OpenCV and Vuforia

And the integration into the FTC SDK

Introduction

- I am Torin Perkins
- Part of FTC team 11089 Bytes Of Kitkats
- I have been in FIRST for 6 years(3 FLL, 3 FTC)
- Used OpenCV and Vuforia for the last two seasons of FTC

In this Presentation

- We will cover...
  - Vuforia
  - OpenCV
  - Integrating both into the FTC SDK
- Make sure to
  - Have something to take notes with
  - To take pictures
  - Follow along

What is OpenCV?

- Open Source Computer Vision Library
- Allows computers to recognize objects in the real world
- Uses include: Facial Recognition, Color Detection, Edge Detection, etc.
- Information at https://opencv.org/

What is VuForia?

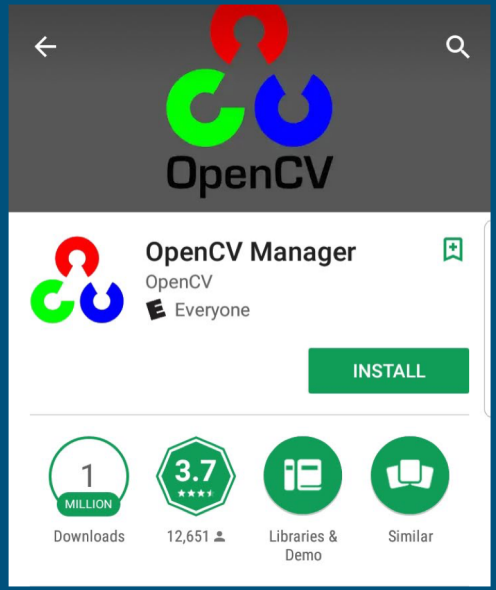
- Augmented Reality Software Development Kit
- Detects ‘VuMarks’
- Returns information depending on the VuMark
- Tracks the VuMark’s position on the X, Y, and Z

Uses of Vuforia and OpenCV in FTC

- Detecting custom FTC VuMarks
- Reading colors on color specific scoring elements
- Edge Detection
- Recognizing different objects

Integrating OpenCV into the FTC SDK

1. Install OpenCV Manager on Robot Controller
    a. Essential when running OpenCV on a mobile device
    b. https://play.google.com/store/apps/details?id=org.opencv.engine



Integrating OpenCV into the FTC SDK

2. Download OpenCV version 3.1 on Source Forge
    a. https://sourceforge.net/projects/opencvlibrary/files/opencv-android/

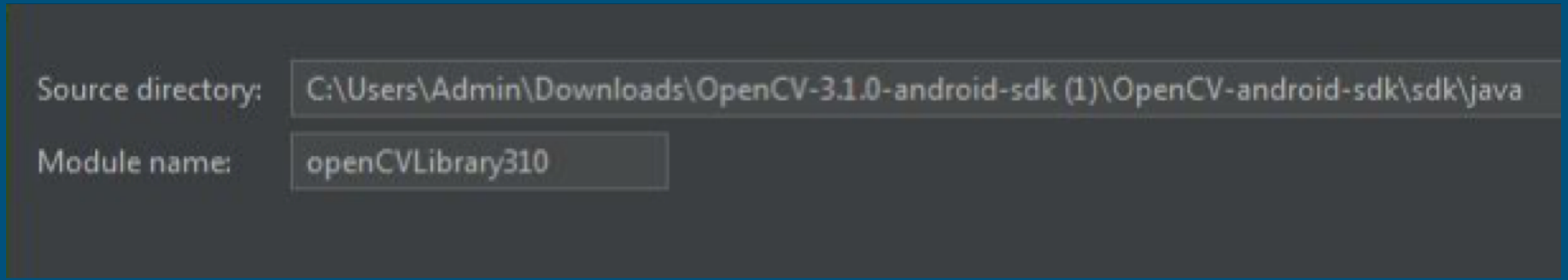
OpenCV-3.1.0-android-sdk.zip	2015-12-18	166.2 MB
Totals: 1 Item		166.2 MB

