Richard Ngo

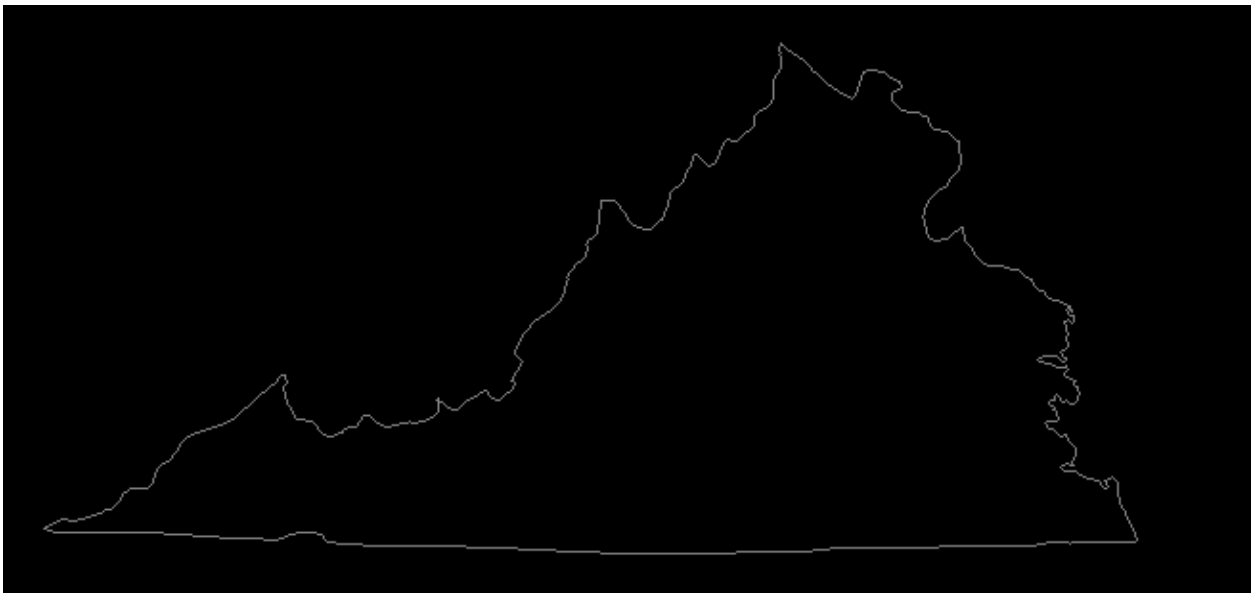
**Part 1**

**Initial Contour**

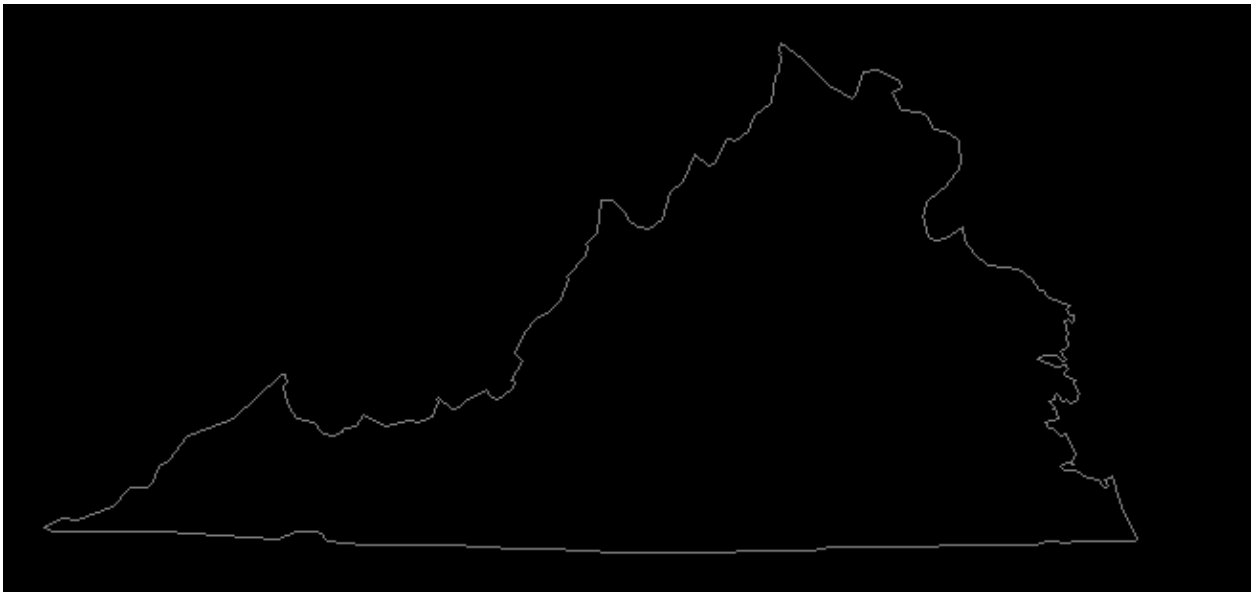
**Step 0 Contour**

Richard Ngo

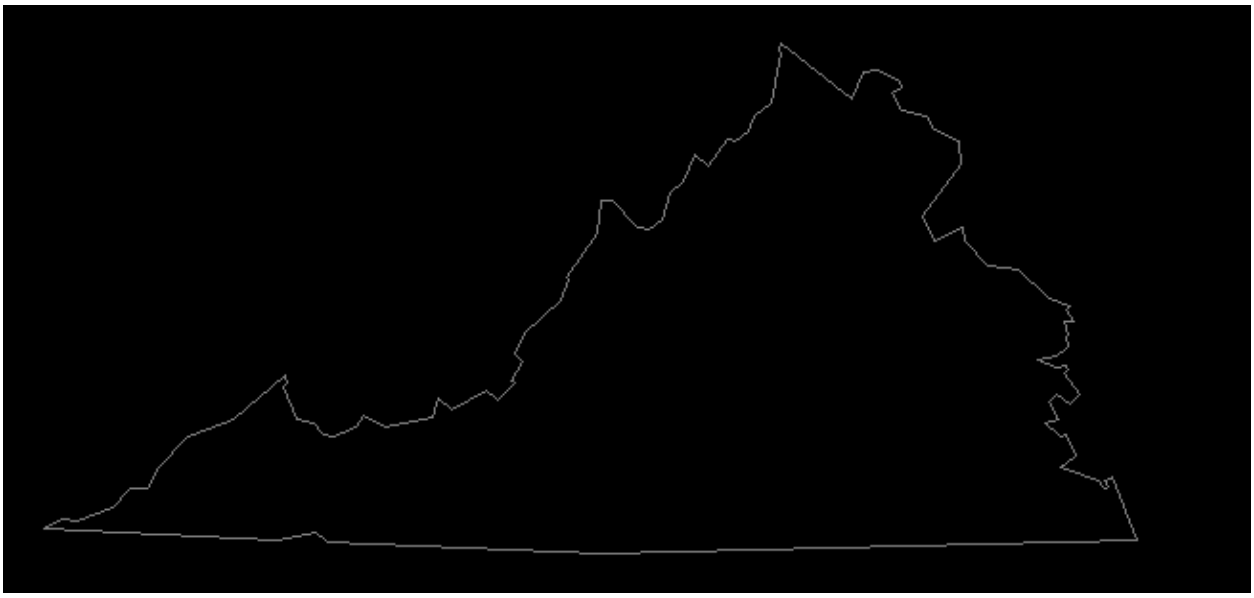
**Step 1 Contour**



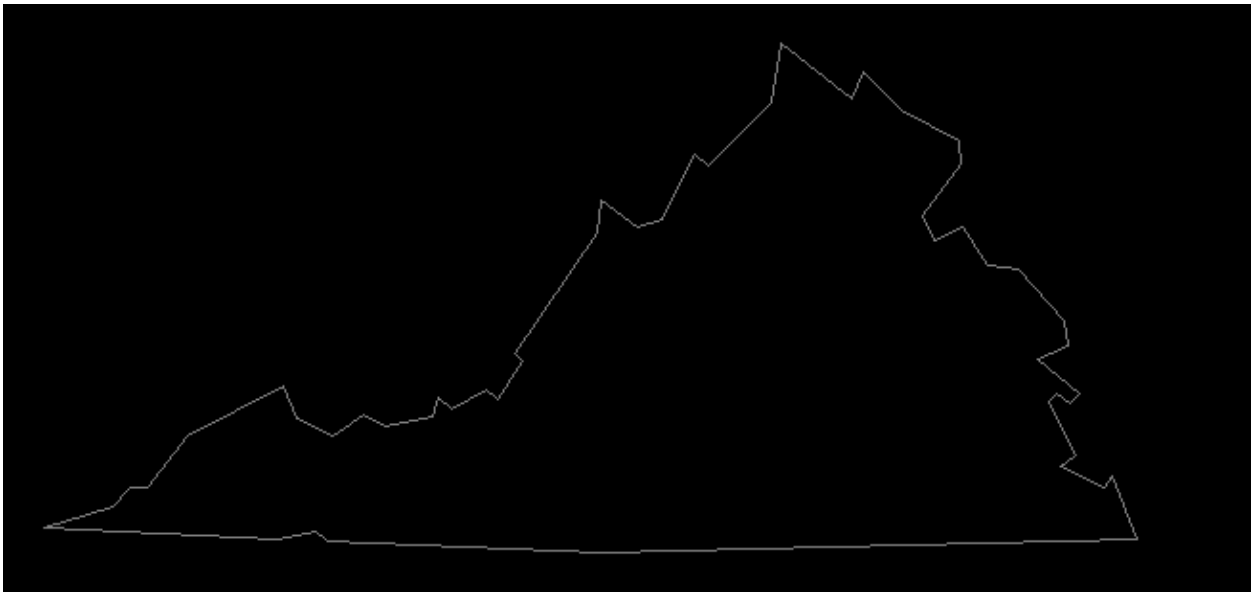
