A Predictive Model for Diagnosing Thyroid Disorders

DISTINGUISHING BETWEEN NORMAL, HYPERTHYROIDISM, AND HYPOTHYROIDISM IN A COST-CONSCIOUS AND RESPONSIBLE WAY

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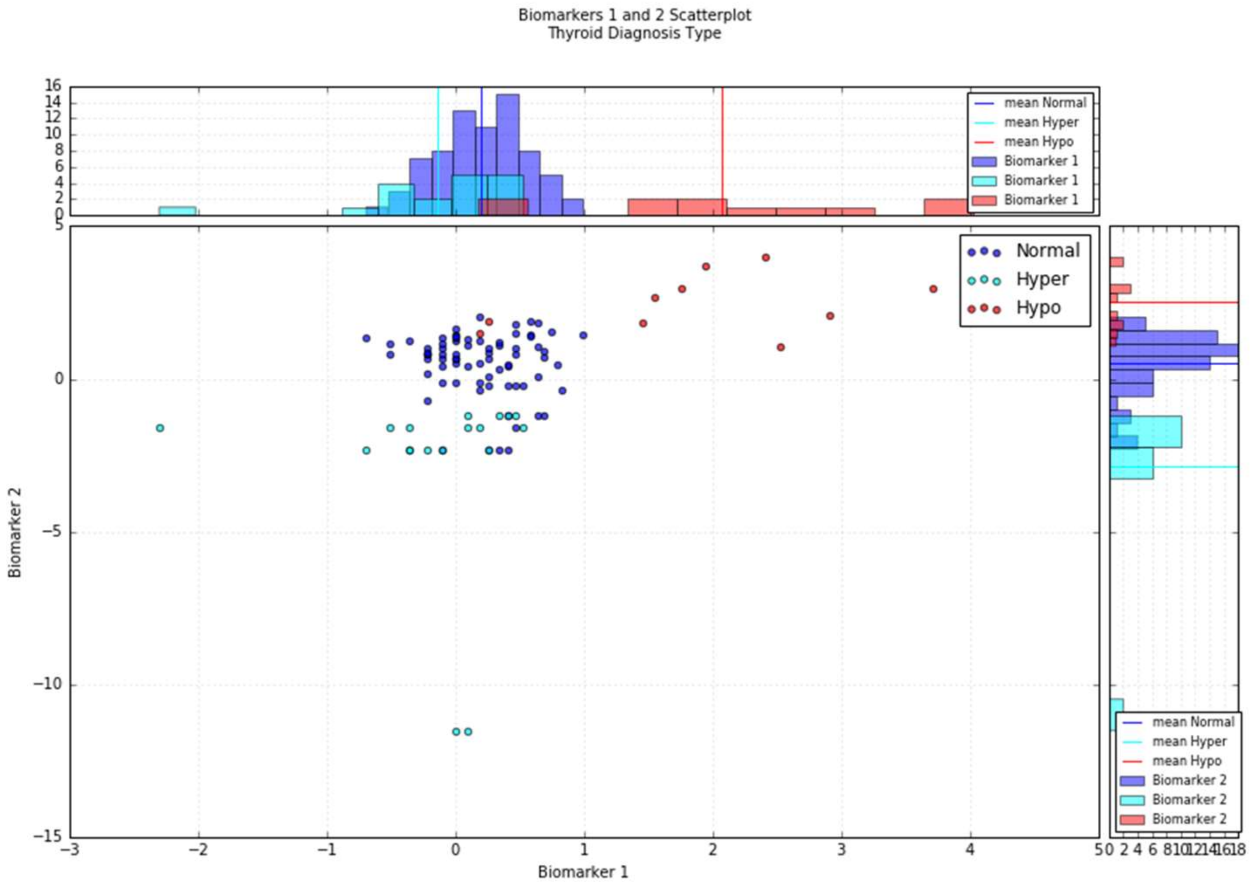
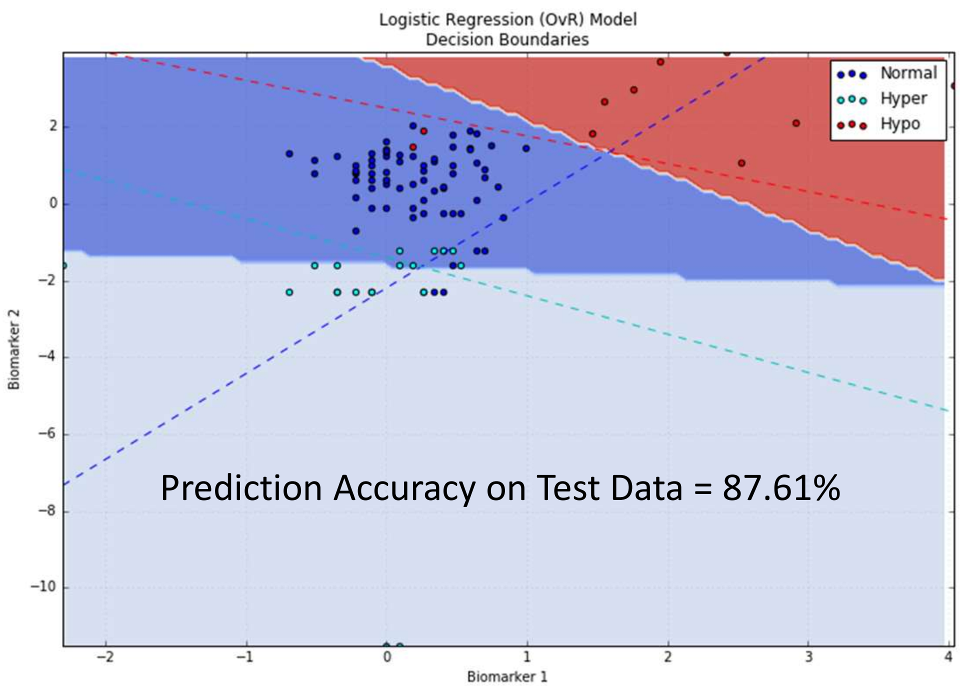
Predictors of Thyroidism Type

