Complete Course of Computer Vision with OpenCV

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Lesson 1: Introduction to OpenCV

Course Content

- **Lesson 1:** Introduction to OpenCV
- **Lesson 2:** The Core Functionality (core module)
- **Lesson 3:** Image Processing (imgproc module)
- **Lesson 4:** High Level GUI and Media (highgui module)
- **Lesson 5:** Image Input and Output (imgcodecs module)
- **Lesson 6:** Video Input and Output (videoio module)
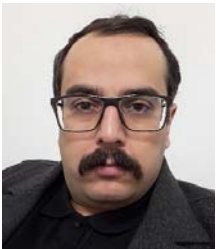- **Lesson 7:** Camera calibration and 3D reconstruction (calib3d module)

Lesson 1: Introduction to OpenCV

Course Content

- **Lesson 8:** 2D Features framework (feature2d module)
- **Lesson 9:** Video analysis (video module)
- **Lesson 10:** Object Detection (objdetect module)
- **Lesson 11:** Deep Neural Networks (dnn module)
- **Lesson 12:** Machine Learning (ml module)
- **Lesson 13:** Graph API (gapi module)
- **Lesson 14:** Computational photography (photo module)

Lesson 1: Introduction to OpenCV

Course Content

- **Lesson 15:** Images stitching (stitching module)
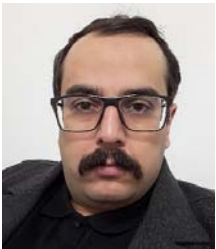- **Lesson 16:** GPU-Accelerated Computer Vision (cuda module)

To get general knowledge about the topic of this tutorial, you can read below blog article:

http://blog.abolfazlm.com/2020/01/17/what-is-computer-vision/
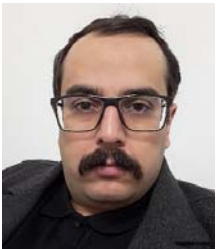
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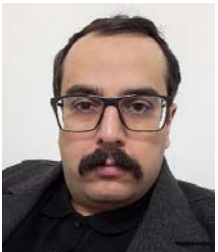
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- OpenCV is a cross-platform library using which we can develop real-time **computer vision applications**. It mainly focuses on image processing, video capture and analysis including features like face detection and object detection. In this tutorial, we explain how you can use OpenCV in your applications.

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Audience

- This tutorial has been prepared for beginners to make them understand the basics of OpenCV library and also some advanced module are explained to make this tutorial somehow comprehensive. We have used the C++ programming language in most of the examples, therefore you should have a basic exposure to C++ in order to benefit from this tutorial.
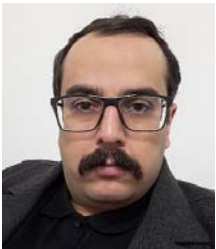
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- Let's start the chapter by defining the term "Computer Vision".
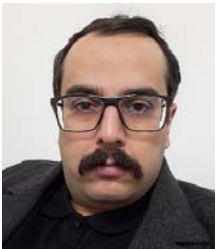
Computer Vision

- Computer Vision can be defined as a discipline that explains how to reconstruct, interrupt, and understand a 3D scene from its 2D images, in terms of the properties of the structure present in the scene. It deals with modeling and replicating human vision using computer software and hardware.

- Computer Vision overlaps significantly with the following fields −

- **Image Processing** − It focuses on image manipulation.

- **Pattern Recognition** − It explains various techniques to classify patterns.

- **Photogrammetry** − It is concerned with obtaining accurate measurements from images.

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Computer Vision Vs Image Processing

- **Image processing** deals with image-to-image transformation. The input and output of image processing are both images.

