Midterm III Study Guide and Review

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Midterm III Study Guide

Format: In Class with open-ended questions.

One-sided Cheat-sheet allowed (A4 paper) and a basic calculator allowed.

- You may use a calculator
- You are not permitted to use a laptop or classroom computer.

Topics

- The exam covers various machine learning topics including k-nearest neighbor, k-means, decision trees and random forests (through Fri. 11/11)
- You will be tested on your conceptual understanding of the machine learning algorithms, the accuracy metrics, and the associated construction of the workflow in R that we have discussed in the class. I will not make you write extremely complicated code from scratch, but be prepared to write small chunks of code. Additional ways I could assess your understanding of R include (but are not limited to):
  - Identifying the error in written code.
  - Putting lines of code in order to complete a specified task.
  - Describing the output resulting from a code/code-chunk.

Sample Questions

Q1: Random Forest

The following example uses `Carseats` data from ISLR package to classify the amount of sales (High or Low) depending on certain number of features.

```
Carseats <- as_tibble(Carseats) %>%
  mutate(High = factor(if_else(Sales <= 8, "No", "Yes"))) %>%
  select(-Sales)
glimpse(Carseats)
## Rows: 400
## Columns: 11
## $ CompPrice   <dbl> 138, 111, 113, 117, 141, 124, 115, 136, 132, 132, 121, 117~
## $ Income      <dbl> 73, 48, 35, 100, 64, 113, 105, 81, 110, 113, 78, 94, 35, 2~
## $ Advertising <dbl> 11, 16, 10, 4, 3, 13, 0, 15, 0, 0, 9, 4, 2, 11, 11, 5, 0, ~
## $ Population  <dbl> 276, 260, 269, 466, 340, 501, 45, 425, 108, 131, 150, 503,~
## $ Price       <dbl> 120, 83, 80, 97, 128, 72, 108, 120, 124, 124, 100, 94, 136~
## $ ShelveLoc   <fct> Bad, Good, Medium, Medium, Bad, Bad, Medium, Good, Medium,~
## $ Age         <dbl> 42, 65, 59, 55, 38, 78, 71, 67, 76, 76, 26, 50, 62, 53, 52~
## $ Education   <dbl> 17, 10, 12, 14, 13, 16, 15, 10, 10, 17, 10, 13, 18, 18, 18~
## $ Urban       <fct> Yes, Yes, Yes, Yes, Yes, No, Yes, Yes, No, No, No, Yes, Ye~
## $ US          <fct> Yes, Yes, Yes, Yes, No, Yes, No, Yes, No, Yes, Yes, Yes, N~
## $ High        <fct> Yes, Yes, Yes, No, No, Yes, No, Yes, No, No, Yes, Yes, No,~
```

(a) Roughly, how many observations are in the test and train datasets? *Answer:*

```
set.seed(1234)
Carseats_split <- initial_split(Carseats, prop = 0.75)
Carseats_train <- training(Carseats_split)
Carseats_test <- testing(Carseats_split)
```

