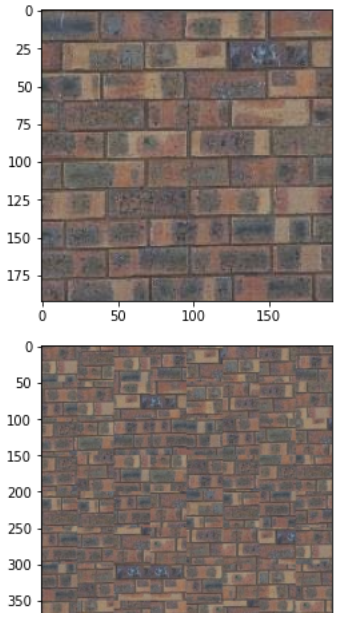
```
import cv2
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import os
from random import random
import time
import random

import utils


from utils import cut # default cut function for seam finding section
```

Part I: Randomly Sampled Texture (10 pts)

```
def quilt_random(sample, out_size, patch_size):
    """
    Randomly samples square patches of size patchsize from sample in order to create an output image of size outsize.

    :param sample: numpy.ndarray   The image you read from sample directory
    :param out_size: int            The width of the square output image
    :param patch_size: int          The width of the square sample patch
    :return: numpy.ndarray
    """
    output = np.zeros((out_size,out_size, sample.shape[2]), np.uint32)
    row = 0
    col = 0

    while (row + patch_size) <= out_size:
      col = 0
      while (col + patch_size) <= out_size:
        rand_row = random.randrange(0, sample.shape[0]-patch_size)
        rand_col = random.randrange(0, sample.shape[0]-patch_size)
        output[row:(row + patch_size), col:(col + patch_size)] =  sample[rand_row:(rand_row + patch_size), rand_col:(rand_col + patch_size)]
        col += patch_size
      row += patch_size
    return output
```

```
sample_img_fn = 'bricks_small.jpg' # feel free to change
sample_img = cv2.cvtColor(cv2.imread(sample_img_fn), cv2.COLOR_BGR2RGB)
plt.imshow(sample_img)
plt.show()
out_size = 400  # change these parameters as needed
patch_size = 50
res = quilt_random(sample_img, out_size, patch_size)
if res is not None:
    plt.imshow(res)
```

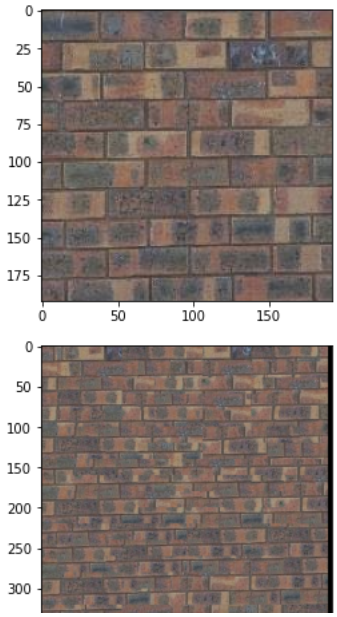


Part II: Overlapping Patches (30 pts)

```
def ssd_patch(template, mask, image):
  """
  """
  b,g,r = cv2.split(image/255)
  b_template, g_template,r_template = cv2.split(template)

  ssd_costb = ((mask*b_template)**2).sum() - 2 * cv2.filter2D(b, ddepth=-1, kernel = mask*b_template) + cv2.filter2D(b**2, ddepth=-1, kernel=
  ssd_costg = ((mask*g_template)**2).sum() - 2 * cv2.filter2D(g, ddepth=-1, kernel = mask*g_template) + cv2.filter2D(g**2, ddepth=-1, kernel=
  ssd_costr = ((mask*r_template)**2).sum() - 2 * cv2.filter2D(r, ddepth=-1, kernel = mask*r_template) + cv2.filter2D(r**2, ddepth=-1, kernel=
  total_cost = ssd_costb + ssd_costg + ssd_costr
  return total_cost

def quilt_simple(sample, out_size, patch_size, overlap, tol):
    """
    Randomly samples square patches of size patchsize from sample in order to create an output image of size outsize.