- **Computer vision** is the construction of explicit, meaningful descriptions of physical objects from their image. The output of computer vision is a description or an interpretation of structures in 3D scene.
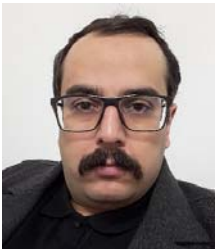
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Applications of Computer Vision

- Here we have listed down some of major domains where Computer Vision is heavily used.
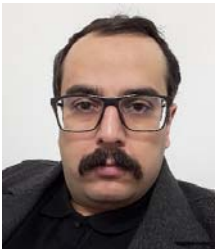
❑ **Robotics Application**

- Localization − Determine robot location automatically

- Navigation

- Obstacles avoidance

- Assembly (peg-in-hole, welding, painting)

- Manipulation (e.g. PUMA robot manipulator)

- Human Robot Interaction (HRI) − Intelligent robotics to interact with and serve people

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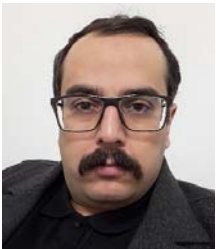# Lesson 1: Introduction to OpenCV

❑ Medicine Application

• Classification and detection (e.g. lesion or cells classification and tumor detection)

• 2D/3D segmentation

• 3D human organ reconstruction (MRI or ultrasound)

• Vision-guided robotics surgery

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❑ **Industrial Automation Application**

• Industrial inspection (defect detection)

• Assembly

• Barcode and package label reading

• Object sorting
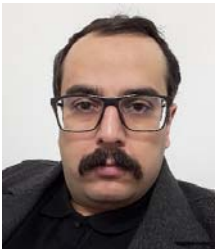
• Document understanding (e.g. OCR)

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❑ Security Application

- Biometrics (iris, finger print, face recognition)
- Surveillance − Detecting certain suspicious activities or behaviors

❑ Transportation Application

- Autonomous vehicle
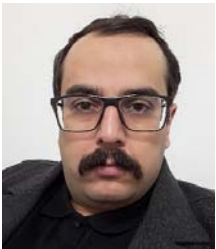- Safety, e.g., driver vigilance monitoring

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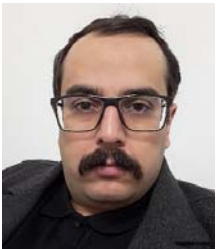❑ **Features of OpenCV Library**

Using OpenCV library, you can −

• Read and write images

• Capture and save videos

• Process images (filter, transform)

• Perform feature detection

• Detect specific objects such as faces, eyes, cars, in the videos or images.

• Analyze the video, i.e., estimate the motion in it, subtract the background, and track objects in it.

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- OpenCV was originally developed in C++. In addition to it, Python and Java bindings were provided. OpenCV runs on various Operating Systems such as windows, Linux, OSx, FreeBSD, Net BSD, Open BSD, etc.

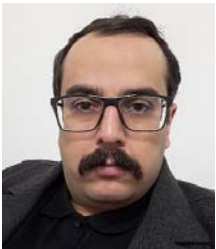- This tutorial explains the concepts of OpenCV with examples using C++.

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OpenCV Library Modules

- Following are the main library modules of the OpenCV library.

❑ Core Functionality

- This module covers the basic data structures such as Scalar, Point, Range, etc., that are used to build OpenCV applications. In addition to these, it also includes the multidimensional array **Mat**, which is used to store the images.
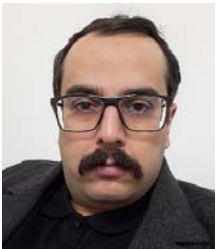
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❑ Image Processing

- This module covers various image processing operations such as image filtering, geometrical image transformations, color space conversion, histograms, etc.
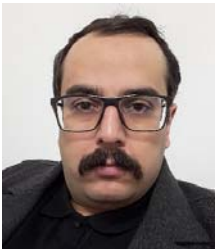
❑ Video

- This module covers the video analysis concepts such as motion estimation, background subtraction, and object tracking.

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❑ **Video I/O**

• This module explains the video capturing and video codecs using OpenCV library **Calib3d.**

• This module includes algorithms regarding basic multiple-view geometry algorithms, single and stereo camera calibration, object pose estimation, stereo correspondence and elements of 3D reconstruction.