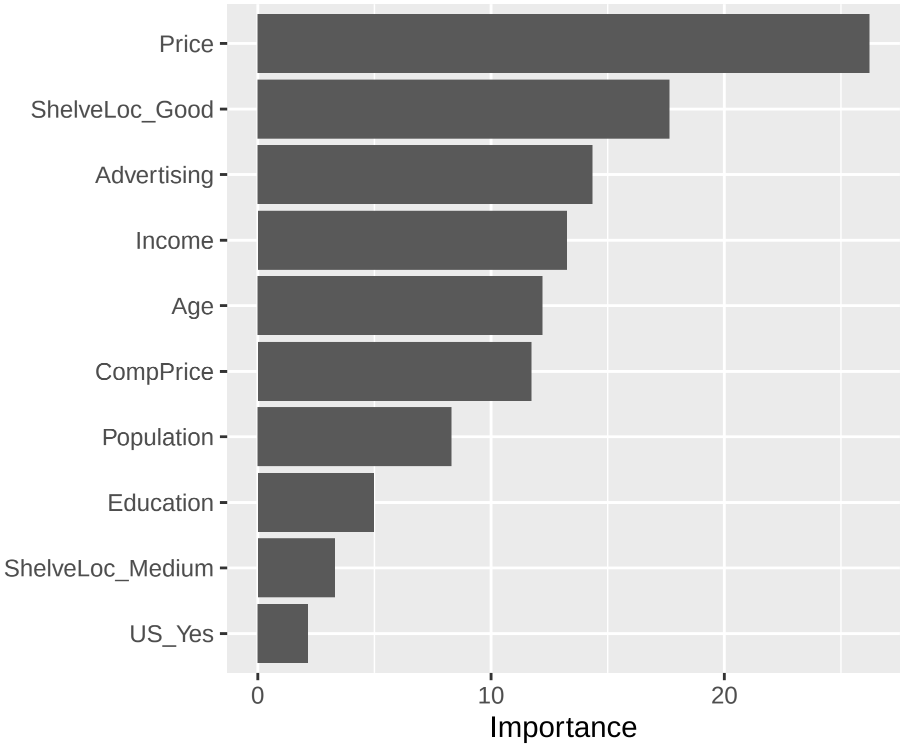
(b) Why do we need to split the data into training and testing set? Explain. *Answer:*

```
Carseats_recipe <- recipe(High ~ ., data = Carseats_train) %>%
 step_dummy(all_nominal(), -all_outcomes()) %>%
 prep()
```

```
decision_tree_rpart_spec <- rand_forest(mtry = tune()) %>%
  set_engine('ranger', importance = "impurity") %>%
  set_mode('classification')
```

(c) Explain the role of `tune()` inside the model specification. *Answer:*

(d) The importance plot for this algorithm is shown below. Which two predictors are most important? *Answer:*



```
tree_last_fit <- final_tree_workflow %>% last_fit(Carseats_split)
tree_predictions <- tree_last_fit %>% collect_predictions()
conf_mat(tree_predictions, truth = High, estimate = .pred_class)
##           Truth
## Prediction No Yes
##        No  46  12
##        Yes 10  32
```

(e) Calculate the accuracy metric of this algorithm based on the following confusion matrix. Accuracy:

Q2 : K-nearest neighbor

Let's fit a K-nearest neighbor algorithm using `Smarket` dataset which has daily percentage returns for the S&P 500 stock index between 2001 and 2005.

```
set.seed(1234)

data_Smarket <- as_tibble(Smarket)
split <- initial_split(data_Smarket, strata = Direction, prop = 4/5)
Smarket_train <- training(split)
Smarket_test <- testing(split)

# glimpses of data
glimpse(Smarket_train)
## Rows: 999
## Columns: 9
## $ Year      <dbl> 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, ~
## $ Lag1      <dbl> 1.032, 1.392, -0.498, 0.546, 0.359, -0.623, 1.183, -0.865, 0~
## $ Lag2      <dbl> 0.959, 0.213, 0.287, -0.562, -1.747, -0.841, -1.334, 1.183, ~
## $ Lag3      <dbl> 0.381, 0.614, 1.303, 0.701, 0.546, -0.151, -0.623, -1.334, -~
## $ Lag4      <dbl> -0.192, -0.623, 0.027, 0.680, -0.562, 0.359, -0.841, -0.623,~
## $ Lag5      <dbl> -2.624, 1.032, -0.403, -0.189, 0.701, -1.747, -0.151, -0.841~
## $ Volume    <dbl> 1.4112, 1.4450, 1.2580, 1.1188, 1.0130, 1.1072, 1.0391, 1.07~
## $ Today     <dbl> -0.623, -0.403, -0.189, -1.747, -0.151, -1.334, -0.865, -0.2~
## $ Direction <fct> Down, Down, Down, Down, Down, Down, Down, Down, Down, Down, ~
glimpse(Smarket_test)
## Rows: 251
## Columns: 9
## $ Year      <dbl> 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, 2001, ~
## $ Lag1      <dbl> 0.381, 0.614, 0.213, 0.287, 0.701, -0.562, -0.151, -0.841, -~
## $ Lag2      <dbl> -0.192, -0.623, 0.614, 1.303, 0.680, 0.701, 0.359, -0.151, -~
## $ Lag3      <dbl> -2.624, 1.032, -0.623, 0.027, -0.189, 0.680, -1.747, 0.359, ~
## $ Lag4      <dbl> -1.055, 0.959, 1.032, -0.403, -0.498, -0.189, 0.546, -1.747,~
## $ Lag5      <dbl> 5.010, 0.381, 0.959, 1.392, 0.287, -0.498, -0.562, 0.546, 0.~
## $ Volume    <dbl> 1.19130, 1.20570, 1.34910, 1.30900, 1.14980, 1.29530, 1.0596~
## $ Today     <dbl> 0.959, 0.213, 1.392, -0.498, -0.562, 0.546, -0.841, -0.623, ~
## $ Direction <fct> Up, Up, Up, Down, Down, Up, Down, Down, Up, Up, Up, Up, Up, ~
```