**Step 2 Contour**



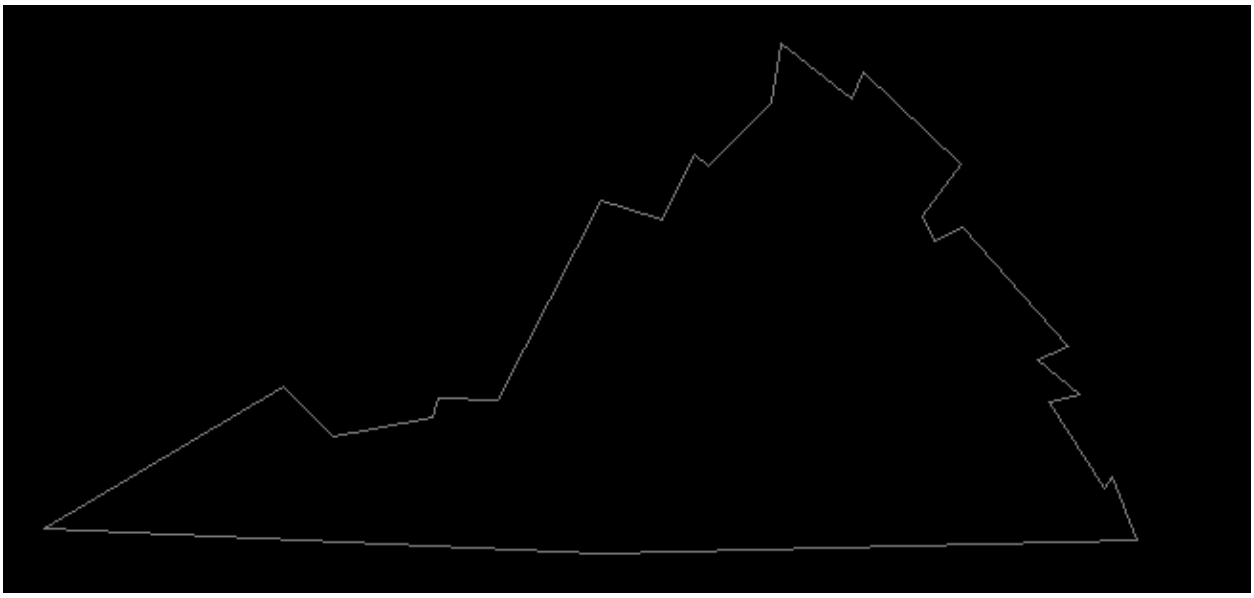
**Step 3 Contour**



**Step 4 Contour**



**Step 5 Contour**



```
Initial Significant Corners: 1612  Initial Gauss Area: 68298.0
Step: 0  Significant Corners: 806  Gauss Area: 68298.0
Step: 1  Significant Corners: 403  Gauss Area: 68296.0
Step: 2  Significant Corners: 202  Gauss Area: 68289.5
Step: 3  Significant Corners: 101  Gauss Area: 68196.5
Step: 4  Significant Corners: 51  Gauss Area: 67876.5
Step: 5  Significant Corners: 26  Gauss Area: 68323.0
```

