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Find distance from camera to object/marker using Python and OpenCV

by **Adrian Rosebrock** on January 19, 2015 in **Image Processing**, **Tutorials**

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A couple of days ago, Cameron, a PyImageSearch reader emailed in and asked about methods to find the distance from a camera to an object/marker in an image. He had spent some time researching, but hadn't found an implementation.

I knew exactly how Cameron felt. Years ago I was working on a small project to analyze the movement of a baseball as it left the pitcher's hand and headed for home plate.

Using motion analysis and trajectory-based tracking I was able to find/estimate the ball location in the frame of the video. And since a baseball has a known size, I was also able to estimate the distance to home plate.

It was an interesting project to work on, although the system was not as accurate as I wanted it to be — the "motion blur" of the ball moving so fast made it hard to obtain highly accurate estimates.

My project was definitely an "outlier" situation, but in general, determining the distance from a camera to a marker is actually a very well

studied problem in the computer vision/image processing space. You can find techniques that are very straightforward and succinct like the triangle similarity. And you can find methods that are complex (albeit, more accurate) using the intrinsic parameters of the camera model.

In this blog post I'll show you how Cameron and I came up with a solution to compute the distance from our camera to a known object or marker.

Definitely give this post a read — you won't want to miss it!

> **Looking for the source code to this post?**
> **Jump right to the downloads section.**

OpenCV and Python versions:
This example will run on **Python 2.7/Python 3.4+** and **OpenCV 2.4.X**.

Triangle Similarity for Object/Marker to Camera Distance

In order to determine the distance from our camera to a known object or marker, we are going to utilize *triangle similarity*.

The triangle similarity goes something like this: Let's say we have a marker or object with a known width *W*. We then place this marker some distance *D* from our camera. We take a picture of our object using our camera and then measure the apparent width in pixels *P*. This allows us to derive the perceived focal length *F* of our camera:

$F = (P \times D) / W$

For example, let's say I place a standard piece of *8.5 x 11in* piece of paper (horizontally; *W = 11*) *D = 24 inches* in front of my camera and take a photo. When I measure the width of the piece of paper in the image, I notice that the perceived width of the paper is *P = 248 pixels*.

My focal length *F* is then:

$F = (248px \times 24in) / 11in = 543.45$

As I continue to move my camera both closer and farther away from the object/marker, I can apply the triangle similarity to determine the distance of the object to the camera:

$D' = (W \times F) / P$

Again, to make this more concrete, let's say I move my camera *3 ft* (or 36 inches) away from my marker and take a photo of the same piece of paper. Through automatic image processing I am able to determine that the perceived width of the piece of paper is now *170 pixels*. Plugging this into the equation we now get:

$D' = (11in \times 543.45) / 170 = 35in$

Or roughly 36 inches, which is 3 feet.

Note: *When I captured the photos for this example my tape measure had a bit of slack in it and thus the results are off by roughly 1 inch. Furthermore, I also captured the photos hastily and not 100% on top of the feet markers on the tape measure, which added to the 1 inch error. That all said, the triangle similarity still holds and you can use this method to compute the distance from an object or marker to your camera quite easily.*

Make sense now?

Awesome. Let's move into some code to see how finding the distance from your camera to an object or marker is done using Python, OpenCV, and image processing and computer vision techniques.

Finding the distance from your camera to object/marker using Python and OpenCV

Let's go ahead and get this project started. Open up a new file, name it `distance_to_camera.py` , and we'll get to work.

Find distance from camera to object using Python and OpenCV — Python

```
# import the necessary packages
import numpy as np
import cv2

def find_marker(image):
    # convert the image to grayscale, blur it, and detect edges
    gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
```

```
 8      gray = cv2.GaussianBlur(gray, (5, 5), 0)
 9      edged = cv2.Canny(gray, 35, 125)
10
11      # find the contours in the edged image and keep the largest one;
12      # we'll assume that this is our piece of paper in the image
13      (cnts, _) = cv2.findContours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
14      c = max(cnts, key = cv2.contourArea)
15
16      # compute the bounding box of the of the paper region and return it
17      return cv2.minAreaRect(c)
```

The first thing we'll do is import our necessary packages. We'll use NumPy for numerical processing and `cv2` for our OpenCV bindings.

From there we define our `find_marker` function. This function accepts a single argument, `image` , and is meant to be utilized to find the object we want to compute the distance to.

In this case we are using a standard piece of 8.5 x 11 inch piece of paper as our marker.

Our first task is to now find this piece of paper in the image.

To to do this, we'll convert the image to grayscale, blur it slightly to remove high frequency noise, and apply edge detection on **Lines 7-9**.

After applying these steps our image should look something like this:

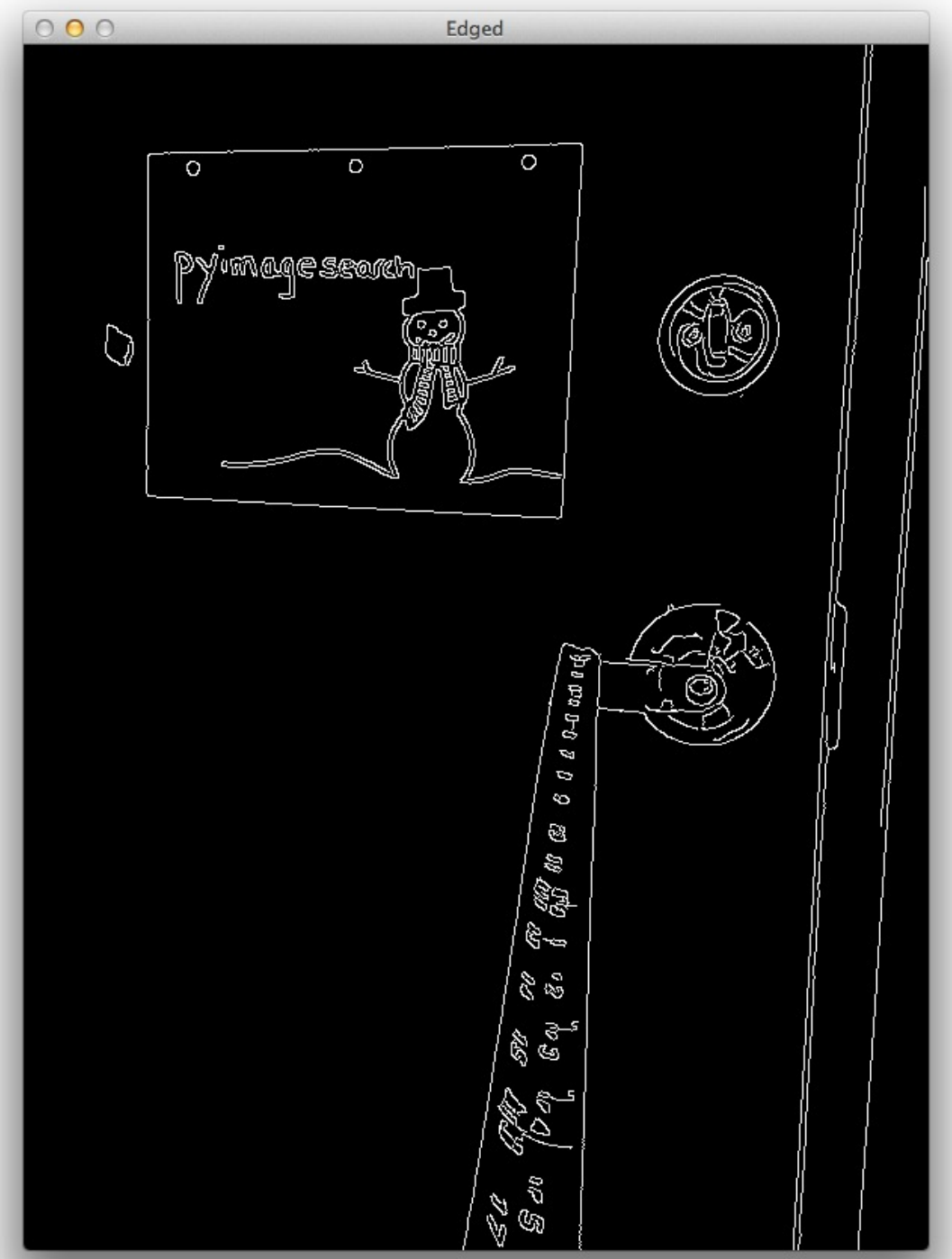

Figure 1: Applying edge detection to find our marker, which in this case is a piece of paper.

As you can see, the edges of our marker (the piece of paper) have clearly been reveled. Now all we need to do is find the contour (i.e. outline) that represents the piece of paper.

We find our marker on **Line 13** by using the `cv2.findContours` function and then determining the contour with the largest area on **Line 14**.

We are making the assumption that the contour with the largest area is our piece of paper. This assumption works for this particular example, but in reality *finding the marker in an image is highly application specific.*

In our example, simple edge detection and finding the largest contour works well. We could also make this example more robust by applying contour approximation, discarding any contours that do not have 4 points (since a piece of paper is a rectangle and thus has 4 points), and then finding the largest 4-point contour.

Note: *More on this methodology can be found in this post on building a kick-ass mobile document scanner.*

Other alternatives to finding markers in images is to utilize color, such that the color of the marker is substantially different from the rest of the scene in the image. You could also apply methods like keypoint detection, local invariant descriptors, and keypoint matching to find markers; however, these approaches are outside the scope of this article and are again, highly application specific.

Anyway, now that we have the contour that corresponds to our marker, we return the bounding box which contains the *(x, y)*-coordinates and width and height of the box (in pixels) to the calling function on **Line 17**.

Let's also quickly to define a function that computes the distance to an object using the triangle similarity detailed above:

Find distance from camera to object using Python and OpenCV — Python

```
19 def distance_to_camera(knownWidth, focalLength, perWidth):
20     # compute and return the distance from the maker to the camera
21     return (knownWidth * focalLength) / perWidth
```

This function takes a `knownWidth` of the marker, a computed `focalLength` , and perceived width of an object in an image (measured in pixels), and applies the triangle similarity detailed above to compute the actual distance to the object.

To see how we utilize these functions, continue reading:

Find distance from camera to object using Python and OpenCV — Python

```
1  # import the necessary packages
2  import numpy as np
3  import cv2
4
5  def find_marker(image):
6      # convert the image to grayscale, blur it, and detect edges
7      gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
8      gray = cv2.GaussianBlur(gray, (5, 5), 0)
9      edged = cv2.Canny(gray, 35, 125)
10
11     # find the contours in the edged image and keep the largest one;
12     # we'll assume that this is our piece of paper in the image
13     (cnts, _) = cv2.findContours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
14     c = max(cnts, key = cv2.contourArea)
15
16     # compute the bounding box of the of the paper region and return it
17     return cv2.minAreaRect(c)
18
19 def distance_to_camera(knownWidth, focalLength, perWidth):
20     # compute and return the distance from the maker to the camera
21     return (knownWidth * focalLength) / perWidth
22
23 # initialize the known distance from the camera to the object, which
24 # in this case is 24 inches
25 KNOWN_DISTANCE = 24.0
26
27 # initialize the known object width, which in this case, the piece of
28 # paper is 11 inches wide
29 KNOWN_WIDTH = 11.0
30
31 # initialize the list of images that we'll be using
32 IMAGE_PATHS = ["images/2ft.png", "images/3ft.png", "images/4ft.png"]
33
34 # load the furst image that contains an object that is KNOWN TO BE 2 feet
35 # from our camera, then find the paper marker in the image, and initialize
36 # the focal length
37 image = cv2.imread(IMAGE_PATHS[0])
38 marker = find_marker(image)
39 focalLength = (marker[1][0] * KNOWN_DISTANCE) / KNOWN_WIDTH
```

The first step to finding the distance to an object or marker in an image is to *calibrate* and *compute the focal length*. To do this, we need to know:

- The distance of the camera from an object.
- The width (in units such as inches, meters, etc.) of this object. *Note:* The height could also be utilized, but this example simply uses the width.

Let's also take a second and mention that what we are doing *is not true camera calibration*. True camera calibration involves the intrinsic parameters of the camera, which you can read more on here.

On **Line 25** we initialize our known `KNOWN_DISTANCE` from the camera to our object to be 24 inches. And on **Line 29** we initialize the `KNOWN_WIDTH` of the object to be 11 inches (i.e. a standard 8.5 x 11 inch piece of paper laid out horizontally).

We then define the paths to our images we are going to use on **Line 32**.

The next step is important: ***it's our simple calibration step.***

We load the first image off disk on **Line 37** — we'll be using this image as our calibration image.

Once the image is loaded, we find the piece of paper in the image on **Line 38**, and then compute our `focalLength` on **Line 39** using the triangle similarity.

Now that we have "calibrated" our system and have the `focalLength`, we can compute the distance from our camera to our marker in subsequent images quite easily.

