**An Introduction to Statistical Learning**
**3.6 Lab: Linear Regression**
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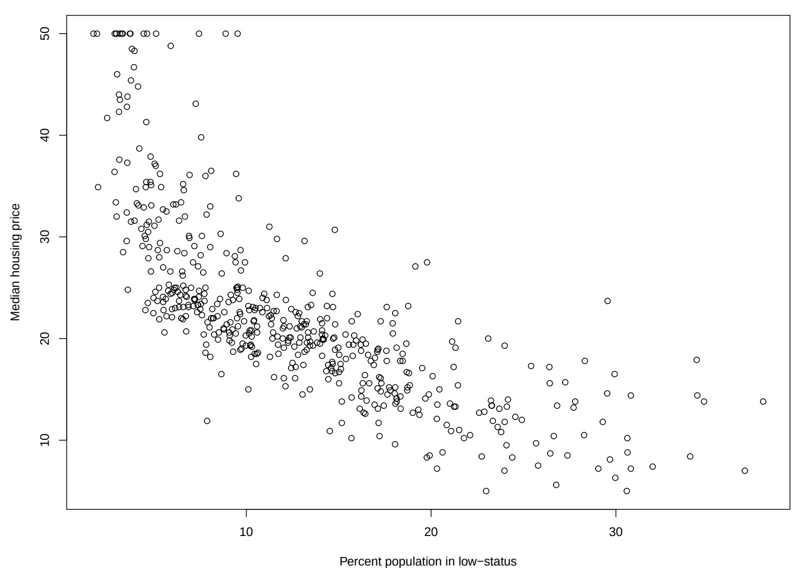
# Section 3.6.2 Simple Linear Regression

## A quick look at our data

We will take the time to look at the Boston housing data set in order to attempt to define a correlation between the median housing prices and percentage of population that are defined as lower status. Both being quantitative data.

A first good step is to take a look at the plot of median housing prices against percent lower status. This will allow us to gain initial insights to the data we are working with.

```
> attach(Boston)
> plot(medv~lstat,
+     xlab="Percent population in low-status",
+     ylab="Median housing price")
```




It is possible to see that yes this graph does seem to have a general downward trend, though definitely not linear if we are to include all data points in this observation. We can use R to find 5 number summaries for these columns.

```
> summary(medv)
  Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  5.00   17.02   21.20   22.53   25.00   50.00
> summary(lstat)
  Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.73    6.95   11.36   12.65   16.95   37.97
```

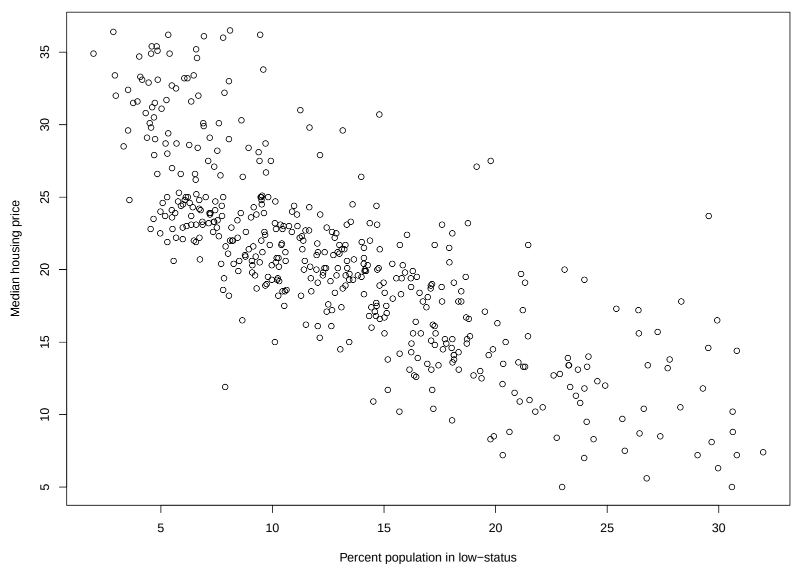
Now knowing the quartiles for our data we can compute the upper and lower fences such that we can remove outliers in our data.

## Removing outliers

$$\text{Inner quartile range} = Q3 - Q1$$
$$\text{Lower fence} = Q1 - 1.5IQR$$
$$\text{Upper fence} = Q3 + 1.5IQR$$

For 'medv' we have bounds at [5.05, 36.97] and for 'lstat' [-8.05, 31.95]. Applying these fences and removing the outliers we have a slightly altered graph:

```
> Boston = Boston[Boston$medv < 37 & Boston$lstat < 32,]
> plot(Boston$medv~Boston$lstat,
+       xlab="Percent population in low-status",
+       ylab="Median housing price")
```




## Applying a linear model

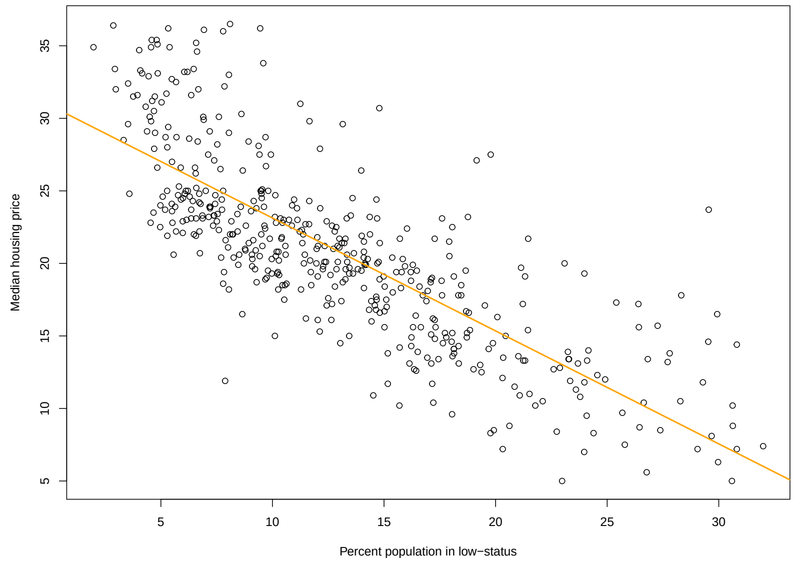
Now we will apply a linear regression model to fit our cleaned data.

```
> lm.fit = lm(medv~lstat, Boston)
> lm.fit    # Display regression equation coefficients

Call:
lm(formula = medv ~ lstat, data = Boston)

Coefficients:
(Intercept)        lstat
    30.9136      -0.7785
```

This tells us that our prediction equation has values $\beta_0 = 30.91, \beta_1 = -0.78$

$$\hat{y_i} = 30.91 - 0.78x_i$$

It can be found through 'summary()' that the p-value for this linear model is less than 2.2e-16, and R-squared value of 0.62 thus fitting our data fairly well.




## Producing confidence intervals

We can find the 95% confidence intervals of our coefficients by calling R's confint() function:

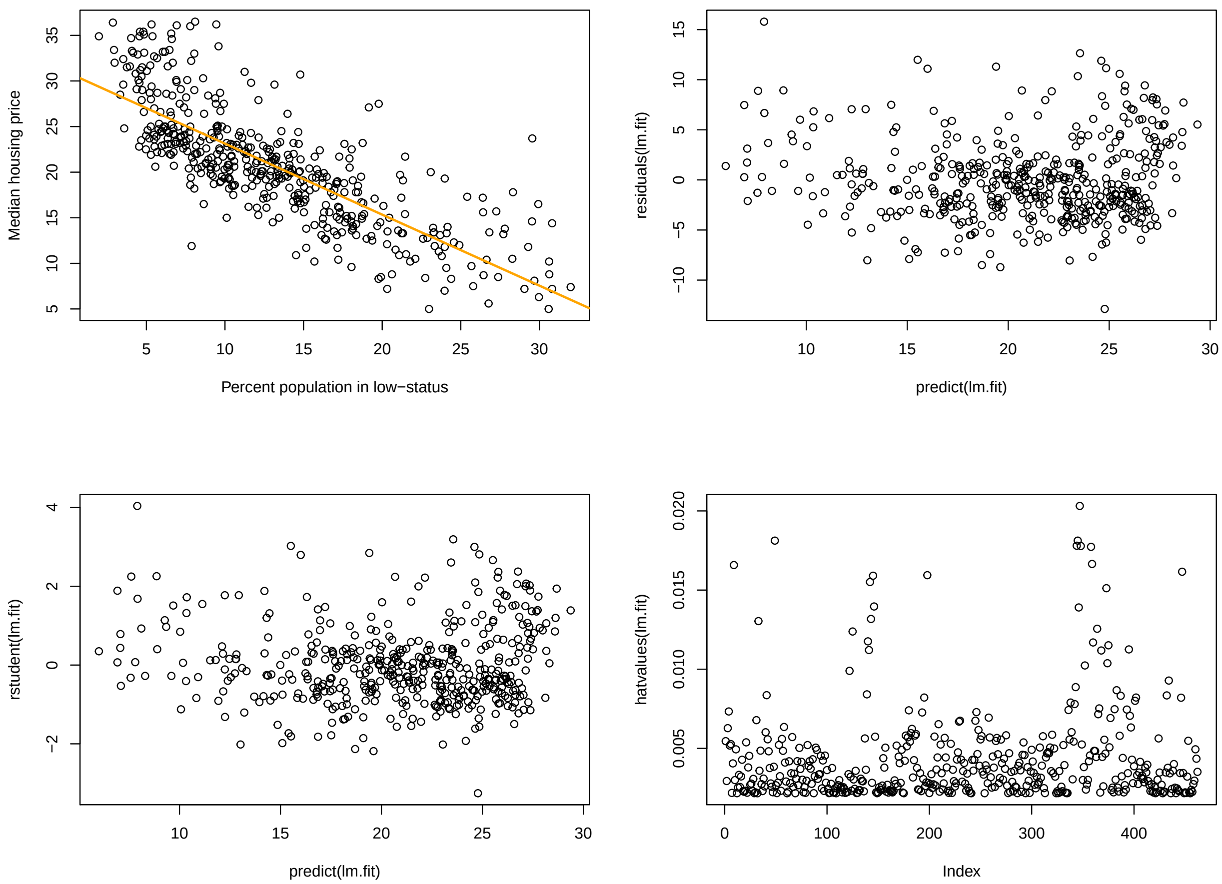
```
> confint(lm.fit)
                 2.5 %     97.5 %
(Intercept) 30.0966007 31.7306978
lstat       -0.8344623 -0.7224984
```

Also prediction intervals for lstat values 5, 10, and 15:

```
> predict(lm.fit, data.frame(lstat=c(5, 10, 15)),
+         interval="confidence")
       fit      lwr      upr
1 27.02125 26.44070 27.60180
2 23.12885 22.72485 23.53284
3 19.23644 18.85424 19.61865
```

This tells us that for a location where about 10 percent of the population that is of lower status, the median value for housing should be between $[22.72, 23.53]$ Similar predictions can be found for any value within the plotted bounds of the graphs above. Otherwise predictions may not be accurate due to extrapolation.

## Diagnostic plots




All code for plots and calculations can be found in 'simple-linear-regression.R'