**Code Used:**

```
# -*- coding: utf-8 -*-
"""
ECE5554 FA19 HW3 part 1.py - contours
Created on Fri Oct 25 10:34:24 2019
@author: crjones4
"""


# CompVisHw3_1.py - implemented Pavlidis contour Extraction
# Created on 11/12/19
# @Updated: Richard Ngo
import numpy as np
```

```
import cv2
import math
#pathName = "C:\\Data\\" # change this for your own file structure
pathName = ""
MAXCONTOUR = 5000
doLogging = False
def showImage(img, name):
 cv2.imshow(name, img)
 return
################################


def saveImage(img, name):
   cv2.imwrite(name + ".png", img)
   return
################################
def GaussArea(pts):
   area = 0
   for i in range(len(pts)):
      if(i==len(pts)-1):
         P1 = pts[i]
         P2 = pts[0]
      else:
         P1 = pts[i]
         P2 = pts[i+1]
      area +=(P1[0]*P2[1]-P1[1]*P2[0])/2
   return abs(area);
################################
def onePassDCE(ctrIn):
   Kmin = 0
```

```
imin = 0
for i in range(len(ctrIn)):
    if(i==0):
        P1 = ctrIn[len(ctrIn)-1]
        P2 = ctrIn[i]
        P3 = ctrIn[i+1]
        #print(P1,P2,P3)
    elif(i==len(ctrIn)-1):
        P1 = ctrIn[i-1]
        P2 = ctrIn[i]
        P3 = ctrIn[0]
    else:
        P1 = ctrIn[i-1]
        P2 = ctrIn[i]
        P3 = ctrIn[i+1]
        #print(P1,P2,P3)
    #print(range(len(ctrIn)))
   # print(P1[1],P2[1],P3[1])
   # print(P1[0],P2[0],P3[0])

    L1 = ((P2[1]-P1[1])**(2)+(P2[0]-P1[0])**(2))**(1/2)
    L2 = ((P3[1]-P2[1])**(2)+(P3[0]-P2[0])**(2))**(1/2)



    if((P2[0]-P1[0]) == 0):
        ang1 = (P2[1]-P1[1])/abs(P2[1]-P1[1])*math.pi/2
    else:
        ang1 = (P2[1]-P1[1])/(P2[0]-P1[0])
```

```
        if((P3[0]-P2[0]) == 0):
            ang2 = (P3[1]-P2[1])/abs(P3[1]-P2[1])*math.pi/2
        else:
            ang2 = (P3[1]-P2[1])/(P3[0]-P2[0])
        angD = math.atan(ang1)-math.atan(ang2)
        K = abs(angD*L1*L2/(L1+L2))
        if(K<Kmin or i==0):
            #print(K,i)
            Kmin = K
            imin = i
    trimmedContour = np.append(ctrIn[0:imin],ctrIn[imin+1:len(ctrIn)], axis=0)
    """
    contourImage = cv2.imread('VAoutline.png')
    for i in range(len(trimmedContour)):
      contourImage[trimmedContour[i,1],trimmedContour[i,0]] = [255,0,0]
    cv2.namedWindow('contour', flags=cv2.WINDOW_NORMAL)
    cv2.imshow('contour', contourImage)
    cv2.resizeWindow('contour', (int(len(contourImage[0])*2), int(len(contourImage)*2)))
    cv2.waitKey(0)
    cv2.destroyAllWindows()
    """
    return trimmedContour
################################
def Pavlidis(img, start):
    contourImage = cv2.imread('VAoutline.png')
    stuck = 0
    points = np.array([start])
    trace = np.array([start[0],start[1]])
    vert=1
```

```
  hor=0
  while 1:
    i = 0
    while i < 3:
      horP = hor
      vertP = vert
      #print(img[trace[1]+(0-1)*hor-1*vert,trace[0]+(0-1)*vert+1*hor], img[trace[1]+(1-1)*hor-
1*vert,trace[0]+(1-1)*vert+1*hor], img[trace[1]+(2-1)*hor-1*vert,trace[0]+(2-1)*vert+1*hor],
trace[1],trace[0], vert, hor, i)
      #if(img[trace[1]+(i-1)*hor-1*vert,trace[0]+(i-1)*vert+1*hor] != img[trace[1]-1*hor,trace[0]-
1*vert]):
      if(img[trace[1]+(i-1)*hor-1*vert,trace[0]+(i-1)*vert+1*hor] > 0):
        #print(trace[1],trace[0], vert, hor)
        stuck=0
        trace[1]+=(i-1)*hor-1*vert
        trace[0]+=(i-1)*vert+1*hor

        contourImage[trace[1],trace[0]] = [255,0,0]

        if(trace[0] == start[0] and trace[1] == start[1]):

          cv2.namedWindow('contour', flags=cv2.WINDOW_NORMAL)
          cv2.imshow('contour', contourImage)
          #print(points)
          cv2.waitKey(0)
          cv2.destroyAllWindows()

          return points
        points = np.append(points, [[trace[0],trace[1]]], axis=0)
        #hor = (i-1)*vertP+horP*(2-i)*(i)
```

