Multiple Costs and Their Combination in Cost Sensitive Learning

By

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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To my wife Yanfang and Our Parents
Abstract

Cost sensitive learning is firstly defined as a procedure of minimizing the costs of classification errors. It has attracted much attention in the last few years. Being cost sensitive has the strength to handle the unbalance on the misclassification errors in some real world applications. Recently, researchers have considered how to deal with two or more costs in a model, such as involving both of the misclassification costs (the cost for misclassification errors) and attribute test costs (the cost incurs as obtaining the attribute’s value) [Tur95, GGR02, LYWZ04]. Cost sensitive learning involving both attribute test costs and misclassification costs is called test cost sensitive learning that is more close to real industry focus, such as medical research and business decision.

Current test cost sensitive learning aims to find an optimal diagnostic policy (simply, a policy) with minimal expected sum of the misclassification cost and test cost that specifies, for example which attribute test is performed in next step based on the outcomes of previous attribute tests, and when the algorithm stops (by choosing to classify). A diagnostic policy takes the form of a decision tree whose nodes specify tests and whose leaves specify classification actions. A challenging issue is the choice of a reasonable one from all possible policies.

This dissertation argues for considering both of the test cost and misclassification cost, or even more costs together, but doubts if the current way, summing up the two costs, is the only right way. Detailed studies are needed to ensure the ways of combination make sense and be “correct”, dimensionally as well as semantically. This
dissertation studies fundamental properties of costs involved and designs new models to combine the costs together.

Some essential properties of attribute test cost are studied. In our learning problem definition, test cost is combined into misclassification cost by choosing and performing proper tests for a better decision. Why do you choose them and how about the ones that are not chosen? Very often, only part of all attribute values are enough for making a decision and rest attributes are left as “unknown”. The values are defined as ‘absent values’ as they are left as unknown purposely for some rational reasons when the information obtained is considered as enough, or when patients have no money enough to perform further tests, and so on.. This is the first work to utilize the information hidden in those “absent values” in cost sensitive learning; and the conclusion is very positive, i.e. “Absent data” is useful for decision making. The “absent values” are usually treated as ‘missing values’ when left as known for unexpected reasons. This thesis studies the difference between ‘absent’ and ‘missing’. An algorithm based on lazy decision tree is proposed to identify the absent data from missing data, and a novel strategy is proposed to help patch the “real” missing values.

Two novel test cost sensitive models are designed for different real work scenarios. The first model is a general test cost sensitive learning framework with multiple cost scales. Previous works assume that the test cost and the misclassification cost must be defined on the same cost scale, such as the dollar cost incurred in a medical diagnosis. And they aim to minimize the sum of the misclassification cost and the test cost. However, costs may be measured in very different units and we may meet difficulty in defining the multiple costs on the same cost scale. It is not only a technology issue, but
also a social issue. In medical diagnosis, how much money should you assign for a misclassification cost? Sometimes, a misclassification may hurt a patient’s life. And from a social point of view, life is invaluable. To tackle this issue, a target-resource budget learning framework with multiple costs is proposed. With this framework, we present a test cost sensitive decision tree model with two kinds of cost scales. The task is to minimize one cost scale, called target cost, and keep the other one within specified budgets. To the best of our knowledge, this is the first attempt to study the cost sensitive learning with multiple costs scales.

The second model is based on the assumption that some attributes of an unlabeled example are known before being classified. A test cost sensitive lazy tree model is proposed to utilize the known information to reduce the overall cost. We also modify and apply this model to the batch-test problem: multiple tests are chosen and done in one shot, rather than in a sequential manner in the test-sensitive tree. It is significant in some diagnosis applications that require a decision to be made as soon as possible, such as emergency treatment.

Extensive experiments are conducted for evaluating the proposed approaches, and demonstrate that the work in this dissertation is efficient and useful for many diagnostic tasks involving target cost minimization and resource utilization for obtaining missing information.
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List of Publications

The following is a list of my research papers published in the proceedings of referred international conferences or journals during my PhD study at University of Technology, Sydney.

