

## ELECTION FORECASTING REVISITED

In the recitation from Unit 3, we used logistic regression on polling data in order to construct US presidential election predictions. We separated our data into a training set, containing data from 2004 and 2008 polls, and a test set, containing the data from 2012 polls. We then proceeded to develop a logistic regression model to forecast the 2012 US presidential election.

In this homework problem, we'll revisit our logistic regression model from Unit 3, and learn how to plot the output on a map of the United States. Unlike what we did in the Crime lecture, this time we'll be plotting predictions rather than data!

First, load the `ggplot2`, `maps`, and `ggmap` packages using the `library` function. All three packages should be installed on your computer from lecture, but if not, you may need to install them too using the `install.packages` function.

Then, load the US map and save it to the variable `statesMap`, like we did during the Crime lecture:

```
statesMap = map_data("state")
```

The `maps` package contains other built-in maps, including a US county map, a world map, and maps for France and Italy.

### PROBLEM 1.1 - DRAWING A MAP OF THE US (1/1 point)

If you look at the structure of the `statesMap` data frame using the `str` function, you should see that there are 6 variables. One of the variables, `group`, defines the different shapes or polygons on the map. Sometimes a state may have multiple groups, for example, if it includes islands. How many different groups are there?

**Answer:** 63

#### EXPLANATION

You can count the number of different values of the `group` variable by using the command `table(statesMap$group)`. There are 63 different values.

Alternatively, you could use the command `length(table(statesMap$group))` as a shortcut to counting the number of groups in the table output.

The variable `"order"` defines the order to connect the points within each group, and the variable `"region"` gives the name of the state.

[Hide Answer](#)*You have used 3 of 3 submissions*

### PROBLEM 1.2 - DRAWING A MAP OF THE US (1/1 point)

You can draw a map of the United States by typing the following in your R console:

```
ggplot(statesMap, aes(x = long, y = lat, group = group)) + geom_polygon(fill = "white", color = "black")
```

We specified two colors in `geom_polygon` -- `fill` and `color`. Which one defined the color of the outline of the states?

- ☐ fill
- ☒ color 
- ☐ Neither

#### EXPLANATION

In our plot, the states are outlined in black, which is the color we specified for the option "color". To confirm that this is changing the outline color of the states, you can try re-running the command with a different color:

```
ggplot(statesMap, aes(x = long, y = lat, group = group)) + geom_polygon(fill = "white", color = "pink")
```

Hide Answer

You have used 1 of 1 submissions

### PROBLEM 2.1 - COLORING THE STATES BY PREDICTIONS (2/2 points)

Now, let's color the map of the US according to our 2012 US presidential election predictions from the Unit 3 Recitation. We'll rebuild the model here, using the dataset [PollingImputed.csv](#). Be sure to use this file so that you don't have to redo the imputation to fill in the missing values, like we did in the Unit 3 Recitation.

Load the data using the `read.csv` function, and call it "polling". Then split the data using the `subset` function into a training set called "Train" that has observations from 2004 and 2008, and a testing set called "Test" that has observations from 2012.

Note that we only have 45 states in our testing set, since we are missing observations for Alaska, Delaware, Alabama, Wyoming, and Vermont, so these states will not appear colored in our map.

Then, create a logistic regression model and make predictions on the test set using the following commands:

```
mod2 = glm(Republican~SurveyUSA+DiffCount, data=Train, family="binomial")
```

```
TestPrediction = predict(mod2, newdata=Test, type="response")
```

`TestPrediction` gives the predicted probabilities for each state, but let's also create a vector of Republican/Democrat predictions by using the following command:

```
TestPredictionBinary = as.numeric(TestPrediction > 0.5)
```

Now, put the predictions and state labels in a data.frame so that we can use `ggplot`:

```
predictionDataFrame = data.frame(TestPrediction, TestPredictionBinary, Test$State)
```

To make sure everything went smoothly, answer the following questions.

For how many states is our binary prediction 1 (for 2012), corresponding to Republican?

