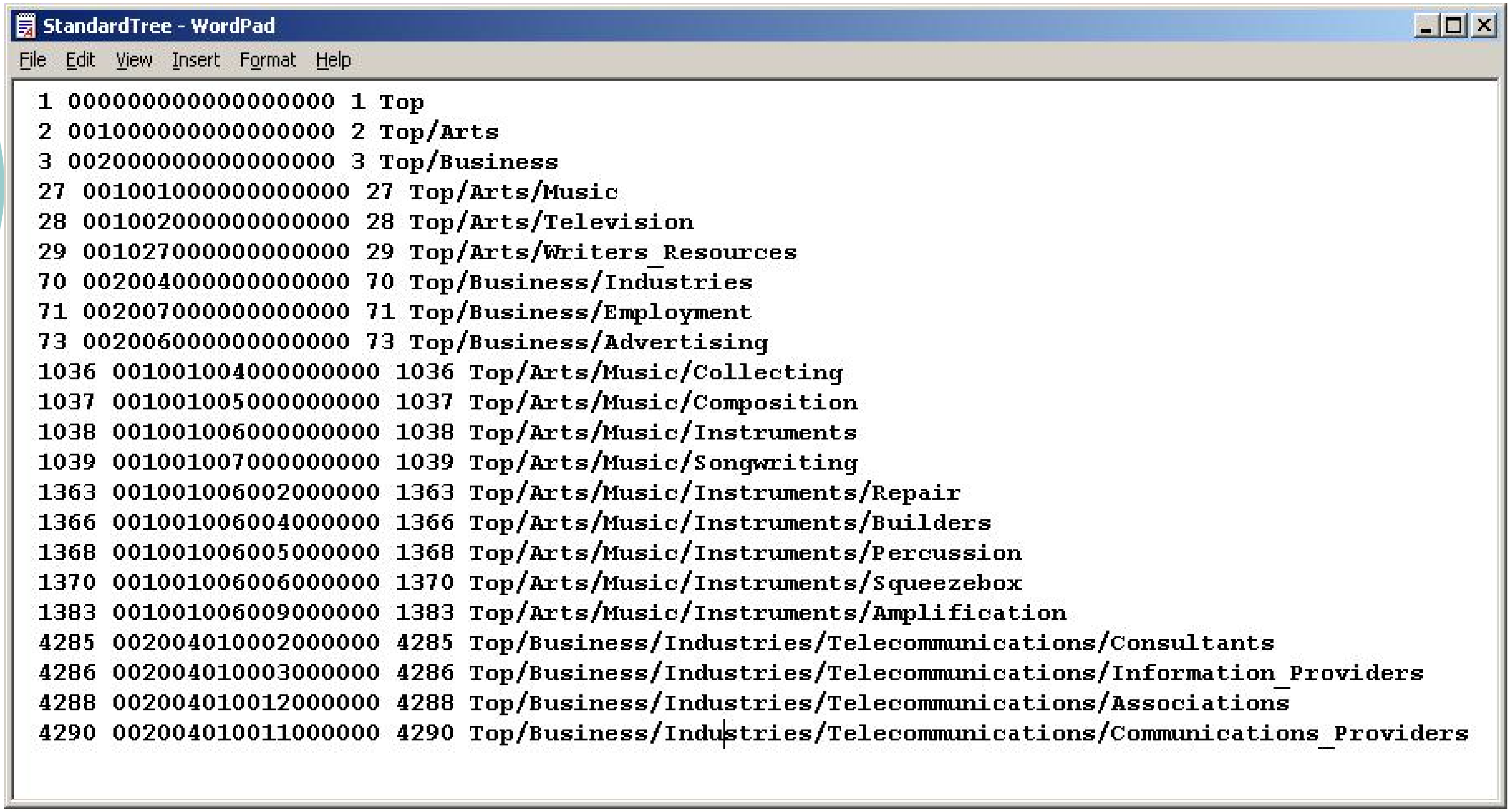
- Classification Phase:

  Classifier assigns category (ies) to new documents based on the similarity of the features of input document and of the categories that it learned during training

Text Classification – Our Approach

- Vector Space model (tf-idf)
- Training data are documents that are manually assigned to the categories Open Directory Project’s Standard Tree which is our reference Ontology
- Classifier creates a vector of vocabulary terms and associated weights in an inverted file

Standard Tree



```
1 000000000000000000 1 Top
2 001000000000000000 2 Top/Arts
3 002000000000000000 3 Top/Business
27 001001000000000000 27 Top/Arts/Music
28 001002000000000000 28 Top/Arts/Television
29 001027000000000000 29 Top/Arts/Writers_Resources
70 002004000000000000 70 Top/Business/Industries
71 002007000000000000 71 Top/Business/Employment
73 002006000000000000 73 Top/Business/Advertising
1036 001001004000000000 1036 Top/Arts/Music/Collecting
1037 001001005000000000 1037 Top/Arts/Music/Composition
1038 001001006000000000 1038 Top/Arts/Music/Instruments
1039 001001007000000000 1039 Top/Arts/Music/Songwriting
1363 001001006002000000 1363 Top/Arts/Music/Instruments/Repair
1366 001001006004000000 1366 Top/Arts/Music/Instruments/Builders
1368 001001006005000000 1368 Top/Arts/Music/Instruments/Percussion
1370 001001006006000000 1370 Top/Arts/Music/Instruments/Squeezebox
1383 001001006009000000 1383 Top/Arts/Music/Instruments/Amplification
4285 002004010002000000 4285 Top/Business/Industries/Telecommunications/Consultants
4286 002004010003000000 4286 Top/Business/Industries/Telecommunications/Information_Providers
4288 002004010012000000 4288 Top/Business/Industries/Telecommunications/Associations
4290 002004010011000000 4290 Top/Business/Industries/Telecommunications/Communications_Providers
```

