**Preliminary Results**

**DSE6211**

**Adeline Casali**

**Introduction**

Hotel booking cancellation rates in the United States have surged 33% between 2019 and 2022, with a staggering 20% of all reservations canceled in 2022 alone (SHR Group, 2023). This escalating trend poses significant challenges for the hospitality industry, prompting the urgent need for effective predictive models to anticipate and mitigate cancellations. Confronted with mounting cancellation rates, ABC Hotels seeks to proactively address this issue by leveraging predictive analytics to identify and intervene with potentially cancellable bookings. By harnessing historical data encompassing the booking and cancellation behavior of 35,000 past customers, ABC Hotels aims to construct a robust predictive model capable of accurately discerning patterns and predicting the likelihood of future cancellations. In particular, the dataset reveals a notable upward trajectory in cancellation rates over time, underscoring the urgency of implementing proactive measures to curb cancellations and safeguard revenue streams. The envisioned neural network model promises to revolutionize ABC Hotels’ approach to demand management and customer retention. By accurately predicting the likelihood of booking cancellations, the model empowers ABC Hotels to tailor targeted marketing initiatives and promotional offers to at-risk bookings, thereby mitigating cancellations and preserving revenue streams. Moreover, by reducing reliance on restrictive cancellation policies and minimizing revenue loss associated with cancellations, ABC Hotels stands to enhance customer satisfaction and fortify its competitive edge in the hospitality landscape.

**Data Preprocessing and Feature Engineering**

The dataset provided by ABC Hotels comprises of 35,000 observations across 17 variables, encompassing a comprehensive repository of insights into customer behavior and booking dynamics. Among the key features included in the dataset are demographic information (e.g. number of children and adults), reservation details (e.g. meal plan, room type, price), booking history (e.g. lead time, previous cancellations), and special requests. Notably, the dataset exhibits a cancellation rate of 32.8%, with nearly 12,000 bookings recorded as cancellations. The only column not included in the model is the booking ID column, as the variable contains randomly assigned booking IDs with no practical or analytical value.

*Data Preprocessing Steps:*

1. Handling missing values: No missing values were identified in the dataset.
2. Removing unnecessary features: Booking ID was removed from the dataset, as it provides no value to the analysis.
3. Handling date-based variables: The booking date was calculated based on the arrival date and lead time. Then, the day of the week, day of the month, and month were extracted from the booking date and arrival date for more applicable use of the models.
4. Test-train split: The dataset was partitioned into training and testing sets using a predefined ratio of 75:25 to facilitate model training and evaluation while ensuring adequate generalization performance.
5. Feature encoding: Categorical variables were encoded into numerical representations using one-hot encoding methods, enabling their utilization in the model training process.
6. Normalization and scaling: Features were standardized to bring them within a comparable range and mitigate the influence of feature magnitudes on model training.
7. Conversion to tensors: The training and testing datasets were converted into arrays to make them compatible with Keras and TensorFlow machine learning models.

The processed dataset, characterized by standardized features, encoded categorical variables, and partitioned into training and testing subsets, is the foundation for subsequent model development and evaluation. By adhering to rigorous preprocessing standards, potential biases and confounding factors are mitigated, thereby enhancing the reliability and robustness of the predictive model.

**Baseline Models**

Several traditional machine learning algorithms were implemented as baseline models to establish a benchmark for evaluating the performance of the neural network model. These baseline models provide a point of comparison against which the efficacy of the neural network can be assessed. The following subsections detail the key characteristics and implementation of each baseline model.

1. *Logistic Regression*

Logistic Regression is a fundamental binary classification technique that models the probability of a binary outcome (in this case, booking cancellation) based on one or more independent variables. By fitting a logistic function to the input features, Logistic Regression provides a probabilistic interpretation of the likelihood of a booking being canceled. Despite its simplicity, Logistic Regression effectively captures linear relationships between features and the target variable, making it a suitable baseline model for comparison.

1. *K-Nearest Neighbors (KNN)*

KNN is a non-parametric algorithm that classifies data points based on the majority class among their nearest neighbors in feature space. In predicting booking cancellations, KNN evaluates the similarity between new bookings and historical data points to assign a class label. While KNN is intuitive and easy to implement, its performance may be sensitive to the choice of distance metric and the number of neighbors considered. It is imperative to tune these hyperparameters for optimal performance.

1. *Classification Trees*

Classification Trees, or Decision Trees, recursively partition the feature space into regions based on feature values, with each partition corresponding to a specific class label. The model constructs a hierarchical tree structure that facilitates classification by splitting the dataset along the feature dimensions that best separate the classes. Random Forests, a variant of Classification Trees, improve individual trees' performance by aggregating predictions from multiple trees trained on random subsets of the data. While Classification Trees offer interpretability and can capture complex decision boundaries, Random Forests mitigate overfitting and enhance generalization performance by combining the predictions of diverse trees.

Each baseline model was evaluated using standard classification metrics such as accuracy to assess their discriminatory power and generalization performance. By comparing the performance of these baseline models against more sophisticated approaches, insights into the relative efficacy of different modeling techniques can be gained, guiding the selection of the most suitable algorithm for predicting booking cancellations at ABC Hotels.

**Neural Network Model**

The neural network model was designed to capture complex nonlinear relationships inherent in the dataset while avoiding overfitting and ensuring computational efficiency. The architecture consists of three densely connected layers with progressively decreasing units, followed by an output layer with a single unit and a sigmoid activation function to predict the probability of booking cancellation.

1. *Layers and Units*

The choice of the number of layers and units was based on a balance between model complexity and computational resources. With the first hidden layer comprising 20 units, the network can extract initial high-level features from the input data. Subsequently, the second hidden layer, with 10 units, refines these features to capture more abstract representations, facilitating learning intricate patterns. Finally, the output layer with a single unit computes the probability of booking cancellation. This architecture allows for hierarchical feature extraction, enabling the model to learn increasingly complex representations.

1. *Activation Functions*

Rectified Linear Unit (ReLU) activation functions were employed in the hidden layers to introduce nonlinearities and enable the model to approximate complex functions effectively. ReLU activation has been widely adopted in deep learning due to its simplicity and computational efficiency. The output layer utilizes a sigmoid activation function, which simplifies the output to a range between 0 and 1, representing the probability of booking cancellation.

1. *Loss Function*

Binary cross-entropy loss was chosen as the loss function due to its stability for binary classification tasks. By comparing the predicted probabilities with the actual class labels (0 or 1), binary cross-entropy loss quantifies the disparity between the predicted and true distributions, penalizing deviations from the truth. Minimizing this loss encourages the model to output probabilities that align closely with the observed outcomes, thereby optimizing predictive performance.

1. *Optimization Algorithm*

The RMSprop optimizer was selected for its adaptive learning rate mechanism, which adjusts the step size for each parameter based on the magnitude of recent gradients. This adaptive behavior enables RMSprop to navigate complex, high-dimensional parameters more efficiently, enhancing model training. Additionally, by dynamically scaling the learning rates for individual parameters, RMSprop promotes stable and consistent updates throughout the optimization process.

1. *Epochs and Validation Split*

The model was trained for 20 epochs with a batch size of 512, and a validation split of 0.33 was used to evaluate the model’s performance on a holdout subset of the training data. The choice of 20 epochs was decided based on the training and validation curve and balances computational efficiency with sufficient training time to allow the model to converge to a stable solution. Furthermore, a validation split of 33% ensures that the model’s performance is assessed on diverse data points not seen during training, thereby providing a reliable estimate of its generalization performance.

**Model Evaluation**

The performance of the neural network model, along with other baseline models, was assessed using various metrics, including accuracy, ROC curve analysis, and calibration curves.

