Fundamentals of Embedded Computer Vision: Creating Machines That See

Day 5: More Algorithms and More on Using OpenCV

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Review from Day 4:
Two easy-to-use tools for getting up and running on OpenCV

BDTI OpenCV Executable Demo Package

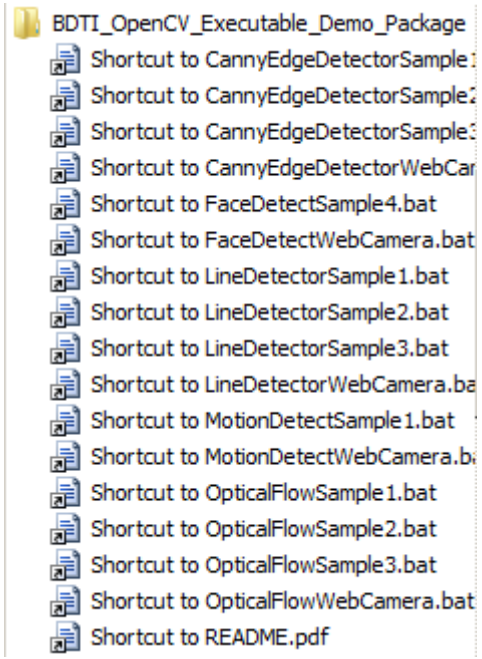
- No programming required
- Windows based
- Easy to install
- No tools required
- Run examples with just a mouse click
- Use mouse to adjust demo parameters in real-time
- Supports video input from files or real-time video using webcam
- Includes example source and reference Visual Studio projects

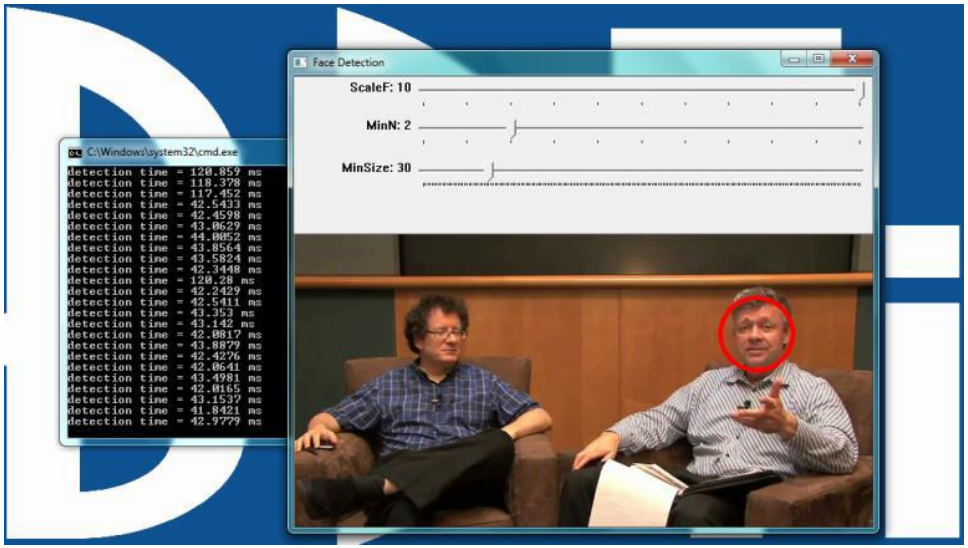
BDTI Quick-Start OpenCV Kit

- Runs on Windows using free VMware player
- OpenCV and required tools pre-installed
- Prebuilt OpenCV libraries
- Eclipse based debugging for OpenCV projects
- Supports real-time video using webcam
- Includes framework to start your own project easily
- Includes example source and makefiles

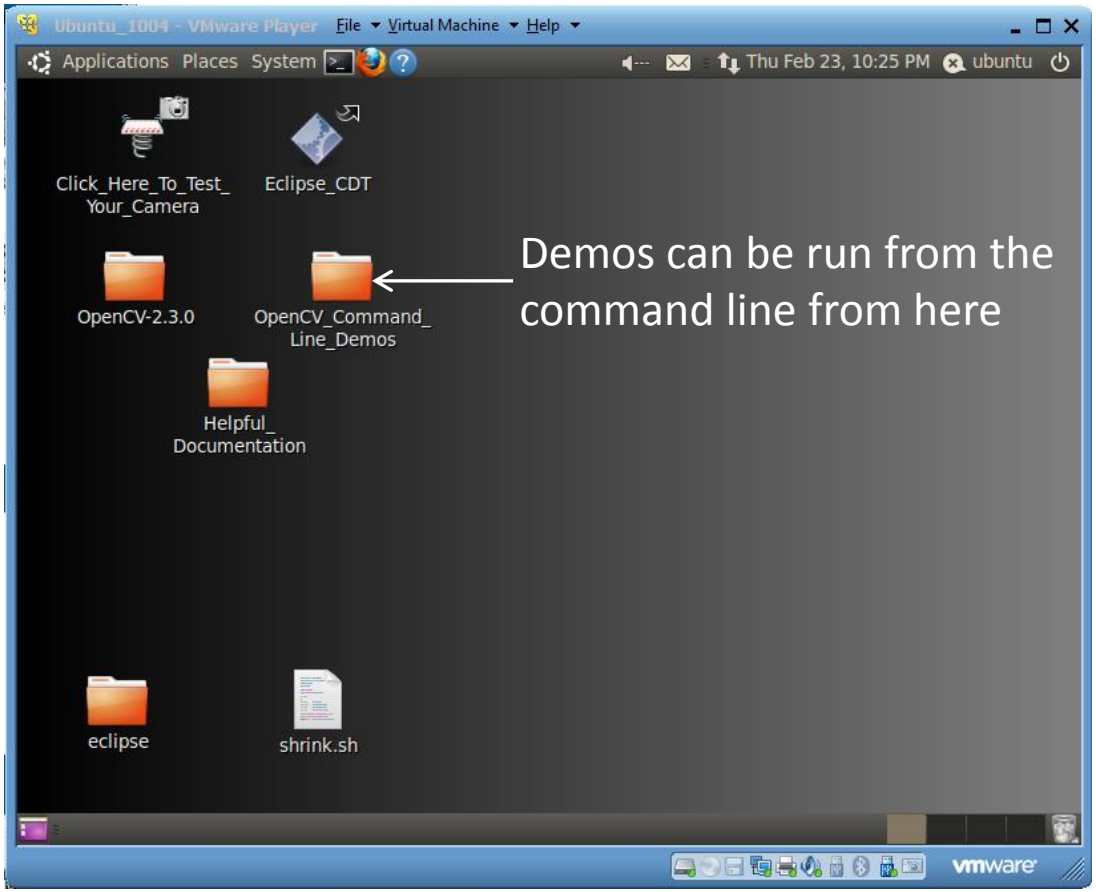
Review from Day 4:
BDTI OpenCV Executable Demo Package