- Two predictors are available for modeling Thyroid conditions: Biomarker 1 and Biomarker 2
- Biomarker 1 is a measure of thyroid-stimulating hormone TSH in the patient; it is used as the base value
- Biomarker 2 is a measure of the change in the TSH hormone after an injection of thyrotropin-releasing hormone
- The scatterplot at the right shows the Thyroidism types in the context of these two biomarkers
- The histograms characterize the distribution of each Biomarker



Predictive Model for Classification



- A type of linear predictive model called logistic regression was used to model the classes
- The model creates boundaries and regions that map new patients to a given class
- However the model is not perfect, as can be seen by classes being assigned to the wrong region on the plot
- Given there is a cost to misclassification of $5000, we can choose to abstain (at a cost of $1000) from making predictions when uncertainty is high
- Abstaining from prediction allows for further investigation

Minimizing Cost by Exploiting Model

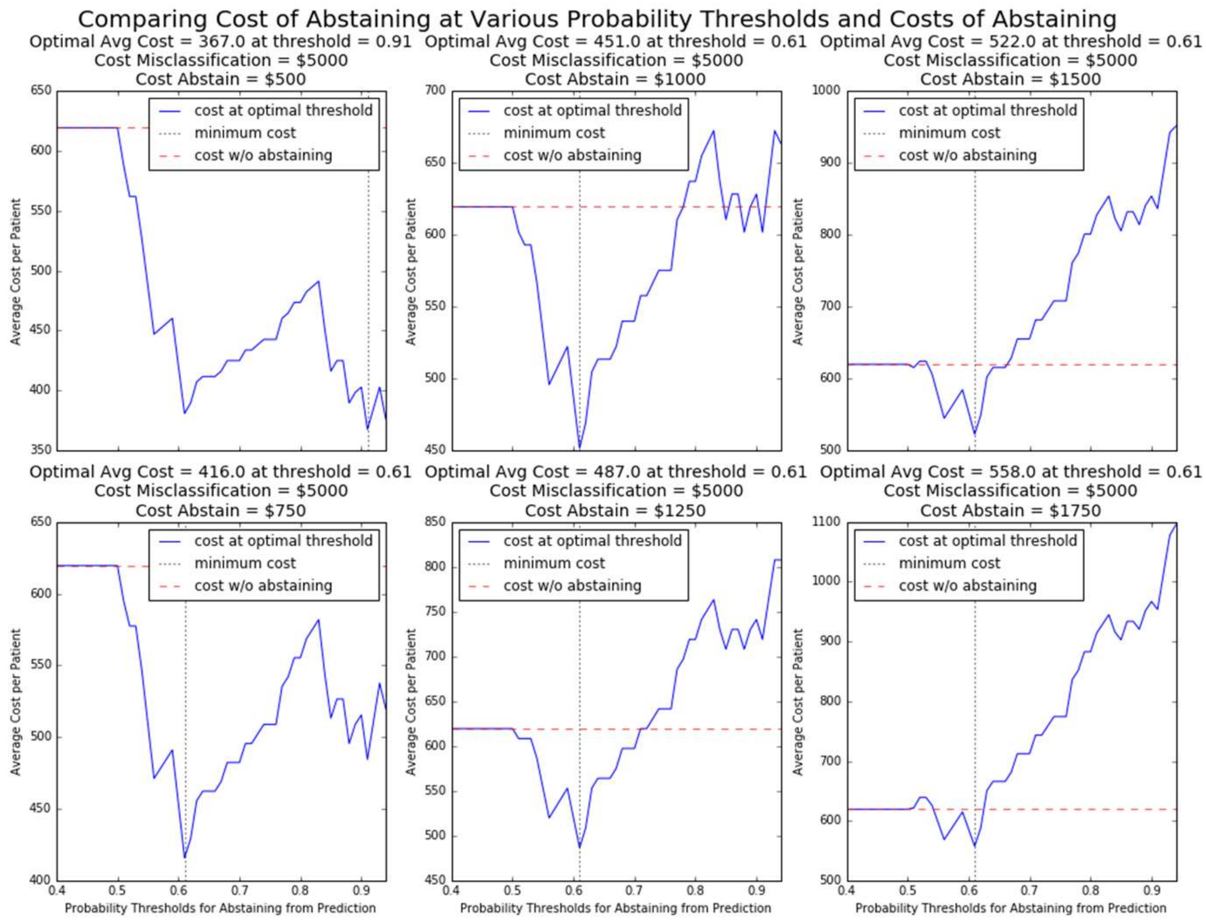
	probability_class_1	probability_class_2	probability_class_3
0	0.984608	0.009109	6.282222e-03
1	0.977985	0.005112	1.690251e-02
2	0.506973	0.493026	4.768765e-07
3	0.974344	0.024496	1.159945e-03
4	0.893660	0.001488	1.048520e-01
5	0.913735	0.001769	8.449622e-02
6	0.330761	0.669238	4.229616e-08
7	0.401381	0.598619	6.190362e-09
8	0.632149	0.367850	1.749310e-06
9	0.967093	0.032227	6.800138e-04

Multiclass logistic regression models ***use probabilities*** to predict classes