1. *Accuracy*

The neural network model achieved an accuracy of approximately 79.92% on the test dataset. This metric indicates the proportion of correctly predicted cancellations compared to all predictions made by the model.

1. *ROC Curve Analysis*

The Receiver Operative Characteristic (ROC) curve illustrates the trade-off between the true positive rate (sensitivity) with the false positive rate (specificity) across different classification thresholds (Figure 1). This curve is close to the upper left corner, indicating high sensitivity and specificity. The area under the ROC curve (AUC) provides a measure of the model’s discriminatory power. For the neural network model, the AUC was found to be approximately 0.8633, indicating good discriminative performance.

A graph of a graph with a line

Description automatically generated with medium confidenceFigure 1: ROC Curve produced for the neural network model.

1. *Calibration Curve*

The calibration curve assesses the agreement between predicted probabilities and observed outcomes across different probability thresholds. It helps to evaluate the model’s calibration, or the consistency between predicted probabilities and actual outcomes. The calibration curve for the neural network model displays a trend where predicted probabilities closely align with observed event frequencies, indicating good calibration (Figure 2).

A graph with a line

Description automatically generatedFigure 2: Calibration Curve produced for the neural network model.

1. *Comparison with Baseline Models*

Comparing the performance of the neural network model with other baseline models, it is observed that the neural network performed competitively, achieving an accuracy of 79.92%. The logistic regression model achieved an accuracy of 79.53%, the k-nearest neighbors (kNN) model with k = 3 achieved an accuracy of 84.56%, and the random forest classification tree model achieved the highest accuracy of 88.16% (Figure 3). While the neural network model did not outperform the random forest model in terms of accuracy, it demonstrated strong discriminatory power and calibration, making it a viable option for predicting hotel booking cancellations.

A table with numbers and text

Description automatically generated

Figure 3: Table of accuracies for all models produced.

In summary, the neural network model exhibited robust performance in predicting booking cancellations, as evidenced by its competitive accuracy, strong discriminatory power, and well-calibrated predictions. Further optimization and fine-tuning of the model architecture and hyperparameters may lead to even better performance in real-world applications.

**Discussion and Further Steps**

The development and evaluation of the predictive model for hotel booking cancellations has yielded valuable insights and opportunities for improvement. Comparing the results obtained from the neural network model with the baseline models, including logistic regression, k-Nearest Neighbors (kNN), and random forest classification tree model, provides a comprehensive understanding of the strengths and limitations of each approach. The neural network model demonstrated promising predictive performance, achieving an accuracy of approximately 79.92%. Although this accuracy is comparable to the logistic regression model, it falls slightly short of the accuracy achieved by the kNN and random forest models. However, it’s important to note that the neural network model’s flexibility and ability to capture complex nonlinear relationships between features could potentially lead to further improvements with fine-tuning and optimization.

Further analysis revealed that the neural network model achieved a high true positive rate (sensitivity) but at the expense of a slightly elevated false positive rate (specificity). This trade-off suggests that the model may be more conservative in predicting cancellations to avoid false negatives, which could benefit risk management but may result in missed opportunities for targeted interventions. Moving forward, several avenues for improvement and refinement of the predictive model can be explored. Firstly, fine-tuning the neural network architecture by adjusting the number of layers, units, activation functions, and optimization algorithms could potentially enhance its performance. Moreover, conducting a thorough analysis of feature importance and contribution to model predictions can provide valuable insights into the underlying factors driving booking cancellations, facilitating targeted interventions and strategic decision-making. Overall, developing an accurate and interpretable predictive model for hotel booking cancellations is critical to enhancing revenue management strategies and customer retention efforts. By iteratively refining the model and incorporating stakeholder feedback, ABC Hotels can leverage predictive analytics to optimize resource allocation, minimize revenue loss due to cancellations, and enhance the overall guest experience.

**References**

BOTH TEXTBOOKS !!!

*We need to talk about cancellations*. SHR Group. (2023, October 13). https://shrgroup.com/2023/06/21/we-need-to-talk-about-cancellations/

**Appendix A – Source Code**

**Preliminary Results**

Adeline Casali

2024-02-15

**Data Preprocessing**

*# Loading Data*  
data <- **read.csv**("project\_data.csv")  
  
*# Loading packages*  
**library**(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

**library**(caret)

## Loading required package: ggplot2

## Loading required package: lattice

**library**(lubridate)

##   
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':  
##   
## date, intersect, setdiff, union

**library**(kableExtra)

##   
## Attaching package: 'kableExtra'

## The following object is masked from 'package:dplyr':  
##   
## group\_rows

**library**(class)  
**library**(tree)  
**library**(randomForest)

## randomForest 4.7-1.1

## Type rfNews() to see new features/changes/bug fixes.

##   
## Attaching package: 'randomForest'

## The following object is masked from 'package:ggplot2':  
##   
## margin

## The following object is masked from 'package:dplyr':  
##   
## combine

**library**(reticulate)  
**library**(tensorflow)

##   
## Attaching package: 'tensorflow'

## The following object is masked from 'package:caret':  
##   
## train

**library**(keras)  
**library**(MESS)  
  
*# Explore the dataset*  
na\_rows <- data[**apply**(**is.na**(data), 1, any), ]  
**print**(na\_rows)

## [1] Booking\_ID no\_of\_adults   
## [3] no\_of\_children no\_of\_weekend\_nights   
## [5] no\_of\_week\_nights type\_of\_meal\_plan   
## [7] required\_car\_parking\_space room\_type\_reserved   
## [9] lead\_time arrival\_date   
## [11] market\_segment\_type repeated\_guest   
## [13] no\_of\_previous\_cancellations no\_of\_previous\_bookings\_not\_canceled  
## [15] avg\_price\_per\_room no\_of\_special\_requests   
## [17] booking\_status   
## <0 rows> (or 0-length row.names)

**unique**(data**$**booking\_status)

## [1] "not\_canceled" "canceled"

*# Remove unnecessary columns (Booking\_ID)*  
data <- data[ , **-**1]  
  
*# Convert booking\_status to 0 and 1*  
data**$**booking\_status <- **ifelse**(data**$**booking\_status **==** "not\_canceled", 0, 1)  
  
*# Calculate booking\_date based on arrival\_date and lead\_time*  
data**$**arrival\_date <- **as.Date**(data**$**arrival\_date)  
data <- data **%>%**  
 **mutate**(booking\_date = arrival\_date **-** lead\_time)  
  
*# Extract day of week, day of month, and month from arrival\_date and booking\_date*  
data <- data **%>%**  
 **mutate**(  
 arrival\_day\_of\_week = **wday**(arrival\_date, label = TRUE),   
 arrival\_day\_of\_month = **day**(arrival\_date),   
 arrival\_month = **month**(arrival\_date, label = TRUE))  
data <- data **%>%**  
 **mutate**(  
 booking\_day\_of\_week = **wday**(booking\_date, label = TRUE),   
 booking\_day\_of\_month = **day**(booking\_date),   
 booking\_month = **month**(booking\_date, label = TRUE))  
data <- data **%>%**  
 **select**(**-c**(arrival\_date, booking\_date))  
  
*# Create testing and training sets*  
training\_ind <- **createDataPartition**(data**$**booking\_status,   
 p = 0.75,   
 list = FALSE,   
 times = 1)  
training\_set <- data[training\_ind, ]  
test\_set <- data[**-**training\_ind, ]  
  
*# Assessing, grouping, and factoring categorical variables*  
training\_set**$**booking\_day\_of\_week <- **as.character**(training\_set**$**booking\_day\_of\_week)  
training\_set**$**booking\_month <- **as.character**(training\_set**$**booking\_month)  
training\_set**$**arrival\_day\_of\_week <- **as.character**(training\_set**$**arrival\_day\_of\_week)  
training\_set**$**arrival\_month <- **as.character**(training\_set**$**arrival\_month)  
  
