Mobile Image Processing

- Examples of mobile image processing
- Android platform
- Class resources for Android
- Eclipse integrated development environment
- Augmentation of viewfinder frames
- Debugging with DDMS perspective
- Taking a device screenshot
- Creating an Android emulator
- Mixed programming with Android JNI
- OpenCV library for Android
- Past class projects

Mobile landmark recognition

Mobile product recognition

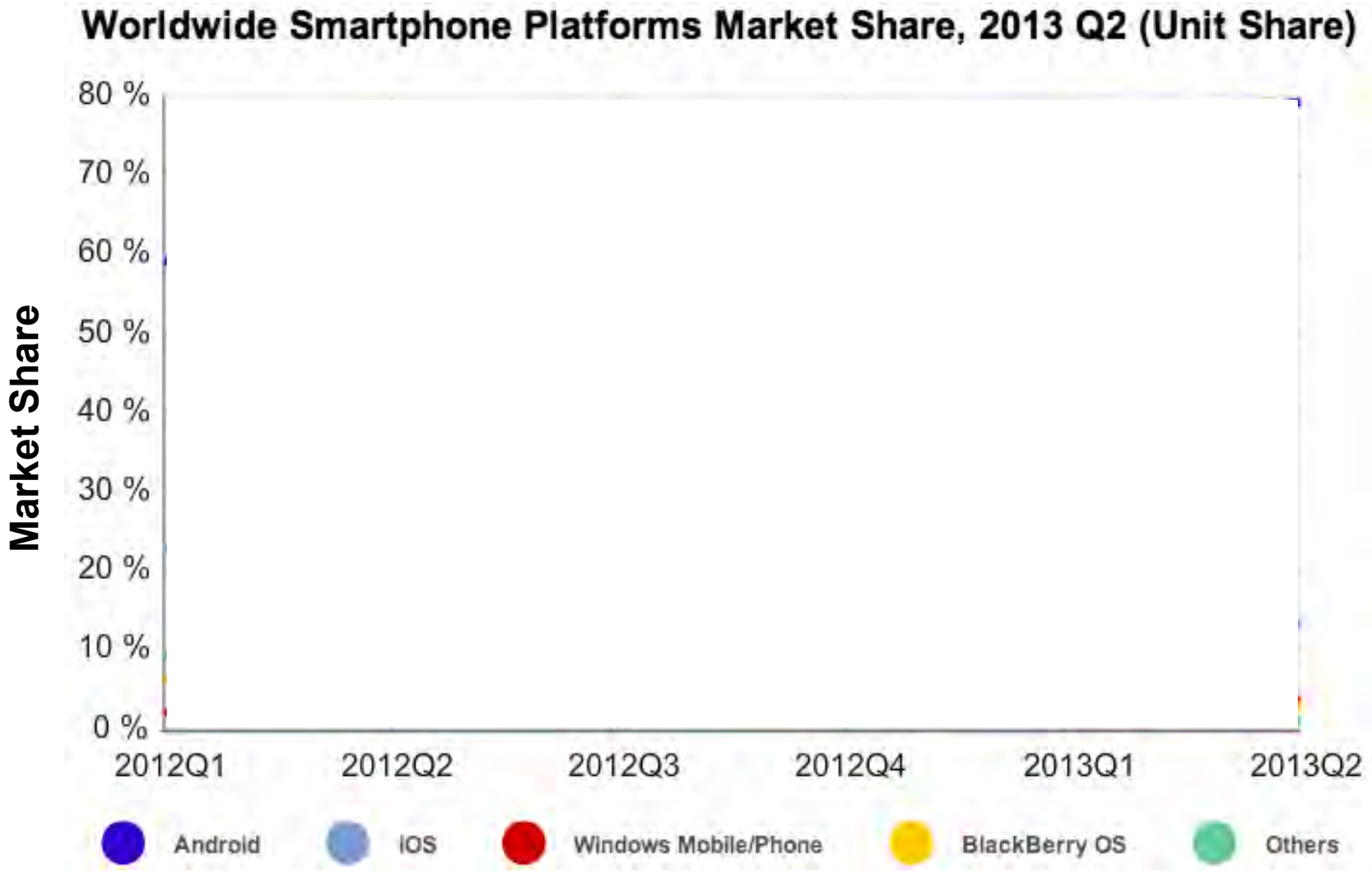
Android platform

- Open source mobile platform developed by Google
- Supported and maintained by Open Handset Alliance
  - 14 mobile operators
  - 23 handset manufacturers
  - 21 semiconductor companies
  - 17 software makers

Android platform

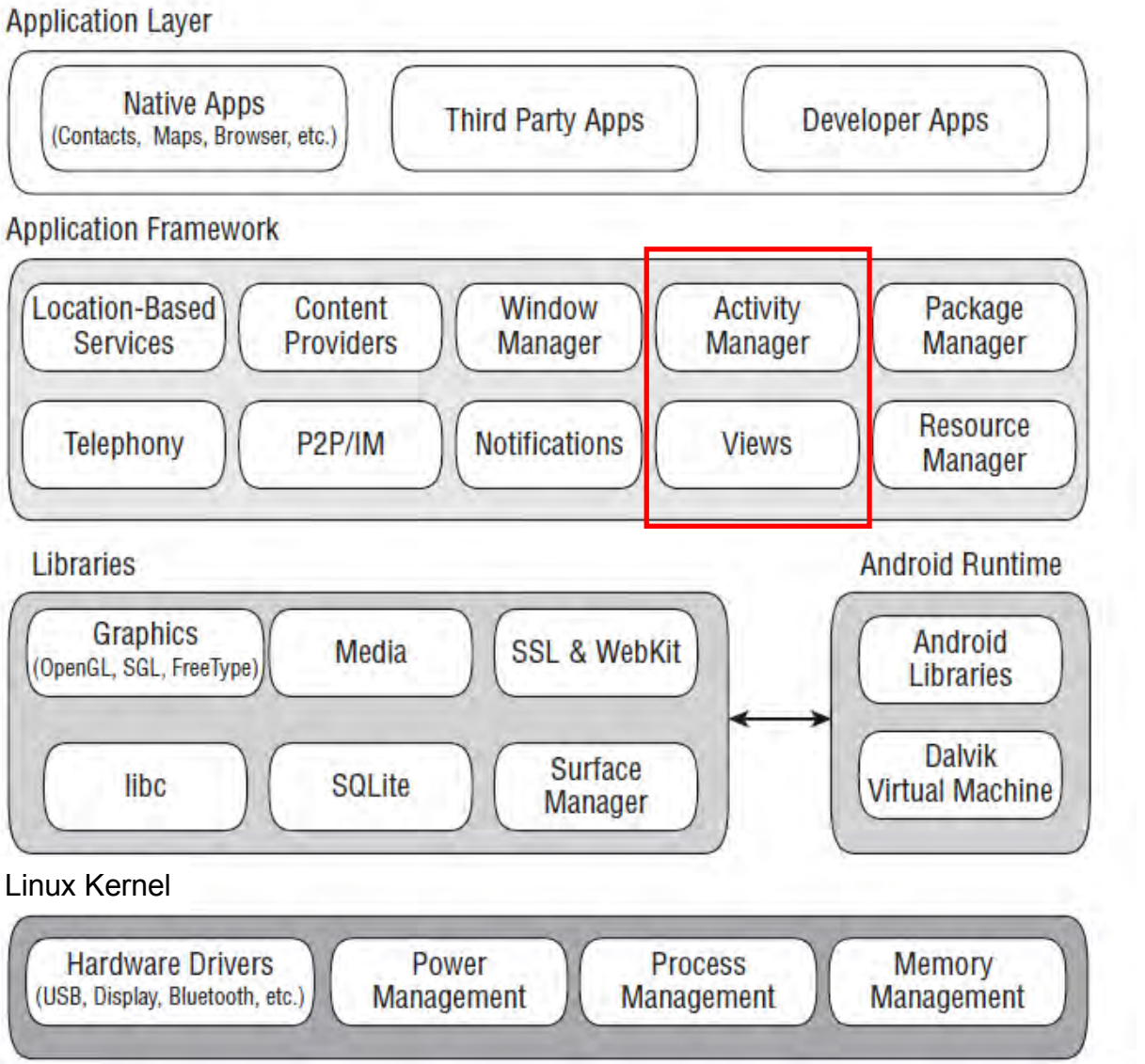
- Open source mobile platform developed by Google
- Supported and maintained by Open Handset Alliance
  - 14 mobile operators
  - 23 handset manufacturers
  - 21 semiconductor companies
  - 17 software makers
- Uses an open-source kernel and a virtual machine designed for mobile hardware
- Commands the largest share of the smartphone market in the world
- Google Play store contains over 1M apps

Distribution of worldwide smartphone sales



IDC Worldwide Mobile Phone Tracker

Android software stack



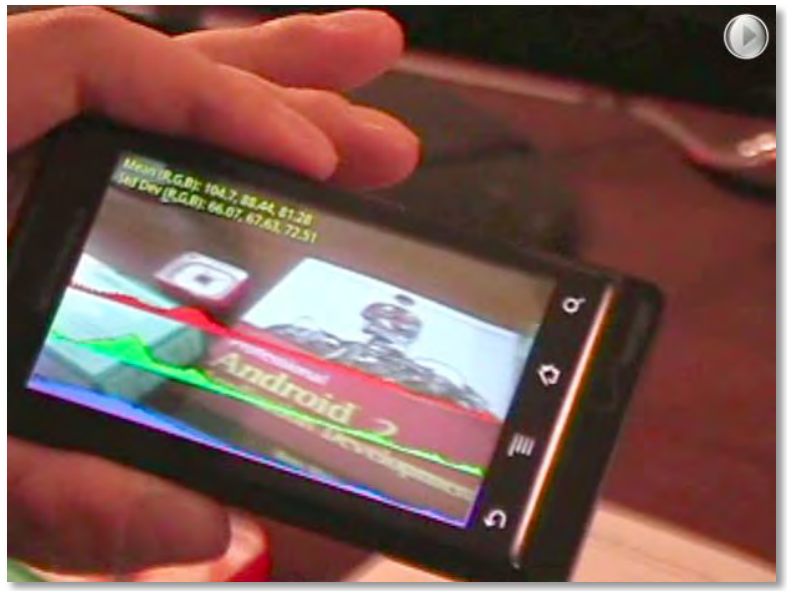
Professional Android Application Development

Programming Android applications in Java

- Android encourages high-level app development
- Android uses Java as the main programming language
- Android inherits basic classes from conventional Java
  - String, Container, Math, IO, Network, …
- Android also adds new classes specific to mobile devices
  - Camera, Telephony, Map, GPS, Speech, …

