# Evaluating the Performance of Hardware Using Computer Vision

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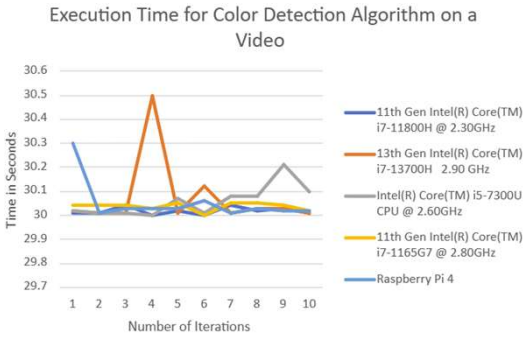
## Abstract

This study evaluates the performance of various hardware platforms, including microcomputers like the Raspberry Pi 4, through the implementation of Computer Vision techniques using OpenCV libraries. Amidst a shortage of Raspberry Pi devices in 2020, alternative microcomputers—Raspberry Pi 3, Le Potato, and VirtualBox—were assessed for their capabilities. VirtualBox served as a baseline for comparison, configured to match Raspberry Pi 4 specifications. The evaluation focused on key metrics: execution time, CPU usage, and memory utilization.

The study involves testing pictures, videos, and live webcam feeds, using Python scripts with psutil and time libraries for performance metrics. Results indicate the Raspberry Pi 4's competitive performance, particularly in video processing, despite its less powerful processor. Virtual machines exhibited CPU and memory usage variations, emphasizing emulation's impact.

Notably, the study faced challenges, such as LePotato video output and OS imaging issues. The Raspberry Pi 3 was also in a continuous reboot state that hindered testing. Video analysis revealed the Raspberry Pi 4's stable execution time but highlighted substantial CPU and memory usage differences in diverse video scenarios. Webcam testing showcased the Pi's efficiency in execution time and CPU usage, offering insights into potential background processes affecting virtual machines.

The study demonstrates that the Raspberry Pi 4 performs comparatively with the tested virtual machines, particularly in video processing. Despite the Le Potato having more RAM than the Raspberry Pi 3, it didn't function properly in our experiments. The research also emphasizes the effects of virtualization, illustrating differences in CPU and memory usage across various platforms.




***Graph 1.*** *Execution time for our solid color video*

## Hardware

**A. VirtualBox:**

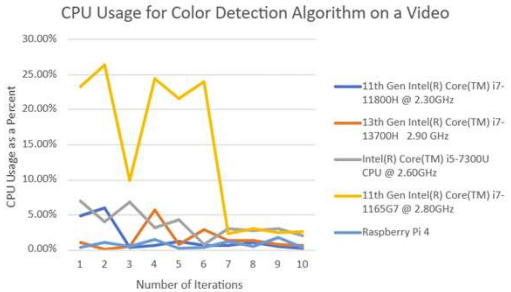
- The purpose of using VirtualBox is to standardize performance evaluation for computer vision algorithms by configuring virtual machines with identical specifications to Raspberry Pi 4.
- The virtual machines are configured with 2000MB base memory and a quad-core CPU to closely match the Raspberry Pi 4 specifications.

**B. Microcomputers:**

- The team aims to analyze three distinct Reduced Instruction Set Computers (RISC), known for their streamlined instruction sets, differing from other architectures.
  - Raspberry Pi 4 Model B: featuring the Broadcom BCM2711 SoC with a quad-core Cortex-A72 CPU clocked at 1.5 GHz and is configured with 2GB of RAM.
  - Raspberry Pi 3 and Le Potato both utilize quad-core ARM Cortex-A53 architectures, with the Raspberry Pi 3 equipped with 1GB of RAM.
  - Le Potato, manufactured by Libre Computer, boasts a Mali-450 MP3 GPU along with 2GB of RAM, enhancing its computational and graphics processing capabilities.