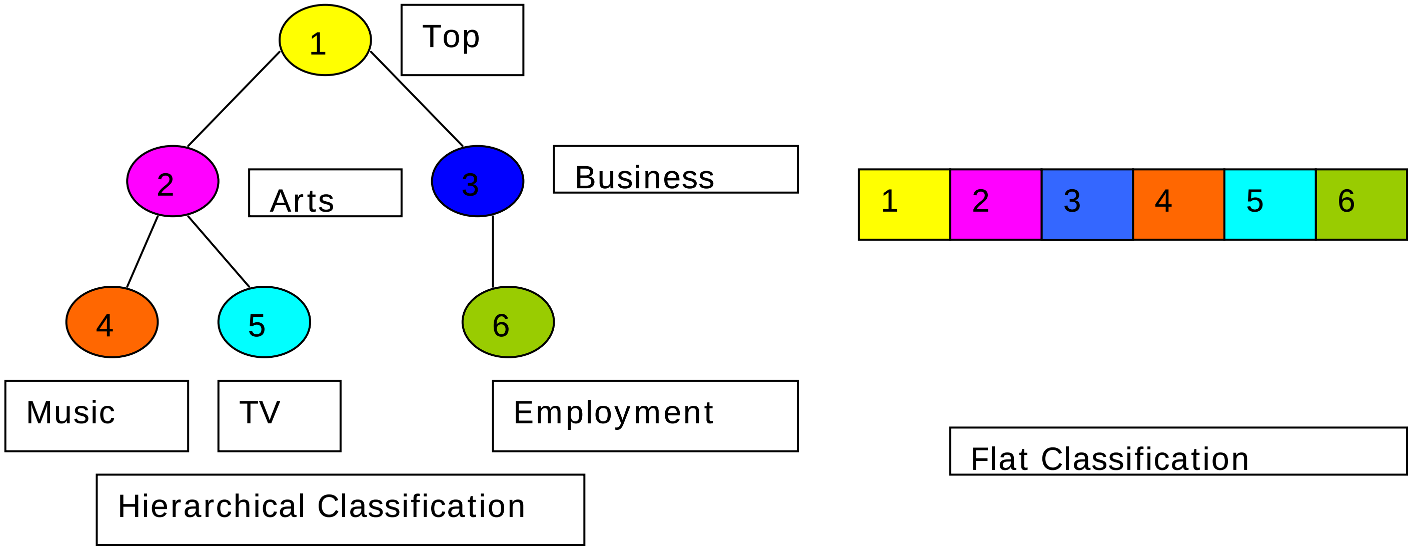
Text Classification – Our Approach ..

Feature selection during training (selecting training documents) plays a primary role towards improving classification accuracy.

○ Hierarchical classification

○ Use of Clustering

Flat Classification vs. Hierarchical Classification



- Top-down level-based Hierarchical classification

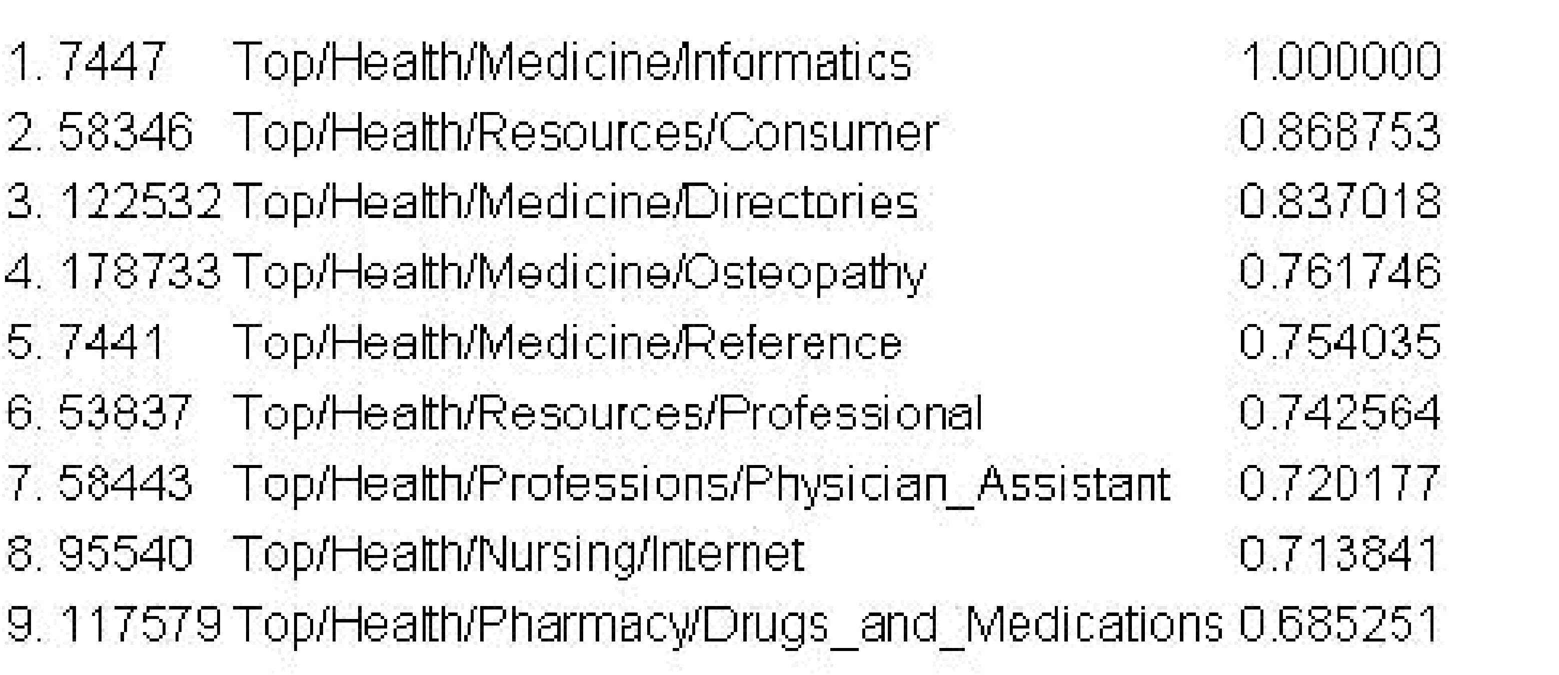
Role of Clustering

- Improve feature selection
- Eliminate documents that tend to confuse the classifier
- Identify within-category clusters, and extract cluster(s)' representative pages
- Document mining within the framework of cluster mining

Text Classification – Our Approach contd…

- During Classification phase, a vector of input document is created
- Similarity between training this vector and vector of each concept during training is computed using dot product
- New document is assigned to the categories with best matches