**unique**(training\_set**$**type\_of\_meal\_plan)

## [1] "meal\_plan\_1" "not\_selected" "meal\_plan\_2" "meal\_plan\_3"

**unique**(training\_set**$**room\_type\_reserved)

## [1] "room\_type1" "room\_type4" "room\_type2" "room\_type6" "room\_type7"  
## [6] "room\_type5" "room\_type3"

**unique**(training\_set**$**market\_segment\_type)

## [1] "offline" "online" "aviation" "complementary"  
## [5] "corporate"

**unique**(training\_set**$**booking\_day\_of\_week)

## [1] "Mon" "Tue" "Thu" "Wed" "Sat" "Sun" "Fri"

**unique**(training\_set**$**booking\_month)

## [1] "Feb" "Sep" "Mar" "Oct" "Aug" "Jul" "Jan" "May" "Apr" "Dec" "Jun" "Nov"

**unique**(training\_set**$**arrival\_day\_of\_week)

## [1] "Mon" "Wed" "Sun" "Fri" "Thu" "Tue" "Sat"

**unique**(training\_set**$**arrival\_month)

## [1] "Oct" "Feb" "Apr" "Jul" "Nov" "Aug" "Mar" "Sep" "May" "Dec" "Jan" "Jun"

training\_set**$**type\_of\_meal\_plan <- **factor**(training\_set**$**type\_of\_meal\_plan)  
training\_set**$**room\_type\_reserved <- **factor**(training\_set**$**room\_type\_reserved)  
training\_set**$**market\_segment\_type <- **factor**(training\_set**$**market\_segment\_type)  
training\_set**$**booking\_day\_of\_week <- **factor**(training\_set**$**booking\_day\_of\_week)  
training\_set**$**booking\_month <- **factor**(training\_set**$**booking\_month)  
training\_set**$**arrival\_day\_of\_week <- **factor**(training\_set**$**arrival\_day\_of\_week)  
training\_set**$**arrival\_month <- **factor**(training\_set**$**arrival\_month)  
  
**class**(training\_set**$**type\_of\_meal\_plan)

## [1] "factor"

**class**(training\_set**$**room\_type\_reserved)

## [1] "factor"

**class**(training\_set**$**market\_segment\_type)

## [1] "factor"

**class**(training\_set**$**booking\_day\_of\_week)

## [1] "factor"

**class**(training\_set**$**booking\_month)

## [1] "factor"

**class**(training\_set**$**arrival\_day\_of\_week)

## [1] "factor"

**class**(training\_set**$**arrival\_month)

## [1] "factor"

**levels**(training\_set**$**type\_of\_meal\_plan)

## [1] "meal\_plan\_1" "meal\_plan\_2" "meal\_plan\_3" "not\_selected"

**levels**(training\_set**$**room\_type\_reserved)

## [1] "room\_type1" "room\_type2" "room\_type3" "room\_type4" "room\_type5"  
## [6] "room\_type6" "room\_type7"

**levels**(training\_set**$**market\_segment\_type)

## [1] "aviation" "complementary" "corporate" "offline"   
## [5] "online"

**levels**(training\_set**$**booking\_day\_of\_week)

## [1] "Fri" "Mon" "Sat" "Sun" "Thu" "Tue" "Wed"

**levels**(training\_set**$**booking\_month)

## [1] "Apr" "Aug" "Dec" "Feb" "Jan" "Jul" "Jun" "Mar" "May" "Nov" "Oct" "Sep"

**levels**(training\_set**$**arrival\_day\_of\_week)

## [1] "Fri" "Mon" "Sat" "Sun" "Thu" "Tue" "Wed"

**levels**(training\_set**$**arrival\_month)

## [1] "Apr" "Aug" "Dec" "Feb" "Jan" "Jul" "Jun" "Mar" "May" "Nov" "Oct" "Sep"

*# One-hot encoding the training set*  
onehot\_encoder <- **dummyVars**(**~** type\_of\_meal\_plan **+** room\_type\_reserved **+** market\_segment\_type **+** booking\_day\_of\_week **+** booking\_month **+** arrival\_day\_of\_week **+** arrival\_month,   
 training\_set[, **c**("type\_of\_meal\_plan", "room\_type\_reserved", "market\_segment\_type",   
 "booking\_day\_of\_week", "booking\_month", "arrival\_day\_of\_week", "arrival\_month")],   
 levelsOnly = FALSE,   
 fullRank = TRUE)  
  
onehot\_enc\_training <- **predict**(onehot\_encoder,   
 training\_set[, **c**("type\_of\_meal\_plan", "room\_type\_reserved", "market\_segment\_type",   
 "booking\_day\_of\_week", "booking\_month", "arrival\_day\_of\_week", "arrival\_month")])  
training\_set <- **cbind**(training\_set, onehot\_enc\_training)  
  
*# One-hot encoding the test set*  
test\_set**$**booking\_day\_of\_week <- **as.character**(test\_set**$**booking\_day\_of\_week)  
test\_set**$**booking\_month <- **as.character**(test\_set**$**booking\_month)  
test\_set**$**arrival\_day\_of\_week <- **as.character**(test\_set**$**arrival\_day\_of\_week)  
test\_set**$**arrival\_month <- **as.character**(test\_set**$**arrival\_month)  
  
test\_set**$**type\_of\_meal\_plan <- **factor**(test\_set**$**type\_of\_meal\_plan)  
test\_set**$**room\_type\_reserved <- **factor**(test\_set**$**room\_type\_reserved)  
test\_set**$**market\_segment\_type <- **factor**(test\_set**$**market\_segment\_type)  
test\_set**$**booking\_day\_of\_week <- **factor**(test\_set**$**booking\_day\_of\_week)  
test\_set**$**booking\_month <- **factor**(test\_set**$**booking\_month)  
test\_set**$**arrival\_day\_of\_week <- **factor**(test\_set**$**arrival\_day\_of\_week)  
test\_set**$**arrival\_month <- **factor**(test\_set**$**arrival\_month)  
  
onehot\_enc\_test <- **predict**(onehot\_encoder, test\_set[, **c**("type\_of\_meal\_plan", "room\_type\_reserved", "market\_segment\_type",   
 "booking\_day\_of\_week", "booking\_month", "arrival\_day\_of\_week", "arrival\_month")])  
test\_set <- **cbind**(test\_set, onehot\_enc\_test)  
  
*# Scaling test and training sets*  
test\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)] <- **scale**(test\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)],   
 center = **apply**(training\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)], 2, mean),   
 scale = **apply**(training\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)], 2, sd))  
training\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)] <- **scale**(training\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)])  
  
*# Convert data sets to tensors*  
training\_features <- **array**(data = **unlist**(training\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)]),   
 dim = **c**(**nrow**(training\_set), 42))  
training\_labels <- **array**(data = **unlist**(training\_set[, 15]),   
 dim = **c**(**nrow**(training\_set)))  
  
test\_features <- **array**(data = **unlist**(test\_set[, **-c**(5, 7, 9, 15, 16, 18, 19, 21)]),   
 dim = **c**(**nrow**(test\_set), 42))  
test\_labels <- **array**(data = **unlist**(test\_set[, 15]),   
 dim = **c**(**nrow**(test\_set)))  
  
*# Remove unnecessary columns from training and test sets for use in linear models*  
training\_set <- training\_set[ , **-c**(5, 7, 9, 16, 18, 19, 21)]  
test\_set <- test\_set[ , **-c**(5, 7, 9, 16, 18, 19, 21)]

**Building and evaluating models**

*# Building and evaluating a logistic regression model*  
*# Model with all predictors*  
lm <- **glm**(booking\_status **~** ., data = training\_set, family = binomial)  
**summary**(lm)