Integrating OpenCV into the FTC SDK

3. Download and import the FTC SDK 3.7
    a. https://github.com/ftctechnh/ftc_app
    b. Import into Android Studio File>New>Import Project>FTC SDK

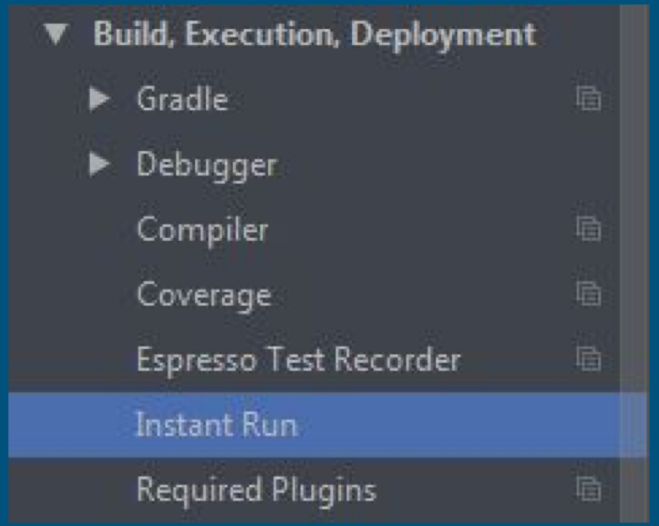
Integrating OpenCV into the FTC SDK

4. Import OpenCV as a module
    a. File>Import New>Module
    b. Import Java folder within SDK



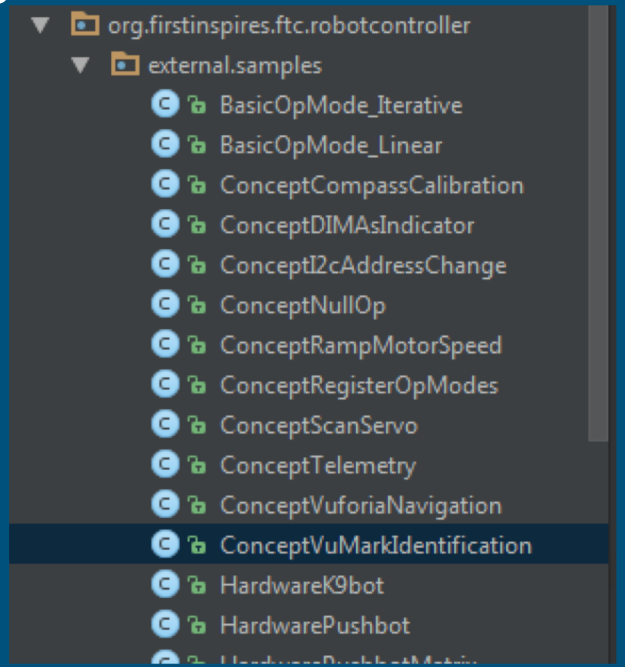
Integrating OpenCV into the FTC SDK

5. Disable Instant Run
    a. Very Important when using OpenCV



Integrating OpenCV into the FTC SDK

6. Copy ConceptVuMarkIdentification into TeamCode
    a. This already uses Vuforia
    b. Next step is to add openCV



Integrating OpenCV into the FTC SDK

7. Comment out ***@disabled*** at line 70
8. Add ***AppUtil appUtil = AppUtil.getInstance();*** at line 74 (Import Class)

```
@Autonomous(name="Concept: VuMark Id", group ="Concept")
//@Disabled
public class ConceptVuMarkIdentification extends LinearOpMode {

    public static final String TAG = "Vuforia VuMark Sample";
    AppUtil appUtil = AppUtil.getInstance();
    OpenGLMatrix lastLocation = null;
```

Integrating OpenCV into the FTC SDK

9. Add private BaseLoaderCallback loaderCallback = new ***BaseLoaderCallback(appUtil.getActivity())***

```
{
    @Override
    public void onManagerConnected(int status) {
        super.onManagerConnected(status);
    }
};
```

At line 78

Integrating OpenCV into the FTC SDK

10. Add ***boolean writeFileOnce = false;***

Log.v(TAG, "Initializing OpenCV");