Referred Journal Papers:


Referred Conference Papers:


Table of Contents

Multiple Costs and Their Combination in Cost Sensitive Learning......................... i

Abstract ................................................................................................................................... iv

Acknowledgements............................................................................................................... vii

List of Publications ................................................................................................................. ix

Table of Contents ................................................................................................................... xi

List of Figures ....................................................................................................................... xiii

Chapter 1 Introduction .......................................................................................................... 1

1.1 Overview of the Thesis ................................................................................................. 1
1.2 Contributions ................................................................................................................... 6
1.3 Organization of the Thesis ............................................................................................. 7

Chapter 2 Background and Literature Review ................................................................... 8

2.1 Background and Definition ............................................................................................ 9
  2.1.1 Classic Decision Trees .......................................................................................... 9
  2.1.2 Classic Cost Sensitive Decision Tree .................................................................. 12
  2.1.3 Types of Cost in Cost Sensitive Learning ......................................................... 17
  2.1.4 Unknown Data in Machine Learning and Data Mining .................................. 21
2.2 Literature Review for Cost-sensitive Learning and Cost Combination .................. 23
  2.2.1 Classifiers for Single Cost .................................................................................... 24
  2.2.2 Classifiers for Multiple Costs .............................................................................. 26
2.3 A Cost Sensitive Decision Tree Involving both of Test and Misclassification Cost ......... 29
  2.3.1 Leaf marking criteria ............................................................................................. 44
  2.3.2 Attribute selecting criteria for internal nodes .................................................... 45
  2.3.3 Resource Control Issues ....................................................................................... 48

Chapter 3 Test Cost Sensitive Decision Trees with Multiple Cost Scales .............. 35

3.1 Motivation ..................................................................................................................... 36
3.2 A General Framework for Learning with Multiple Cost Scales ............................... 37
  3.2.1 Classic cost sensitive learning framework ......................................................... 37
  3.2.2 Test cost sensitive learning framework with single cost scale ....................... 38
  3.2.3 Test cost sensitive learning framework with multiple cost scales ................. 39
3.3 Test Cost Sensitive Learning Decision Tree with Multiple Costs Scales ............ 43
  3.3.1 Leaf marking criteria ............................................................................................. 44
  3.3.2 Attribute selecting criteria for internal nodes .................................................... 45
  3.3.3 Resource Control Issues ....................................................................................... 48
<table>
<thead>
<tr>
<th>Chapter 4 Utilization based Test Cost Sensitive Decision Trees</th>
<th>59</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Lazy Test Cost Sensitive Decision Trees with Multiple Cost Scales</td>
<td>60</td>
</tr>
<tr>
<td>4.1.1 Motivation</td>
<td>60</td>
</tr>
<tr>
<td>4.1.2 Classic lazy decision tree</td>
<td>60</td>
</tr>
<tr>
<td>4.1.3 Lazy Test Cost Sensitive Decision Tree with Two Cost Scales</td>
<td>62</td>
</tr>
<tr>
<td>4.1.4 Performance Evaluation</td>
<td>65</td>
</tr>
<tr>
<td>4.2 Batch Testing Strategies for Test Cost Sensitive Decision Trees</td>
<td>68</td>
</tr>
<tr>
<td>4.2.1 Batch Tests Selection</td>
<td>68</td>
</tr>
<tr>
<td>4.2.2 Hybrid Lazy Tree for Batch Tests Selection</td>
<td>70</td>
</tr>
<tr>
<td>4.2.3 Performance Evaluation</td>
<td>73</td>
</tr>
<tr>
<td>4.3 Conclusions and Future Work</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 5 Absent and Missing Values in Cost-Sensitive Decision Trees</th>
<th>76</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Introduction</td>
<td>77</td>
</tr>
<tr>
<td>5.1.1 Missing fields in data set</td>
<td>77</td>
</tr>
<tr>
<td>5.1.2 Missing or Absent?</td>
<td>78</td>
</tr>
<tr>
<td>5.2 Review of Previous Work</td>
<td>81</td>
</tr>
<tr>
<td>5.3 Dealing with Missing Values in Cost-sensitive Decision Trees</td>
<td>82</td>
</tr>
<tr>
<td>5.3.1 The Known Value Strategy</td>
<td>82</td>
</tr>
<tr>
<td>5.3.2 The Null Strategy</td>
<td>83</td>
</tr>
<tr>
<td>5.3.3 The Internal Node Strategy</td>
<td>84</td>
</tr>
<tr>
<td>5.3.4 The C4.5 Strategy</td>
<td>84</td>
</tr>
<tr>
<td>5.4 Evaluating and patching up missing values from absent values with hybrid lazy tree</td>
<td>85</td>
</tr>
<tr>
<td>5.4.1 Identifying missing data from absent data</td>
<td>86</td>
</tr>
<tr>
<td>5.4.2 Patching up missing data</td>
<td>86</td>
</tr>
<tr>
<td>5.5 Experiments</td>
<td>88</td>
</tr>
<tr>
<td>5.5.1 Comparing the Four Missing-value Strategies</td>
<td>88</td>
</tr>
<tr>
<td>5.5.2 Experiments for identifying absent data</td>
<td>93</td>
</tr>
<tr>
<td>5.6 Conclusions and Future Work</td>
<td>95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 6 Conclusions and Future Research</th>
<th>97</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Conclusions</td>
<td>97</td>
</tr>
<tr>
<td>6.2 Future Research</td>
<td>99</td>
</tr>
<tr>
<td>6.2.1 Combination of Multiple costs</td>
<td>100</td>
</tr>
<tr>
<td>6.2.2 Properties of other costs</td>
<td>100</td>
</tr>
</tbody>
</table>

