



Fundamentals of Embedded Computer Vision: Creating Machines That See

Day 4: Introduction to Vision Algorithms and Some Free Tools

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What is OpenCV?

An open source library of over 500 functions

Over 2 dozen examples

An easy tool for experimenting with computer vision

C/C++/Python API

Windows/Linux/

Android/iPhone platforms

Over 3,000,000 downloads

OpenCV Overview: > 500 functions
opencv.willowgarage.com

Robot support

General Image Processing Functions

Image Pyramids
 Coarse-to-fine optical flow estimation

Geometric descriptors

Segmentation

Camera calibration, Stereo, 3D

Utilities and Data Structures

Fitting

Tracking
 Optical Flow in 1D

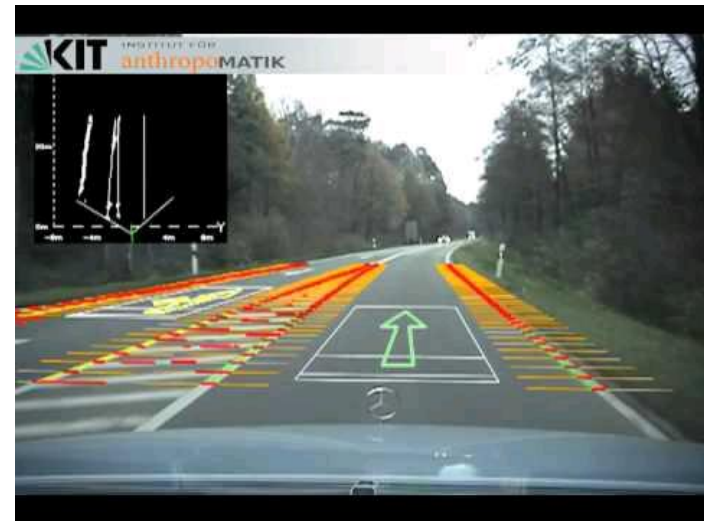
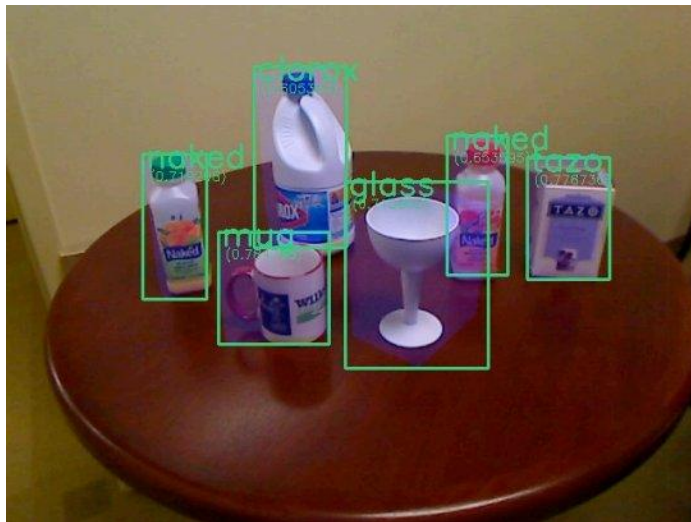
Matrix Math

Machine Learning:
 • Detection,
 • Recognition

Features

Transforms

What Can OpenCV Do?



OpenCV in The Embedded Space

OpenCV has always been available to the embedded space under Linux.

The library has been ported to: PowerPC, MIPS, Blackfin, Xscale and ARM.

If it can run Linux, it can run OpenCV.



<http://whatnicklife.blogspot.com/2010/05/beagle-has-2-eyes-opencv-stereo-on.html>



On YouTube, you can find demonstrations of OpenCV running on the TI Beagleboard, Freescale i.MX53 Quick Start Board, and various NVIDIA based tablets and phones.

In the mobile market you can find examples of OpenCV running on the iPhone and Android devices.