- OpenCV with just a mouse click
- No programming required
- START→BDTi_OpenCV_Examples→*The example you want to run*





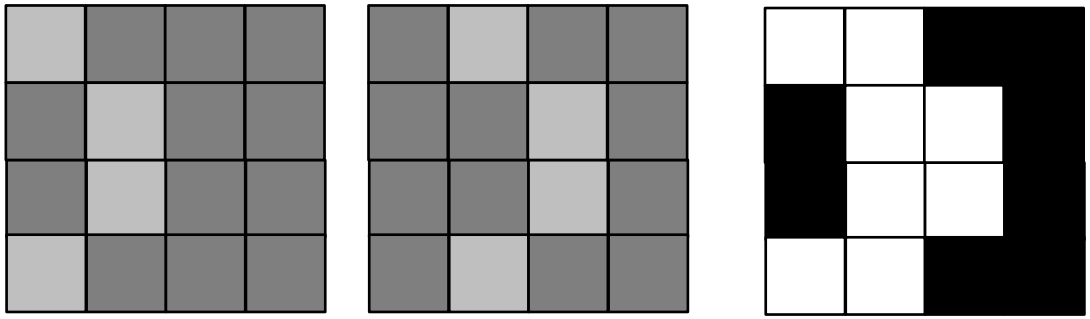
Review from Day 4:
BDTI Quick-Start OpenCV Kit—Ubuntu Desktop in VMware



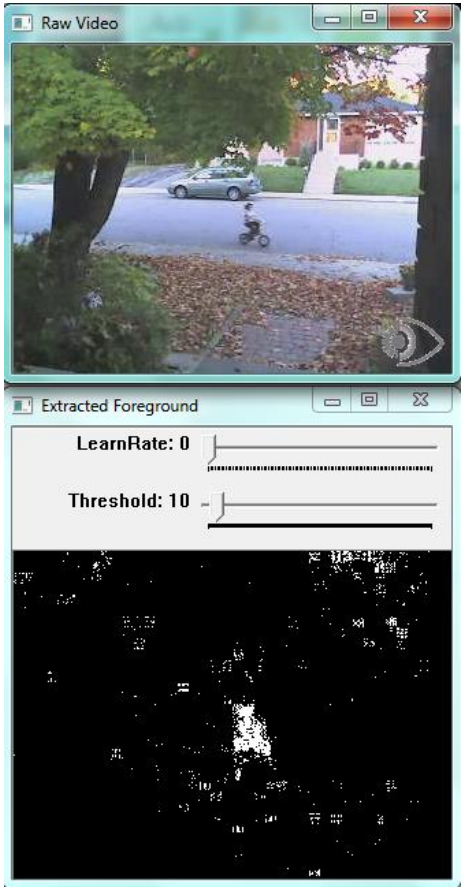
MOTION DETECTION

Motion Detection

- Motion detection in this context is done using frame subtraction, commonly referred to as background subtraction.
- The video is converted to monochrome and each pixel in the previous frame is subtracted from the current frame.
- If nothing changed between frames, the result of all the pixel subtractions will be 0.



