CM146, Fall 2018
Problem Set 01: Jonathan Chu

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1 Problem 2

(a) **Solution:**

$$Gain(S, X_j) = Entropy(S) - \sum_{v \in V} \frac{|S_v|}{|S|} Entropy(S_v)$$

$$Gain(S, X_j) = B\left(\frac{p}{p+n}\right) - \sum_{v \in V} \frac{|S_v|}{|S|} B\left(\frac{p}{p+n}\right)$$

$$Gain(S, X_j) = B\left(\frac{p}{p+n}\right)\left(1 - \sum_{v \in V} \frac{|S_v|}{|S|}\right) = 0$$

2 Problem 3

(a) **Solution:** Because a point is considered its own neighbor, the value of k that minimizes the training set error is 1. The resulting training error is 0, since our prediction will always equal the training example's value.

(b) **Solution:** Since our task is binary {-1, 1}, a very large value of k would cause the average output of neighbors to be very close to 0, meaning our prediction will always be low confidence.

A very small value of k could result in overfitting, since we only consider very similar examples in the training set when making a prediction. Outliers in the training data would have more impact on our predictions.

(c) **Solution:** By inspection, there is no value of k for which we can correctly predict the 2 upper +'s and the 2 lower -'s in a leave-one-out setting. Thus, the minimum error we can hope to achieve is 4/14.

Intuitively, we seek k values that encompass all or at least most of the other points in the same group of 7.

Values of k that achieve this are 5 and 7. 6 is not guaranteed to achieve minimum error because, for example, (1, 5) is equidistant to both (5, 1) which is not the desired prediction, and (5, 9) which is.

3 Problem 4

(a) **Solution:**

Pclass: The better the class, the greater the chance of survival. The 3rd class had a much lower frequency of survival than the other classes. Roughly 2/3 of first class members survived, and the 2nd class was fairly even between survivors and deaths.

Sex: There is a large disparity in survival rate between men and women, women being more fortunate.

Age: Children under ten had the highest survival rate. Otherwise, there isnt an obvious trend.

Siblings/Spouses: There werent many individuals with more than one sibling/spouse. Individuals with 1 sibling/spouse had the highest frequency of survival, and those with 0 had a rather low frequency of survival.

Parents/Children: There were very few individuals with more than 2 parents/children. Those with 1-2 had a high frequency of survival, and those with 0 had lower rates.

Fare: The majority of passengers paid a fare below 50, and these individuals had a rather low frequency of survival. All passengers who paid more had much greater survival rates.

Port of Embarkation: Passengers who embarked from Cherbourg had a much higher frequency of survival than the other 2 ports.

(b) **Solution:** We set the probabilities to [occurrences of 0]/[length of y] and [occurrences of 1]/[length of y] for 0 and 1, respectively, and generate n random values from {0, 1} using those probabilities:

Classifying using Random...

– training error: 0.485

(c) **Solution:**

Classifying using Decision Tree...

– training error: 0.014

(d) **Solution:**

Classifying using k-Nearest Neighbors...

– training error for k=3: 0.167

– training error for k=5: 0.201

– training error for k=7: 0.240

(e) **Solution:** Investigating various classifiers...

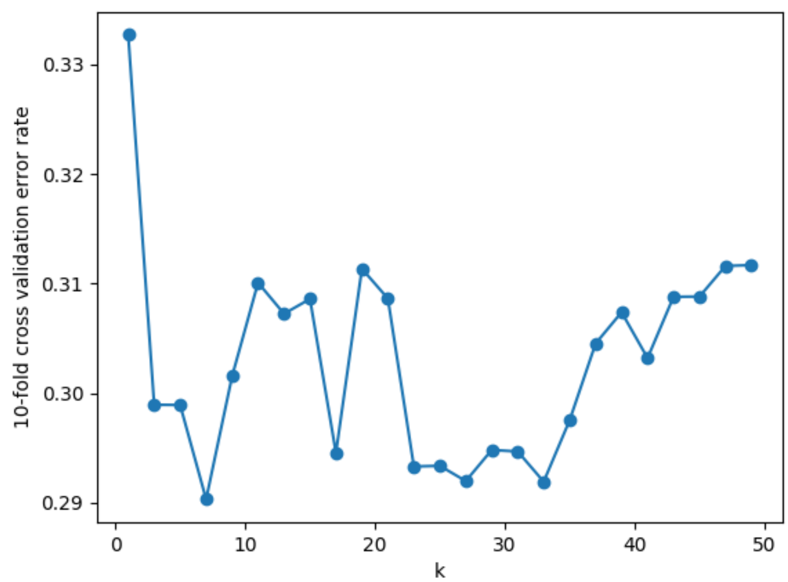
– MajorityVote: training error = 0.400, test error = 0.403

– Random: training error = 0.484, test error = 0.481

– DecisionTree: training error = 0.011, test error = 0.243

– KNeighbors: training error = 0.210, test error = 0.311

(f) **Solution:** Finding the best k for KNeighbors classifier... – the value of k that minimizes cross validation error is 7



(g) **Solution:** Investigating depths...

– the depth that minimizes cross validation error is 11

For larger depth values, there is clearly overfitting. The training error approaches zero, while the test error remains somewhat consistent.