    Feel free to add function parameters
    :param sample: numpy.ndarray
    :param out_size: int
    :param patch_size: int
    :param overlap: int
    :param tol: float
    :return: numpy.ndarray
    """
    #randomly sample and fill in upper left part of the image:
    output = np.zeros((out_size, out_size, sample.shape[2]), np.float32)
    rand_row = random.randrange(0, sample.shape[0]-patch_size)
    rand_col = random.randrange(0, sample.shape[0]-patch_size)
    output[0:patch_size, 0:patch_size] =  sample[rand_row:(rand_row + patch_size), rand_col:(rand_col+patch_size)]/255

    horizontal_mask = np.zeros((patch_size,patch_size), np.float32)
    vertical_mask = np.zeros((patch_size,patch_size),np.float32)
    mask = np.zeros((patch_size,patch_size),np.float32)

    #create each type of mask:
    for row in horizontal_mask:
      row[0:overlap] = 1
    vertical_mask[0:overlap][:] = 1
    for row in mask:
      row[0:overlap] = 1
    mask[0:overlap][:] = 1

    row = 0
    half_patch = int(patch_size/2)
    col = patch_size - overlap
    while ((row + patch_size) <= out_size):
      while ((col + patch_size) <= out_size):
        template = output[row:(row + patch_size), col:(col + patch_size)]
```

```
        if (row == 0): #only overlap horizontally
          row_patch, col_patch = choose_sample(ssd_patch(template, horizontal_mask, sample), tol, patch_size)
        elif (col == 0): #only overlap vertically
          row_patch, col_patch = choose_sample(ssd_patch(template, vertical_mask, sample), tol, patch_size)
        else: #overlap horizontally and vertically
          row_patch, col_patch = choose_sample(ssd_patch(template, mask, sample), tol, patch_size)
        output[row:(row + patch_size), col:(col + patch_size)] = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-half_
        col += (patch_size - overlap)
      col = 0
      row += (patch_size - overlap)
    return output


def choose_sample(cost_image, tol, patch_size):
  """
    Finds the patch with the lowest cost
    :param cost_image: image where each pixel holds a cost
    :param tol: tells how many of the lowest cost patches to randomly choose from
    :param patch_size, int
  """
  rows = []
  cols = []
  height = cost_image.shape[0] - patch_size
  width = cost_image.shape[1] - patch_size
  image = cost_image[patch_size:height, patch_size:width]
  sorted_costs = sorted(image.flatten())
  sorted_costs = sorted_costs[0:tol]
  for row in range(0, cost_image.shape[0]):
    for col in range(0, cost_image.shape[1]):
      if (cost_image[row][col] in sorted_costs):
        rows.append(row)
        cols.append(col)
      if (len(rows) == tol):
        break
  choose =  random.randrange(0, len(rows))
  return rows[choose], cols[choose]
```

```
sample_img_fn = 'bricks_small.jpg'
sample_img = cv2.cvtColor(cv2.imread(sample_img_fn), cv2.COLOR_BGR2RGB)
plt.imshow(sample_img)
plt.show()

out_size = 360  # change these parameters as needed
patch_size = 35
overlap = 15
tol = 3
res = quilt_simple(sample_img, out_size, patch_size, overlap, tol) #feel free to change parameters to get best results
if res is not None:
    plt.imshow(res)
```



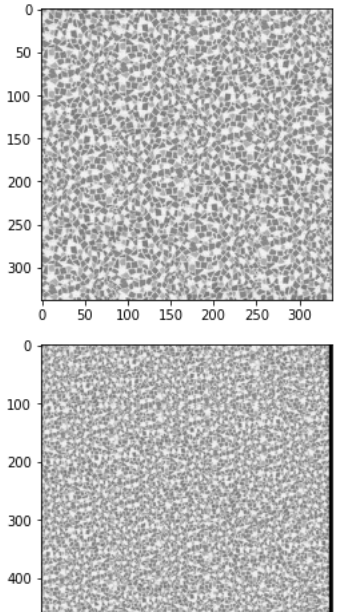
Part III: Seam Finding (20 pts)

```
# optional or use cut(err_patch) directly
def customized_cut(bndcost):
    pass


def quilt_cut(sample, out_size, patch_size, overlap, tol):
    """
    Samples square patches of size patchsize from sample using seam finding in order to create an output image of size outsize.