| Bibliography | 102 |
List of Figures

Figure 2.1  An example of Decision Tree on Credit Card Application.......................10
Figure 2.2  A decision tree built from the Ecoli dataset (costs are set as in Table 2.3).32
Figure 3.1 Relationship of cost-sensitive learning models.............................................42
Figure 3.2 Three different decision trees for Ecoli data (single cost scale) built with
different resource budgets.............................................................................................50
Figure 3.3. Three different decision trees for Ecoli data (multiple cost scales) built with
different resource budget .............................................................................................51
Figure 3.4 Comparing the total cost under 3 different resource budgets .....................52
Figure 3.5. Comparing the total cost under different resource budgets .....................55
Figure 3.6. Comparing the resource utilization (percentage) under different resource
budgets.............................................................................................................................55
Figure 4.1 A generic lazy decision tree algorithm .............................................................61
Figure 4.2 Lazy test sensitive decision tree algorithm with two cost scales .................64
Figure 4.3. The total average target costs of single and multiple cost scales tree under
different resource budgets (Dataset Ecoli)...................................................................66
Figure 4.4. The total average target costs for Dataset Breast............................................66
Figure 4.5. The total average target costs for Dataset Heart Disease..............................67
Figure 4.6. The average total target costs for Dataset Australia.......................................67
Figure 4.7. An overall test cost sensitive decision tree ......................................................69
Figure 4.8 Lazy test sensitive decision tree algorithm with two cost scales ...................71
Figure 4.9. Choosing known attribute as an internal node ...............................................72
Figure 4.10 A hybrid lazy decision tree extended from figure 5.2 .................................72
Figure 4.11. Total target costs with different ratio of known attributes on dataset Ecoli.
Target costs in two strategies go down when more known attributes are available.
..........................................................................................................................................73
Figure 4.12. Total target costs with different ratio of known information on dataset
Breast................................................................................................................................74
Figure 4.13. Total target costs with different ratio of known information on dataset
   Heart .................................................................................................................................74

Figure 4.14. Total target costs with different ratio of known information on dataset
   Australia ...........................................................................................................................74

Figure 5.1. A decision tree built extended from figure 7.1..............................87

Figure 5.3 Total average costs for Ecoli. In this and the following figures, “KV” stands
   for the Known Value Strategy, “NULL” for the Null Strategy, “Internal” for the
   Internal Node Strategy, and “C4.5” for the C4.5 Strategy........................................91

Figure 5.4 Total average costs for Breast .................................................................91

Figure 5.5 Total average costs for Heart .................................................................92

Figure 5.6 Total average costs for Thyroid...............................................................92

Figure 5.7 Total average costs for Australia .........................................................93

Figure 5.8 Comparing of average cost of three handling strategies on all datasets.....94

Figure 5.9 Influence of cost matrix on our patching model ......................................94