Class resources for mobile image processing

- Tutorial #1: Basic Android Setup
  - Image processing-oriented introduction to Android
  - Explains how to download and install the different software packages (JDK, SDK, Eclipse) on your own computer or use these pre-installed packages on SCIEN machines
  - Shows how to build and run viewfinder augmentation apps in real time



http://www.stanford.edu/ee368/Android

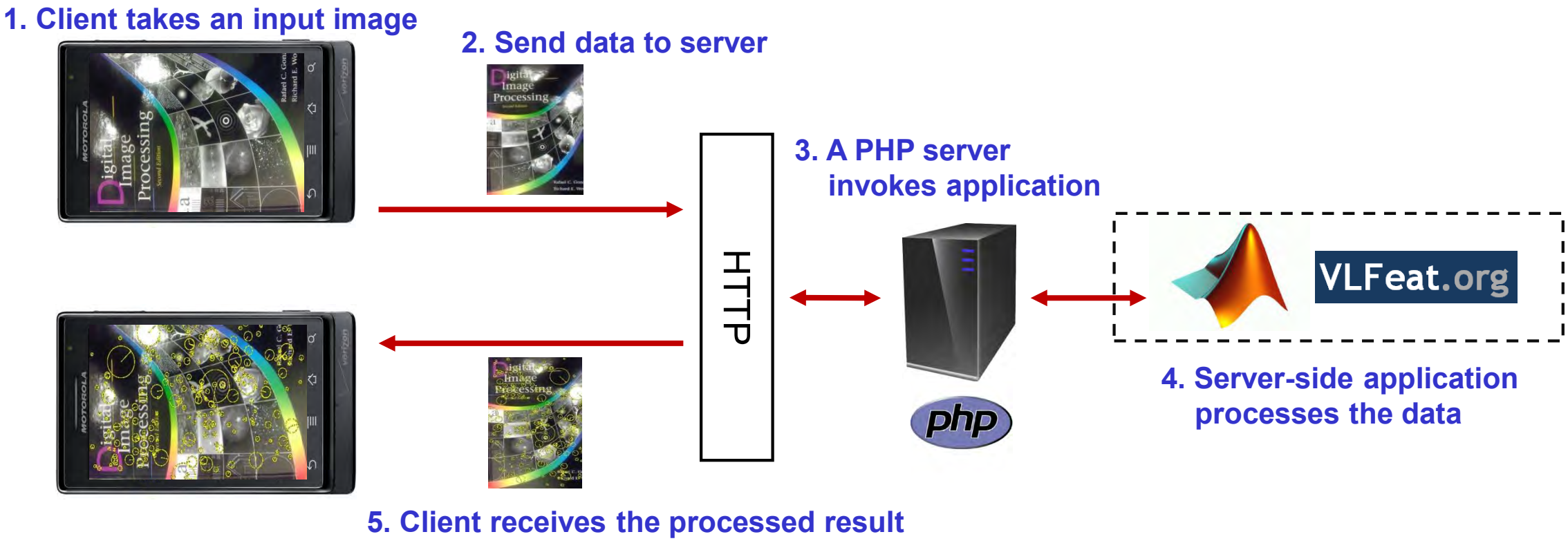
Class resources for mobile image processing

- Tutorial #2: OpenCV for Android Setup
  - Builds on core skills developed in Tutorial #1
  - Explains how to download and install OpenCV for Android
  - Shows how to build viewfinder apps that detect circles and lines, detect feature keypoints, track feature keypoints, perform locally adaptive thresholding, detect human faces

http://www.stanford.edu/ee368/Android

Class resources for mobile image processing

- Tutorial #3: Server-client communications



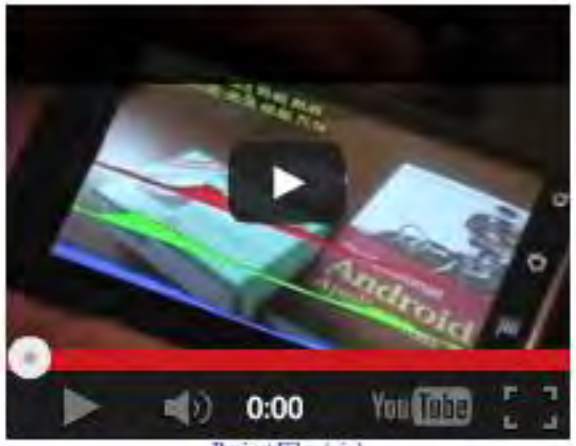
http://www.stanford.edu/ee368/Android

Sample mobile image processing projects

Histogram Equalization

Project Files (zip)

Color Histograms



Project Files (zip)

Feature Tracking

Project Files (zip)

Locally Adaptive Binarization

Project Files (zip)

Edges, Lines, and Circles

Project Files (zip)

Local Feature Keypoints

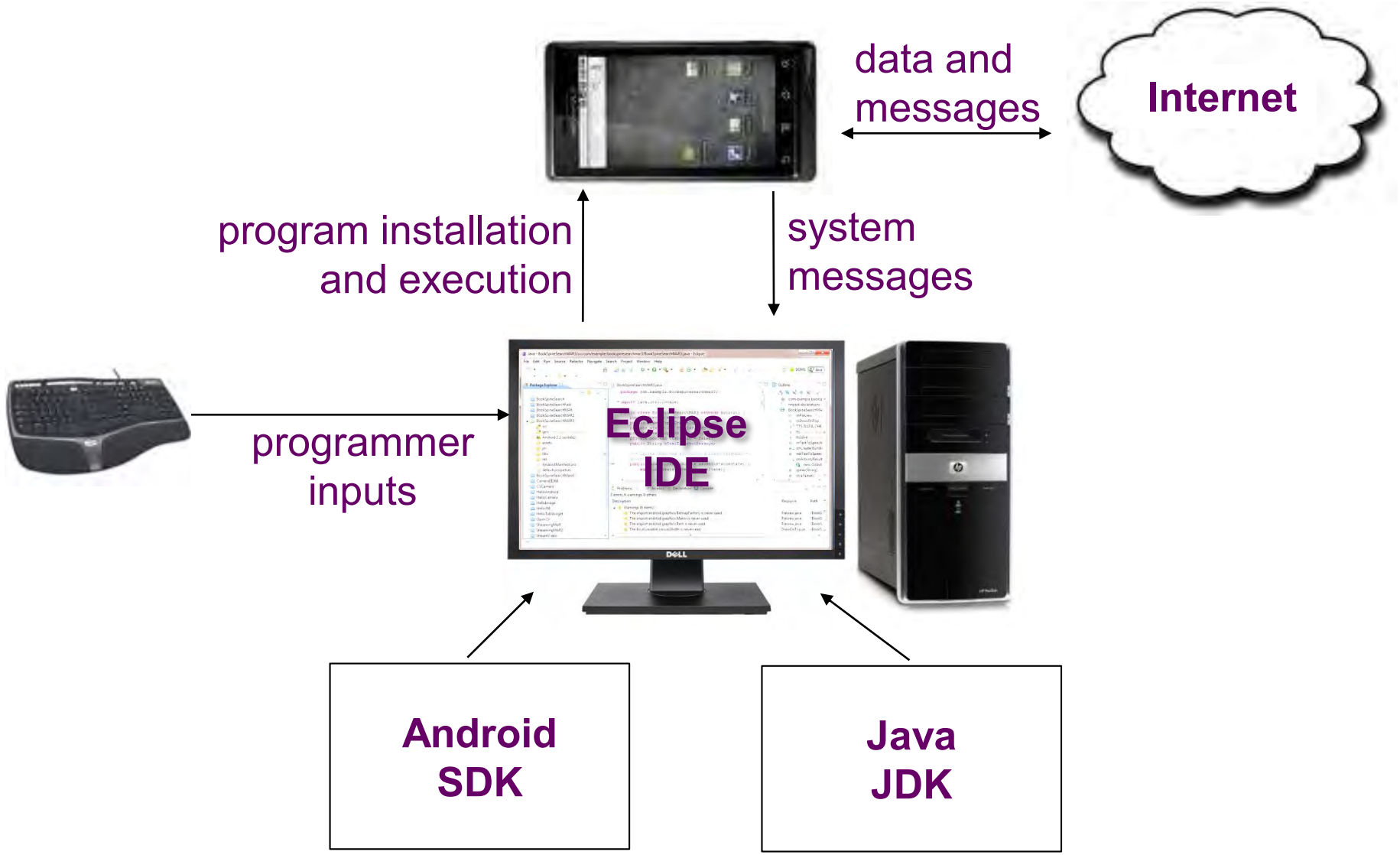
Project Files (zip)

Human Face Detection

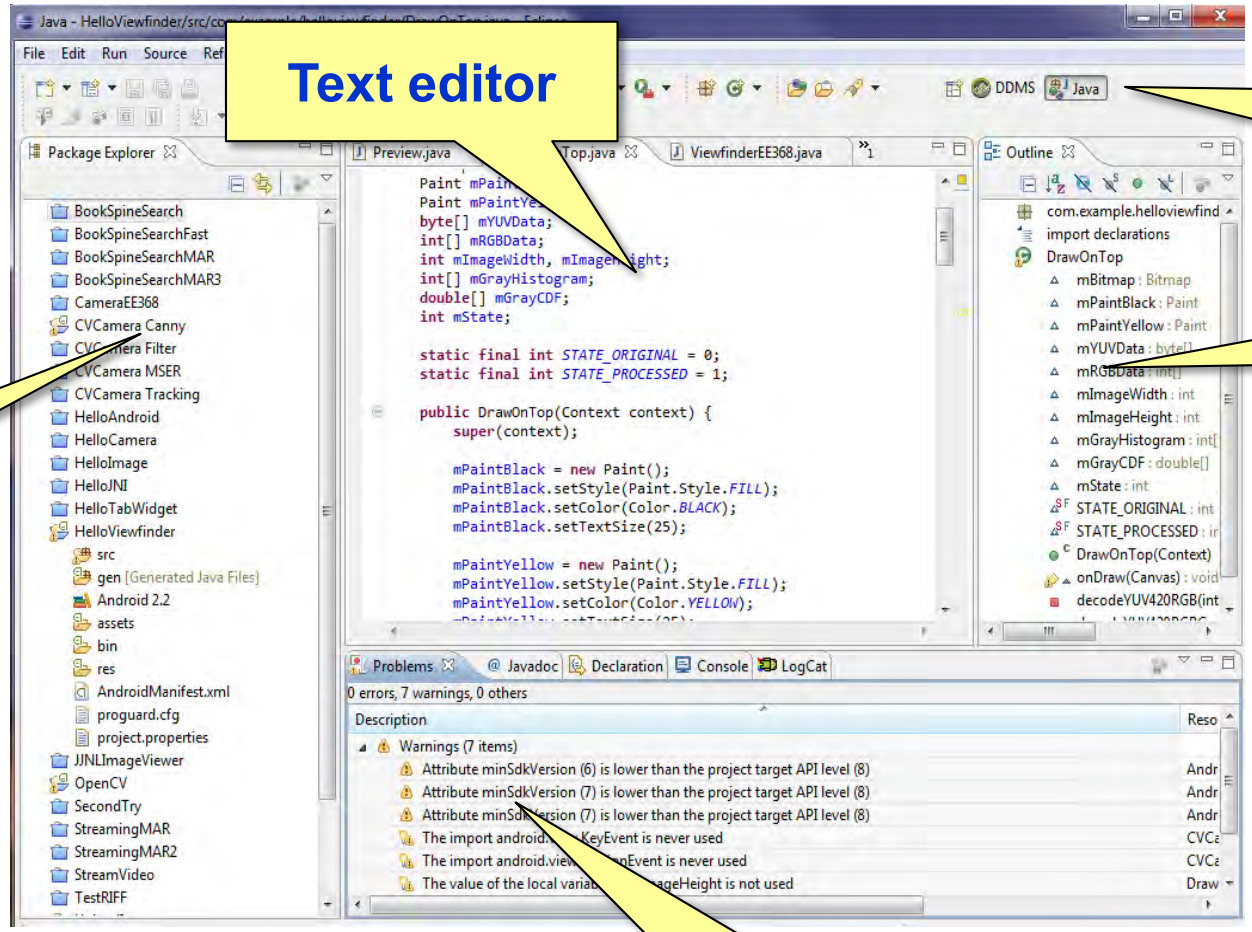
Project Files (zip)