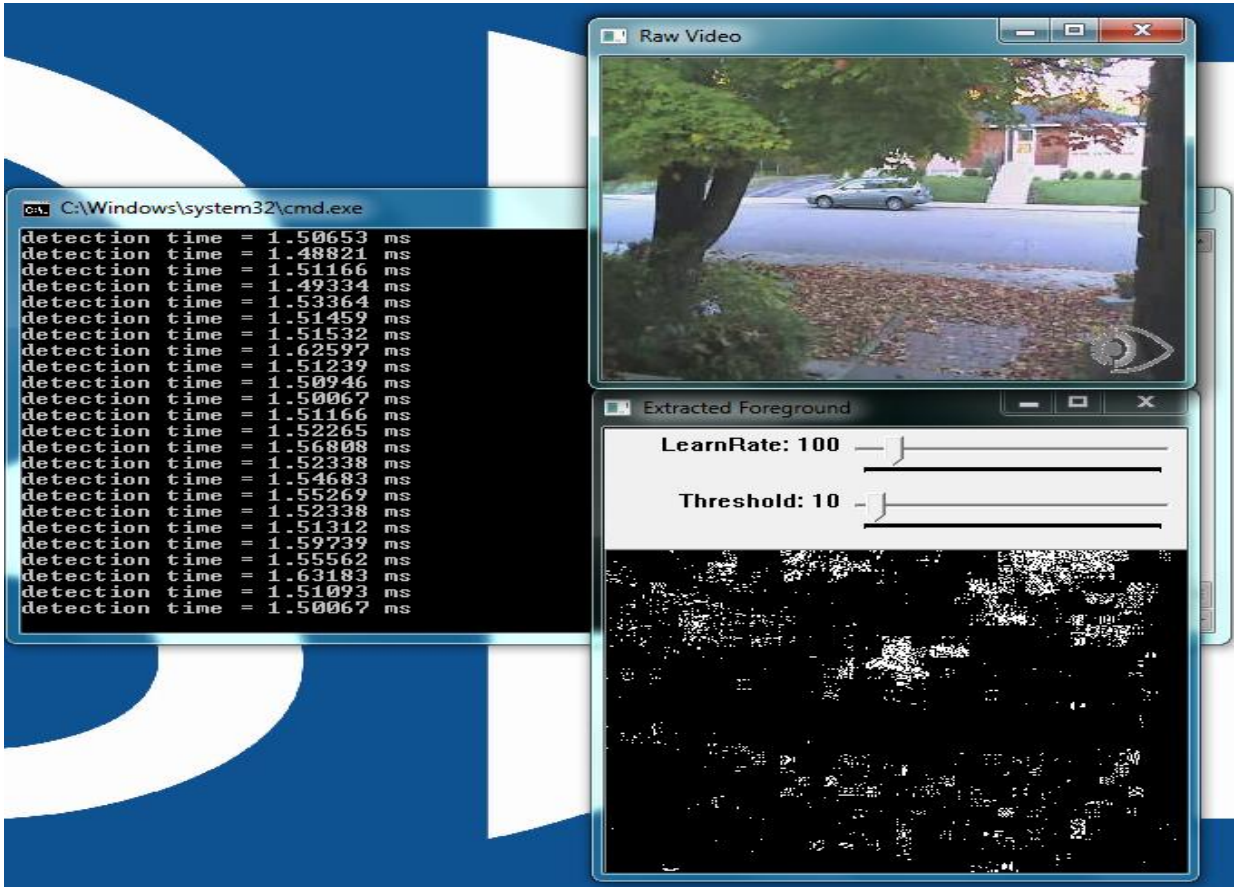
previous frame – current frame =



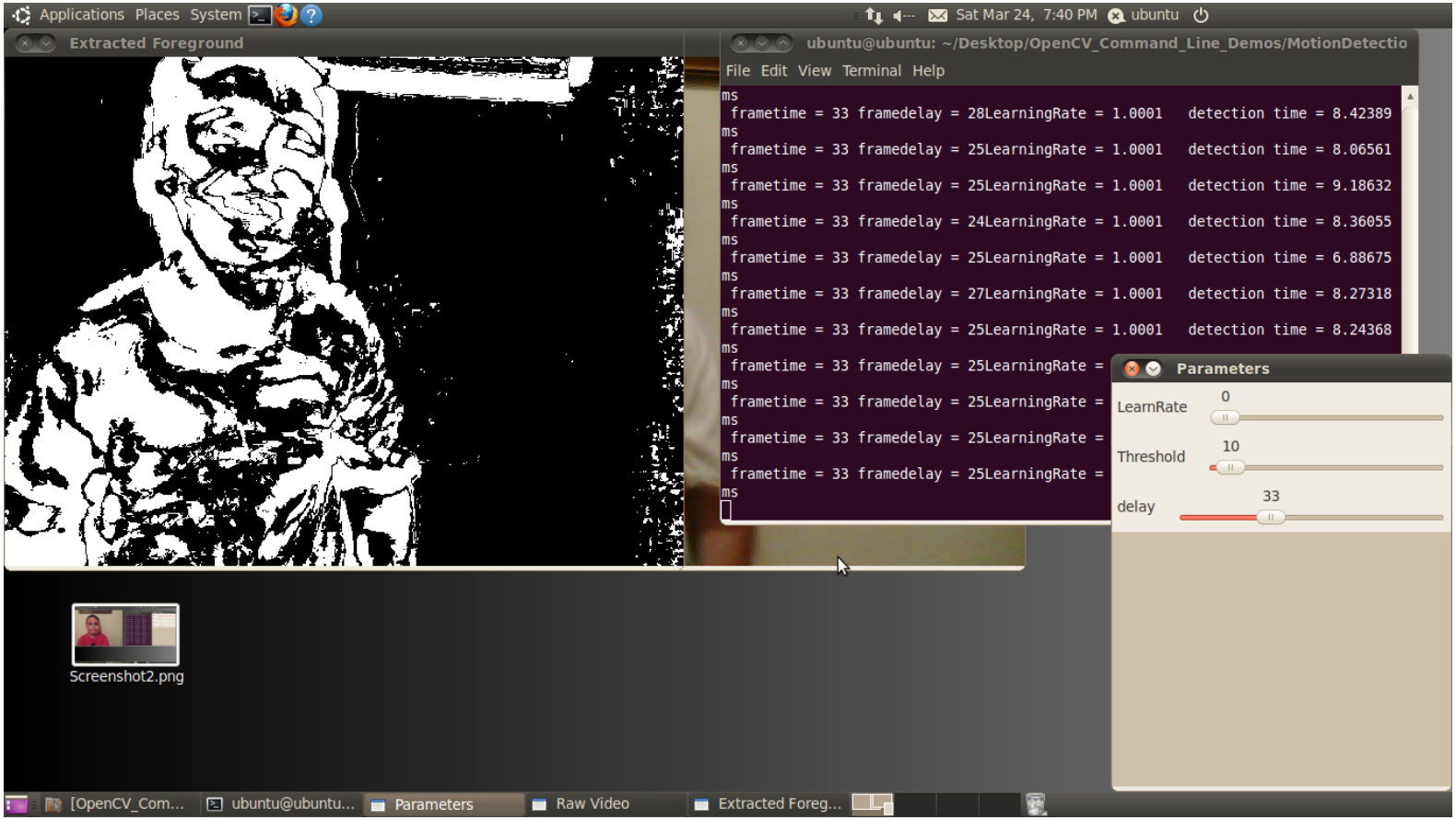
Demo 1—Motion Detection

- **LearnRate**—Regulates the update speed (how fast the accumulator "forgets" about earlier images).
- **Threshold**—The minimum value for a pixel difference to be considered moving.