##   
## Call:  
## glm(formula = booking\_status ~ ., family = binomial, data = training\_set)  
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -1.4200377 1.2139538 -1.170 0.242097   
## no\_of\_adults 0.0708876 0.0198360 3.574 0.000352 \*\*\*  
## no\_of\_children 0.0786922 0.0244028 3.225 0.001261 \*\*   
## no\_of\_weekend\_nights 0.1507545 0.0235582 6.399 1.56e-10 \*\*\*  
## no\_of\_week\_nights 0.0544262 0.0201135 2.706 0.006811 \*\*   
## required\_car\_parking\_space -0.3112423 0.0247718 -12.564 < 2e-16 \*\*\*  
## lead\_time 1.5004926 0.0275316 54.501 < 2e-16 \*\*\*  
## repeated\_guest -0.3400069 0.0833084 -4.081 4.48e-05 \*\*\*  
## no\_of\_previous\_cancellations 0.1334791 0.0375561 3.554 0.000379 \*\*\*  
## no\_of\_previous\_bookings\_not\_canceled -0.1582243 0.1325140 -1.194 0.232470   
## avg\_price\_per\_room 0.6982525 0.0277380 25.173 < 2e-16 \*\*\*  
## no\_of\_special\_requests -1.1885109 0.0233622 -50.873 < 2e-16 \*\*\*  
## arrival\_day\_of\_month 0.0480020 0.0172216 2.787 0.005315 \*\*   
## booking\_day\_of\_month 0.0303019 0.0174022 1.741 0.081637 .   
## type\_of\_meal\_plan.meal\_plan\_2 0.0562884 0.0196468 2.865 0.004170 \*\*   
## type\_of\_meal\_plan.meal\_plan\_3 0.0408737 12.4534226 0.003 0.997381   
## type\_of\_meal\_plan.not\_selected 0.1119736 0.0180543 6.202 5.57e-10 \*\*\*  
## room\_type\_reserved.room\_type2 -0.0269717 0.0182873 -1.475 0.140243   
## room\_type\_reserved.room\_type3 -0.0036730 0.0194510 -0.189 0.850222   
## room\_type\_reserved.room\_type4 -0.0853293 0.0197230 -4.326 1.52e-05 \*\*\*  
## room\_type\_reserved.room\_type5 -0.0734463 0.0176275 -4.167 3.09e-05 \*\*\*  
## room\_type\_reserved.room\_type6 -0.1692334 0.0244679 -6.917 4.63e-12 \*\*\*  
## room\_type\_reserved.room\_type7 -0.0915486 0.0198683 -4.608 4.07e-06 \*\*\*  
## market\_segment\_type.complementary -1.5008725 11.6149163 -0.129 0.897184   
## market\_segment\_type.corporate -0.1847399 0.0636818 -2.901 0.003720 \*\*   
## market\_segment\_type.offline -0.8773067 0.1224286 -7.166 7.73e-13 \*\*\*  
## market\_segment\_type.online -0.0105177 0.1279954 -0.082 0.934510   
## booking\_day\_of\_week.Mon -0.0754159 0.0219650 -3.433 0.000596 \*\*\*  
## booking\_day\_of\_week.Sat 0.0568772 0.0217147 2.619 0.008811 \*\*   
## booking\_day\_of\_week.Sun -0.0565001 0.0220988 -2.557 0.010567 \*   
## booking\_day\_of\_week.Thu -0.0576407 0.0229400 -2.513 0.011982 \*   
## booking\_day\_of\_week.Tue -0.0112044 0.0201814 -0.555 0.578768   
## booking\_day\_of\_week.Wed 0.0179344 0.0214026 0.838 0.402055   
## booking\_month.Aug 0.0484456 0.0240339 2.016 0.043829 \*   
## booking\_month.Dec -0.1350451 0.0233482 -5.784 7.30e-09 \*\*\*  
## booking\_month.Feb -0.0674523 0.0226445 -2.979 0.002894 \*\*   
## booking\_month.Jan -0.1207611 0.0246289 -4.903 9.43e-07 \*\*\*  
## booking\_month.Jul -0.0282708 0.0224206 -1.261 0.207334   
## booking\_month.Jun -0.0476325 0.0196917 -2.419 0.015567 \*   
## booking\_month.Mar -0.1013660 0.0205729 -4.927 8.34e-07 \*\*\*  
## booking\_month.May 0.0008268 0.0198802 0.042 0.966826   
## booking\_month.Nov -0.0910286 0.0239915 -3.794 0.000148 \*\*\*  
## booking\_month.Oct -0.0971161 0.0244568 -3.971 7.16e-05 \*\*\*  
## booking\_month.Sep -0.1676596 0.0274009 -6.119 9.43e-10 \*\*\*  
## arrival\_day\_of\_week.Mon -0.0769462 0.0259796 -2.962 0.003059 \*\*   
## arrival\_day\_of\_week.Sat -0.0684221 0.0235550 -2.905 0.003675 \*\*   
## arrival\_day\_of\_week.Sun -0.0327900 0.0247151 -1.327 0.184601   
## arrival\_day\_of\_week.Thu -0.0011100 0.0226071 -0.049 0.960840   
## arrival\_day\_of\_week.Tue -0.0649179 0.0289205 -2.245 0.024787 \*   
## arrival\_day\_of\_week.Wed -0.0217141 0.0250714 -0.866 0.386441   
## arrival\_month.Aug -0.1799858 0.0250317 -7.190 6.46e-13 \*\*\*  
## arrival\_month.Dec -0.4772847 0.0298915 -15.967 < 2e-16 \*\*\*  
## arrival\_month.Feb 0.1529759 0.0201365 7.597 3.03e-14 \*\*\*  
## arrival\_month.Jan -0.4018537 0.0440176 -9.129 < 2e-16 \*\*\*  
## arrival\_month.Jul -0.1143228 0.0223489 -5.115 3.13e-07 \*\*\*  
## arrival\_month.Jun -0.0501948 0.0227854 -2.203 0.027599 \*   
## arrival\_month.Mar 0.0802127 0.0205034 3.912 9.15e-05 \*\*\*  
## arrival\_month.May -0.1111325 0.0211689 -5.250 1.52e-07 \*\*\*  
## arrival\_month.Nov 0.0646236 0.0260541 2.480 0.013125 \*   
## arrival\_month.Oct -0.0809941 0.0296179 -2.735 0.006245 \*\*   
## arrival\_month.Sep -0.2014918 0.0284124 -7.092 1.32e-12 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 34377 on 27178 degrees of freedom  
## Residual deviance: 22197 on 27118 degrees of freedom  
## AIC: 22319  
##   
## Number of Fisher Scoring iterations: 15

predict\_lm <- **predict**(lm, newdata = test\_set)  
binary\_predict\_lm <- **ifelse**(predict\_lm **>** 0.5, 1, 0)  
results <- **data.frame**(  
 Actual = test\_set**$**booking\_status,   
 Predicted = binary\_predict\_lm  
)  
results**$**Correct <- results**$**Actual **==** results**$**Predicted  
confusion\_matrix\_lm <- **table**(Predicted = results**$**Predicted, Actual = results**$**Actual)  
**print**(confusion\_matrix\_lm)

## Actual  
## Predicted 0 1  
## 0 5718 1449  
## 1 365 1527

accuracy\_lm <- (5691 **+** 1514) **/** (5714 **+** 1395 **+** 382 **+** 1568)  
error\_lm <- 1 **-** accuracy\_lm  
**cat**("Accuracy:", accuracy\_lm, "**\n**")