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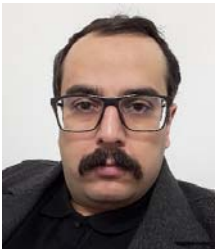
❑ features2d

- This module includes the concepts of feature detection and description.

❑ Objdetect

- This module includes the detection of objects and instances of the predefined classes such as faces, eyes, mugs, people, cars, etc.
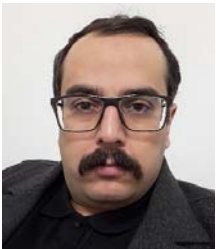
❑ Highgui

- This is an easy-to-use interface with simple UI capabilities.

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A Brief History of OpenCV

- OpenCV was initially an Intel research initiative to advise CPU-intensive applications. It was officially launched in 1999.

- In the year 2006, its first major version, OpenCV 1.0 was released.

- In October 2009, the second major version, OpenCV 2 was released.

- In August 2012, OpenCV was taken by a nonprofit organization OpenCV.org.

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How to install OpenCV on a windows Machine?!

Installation by Using the Pre-built Libraries

1- Launch a web browser of choice and go to page:

https://sourceforge.net/projects/opencvlibrary/files/opencv-win/

2- Choose a build you want to use and download it.

3- Make sure you have admin rights. Unpack the self-extracting archive in C:\OpenCV directory.

4- You can check the installation at the chosen path after extraction.

5- To finalize the installation go to the Set the OpenCV environment variable and add it to the systems path section.
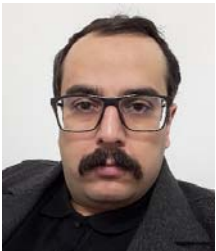
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Building First OpenCV Code in visual studio

To check that OpenCV installed properly, we write a simple code in visual studio.
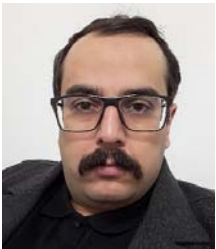
1- open visual studio → new project → visual C++ → win32 console application → name it firstOpenCVapp → next → check empty project → finish

2- right click on "source files" in solution explorer → add new item → C++ file → change name to app.cpp

3- include these at top of app.cpp

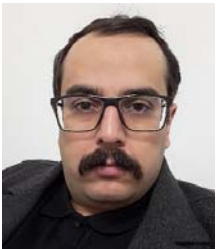#include<opencv2/opencv.hpp>   #include<iostream>

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4- Then add these lines of code to app.cpp

```cpp
using namespace std;              using namespace cv;
int main()
{
        Mat img = imread("Abolfazl.jpg");
        namedWindow("image" , WINDOW_NORMAL);
        imshow("image" , img);
        waitKey(0);
        return 0;
}
}
```
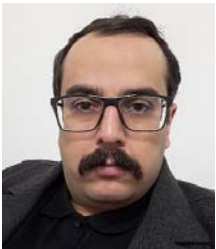
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5- Copy an arbitrary image with name "Abolfazl.jpg", as mentioned in code, to your project folder.

6- change debug mode in visual studio to x64.

As you see there are a lot of errors in your code. Mainly because opencv is not known for you project. So, you need to follow below instruction to add opencv to your project:

1- right click on project name in solution explorer → click on properties → C/C++ → General → in front of "additional include directories", paste this address: C:\OpenCV4.3\opencv\build\include

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2- Linker ➔ General ➔ in front of "additional library directories", paste this address:
C:\OpenCV4.3\opencv\build\x64\vc15\lib

3- Linker ➔ Input ➔ in front of "additional dependencies", click on edit ➔ copy this "opencv_world430d.lib" which is name of the debugger came from this address:
C:\OpenCV4.3\opencv\build\x64\vc15\lib\opencv_world430d.lib

4- click on apply and Ok and you are ready to run your first code

5- in visual studio ➔ Build ➔ build solution

6- in visual studio ➔ click on run icon (Local Windows Debugger)

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THANK YOU FOR YOUR ATTENTION!

You can keep in touch with me for any other possible helps or workshops, via:

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