http://www.stanford.edu/ee368/Android

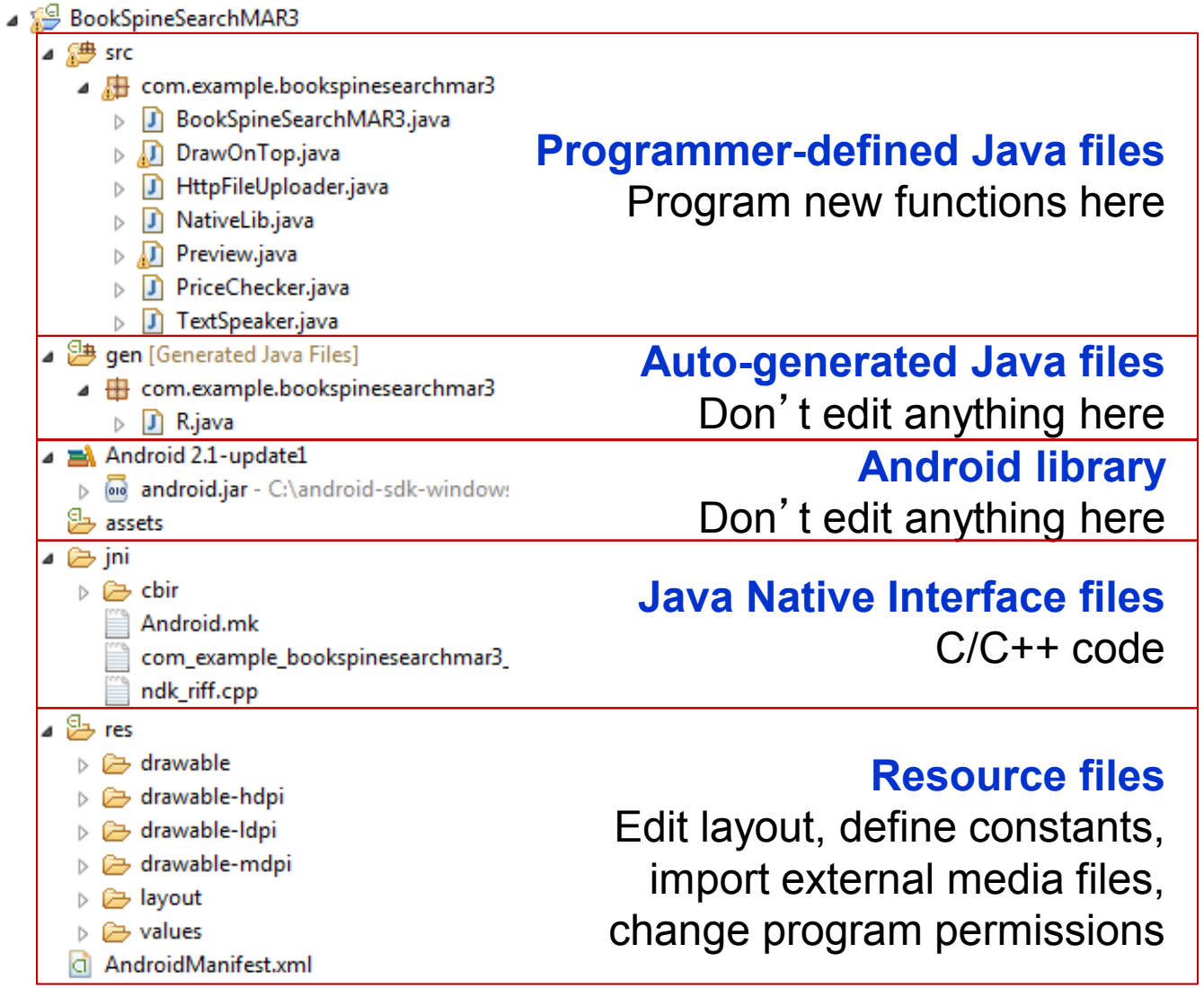
Android development with Eclipse



Eclipse integrated development environment

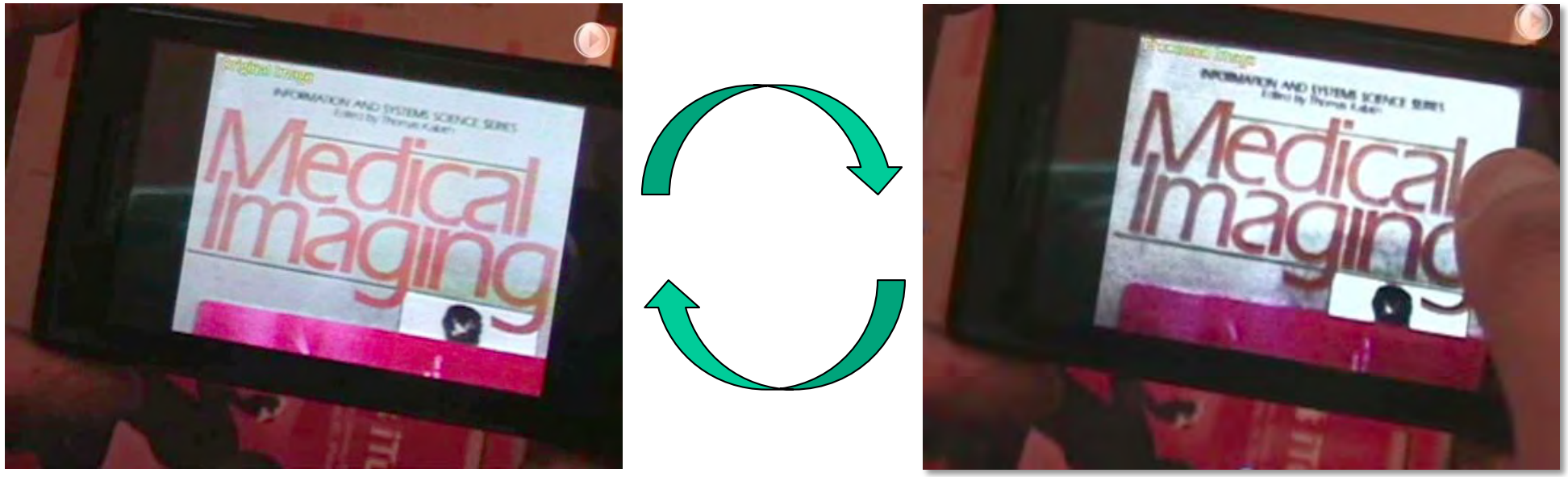


Structure of an Android project

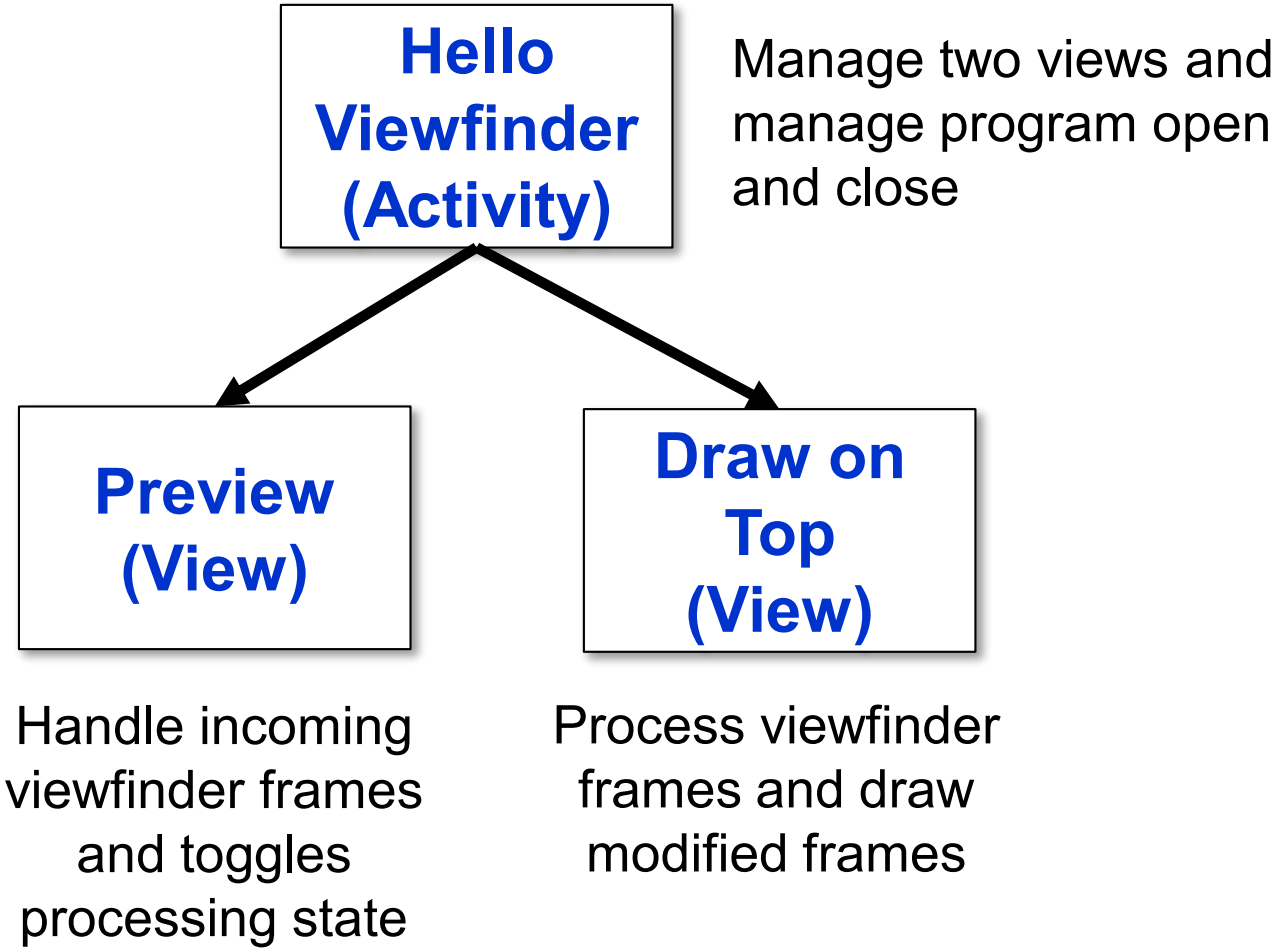


“Hello Viewfinder” project

- Goals of this project
  - Learn how to create a simple Android project
  - Learn how to display viewfinder frames
  - Learn how to process viewfinder frames
- Full source available on class website