BDTI OpenCV Executable Demo Package



BDTI Quick-Start OpenCV Kit

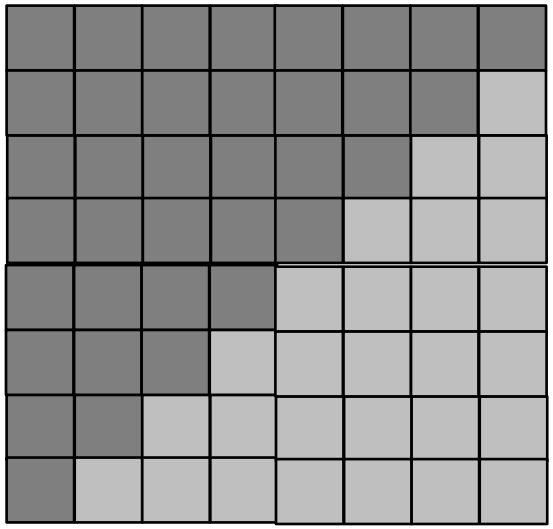


LINE DETECTION

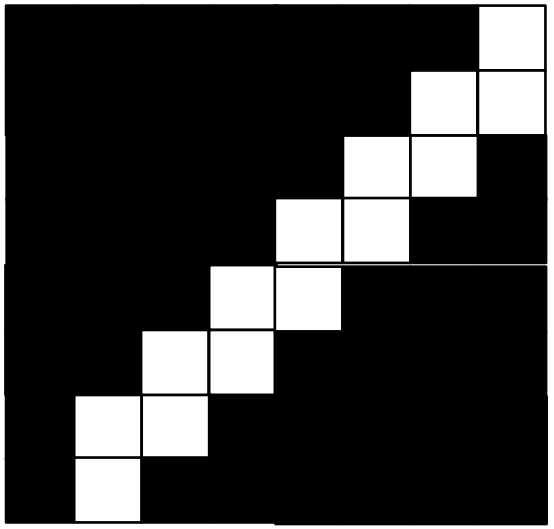
Line Detection Using Edges

In a monochrome image, a line is defined as a group of pixels organized along a straight edge.

An edge in a monochrome image is defined as a dark pixel next to a lighter pixel.



original image



detected edge

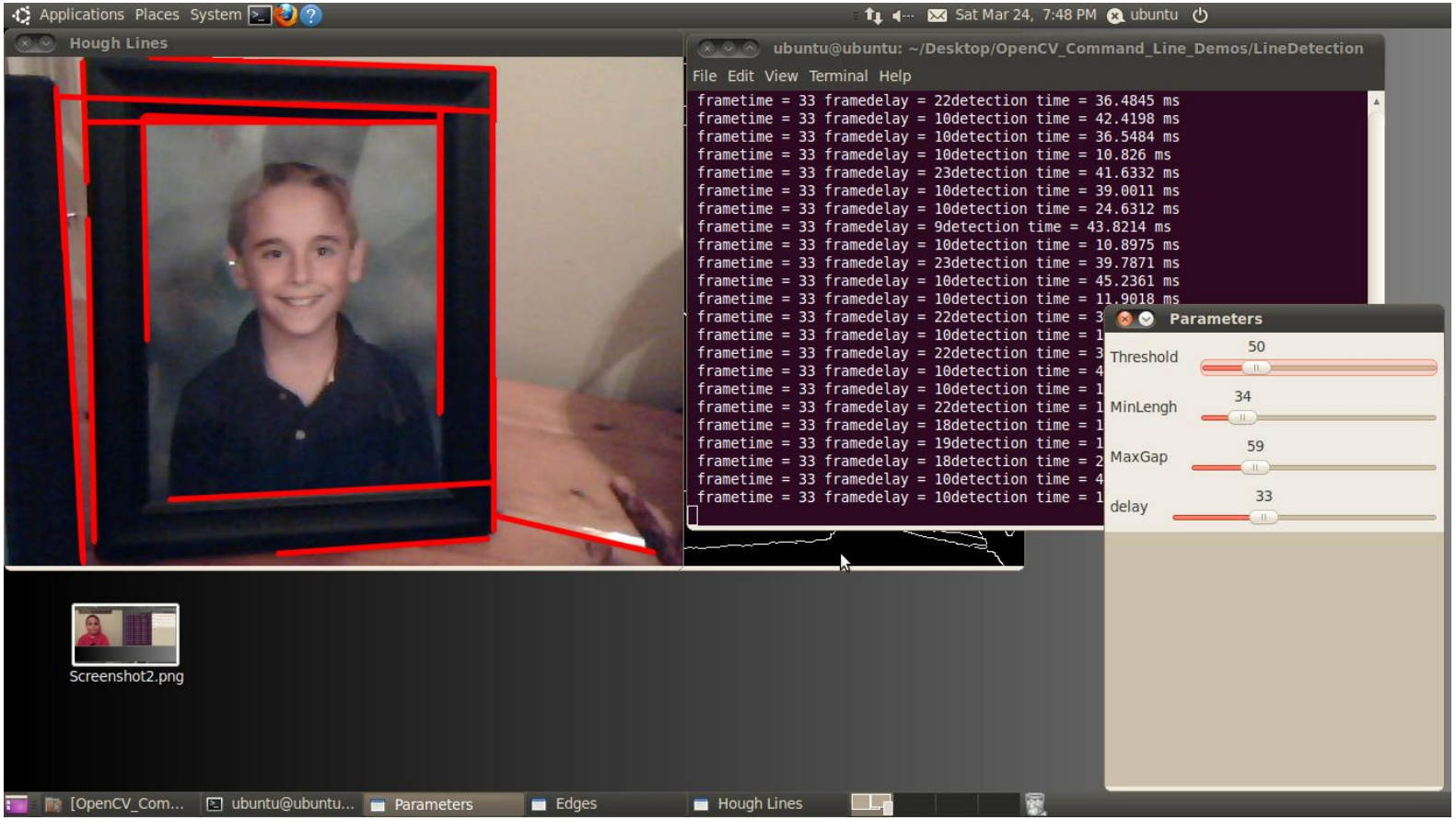
Line Detection Using Edges

- After the edge detector finds the edges, another algorithm called the Hough transform finds edge pixels that line-up in straight lines.
- Straight lines are a valuable feature in a image.
- Straight lines define the boundaries of objects in an image and can be used for tracking purposes in a video stream.