// Initialize OpenCV

if (!OpenCVLoader.initDebug()) {

OpenCVLoader.initAsync(OpenCVLoader.OPENCV_VERSION_3_1_0,

appUtil.getActivity(), loaderCallback);

}

else {

loaderCallback.onManagerConnected(LoaderCallbackInterface.SUCCESS);

} At line 96 under runOpMode()

Integrating OpenCV into the FTC SDK

11. Create account for Vuforia License Manager and obtain License

https://developer.vuforia.com/license-manager

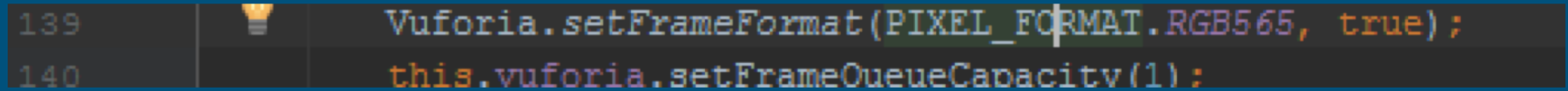
a. Enter any Information
b. Obtain Vuforia License Code and Copy into Program at line 28

```
127     */
128    parameters.vuforiaLicenseKey = "ATsODcD/////AAAAAVw21R...d45oGpdljdOh5LuFB9nDNfckoxb8COxKSFX";
```

Integrating OpenCV into the FTC SDK

12. Change frame queue capacity

    a. Add ***Vuforia.setFrameFormat(PIXEL_FORMAT.RGB565, true);*** ***this.vuforia.setFrameQueueCapacity(1);*** at line 139



Integrating OpenCV into the FTC SDK

13. Add ***if (!writeFileOnce) {***

```
VuforiaLocalizer.CloseableFrame frame;
try {
    frame = this.vuforia.getFrameQueue().take();
} catch (InterruptedException e) {
    Log.v(TAG, "Exception!!");
    break;
}
```

Matrix34F raw = new Matrix34F(); at line 195

Integrating OpenCV into the FTC SDK

14. Add ***float[] rawData = Arrays.copyOfRange(pose.transposed().getData(), 0, 12);***

raw.setData(rawData);

Vec2F pointCenter =

Tool.projectPoint(this.vuforia.getCameraCalibration(),

raw, new Vec3F(0, 0, 0));

Log.v(TAG, "Center: " + (int) pointCenter.getData()[0] + ", " + (int) pointCenter.getData()[1]); At line 209

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15. Add ***long numImages = frame.getNumImages();***

```
for (int i = 0; i < numImages; i++) {
    if (frame.getImage(i).getFormat() == PIXEL_FORMAT.RGB565) {
        Image rgb = frame.getImage(i);
        if (rgb != null) {
            Bitmap bm = Bitmap.createBitmap(rgb.getWidth(),
                    rgb.getHeight(),
                    Bitmap.Config.RGB_565);
            bm.copyPixelsFromBuffer(rgb.getPixels());
```

at line 220

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16. Add ***Mat img = new Mat(rgb.getHeight(), rgb.getWidth(),***
CvType.CV_8UC3);
Utils.bitmapToMat(bm, img);

Imgproc.cvtColor(img, img, Imgproc.COLOR_RGB2BGR);
Imgproc.cvtColor(img, img, Imgproc.COLOR_BGR2HSV);

String filePath = "/sdcard/FIRST/rgbFile.png";
Log.v(TAG, "Saving image" + filePath);
Imgcodecs.imwrite(filePath, img);
img.release(); at line 235

Integrating OpenCV into the FTC SDK

17. Add writeFileOnce = true;

```
                    }
                    break;
                }

            }
                frame.close();

        }
```

Results

- Creates a HSV image of the VuMark with Vuforia Overlay
- Just a Concept
  - Much more can be done with OpenCV and Vuforia

Wrap Up

- Feel free to email our team bytesofkitkats@gmail.com with questions
- Visit our Github Bytes_Of_Kitkats
- Links that may be useful in the future

https://developer.vuforia.com/home-page

https://opencv.org/