Computer and Machine Vision

Lecture Week 7
Part-2
(Exam #1 Review)
Outline of Week 7

- Basic Convolution Transform Speed-Up
- Concepts for Computer Vision

- Hough Linear Transform

- Review for Exam #1

- Exam #1 – Next Week Friday/Saturday
  - Friday In Person 9am to 12noon
  - Or Via E-mail Between 9am Friday and 9pm Saturday
Exam #1 Review

CV and Learning OpenCV
Chapters 1 to 4 and from Lecture
Exam Format

- 1 Question from CV Ch. 1
- 2+ CV Ch. 1-2
- 2+ CV Ch. 3 & 4
- 2+ from Notes

8 Questions Total
- Some True/False (1 or 2)
- Some Multiple Choice (1 or 2)
- Some Short Answer, Pseudo-Code (C/C++ or OpenCV), Diagrams or English Description

See Blackboard for Remote Instructions
Open Book and Notes
Provide Citations (Detailed) if You Re-Use Code!
Notes in Class – Analog vs. Digital Video

- Analog vs Digital Encoding for Transmission
  - NTSC Basics
  - Impact of Digital Encoding on Computer Vision

- Digital is Routed (Diversely), Buffered, Compressed
  - Multiplexed (Shares Transmission Carrier)
  - Higher Latency, but More Flexible (Can be Processed)
  - Transported by Large (IP 1500 byte MTU) or Small (188 byte MPEG) packets? Out-of-order arrival?
  - Bandwidth Delay Product – Bits in Network (e.g. Gbits/sec \times seconds of transport latency)
  - QoS – Does Packet Switched Approach Ideal of Constant Bit Rate?

- Analog is Continuous Transmission
  - Known Deterministic Latency
  - Can’t be Processed Easily
  - Typically Lower Resolution and Not as Bandwidth Efficient
MPEG Order of Operations and Lossy Steps

#1: POINT (Pixel) Encoding, Lossy for YCrCb 4:2:2, 4:2:0
#2 A-C: Macro-Block Lossy Intra-Frame Compression
#3: Motion-Based Lossy Compression in Group of Pictures
Notes in Class, Labs - Encoding

Pixel (Point) Encoding
- RGB-α (Alpha is the opacity, a multiplier for each band for foreground pixels, 1-Alpha for background pixels)
- YCrCb – Know Sub-Sampling Formats

Frame Encoding
- I-frame (compression limited to data contained in frame)
- Uncompressed formats – PPM, PGM, PBM (TIFF)
- Compressed formats – JPG, PNG, MPEG I-frame
- Common Resolutions and Aspect Ratios (2K, 1080p, 720p, etc/)

Group of Pictures
- I-frame starts, B (bidirectional) and P (predicted) frames reference I-frame (I-frame Only Better for CV)
- Ffmpeg basics
- Lossy vs. lossless steps (e.g. quantization and DCT for macro-block)
- Ok for Machine Vision? What Do We Lose?
Color Models and Tri-Stimulus

- Graphics and MV use Additive Models
  - RGB cube
  - HSV cylinder

- Human Physiology Limits Perception
  - Tri-stimulus – XYZ based on Human Eye Sensitivity to Short (420-440nm), Medium (530-540nm), Long (560-580nm) Wavelength Light in Visible range of Spectrum

\[
\begin{bmatrix}
X \\
Y \\
Z \\
\end{bmatrix} = \frac{1}{b_{21}} \begin{bmatrix}
b_{11} & b_{12} & b_{13} \\
b_{21} & b_{22} & b_{23} \\
b_{31} & b_{32} & b_{33} \\
\end{bmatrix} \begin{bmatrix}
R \\
G \\
B \\
\end{bmatrix} = \frac{1}{0.17697} \begin{bmatrix}
0.49 & 0.31 & 0.20 \\
0.17697 & 0.81240 & 0.01063 \\
0.00 & 0.01 & 0.99 \\
\end{bmatrix} \begin{bmatrix}
R \\
G \\
B \\
\end{bmatrix}
\]

- Gamut – complete subset of colors in visible spectrum based on CIE model for wavelength
  - Note that in gray levels, levels are brightness only at the same chromaticity (e.g. white with more or less brightness)
  - 24-bit, 8-bit per Channel RGB has 16 million color Palette (2^24)

- Gamma – non-linear correction factor to account for perception of adjacent gray levels that is not a linear progression of intensity

- Radiometry vs Photometry – Know the Difference

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CV Chapter 1

Basic Concepts
- Computer vs. Machine Vision - Goals
- Parsing an Imaged Scene into a List of Objects
- Perception
- History

The Challenges of Computer Vision
- Does an Image Match a Known Pattern
- Does this Generalize?
- What if Object is Rotated?
- Scaled?
- Blurred?
- Seen from an Angle?
- In Bad Lighting?

Value of Color in Scene Segmentation and 3D Visual Cues
CV Chapter 2 – Images and Transforms

- \{P\}, \{Q\}, \{R\} notation, Transformations, and Convolution

- Convolution Application of PSF
  - Must be $1/9 \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ to avoid change in intensity of original

- CV Convention for a PBM, PGM, PPM – Frames are: \{A\}, \{B\}, \{C\}
  - All Pixels in each Image are 0 or 1 only – PBM
  - Simple threshold conversion from PGM to PBM, Graymap to Bitmap, is: for all pixels do \{ if(P0 > thresh) A0=0; else A0=1 \}
  - For PBM display purposes, use: for all pixels do \{R0 = 255((1-A0))\} for image between 0 and saturation
  - Review Basic transformations like shrinking and edge finding

- Geometric Transformations (Review) – 2D Planar, Perspective, Orthographic
Color and Pixel Encoding

- OpenCV Image, Mat, Array
- RGB Color Channels
- Conversion from RGB to YCrCb
- RGB, Alpha (24-bit RGB, add Alpha for 32-bit for Composite Images)
  - Alpha Compositing and Opaque Layers – $C = \alpha \times C_{\text{foreground}} + (1-\alpha) \times C_{\text{background}}$
CV Chapter 3

- Noise Suppression Concepts and Filters
- Median Filters
- Mode Filters (Understand Concept)
- How to Apply to Color vs. PGM?
- Sharpen, Blur and Noise Removal

- Filters for Color (Understand Concepts that Complicate)
  - Apply Filter to Each Color Band Separately – Causes Color Bleeding
  - Vector Median Filter is Solution (Not Responsible For, but Know)

- Pyramids for Resolution Decimation – Know This!
Segmentation – By Threshold and By Edge Finding

Sobel Transform (Why Better than Others)?

Canny Concepts (Why Better than Sobel?)

Algorithm for Hough Linear Transform and Concept for RANSAC

Basic Concepts for Keypoint Feature Selection, Detection, and Match for Correspondence – Not full SIFT (yet)

Application of a Histogram to Count Occurrence of Intensity Levels in an Image or Kernel by Bin

- Simple Single Peaked Histogram Has Well-defined Threshold
- Bi-modal or Multi-modal Histogram has No Obvious Threshold
- Background Elimination for a Stable Background Can Help

Alternative is Adaptive Threshold

- Threshold Varies According to Location in Image
- Threshold Varies over Time

Analysis and Experimentation with Threshold are Focus of Lab #3
Learning OpenCV

- Examples Used in Class and Labs – Know Them

- Ch. 1 – OpenCV API Concepts

- Ch. 2 – Simple Camera Capture and Image file Input/Output and Transforms

- Ch. 3 – IplImage Data Structure (Mat, Array access by channel)

- HighGui and Interactive CV – Basics from Labs