GETTING STARTED WITH OPENCV THE EASY WAY USING BDTI'S FREE TOOLS

Two Easy-to-Use Tools for Getting Up and Running on OpenCV

BDTI OpenCV Executable Demo Package

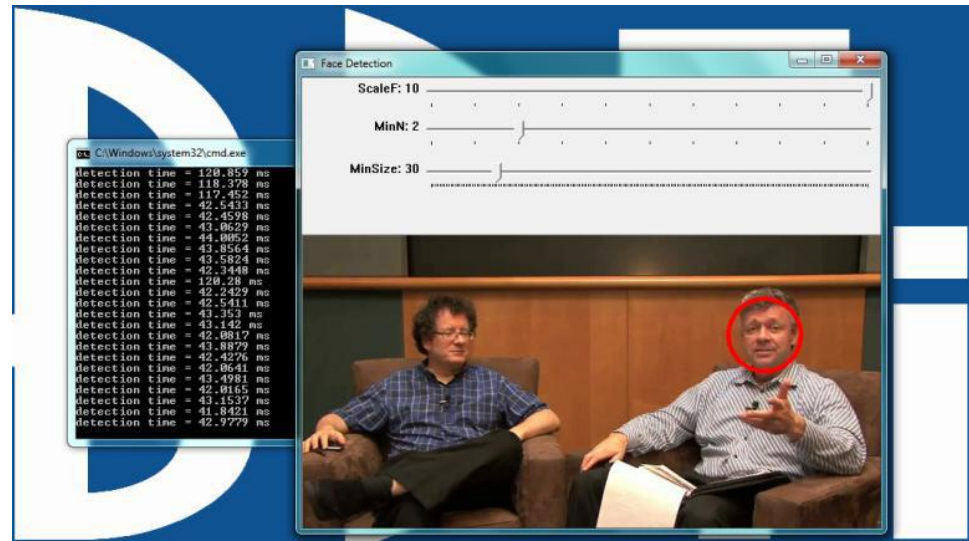
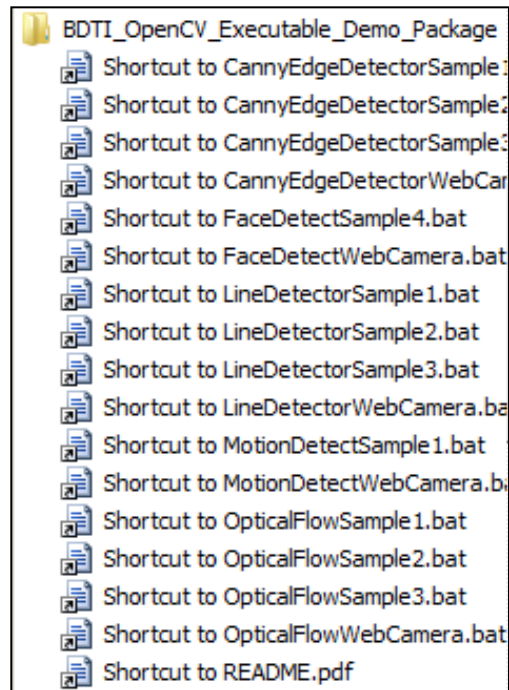
- No programming required
- Windows based
- Easy to install
- No tools required
- Run examples with just a mouse click
- Use mouse to adjust demo parameters in real-time
- Supports video input from files or real-time video using webcam
- Includes example source and reference Visual Studio projects

