

A simple t -test

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1 Statement

Every claims that the flags of the world are cut along a golden ratio, that is

$$\frac{width}{height} = \frac{1}{2} + \frac{\sqrt{5}}{2} \approx 1.618$$

... in average. Evaluate this statement with a significance of $\alpha = 0.05$.

2 Data

We fetch the data from [Wik21] using a little web-page script as follows:

```
f = (img) => {  
  let countryName = img.parentElement.parentElement.parentElement.innerText;  
  if (countryName.startsWith("Flag of ")) countryName = countryName.substring(8);  
  let txt = ''' + countryName + ',' + img.width/img.height + '\n';  
  allText = allText + txt; console.log(txt)  
}  
var imgs = jQuery(".mw-parser-output img")  
var allText = ""; imgs.each((n)=>{f(imgs[n]);})
```

This obtains the values in the neighbour CSV file with $n = 206$ flags and an average of about 1.67 and standard deviation of 0.257.

3 Interpretation

We make the hypothesis that the aspect ratio of the flags R is distributed along a normal distribution $R \sim \mathcal{N}(1.618, \sigma)$. Where σ is a standard-deviation that we do not know of.

We want to evaluate if the sample that we have follows a normal distribution with the same average with significance 0.01 and formulate the hypotheses:

- $H_0: \mu_R \approx 1.618$
- $H_1: \mu_R \not\approx 1.618$

We thus want to apply a two-tailed t -test e.g. [LM18, theorem 7.4.2] which will allow us to reject the H_0 in favour of H_1 if $t \leq -t_{\alpha/2, n-1}$ or $t \geq t_{\alpha/2, n-1}$

4 Theory

The student- t -theorem tells us that, considering R_1, \dots, R_n independent normal random variables, the following variable follows a Student- t -distribution of $n-1$ degrees of freedom:

$$T_{n-1} = \frac{\bar{R} - \mu}{S_{R_1, \dots, R_n} / \sqrt{n}}$$

where S_{R_1, \dots, R_n} is the sample standard deviation ([NIS21]).

Applying the t -test means testing if the probability of having this sample is at least $1 - \alpha$.

5 Computation

$$t \approx \frac{1.67 - 1.618}{0.257 \cdot \sqrt{206}} \approx 0.014$$

$$t_{\alpha/2, n-1} \approx 1.960$$

So t is by far not less than $-t_{\alpha/2, n-1}$ or bigger than $t_{\alpha/2, n-1}$.

6 Conclusion

We are not able to conclude that the flags follow a different distribution.

References

- [LM18] Richard Larsen and Morris Marx. *Introduction to mathematical statistics and its applications*. Pearson, Boston, US, 2018.
- [NIS21] NIST. *e-Handbook of Statistical Methods: Confidence limits for the mean*. 2021. Accessible from <https://www.itl.nist.gov/div898/handbook/eda/section3/eda352.htm>.
- [Wik21] Wikipedia. Gallery of sovereign state flags, 2021. Accessible from https://en.wikipedia.org/wiki/Gallery_of_sovereign_state_flags. Last accessed 2021-05-20.