## Conclusion:

There seems to be no direct substitute for the Raspberry Pi. None of the virtual machines can guarantee similar values to the Raspberry Pi on all tests. If needing to simulate a Raspberry Pi 4's performance on a color recognition algorithm, a processor that will operate closely to the Pi based on how one plans to run the algorithm has to be chosen. To simulate a Raspberry Pi when detecting color in a simple video, use the 11th Gen Intel(R) Core(TM) i7-11800H 2.30 GHz. This processor would also be good to get realistic values of a Raspberry Pi 4's CPU usage and execution time, except for the CPU usage when using the algorithm for a complex video. To accurately simulate the color-detecting algorithm running on a Raspberry Pi 4's memory with a more complicated video or webcam, there is no processor that can perform this task. No processor is suitable for measuring CPU usage during complex video playback. Overall, to use simulators to measure the performance of a Raspberry Pi 4, one must use processors that would best reflect the aspect of the hardware to measure.




***Graph 2.*** *CPU usage for our solid color video*

## Results:

**A. Test Performed**

For this experiment, we have created three color recognition programs to recognize color in pictures, videos and through a webcam. We have the program measure execution time, memory and CPU usage. We ran the programs under different situations for 10 times and calculated averages for each processor. We ran the programs while our machines were connected to power for the sake of consistency. In the cases where we are running the program on some videos, we stopped the program at 30 seconds since that is all we need to gather our data and be consistent when we are testing our program on different videos. Due to our Raspberry Pi breaking down on us before we can perform a picture test with it. We do not include the data obtain from running the picture program. Below are some of the more significant pieces of data we noticed from our experiment.

**B. Video 1**

This video consists of one solid color which changes and cycles around into other solid colors. A visual box would appear around all the object of the programmed color inside the box.

- Lowest average execution time: 11th Gen Intel(R) Core(TM) i7-11800H @ 2.30GHz with 30.018 seconds
- Highest execution time recorded: 13th Gen Intel(R) Core(TM) i7 13700H 2.90 GHz with 30.5 seconds
- Lowest average CPU usage: 4 Core ARMv8 Cortex-A72 1.8GHz with 0.76% usage
- Highest average CPU usage: 11th Gen Intel i7-1165G7 @ 2.80GHz with 14.01% usage
- Lowest average memory usage: 4 Core ARMv8 Cortex-A72 1.8GHz with 57.19% usage
- Highest memory usage recorded: 11th Gen Intel i7-1165G7 @ 2.80GHz with 73.80%

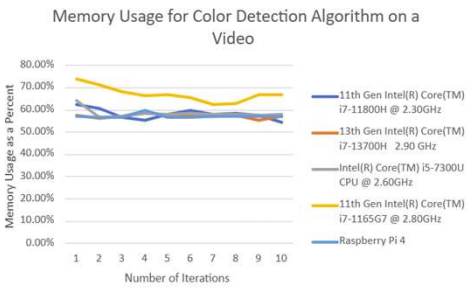
**C. Video 2**

This video consist of different liquid colors appearing and mixing together underwater. A visual box would appear around all the object of the programmed color inside the box. The graphs show our results for this part of our experiment

**D. Webcam**

During these trials, we had our devices display a video of what it sees and create a box around all the things that contain objects of a specific color we coded them to look for.

- Highest average execution time: 11th Gen Intel(R) Core(TM) i7-1165G7 2.80 GHz with 30.375 seconds
- Lowest average execution time obtained: 13th Gen Intel(R) Core (TM) i7-13700H 2.90 GHz with 30.018 seconds
- Lowest average CPU usage: 4 Core ARMv8 Cortex-A72 1.8GHz with 0.47%
- Highest average CPU usage: 11th Gen Intel(R) Core(TM) i7-1165G7 2.80 GHz with 1.73%
- Lowest average memory usage: 11th Gen Intel(R) Core(TM) i7-11800H 2.30 GHz with 50.34%
- Highest average memory usage: 11th Gen Intel(R) Core(TM) i7-1165G7 2.80 GHz with 68.43%




***Graph 3.*** *Memory usage for our solid color video*

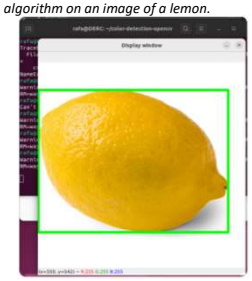


***Figure 1.*** *Output window of color detection algorithm on an image of a lemon.*

https://github.com/evolutis101/Evaluating-Performance-of-Hardware-using-Computer-Vision-