a. Briefly describe what the above set of codes do. Why do we need to split the data into training and test set? *Answer:*

b. The following trained model is used to produce a data-frame of the actual and predicted `Direction` in the test dataset. Call this data-frame `Smarket_results`. What information does

`Smarket_results` contain? What is the dimension of this dataset? Explain. *Answer:*

```r
Smarket_recipe <- recipe(Direction ~ Lag1 + Lag2 + Lag3 + Year + Volume,
                         data = Smarket_train) %>%
  step_center(all_predictors()) %>%
  step_scale(all_predictors()) %>%
  prep()

Smarket_knn_spec <- nearest_neighbor(mode = "classification",
                             engine = "kknn",
                             weight_func = "rectangular",
                             neighbors = 5)

Smarket_workflow <- workflow() %>%
  add_recipe(Smarket_recipe) %>%
  add_model(Smarket_knn_spec)

Smarket_fit <- fit(Smarket_workflow, data = Smarket_train)

test_features <- Smarket_test %>% select(Direction, Lag1, Lag2, Lag3, Year, Volume)
nn1_pred3 <- predict(Smarket_fit, test_features, type = "raw")
Smarket_results <- Smarket_test %>%
  select(Direction) %>%
  bind_cols(predicted = nn1_pred3) %>% mutate(Direction = as.factor(Direction))
```

c. The following is a confusion matrix from the prediction results from b. Calculate by hand the sensitivity, specificity, accuracy, and positive predictive value of the classifier. *Answer:*

Q3 Miscellaneous

(a) Explain the difference between unsupervised learning and supervised learning. *Answer:*

(b) Is feature scaling required for the K-NN algorithm? Explain with proper justification. *Answer:*

(c) For two runs of K-Mean clustering is it expected to get same clustering results? *Answer:*

(d) Is it possible that assignment of observations to clusters does not change between successive iterations in K-Means? *Answer:*

(e) (True/False) Precision is a useful metric in cases where False Positive is a higher concern than False Negatives. Provide explanations as well. *Answer:*

(f) Explain how you can use total within cluster sum of squares to find the "best" choice of K in a K-means clustering algorithm. *Answer:*

(g) Briefly explain why do we preprocess data in k nearest neighbors algorithm. *Answer:*

(h) (Multiple Choice) Given the following models trained using K-NN, the model which could result in underfitting will most likely have the value of K as

1. 30
2. 5
3. 1

Answer:

(i) Does centroid initialization affect K-means algorithm? Explain your answer. *Answer:*

(j) Logistic regression is a machine learning algorithm that is used to predict the probability of a ________? Write your letter choice in the blank.

(A) categorical independent variable
(B) categorical dependent variable.
(C) numerical dependent variable.
(D) numerical independent variable.

Answer: