Hypothesis Testing

Thileepan Paulraj

14 March 2019

About a year ago, I thought I have learned hypothesis testing, but when I wanted to recollect the concept of hypothesis testing last week, I realised that the concept is not clear for me.

So, I decided to learn it again.

Steps to do hypothesis testing

1. Start by saying the null hypothesis (H_0) is true.
2. Take a sample and get test statistic
3. Work out to find out how likely or unlikely it is to get a statistic like this if the null-hypothesis is true. p-value will help us here.

What is p-value?

Given our null hypothesis (H_0) is true, p-value gives us the probability that our observed result has happened due to luck or random chance.

Problem statement

One day the window in my living room was open so the noise level inside the house was higher than usual. My kitchen in next to my living room. I wanted to check if the noise levels inside my kitchen and living room are the same.

So my null hypothesis is that the average noise level in my kitchen and living room are the same.

$H_0 : \text{NOISE}_{\text{Kitchen}} = \text{NOISE}_{\text{Living\_room}}$

My alrernative hypothesis is the average noise levels in my kitchen and living room are different.

$H_A : \text{NOISE}_{\text{Kitchen}} != \text{NOISE}_{\text{Living\_room}}$

Data collection

I used a mobile application to calculate 10 seconds average Sound Pressure Levels (SPL) both in my kitchen and my living room. I took 15 measurements at both the locations.

```
kitchen.noise = c(27,30,30,30,30,30,29,29,27,29,30,35,33,33,32)

living.noise = c(32,31,31,30,29,29,29,29,28,28,28,28,27,27,37)
```

Calculating the mean difference

It is easy to calculate the mean of both these noise calculations ans see the difference between both the locations. This will give a hunch about the noise levels at both the locations.

```
diff.in.mean = mean(kitchen.noise) - mean(living.noise)
diff.in.mean
```

```
## [1] 0.7333333
```

We observe a 0.733 dB difference in mean SPLs at both the locations. This will easily dismiss our H_0. But is this reliable? can we so easily dismiss our H_0? can we say that this difference we observe is statistically significant? This is where p-value will help us.

Choosing the appropriate test

There are different tests available to test our hypothesis. Choosing the appropriate test is important.

Assumptions of normal distribution.

We only have 15 samples in our dataset, they are not big enough to assume normal distribution. If we are comparing the sample means of two groups and we assume that the groups follow normal distribution then we use paired or unpaired t-test. While comparing the sample means of 2 groups if the assumptions of normal distribution is not met then we use Mann-Whitney-Wilcoxon test.

Testing normality in data

For testing normality I will use the Shapiro Wilk test. I will also calculate the skewness and kurtosis of the data and visualize the density plot as well as the histograms of these data.

Skewness

```r
library(moments)
```

```
## Warning: package 'moments' was built under R version 3.5.2
```

```r
skewness(kitchen.noise)
```

```
## [1] 0.5387156
```

```r
skewness(living.noise)
```

```
## [1] 1.777656
```

Skewness results indicate that the data is slightly skewed to the right.

Kurtosis

```r
kurtosis(kitchen.noise)
```

```
## [1] 2.873121
```

```r
kurtosis(living.noise)
```

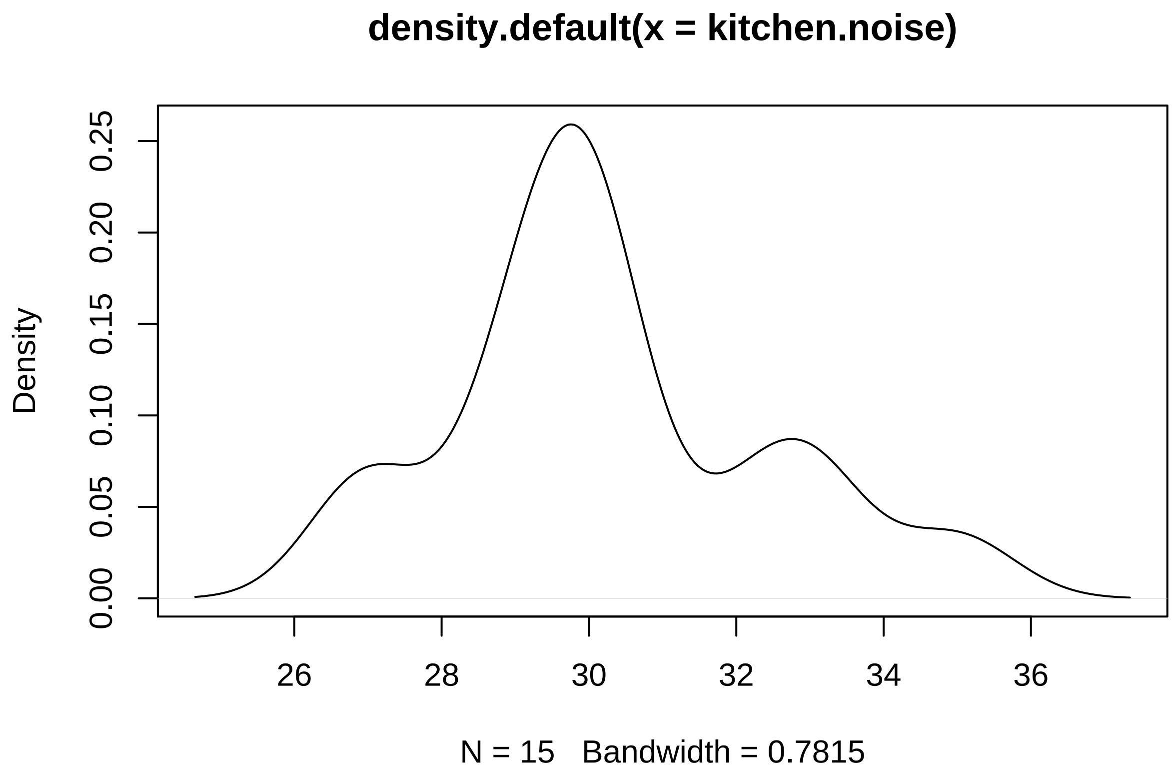
```
## [1] 6.071703
```

Both the data has positive kurtosis and indicates a *fat-tailed* distribution. This kind of kurtosis is called **leptokurtic**

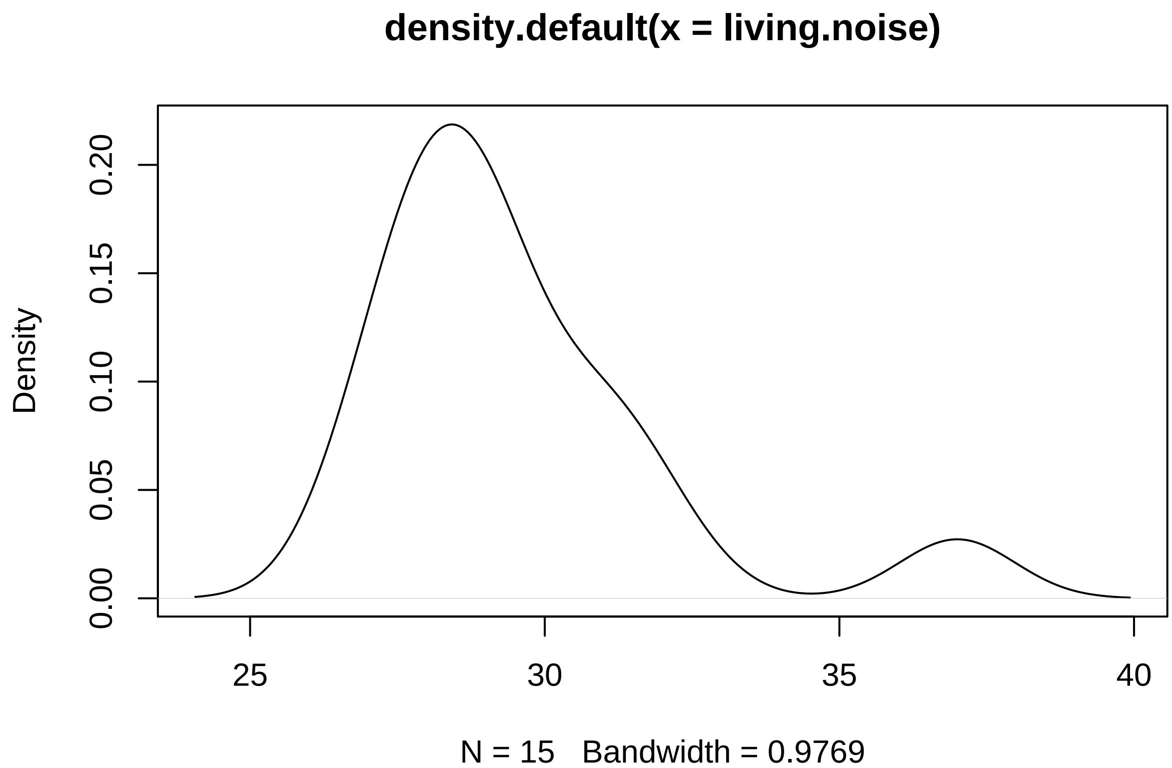
Desnity plot

We can plot the density plot of the data set to see if it has a bell-shaped curve.

```r
plot(density(kitchen.noise))
```




```r
plot(density(living.noise))
```



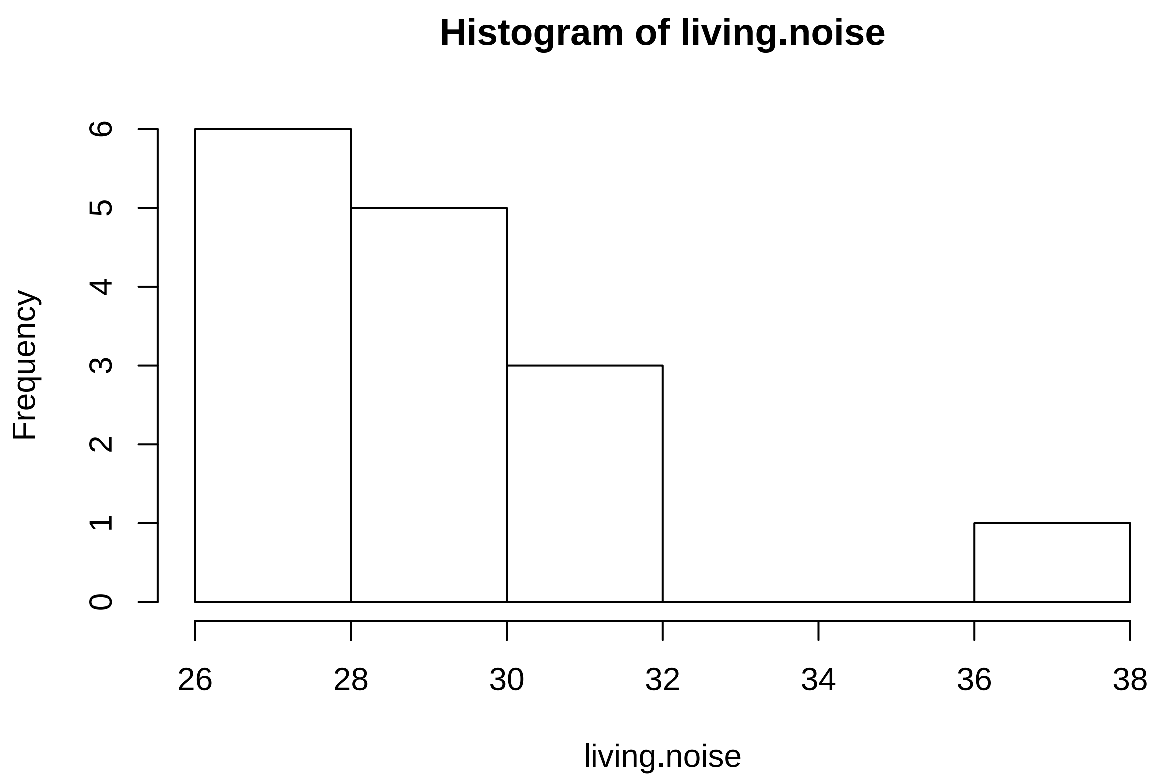
The noise levels in kitchen has a distribution shape which is close to the bell shaped curve but still it's not bell shaped.

Living room noise levels are clearly not bell shaped at all.

Histograms

```
hist(kitchen.noise)
```


```r
hist(living.noise)
```



The histograms of both the kitchen and living room noise levels doesn't clearly indicate a normal distibution.

Shapiro Wilk test

```
shapiro.test(living.noise)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  living.noise
## W = 0.80024, p-value = 0.003702
```

```
shapiro.test(kitchen.noise)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  kitchen.noise
## W = 0.90901, p-value = 0.1308
```

For the noise levels in kitchen the p-value of the shapiro wikk test is greater than 0.05 therefore we can assume it to be normally distributed. But the p-value of the shapiro test on the living room noise is less than 0.05 therefore we can't assume it to be normally distributed.

conclusion on normality

Since the size of the dataset is small and also there is no clear evidence to prove normal distribution of the data I will not assume the data is normally distributed. Therefore I will use the Mann-Whitney-Wilcoxon test.

Testing the hypothesis

```r
wilcox.test(living.noise, kitchen.noise)
```

```
## Warning in wilcox.test.default(living.noise, kitchen.noise): cannot compute
## exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  living.noise and kitchen.noise
## W = 80.5, p-value = 0.1846
## alternative hypothesis: true location shift is not equal to 0
```

Our p-value 0.1846 which is greater than 0.05. This tell us that there is a 18.46% chance that the the difference in mean that we observed occurred due to random chance if our H_0 is true (i.e. the average noise levels in the kitchen and living room are the same).

Since the possibility of random chance is greater than 5% (0.05) we do not have sufficient evidence to reject our null hypothesis (H_0).

Result

The result of the Mann-Whitney-Wilcoxon test has p-value of 0.186 which is greater than 0.05. Therefore I don't find enough evidence to reject my null hypothesis. So I stick to my null hypothesis and conclude that the mean noise levels in my kitchen and living room are the same. The difference in mean that I observed in my measurements is not statistically significant.

Note

1. Hypothesis testing could also be done using the critical value approach which is an old school text book method. I have used the p-value method since it is easy to implement that in modern statistical software.
2. Hypothesis testing is not as simple as it sounds.
3. Understanding what p-value means indicates is crucial.