CATÓLICA
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Escola das Artes

Computer Vision Techniques for Musical Interaction

Using Processing

Computer Music Doctoral Program

http://www.artes.ucp.pt/si/doutoramento/index.html

Topics

- Introduction to session
  - What (is this session about)
  - How (the session will go through)
  - Who (am I)
- Techniques – Examples and live demos
  - Brightness/Color detection
  - Background subtraction
  - Movement detection
  - Movement estimation
  - Face Detection
- Techniques – Code Overview
  - (Depending on time left)
  - Mixed Initiative (tell me what you want to see in more detail)

What

- Overview of some computer vision techniques
  - How they work and what are the main limitations
  - How to use them in Processing
- Some –very simple(istic)– examples of how they can be used for musical interaction

*"**Computer vision** is the science and technology of machines that see. As a scientific discipline, computer vision is concerned with the theory for building artificial systems that obtain information from images"* – Computer vision. (2009, April 24). In *Wikipedia, The Free Encyclopedia*. Retrieved 11:53, May 9, 2009, from http://en.wikipedia.org/w/index.php?title=Computer_vision&oldid=285848177

What

- Techniques
  - **Color detection** (where in the image, does a given color appear – can be used for tracking objects)
  - **Brightness detection** (what is the position of the brightest pixels)
  - **Background subtraction** for object vectorization
  - **Movement detection** (where –coordinates– in the image has movement occurred)
  - **Movement estimation** (what direction are the objects moving)
  - **Face detection** (is there a face in the image? where?)

How

- General overview of how those CV techniques work
  - Will try not to dwelve much into code in this phase
- Examples of what can be accomplished with the techniques
  - Vídeos
  - Live demos
- Depending on time left
  - Tell me if you want to see something in more detail
  - More detailed description of code (libraries needed, etc)

Who

- Jorge Cardoso (http://jorgecardoso.eu)
- Teacher of Interactive Video Art course (School of Arts)
  - Mainly computer vision techniques for (full) body interaction with screen projections
  - Students use Processing and CV techniques for interactive art projects

Color detection

- Isolate color regions in an image
- Procedure:
  - Go through the image, pixel by pixel
  - Calculate the distance between the color of the current pixel and the reference color
  - If distance is smaller than a given threshold, keep the pixel

Color Detection

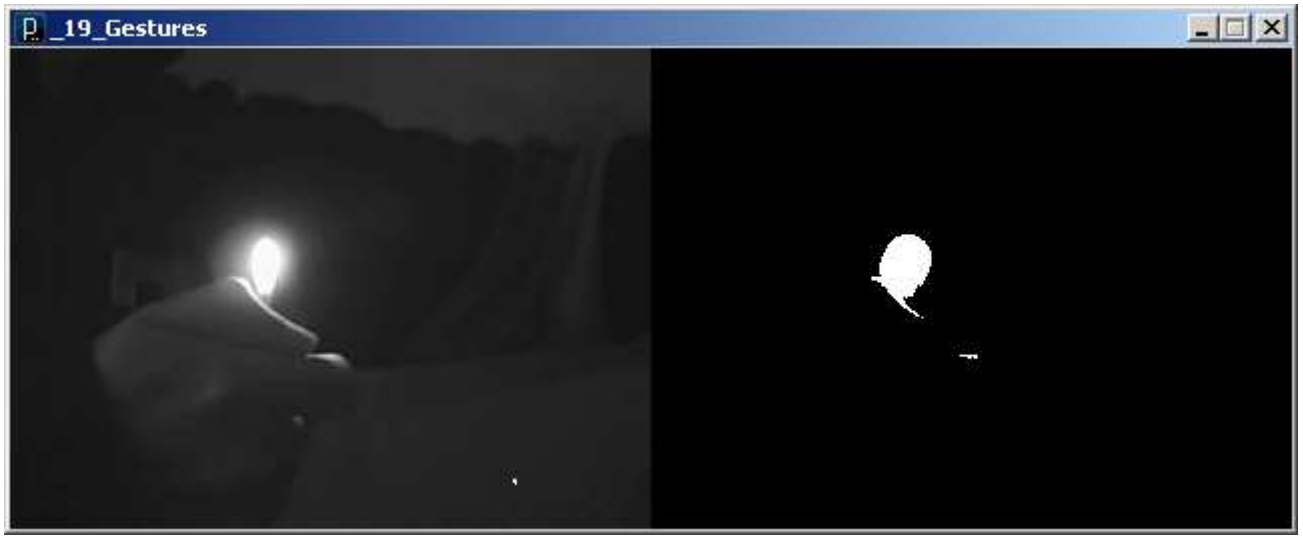
- Q: How do we calculate the "distance" between two pixels?
- A: Simple version: euclidean distance.
  - Take a color as a point in 3D space (RGB -> XYZ)
  - Calculate the distance between the two points
    - Subtract each component (dR = R1-R2, dG = G1-G2, dB = B1-B2)
    - Dist = Sqrt(dR*dR + dG*dG + dB*dB)
- A1: Slightly (perceptively) better version: weight each component differently:
    - Dist = Sqrt(2*dR*dR + 4*dG*dG + 3*dB*dB)

Color Detection

- Q: What's it good for?