Let's see how this is done:

Find distance from camera to object using Python and OpenCV — Python

```
41 # loop over the images
42 for imagePath in IMAGE_PATHS:
43     # load the image, find the marker in the image, then compute the
44     # distance to the marker from the camera
45     image = cv2.imread(imagePath)
46     marker = find_marker(image)
47     inches = distance_to_camera(KNOWN_WIDTH, focalLength, marker[1][0])
48
49     # draw a bounding box around the image and display it
50     box = np.int0(cv2.cv.BoxPoints(marker))
51     cv2.drawContours(image, [box], -1, (0, 255, 0), 2)
52     cv2.putText(image, "%.2fft" % (inches / 12),
53         (image.shape[1] - 200, image.shape[0] - 20), cv2.FONT_HERSHEY_SIMPLEX,
54         2.0, (0, 255, 0), 3)
55     cv2.imshow("image", image)
56     cv2.waitKey(0)
```

We start looping over our image paths on **Line 42**.

Then, for each image in the list, we load the image off disk on **Line 45**, find the marker in the image on **Line 46,** and then compute the distance of the object to the camera on **Line 47**.

From there, we simply draw the bounding box around our marker and display the distance on **Lines 50-56**.

Results

To see our script in action, open up a terminal, navigate to your code directory, and execute the following command:

Find distance from camera to object using Python and OpenCV — Shell

```
1 $ python distance_to_camera.py
```

If all goes well you should first see the results of `2ft.png`, which is the image we use to "calibrate" our system and compute our initial `focalLength`:

Figure 2: This image is used to compute the initial focal length of the system. We start by utilizing the known width of the object/marker in the image and the known distance to the object.

From the above image we can see that our focal length is properly determined and the distance to the piece of paper is 2 feet, per the `KNOWN_DISTANCE` and `KNOWN_WIDTH` variables in the code.

Now that we have our focal length, we can compute the distance to our marker in subsequent images:

Figure 3: Utilizing the focal length to determine that our piece of paper marker is roughly 3 feet from our camera.

In above example our camera is now approximate 3 feet from the marker.

Let’s try moving back another foot:

Figure 4: Utilizing the computed focal length to determine our camera is roughly 4 feet from our marker.

Again, it's important to note that when I captured the photos for this example I did so hastily and left too much slack in the tape measure. Furthermore, I also did not ensure my camera was 100% lined up on the foot markers, so again, there is roughly 1 inch error in these examples.

That all said, the triangle similarity approach detailed in this article will still work and allow you to find the distance from an object or marker in an image to your camera.

Summary

In this blog post we learned how to determine the distance from a *known object* in an image to our camera.

To accomplish this task we utilized the *triangle similarity*, which requires us to know two important parameters prior to applying our algorithm:

1. The *width (or height)* in some distance measure, such as inches or meters, of the object we are using as a marker.
2. The *distance* (in inches or meters) of the camera to the marker in step 1.

Computer vision and image processing algorithms can then be used to automatically determine the perceived width/height of the object in pixels and complete the triangle similarity and give us our focal length.

Then, in subsequent images we simply need to find our marker/object and utilize the computed focal length to determine the distance to the object from the camera.

Downloads:

If you would like to download the code and images used in this post, please enter your email address in the form below. Not only will you get a .zip of the code, I'll also send you a **FREE 11-p**
Image Search Engines, including **exclusive techniques** that I don't p ail

Free 21-day crash course on computer vision & image search engines

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Your email address

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calibration, **contours**, **distance to marker**, **distance to object**, **focal length**, **opencv distance**

‹ 25 minutes later…PyimageSearch Gurus is FULLY FUNDED!

Multi-scale Template Matching using Python and OpenCV ›

127 Responses to *Find distance from camera to object/marker using Python and OpenCV*

Mike January 19, 2015 at 5:28 pm #

REPLY

Good info here:

http://photo.stackexchange.com/questions/12434/how-do-i-calculate-the-distance-of-an-object-in-a-photo

joe January 22, 2015 at 12:11 pm #

REPLY

How could you apply these techniques to sports events photos taken with a telephoto lens?

Adrian Rosebrock January 22, 2015 at 12:43 pm #

REPLY

You would have to estimate the intrinsic parameters of the camera which requires calibration with a "chessboard".

André January 27, 2015 at 7:14 am #

REPLY

HI Adrian,

Nice post, I will try to implement the idea to determine the size of an object after the calibration.

Hajar February 6, 2015 at 11:38 am #

REPLY

Great article Adrian, it was really helpful! Thank you so much!

Adrian Rosebrock February 6, 2015 at 1:15 pm #

REPLY

I'm glad you enjoyed it Hajar! ☐

JD April 11, 2015 at 2:01 am #

REPLY

hey, Adrian

it's a great piece of work you have done here and i used this technique working for my android device , and i want to take it to next level by measuring multiple object distances..but getting same results if two objects are on same position. any suggestions would be appreciated

thnx

Adrian Rosebrock April 11, 2015 at 8:54 am #

REPLY

Hi JD, if you are looking to measure multiple objects, you just need to examine multiple contours from the cv2.findContours function. In this example, I'm simply taking the largest one, but in your case, you should loop over each of the contours individually and process them and see if they correspond to your marker.

Anton April 12, 2015 at 6:05 am #

REPLY

on above example, we know the width of an object. What if we don't know the width of the object ? for example in real life situation where a robot need to navigate the it meets each unknown object and need to find the distance even tough it has now knowledge about each objects actual width. Any other examples ?

Adrian Rosebrock April 12, 2015 at 7:18 pm #

REPLY

In general, you'll need to know the dimension of the object in order to get an accurate reading on the width/height. However, in unconstrained environments you might be able to use a stereo camera so you can compute the "depth" of an image and do a better job avoiding obstacles.

Abu April 25, 2015 at 12:32 pm #

REPLY

Is it possible to do this using the back end of a car in realtime? Maybe a HOG classifier could detect it and than the program? Any insight would be helpful.

Thanks

Adrian Rosebrock May 1, 2015 at 7:08 pm #

REPLY

Take a look at this post on HOG + Linear SVM, I think it will really help you get started.

Dries May 2, 2015 at 6:20 am #

REPLY

Hi there Andrian!

First of all i'm very thankful for this and other tutorials out there! this is by far the best series of tutorials online! Perfectly described step by step and explained why to preform every step ☐ I can't thank you enough!

I'm trying to do the same thing as described in the above tutorial (finding an object and determine the distance between obj and camera) but i wonder how i should do it when using constant streaming video instead of loading images?

thanks!

Adrian Rosebrock May 2, 2015 at 7:10 am #

REPLY

Hi Dries, thanks for the great comment, it definitely put a smile on my face ☐ A

loading images, there is no real difference, you just need to update the code to use a video stream. It's actually a lot easier than it sounds and I cover it both in Practical Python and OpenCV and this post.

lady kenna June 7, 2015 at 2:11 am #

REPLY

what if i wanted to display cm instead of ft?