Demo 2—Line Detection Using Edges

- **Threshold**—Set the minimum difference between adjoining groups of pixels to be classified as an edge.
- **MinLength**—The minimum number of "continuous" edge pixels required to be classified as a straight line.
- **MaxGap**—The maximum number of missing edge pixels within a straight line, while still being considered "continuous".

BDTI Quick-Start OpenCV Kit



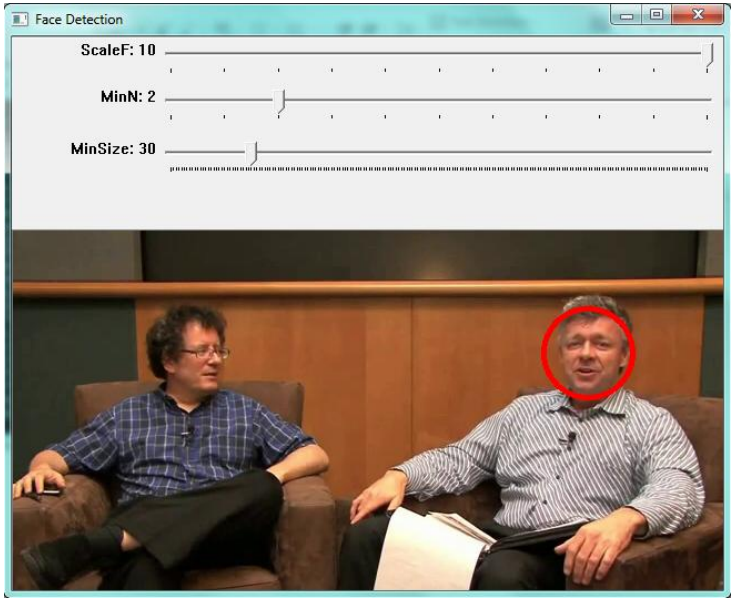
FACE DETECTION

Face Detection

As the name implies, face detection is used to find faces in an image. The underlying algorithm can actually be used to detect any object. This algorithm is trained to look for specific features, in a specific order.

Training is done offline, and is accomplished by “showing” the learning algorithm both positive and negative images (images with a face and without a face).

The result of the training is a file that describes the object to detect, using very specific features.

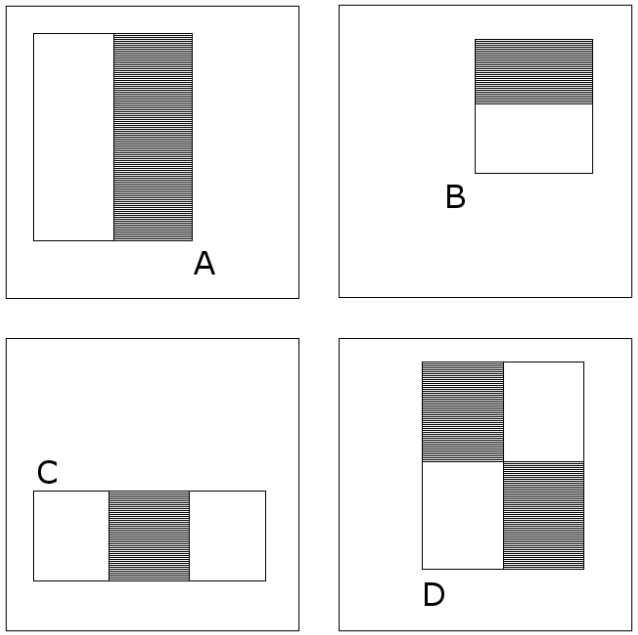


Face Detection

Face detection, as demonstrated in this context, uses a set of four distinct templates to define unique features.

Templates are used because they can be processed faster then other techniques.

The template is laid over a portion of the image, and a weight is calculated based on the pixels under the template.

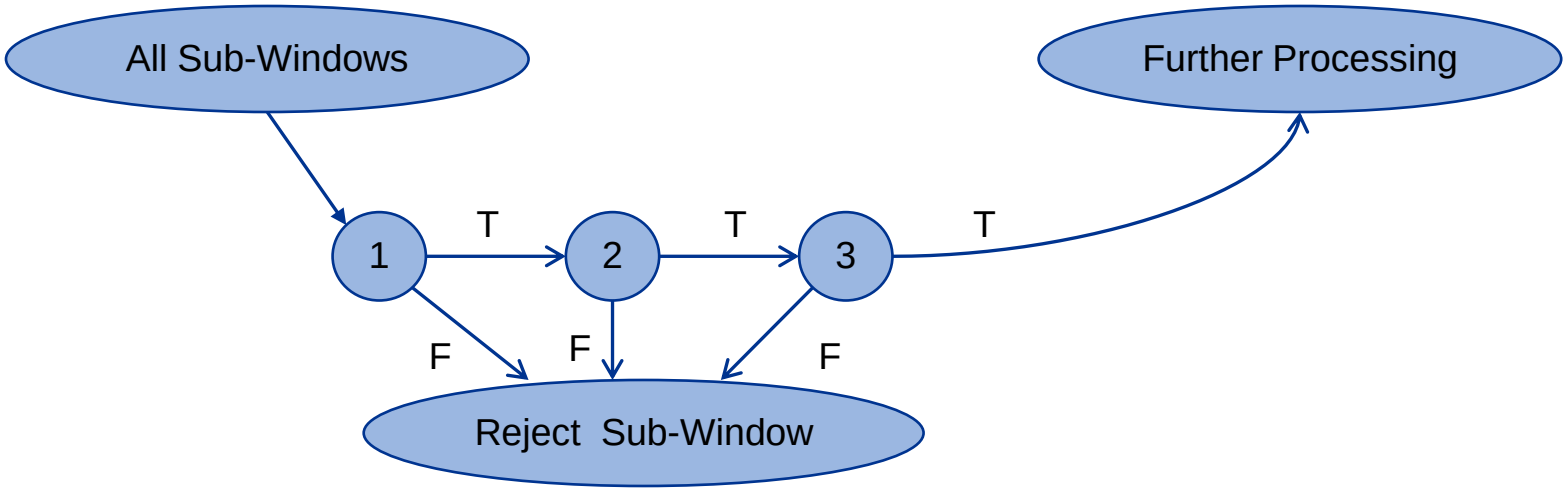


Face Detection

How does training work?