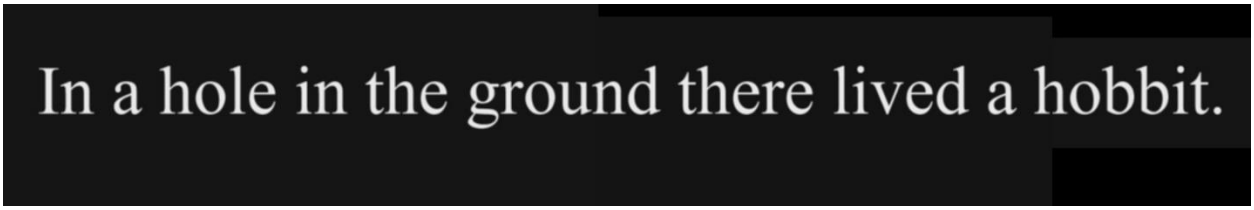
```
            #vert = -(i-1)*horP+vertP*(2-i)*(i)
            if(i!=2):
               hor = (i-1)*vertP+horP*i
               vert = -(i-1)*horP+vertP*i
            i=-1
         i+=1
      stuck = stuck+1
      if(stuck == 3):
         points = np.append(points, [[trace[0],trace[1]]], axis=0)
         return points
      hor = vertP
      vert = -horP
################################
def showContour(ctr, img, name):
   contourImage = img
   length = ctr.shape[0]
   for count in range(length):
      contourImage[ctr[count, 1], ctr[count, 0]] = 0
      cv2.line(contourImage,(ctr[count, 0], ctr[count, 1]), \
            (ctr[(count+1)%length, 0], ctr[(count+1)%length, 1]),(128,128,128),1)
   showImage(contourImage, name)
   saveImage(contourImage, name)
################################
inputImage = cv2.imread(pathName + 'VAoutline.png', cv2.IMREAD_GRAYSCALE)
thresh = 70;
binary = cv2.threshold(inputImage, thresh, 255, cv2.THRESH_BINARY)[1]
(height, width) = binary.shape
# find a start point
ystt = np.uint8(height/2) # look midway up the image
```

```
for xstt in range(width): # from the left
    if (binary[ystt, xstt] > 0):
        break
contour = Pavlidis(binary, [xstt, ystt])
showContour(contour, inputImage, "CONTOUR")
print("Initial Significant Corners:",contour.shape[0], " Initial Gauss Area:",GaussArea(contour))
for step in range(6):
    numLoops = math.floor(contour.shape[0]/2)
    for idx in range(numLoops):
        contour = onePassDCE(contour)
    showContour(contour, np.zeros_like(inputImage), "STEP"+str(step))
    print("Step:",step," Significant Corners:",contour.shape[0], " Gauss Area:",GaussArea(contour))
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Richard Ngo

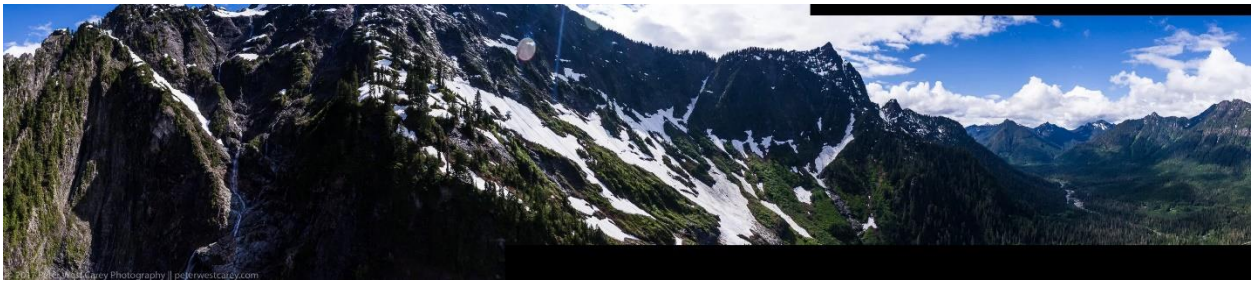
**Part 2**

**hobbit Aligned Images**




**Goodwin Aligned Images**

**BigFour Aligned Images**



**Code Used:**

