MineClass: A Synergy of Data Stream Classification and Novel Class Detection

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Introduction

Data Stream Classification faces three major problems:

- **Infinite length:** solution – incremental learning
- **Concept-drift:** solution – adapting to the most recent concept
- **Novel class:** solution - *MineClass*

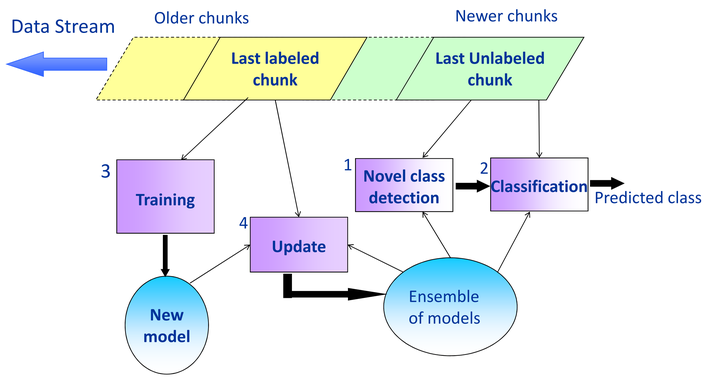


Figure 1. Overview of MineClass

Applications of novel class detection:

- Intrusion detection: detecting new kind of attack
- Text classification: detecting new category of text
- Fault detection: detecting new kind of fault

Basic idea

Assumption: A data point should be closer to the data points of its own class (cohesion) and farther apart from the data points of any other classes (separation).

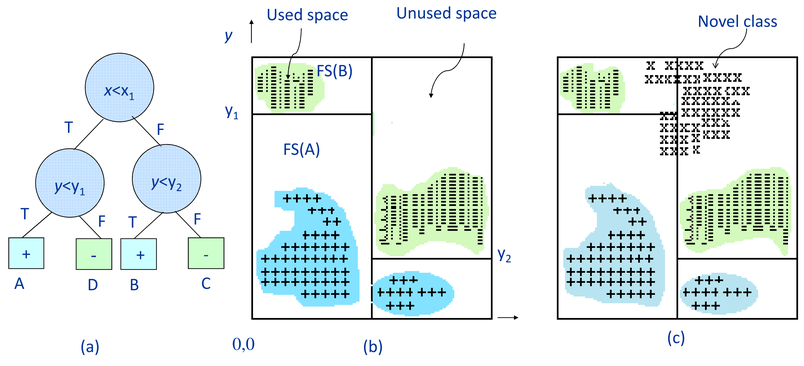


Figure 2. A decision tree (a), corresponding feature-space partitioning (b), and arrival of a novel class in the unused portions of the feature space (c).

Novel class detection

Steps:

1. **Save inventory of used spaces during training**
2. **Outlier detection and filtering**
3. **Measuring cohesion and separation**

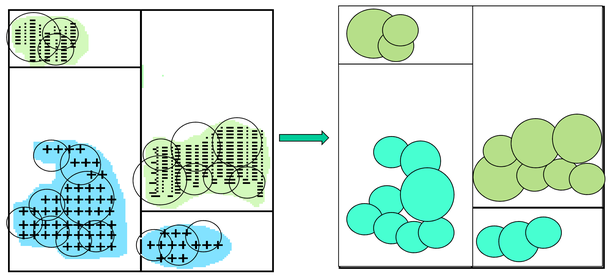


Figure 3. Saving inventory of used spaces as micro-clusters

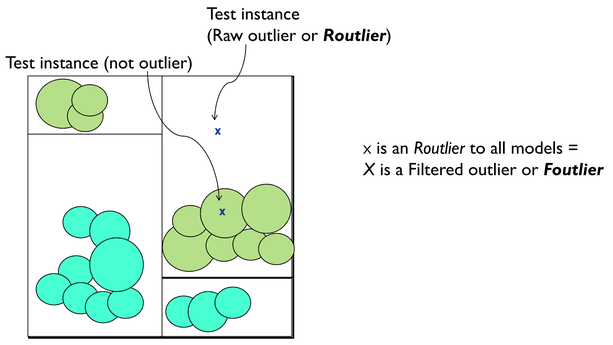
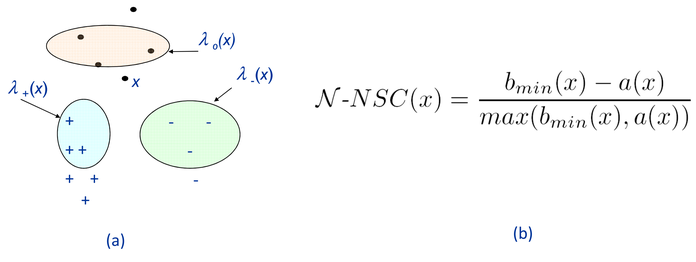


Figure 4. Outlier detection and filtering



$$\mathcal{N}\text{-}NSC(x) = \frac{b_{min}(x) - a(x)}{max(b_{min}(x), a(x))}$$

Figure 5. Measuring cohesion and separation by computing (a) λ_c neighborhood for *N*=3, and (b) *N*-neighborhood silhouette coefficient (*N*-NSC). A novel class is declared if *N*-NSC(.) is positive for at least *N* instances

Experiments and results

We evaluated our approach on two synthetic and two real datasets

Baseline: MineClass (MC), WCE-OLINDDA_PARALLEL(W-OP): WCE-OLINDDA_SINGLE(W-OS)

WCE-OLINDDA is a combination of the Weighted Classifier Ensemble (WCE) [1] and novel class detector OLINDDA [2]

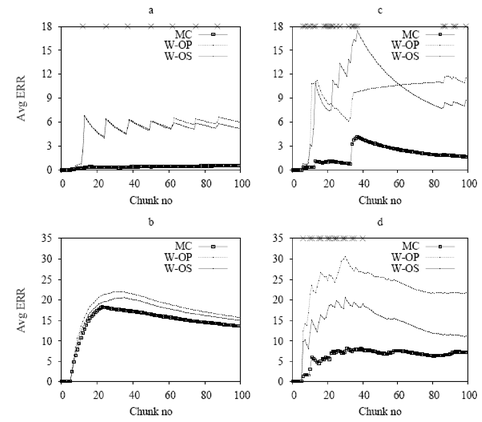


Figure 5. Error comparison on (a) SynCN, (b) SynC, (c) KDD and (d) Forest Cover.

Table-I. Run-time comparison on all datasets

Dataset	Time(sec)/chunk			Points/sec			Speed gain	
	MC	W-OP	W-OS	MC	W-OP	W-OS	MC over W-OP	MC over W-OS
SynC	**0.18**	0.81	0.19	**5,446**	1,227	5,102	**4**	**1**
SynCN	**0.27**	52.9	7.34	**3,656**	18	135	**203**	**27**
KDD	**0.95**	1369.5	222.8	**4,190**	2	17	**2,095**	**246**
Forest cover	**2.11**	213.1	10.79	**1,899**	18	370	**105**	**5**

Conclusion

MineClass handles all three problems in data stream classification:

- Handles infinite memory and concept-drift problem using ensemble classification
- Novel class detection problem using "class mining"
- It is an unique combination of stream classification and novel class detection

References

[1] E. J. Spinosa, A. P. de Leon F. de Carvalho, and J. Gama. Olindda: a cluster-based approach for detecting novelty and concept drift in data streams. In Proc. 2007 ACM symposium on Applied computing, pages 448–452, 2007.

[2] H. Wang, W. Fan, P. Yu, and J. Han. Mining concept-drifting data streams using ensemble classifiers. In Proc. SIGKDD, 2003.