22

**Answer:** 22

What is the average predicted probability of our model (on the Test set, for 2012)?

0.4853000

**Answer:** 0.4852626

#### EXPLANATION

You can create the data frame `predictionDataFrame` by running the following lines of R code:

```
polling = read.csv("PollingImputed.csv")
```

```
Train = subset(polling, Year < 2012)
```

```
Test = subset(polling, Year == 2012)
```

```
mod2 = glm(Republican~SurveyUSA+DiffCount, data=Train, family="binomial")
```

```
TestPrediction = predict(mod2, newdata=Test, type="response")
```

```
TestPredictionBinary = as.numeric(TestPrediction > 0.5)
```

```
predictionDataFrame = data.frame(TestPrediction, TestPredictionBinary, Test$State)
```

You can answer the two questions with the functions `table(TestPredictionBinary)` and `mean(TestPrediction)`.

Hide Answer

*You have used 3 of 3 submissions*

## PROBLEM 2.2 - COLORING THE STATES BY PREDICTIONS (2/2 points)

Now, we need to merge "predictionDataFrame" with the map data "statesMap", like we did in lecture. Before doing so, we need to convert the `Test.State` variable to lowercase, so that it matches the `region` variable in `statesMap`. Do this by typing the following in your R console:

```
predictionDataFrame$region = tolower(predictionDataFrame$Test.State)
```

Now, merge the two data frames using the following command:

```
predictionMap = merge(statesMap, predictionDataFrame, by = "region")
```

Lastly, we need to make sure the observations are in order so that the map is drawn properly, by typing the following:

```
predictionMap = predictionMap[order(predictionMap$order),]
```

How many observations are there in `predictionMap`?

15034

**Answer:** 15034

How many observations are there in `statesMap`?

15537

**Answer:** 15537

#### EXPLANATION

If you type `str(predictionMap)`, you should see that there are 15034 observations, and if you type `str(statesMap)` you should see that there are 15537 observations.

Hide Answer

You have used 3 of 3 submissions

### PROBLEM 2.3 - COLORING THE STATES BY PREDICTIONS (1 point possible)

When we merged the data in the previous problem, it caused the number of observations to change. Why? Check out the help page for `merge` by typing `?merge` to help you answer this question.

- ☐ Merging the data just combines the two data frames like it would if we used `rbind`, so the number of observations increased.
- ☐ We have more observations for each state now, because some observations have the `statesMap` data, and some observations have the prediction data.
- ☒ Because we only make predictions for 45 states, we no longer have observations for some of the states. These observations were removed in the merging process.
- ☐ We merged the observations for which our predictions are identical.

#### EXPLANATION

When we merge data, it only merged the observations that exist in both data sets. So since we are merging based on the `region` variable, we will lose all observations that have a value of "region" that doesn't exist in both data frames. You can change this default behavior by using the `all.x` and `all.y` arguments of the `merge` function. For more information, look at the help page for the `merge` function by typing `?merge` in your R console.

Hide Answer


You have used 1 of 1 submissions

### PROBLEM 2.4 - COLORING THE STATES BY PREDICTIONS (1/1 point)

Now we are ready to color the US map with our predictions! You can color the states according to our binary predictions by typing the following in your R console:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPredictionBinary)) + geom_polygon(color = "black")
```

The states appear light blue and dark blue in this map. Which color represents a Republican prediction?

- ☒ Light blue 
- ☐ Dark blue

#### EXPLANATION

Our logistic regression model assigned 1 to Republican and 0 to Democrat. As we can see from the legend, 1 corresponds to a light blue color on the map and 0 corresponds to a dark blue color on the map.

Hide Answer

You have used 1 of 1 submissions


## PROBLEM 2.5 - COLORING THE STATES BY PREDICTIONS (1/1 point)

We see that the legend displays a blue gradient for outcomes between 0 and 1. However, when plotting the binary predictions there are only two possible outcomes: 0 or 1. Let's replot the map with discrete outcomes. We can also change the color scheme to blue and red, to match the blue color associated with the Democratic Party in the US and the red color associated with the Republican Party in the US. This can be done with the following command:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPredictionBinary)) + geom_polygon(color = "black") +  
scale_fill_gradient(low = "blue", high = "red", guide = "legend", breaks = c(0,1), labels = c("Democrat", "Republican"), name =  
"Prediction 2012")
```