```
# CompVisHw3_1.py - Updated Code example code listed in lecture notes for image alignment
# https://www.learnopencv.com/image-alignment-feature-based-using-opencv-c-python/
# Created on 11/12/19
```

```
# @Updated: Richard Ngo


from __future__ import print_function
import cv2
import numpy as np
MAX_FEATURES = 500
GOOD_MATCH_PERCENT = 0.015
################################################################
def showimg(img):
   cv2.namedWindow('showimg', flags=cv2.WINDOW_NORMAL)
   cv2.imshow('showimg', img)
   #cv2.resizeWindow('showimg', (int(len(img[0])*2), int(len(img)*2)))
   #print(img)
   cv2.waitKey(0)
   cv2.destroyAllWindows()
################################################################
def findMatches(im1, im2):
# Convert images to grayscale
   im1Gray = cv2.cvtColor(im1, cv2.COLOR_BGR2GRAY)
   im2Gray = cv2.cvtColor(im2, cv2.COLOR_BGR2GRAY)
   # Detect ORB features and compute descriptors.
   orb = cv2.ORB_create(MAX_FEATURES)
   keypoints1, descriptors1 = orb.detectAndCompute(im1Gray, None)
   keypoints2, descriptors2 = orb.detectAndCompute(im2Gray, None)
   # Match features.
   matcher = cv2.DescriptorMatcher_create(cv2.DESCRIPTOR_MATCHER_BRUTEFORCE_HAMMING)
   matches = matcher.match(descriptors1, descriptors2, None)
   # Sort matches by score
   matches.sort(key=lambda x: x.distance, reverse=False)
```

```
    # Remove not so good matches
    numGoodMatches = int(len(matches) * GOOD_MATCH_PERCENT)
    matches = matches[:numGoodMatches]
    # Draw top matches
    imMatches = cv2.drawMatches(im1, keypoints1, im2, keypoints2, matches, None)
    cv2.imwrite("matches.jpg", imMatches)
    # Extract location of good matches
    points1 = np.zeros((len(matches), 2), dtype=np.float32)
    points2 = np.zeros((len(matches), 2), dtype=np.float32)
    for i, match in enumerate(matches):
        points1[i, :] = keypoints1[match.queryIdx].pt
        points2[i, :] = keypoints2[match.trainIdx].pt
    return points1, points2, matches[len(matches)-1].distance
################################################################
def combineImages(points1, points2, im1,im2):
     # Find homography
    h, mask = cv2.findHomography(points1, points2, cv2.RANSAC)
    print("here")
    print(h)
    # Use homography
    height1, width1, channels1 = im1.shape
    height2, width2, channels2 = im2.shape
    if(h[0,2]<=0):
        h1 = np.copy(h)
        h1[0,2] = 0
        h2=np.identity(3)
        h2[0,2]=-h[0,2]
        width = width2
    else:
```

```
        h1 = np.copy(h)
        h2=np.identity(3)
        width = width1
    part1 = cv2.warpPerspective(im1, h1, (width+int(round(abs(h[0,2])))),
height2))#width+math.ceil(h2[0,2])
    part2 = cv2.warpPerspective(im2, h2, (width+int(round(abs(h[0,2])))), height2))
    #showimg(part1)
    #showimg(part2)
    #imReg = np.zeros(shape=(height,width))
    """
    if(h1[0,2]==0):
        #imReg[:math.floor(h2[0,2])] = part1[:math.floor(h2[0,2])]
        imReg=part1
        imReg[:,int(round(h2[0,2])):,:] = part2[:,int(round(h2[0,2])):,:]
    else:
        #imReg[:math.floor(h1[0,2])] = part2[:math.floor(h1[0,2])]
        imReg=part2
        imReg[:,int(round(h1[0,2])):,:] = part1[:,int(round(h1[0,2])):,:]
    """
    """
    if(h1[0,2]==0):
        #imReg[:math.floor(h2[0,2])] = part1[:math.floor(h2[0,2])]
        imReg=part1
        imReg[part2>0] = part2[part2>0]
    else:
        #imReg[:math.floor(h1[0,2])] = part2[:math.floor(h1[0,2])]
        imReg=part2
        imReg[part1>0] = part1[part1>0]
    """
```