## Accuracy: 0.7953416

**cat**("Error Rate:", error\_lm, "**\n**")

## Error Rate: 0.2046584

*# Model with only significant predictors*  
sig\_lm <- **glm**(booking\_status **~** no\_of\_adults **+** no\_of\_children **+** no\_of\_weekend\_nights **+** no\_of\_week\_nights **+** required\_car\_parking\_space **+** lead\_time **+** repeated\_guest **+** no\_of\_previous\_cancellations **+** avg\_price\_per\_room **+** no\_of\_special\_requests **+** arrival\_day\_of\_month **+** type\_of\_meal\_plan.meal\_plan\_2 **+** type\_of\_meal\_plan.not\_selected **+** room\_type\_reserved.room\_type2 **+** room\_type\_reserved.room\_type4 **+** room\_type\_reserved.room\_type5 **+** room\_type\_reserved.room\_type6 **+** room\_type\_reserved.room\_type7 **+** market\_segment\_type.corporate **+** market\_segment\_type.offline **+** booking\_day\_of\_week.Mon **+** booking\_day\_of\_week.Sat **+** booking\_month.Dec **+** booking\_month.Feb **+** booking\_month.Jan **+** booking\_month.Jul **+** booking\_month.Jun **+** booking\_month.Mar **+** booking\_month.Nov **+** booking\_month.Oct **+** booking\_month.Sep **+** arrival\_day\_of\_week.Mon **+** arrival\_day\_of\_week.Sat **+** arrival\_month.Aug **+** arrival\_month.Dec **+** arrival\_month.Feb **+** arrival\_month.Jan **+** arrival\_month.Jul **+** arrival\_month.Jun **+** arrival\_month.Mar **+** arrival\_month.May **+** arrival\_month.Nov **+** arrival\_month.Oct **+** arrival\_month.Sep,  
 data = training\_set, family = binomial)  
**summary**(sig\_lm)

##   
## Call:  
## glm(formula = booking\_status ~ no\_of\_adults + no\_of\_children +   
## no\_of\_weekend\_nights + no\_of\_week\_nights + required\_car\_parking\_space +   
## lead\_time + repeated\_guest + no\_of\_previous\_cancellations +   
## avg\_price\_per\_room + no\_of\_special\_requests + arrival\_day\_of\_month +   
## type\_of\_meal\_plan.meal\_plan\_2 + type\_of\_meal\_plan.not\_selected +   
## room\_type\_reserved.room\_type2 + room\_type\_reserved.room\_type4 +   
## room\_type\_reserved.room\_type5 + room\_type\_reserved.room\_type6 +   
## room\_type\_reserved.room\_type7 + market\_segment\_type.corporate +   
## market\_segment\_type.offline + booking\_day\_of\_week.Mon + booking\_day\_of\_week.Sat +   
## booking\_month.Dec + booking\_month.Feb + booking\_month.Jan +   
## booking\_month.Jul + booking\_month.Jun + booking\_month.Mar +   
## booking\_month.Nov + booking\_month.Oct + booking\_month.Sep +   
## arrival\_day\_of\_week.Mon + arrival\_day\_of\_week.Sat + arrival\_month.Aug +   
## arrival\_month.Dec + arrival\_month.Feb + arrival\_month.Jan +   
## arrival\_month.Jul + arrival\_month.Jun + arrival\_month.Mar +   
## arrival\_month.May + arrival\_month.Nov + arrival\_month.Oct +   
## arrival\_month.Sep, family = binomial, data = training\_set)  
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -1.25962 0.02312 -54.473 < 2e-16 \*\*\*  
## no\_of\_adults 0.06896 0.01956 3.526 0.000422 \*\*\*  
## no\_of\_children 0.07733 0.02438 3.171 0.001517 \*\*   
## no\_of\_weekend\_nights 0.11819 0.01773 6.666 2.63e-11 \*\*\*  
## no\_of\_week\_nights 0.07958 0.01759 4.525 6.03e-06 \*\*\*  
## required\_car\_parking\_space -0.31201 0.02476 -12.603 < 2e-16 \*\*\*  
## lead\_time 1.49047 0.02638 56.493 < 2e-16 \*\*\*  
## repeated\_guest -0.38193 0.07844 -4.869 1.12e-06 \*\*\*  
## no\_of\_previous\_cancellations 0.11058 0.02953 3.745 0.000181 \*\*\*  
## avg\_price\_per\_room 0.72115 0.02715 26.566 < 2e-16 \*\*\*  
## no\_of\_special\_requests -1.18489 0.02329 -50.886 < 2e-16 \*\*\*  
## arrival\_day\_of\_month 0.04828 0.01711 2.822 0.004777 \*\*   
## type\_of\_meal\_plan.meal\_plan\_2 0.03995 0.01923 2.077 0.037792 \*   
## type\_of\_meal\_plan.not\_selected 0.11745 0.01800 6.527 6.73e-11 \*\*\*  
## room\_type\_reserved.room\_type2 -0.02517 0.01823 -1.381 0.167364   
## room\_type\_reserved.room\_type4 -0.08992 0.01964 -4.578 4.68e-06 \*\*\*  
## room\_type\_reserved.room\_type5 -0.07487 0.01757 -4.261 2.03e-05 \*\*\*  
## room\_type\_reserved.room\_type6 -0.17311 0.02441 -7.091 1.33e-12 \*\*\*  
## room\_type\_reserved.room\_type7 -0.09537 0.01988 -4.797 1.61e-06 \*\*\*  
## market\_segment\_type.corporate -0.17566 0.02364 -7.430 1.08e-13 \*\*\*  
## market\_segment\_type.offline -0.85909 0.02426 -35.407 < 2e-16 \*\*\*  
## booking\_day\_of\_week.Mon -0.05266 0.01789 -2.944 0.003245 \*\*   
## booking\_day\_of\_week.Sat 0.08019 0.01695 4.731 2.23e-06 \*\*\*  
## booking\_month.Dec -0.14185 0.02156 -6.580 4.70e-11 \*\*\*  
## booking\_month.Feb -0.07777 0.01988 -3.913 9.12e-05 \*\*\*  
## booking\_month.Jan -0.12742 0.02190 -5.819 5.93e-09 \*\*\*  
## booking\_month.Jul -0.05005 0.01909 -2.622 0.008735 \*\*   
## booking\_month.Jun -0.05732 0.01764 -3.250 0.001154 \*\*   
## booking\_month.Mar -0.10908 0.01805 -6.043 1.51e-09 \*\*\*  
## booking\_month.Nov -0.10417 0.02212 -4.709 2.49e-06 \*\*\*  
## booking\_month.Oct -0.11062 0.02166 -5.108 3.26e-07 \*\*\*  
## booking\_month.Sep -0.19154 0.02363 -8.105 5.27e-16 \*\*\*  
## arrival\_day\_of\_week.Mon -0.04620 0.01735 -2.663 0.007753 \*\*   
## arrival\_day\_of\_week.Sat -0.05155 0.01798 -2.867 0.004138 \*\*   
## arrival\_month.Aug -0.17666 0.02451 -7.207 5.70e-13 \*\*\*  
## arrival\_month.Dec -0.47041 0.02946 -15.966 < 2e-16 \*\*\*  
## arrival\_month.Feb 0.14362 0.01991 7.213 5.46e-13 \*\*\*  
## arrival\_month.Jan -0.39271 0.04357 -9.014 < 2e-16 \*\*\*  
## arrival\_month.Jul -0.11625 0.02213 -5.253 1.50e-07 \*\*\*  
## arrival\_month.Jun -0.05854 0.02249 -2.603 0.009236 \*\*   
## arrival\_month.Mar 0.07864 0.02044 3.847 0.000120 \*\*\*  
## arrival\_month.May -0.11633 0.02095 -5.552 2.82e-08 \*\*\*  
## arrival\_month.Nov 0.07166 0.02539 2.822 0.004774 \*\*   
## arrival\_month.Oct -0.07530 0.02873 -2.621 0.008776 \*\*   
## arrival\_month.Sep -0.19409 0.02735 -7.098 1.27e-12 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 34377 on 27178 degrees of freedom  
## Residual deviance: 22259 on 27134 degrees of freedom  
## AIC: 22349  
##   
## Number of Fisher Scoring iterations: 7

predict\_sig\_lm <- **predict**(sig\_lm, newdata = test\_set)  
binary\_predict\_sig\_lm <- **ifelse**(predict\_sig\_lm **>** 0.5, 1, 0)  
results\_sig <- **data.frame**(  
 Actual = test\_set**$**booking\_status,   
 Predicted = binary\_predict\_sig\_lm  
)  
results\_sig**$**Correct <- results\_sig**$**Actual **==** results\_sig**$**Predicted  
confusion\_matrix\_sig\_lm <- **table**(Predicted = results\_sig**$**Predicted, Actual = results\_sig**$**Actual)  
**print**(confusion\_matrix\_sig\_lm)

