Summary Report

Introduction

CPU performance is popularly benchmarked using various tools such as HWMonitor, 3DMark, UserBenchmark, CineBench, and more. These tools score the CPUs on their single-core and multi-core performance, depending on cache size, the number of cores, and clock speed. In most CPUs, there are 2 clock speeds - the base clock speed and the turbo clock speed. The base clock speed is the frequency at which the CPU operates at minimum, whereas the turbo clock speed is the maximum frequency the CPU can boost to handle heavy programs. The question we need to solve here is: Are CPUs' boost clock speeds accurate performance measures?

As technology enthusiasts, we love to understand our hardware. We believe that there is a lot of ignorance among gamers and general computer productivity users about the kind of machines they drive daily. As a result, most people end up overspending on their computers. We feel that this can be easily avoided by educating the general audience about the itty bitty details of the components that go into their computers. We hope to shine light on one of the most important components, the CPU of the computer.

Hypothesis

H_0 -> No linear relationship between single-core scores and turbo clock speeds ($ß_1 = 0$)

H_a- > Positive linear relationship between single-core scores and turbo clock speeds ($ß_1 > 0$)

Methods

Users run the CineBench R23 software on their PCs and submit their scores to the CineBench website. A random sample of this data has been used for our analysis. The data contains nine columns (‘manufacturer’, ‘cpuName’, ‘singleScore’, ‘multiScore’, ‘cores’, ‘threads’, ‘baseClock’, ‘turboClock’, ‘type’) and 215 rows of observation of Intel, AMD and Apple CPUs.

We will perform a linear regression hypothesis test to check the linearity between single-core scores and the turbo clock speeds of CPUs. We will be focusing on single-core evaluation scores and turbo clock speed.

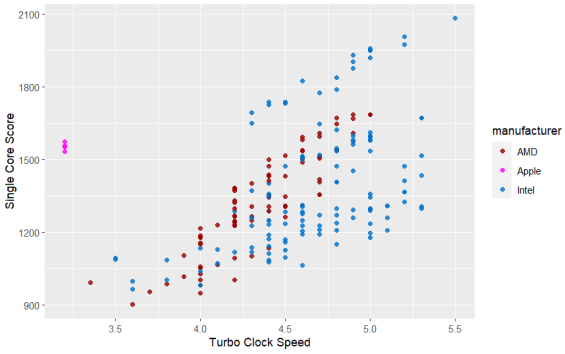
Linear regression equation (Population model):

$$\textit{Single Core Score} = ß_0 + ß_1 * (\textit{Turbo Clock Speed}) + \varepsilon$$

$ß_0$ -> Intercept of the regression line on the y-axis
$ß_1$ -> Slope of the regression line of single-core scores and turbo clock speeds
ε -> Error ~ $N(0, \sigma^2)$

Results

Fig. 1: Single core scores vs. Turbo clock speed



Shows the relationship between single core scores and the turbo clock speeds

Conditions

We found that our scatterplot is fairly linear (Fig. 2). The variables are independent by nature of the way the data was collected. Other conditions, such as normality of the residuals (Fig. 3) and equal variance of the response variable (single core scores) (Fig. 4), are also satisfied.

Our regression model

$$\text{Single Core Score} = 72.85 + 286.78 * (\text{Turbo Clock Speed}) + 31.61$$

Test Statistic = 9.071 **p-value** = < 2e-16 **Conf. Int.** = (224.4601, 349.0955)

Since the p-value is less than 0.05, we reject the Null Hypothesis. Thus the single core score and the turbo clock speeds have a **positive linear** relationship.

Secondary Analysis

The scatterplot shows that Apple produces high values of single core scores at low turbo clock speeds. AMD shows a consistent increase in performance with an increase in their turbo clock speeds, and Intel, on the other hand, offers a high variance of performance at any particular clock speed. Thus we can say that the performance of Intel CPUs is relatively unpredictable.

Discussion

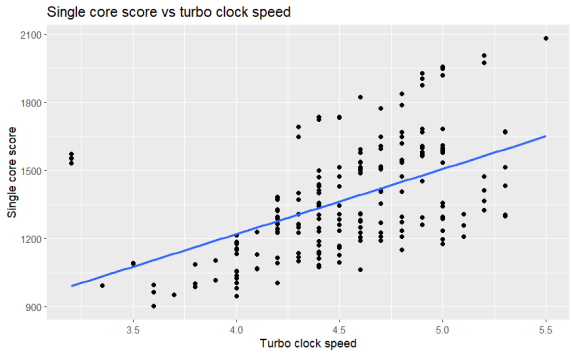
We have successfully shown that the single-core performance of CPUs increases linearly with the turbo clock speeds. This proves the fact that, in general, a CPU that boasts a high turbo clock speed is better for a lot of single-core applications. We have additionally compared trends of performance increase in Apple, AMD, and Intel CPUs. A few limitations in our study come from the authenticity of the data we used since the data comes from independent users. Additionally, certain essential factors, such as CPU architecture, transistor size, cache, etc., are missing in our data, influencing the performance scores considerably.

References

1. https://www.kaggle.com/datasets/alanjo/cinebench-r23-scores-may-2022
2. https://www.researchgate.net/publication/353115679_Changing_Trends_in_Computer_Architecture_A_Comprehensive_Analysis_of_ARM_and_x86_Processors

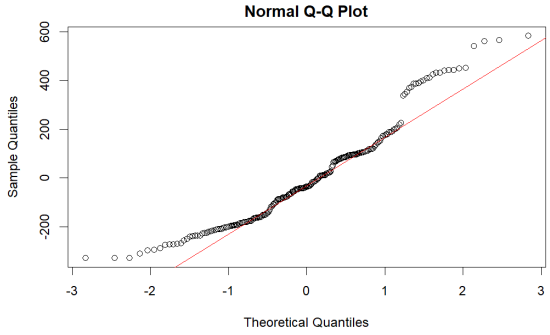
Appendix

Fig. 2: Linearity



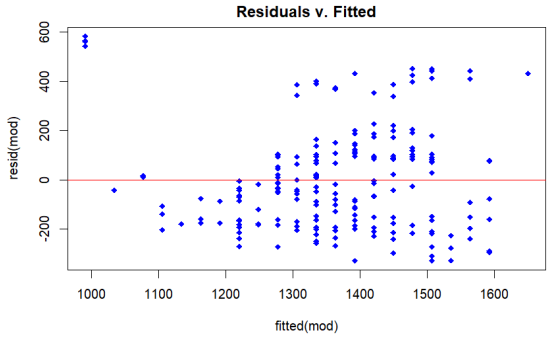
Shows the linear relationship between the single core score and the turbo clock speeds

Fig. 3: Normality



Shows the normality of the residuals of the single cores scores

Fig. 4: Equal variance



Shows the equal variance of the single core scores about the linear regression line