```
    imReg=part1
    imReg[part2>0] = part2[part2>0]
    #showimg(imReg)
    return imReg, h
#############################################################
def alignImages(im1in, im2in, im3in):
    #sorter = [im1in,im2in,im3in]
    #sorter.sort(key=lambda x: len(x), reverse=True)
    #[im1, im2, im3] = sorter

    points12, points21, MD12 = findMatches(im1in,im2in)
    points13, points31, MD13 = findMatches(im1in,im3in)

    points21, points12, MD21 = findMatches(im2in,im1in)
    points23, points32, MD23 = findMatches(im2in,im3in)

    points31, points13, MD31 = findMatches(im3in,im1in)
    points32, points23, MD32 = findMatches(im3in,im2in)

    compad = [MD12+MD13,MD21+MD23,MD31+MD32]
    center = compad.index(min(compad))

    if(center == 0):
        if(MD12<MD13):
            [im1,im2,im3]=[im2in,im1in,im3in]
            [points1,points2] = [points21, points12]
        else:
            [im1,im2,im3]=[im3in,im1in,im2in]
            [points1,points2] = [points31, points13]
```

```
elif(center == 1):
    if(MD21<MD23):
        [im1,im2,im3]=[im1in,im2in,im3in]
        [points1,points2] = [points12, points21]
    else:
        [im1,im2,im3]=[im3in,im2in,im1in]
        [points1,points2] = [points32, points23]
else:
    if(MD31<MD32):
        [im1,im2,im3]=[im1in,im3in,im2in]
        [points1,points2] = [points13, points31]
    else:
        [im1,im2,im3]=[im2in,im3in,im1in]
        [points1,points2] = [points23, points32]
#[im1,im2]=[np.copy(im2),np.copy(im1)]
#[points1,points2]=[np.copy(points2),np.copy(points1)]
#[im1,im3]=[np.copy(im3),np.copy(im1)]
#points1, points2, matches = findMatches(im1,im2)
"""
print(matches2[len(matches2)-1].distance, len(matches2))
print("here")
print(matches3[len(matches3)-1].distance, len(matches3))
if(matches2[len(matches2)-1].distance<=matches3[len(matches3)-1].distance):
"""
halfReg, h1= combineImages(points1, points2,im1,im2)
points1, points2, matches3 = findMatches(halfReg,im3)
fullReg, h2 = combineImages(points1, points2,halfReg,im3)
"""
else:
```

```
    halfReg, h1 = combineImages(points13, points31,im1,im3)
    points1, points2, matches2 = findMatches(halfReg,im2)
    fullReg, h2 = combineImages(points1, points2,halfReg,im2)
    """
  #showimg(fullReg[:,:(width1+width2+width3-abs(math.floor(h1[0,2]))-abs(math.floor(h2[0,2]))),:])
  return fullReg, h1, h2
################################################################
if __name__ == '__main__':
  # # Read images to be aligned
  ImgNames = ["hobbit","goodwin","BigFour"]
  for I in ImgNames:
    im1R = I+"0.png"
    im2R = I+"1.png"
    im3R = I+"2.png"
    print("Reading ", im1R)
    im1 = cv2.imread(im1R, cv2.IMREAD_COLOR)
    print("Reading ", im2R)
    im2 = cv2.imread(im2R, cv2.IMREAD_COLOR)
    print("Reading ", im3R)
    im3 = cv2.imread(im3R, cv2.IMREAD_COLOR)

    print("Aligning images ...")
    # Registered image will be resotred in imReg.
    # The estimated homography will be stored in h.
    imReg, h1, h2 = alignImages(im1, im2, im3)
    # Write aligned image to disk.
    outFilename = I+"_aligned.jpg"
    print("Saving aligned image : ", outFilename);
    cv2.imwrite(outFilename, imReg)
```

```
# Print estimated homography
print("Estimated homographies for: "+I+"\n", h1)
print(h2)
```