CLASSIFICATION VS REGRESSION

Your goal is to identify students who might need early intervention - which type of supervised machine learning problem is this, classification or regression? Why?

Answer

It is a classification problem because the goal is to classify students in two groups. The ones that need early intervention; and the ones that the early intervention is not needed.

EXPLORING THE DATA

Can you find out the following facts about the dataset?

Variable	Answer
Total number of students	395
# of students who passed	265
# of students who failed	130
# of features	31
Graduation rate of the class (%)	67.0

TRAINING AND EVALUATING THE MODELS

Choose 3 supervised learning models that are available in scikit-learn, and appropriate for this problem.

1. Gaussian Naive Bayes

1. What are the general applications of this model? It is a classification algorithm that assigns each observation to the most likely class given its predictor

values.
2. What are its strengths and weaknesses?
    1. **Strengths:** Easy to train.
    2. **Weaknesses**: Assumption of independence of attributes is constraining. For example, there is a high correlation between the father and the mother's education. These two attributes are arguably not independent.
3. Given what you know about the data so far, why did you choose this model to apply? It is intuitively easy to explain the results.
4. Fit this model to the training data, try to predict labels (for both training and test sets), and measure the F1 score.

	Training set	**Test set**
F1	79%	75%

1. Repeat this process with different training set sizes (100, 200, 300), keeping test set constant.
   Produce a table showing training time, prediction time, F1 score on training set and F1 score on test set, for each training set size.

Variable	**Training set size**		
	100	**200**	**300**
Training time (secs)	0.001	0.001	0.001
Prediction time (secs)	0	0	0
F1 score training set	81.9%	80.9%	79.0%
F1 score test set	78.1%	75.2%	71.3%

2. Support Vector Machine

1. What are the general applications of this model? It is an algorithm that performs classification tasks by constructing hyperplanes in a multidimensional space that separates cases of different class labels.
2. What are its strengths and weaknesses?
    1. **Strengths:**
        1. High accuracy
        2. With an appropiate kernel SVM work well even when data is not linearly separable

2. **Weaknesses**:
    1. Finding the right kernel might be difficult
    2. Training takes longer than Naive Bayes.

3. Given what you know about the data so far, why did you choose this model to apply? It much have higher accuracy than Naive Bayes

4. Fit this model to the training data, try to predict labels (for both training and test sets), and measure the F1 score.

	Training set	Test set
F1	79.0%	77.8%

1. Repeat this process with different training set sizes (100, 200, 300), keeping test set constant.
   Produce a table showing training time, prediction time, F1 score on training set and F1 score on test set, for each training set size.

Variable	Training set size		
	100	**200**	**300**
Training time (secs)	0.001	0.003	0.006
Prediction time (secs)	0.001	0.002	0.007
F1 score training set	87.3%	89.2%	88.3%
F1 score test set	81.2%	76.4%	77.8%

3. Decision Tree

1. What are the general applications of this model? It is algorithm that predict the value of a target variable by learning simple decision rules inferred from the data features.
2. What are its strengths and weaknesses?
    1. **Strengths:**
        1. Perhaps the most easiest model to interpret and explain
        2. It is non-parametric so that the date his non linearly separable is not a concern
    2. **Weaknesses**:

   1. Easy to overfit the data
   2. Training takes longer than Naive Bayes.

3. Given what you know about the data so far, why did you choose this model to apply? It much have higher accuracy than Naive Bayes

4. Fit this model to the training data, try to predict labels (for both training and test sets), and measure the F1 score.

	Training set	Test set
F1	79.0%	68.9%

1. Repeat this process with different training set sizes (100, 200, 300), keeping test set constant.
   Produce a table showing training time, prediction time, F1 score on training set and F1 score on test set, for each training set size.

Variable	Training set size		
	100	200	300
Training time (secs)	0.001	0.001	0.002
Prediction time (secs)	0.000	0.000	0.000
F1 score training set	100%	100%	100%
F1 score test set	72.6%	69.9%	68.9%

CHOOSING THE BEST MODEL

Based on the experiments you performed earlier, in 2–3 paragraphs explain to the board of supervisors what single model you choose as the best model. Which model has the best test F1 score and time efficiency? Which model is generally the most appropriate based on the available data, limited resources, cost, and performance? Please directly compare and contrast the numerical values recored to make your case.

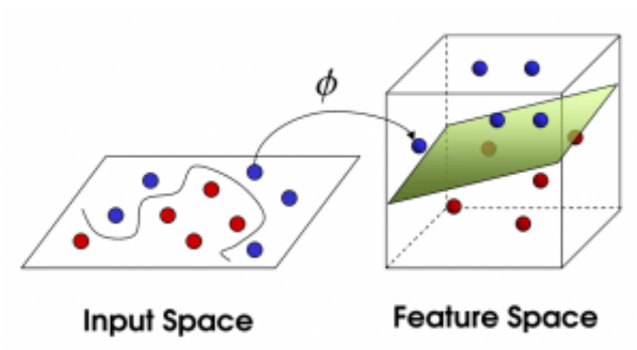
Answer

I would choose the SVM model because it has the best F1 score, and does not take much time to training it. That is, this model classifies correctly 78% of the students based on their information and is fast. Although estimating this model takes longer that the others, in practice, the difference is less than a fraction of a second.

Additionally the prediction gains are very noticeable. The SVM model has an accuracy of 78%, 9 percentage points above the tree model and 3 percentage points above the naive Bayes model.

How does this model work? Support vector machines projects all the futures in other space, facilitating the separation of the students according to their probability of passing their high school final exam.

In the following figure there is an example with two features (x and y axis) and two labels (the blue and red circles). Initially there is not a linar function that separates the labels. However, when one projects each point to a higher dimensional space, one can find a linear hyperplane that makes the separation possible. This is how SVM works.



Fine-tune the model. Use gridsearch with at least one important parameter tuned and with at least 3 settings. Use the entire training set for this.

What is the model's final F1 score?

Answer

The F1 score improved from 77.8% to 80.8% after tuning the model. A penalty value of 10, and a gamma of 0.001 were the optimal values in the grid search.