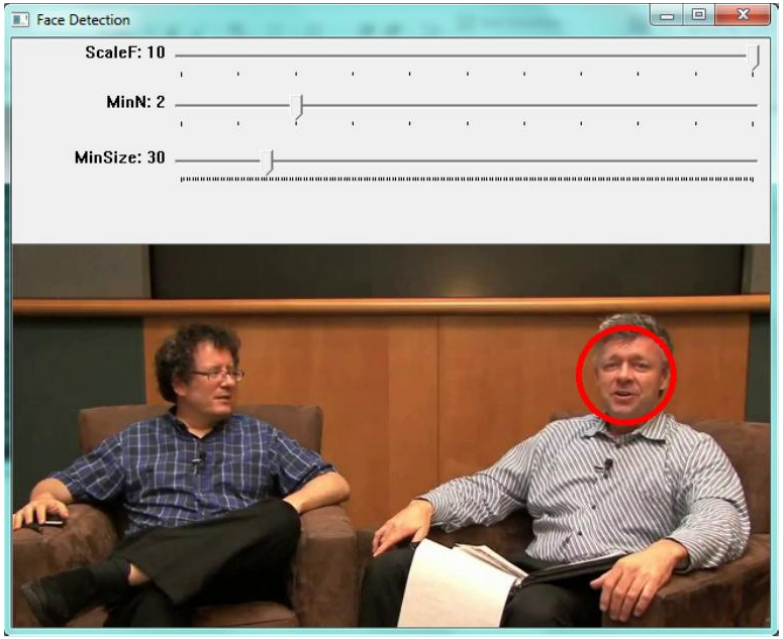
A face of 24 24 pixels can have 45,396 possible combinations/scales of the templates from the pervious slide.

The purpose of training is to reduce the 45,396 possible combinations down to a minimum number and an ideal order.



Demo 3—Face Detection

- **MinSize**—The smallest face to detect. As a face gets further from the camera, it appears smaller. This parameter also defines the farthest a face can be from the camera and still get detected.
- **MinN**—The Minimum Neighbor parameter groups faces that are detected multiple times into one detection.
- **ScaleF**—Scale Factor determines the number of times the face detector is run at each pixel location. The Haar Cascade (xml file) that determines what the detector will detect, is designed for an object of only one size. In order to detect objects of various sizes (faces close to the camera as well as far from the camera) the detector must be scaled.



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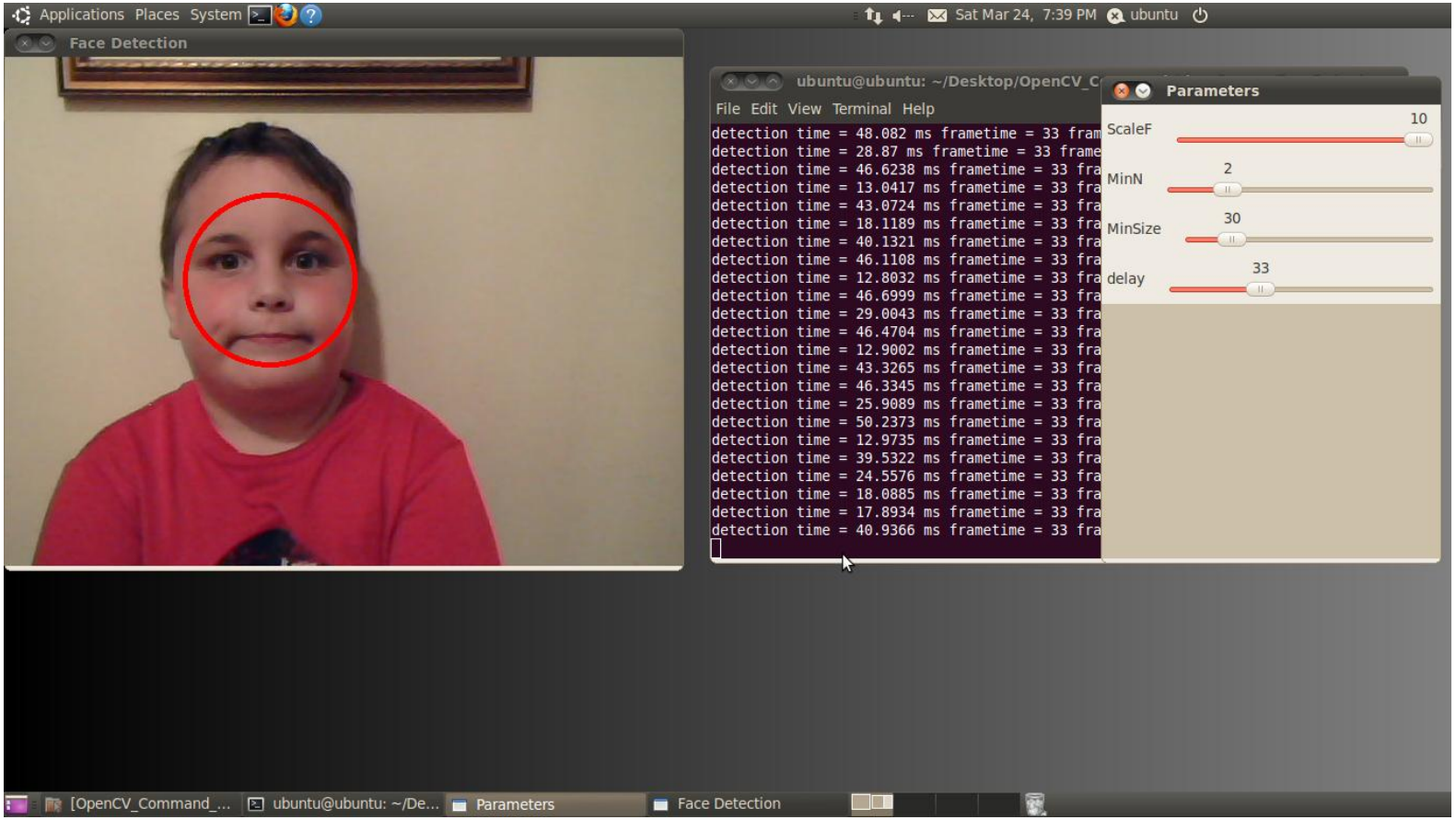
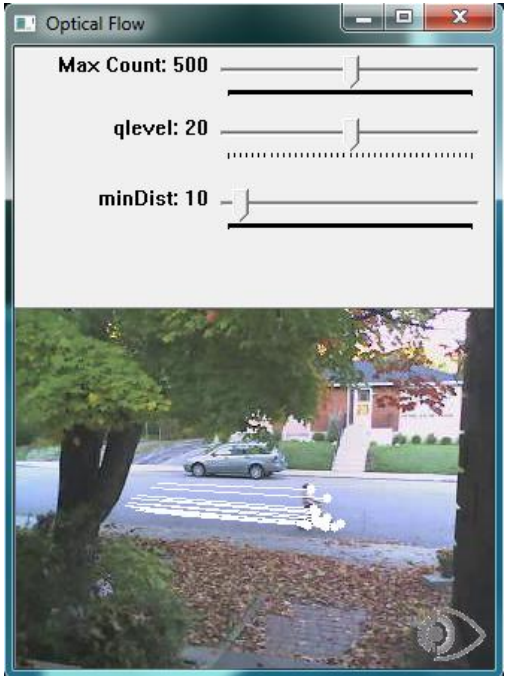
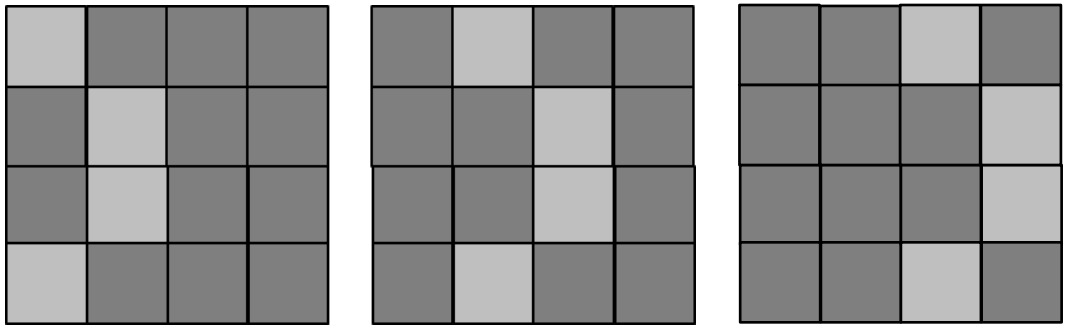


