HPC - 1.4.1

Taha Enayat
Spring 2024

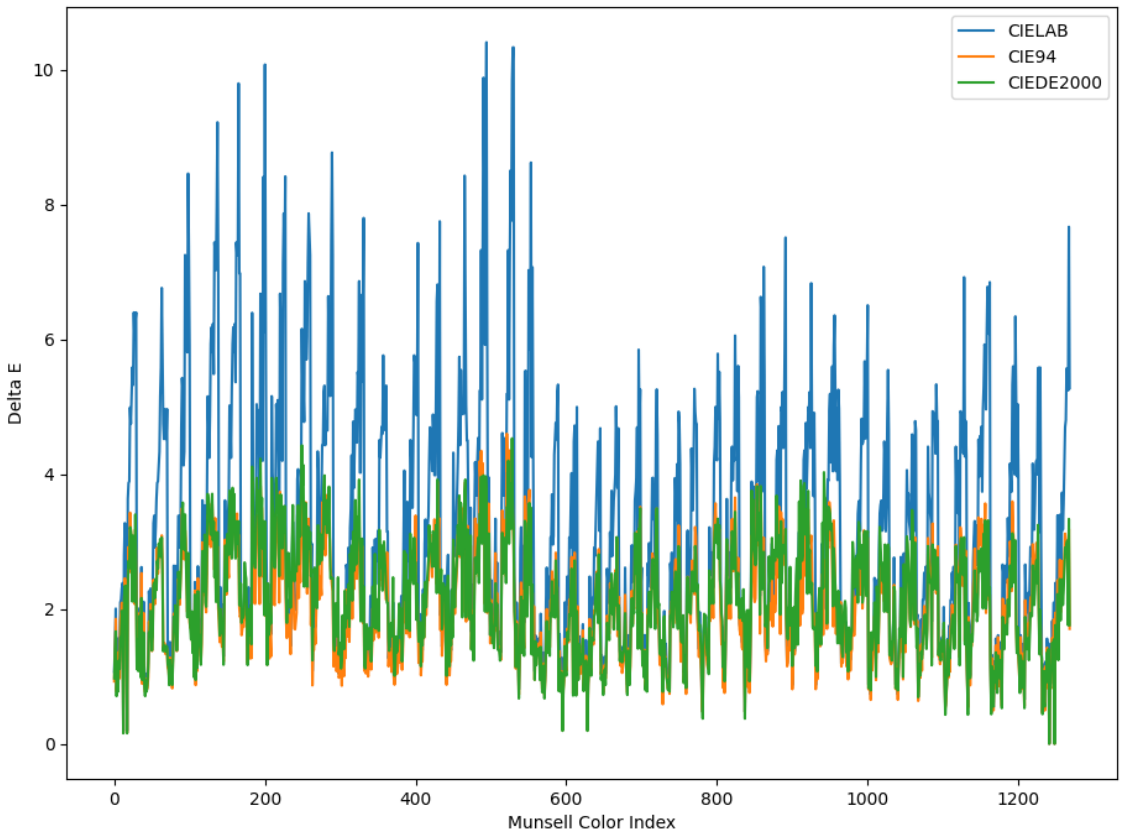
In this exercise, I explore the color differences between Munsell color chips using three different color difference formulas: CIELAB, CIE94, and CIEDE2000. The Munsell Book of Color is supposed to represent a uniform color space, meaning that the perceived color difference between each chip and its nearest neighbor should be roughly the same. Generally:

- CIELAB: is the simplest and oldest. It's widely used but sometimes doesn't match human perception perfectly.
- CIE94: Is an improvement on CIELAB that tries to address some of its shortcomings, making it a bit closer to what we actually see.
- CIEDE2000: is the latest and most complex formula, aiming to provide the best match to visual perception by addressing even more nuances.

To determine if these formulas agree with visual perception, we need to see how uniform the color differences are. Here is the table of the results:

Color Difference Formula	Average ΔE
CIELAB	3.1506
CIE94	2.0521
CIEDE2000	2.1351

Looking at the average ΔE values, it's clear that CIELAB tends to give higher values, suggesting it might overestimate the perceived difference. CIE94 and CIEDE2000 are closer to each other, which might indicate they're better at matching what we see. Below, you can see the figure of ΔE for each Munsell chip:



The graph I made shows ΔE values across all chips. CIELAB (blue) is much more variable, with many spikes, while CIE94 (orange) and CIEDE2000 (green) are more stable and closer together. This suggests that CIE94 and CIEDE2000 are more consistent with the idea of uniform color difference in the Munsell system.

It's also interesting to see if the same nearest neighbors are found by all formulas. In **72.89%** of the cases, they do agree. This high percentage indicates that while the formulas do differ, they often point to the same nearest neighbor, reinforcing the idea that they are all capturing something real about color differences, even if they do it slightly differently.

Breaking this down further, we see:

- CIELAB and CIE94 agree on the nearest neighbor 82.2% of the time.
- CIELAB and CIEDE2000 agree 76.7% of the time.
- CIE94 and CIEDE2000 agree 84.6% of the time.

These percentages suggest that CIE94 and CIEDE2000 are more aligned with each other than either is with CIELAB, supporting the idea that they might

better reflect visual perception.

Overall, CIE94 and CIEDE2000 seem to align better with the concept of uniform color differences in the Munsell system compared to CIELAB.