    Feel free to add function parameters
    :param sample: numpy.ndarray
    :param out_size: int
    :param patch_size: int
    :param overlap: int
    :param tol: float
    :return: numpy.ndarray
    """
    #randomly sample and fill in upper left part of the image:
    output = np.zeros((out_size, out_size, sample.shape[2]), np.float32)
    rand_row = random.randrange(0, sample.shape[0]-patch_size)
    rand_col = random.randrange(0, sample.shape[0]-patch_size)
    output[0:patch_size, 0:patch_size] =  sample[rand_row:(rand_row + patch_size), rand_col:(rand_col+patch_size)]/255

    horizontal_mask = np.zeros((patch_size,patch_size), np.float32)
    vertical_mask = np.zeros((patch_size,patch_size),np.float32)
    mask = np.zeros((patch_size,patch_size),np.float32)

    #create each type of mask:
    for row in horizontal_mask:
      row[0:overlap] = 1
    vertical_mask[0:overlap][:] = 1
    for row in mask:
      row[0:overlap] = 1
    mask[0:overlap][:] = 1

    row = 0
    half_patch = int(patch_size/2)
    col = patch_size - overlap

    while ((row + patch_size) <= out_size):
      while ((col + patch_size) <= out_size):
        template = output[row:(row + patch_size), col:(col + patch_size)]
        if (row == 0): #only overlap horizontally
          row_patch, col_patch = choose_sample(ssd_patch(template, horizontal_mask, sample), tol, patch_size)
          sample_overlap = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-half_patch):(col_patch - half_patch + overl
          output_overlap = output[row:(row + patch_size), (col):(col+overlap)]
          err_patch = ((output_overlap - sample_overlap)**2).sum(axis=-1).T

          overlap_mask = utils.cut(err_patch).T
          inv_overlap_mask = np.where(overlap_mask == 0, 1, 0)

          # plt.figure()
          # plt.imshow(output_overlap)

          # plt.figure()
          # plt.imshow(sample_overlap)

          # plt.figure()
          # plt.imshow(err_patch)

          # plt.figure()
          # plt.imshow(overlap_mask)

          # plt.figure()
          # plt.imshow(horizontal_mask)

          # plt.figure()
          # plt.imshow(vertical_mask)

          # plt.figure()
          # plt.imshow(mask)

          o_b, o_g, o_r = cv2.split(output_overlap)
          s_b, s_g, s_r = cv2.split(sample_overlap)
```

```
  o_b = o_b * inv_overlap_mask
  o_g = o_g  * inv_overlap_mask
  o_r = o_r * inv_overlap_mask
  output_overlap = cv2.merge((o_b,o_g,o_r))

  s_b = s_b * overlap_mask
  s_g = s_g * overlap_mask
  s_r = s_r * overlap_mask
  sample_overlap = cv2.merge((s_b,s_g,s_r))

  output[row:(row + patch_size), col:(col + patch_size)] = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-hal
  output[row:(row + patch_size), col:(col + overlap)] = output_overlap + sample_overlap

elif (col == 0): #only overlap vertically
  row_patch, col_patch = choose_sample(ssd_patch(template, vertical_mask, sample), tol, patch_size)
  sample_overlap = sample[(row_patch-half_patch):(row_patch-half_patch+overlap), (col_patch - half_patch):(col_patch + half_patch + 1
  output_overlap = output[(row):(row + overlap), col:(col + patch_size)]
  err_patch = ((output_overlap - sample_overlap)**2).sum(axis=-1)
  overlap_mask = utils.cut(err_patch)
  inv_overlap_mask = np.where(overlap_mask == 0, 1, 0)

  o_b, o_g, o_r = cv2.split(output_overlap)
  s_b, s_g, s_r = cv2.split(sample_overlap)