“Hello Viewfinder” class hierarchy



Main activity class

```
public class HelloViewfinderActivity extends Activity {
    private Preview mPreview;
    private DrawOnTop mDrawOnTop;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        // Hide the window title and set full screen
        getWindow().setFlags(... Full Screen Parameters ...);
        requestWindowFeature(Window.FEATURE_NO_TITLE);

        // Create Preview and DrawOnTop
        mDrawOnTop = new DrawOnTop(this);
        mPreview = new Preview(this, mDrawOnTop);
        setContentView(mPreview);
        addContentView(mDrawOnTop, ... Layout Options ...)
    }
}
```

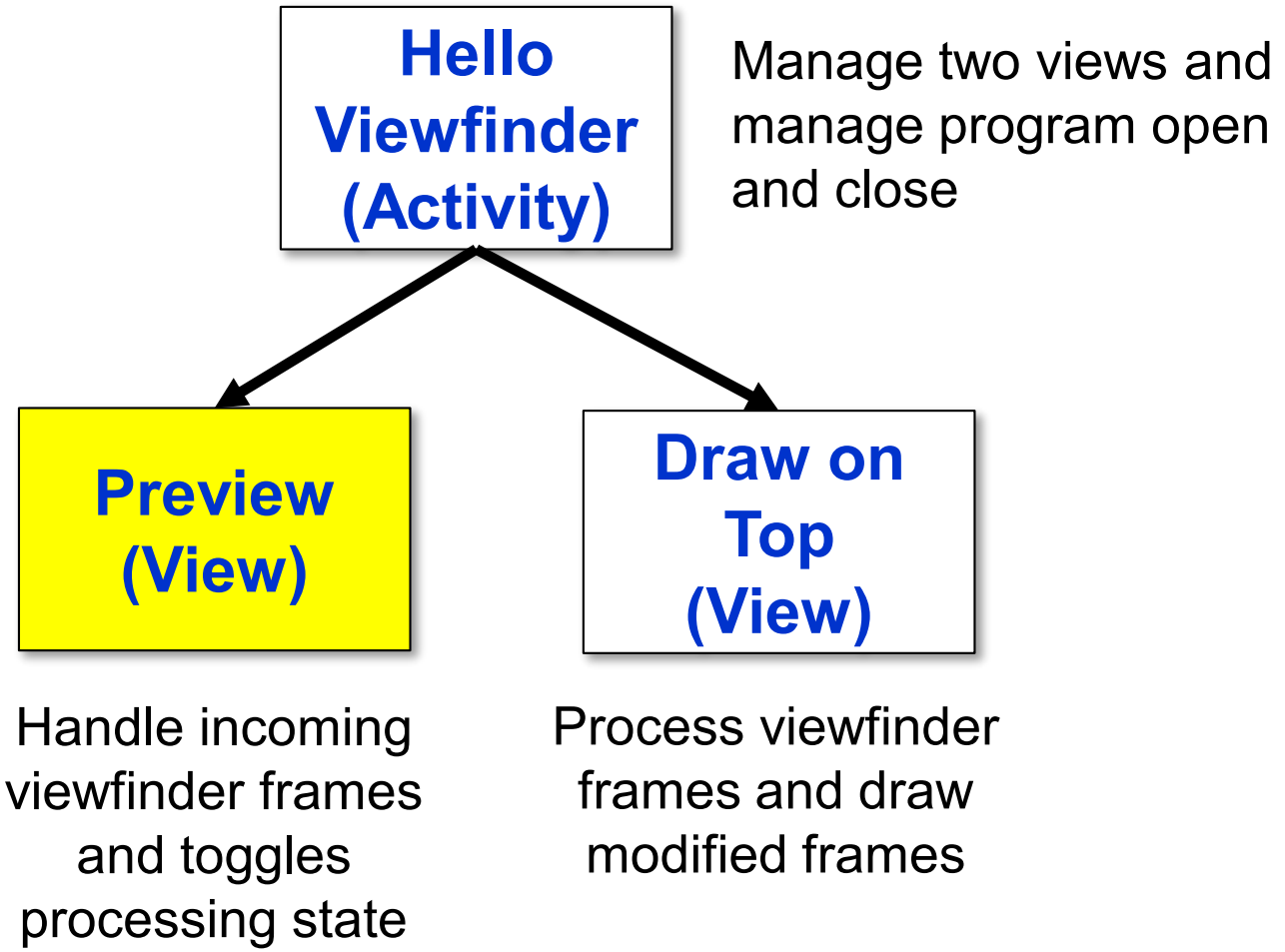
Make this class inherit the properties of an Activity

Called when the activity is first created

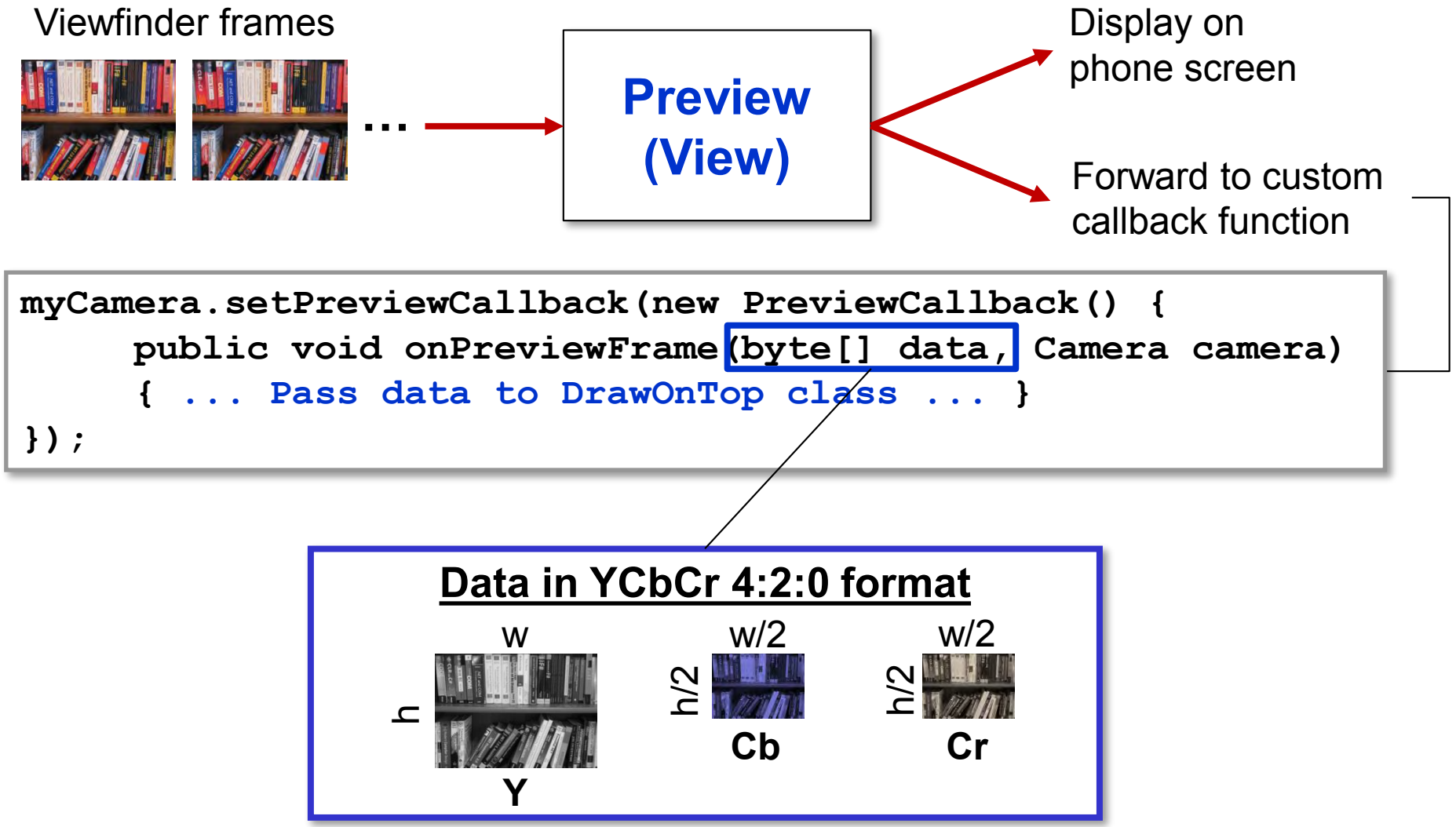
Make the application appear in full screen

