

CS 331

Computer Vision

10 / 01 / 2026

Instructor: Michael Eckmann

Today's Topics

- Questions / Comments?
- Computing bin numbers fast under certain conditions
- Earth Mover's Distance
- Start OpenCV introduction

histograms

- Let's look back at these bins and then efficient operations to compute bin# based on R,G,B value.
- Bin0 those with R in 0-127, G in 0-63, B in 0-127
- Bin1 those with R in 0-127, G in 0-63, B in 128-255
- Bin2 those with R in 0-127, G in 64-127, B in 0-127
- Bin3 those with R in 0-127, G in 64-127, B in 128-255
- Bin4 those with R in 0-127, G in 128-191, B in 0-127
- Bin5 those with R in 0-127, G in 128-191, B in 128-255
- Bin6 those with R in 0-127, G in 192-255, B in 0-127
- Bin7 those with R in 0-127, G in 192-255, B in 128-255
- Bin8 those with R in 128-255, G in 0-63, B in 0-127
- Bin9 those with R in 128-255, G in 0-63, B in 128-255
- Bin10 those with R in 128-255, G in 64-127, B in 0-127
- Bin11 those with R in 128-255, G in 64-127, B in 128-255
- Bin12 those with R in 128-255, G in 128-191, B in 0-127
- Bin13 those with R in 128-255, G in 128-191, B in 128-255
- Bin14 those with R in 128-255, G in 192-255, B in 0-127
- Bin15 those with R in 128-255, G in 192-255, B in 128-255

Histograms

- How to determine bin # for an RGB (assumes each channel is divided into a power-of-2 range)
- Since R and B are each divided into 2 groups of values (which means divide by $256/2 = 128$)
- G is divided into 4 groups of values (divide by $256/4 = 64$)
- $R_{\text{shifted}} = R \gg 7$ # same as $R // 128$ note: 2 to the 7th is 128
- $G_{\text{shifted}} = G \gg 6$ # same as $G // 64$ note: 2 to the 6th is 64
- $B_{\text{shifted}} = B \gg 7$
- Then to compute bin number:
- $R_{\text{shifted}} \ll 3 + G_{\text{shifted}} \ll 1 + B_{\text{shifted}}$
- Same as $R_{\text{shifted}} * 8$ (2 to the 3rd) + $G_{\text{shifted}} * 2 + B_{\text{shifted}}$

Histograms

- Notice that L1 and L2 distances are bin-to-bin comparison. Bins that are near each other vs. far from each other have the same affect on the distance.
- e.g. on the board
- Two pairs of histograms that have equal L1 distance, but with EMD (described on next slide), one pair has a lesser distance

Histograms

- Then let's consider that we have our image converted to HSV. We can create a histogram of Hues, where nearby bins have more similarity than bins that are further apart and instead of doing L1 or L2 which are bin-to-bin comparisons, consider a different distance measure that takes into account cells that are nearby like Earth Mover's Distance (EMD)
- Earth Mover's Distance
 - Think of the values in bins as amounts of dirt and the distance between two histograms is the least amount of work to transform one of the histograms to the other (least amount of work to move the dirt)
 - The amount of work to move dirt is equal to the amount of dirt being moved times the distance moved
 - Example on the board
 - Thoughts on difference between EMD and L1 or L2

OpenCV introduction

- OpenCV uses numpy
- Let me give you a quick introduction to openCV and numpy