  o_b = o_b * inv_overlap_mask
  o_g = o_g  * inv_overlap_mask
  o_r = o_r * inv_overlap_mask
  output_overlap = cv2.merge((o_b,o_g,o_r))

  s_b = s_b * overlap_mask
  s_g = s_g * overlap_mask
  s_r = s_r * overlap_mask
  sample_overlap = cv2.merge((s_b,s_g,s_r))

  output[row:(row + patch_size), col:(col + patch_size)] = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-hal
  output[row:(row+overlap), col:(col+patch_size)] = output_overlap + sample_overlap

else: #overlap horizontally and vertically
  row_patch, col_patch = choose_sample(ssd_patch(template, horizontal_mask, sample), tol, patch_size)
  sample_overlap_vert = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-half_patch):(col_patch - half_patch + 
  output_overlap_vert = output[row:(row + patch_size), (col):(col+overlap)]
  err_patch_vert = ((output_overlap_vert - sample_overlap_vert)**2).sum(axis=-1).T
  vertical_seam = utils.cut(err_patch_vert).T

  sample_overlap_horiz = sample[(row_patch-half_patch):(row_patch-half_patch+overlap), (col_patch - half_patch):(col_patch + half_pat
  output_overlap_horiz = output[(row):(row + overlap), col:(col + patch_size)]
  err_patch_horiz = ((output_overlap - sample_overlap)**2).sum(axis=-1)
  horizontal_seam = utils.cut(err_patch_horiz)

  combined_mask = np.logical_and(horizontal_seam[0:overlap, 0:overlap], vertical_seam[0:overlap, 0:overlap])
  inv_combined_mask = np.where(combined_mask == 0, 1, 0)

  inv_vertical_seam = np.where(vertical_seam == 0, 1, 0)
  inv_horiz_seam = np.where(horizontal_seam == 0, 1, 0)

  ov_b, ov_g, ov_r = cv2.split(output_overlap_vert)
  sv_b, sv_g, sv_r = cv2.split(sample_overlap_vert)

  oh_b, oh_g, oh_r = cv2.split(output_overlap_horiz)
  sh_b, sh_g, sh_r = cv2.split(sample_overlap_horiz)

  #Upper left hand corner of overlap
  ov_b[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]
  ov_g[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]
  ov_r[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]

  oh_b[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]
  oh_g[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]
  oh_r[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]

  #Left vertical overlap
  ov_b[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]
  ov_g[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]
  ov_r[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]

  sv_b[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]
```

```
            sv_g[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]
            sv_r[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]


            #Upper horizontal overlap
            oh_b[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]
            oh_g[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]
            oh_r[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]

            sh_b[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]
            sh_g[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]
            sh_r[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]

            #Combine everything back together
            combined_vert = cv2.merge((ov_b[(0):(overlap),(0):(overlap)],ov_g[(0):(overlap),(0):(overlap)],ov_r[(0):(overlap),(0):(overlap)]))
            combined_horiz = cv2.merge((oh_b[(0):(overlap),(0):(overlap)],oh_g[(0):(overlap),(0):(overlap)],oh_r[(0):(overlap),(0):(overlap)]))