- A:
  - Catch of the day [video]
  - Play-doh as Piano Keyboard [video]
  - ColorDifferenceInstrument [live demo]
  - ColorDifferenceDistanceInstrument [live demo]
  - ColorDifferenceAngleInstrument [live demo]

Brighteness detection



- Slight variation on color detection when we're only interested in tracking bright pixels
  - For example, to track a light
- Procedure:
  - Same as color detection but extract the brightness of each pixel and keep only the highest

Brighteness detection

- Q: How do we calculated the "brightness" of a color?
- A:
  - In RGB:
    - (perceptive) Brightness = (0.2126*R) + (0.7152*G) + (0.0722*B)
    - (physical/energy) Brightness = (R+G+B)/3
    - …
  - In HSB:
    - Brightness = B ☺
  - Just use the brightness() function in whatever language…

Brighteness detection

- Q: Why not just color detection?
- A:
  - Brightness detection is more robust (i.e., less influenced by lighting conditions)
  - You don't care about color, just the brightness (for example to detect a lantern)

Brighteness detection

- Q: What's it good for?
- A:
  - Drawing With Light [video]
  - Burning the Sound [video]

Background subtraction

- If we have a fixed camera, and a background image for reference, we can subtract the background to each frame to isolate new objects

This - This = This

Background subtraction

- Q: How do we "subtract" two images?
- A: Pixel by pixel

- Q: How do we "subtract" two pixels?
- A: Channel by channel (color component by color component, usually R, G and B)

Background subtraction

- Pixel subtraction alone doesn't work very well due to noise or shadows in the image
- The resulting subtraction must be thresholded to eliminate noise

Background subtraction

- After subtracting and thresholding, we can binarize the image to get a mask

Background Subtraction

- Q: What's it good for?
- A: Isolating objects in a scene. The mask can be vectorized, giving us access to it's contour (polygon).
  - Bg Subtraction [Live demo]
  - Position Through Background [Video]
  - BouncingBalls [Live demo]
  - SoundingPolygon [Live demo]

Movement Detection

- If we subtract two consecutive video frames, threshold and binarize it, we get a rough view of the movement in the video
- Since we don't need a reference frame, this technique is more rubost in face of lighting conditions

Movement Detection

- Q: What's it good for?
- A:
  - WebCam Piano [video]
  - Air Piano [live demo]

Motion Estimation (aka Optical Flow)

- Estimate the movement vectors of blocks in a sequence of two images
- Procedure
  - Divide both images into blocks
  - For each block in image one, find the closest (more similar) block in image two

Image: http://grauonline.de/wordpress/wp-content/uploads/ovscreenshot1.png

Motion Estimation

- Q: What's it good for?
- A:
  - BryanChung Example [video]
  - OpticalFlowMidi [live demo]

Face detection

- Not recognition!
- Needs a configuration file that determins what to detect (front faces, side faces, body, etc)
- Returns the position and size of detected faces

Face Detection

- Q: What's it good for?
- A:
  - Face Detection With A Smiley [video]
  - Funny Eyes [video] [live demo]

Summary

- Color detection
  - Needs good lighting
  - Can track (several) objects by color
- Brighteness detection
  - Robust, needs only slightly controled lighting conditions (low light)
  - High accuracy of position and movement
  - Can track several objects at the same time (with some restrictions)

Summary

- Background subtraction
  - Needs initial setup on startup (reference frame)
  - Needs highly controled lighting conditions.
  - Isolates objects without any marker (color or light)
  - Can be used to determine distance to camera (without great accuracy)
  - Can be used to detect movement

Summary

- Movement Detection/Estimation
  - No startup configuration
  - Doesn't need very controlled lighting conditions
  - Determins regions where movement occured
  - Hard to determine number of objects moving

Summary

- Face detection
  - Needs relatively controlled lighting conditions
  - Needs relatively controlled positioning of people (near and looking directly at the camera)
  - Detects position and size (approximate) of faces

References

- Videos
  - Catch of the day: http://www.youtube.com/watch?v=G8-Nvyx0xtk
  - Play-Doh as Piano Keyboard!: http://vimeo.com/465726?pg=embed&sec=
  - Drawing with Light: http://www.youtube.com/watch?v=VDP3e20uYMI
  - Burning the Sound: http://www.vimeo.com/3096584
  - Position through background subtraction: http://www.youtube.com/watch?v=yyc8aionno4
  - Webcam piano: http://www.vimeo.com/1219327?pg=embed&sec=1219327
  - Bryan Chung optical flow: http://www.youtube.com/watch?v=WCdQ8KQ_Wyo&
  - Face detection with a smiley: http://www.youtube.com/watch?v=r4XArSFPwPc
  - Funny Eyes: http://www.youtube.com/watch?v=9WXLs4qQ5nk

References

- Webpages
  - Computer vision techniques for artists (by Golan Levin): http://www.flong.com/texts/essays/essay_cvad/
  - Processing Website: http://processing.org/
  - Processing Books: http://processing.org/learning/books/
  - Portuguese Processing Forum: http://processing.jorgecardoso.eu
  - Color metrics: http://www.compuphase.com/cmetric.htm
  - Bryan Chung (Optical Flow videos): http://www.bryanchung.net/?p=262
  - OpenCV Processing library: http://ubaa.net/shared/processing/opencv/

Stuff you need to make the examples run

- Processing
- OpenCV processing library
- Webcam

The End

- Code Overview – anything in particular?
- Questions?
- …