OPTICAL FLOW BASED TRACKING

Optical Flow Based Tracking

Optical flow is the change in position of a group of pixels (feature) from one image to the next.





Optical Flow

The first step in optical flow is determining which features to use.

The algorithm used in this example uses features like corners, edges, and points of brightness.

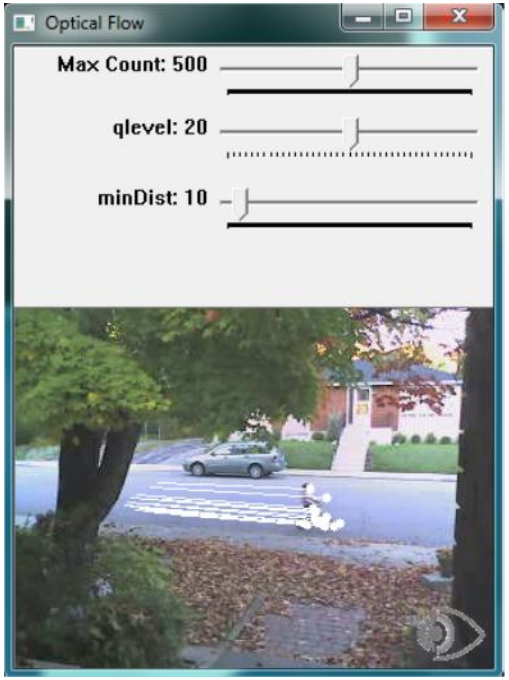
These “good” features are found in each frame of a video stream.

With this data, a tracking algorithm can then be applied to predict where the object will appear in the next frame. This is object tracking.



Demo 4—Optical Flow Based Tracking

- **MaxCount** —The maximum number of good features to look for in a frame.
- **qlevel** —The quality of the features to accept. A higher quality feature is more likely to be unique, and be correctly found in the next frame. A low quality feature may get lost in the next frame, or worse be confused with another point in the image of the next frame.
- **minDist** —The minimum distance between features selected.