            output_overlap_vertf = cv2.merge((ov_b[(overlap):(patch_size),(0):(overlap)],ov_g[(overlap):(patch_size),(0):(overlap)],ov_r[(overl
            sample_overlap_vertf = cv2.merge((sv_b[(overlap):(patch_size),(0):(overlap)],sv_g[(overlap):(patch_size),(0):(overlap)],sv_r[(overl

            output_overlap_horizf = cv2.merge((oh_b[(0):(overlap),(overlap):(patch_size)],oh_g[(0):(overlap),(overlap):(patch_size)],oh_r[(0):(
            sample_overlap_horizf = cv2.merge((sh_b[(0):(overlap),(overlap):(patch_size)],sh_g[(0):(overlap),(overlap):(patch_size)],sh_r[(0):(

            #Put everything into output image
            output[(row+overlap):(row + patch_size), (col+overlap):(col + patch_size)] = sample[(row_patch-half_patch +overlap):(row_patch + ha
            output[row:(row+overlap), (col + overlap):(col+patch_size)] = output_overlap_horizf + sample_overlap_horizf
            output[(row + overlap):(row + patch_size), col:(col + overlap)] = output_overlap_vertf + sample_overlap_vertf
            output[row:(row+overlap), col:(col+overlap)] = combined_vert + combined_horiz

          col += (patch_size - overlap)

        col = 0
        row += (patch_size - overlap)

      return output

def ssd_patch(template, mask, image):
  """
  """
  b,g,r = cv2.split(image/255)
  b_template, g_template,r_template = cv2.split(template)

  ssd_costb = ((mask*b_template)**2).sum() - 2 * cv2.filter2D(b, ddepth=-1, kernel = mask*b_template) + cv2.filter2D(b**2, ddepth=-1, kernel=
  ssd_costg = ((mask*g_template)**2).sum() - 2 * cv2.filter2D(g, ddepth=-1, kernel = mask*g_template) + cv2.filter2D(g**2, ddepth=-1, kernel=
  ssd_costr = ((mask*r_template)**2).sum() - 2 * cv2.filter2D(r, ddepth=-1, kernel = mask*r_template) + cv2.filter2D(r**2, ddepth=-1, kernel=
  total_cost = ssd_costb + ssd_costg + ssd_costr

  return total_cost

def choose_sample(cost_image, tol, patch_size):
  """
    Finds the patch with the lowest cost
    :param cost_image: image where each pixel holds a cost
    :param tol: tells how many of the lowest cost patches to randomly choose from
    :param patch_size, int
  """
  rows = []
  cols = []
  height = cost_image.shape[0] - patch_size
  width = cost_image.shape[1] - patch_size
  image = cost_image[patch_size:height, patch_size:width]
  sorted_costs = sorted(image.flatten())
  sorted_costs = sorted_costs[0:tol]
  for row in range(0, cost_image.shape[0]):
    for col in range(0, cost_image.shape[1]):
      if (cost_image[row][col] in sorted_costs):
        rows.append(row)
        cols.append(col)
      if (len(rows) == tol):
        break
  choose =  random.randrange(0, len(rows))
  return rows[choose], cols[choose]

sample_img_fn = 'floor_texture.jfif'
sample_img = cv2.cvtColor(cv2.imread(sample_img_fn), cv2.COLOR_BGR2RGB)
plt.imshow(sample_img)
plt.show()
```

```
out_size = 500  # change these parameters as needed
patch_size = 35
overlap = 15
tol = 3
res = quilt_cut(sample_img, out_size, patch_size, overlap, tol)
if res is not None:
    # plt.figure(figsize=(8, 8))
    plt.figure()
    plt.imshow(res)
```



part IV: Texture Transfer (30 pts)

```
def texture_transfer(sample, patch_size, overlap, tol, guidance_im, alpha):
    """
    Samples square patches of size patchsize from sample using seam finding in order to create an output image of size outsize.