Create two children objects for displaying frames

“Hello Viewfinder” class hierarchy



Preview class: viewfinder frames go down two paths



Preview class: toggle states via touch screen

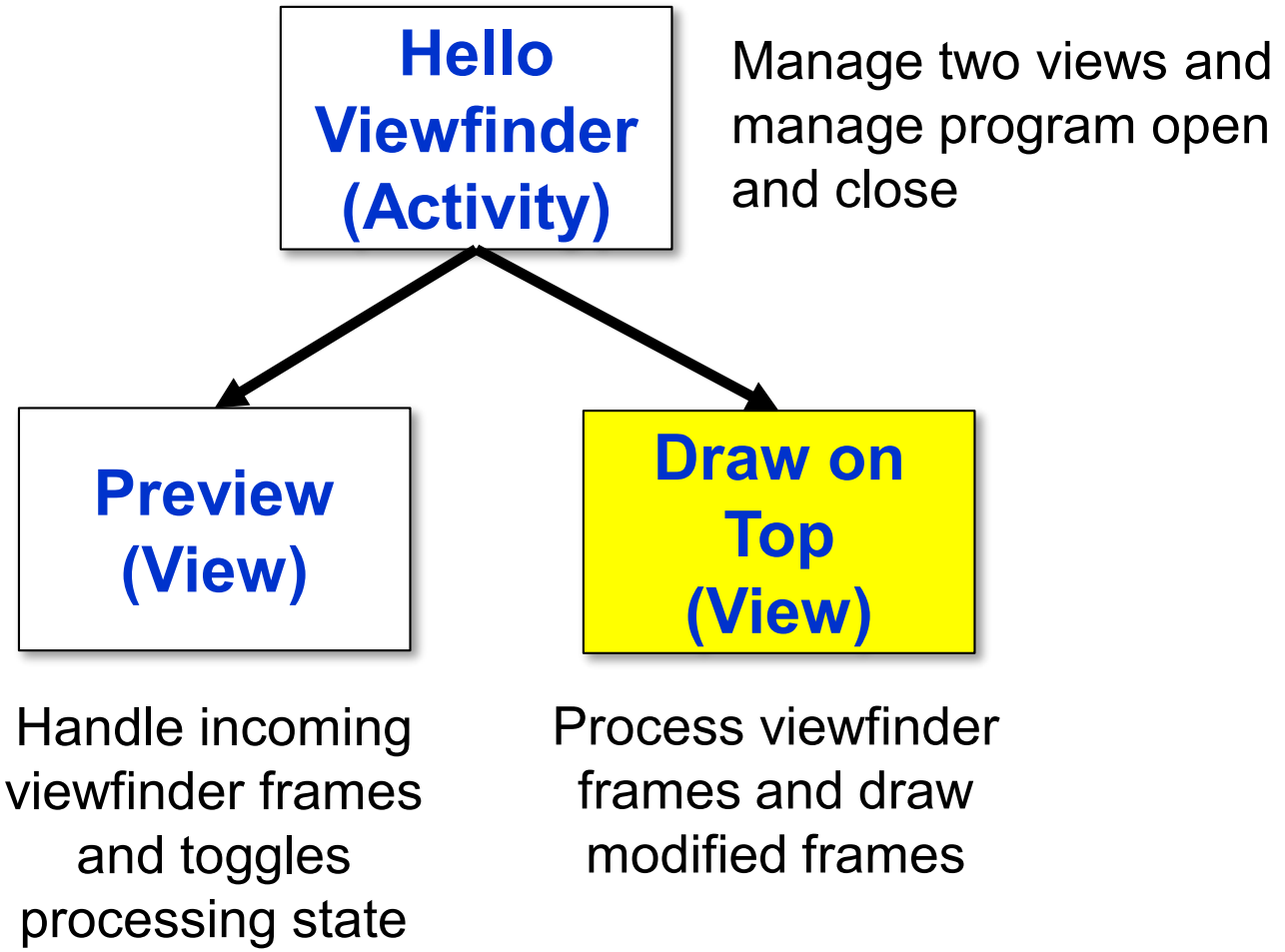
```
// Define on touch listener
this.setOnTouchListener(new OnTouchListener() {
   public boolean onTouch(View v, MotionEvent event)
   {
       if (mDrawOnTop.mState == DrawOnTop.STATE_ORIGINAL)
        {
          mDrawOnTop.mState = DrawOnTop.STATE_PROCESSED;
        }
        else if (mDrawOnTop.mState == DrawOnTop.STATE_PROCESSED)
        {
          mDrawOnTop.mState = DrawOnTop.STATE_ORIGINAL;
        }
        return false;
   }
});
```

Define an anonymous touch listener object

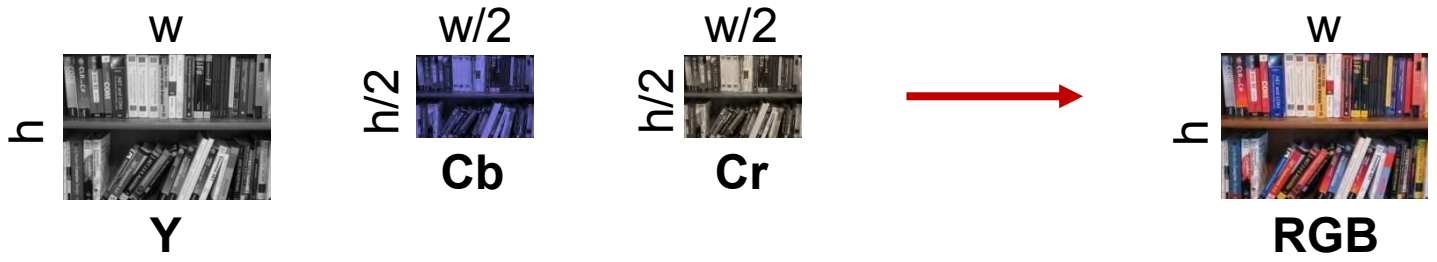
If in original state, toggle to processed state

If in processed state, toggle to original state

“Hello Viewfinder” class hierarchy



Draw on Top class: YCbCr to RGB conversion



$$R = \frac{298.08 \cdot Y}{256} + \frac{408.58 \cdot Cr}{256} - 222.921$$

$$G = \frac{298.08 \cdot Y}{256} - \frac{100.29 \cdot Cb}{256} - \frac{208.12 \cdot Cr}{256} + 135.58$$

$$B = \frac{298.08 \cdot Y}{256} + \frac{516.41 \cdot Cb}{256} - 276.84$$

Draw-on-top class: process viewfinder frames

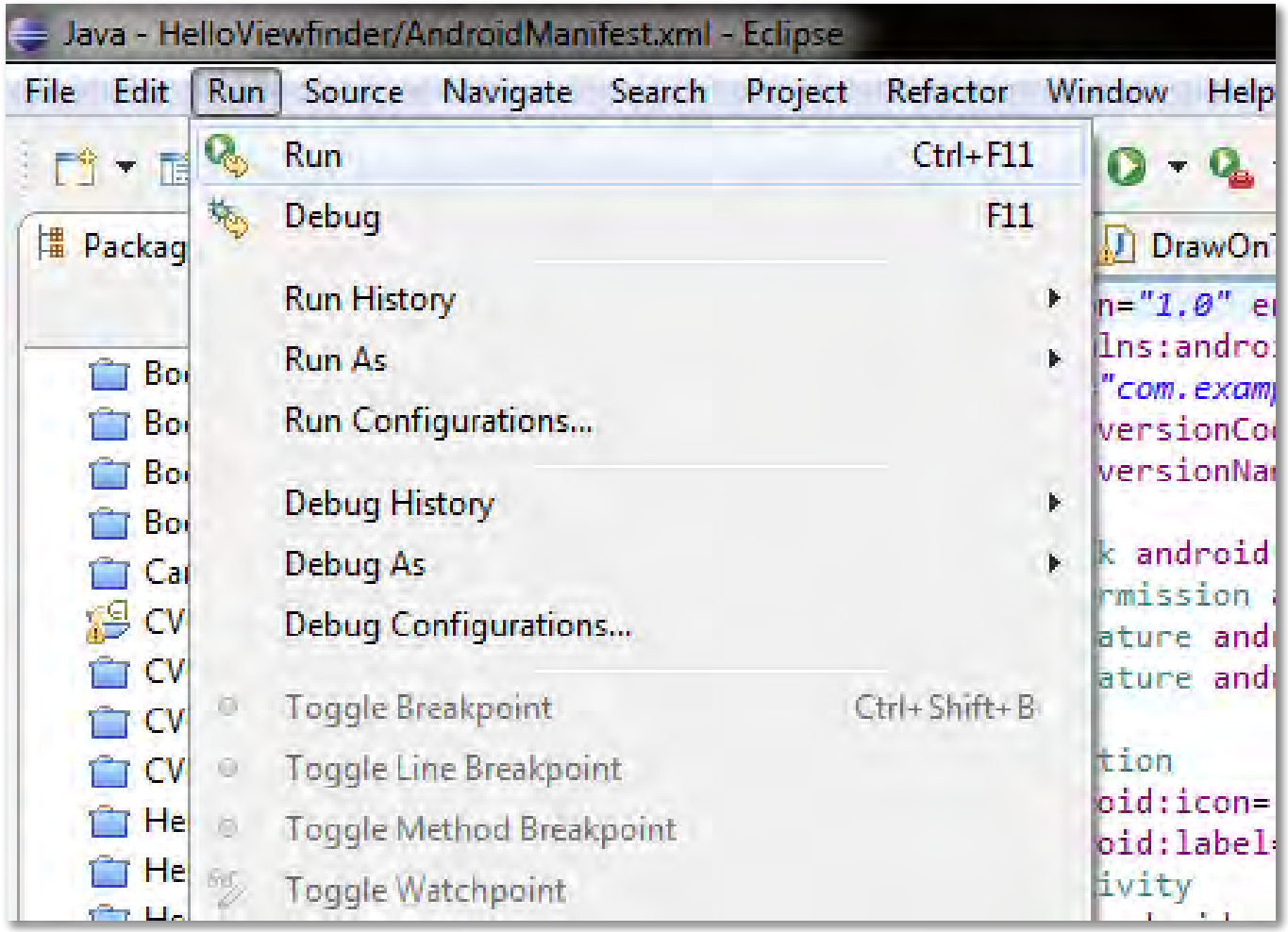
```
// Called whenever a repaint is requested
protected void onDraw(Canvas  canvas)
{
    ...
    // Convert from YCbCr to RGB
    if (mState == STATE_ORIGINAL)
         decodeYCbCr420RGB(mRGBData, mYCCData, mWidth, mHeight);
    else
         decodeYCbCr420RGBHistEq(mRGBData, mYCCData, mWidth, mHeight);

    // Draw bitmap
    mBitmap.setPixels(mRGBData, 0, mWidth, 0, 0, mWidth, mHeight);
    Rect src = new Rect(... Size parameters ...);
    Rect dst = new Rect(... Size parameters ...);
    canvas.drawBitmap(mBitmap, src, dst, mPaintBlack);
    ...
}
```

Called whenever this view is repainted

Decode frame with or without hist. eq.

Draw decoded frame in new layer

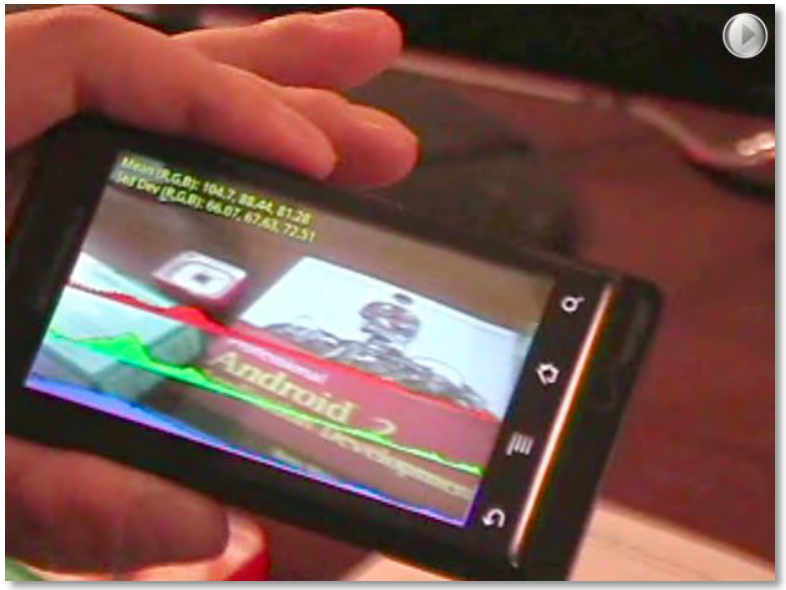
Running the program on an Android device