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

BDTI OpenCV Executable Demo Package

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

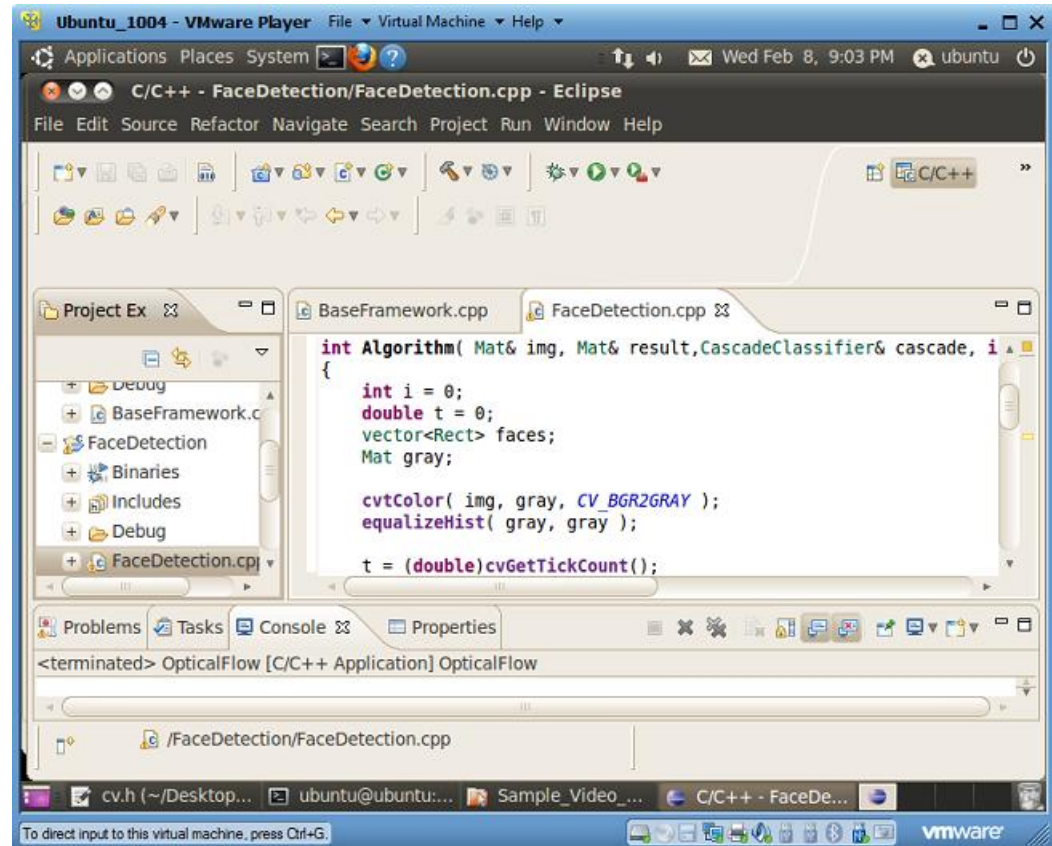


BDTI Quick-Start OpenCV Kit

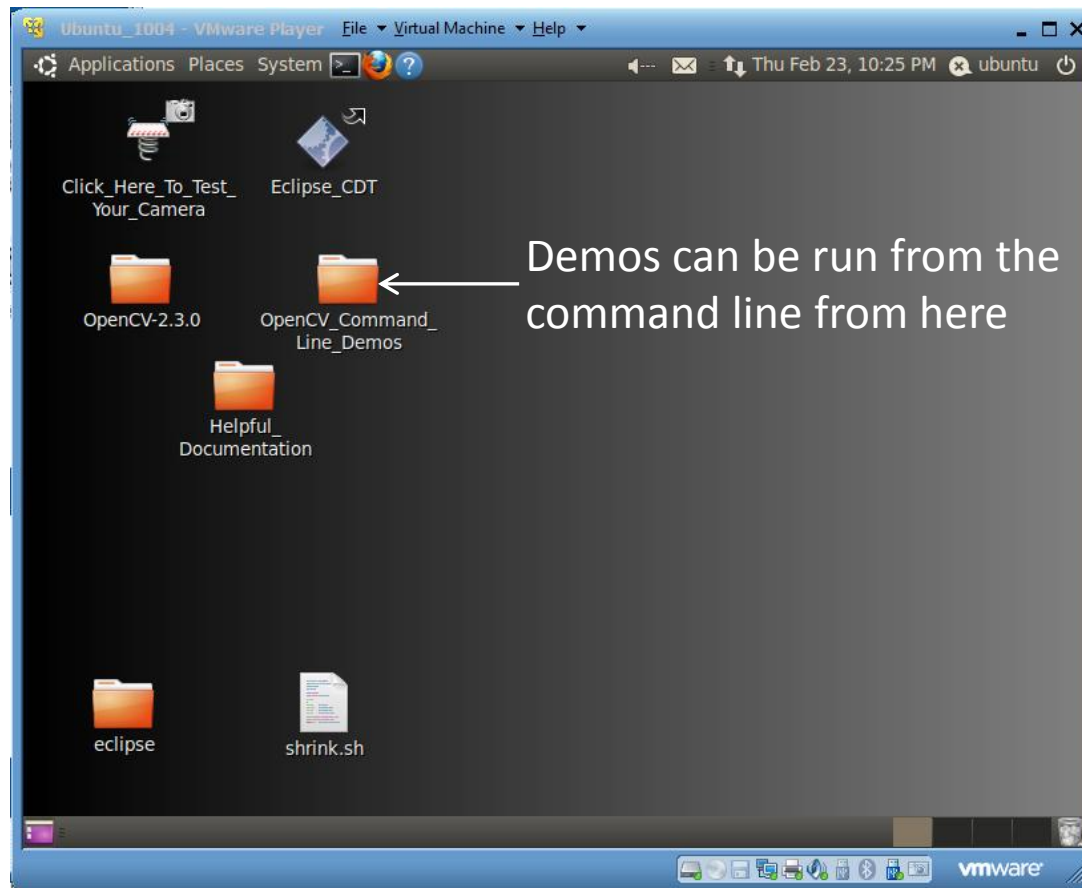
The Ubuntu OS and GCC compiler runs in a VMware image.