Classifier Output



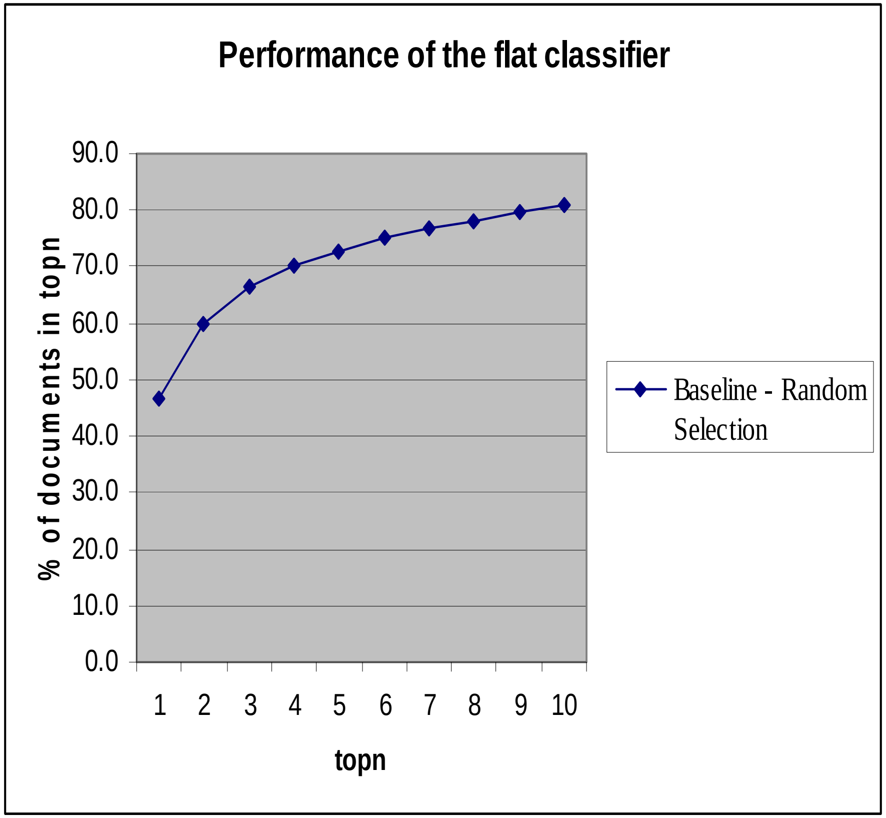
```
1. 7447    Top/Health/Medicine/Informatics                     1.000000
2. 58346   Top/Health/Resources/Consumer                       0.868753
3. 122532 Top/Health/Medicine/Directories                      0.837018
4. 178733 Top/Health/Medicine/Osteopathy                       0.761746
5. 7441    Top/Health/Medicine/Reference                       0.754035
6. 53837   Top/Health/Resources/Professional                   0.742564
7. 58443   Top/Health/Professions/Physician_Assistant          0.720177
8. 95540   Top/Health/Nursing/Internet                         0.713841
9. 117579 Top/Health/Pharmacy/Drugs_and_Medications 0.685251
```

Experimental Set-up

- Source of training data: Open Directory Project (dmoz.org) – ODP ontology contains hierarchical information
- Test data: Randomly-selected level 3 documents
- Clustering package: CLUTO
  - Clustering method: Partitional clustering
  - Similarity function: Cosine function
  - Program used: *vcluster - zscores*

Experimental Setup…..
Baseline – Random Selection

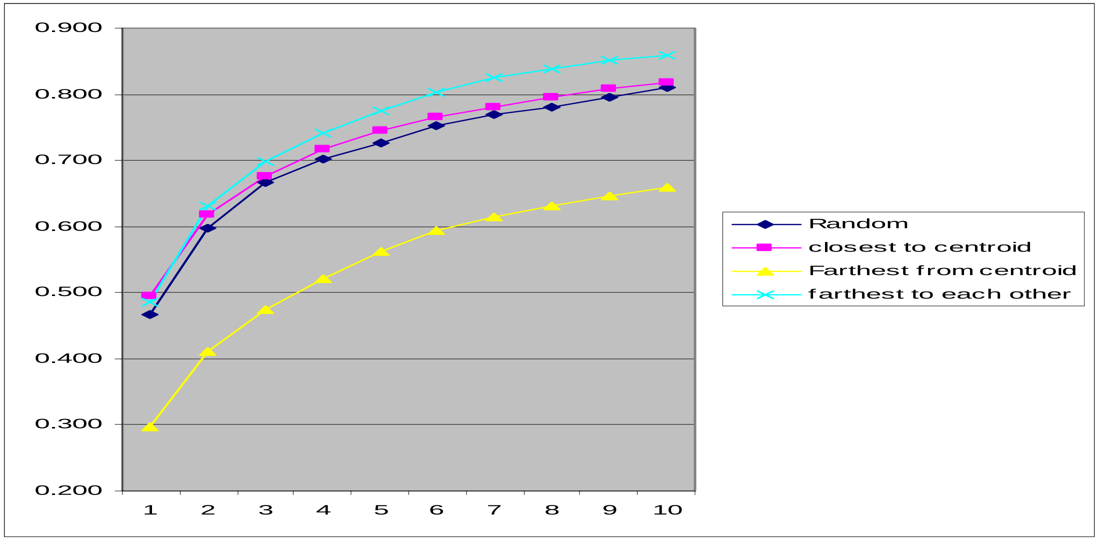
- All concepts from levels 1, 2 and 3 with at least 32 documents (total 1484)
- 2 documents from each concept was randomly withheld for testing (total - 2978)
- Trained with randomly-selected 30 documents from each concept(around 44500)
- Accuracy = 46.6 %



Evaluation

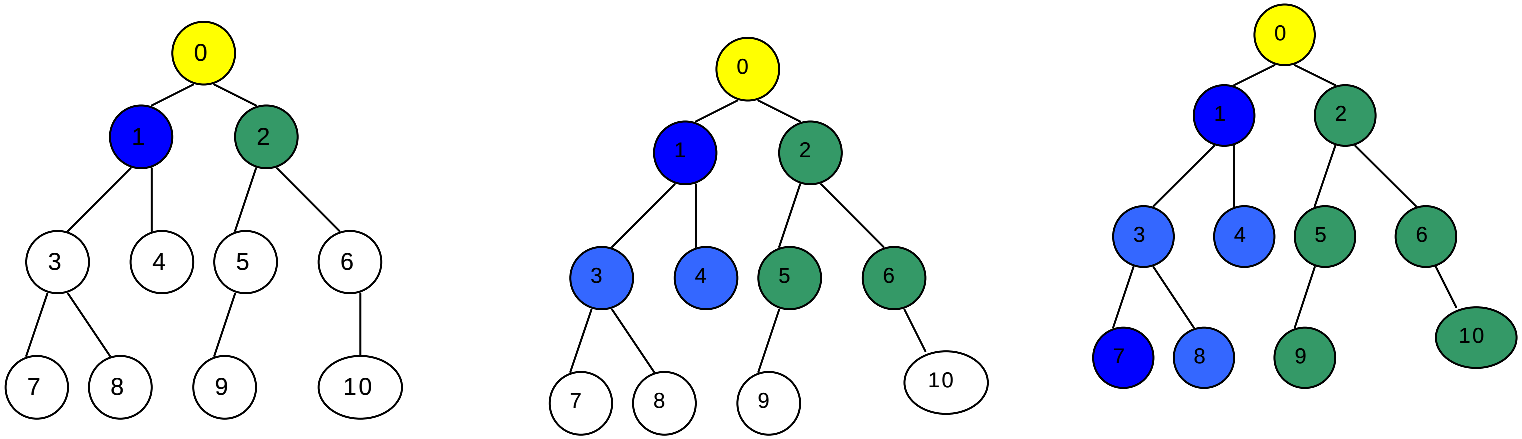
- Does selecting documents closest to the centroid to train improve accuracy ?
- For hierarchical classification, how far down the hierarchy should we go in each step ?
- What is the number of documents to train the classifier to get best results ?
- ‘Ignore’ or ‘consider’ tree structure among children ?