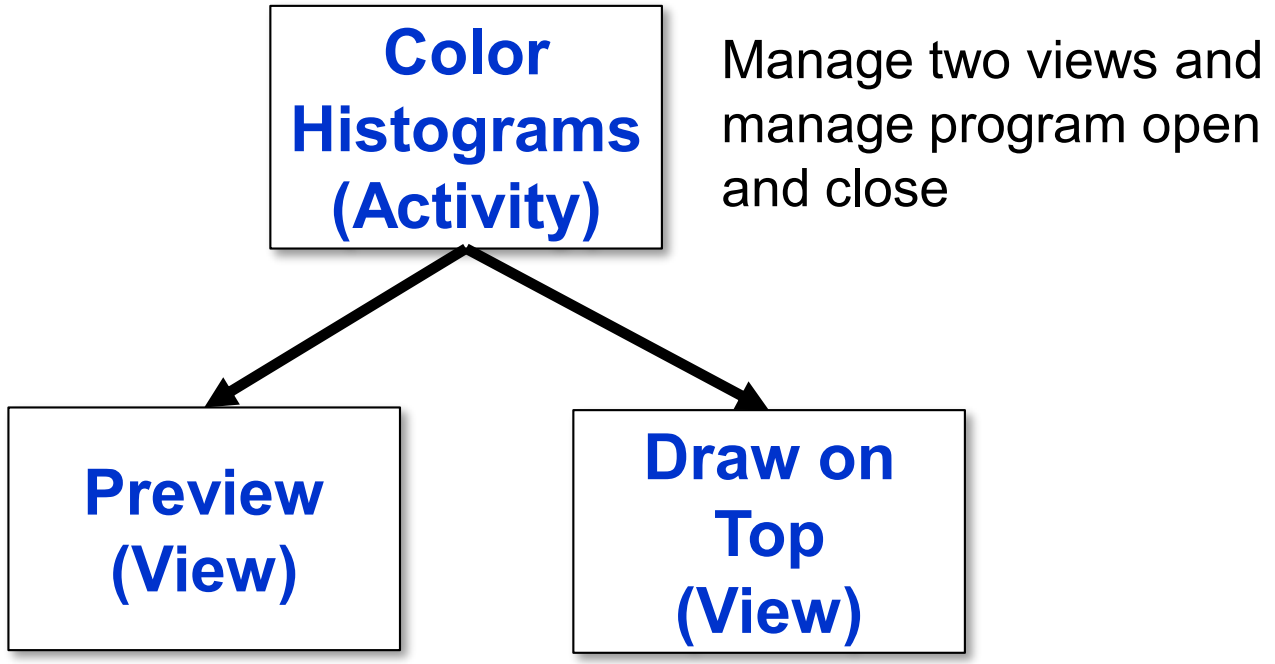
“Hello Viewfinder” application running on device

“Color Histograms” project

- Goals of this project
  - Learn how to modify camera parameters
  - Learn how to create drawing instruments
  - Learn how to augment the viewfinder frames
- Full source available on class website

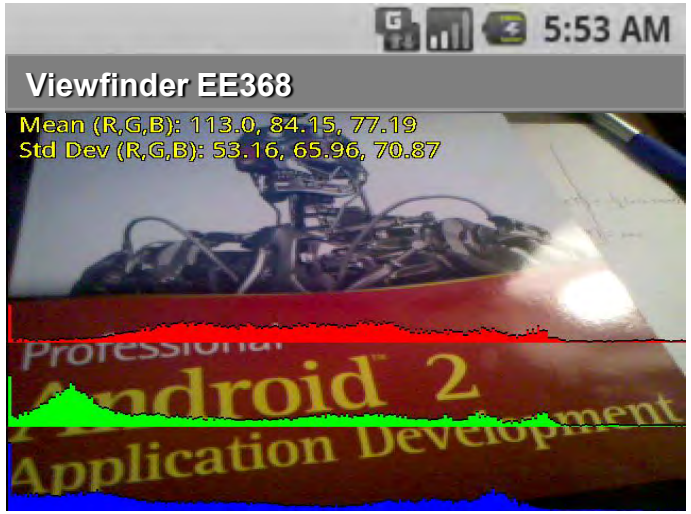


“Color Histograms” class hierarchy

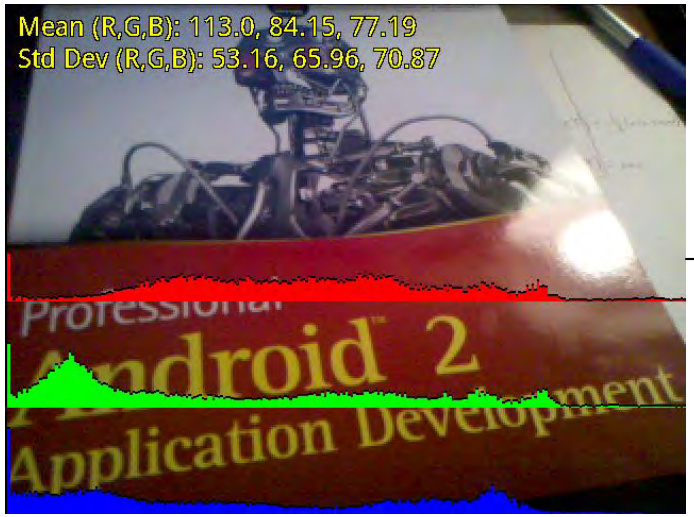


Main activity class: set full screen mode

Icon and title bars visible

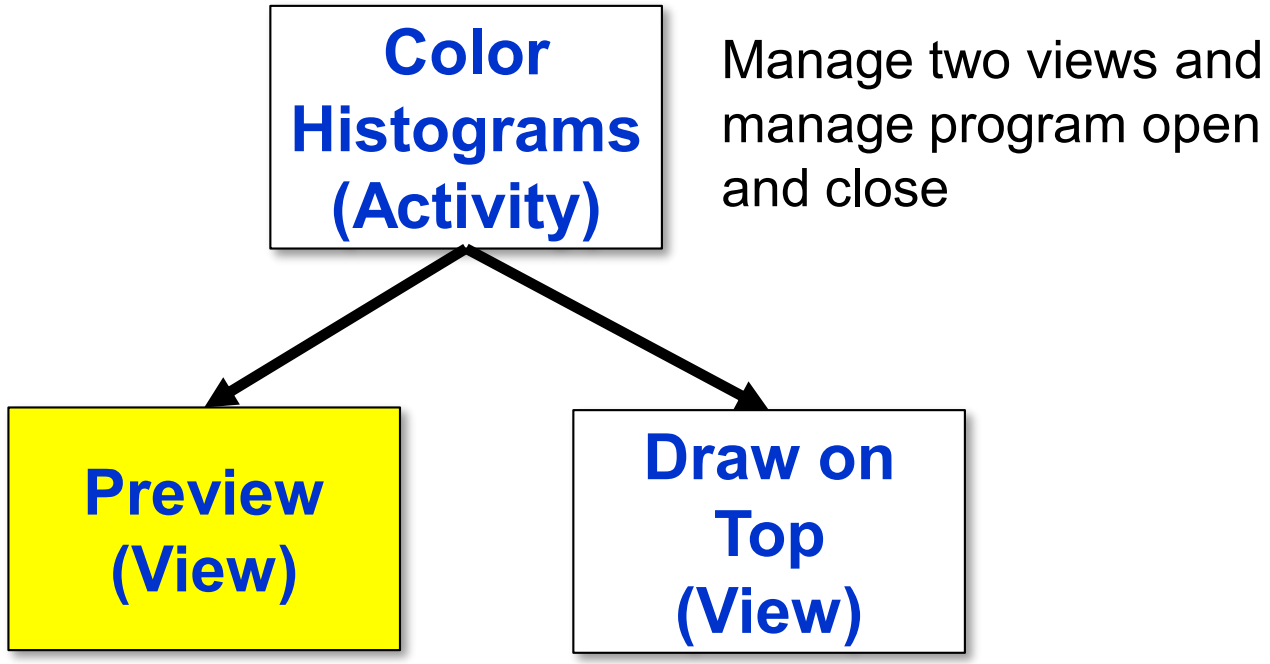


Icon and title bars hidden

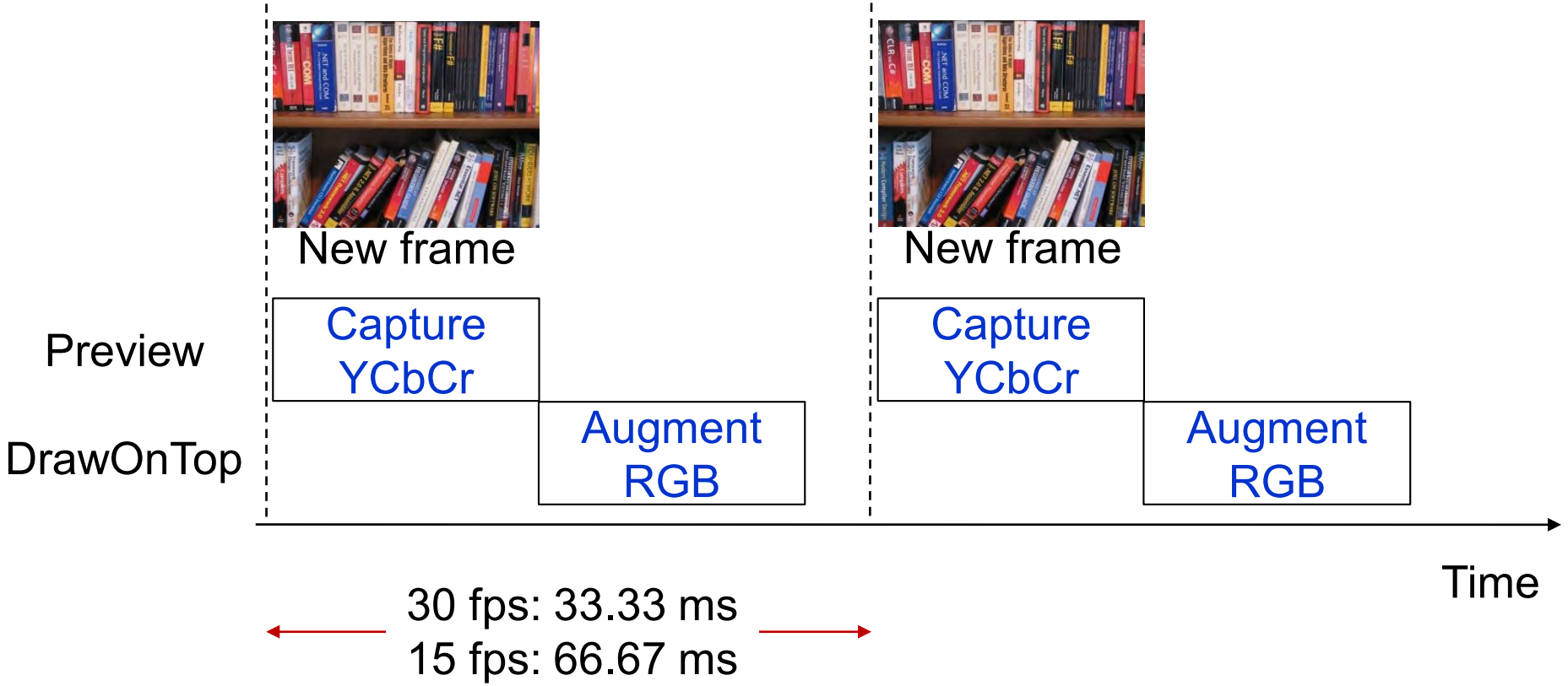



```
public void onCreate(Bundle savedInstanceState) {
    ...
    getWindow().setFlags(
          WindowManager.LayoutParams.FLAG_FULLSCREEN,
          WindowManager.LayoutParams.FLAG_FULLSCREEN
    );
    requestWindowFeature(Window.FEATURE_NO_TITLE);
    ...
}
```

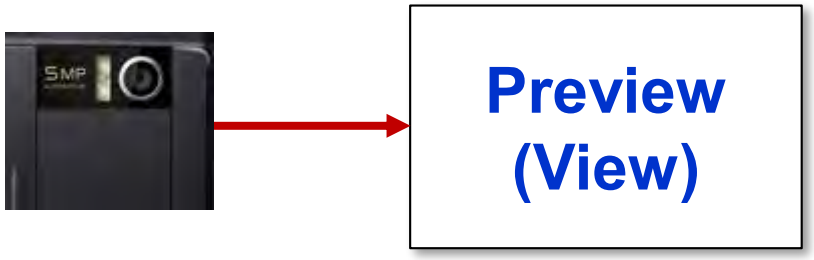
“Color Histograms” class hierarchy



Timeline of events on the mobile device

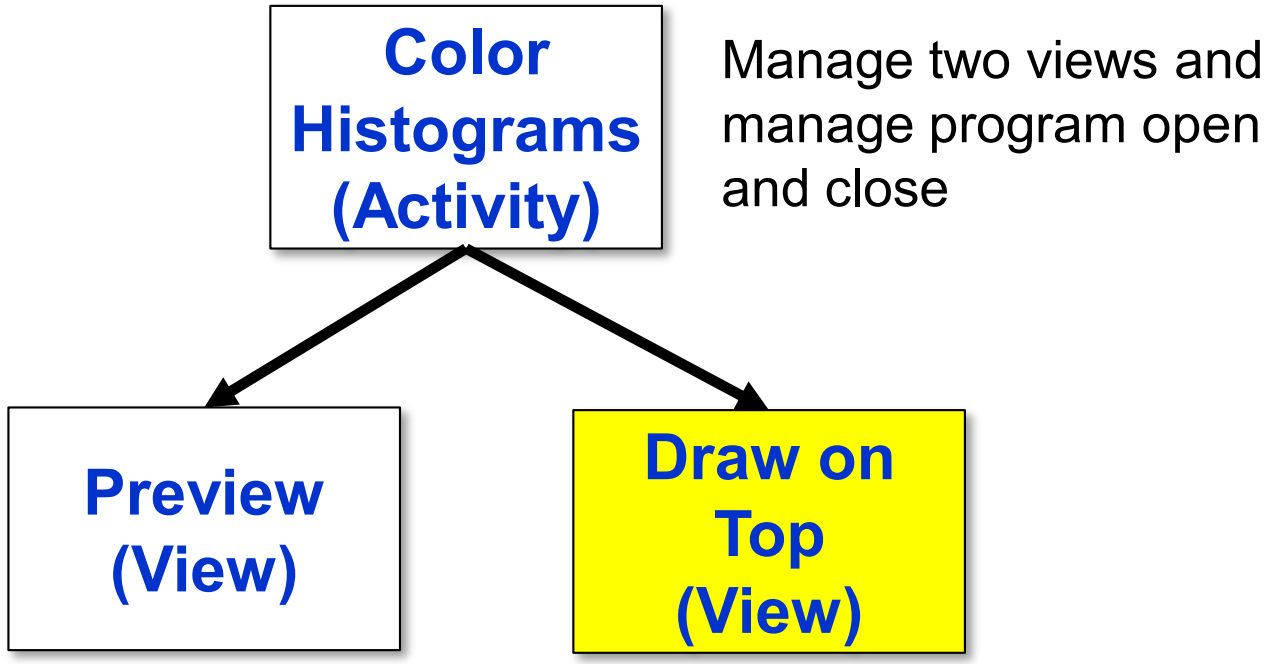


Preview class: set camera parameters




```
Camera.Parameters parameters = myCamera.getParameters();
parameters.setPreviewSize(640, 480);
parameters.setPreviewFrameRate(15);
parameters.setSceneMode(Camera.Parameters.SCENE_MODE_NIGHT);
parameters.setFocusMode(Camera.Parameters.FOCUS_MODE_AUTO);
myCamera.setParameters(parameters);
```

“Color Histograms” class hierarchy



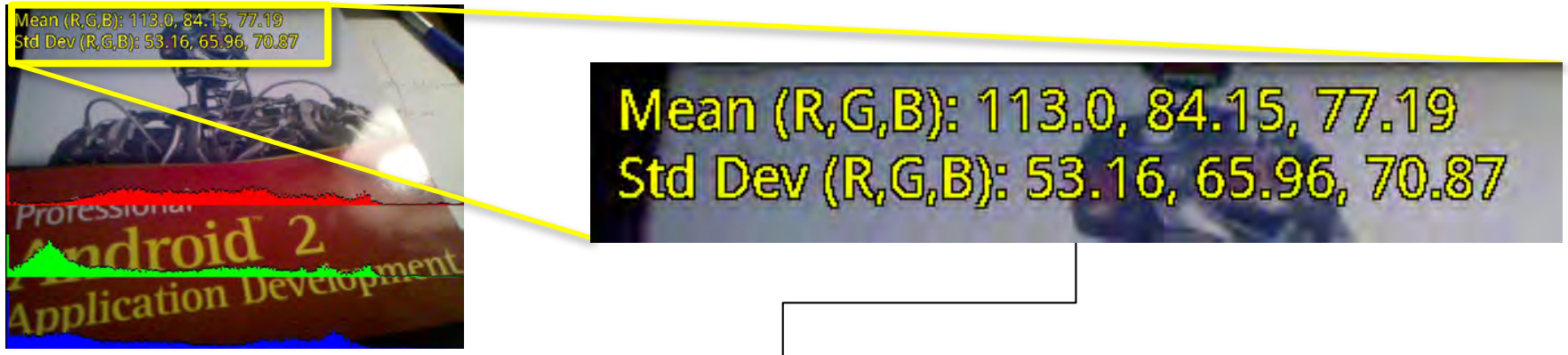
Draw on Top class: create some paint brushes

```
myPaintRed = new Paint();
myPaintRed.setStyle(Paint.Style.FILL);
myPaintRed.setColor(Color.RED);
myPaintRed.setTextSize(25);
```

```
myPaintGreen = new Paint();
myPaintGreen.setStyle(Paint.Style.FILL);
myPaintGreen.setColor(Color.GREEN);
myPaintGreen.setTextSize(25);
```

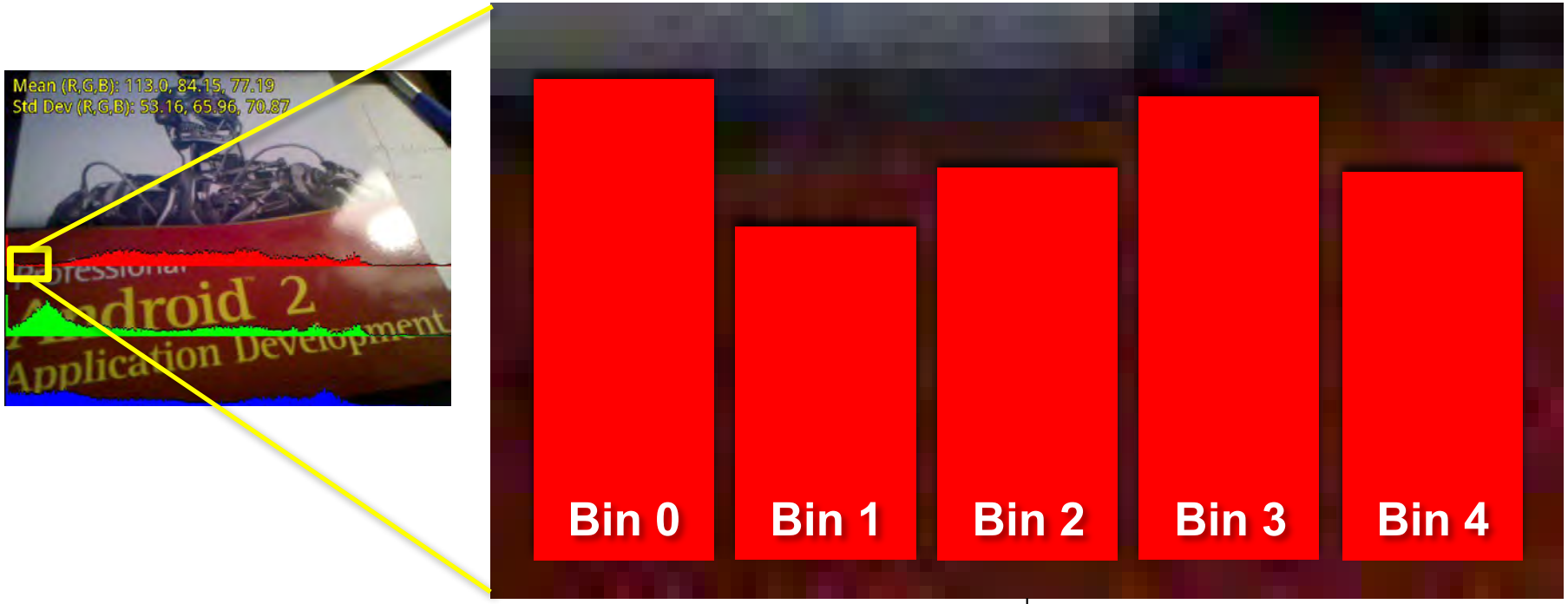
```
myPaintBlue = new Paint();
myPaintBlue.setStyle(Paint.Style.FILL);
myPaintBlue.setColor(Color.BLUE);
myPaintBlue.setTextSize(25);
```

Draw on Top class: write text on canvas




```
String meanStr = "Mean (R,G,B): " +
        String.format("%.4g", imageRedMean) + ", " +
        String.format("%.4g", imageGreenMean) + ", " +
        String.format("%.4g", imageBlueMean);
myCanvas.drawText(meanStr, x, y, mPaintYellow);
```