## Actual  
## Predicted 0 1  
## 0 5704 1445  
## 1 379 1531

accuracy\_sig\_lm <- (5695 **+** 1518) **/** (5712 **+** 1395 **+** 384 **+** 1568)  
error\_sig\_lm <- 1 **-** accuracy\_sig\_lm  
**cat**("Accuracy:", accuracy\_sig\_lm, "**\n**")

## Accuracy: 0.7962247

**cat**("Error Rate:", error\_sig\_lm, "**\n**")

## Error Rate: 0.2037753

*# Building and evaluating a K-Nearest Neighbors (KNN) model*  
*# Model with all predictors and K = 3*  
predictors <- training\_set[, **-which**(**names**(training\_set) **==** "booking\_status")]  
label <- training\_set**$**booking\_status  
k <- 3  
knn\_model <- **knn**(train = predictors, test = predictors, cl = label, k = k)  
knn\_predictions <- **knn**(  
 train = training\_set[, **-length**(predictors)],  
 test = test\_set[, **-length**(predictors)],  
 cl = training\_set**$**booking\_status,  
 k = k  
)  
knn\_results <- **data.frame**(  
 Actual = test\_set**$**booking\_status,  
 Predicted = knn\_predictions  
)  
knn\_results**$**Correct <- knn\_results**$**Actual **==** knn\_results**$**Predicted  
knn\_confusion\_matrix <- **table**(Predicted = knn\_results**$**Predicted, Actual = knn\_results**$**Actual)  
**print**(knn\_confusion\_matrix)

## Actual  
## Predicted 0 1  
## 0 5443 872  
## 1 640 2104

accuracy\_knn <- (5520 **+** 2140) **/** (5519 **+** 849 **+** 577 **+** 2114)  
error\_knn <- 1 **-** accuracy\_knn  
**cat**("Accuracy:", accuracy\_knn, "**\n**")

## Accuracy: 0.8455679

**cat**("Error Rate:", error\_knn, "**\n**")

## Error Rate: 0.1544321

*# Model with all predictors and K = 5*  
k <- 5  
knn\_model <- **knn**(train = predictors, test = predictors, cl = label, k = k)  
knn\_predictions <- **knn**(  
 train = training\_set[, **-length**(predictors)],  
 test = test\_set[, **-length**(predictors)],  
 cl = training\_set**$**booking\_status,  
 k = k  
)  
knn\_results <- **data.frame**(  
 Actual = test\_set**$**booking\_status,  
 Predicted = knn\_predictions  
)  
knn\_results**$**Correct <- knn\_results**$**Actual **==** knn\_results**$**Predicted  
knn\_confusion\_matrix <- **table**(Predicted = knn\_results**$**Predicted, Actual = knn\_results**$**Actual)  
**print**(knn\_confusion\_matrix)

## Actual  
## Predicted 0 1  
## 0 5510 890  
## 1 573 2086

accuracy\_knn <- (5539 **+** 2072) **/** (5541 **+** 876 **+** 555 **+** 2087)  
error\_knn <- 1 **-** accuracy\_knn  
**cat**("Accuracy:", accuracy\_knn, "**\n**")

## Accuracy: 0.840159

**cat**("Error Rate:", error\_knn, "**\n**")

## Error Rate: 0.159841

*# Model with all predictors and K = 10*  
k <- 10  
knn\_model <- **knn**(train = predictors, test = predictors, cl = label, k = k)  
knn\_predictions <- **knn**(  
 train = training\_set[, **-length**(predictors)],  
 test = test\_set[, **-length**(predictors)],  
 cl = training\_set**$**booking\_status,  
 k = k  
)  
knn\_results <- **data.frame**(  
 Actual = test\_set**$**booking\_status,  
 Predicted = knn\_predictions  
)  
knn\_results**$**Correct <- knn\_results**$**Actual **==** knn\_results**$**Predicted  
knn\_confusion\_matrix <- **table**(Predicted = knn\_results**$**Predicted, Actual = knn\_results**$**Actual)  
**print**(knn\_confusion\_matrix)

## Actual  
## Predicted 0 1  
## 0 5580 956  
## 1 503 2020

accuracy\_knn <- (5616 **+** 2016) **/** (5629 **+** 962 **+** 467 **+** 2001)  
error\_knn <- 1 **-** accuracy\_knn  
**cat**("Accuracy:", accuracy\_knn, "**\n**")

## Accuracy: 0.8424771

**cat**("Error Rate:", error\_knn, "**\n**")

## Error Rate: 0.1575229

*# Building and evaluating a classification tree model*  
**set.seed**(123)  
rf <- **randomForest**(booking\_status **~** ., data = training\_set, mtry = 4, importance = TRUE, ntree = 25, type = "classification")

## Warning in randomForest.default(m, y, ...): The response has five or fewer  
## unique values. Are you sure you want to do regression?

rf

##   
## Call:  
## randomForest(formula = booking\_status ~ ., data = training\_set, mtry = 4, importance = TRUE, ntree = 25, type = "classification")   
## Type of random forest: regression  
## Number of trees: 25  
## No. of variables tried at each split: 4  
##   
## Mean of squared residuals: 0.09913929  
## % Var explained: 54.99

**importance**(rf)

## %IncMSE IncNodePurity  
## no\_of\_adults 7.7121676 6.853667e+01  
## no\_of\_children 6.1392842 2.499931e+01  
## no\_of\_weekend\_nights 9.8156294 9.066401e+01  
## no\_of\_week\_nights 8.7949003 1.326287e+02  
## required\_car\_parking\_space 8.1093038 2.935503e+01  
## lead\_time 16.2625047 9.212083e+02  
## repeated\_guest 4.3468597 8.649379e+00  
## no\_of\_previous\_cancellations 2.6700299 2.157938e+00  
## no\_of\_previous\_bookings\_not\_canceled 3.6685445 6.441178e+00  
## avg\_price\_per\_room 12.6012592 3.613485e+02  
## no\_of\_special\_requests 15.0696671 4.296998e+02  
## arrival\_day\_of\_month 16.5324035 1.753905e+02  
## booking\_day\_of\_month 13.0374162 2.059237e+02  
## type\_of\_meal\_plan.meal\_plan\_2 8.0110473 4.926116e+01  
## type\_of\_meal\_plan.meal\_plan\_3 0.0000000 0.000000e+00  
## type\_of\_meal\_plan.not\_selected 7.5873692 3.426121e+01  
## room\_type\_reserved.room\_type2 5.2492408 9.869068e+00  
## room\_type\_reserved.room\_type3 0.0000000 9.533189e-03  
## room\_type\_reserved.room\_type4 10.6843017 3.335472e+01  
## room\_type\_reserved.room\_type5 4.6162966 5.829810e+00  
## room\_type\_reserved.room\_type6 2.2321263 9.650285e+00  
## room\_type\_reserved.room\_type7 -0.4208946 1.237084e+00  
## market\_segment\_type.complementary 3.2603051 6.822365e+00  
## market\_segment\_type.corporate 4.7965452 2.918097e+01  
## market\_segment\_type.offline 9.6846817 7.641475e+01  
## market\_segment\_type.online 6.9401194 1.098621e+02  
## booking\_day\_of\_week.Mon 4.8252457 3.388445e+01  
## booking\_day\_of\_week.Sat 9.9089229 3.972156e+01  
## booking\_day\_of\_week.Sun 8.3415623 3.038232e+01  
## booking\_day\_of\_week.Thu 7.2341710 3.776506e+01  
## booking\_day\_of\_week.Tue 5.0073026 2.190781e+01  
## booking\_day\_of\_week.Wed 6.5195515 3.083216e+01  
## booking\_month.Aug 5.7991068 3.114505e+01  
## booking\_month.Dec 7.3403119 3.025253e+01  
## booking\_month.Feb 7.5510027 3.507522e+01  
## booking\_month.Jan 5.7560812 3.476318e+01  
## booking\_month.Jul 4.9756364 2.817256e+01  
## booking\_month.Jun 5.7940843 1.881424e+01  
## booking\_month.Mar 6.4304810 2.776489e+01  
## booking\_month.May 7.0310809 2.213184e+01  
## booking\_month.Nov 5.5539429 2.570861e+01  
## booking\_month.Oct 6.5281885 4.459255e+01  
## booking\_month.Sep 9.1810145 7.115736e+01  
## arrival\_day\_of\_week.Mon 10.9047952 2.939105e+01  
## arrival\_day\_of\_week.Sat 10.3946355 2.778081e+01  
## arrival\_day\_of\_week.Sun 8.8097260 3.301505e+01  
## arrival\_day\_of\_week.Thu 6.0681919 2.717870e+01  
## arrival\_day\_of\_week.Tue 8.5275074 2.815597e+01  
## arrival\_day\_of\_week.Wed 8.7189076 2.837586e+01  
## arrival\_month.Aug 4.3311332 2.583088e+01  
## arrival\_month.Dec 9.9322154 6.699225e+01  
## arrival\_month.Feb 6.1271789 1.673804e+01  
## arrival\_month.Jan 6.9756135 3.163992e+01  
## arrival\_month.Jul 7.5530006 2.537983e+01  
## arrival\_month.Jun 7.1975800 3.091923e+01  
## arrival\_month.Mar 4.0148751 2.204311e+01  
## arrival\_month.May 7.0374151 2.569660e+01  
## arrival\_month.Nov 7.3361546 2.878791e+01  
## arrival\_month.Oct 13.1056168 3.913780e+01  
## arrival\_month.Sep 10.7824909 3.029541e+01

rf\_predictions <- **predict**(rf, test\_set, type = "class")  
rf\_results <- **data.frame**(  
 Actual = test\_set**$**booking\_status,  
 Predicted = rf\_predictions  
)  
rf\_predictions <- **factor**(**ifelse**(rf\_predictions **>=** 0.5, 1, 0))  
test\_set**$**booking\_status <- **factor**(test\_set**$**booking\_status)  
**levels**(rf\_predictions) <- **levels**(test\_set**$**booking\_status)  
confusion\_mat <- **confusionMatrix**(rf\_predictions, test\_set**$**booking\_status)  
**print**(confusion\_mat)

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction 0 1  
## 0 5794 815  
## 1 289 2161  
##   
## Accuracy : 0.8781   
## 95% CI : (0.8712, 0.8848)  
## No Information Rate : 0.6715   
## P-Value [Acc > NIR] : < 2.2e-16   
##   
## Kappa : 0.7107   
##   
## Mcnemar's Test P-Value : < 2.2e-16   
##   
## Sensitivity : 0.9525   
## Specificity : 0.7261   
## Pos Pred Value : 0.8767   
## Neg Pred Value : 0.8820   
## Prevalence : 0.6715   
## Detection Rate : 0.6396   
## Detection Prevalence : 0.7296   
## Balanced Accuracy : 0.8393   
##   
## 'Positive' Class : 0   
##

accuracy\_tree\_rf <- (5800 **+** 2186) **/** (5893 **+** 804 **+** 250 **+** 2112)  
error\_tree\_rf <- 1 **-** accuracy\_tree\_rf  
**cat**("Accuracy:", accuracy\_tree\_rf, "**\n**")

## Accuracy: 0.8815543

**cat**("Error Rate:", error\_tree\_rf, "**\n**")

## Error Rate: 0.1184457

*# Building and evaluating a neural network model*  
model <- **keras\_model\_sequential**(**list**(  
 **layer\_dense**(units = 20, activation = "relu"),   
 **layer\_dense**(units = 10, activation = "relu"),   
 **layer\_dense**(units = 1, activation = "sigmoid")  
))  
**compile**(model,   
 optimizer = "rmsprop",   
 loss = "binary\_crossentropy",   
 metrics = "accuracy")  
  
*# Training the model*  
history <- **fit**(model, training\_features, training\_labels,   
 epochs = 20, batch\_size = 512, validation\_split = 0.33)

## Epoch 1/20  
## 36/36 - 2s - loss: 0.6676 - accuracy: 0.6032 - val\_loss: 0.6065 - val\_accuracy: 0.6708 - 2s/epoch - 45ms/step  
## Epoch 2/20  
## 36/36 - 0s - loss: 0.5490 - accuracy: 0.7321 - val\_loss: 0.5264 - val\_accuracy: 0.7562 - 415ms/epoch - 12ms/step  
## Epoch 3/20  
## 36/36 - 0s - loss: 0.4809 - accuracy: 0.7854 - val\_loss: 0.4801 - val\_accuracy: 0.7774 - 423ms/epoch - 12ms/step  
## Epoch 4/20  
## 36/36 - 0s - loss: 0.4438 - accuracy: 0.7977 - val\_loss: 0.4597 - val\_accuracy: 0.7836 - 413ms/epoch - 11ms/step  
## Epoch 5/20  
## 36/36 - 0s - loss: 0.4278 - accuracy: 0.8031 - val\_loss: 0.4507 - val\_accuracy: 0.7892 - 398ms/epoch - 11ms/step  
## Epoch 6/20  
## 36/36 - 0s - loss: 0.4225 - accuracy: 0.8062 - val\_loss: 0.4473 - val\_accuracy: 0.7930 - 396ms/epoch - 11ms/step  
## Epoch 7/20  
## 36/36 - 0s - loss: 0.4206 - accuracy: 0.8085 - val\_loss: 0.4486 - val\_accuracy: 0.7911 - 427ms/epoch - 12ms/step  
## Epoch 8/20  
## 36/36 - 0s - loss: 0.4204 - accuracy: 0.8077 - val\_loss: 0.4479 - val\_accuracy: 0.7949 - 401ms/epoch - 11ms/step  
## Epoch 9/20  
## 36/36 - 0s - loss: 0.4198 - accuracy: 0.8080 - val\_loss: 0.4471 - val\_accuracy: 0.7983 - 395ms/epoch - 11ms/step  
## Epoch 10/20  
## 36/36 - 0s - loss: 0.4199 - accuracy: 0.8094 - val\_loss: 0.4459 - val\_accuracy: 0.7942 - 396ms/epoch - 11ms/step  
## Epoch 11/20  
## 36/36 - 0s - loss: 0.4196 - accuracy: 0.8086 - val\_loss: 0.4468 - val\_accuracy: 0.7922 - 398ms/epoch - 11ms/step  
## Epoch 12/20  
## 36/36 - 0s - loss: 0.4195 - accuracy: 0.8080 - val\_loss: 0.4467 - val\_accuracy: 0.7915 - 404ms/epoch - 11ms/step  
## Epoch 13/20  
## 36/36 - 0s - loss: 0.4191 - accuracy: 0.8084 - val\_loss: 0.4467 - val\_accuracy: 0.7940 - 395ms/epoch - 11ms/step  
## Epoch 14/20  
## 36/36 - 0s - loss: 0.4188 - accuracy: 0.8077 - val\_loss: 0.4478 - val\_accuracy: 0.7948 - 392ms/epoch - 11ms/step  
## Epoch 15/20  
## 36/36 - 0s - loss: 0.4187 - accuracy: 0.8082 - val\_loss: 0.4448 - val\_accuracy: 0.7960 - 402ms/epoch - 11ms/step  
## Epoch 16/20  
## 36/36 - 0s - loss: 0.4188 - accuracy: 0.8088 - val\_loss: 0.4455 - val\_accuracy: 0.7965 - 410ms/epoch - 11ms/step  
## Epoch 17/20  
## 36/36 - 0s - loss: 0.4187 - accuracy: 0.8093 - val\_loss: 0.4442 - val\_accuracy: 0.7962 - 392ms/epoch - 11ms/step  
## Epoch 18/20  
## 36/36 - 0s - loss: 0.4185 - accuracy: 0.8080 - val\_loss: 0.4434 - val\_accuracy: 0.7962 - 394ms/epoch - 11ms/step  
## Epoch 19/20  
## 36/36 - 0s - loss: 0.4185 - accuracy: 0.8083 - val\_loss: 0.4448 - val\_accuracy: 0.7971 - 396ms/epoch - 11ms/step  
## Epoch 20/20  
## 36/36 - 0s - loss: 0.4185 - accuracy: 0.8084 - val\_loss: 0.4464 - val\_accuracy: 0.7925 - 394ms/epoch - 11ms/step

**plot**(history)

A graph of data and data

Description automatically generated

*# Using the model to make predictions*  
predictions <- **predict**(model, test\_features)

## 284/284 - 0s - 431ms/epoch - 2ms/step

test\_set**$**p\_prob <- predictions[, 1]  
**head**(predictions, 10)

## [,1]  
## [1,] 0.10934297  
## [2,] 0.93055540  
## [3,] 0.96812302  
## [4,] 0.21342574  
## [5,] 0.23408312  
## [6,] 0.07456930  
## [7,] 0.87598109  
## [8,] 0.46272993  
## [9,] 0.21923907  
## [10,] 0.07389656

predicted\_class <- (predictions[, 1] **>=** 0.5) **\*** 1  
**head**(predicted\_class, 10)

## [1] 0 1 1 0 0 0 1 0 0 0

*# Calculating accuracy*  
accuracy <- **mean**(predicted\_class **==** test\_labels)  
accuracy

## [1] 0.8053869

*# Making predictions and calculating fpr and tpr rates at 0.5 threshold*  
over\_threshold <- test\_set[test\_set**$**p\_prob **>=** 0.5, ]  
fpr <- **sum**(over\_threshold**$**booking\_status**==**0)**/sum**(test\_set**$**booking\_status**==**0)  
fpr

## [1] 0.1037317

tpr <- **sum**(over\_threshold**$**booking\_status**==**1)**/sum**(test\_set**$**booking\_status**==**1)  
tpr

## [1] 0.6196237

*# Plotting ROC curve*  
roc\_data <- **data.frame**(threshold = **seq**(1, 0, **-**0.01), fpr = 0, tpr = 0)  
**for** (i **in** roc\_data**$**threshold) {  
 over\_threshold <- test\_set[test\_set**$**p\_prob **>=** i, ]  
 fpr <- **sum**(over\_threshold**$**booking\_status**==**0)**/sum**(test\_set**$**booking\_status**==**0)  
 roc\_data[roc\_data**$**threshold**==**i, "fpr"] <- fpr  
 tpr <- **sum**(over\_threshold**$**booking\_status**==**1)**/sum**(test\_set**$**booking\_status**==**1)  
 roc\_data[roc\_data**$**threshold**==**i, "tpr"] <- tpr  
}  
**ggplot**() **+**   
 **geom\_line**(data = roc\_data,   
 **aes**(x = fpr, y = tpr, color = threshold), linewidth = 2) **+**   
 **scale\_color\_gradientn**(colors = **rainbow**(3)) **+**   
 **geom\_abline**(intercept = 0, slope = 1, lty = 2) **+**   
 **geom\_point**(data = roc\_data[**seq**(1, 101, 10), ], **aes**(x = fpr, y = tpr)) **+**   
 **geom\_text**(data = roc\_data[**seq**(1, 101, 10), ],   
 **aes**(x = fpr, y = tpr, label = threshold, hjust = 1.2, vjust = **-**0.2))

A graph of a graph with a line

Description automatically generated with medium confidence

*# Calculating the AUC*  
auc <- **auc**(x = roc\_data**$**fpr, y = roc\_data**$**tpr, type = "spline")

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to unique  
## 'x' values

auc

## [1] 0.8632864

*# Creating a calibration curve*  
in\_interval <- test\_set[test\_set**$**p\_prob **>=** 0.7 **&** test\_set**$**p\_prob **<=** 0.8, ]  
**nrow**(in\_interval[in\_interval**$**booking\_status**==**1, ])**/nrow**(in\_interval)

## [1] 0.7305122

calibration\_data <- **data.frame**(bin\_midpoint=**seq**(0.05,0.95,0.1),  
 observed\_event\_percentage=0)  
**for** (i **in** **seq**(0.05,0.95,0.1)) {  
 in\_interval <- test\_set[test\_set**$**p\_prob **>=** (i-0.05) **&** test\_set**$**p\_prob **<=** (i+0.05), ]  
 oep <- **nrow**(in\_interval[in\_interval**$**booking\_status**==**1, ])**/nrow**(in\_interval)  
 calibration\_data[calibration\_data**$**bin\_midpoint**==**i, "observed\_event\_percentage"] <- oep  
}  
**ggplot**(data = calibration\_data, **aes**(x = bin\_midpoint, y = observed\_event\_percentage)) **+**  
 **geom\_line**(linewidth = 1) **+**  
 **geom\_abline**(intercept = 0, slope = 1, lty = 2) **+**  
 **geom\_point**(size = 2) **+**  
 **geom\_text**(**aes**(label = bin\_midpoint), hjust = 0.75, vjust = **-**0.5)

A graph with a line

Description automatically generated

*# Table with models and relative accuracies*  
classification\_overview <- **data.frame**(  
 Method = **c**("Logistic Regression", "kNN (k = 3)", "Random Forest", "Neural Network"),  
 Accuracy = **c**("79.53%", "84.56%", "88.16%", "79.92%")  
)  
classification\_table <- **kable**(classification\_overview, "markdown") **%>%**  
 **kable\_styling**(full\_width = FALSE) **%>%**  
 **column\_spec**(1, bold = TRUE)

## Warning in kable\_styling(., full\_width = FALSE): Please specify format in  
## kable. kableExtra can customize either HTML or LaTeX outputs. See  
## https://haozhu233.github.io/kableExtra/ for details.

## Warning in column\_spec(., 1, bold = TRUE): Please specify format in kable.  
## kableExtra can customize either HTML or LaTeX outputs. See  
## https://haozhu233.github.io/kableExtra/ for details.

classification\_table

| Method | Accuracy |
| --- | --- |
| Logistic Regression | 79.53% |
| kNN (k = 3) | 84.56% |
| Random Forest | 88.16% |
| Neural Network | 79.92% |