Experiment 1 : Effect of clustering on Flat Classification



- Best observed accuracy – Selecting documents closest to the centroid (49.5%)
- Poor performance – Selecting documents farthest from the centroid (29.5%)
- Selecting documents farthest from each other – 48.6%

Experiment 2- Effect of clustering on training Set selection for hierarchical classification

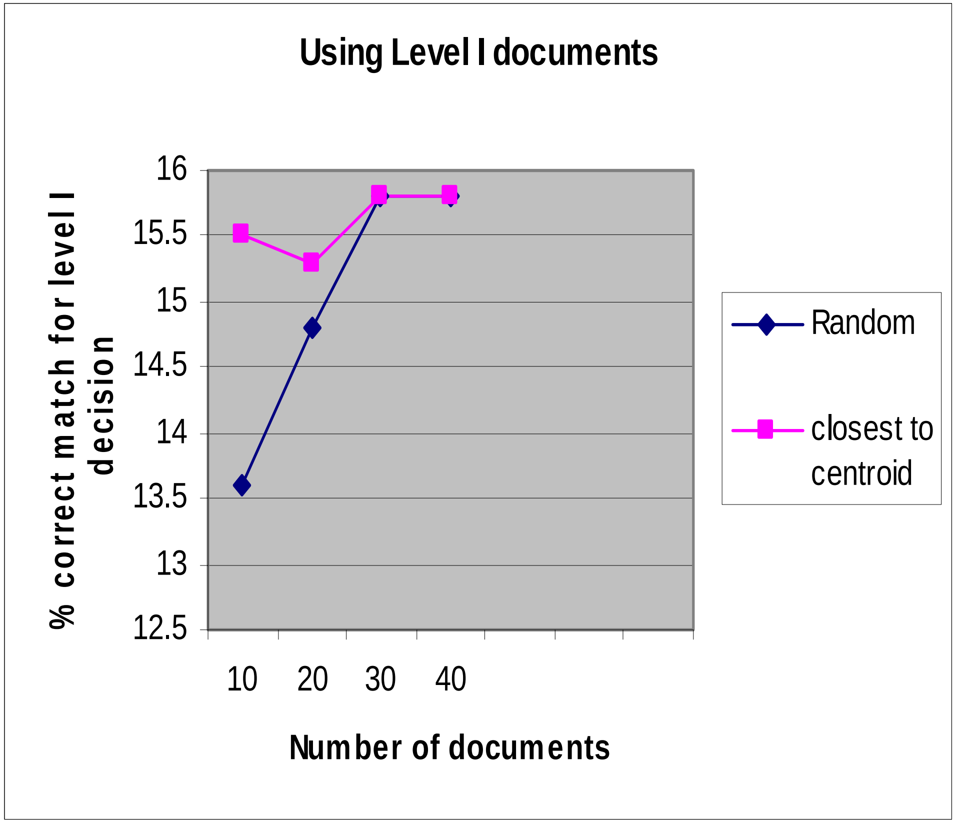


- 1 Classifier at level 1, 15 at level 2, 358 at level 3
- Documents from parent & children (& grandchildren put in the same pool to select)
- Parameters we tune : Depth, Random selection vs. clustering, # of documents

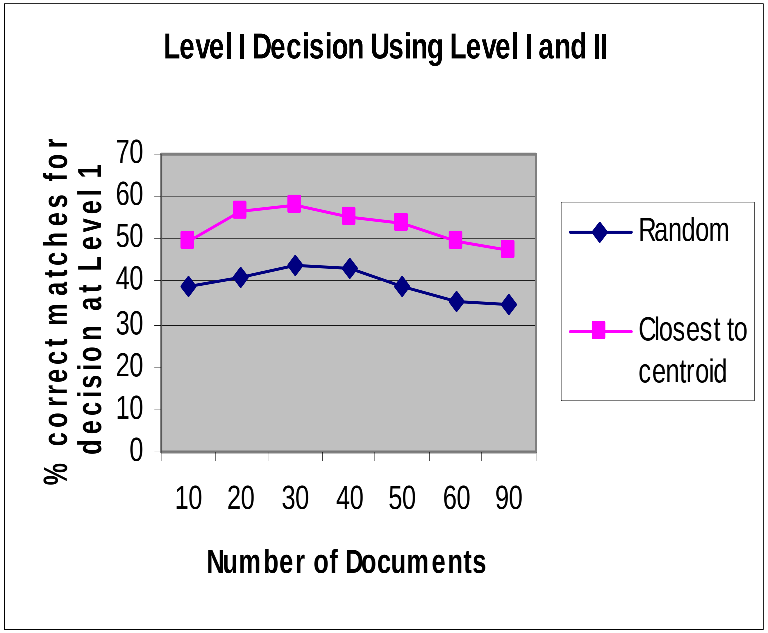
Experiment 2a – Study of Level 1 Decision

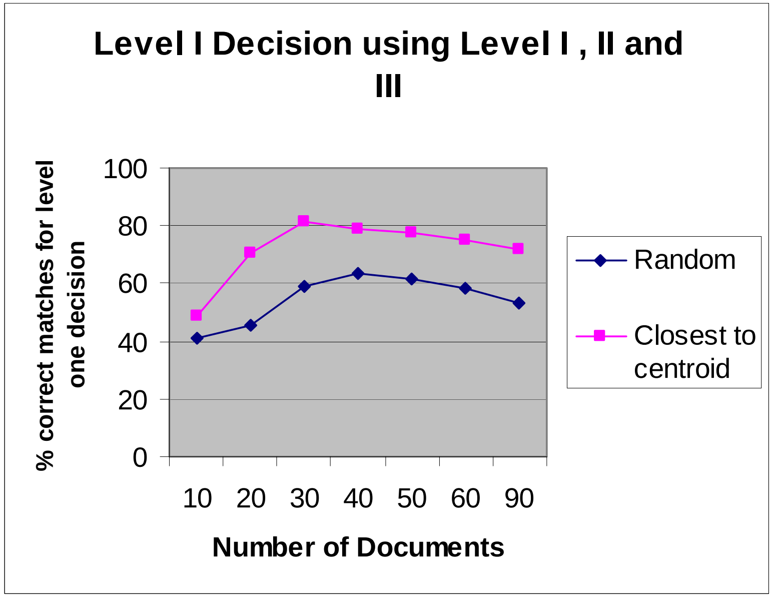
- Maximum observed accuracy 15.8% - Very Poor
- Very few documents at level-1

So, go deeper……



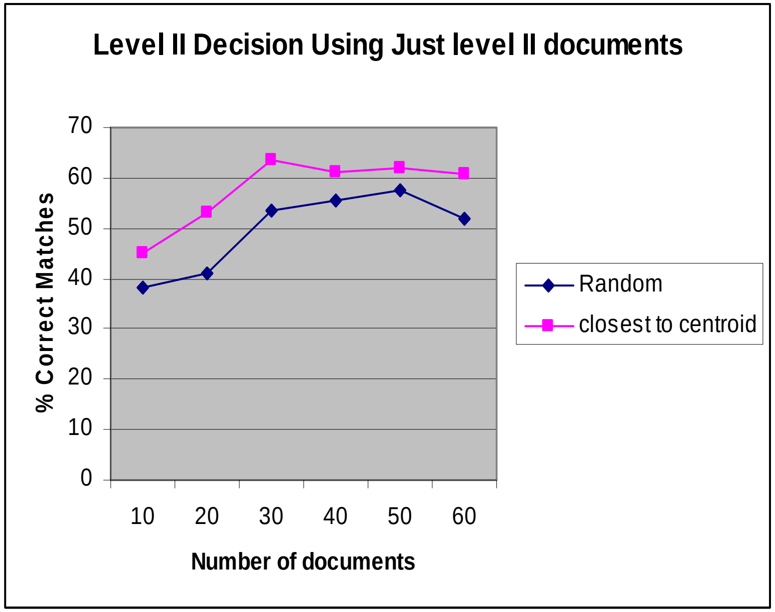
2.a: Study of Level 1 Decision.....

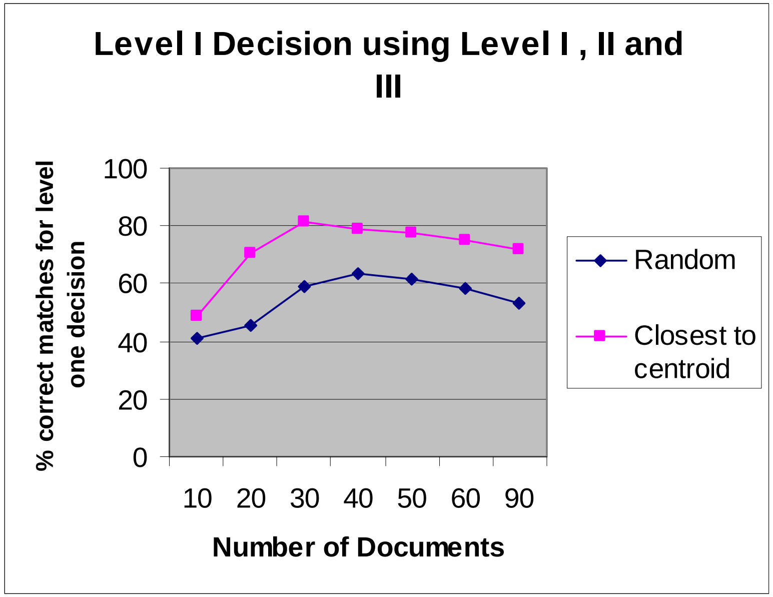




Maximum accuracy of 81.6% for level 1 decision when documents from levels 1,2 & 3 are used

Expt 2.b: Study of level 2 decision

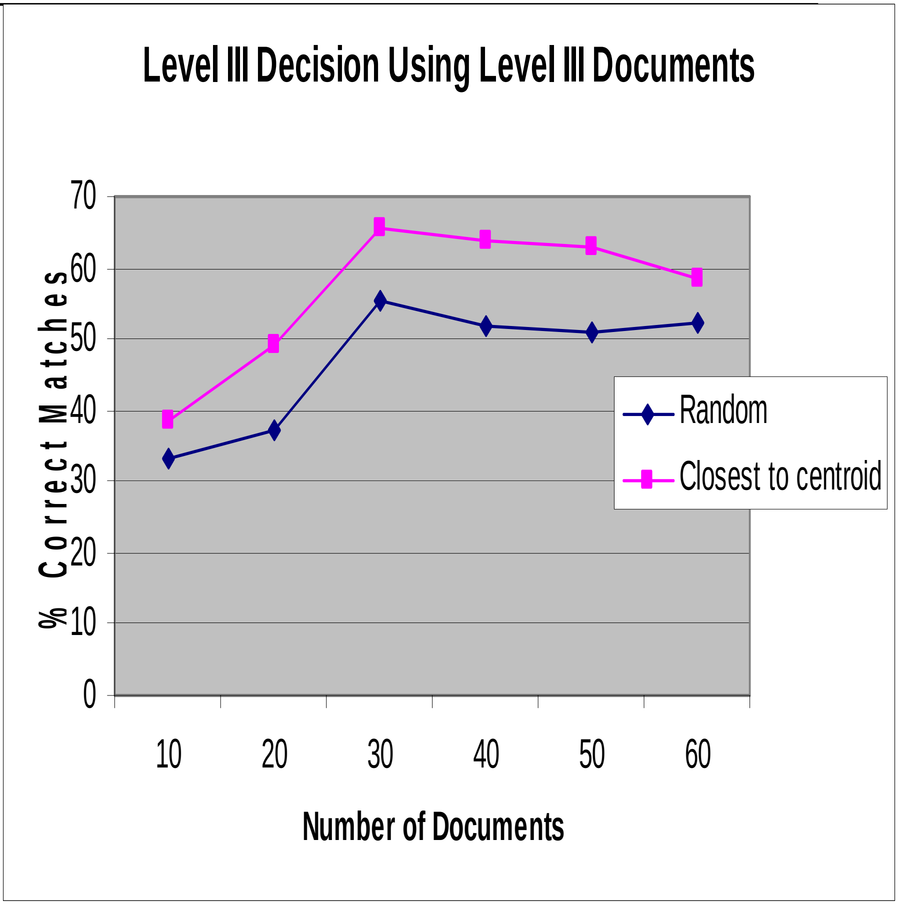




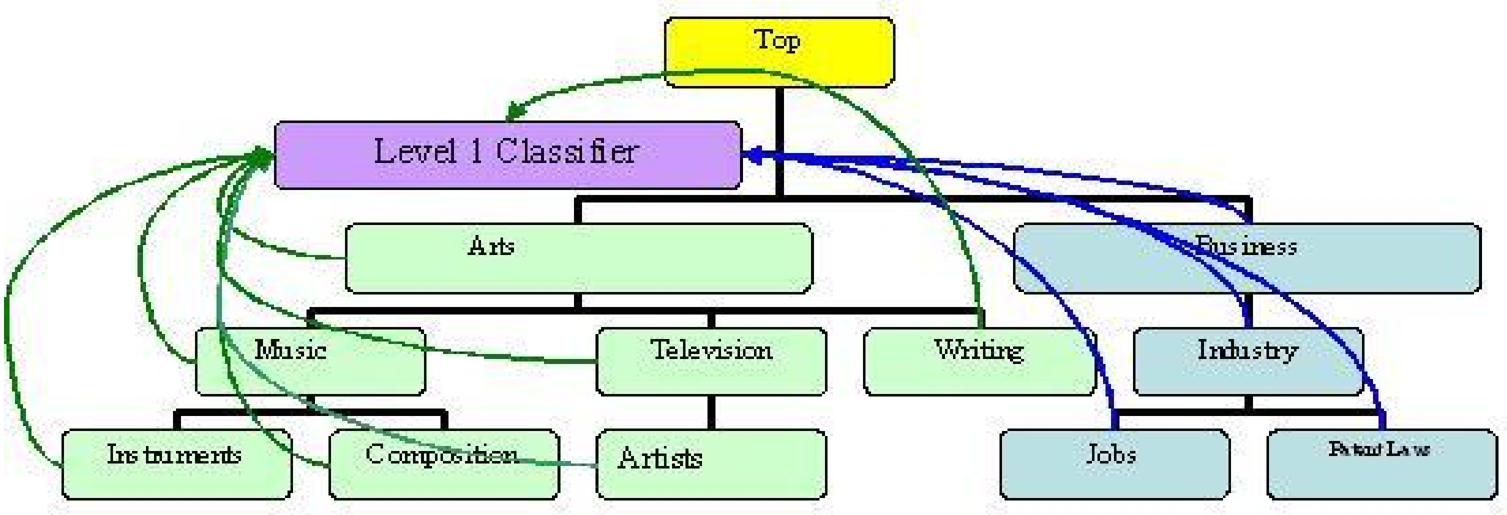
Maximum accuracy of 71.3% for level 2 decision when documents from levels 1,2 & 3 are used. 40 documents to train per concept.

Expt 2.c: Study of Level 3 Decision

- Maximum accuracy for random selection = 55.2%
- Maximum accuracy by selecting docts closest to the centroid = 65.4%
- 40.3% relative improvement over baseline

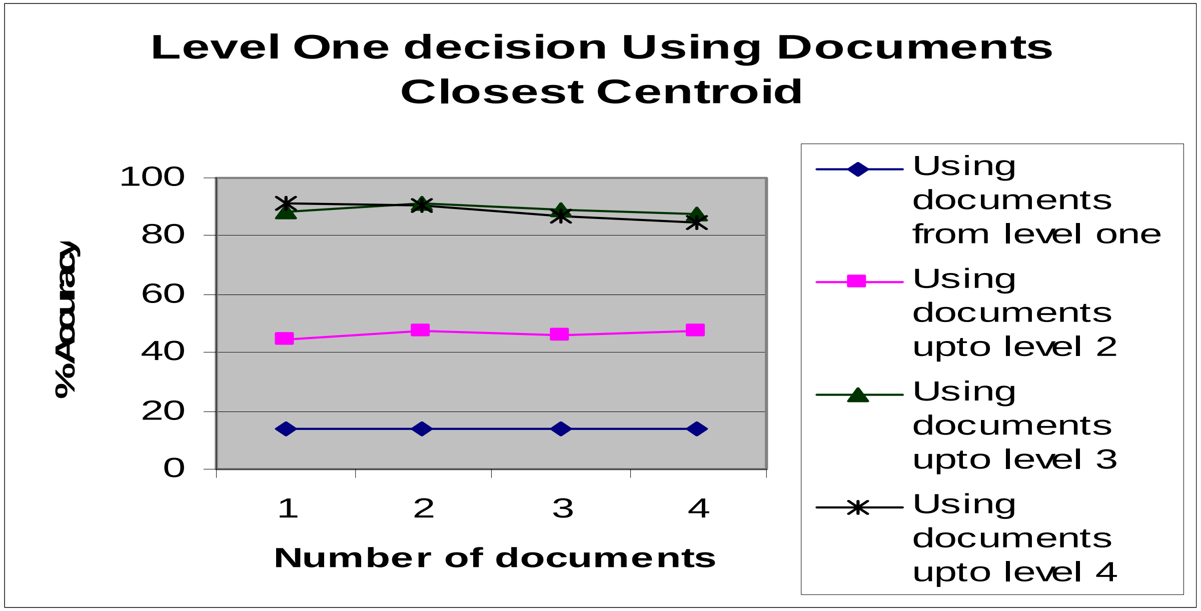


Expt 3: Effect of clustering on hierarchical classification, distributing training set across sub-concepts



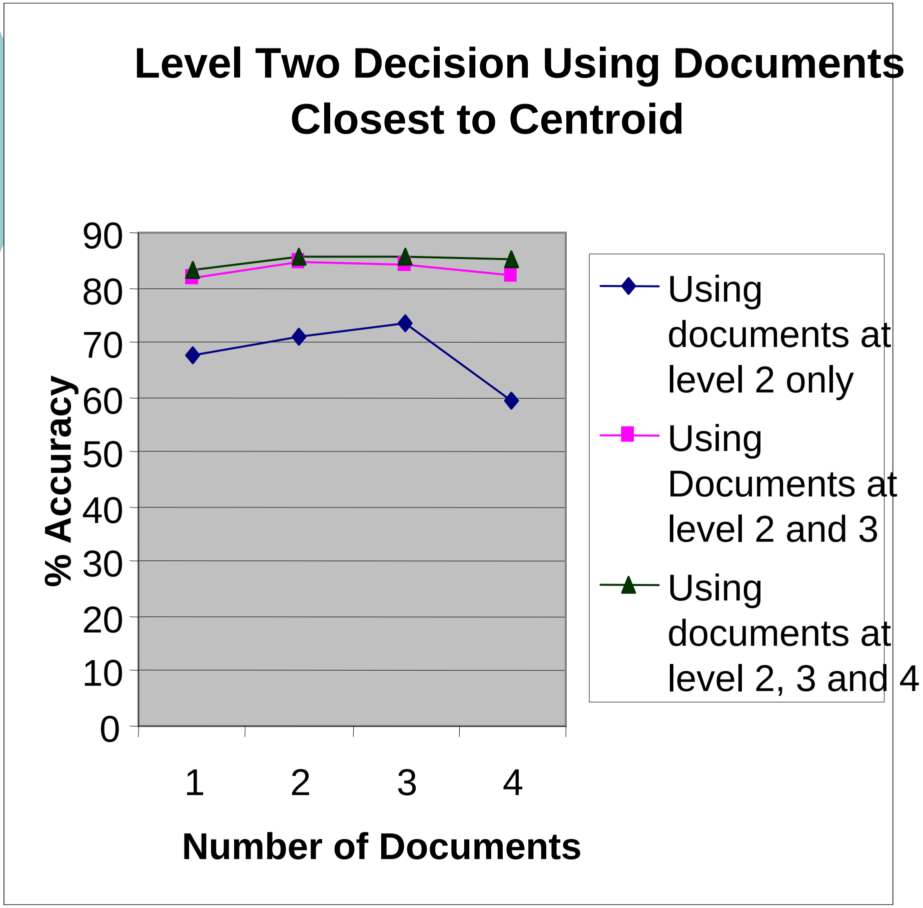
- Documents selected from each sub-concept
- Parameters we plan to tune : Depth, # of docts, random vs. closest to the centroid

Experiment 3.a: Level 1 Decision



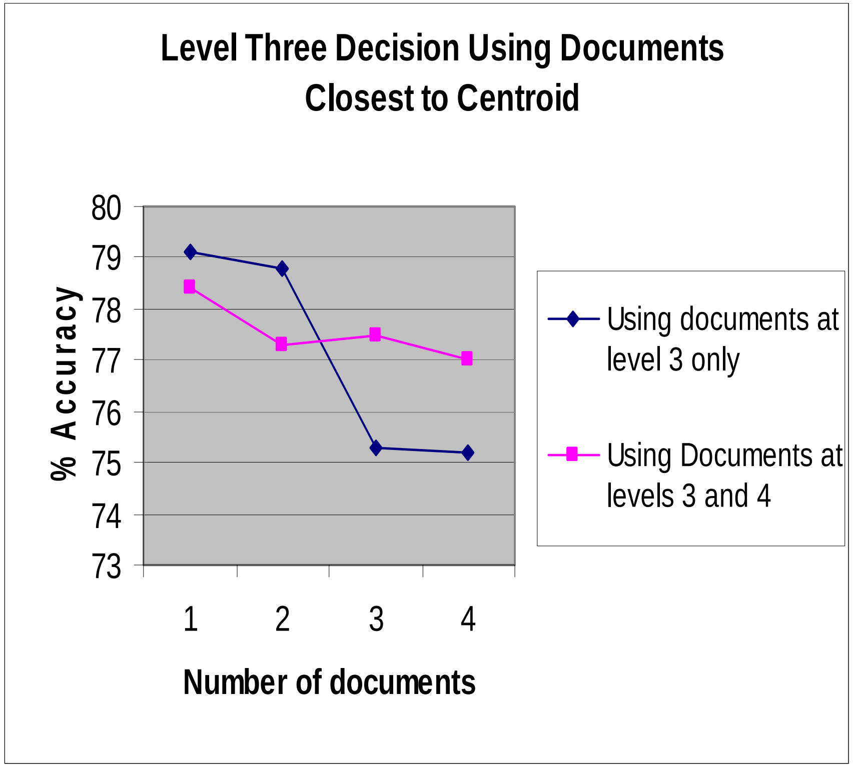
- Including level 4 – almost same results as level 3
- 91.2% Accuracy – 2 documents closest to the centroid from each concept down till level 3
- Poor results while using just level 1 or level 1 & 2

Experiment 3.b: Level 2 Decision



- ○ Using documents from levels 2&3, 2,3&4 yield almost identical results
- ○ We use till level 3 - computational time and complexity
- ○ Best observed accuracy – 84.4% - 2 docts per concept closest to the centroid