Alternatively, we could plot the probabilities instead of the binary predictions. Change the plot command above to instead color the states by the variable `TestPrediction`. You should see a gradient of colors ranging from red to blue. Do the colors of the states in the map for `TestPrediction` look different from the colors of the states in the map with `TestPredictionBinary`? Why or why not?

NOTE: If you have a hard time seeing the red/blue gradient, feel free to change the color scheme, by changing the arguments `low = "blue"` and `high = "red"` to colors of your choice (to see all of the color options in R, type `colors()` in your R console). You can even change it to a gray scale, by changing the low and high colors to `"gray"` and `"black"`.

- ☒ The two maps look very similar. This is because most of our predicted probabilities are close to 0 or close to 1. 
- ☐ The two maps look very similar. This is because `TestPrediction` and `TestPredictionBinary` have the exact same values.
- ☐ The two maps look very different. This is because we have switched from plotting discrete values to plotting continuous values.
- ☐ The two maps look very different. This is because our predicted probabilities have a wide range of values, and we were not sure about many states.

### EXPLANATION

This plot can be generated by using the command:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPrediction)) + geom_polygon(color = "black") +  
scale_fill_gradient(low = "blue", high = "red", name = "Prediction 2012")
```


The only state that appears purple (the color between red and blue) is the state of Iowa, so the maps look very similar. If you take a look at `TestPrediction`, you can see that most of our predicted probabilities are very close to 0 or very close to 1. In fact, we don't have a single predicted probability between 0.065 and 0.93.

Hide Answer

You have used 2 of 2 submissions

## PROBLEM 3.1 - UNDERSTANDING THE PREDICTIONS (1/1 point)

In the 2012 election, the state of Florida ended up being a very close race. It was ultimately won by the Democratic party. Did we predict this state correctly or incorrectly? To see the names and locations of the different states, take a look at the World Atlas map [here](#).

- ☐ We correctly predicted that this state would be won by the Democratic party.
- ☒ We incorrectly predicted this state by predicting that it would be won by the Republican party. 

### EXPLANATION

In our prediction map, the state of Florida is colored red, meaning that we predicted Republican. So we incorrectly predicted this state.

Hide Answer

You have used 1 of 1 submissions

## PROBLEM 3.2 - UNDERSTANDING THE PREDICTIONS (2/2 points)

What was our predicted probability for the state of Florida?


0.9640395

**Answer:** 0.9640395

### EXPLANATION

You can find the predicted probability for Florida by typing `predictionDataFrame` in your R console, and finding that Florida is the 6th observation, and then finding the 6th probability in the column `TestPrediction`.

What does this imply?

- ☐ Our prediction model did a good job of correctly predicting the state of Florida, and we were very confident in our prediction.
- ☐ Our prediction model did a good job of correctly predicting the state of Florida, but we were not very confident in the prediction.
- ☐ Our prediction model did not do a very good job of correctly predicting the state of Florida, but we were not very confident in our prediction.
- ☒ Our prediction model did not do a very good job of correctly predicting the state of Florida, and we were very confident in our incorrect prediction. 

### EXPLANATION

We predicted Republican for the state of Florida with high probability, meaning that we were very confident in our incorrect prediction! Historically, Florida is usually a close race, but our model doesn't know this. The model only uses polling results for the particular year. For Florida in 2012, Survey USA predicted a tie, but other polls predicted Republican, so our model predicted Republican.

Hide Answer

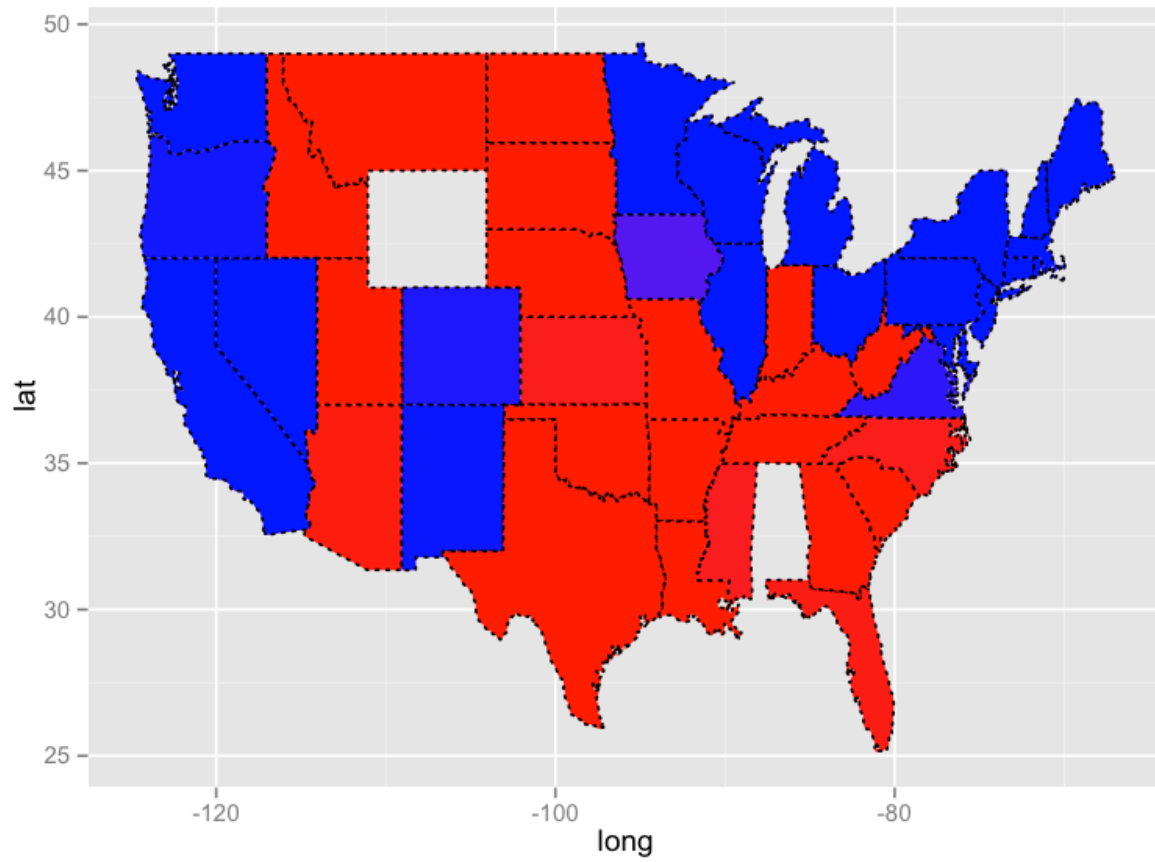
You have used 2 of 2 submissions

## PROBLEM 4 - PARAMETER SETTINGS

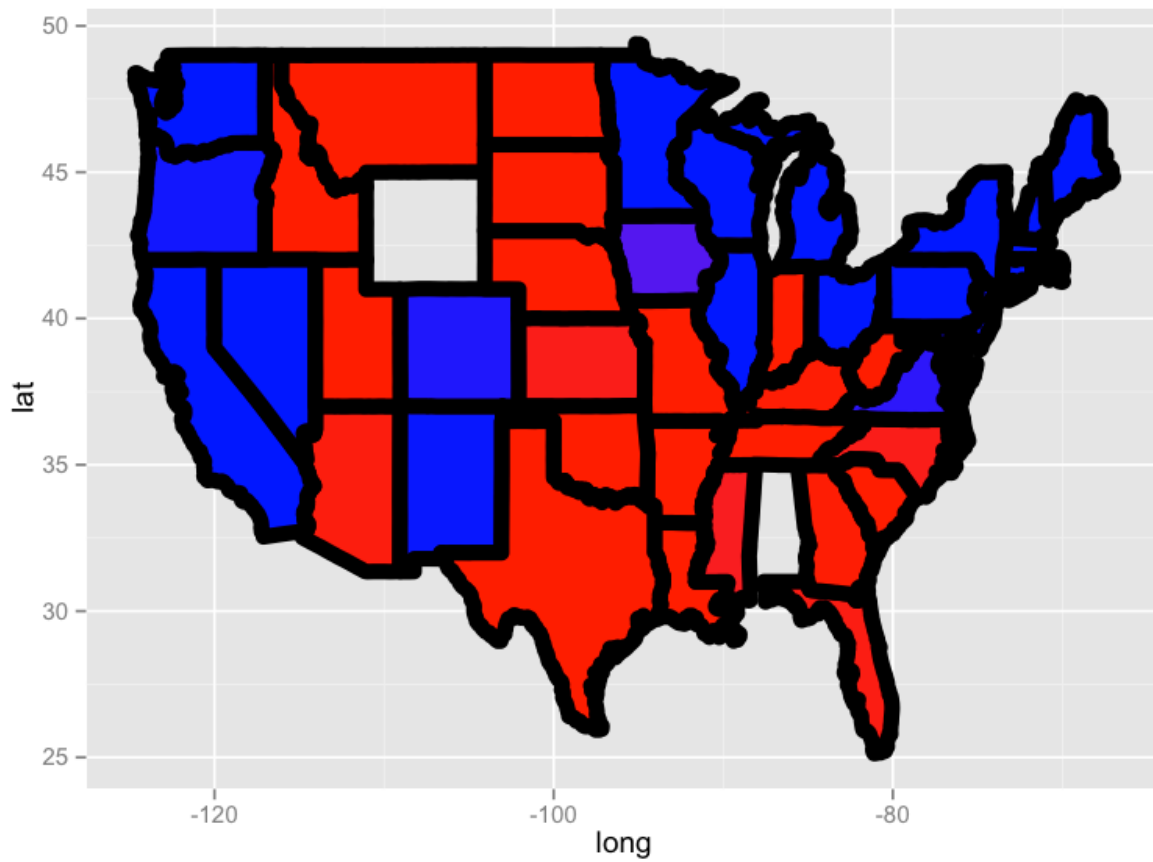
In this part, we'll explore what the different parameter settings of `geom_polygon` do. Throughout the problem, use the help page for `geom_polygon`, which can be accessed by `?geom_polygon`. To see more information about a certain parameter, just type a question mark and then the parameter name to get the help page for that parameter. Experiment with different parameter settings to try and replicate the plots!

We'll be asking questions about the following three plots:

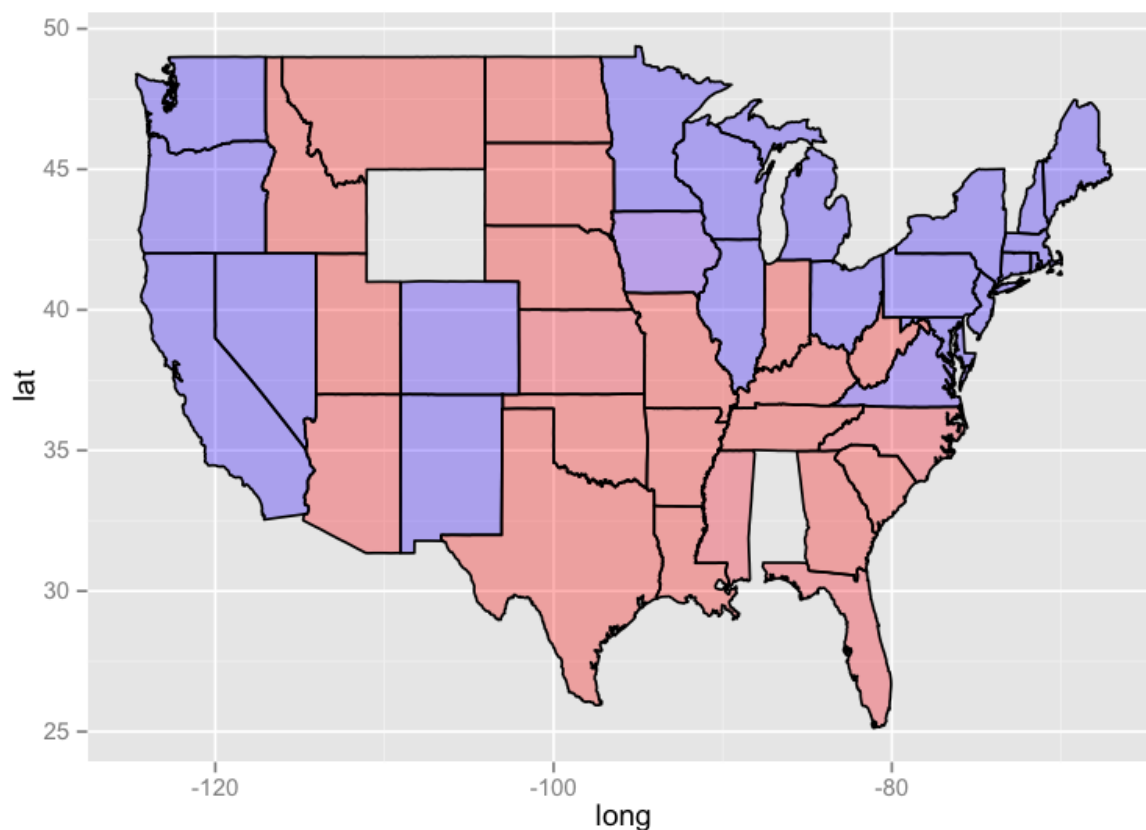
Plot (1)



Plot (2)



Plot (3)



#### PROBLEM 4.1 - PARAMETER SETTINGS (2/2 points)

Plots (1) and (2) were created by setting different parameters of `geom_polygon` to the value 3.

What is the name of the parameter we set to have value 3 to create plot (1)?

**Answer:** linetype

What is the name of the parameter we set to have value 3 to create plot (2)?

**Answer:** size

#### EXPLANATION

The first plot can be generated by setting the parameter `linetype = 3`:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPrediction)) + geom_polygon(color = "black",
linetype=3) + scale_fill_gradient(low = "blue", high = "red", guide = "legend", breaks= c(0,1), labels = c("Democrat",
"Republican"), name = "Prediction 2012")
```

The second plot can be generated by setting the parameter `size = 3`:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPrediction)) + geom_polygon(color = "black", size=3)
+ scale_fill_gradient(low = "blue", high = "red", guide = "legend", breaks= c(0,1), labels = c("Democrat", "Republican"),
name = "Prediction 2012")
```

Hide Answer

You have used 3 of 3 submissions



## PROBLEM 4.2 - PARAMETER SETTINGS (1/1 point)

Plot (3) was created by changing the value of a different `geom_polygon` parameter to have value 0.3. Which parameter did we use?

alpha

**Answer:** alpha

### EXPLANATION

Plot (3) can be created by changing the alpha parameter:

```
ggplot(predictionMap, aes(x = long, y = lat, group = group, fill = TestPrediction))+ geom_polygon(color = "black",  
alpha=0.3) + scale_fill_gradient(low = "blue", high = "red", guide = "legend", breaks= c(0,1), labels = c("Democrat",  
"Republican")), name = "Prediction 2012")
```

The "alpha" parameter controls the transparency or darkness of the color. A smaller value of alpha will make the colors lighter.

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