Adrian Rosebrock June 7, 2015 at 6:44 am #

REPLY

Your final metric is completely arbitrary — you can use feet, meters, centimeters, whatever you want. Take a look at **Lines 25 and 29** and redefine them using the metric you want. And then you'll need to modify **Line 52** to output your metric instead of feet.

raj August 18, 2015 at 11:41 am #

REPLY

Hi there,
when i try the same code using 2 feet and an image of 1 inch ,the focal length is around 1260 . Is this ok ? coz im getting unacceptable distances of around 3.4 feet for 6 feet… Are there any limits for this method . I find this method really interesting , i am thinking forward to do this in my project .
One more thing , will this work for webcam from a laptop .
Thanks in advance

Adrian Rosebrock August 19, 2015 at 6:50 am #

REPLY

The main limitation of this method is that you need to have a straight-on view of the object you are detecting. As the viewpoint becomes angled, it distorts the calculation of the bounding box and thus the overall returned distance. And yes, this method will work with your laptop webcam, you just need to update the code to grab frames using the cv2.VideoCapture function. See this post for an example of grabbing frames from the webcam stream.

David September 4, 2015 at 2:15 pm #

REPLY

Hi Adrian, Excelent tutorial i have a question for you, i hope you can help me.

i need the position (X,Y,Z) in mm, with your tutorial i could get the point z, my problem is when i calibrate the camera to get the points X,Y my Z is wrong.

do you know what happens?

Thanks.

Adrian Rosebrock September 5, 2015 at 5:28 am #

REPLY

Are you doing work in 3D? If so, this method is not suited for 3D and you'll need to use a different calibration method to examine the intrinsic parameters.

David September 6, 2015 at 11:50 pm #

REPLY

Hi Adrian, Thanks for answer me.

I'll tell you what my project. I detect a small object in real time with a webcam, with the position of the object, will point a laser that will be about two servos , one for the X axis , and one for the Y axis.

I am ready the detection and tracking. but I'm having trouble getting the positions X , Y, Z . I research the transformation from 3D to 2D but there are certain points that do not understand.

do you can help me?

Thanks a lot

Matt April 20, 2016 at 8:39 am #

REPLY

Hi David !

Currently, I'm working on a similar project, and I have a problem to do the relationship between coordinates in the 3D and servos. First, I would like to compute and track my 3D-coordinates object but it does not work.

Did you find an idea ?

Thanks

murugan October 16, 2015 at 10:35 am #

REPLY

awesome program.but how to use it for a real streaming purpose.

Adrian Rosebrock October 17, 2015 at 6:46 am #

REPLY

This code can be easily adapted to work in real-time video streams. I would start by looking up the cv2.VideoCapture function. I use it multiple times on the PyImageSearch blog — I think this post can help get you started.

murugan October 20, 2015 at 1:17 am #

REPLY

hi sir
i tried cv2.videocapture but ended with errors so i request you to modify the program

Adrian Rosebrock October 20, 2015 at 6:11 am #

REPLY

If you are getting errors related to cv2.VideoCapture you should ensure that your installation of OpenCV has been compiled with video support.

hyshan October 21, 2015 at 9:43 pm #

REPLY

Hi Adrian, how do you define the marker?

Adrian Rosebrock October 22, 2015 at 6:19 am #

REPLY

In the case of this blog post, I defined a marker as a large rectangle. Rectangle-like regions have the benefit of being easy to find in an image. Markers can be made more robust by adding (1) color or (2) any type of special design on the marker themselves.

li October 26, 2015 at 11:26 am #

REPLY

excuse me, I want to know how to realise it in real-time camera?

Adrian Rosebrock October 27, 2015 at 4:55 am #

REPLY

In order to perform real-time distance detection, you'll need to leverage the cv2.VideoCapture function to access the video stream of your camera. I have an example of accessing the video stream in this post. I also cover accessing the video stream more thoroughly inside Practical Python and OpenCV.

Shatha Omar November 1, 2015 at 11:07 pm #

REPLY

Hi , this is a great helpful job
please i'm working on application that take an image then find the object to calculate its dimensins , so i need to know the distance or if there is another blog/ article/ refferance you can help me with

Adrian Rosebrock November 3, 2015 at 10:18 am #

REPLY

In order to compute the distance to an object in an image, you need to be able to identify *what* the object is. For example, you could maintain a know database of objects and their dimensions, so when you find them, just pull out the dimensions and run the distance calculation.

khalil November 19, 2015 at 1:29 pm #

REPLY

Thanks for your nice post.. it is really a good job.. dear, is there any additional procedure for which i can use this procedure for the unknown object distance measurement from camera….

Adrian Rosebrock November 20, 2015 at 6:30 am #

REPLY

You'll need to know the size of some object in the image to perform camera calibration. In this example, we have a piece of paper. But you could have used a coin. A coffee cup. A book. But the point is that you *need* to know the size of object(s) you'll be using to perform the camera calibration using triangle similarity.

Minjae November 24, 2015 at 2:39 am #

REPLY

Hi, Thank you for this post.

I'm looking for like Johnny Chung Lee's Wii headtracking in VR Juggler through VRPN projects.

Anyway,
when I tried this code, there are some isues.
My pi2 connected with noir-picam and ms-webcam.

1. X-window
(image:1297): GdkGLExt-WARNING **: Window system doesn't support OpenGL.

2. X-wondow with cv virtualenv
Traceback (most recent call last):
File "distance_to_camera.py", line 41, in
marker = find_marker(image)
File "distance_to_camera.py", line 16, in find_marker
(cnts, _) = cv2.findCountours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
ValueError: too many values to unpack (expected 2)

3. console
(image:867): Gtk-WARNING **: cannot open display:

4. cv virtualenv
same with 2.

Please let me know the reason…

Adrian Rosebrock November 24, 2015 at 6:35 am #

REPLY

Hey Minjae:

1. I'm not a Windows user, so I'm not sure a about this particular problem. Perhaps another PyImageSearcher reacher can help you out here.

2. The code associated with this post was built for OpenCV 2.4. You are using OpenCV 3. You need to update the cv2.findContours function call, here to work with OpenCV 3..

3. Are you SSH'ing into your Pi? If so, make sure you pass in the -X flag for X11 forward

nami November 25, 2015 at 9:14 am #

REPLY

Hi adrian,

Thanks for sharing.
I have tried your code and its work.
But is it possible to calculate the object distance if the object size in real world (width / height) unknown? Just using internal camera parameter and object size in pixels..

Adrian Rosebrock November 25, 2015 at 1:54 pm #

REPLY

Hey Nami, you might want to look into camera calibration and the intrinsic camera parameters.

nami November 26, 2015 at 12:11 am #

REPLY

Hi adrian,

So after we do camera calibration and get focal length (fx, fy), principal point, etc. How can i measure the object distance? with object size in real world undefine..
Thanks..

Adrian Rosebrock November 26, 2015 at 6:52 am #

REPLY

You basically need to convert the “pixel points” to “real world” points, from there the distance between objects can be measured. This is something I’ll try to cover on PyImageSearch in the future, but in the meantime, this is a really good MATLAB tutorial that demonstrates the basics.

mert January 7, 2016 at 7:54 am #

REPLY

Hello Adrian. First of all , This is a great website. I have a question : Is this distance estimation can be done in real time processing applications. I mean I want to measure distance from an object(cicular and coorful) to my robot while the robot moving on a straight line. I use a moderate camera with low resolution(usb cam).How should I do that

Adrian Rosebrock January 7, 2016 at 12:36 pm #

REPLY

Yes, this can absolutely be done in real-time processing, that’s not an issue. As long as you perform the calibration ahead of time, you can certainly perform the distance computation in your video pipeline.

mert January 8, 2016 at 7:28 am #

REPLY

Thanks for the help and your fast reply man. Camera Calibration looks like complicated though. Cause I wiil look at an object from an angled position say 30 degree(initially) while I m moving on a straigt line the angle will increase. In each time. So I have to make sure that the object is almost middle in the frame to use above code?

Adrian Rosebrock January 8, 2016 at 9:21 am #

REPLY

Camera calibration (at least the calibration discussed in this post) is actually pretty straightforward. This post assumes you have a 90-degree straight-on view of the object. For angled positioning this approach won’t work well unless you can apply a perspective transform. You should look into more advanced camera calibration methods.

mert January 8, 2016 at 1:52 pm #

Got it. I’ll get right on it. Hope to meet you

JolyDroneSP January 18, 2016 at 9:17 am #

REPLY

Hi Adrian. Thanks for the good work, it's the most concise guide to this topic that I have found!

By the way, what camera did you use for this project?

I am trying to implement it through raspberry pi board camera and it doesn't seem to work…

Adrian Rosebrock January 18, 2016 at 3:19 pm #

REPLY

I simply took photos using my iPhone for this post, but the code can work with either a built-in/USB webcam or the Raspberry Pi camera. If you're having trouble getting your Raspberry Pi camera + code working, I suggest reading this post on accessing the Raspberry Pi camera.

Tejas January 22, 2016 at 1:40 pm #

REPLY

Hello Adrian!

First of all, thank you for a wonderful tutorial as always. I am working on a similar project and need some help.

1. Is there a literature review available regarding all methods of depth estimation without using a stereo camera i.e. using only a normal single lens camera? If not, can you point me to resources – papers and hopefully implementations – about the state-of-the-art on this problem? I should mention that I am mainly interested in understanding the physics of the scene and not reconstructing per se. I haven't been able to find any decent open implementations of these and that's kind of sad.

2. I am investigating the importance of head movements in animals(humans included) for depth perception and came across few decade old papers on the topic. Can you provide me references on how motion of camera affects detection of edges, depth estimation etc from a computer vision perspective? Aligning with point 1, I am looking for something on the lines of how one can estimate depth accurately by moving the single lens camera and detect edges and/or object boundaries by virtue of this movement. Methods like triangle similarity aren't really helpful since they need an estimate of the original size of object/marker in question.

Please help me out with this and keep up the good work! ☐

Adrian Rosebrock January 22, 2016 at 4:43 pm #

REPLY

For both questions, my suggestion would be start off with this paper and follow the references. This paper is heavily cited in the CV literature and links to previous works that should also help you out.

Tyrone Robinson February 5, 2016 at 2:43 pm #

REPLY

I may be coming in a little for this post but Im having trouble with the code.
When I run it I get the following error. Can you please assist me with this.
By the wayI think you are doing an awesome job.

```
1 (cnts, _) = cv2.findContours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
2 ValueError: too many values to unpack
```

Adrian Rosebrock February 6, 2016 at 9:56 am #

REPLY

Please see my reply to Minjae above and read this post for more information.

Swan August 22, 2016 at 7:52 pm #

REPLY

Thanks for that clarification!

azizul February 17, 2016 at 3:24 am #

REPLY

hello Adrian. it a very good work.
but can i ask question, how to implement stereo vision in this project?

Adrian Rosebrock February 17, 2016 at 12:36 pm #

REPLY

I honestly don't do much work in stereo vision, although that's something I would like to cover in 2016. Once I get a tutorial going for stereo version, I'll be sure to let you know!

azizul February 18, 2016 at 12:26 am #

REPLY

i will be really please to hear the news from u…thnk u very much ☐

Jon February 21, 2016 at 5:52 pm #

REPLY

Hi Adrian!

First off, kudos on making such a complex system seem so intuitive! It makes the process look so much less intimidating to us newbies (whether I'm able to follow along once my picam gets here is another story!)

My question for ya is this: assuming I can manage to follow along and get distance readings for my marker, how difficult would it be to add the code required to trigger an event on a device that the marker is mounted to? In my case, I am looking to vibrate a small motor when the tracked object is more than 10 feet away. Ideally, it would increase in intensity based on how much further the object gets from the camera. I know this would require some investment in more hardware, but does it sound like a plausible idea?

Thanks for posting this, and being so generous with helping out in the comments!

Adrian Rosebrock February 22, 2016 at 4:23 pm #

REPLY

The short answer to your question is that it would be easy to implement this type of functionality. All you would need to do is wrap this code in a VideoStream rather than processing a single image. From there, you can make a check if the object is > 10 feet away. If it is, then you call your buzzer code.

Randy April 7, 2016 at 6:38 am #

REPLY

In OpenCV 3, we must use cv2.boxPoints(marker) instead of cv2.cv.BoxPoints(marker).

Adrian Rosebrock April 7, 2016 at 12:33 pm #

REPLY

You're absolutely right Randy!

Kenton May 26, 2017 at 1:15 pm #

REPLY

Hey,

I'm messing with this stuff now and it's not working out too well for this part.
My error is cv2 has no attribute boxPoints.
Is there a way around this you can think of?

Thanks

Adrian Rosebrock May 28, 2017 at 1:07 am #

REPLY

Hi Kenton — can you check which version of OpenCV that you are using? The cv2.boxPoints function is named differently depending on your OpenCV version.

Kevin April 13, 2016 at 7:50 pm #

REPLY

Hey Adrian, great work! This was very informative and well done. I have a quick question regarding the limitations of such an approach when using larger distances. For example, 30 feet. At this distance, a relatively small object may be represented by very few pixels right? I'm assuming the better the camera (with better resolution) the farther the range in which this approach can still be accurate. My question is whether my assumption is indeed correct?

Furthermore, I find that when I utilize this approach, the distance calculation sometimes fluctuates as the perceived width in pixels fluctuates. Could this be due to noise? And if so, what are some good techniques to reduce said noise? I've looked into the blur function in OpenCV, but I haven't had much luck with that.

Thanks again for the website, it's super helpful. Look forward to hearing from you. Thank you!

Adrian Rosebrock April 14, 2016 at 4:51 pm #

REPLY

Indeed, that is correct. The farther away the object is and the smaller the resolution of the camera is, the less accurate the approximation will be. As for reducing noise, that is entirely dependent on the image data you are working with. Blurring is one way to reduce noise. You might also want to look into the segmentation process and ensure you are obtaining an accurate segmentation of the background from the foreground. This can be improved by tweaking Canny edge detection parameter, threshold values, etc.

mahdi April 16, 2016 at 8:17 am #

REPLY

hello, please hellp me can i run this with opencv 3.1.0 ?

Adrian Rosebrock April 17, 2016 at 3:31 pm #

REPLY

Please see my response to "Tyrone" above — the only change needed for this code to run with OpenCV 3 is to modify the cv2.findContours.

Abdul Javed May 8, 2016 at 2:59 pm #

REPLY

Hello Adrian… i just wanted to know that how can i use this distance recognition technique to make a 2D map of a vertical wall(whose photo can be taken easily) to precisely know the position of doors windows and other stuffs on the wall and the distances between each other and their dimensions with certain accuracy……???

Adrian Rosebrock May 9, 2016 at 6:54 pm #

REPLY

Hi Adbul — I'm not sure quite sure what you mean by a 2D map of a vertical wall, but if you want *super precise* measurements between doors, windows, etc., then I would suggest using a 3D/stereo camera instead of a 2D camera. This will give you *much* better results.

Matt May 10, 2016 at 8:07 am #

REPLY

Hi Adrian,

Thanks for your tuto again. I have a question. What happened if you tilt the paper with an angle, with respect to the camera ? Does your algo consider it ?

Thanks.

Adrian Rosebrock May 10, 2016 at 8:12 am #

REPLY

Yes, even with the paper titled, this algorithm will still find the paper, *provided that* the paper is the largest contour area in the image. For a more robust algorithm for finding rectangular regions (and verifying that they indeed have 4 vertices), please see this post.

Matt May 10, 2016 at 9:31 am #

REPLY

Ok, but for example, if you tilted your paper with an angle of 90 degrees, you do not detect a rectangle, so you do not know the distance between the object and the camera no?

Adrian Rosebrock May 10, 2016 at 6:24 pm #

REPLY

Hey Matt, I'm not sure I understand your question — a rectangle has 4 vertices, no matter how you rotate it. An easy way to detect rectangles in an image is to simply use contour approximation, which I mentioned in my previous comment.

Matt May 12, 2016 at 5:27 am #

If you consider z the axis on which you compute the distance object-camera, x and y the additional axes, and if you rotate with an angle 90 degrees around x-axis or y-axis, your camera do not detect a rectangle but a straight line. So what happens in this case ?

Thanks.

Adrian Rosebrock May 12, 2016 at 3:33 pm #

Oh, you were referring to the z-axis, that was my mistake. In that case, you would need utilize a more advanced algorithm to detect your object. This blog post is primarily geared towards easily detectable objects and computing the distance.

Frane May 30, 2016 at 4:49 pm #

REPLY

Hi Adrian, i need to find the distance and cordinates of the red marker. I made the filter to see red color only but i have problem considering distance. I lose the "seeing" the red color after 10cm (the markers are 3 red circle diameter 10cm each in triangle formation). Im using raspberry pi 2 b+ and pi camera

Adrian Rosebrock May 31, 2016 at 3:47 pm #

REPLY

How are you looking for the red color? Via color thresholding? If so, investigate the mask that is being generated from cv2.inRange and see if the red color region exists in the mask. If it does, then you'll likely want to look at the contours being detected and see if red masked region is being returned.

yousaf shah June 5, 2016 at 7:59 am #

REPLY

how to work when difference size of same object?

Adrian Rosebrock June 5, 2016 at 11:20 am #

REPLY

You normally would use a single reference object to calibrate your camera. Once you have the camera calibrated, you can detect the distances/object sizes of varying sizes. See this blog post for more information.

Farzaneh Golkhoo June 5, 2016 at 2:25 pm #

REPLY

Hi Adrian
Thanks for your great information, just I have a question.
if you take a picture of a special object for example in the ceiling and you are required to kno
not the perpendicular distance, what should we do?

In fact I know the exact location of the camera (x,y,z) and also the location of the object in the ceiling in terms of (x,y) but I do not know the z of the object. I want to measure z.
As you said I can measure the perpendicular distance between the camera an the object by taking a picture of the object, but I have to know the direct distance (not perpendicular) between the camera and the object.

Thank you so much

Mr.E June 8, 2016 at 7:36 am #

REPLY

Hi dear Adrian . tanks for all of your good and useful information.I had very good result of this algorithm on mobile photography or raspberry camera . but i just have big problem with the digital camera witch has a lenses (DSLR or compact). Can you help me about this?? if i know the F of the camera for example 3.2 how should be put it on my calculating ???
what i calculate (F) is about 3600~3700 . and so it's give me wrong answer .

Adrian Rosebrock June 9, 2016 at 5:27 pm #

REPLY

There is a difference between the focal length of the physical lens and the perceived focal length from the image. You'll need to calibrate your DSLR camera in the same way that you performed the calibrations on the Pi and mobile phone.

Chandrama June 13, 2016 at 4:28 am #

REPLY

Hello i am trying to use your code but not able to get output ,

getting error like..

```
1 Traceback (most recent call last):
2 (cnts, _) = cv2.findContours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
3 ValueError: too many values to unpack
```

Please help to resolve

Adrian Rosebrock June 15, 2016 at 12:51 pm #

REPLY

Please read the comments to this post before you post as I've already addressed this issue multiple times. Since you're using OpenCV 3, you need to change the cv2.findContours call to:

(_, cnts, _) = cv2.findContours(edged.copy(), cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)

You can read more about the change to cv2.findContours between OpenCV 2.4 and OpenCV 3 in this blog post.

Talgat July 12, 2016 at 4:34 am #

REPLY

Thank you!

Excellent article! But one little mistake that can confuse beginners, you wrote "perceived width of the paper is P = 249 pixels" but in calculations you used 248. Hope to see the tutorial on finding the distance to an randomly chosen object by using stereo-pair of cameras.

Adrian Rosebrock July 12, 2016 at 4:32 pm #

REPLY

Thanks for pointing out the typo! I have corrected it now.

Amigo July 24, 2016 at 8:11 am #

REPLY

Please comment on how accurate can this method be, i.e mm cm or in inches etc. also if I want to find distance between two objects, how should I modify this code?

Adrian Rosebrock July 27, 2016 at 2:40 pm #

REPLY

The level of accuracy depends on the resolution of your camera. The smaller the resolution, the less accurate. The further the objects are away, the less accurate. This script does not perform radial distortion correct, which is something else to consider. As for finding the distance *between* two objects, please see this post.

Shiva September 6, 2016 at 2:19 am #

REPLY

Hello Adrain,
Great Article to start with the distance estimation.
I have downloaded your code and trying to validate with images, but i am not getting the distance as expected. Could you please send me some reference images.

Adrian Rosebrock September 6, 2016 at 3:38 pm #

REPLY

Hey Shiva — the downloads to this blog post also include the example images I included in this post. You can use these images to validate your distances.

Thommy September 8, 2016 at 2:36 am #

REPLY

Hai Adrian, when i try run the code, i got error :

```
1 Traceback(most recent call last):
2 File "/home/pi/distance_to_camera.py", line 53, in
3   box=np.int0(cv2.cv.BoxPoints(marker))
4 AttributeError: 'module' object has no attribute 'cv'
```

Please, hope the resolve

Adrian Rosebrock September 8, 2016 at 1:15 pm #

REPLY

The code for this blog post was intended for OpenCV 2.4; however, you are using OpenCV 3. You can resolve the issue by changing the code to:

box = cv2.boxPoints(marker)

Ankit September 17, 2016 at 9:24 am #

REPLY

Hello Adrian Rosebrock,
Your explanation helped me understand the concept very well. I am still perplexed by another problem. For example, I have a calibrated camera, i.e. I know the focal lengths and the optical offsets of the lens and sensor. Then, the relation between pixel and the actual height/width of an object is true only if the object is placed at the focal length. If I place an object of unknown dimensions at an unknown distance from the camera lens, then there is no way to estimate the distance between them. Am I thinking right or is something missing? Can you please help.

Thanks

Ondrej September 17, 2016 at 4:48 pm #

REPLY

Hi. I was thinking about make mobile app which will measure width and height some objects by using dual cameras like this:www.theverge.com/2016/4/6/11377202/huawei-p9-dual-camera-system-how-it-works . Do you think that it will be working? Thank you for your answer.

Adrian Rosebrock September 19, 2016 at 1:10 pm #

REPLY

Using two cameras you can measure the “depth” of an image. I don’t cover this on the PyImageSearch blog, but it is absolutely possible.

Erwin October 5, 2016 at 1:52 am #

REPLY

Hi Adrien,

Thanks for the information. I have one question: Is it possible to incorporate the distance estimation with the ball tracking code you have? I am currently working on a project whereby I am trying to detect an object with the color green and find the distance between the camera and the object.

Adrian Rosebrock October 6, 2016 at 6:55 am #

REPLY

Absolutely, but you need to calibrate your system first as I did in this blog post only this time using the green ball. From there you will be able to estimate distance.

Erwin October 7, 2016 at 1:26 am #

REPLY

Sorry, i seems to have phrased my question wrongly. What I meant was is it possible to find the distance from the camera to the green ball in real time? So instead of making it detect edges, i modified it to detect green?

Adrian Rosebrock October 7, 2016 at 7:21 am #

REPLY

Yes, it's absolutely possible. As long as you perform the calibration step *before* you try to find the distances you can use the same technique to determine the distance to the ball in real-time.

Erwin October 10, 2016 at 3:53 am #

Your help is greatly appreciated. Thank you.

Josue Godinez October 8, 2016 at 1:38 pm #

REPLY

Hello Adrian, nice post.

Just a simple question. How you determine the "focalLength"?

Adrian Rosebrock October 11, 2016 at 1:09 pm #

REPLY

Take a look at the example in the "Triangle Similarity for Object/Marker to Camera Distance" section to see how focal length is computed. Otherwise, Lines 38 and 39 compute the focalLength variable.

John October 9, 2016 at 6:09 am #

REPLY

Hello . I want to use this code to detect images real time using the PiCamera. I read your replies and honestly have no idea how to " Use the cv2.VideoCapture function to access the stream of your camera " . Playing with the code results in all sorts of errors. Could you help me by giving a detailed explanation ? Thanks

Adrian Rosebrock October 11, 2016 at 1:05 pm #

REPLY

If you want to use the Raspberry Pi camera module you should start by reading this blog post on accessing the Pi camera module before doing anything else. From there, you can take the code from this post and use it with your Raspberry Pi camera.

Mostafa Sabry October 17, 2016 at 3:00 pm #

REPLY

Hi Adrain,

I am a big fan of your posts, I was impressed with all of what I have seen. I have a problem in my thesis that I guess you might help me in related to localization. My thesis project is automating the process of lawn mower. The mower will be given the size of a rectangle to cover then it will move back and forth starting from one of the corners. It will track its distance using wheel en
drifting. Therefore, we need a reliable method through which we can know the absolute locat
wheel encoders. We have tried several methods and all had some problems:

1- Tracking successive features in frames to estimate the rotational and transnational matrices however for sharp turns it looses track of everything.
2- Triangulation by placing three balls of different colors and identifying the angle of each through a camera on a motor however using colors outdoor is so unreliable due different lightening at different day times. When you decrease the HSV scale becomes more accurate but increases the probability of loses balls and increasing range catches noise from the environment.
3- Using homography instead of color balls for triangulation but it is computationally slow.
4- Using April Tags or Aruco tags but as mechanical engineers, were are finding it hard to develop our algorithm and still we didn't find a starting point to continue on by finding a code and understanding it.
Hope U can help us and sorry for the long post

Adrian Rosebrock October 17, 2016 at 3:54 pm #

REPLY

To start, it's always helpful to have actual real-world images of what you're working with. This helps me and other readers visually see and appreciate what you are trying to accomplish. Myself, as I imagine many other readers, don't know much about the intricacies of lawn mowers, wheel encoders, or slippage/drifting.

That said, based on your comment it seems that the homography is producing the correct results, correct? And if that's the case why not focus your efforts on speeding up the homography estimation? Try to reduce the number of keypoints? Utilize binary rather than real-valued descriptors? Implement this part of the algorithm in C/C++ for an extra speed gain?

Eren November 30, 2016 at 8:55 am #

REPLY

hi Adrian. Firstly,thank you for sharing.nowadays I am working similar projects.
so I have a question.there is an object with a known width w and I don't know distance D from my camera.in fact I will do that I will put a rectangular object (a box) with a known size under camera I will measure distance from object but I know only distance between camera and ground. how to do?

Adrian Rosebrock December 1, 2016 at 7:34 am #

REPLY

If you know the distance from the ground to the camera and know the size of the object in both units (inches, millimeters, etc.) then you should be able to apply some trigonometry to workout the triangle property. I haven't actually tried this, so I'm just thinking off the top of my head. It might not work, but it's worth a shot.

Alex December 6, 2016 at 10:06 am #

REPLY

Hi Adrian, first of all, excellent article!
I have a question, regarding this code. I'm currently carrying out research for my dissertation which requires using stereo vision to calculate distance from the camera to a chosen object/area. Will this code be applicable for stereo vision as well ?

Thanks!

Adrian Rosebrock December 7, 2016 at 9:42 am #

REPLY

No, I would not use this code for stereo vision. The reason is because stereo cameras (by definition) can give you a much more accurate depth map. I don't do much work in stereo vision, but this short tutorial or computing a depth map should help you out.

Alpha January 5, 2017 at 11:10 am #

REPLY

i am doing a project in which i need to get the exact location of a human at a distance. Exact location refers to the EXACT location as used by a gun to aim at an enemy. Here, i dont have any marker object or any known distances. Any way out?

Adrian Rosebrock January 7, 2017 at 9:38 am #

REPLY

You would need to compute the intrinsic properties of the camera first. I would suggest starting here.

Tanya January 13, 2017 at 12:37 am #

Hey Adrian,

This is super nice tutorial ever!!
I am working on the project about detecting the distance changing of array sphere. (changing like mm in unit)

I gotta put the camera at the same axis of the movement so its very hard to see the difference.(the sphere is very small like 2 mm)

Do you think is it possible to detect using your algorithm?

Adrian Rosebrock January 13, 2017 at 8:32 am #

REPLY

It really depends on the quality of the images themselves. How high is the resolution of your image capture?

Tanya January 15, 2017 at 7:36 pm #

REPLY

around 640 × 480 pixels/each image
for area of 1 x 2 cm

Adrian Rosebrock January 16, 2017 at 8:09 am #

REPLY

Hmm, that's a pretty small resolution for that accurate of results. The first step would be to calibrate your camera and account for barrel distortion. If your images are really noisy and you can't *accurately* segment the object from every image, then you're in for some real trouble. But if you can get a nice segmentation I would give it a try and see what results you come up with. It's best to experiment with projects like these and note what does and does not work.

Dasaradh S K January 14, 2017 at 9:33 am #

REPLY

Hi Adrian. i would like to calculate the distance between a drone flying at a good height (with a cam & MCUs) and people at the ground. Please help me Adrian. 😀

Rahmat Hardian Putra January 15, 2017 at 7:15 am #

REPLY

Hi Adrian.. your article is a really great tutorial 😀
btw i'm working on a project that measure distance of a fire, but fire tend to change it shape, whether it smaller or bigger, so the marker also get bigger or smaller, therefore I can't define the width and height of the marker.

the question is, can I modify your algorithm so that I can measure distance with my condition ? or do you have another method that suitable to measure distance of a fire ?
Thanks in advance

Regards
Rahmat Hardian

Adrian Rosebrock January 15, 2017 at 12:01 pm #

REPLY

It sounds like you might need a more advanced calibration technique. I personally haven't done/read any research related to fire direction techniques with computer vision, but I would suggest reading up on intrinsic camera properties for calibration.

---

kartik pandey February 27, 2017 at 8:09 am #

REPLY

can you please describe the hardware part of this amazing project of yours as i need it for a small project of mine too like how did u integrate the phones camera or did u use raspberry pi with a camera module please let me know

Adrian Rosebrock February 27, 2017 at 11:02 am #

REPLY

I used my iPhone to capture the example photos. The photos were moved to my laptop. And then I processed the photos using my laptop. The actual method used to capture the photos doesn't matter as long as (1) its consistent and (2) you are calibrating your camera.

Musa April 17, 2017 at 3:44 pm #

REPLY

Hi Adrian,
I'm trying to copy this method for a USB camera and have used your previous posts to modify it to work with a camera using a while loop. The problem I'm having is the max function in find_marker is constantly coming out as None hence resulting in the distance_to_camera function throwing an error. Do you have any idea why this could be?

Horus May 19, 2017 at 5:18 am #

REPLY

Hi,

I have an CT 2D image with two projection. in the image there are spherical objects, free or occluded. How can I get the depth of these spheres and their centre. An idea or any help would be great.

Israa June 10, 2017 at 6:24 pm #

REPLY

Hi adrian,
please help me
when I use the same code and the same images, I get these results .

inches:
24.0
201.873157429
17.7140389174

what is error?

youssef June 13, 2017 at 4:21 am #

REPLY

Hey adrian, this website is the bestest reference for beginners, but may i ask if for example the camera is not looking straight to the object the distance in pixels would change so it wouldnt work right ?
if my logic was correct how to overcome this ?
thank you

Adrian Rosebrock June 13, 2017 at 10:54 am #

REPLY

If there is variation of viewpoint then you would definitely want to calibrate your camera by computing the intrinsic properties of the camera. This will give you more reliable results.

Randy June 15, 2017 at 8:45 am #

REPLY

Hi, excellent tutorial, i got the following error, maybe you or someone can help me:
OpenCV Error: Assertion failed (scn == 3 || scn == 4) in cvtColor,
…

Adrian Rosebrock June 16, 2017 at 11:17 am #

REPLY

Hi Randy — double check your image paths to cv2.imread. It looks like your image path was invalid, causing cv2.imread to return None. The cv2.imread function does not throw an error when an invalid image path is supplied.

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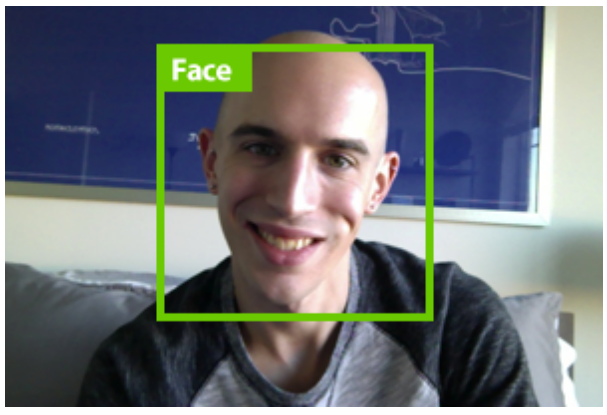

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