- Simply, the max probability is the predicted class
- However, sometimes this max probability isn't very high relative to the other probabilities (see right)
- These close-call predictions could end up being very costly when the cost of misclassification is $5000
- A simple extension to this model is to abstain from prediction (at a cost) when the maximum probability (of the predicted class) is less than a given threshold
- An optimal threshold will minimize cost per patient

Average Cost at Various Abstain Thresholds

- The plots at the right show the calculated cost on a held-out dataset of abstaining from prediction at various thresholds
- Each plot uses a given cost of misclassification (constant at $5000) and a varying cost of abstaining to iteratively calculate the average cost per patient at every threshold between 0 and 1
- It is shown that at each cost of abstaining this approach is capable of identifying a minimum cost that is lower than the baseline average cost where there is no abstaining
- This robust approach is capable of adapting with changing abstain costs



Conclusions

By abstaining from prediction at an optimal probability threshold we can infuse human expertise into this predictive model, and recommend patients for further testing when the model is uncertain of its prediction.

WHILE NO DIAGNOSTIC MODEL WILL EVER BE PERFECT, THIS APPROACH CAN ACHIEVE LOWER AVERAGE COSTS – EVEN IN THE FACE OF CHANGING COSTS OF ABSTAINING – THAN THE MODEL ALONE CAN ACHIEVE.