OpenCV is pre-installed and configured with all source.

Example applications use the Eclipse graphical debugging environment.



BDTI Quick-Start OpenCV Kit—Ubuntu Desktop in VMware



The Embedded Vision Alliance

The tools used in this presentation can be downloaded at:
www.embeddedvisionacademy.com

The screenshot shows the homepage of the Embedded Vision Academy. At the top left is the Embedded Vision Alliance logo. To its right is a 'Free Technical Training' badge and 'REGISTER' and 'SIGN IN' buttons. Below these are social media icons for LinkedIn, Twitter, Facebook, and RSS, along with a search bar. A green navigation bar contains the following menu items: 'What is Embedded Vision?', 'The E.V. Alliance', 'Platinum Members', 'Technology', 'Applications', 'Industry Analysis', and 'Forums'. The main heading is 'Embedded Vision Academy'. Below this is a 'Welcome' section with an RSS icon and three paragraphs of text. The right sidebar features a list of filters: 'Newest', 'Technologies', 'Applications', 'Functions', 'Level', 'Provider', and 'Type'. The text in the 'Welcome' section reads: 'The Embedded Vision Academy is a free online training facility for embedded vision product developers. This program provides educational and other resources to help engineers integrate visual intelligence—the ability of electronic systems to see and understand their environments—into next-generation embedded and consumer devices. The goal of the Academy is to make it possible for engineers worldwide to gain the skills needed for embedded vision product and application development. Course material in the Embedded Vision Academy spans a wide range of vision-related subjects, from basic vision algorithms to image pre-processing, image sensor interfaces, and software development techniques and tools such as OpenCV. Courses will incorporate training videos, interviews, demonstrations, downloadable code, and other developer resources—all oriented towards developing embedded vision products. The Alliance plans to continuously expand the curriculum of the Embedded Vision Academy, so engineers will be able to return to the site on an ongoing basis for new courses and resources. The listing below showcases the most recently published Embedded Vision Academy content. Reference the links on the right side of this page to access the full suite of embedded vision content, sorted by technology, application, function, viewer experience level, provider, and

Embedded Vision Academy Type Downloads

BDTI Quick-Start OpenCV Kit—for programmers

www.embeddedvisionacademy.com/opencvkit

BDTI OpenCV Executable Demo Package—No programming required

www.embeddedvisionacademy.com/opencvdemo

The screenshot shows the Embedded Vision Academy website. At the top, there is a navigation bar with links for 'About Embedded Vision', 'The Embedded Vision Alliance', 'Platinum Members', 'Embedded Vision Academy', 'Industry Analysis', and 'Forums'. The main content area is titled 'Embedded Vision Academy' and features a 'Downloads' section. Two download links are highlighted with red arrows:

- Start Developing OpenCV Applications Immediately Using the BDTI Quick-Start OpenCV Kit (Download)**: April 25, 2012. This link is associated with the URL www.embeddedvisionacademy.com/opencvkit.
- Introduction To Computer Vision Using OpenCV (Software Demo)**: November 25, 2011. This link is associated with the URL www.embeddedvisionacademy.com/opencvdemo.

On the right side of the page, there is a sidebar with a search bar and a list of categories: Newest, Technologies, Applications, Functions, Level, Provider, Type, Videos, Documents, and Downloads. The 'Type' and 'Downloads' categories have red arrowheads pointing to the right.