    Feel free to modify function parameters
    :param sample: numpy.ndarray
    :param patch_size: int
    :param overlap: int
    :param tol: float
    :param guidance_im: target overall appearance for the output
    :param alpha: float 0-1 for strength of target
    :return: numpy.ndarray
    """
    output = np.zeros((guidance_im.shape[0], guidance_im.shape[1], sample.shape[2]), np.float32)
    rand_row = random.randrange(0, guidance_im.shape[0]-patch_size)
    rand_col = random.randrange(0, guidance_im.shape[1]-patch_size)
    output[0:patch_size, 0:patch_size] =  sample[rand_row:(rand_row + patch_size), rand_col:(rand_col+patch_size)]/255

    horizontal_mask = np.zeros((patch_size,patch_size), np.float32)
    vertical_mask = np.zeros((patch_size,patch_size),np.float32)
    mask = np.zeros((patch_size,patch_size),np.float32)

    #create each type of mask:
    for row in horizontal_mask:
      row[0:overlap] = 1
    vertical_mask[0:overlap][:] = 1
    for row in mask:
```

```
  row[0:overlap] = 1
mask[0:overlap][:] = 1

row = 0
half_patch = int(patch_size/2)
col = patch_size - overlap

while ((row + patch_size) <= guidance_im.shape[0]):
  while ((col + patch_size) <= guidance_im.shape[1]):
    template = output[row:(row + patch_size), col:(col + patch_size)]
    if (row == 0): #only overlap horizontally
      row_patch, col_patch = choose_sample(ssd_patch(template, horizontal_mask, sample, guidance_im[row:(row + patch_size), col:(col + pa
      sample_overlap = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-half_patch):(col_patch - half_patch + overl
      output_overlap = output[row:(row + patch_size), (col):(col+overlap)]
      err_patch = ((output_overlap - sample_overlap)**2).sum(axis=-1).T
      overlap_mask = utils.cut(err_patch).T
      inv_overlap_mask = np.where(overlap_mask == 0, 1, 0)

      o_b, o_g, o_r = cv2.split(output_overlap)
      s_b, s_g, s_r = cv2.split(sample_overlap)

      o_b = o_b * inv_overlap_mask
      o_g = o_g  * inv_overlap_mask
      o_r = o_r * inv_overlap_mask
      output_overlap = cv2.merge((o_b,o_g,o_r))

      s_b = s_b * overlap_mask
      s_g = s_g * overlap_mask
      s_r = s_r * overlap_mask
      sample_overlap = cv2.merge((s_b,s_g,s_r))

      output[row:(row + patch_size), col:(col + patch_size)] = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-hal
      output[row:(row + patch_size), col:(col + overlap)] = output_overlap + sample_overlap

    elif (col == 0): #only overlap vertically
      row_patch, col_patch = choose_sample(ssd_patch(template, vertical_mask, sample, guidance_im[row:(row + patch_size), col:(col + patc
      sample_overlap = sample[(row_patch-half_patch):(row_patch-half_patch+overlap), (col_patch - half_patch):(col_patch + half_patch + 1
      output_overlap = output[(row):(row + overlap), col:(col + patch_size)]
      err_patch = ((output_overlap - sample_overlap)**2).sum(axis=-1)
      overlap_mask = utils.cut(err_patch)
      inv_overlap_mask = np.where(overlap_mask == 0, 1, 0)

      o_b, o_g, o_r = cv2.split(output_overlap)
      s_b, s_g, s_r = cv2.split(sample_overlap)

      o_b = o_b * inv_overlap_mask
      o_g = o_g  * inv_overlap_mask
      o_r = o_r * inv_overlap_mask
      output_overlap = cv2.merge((o_b,o_g,o_r))

      s_b = s_b * overlap_mask
      s_g = s_g * overlap_mask
      s_r = s_r * overlap_mask
      sample_overlap = cv2.merge((s_b,s_g,s_r))

      output[row:(row + patch_size), col:(col + patch_size)] = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-hal
      output[row:(row+overlap), col:(col+patch_size)] = output_overlap + sample_overlap

    else: #overlap horizontally and vertically
      row_patch, col_patch = choose_sample(ssd_patch(template, horizontal_mask, sample, guidance_im[row:(row + patch_size), col:(col + pa
      sample_overlap_vert = sample[(row_patch-half_patch):(row_patch + half_patch + 1), (col_patch-half_patch):(col_patch - half_patch + 
      output_overlap_vert = output[row:(row + patch_size), (col):(col+overlap)]
      err_patch_vert = ((output_overlap_vert - sample_overlap_vert)**2).sum(axis=-1).T