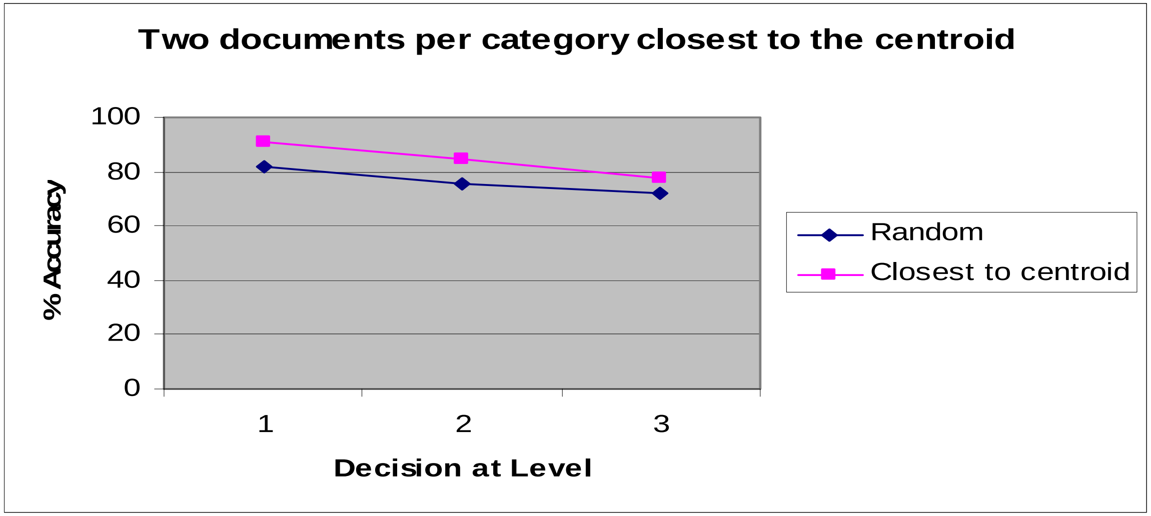
Experiment 3.c Level 3 decision



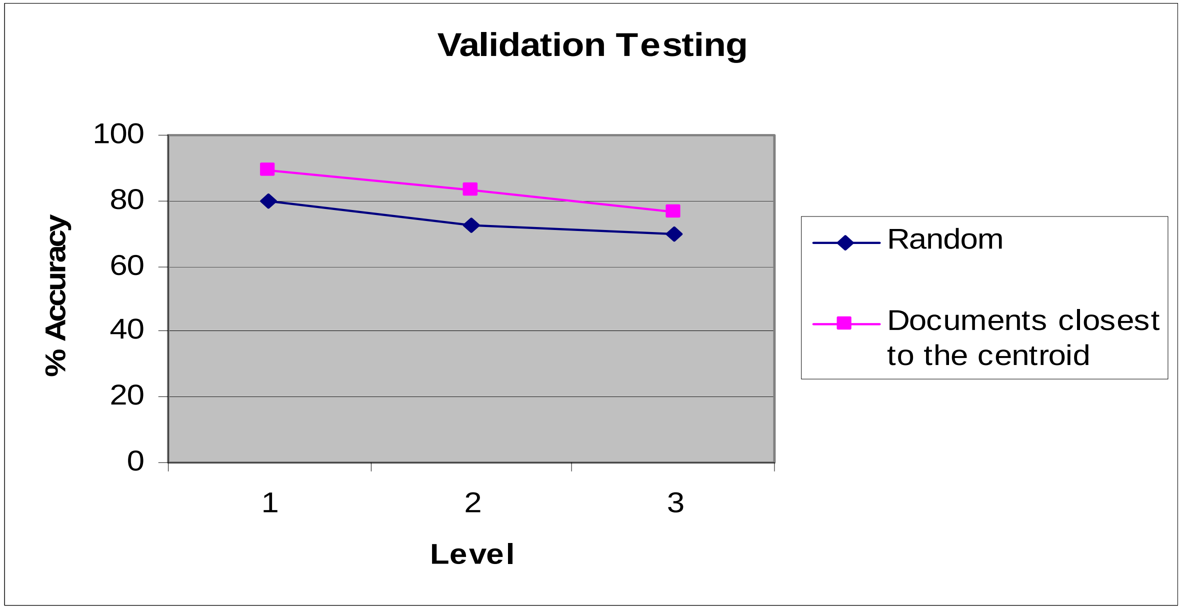
- Overall best accuracy of 79.1% at level 3 using one document from each concept that is closest to the centroid.

Training Strategy

- 2 training documents from each concept
- Down to level-3
- These documents are closest to the centroid in each concept
- Accuracy of 77.9% when we use clustering as compared to 71.8% when we select random documents

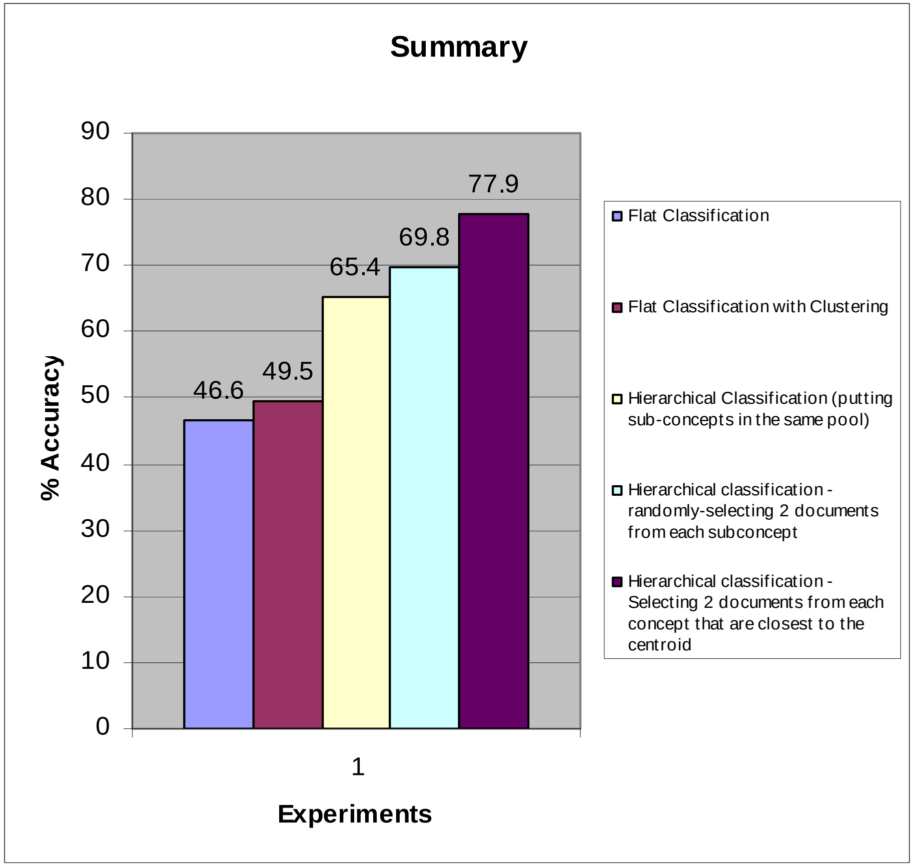


Validation Testing



- Different Test data
- Role of clustering enhances accuracy from 79.7% to 89% at level-1 and final accuracy from 69.8% to 76.2%.
- Statistically significant(*t-test value = 3.23E-05)* improvement

Conclusions



Maximum Accuracy of 77.9% when we use :

Hierarchical Classification,

2 documents closest to the centroid from each concept down till level-3 to train the classifier

Future Work

- ○ Use of other classifiers like the SVM
- ○ How to deal with the dynamic web ?
- ○ Trials on other data sets
- ○ Recovery mechanism when error is made at the parent level
- ○ Further 'divide and conquer' – Binary decisions

????’s or !!!!’s

Thank You