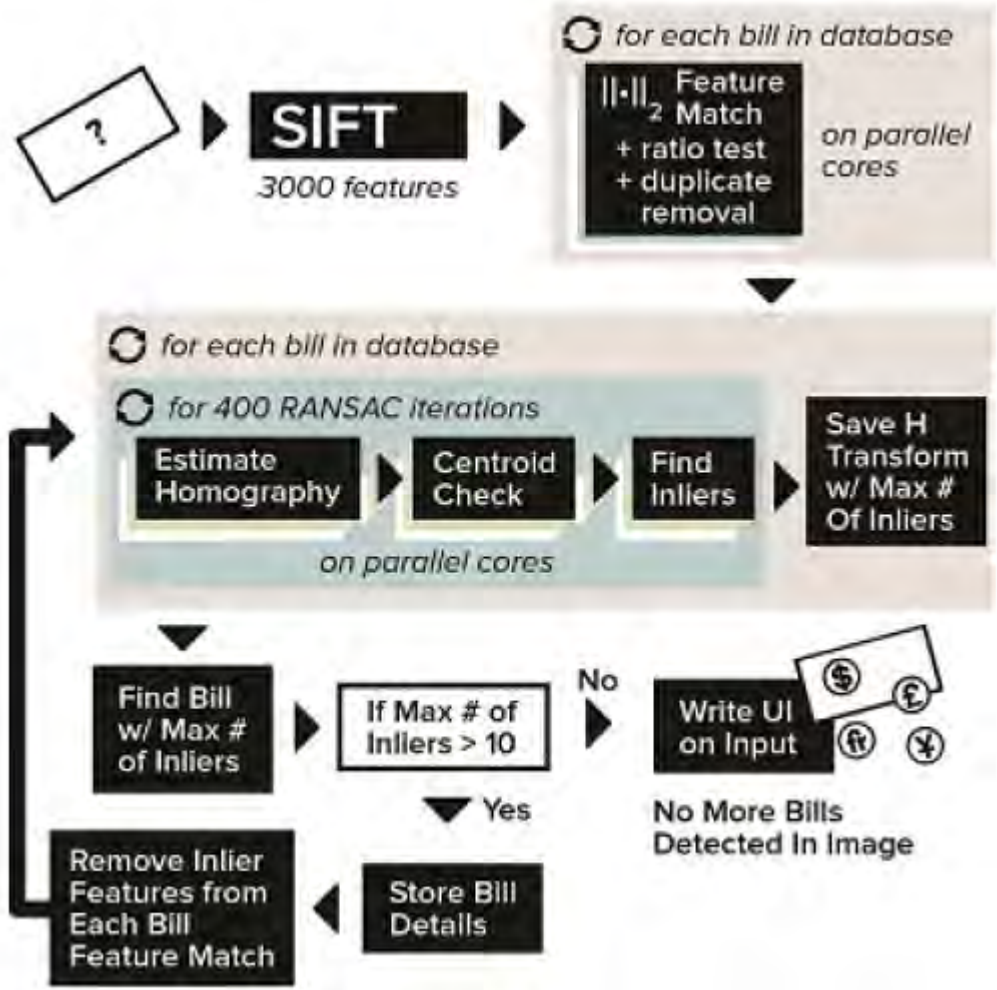
Draw on Top class: draw histograms on canvas




```
// Draw red rectangle
Rect rect = new Rect(
        left x, top y, right x, bottom y
);
myCanvas.drawRect( rect, myPaintRed );
```

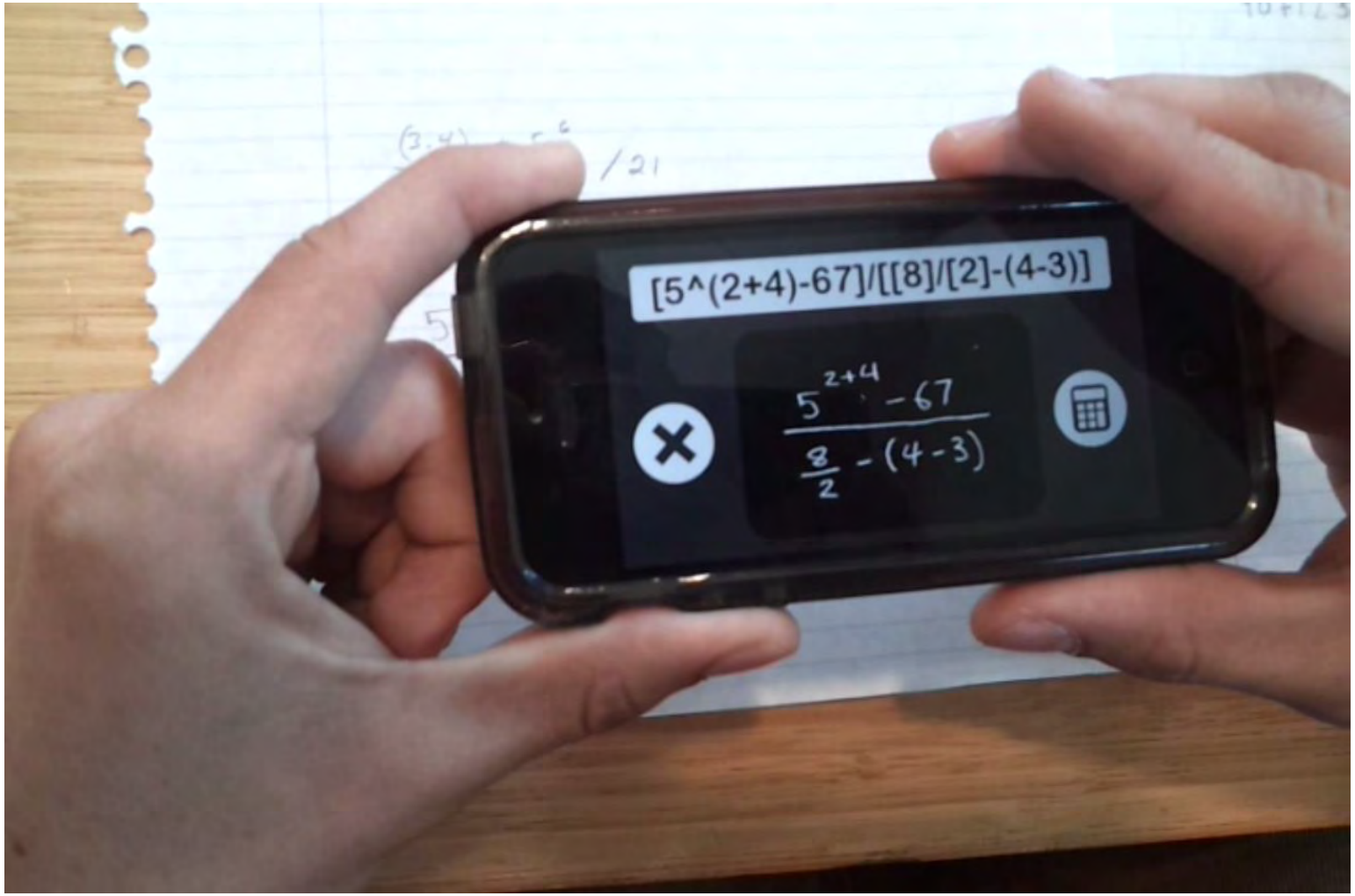
“Color Histograms” app running on device

Class project: Foreign bill detector and converter



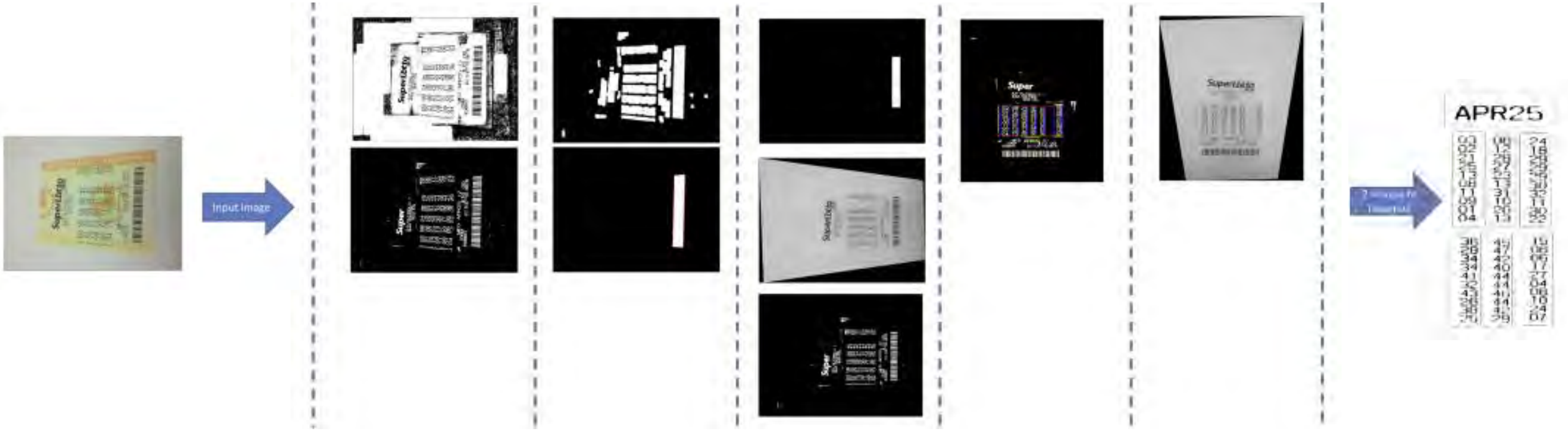
M. Digman and C. Elder, Spring 2013

Class project: Handwritten expression solver



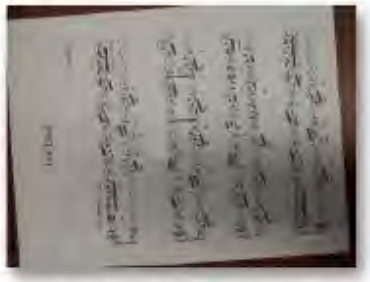
S. Harvey and W. Harvey, Spring 2013

Class project: Lottery ticket checker

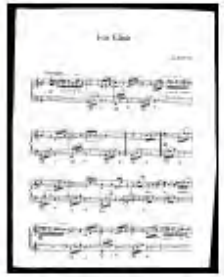


T. Zou and A. Gupta, Spring 2012

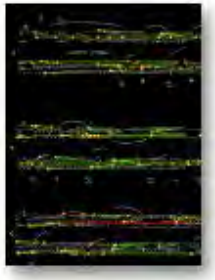
Class project: Optical music recognition and playback



Captured Image of music staff

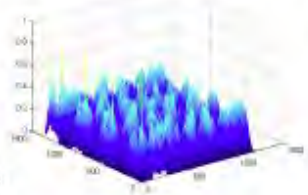


Upright Image after rotation



Horizontal Line Detection

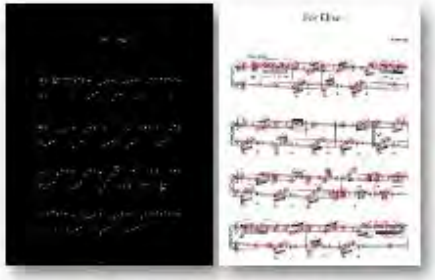
Clef Template



Clef Peak Detection

Matched Clefs

Top & Bottom Stave with red marks



Detected Note Heads

S. Dai, C.-W. Lee, Y. Tian, Spring 2012