Additional Tutorials—Embedded Vision Academy

www.embeddedvisionacademy.com/bdtitraining



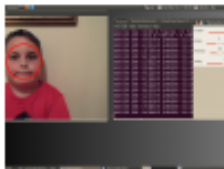
Building Machines That See: Finding Edges in Images

August 08, 2012

By [Eric Gregori](#)

Senior Software Engineer

BDTI



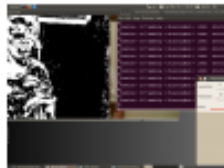
Introduction to Embedded Vision and the OpenCV Library (Embedded.com Article)

August 03, 2012

By [Eric Gregori](#)

Senior Software Engineer

BDTI



Start Developing OpenCV Applications Immediately Using the BDTI Quick-Start OpenCV Kit (Article)

April 26, 2012

OpenCV is an open-source software component library for computer vision application development. OpenCV is a powerful tool for prototyping embedded vision algorithms. Originally released in 2000, it has been downloaded over 3.5 million times. The OpenCV library supports over 2,500 functions and contains dozens of valuable vision application examples. The library supports C, C++, and Python and has been ported to Windows, Linux, Android, MAC OS X and iOS.

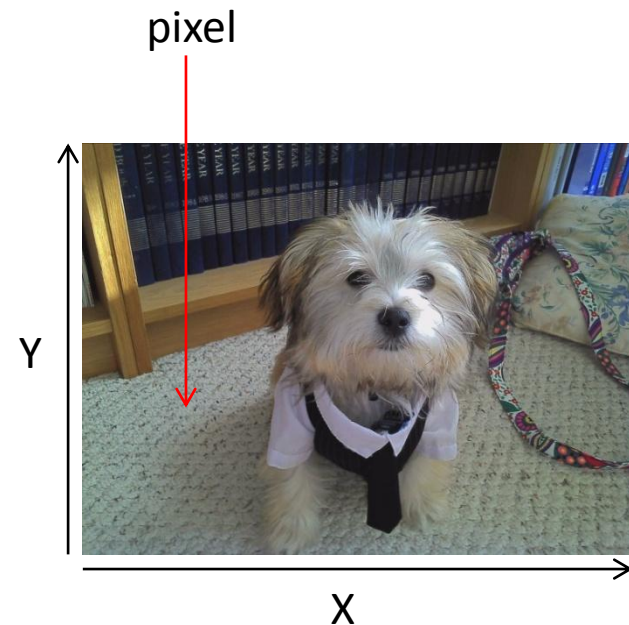




COMPUTER VISION FUNDAMENTALS

The Basics—An “Image” and A “Frame”

- Both images and frames are made up of individual pixels organized in a 2 dimensional array.
- For a color image, each pixel can be anything from 8 to 32 bits wide.
- Most monochrome images use 8 bits per pixel.
- A frame is a single image in a video sequence.



“Feature”—A Fundamental Concept in Computer Vision

feature (fchr)n.

A prominent or distinctive aspect, quality, or characteristic: a feature of one’s personality; a feature of the landscape.

<http://www.thefreedictionary.com/feature>

The concept of, “a feature of an object” is very important for most computer vision algorithms.

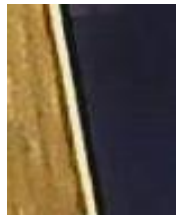
In a image or frame, a feature is a group of pixels with some unique attribute.



corner



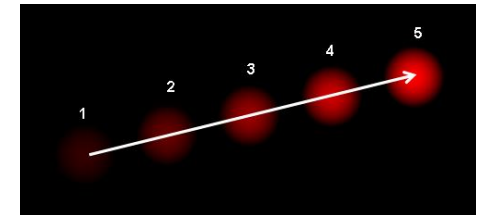
points



edge



contrast



motion

Some Basic “Building Block” Algorithms Used in Computer Vision

- **Detection**
 - Motion Detection—Finds groups of pixels (features) that are in motion (change in position from one frame to the next).
 - Line Detection—Finds groups of pixels (features) that are organized in straight lines, along edges.
 - Face Detection—Finds groups of pixels organized in a group that fits the template of a face.
- **Tracking**
 - Optical Flow based tracking—A combination of algorithms used to track moving objects in a video using features.

Summary:

- Computer vision represents the “software sensor” of the future.
- In some instances, computer vision can be considered a “software scalable sensor”. As the available CPU horsepower 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.
- BDTI has free tools to enable both programmers and non-programmers to experiment with computer vision and OpenCV.

Next Up:

- Tomorrow we will use the tools discussed today to demonstrate various computer vision algorithms.
- Tomorrow you will learn how to use OpenCV to do:
 - Face detection
 - Line detection
 - Edge detection
 - Motion detection
 - Optical flow
- If you have not already, please download the www.embeddedvisionacademy.com/opencvkit



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



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



Embedded Vision Insights
The Latest Developments on Designing Machines that See

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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.