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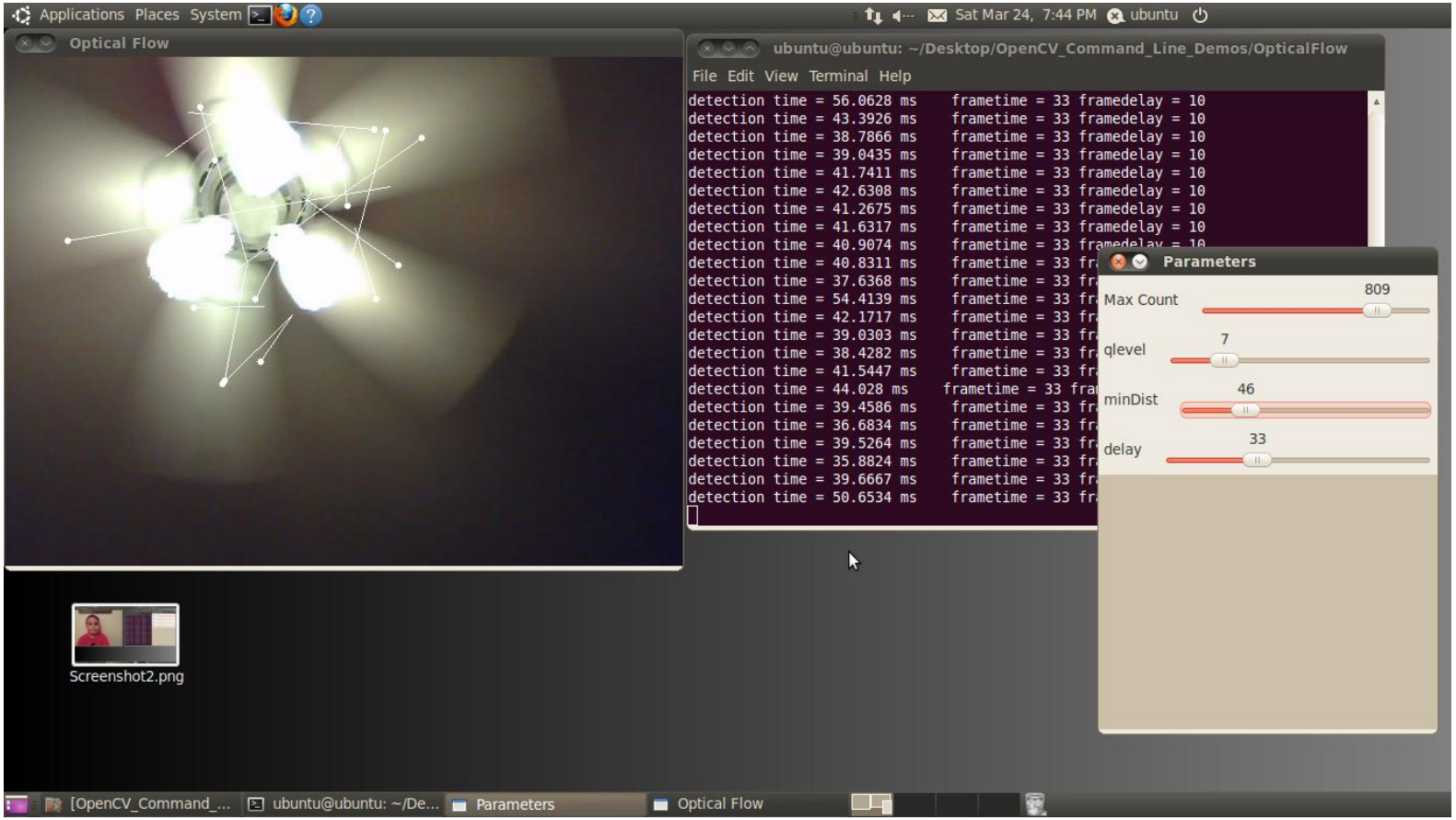

Summary

- Computer vision represents the “software sensor” of the future.
- Computer vision trades unique hardware for software.
- In some instances, computer vision can be considered a “software scalable sensor”. As the available processing power increases, the capabilities of the technology increase.
- OpenCV is a free computer vision library that has been downloaded over 3 million times.
- This presentation covered only 4 of the over 2,000 algorithms available in OpenCV.

RESOURCES

The *Embedded Vision Summit*
A Free Educational Event for Engineers—Boston, September 19th

Learn how to use the coolest new technology in the industry to create "machines that see"

- Technical presentations on sensors, processors, tools, and design techniques
- Keynotes by Prof. Rosalind Picard, MIT Media Lab and Gary Bradski, CEO, OpenCV Foundation
- Cool demonstrations and opportunities to meet with leading vision technology suppliers

Part of UBM Electronics' DESIGN East event

- DESIGN East also includes the Embedded Systems Conference, Sensors in Design, DesignMED, Android Summit, LED Summit, and exhibits

The Summit is free, but space is limited. To begin the registration process, send an email to summit@Embedded-Vision.com

For more info: www.embedded-vision.com/embedded-vision-summit

Selected Resources: The Embedded Vision Alliance

The Embedded Vision Alliance is an industry partnership to transform the electronics industry by inspiring and empowering engineers to design systems that see and understand

AMD · Analog Devices · apical · Aptina Imaging · Avnet · BDTi · CEVA The DSP Powerhouse · Cognimem Technologies, Inc. · cognivue Corporation · eyeSight · freescale semiconductor · IMS research excellence in market intelligence · intel · MathWorks · MAXIM Innovation Delivered · National Instruments · nVIDIA · omek · PointGrab · Synopsys · Texas Instruments · Tokyo Electron Device Limited · VanGoghImaging A New Vision for Mobile 3D Apps · XILINX

Free Resources from the Embedded Vision Alliance

The Embedded Vision Alliance web site, at www.Embedded-Vision.com covers embedded vision applications and technology, including interviews and demonstrations

The Embedded Vision Academy, a free service of the Alliance, offers free in-depth tutorial articles, video "chalk talks," code examples and discussion forums: www.EmbeddedVisionAcademy.com

The Embedded Vision Insights newsletter provides updates on new materials available on the Alliance website. Sign up at www.Embedded-Vision.com/user/register

Embedded vision technology and services companies interested in becoming sponsoring members of the Alliance may contact info@Embedded-Vision.com

What is BDTI?

BDTI is a group of engineers dedicated to helping the electronics industry effectively use embedded digital signal processing technology

BDTI performs hands-on, independent benchmarking and evaluation of chips, tools, algorithms, and other technologies

BDTI helps system designers implement their products through specialized engineering services

BDTI offers a wealth of free information for engineers

Additional Resources

BDTI's web site, www.BDTI.com, provides a variety of free information on processors used in vision applications.

BDTI's free "InsideDSP" email newsletter covers tools, chips, and other technologies for embedded vision and other DSP applications. Sign up at www.BDTI.com.