      vertical_seam = utils.cut(err_patch_vert).T

      sample_overlap_horiz = sample[(row_patch-half_patch):(row_patch-half_patch+overlap), (col_patch - half_patch):(col_patch + half_pat
      output_overlap_horiz = output[(row):(row + overlap), col:(col + patch_size)]
      err_patch_horiz = ((output_overlap - sample_overlap)**2).sum(axis=-1)
      horizontal_seam = utils.cut(err_patch_horiz)

      combined_mask = np.logical_and(horizontal_seam[0:overlap, 0:overlap], vertical_seam[0:overlap, 0:overlap])
      inv_combined_mask = np.where(combined_mask == 0, 1, 0)

      inv_vertical_seam = np.where(vertical_seam == 0, 1, 0)
      inv_horiz_seam = np.where(horizontal_seam == 0, 1, 0)

      ov_b, ov_g, ov_r = cv2.split(output_overlap_vert)
```

```
            sv_b, sv_g, sv_r = cv2.split(sample_overlap_vert)

            oh_b, oh_g, oh_r = cv2.split(output_overlap_horiz)
            sh_b, sh_g, sh_r = cv2.split(sample_overlap_horiz)

            #Upper left hand corner of overlap
            ov_b[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]
            ov_g[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]
            ov_r[(0):(overlap),(0):(overlap)] *=  inv_combined_mask[0:(overlap), 0:(overlap)]

            oh_b[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]
            oh_g[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]
            oh_r[(0):(overlap),(0):(overlap)] *=  combined_mask[0:(overlap), 0:(overlap)]

            #Left vertical overlap
            ov_b[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]
            ov_g[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]
            ov_r[(overlap):(patch_size),(0):(overlap)] *=  inv_vertical_seam[(overlap):(patch_size),(0):(overlap)]

            sv_b[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]
            sv_g[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]
            sv_r[(overlap):(patch_size),(0):(overlap)] *=  vertical_seam[(overlap):(patch_size),(0):(overlap)]


            #Upper horizontal overlap
            oh_b[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]
            oh_g[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]
            oh_r[(0):(overlap),(overlap):(patch_size)] *=  inv_horiz_seam[(0):(overlap),(overlap):(patch_size)]

            sh_b[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]
            sh_g[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]
            sh_r[(0):(overlap),(overlap):(patch_size)] *= horizontal_seam[(0):(overlap),(overlap):(patch_size)]

            #Combine everything back together
            combined_vert = cv2.merge((ov_b[(0):(overlap),(0):(overlap)],ov_g[(0):(overlap),(0):(overlap)],ov_r[(0):(overlap),(0):(overlap)]))
            combined_horiz = cv2.merge((oh_b[(0):(overlap),(0):(overlap)],oh_g[(0):(overlap),(0):(overlap)],oh_r[(0):(overlap),(0):(overlap)]))

            output_overlap_vertf = cv2.merge((ov_b[(overlap):(patch_size),(0):(overlap)],ov_g[(overlap):(patch_size),(0):(overlap)],ov_r[(overl
            sample_overlap_vertf = cv2.merge((sv_b[(overlap):(patch_size),(0):(overlap)],sv_g[(overlap):(patch_size),(0):(overlap)],sv_r[(overl

            output_overlap_horizf = cv2.merge((oh_b[(0):(overlap),(overlap):(patch_size)],oh_g[(0):(overlap),(overlap):(patch_size)],oh_r[(0):(
            sample_overlap_horizf = cv2.merge((sh_b[(0):(overlap),(overlap):(patch_size)],sh_g[(0):(overlap),(overlap):(patch_size)],sh_r[(0):(

            #Put everything into output image
            output[(row+overlap):(row + patch_size), (col+overlap):(col + patch_size)] = sample[(row_patch-half_patch +overlap):(row_patch + ha
            output[row:(row+overlap), (col + overlap):(col+patch_size)] = output_overlap_horizf + sample_overlap_horizf
            output[(row + overlap):(row + patch_size), col:(col + overlap)] = output_overlap_vertf + sample_overlap_vertf
            output[row:(row+overlap), col:(col+overlap)] = combined_vert + combined_horiz

          col += (patch_size - overlap)

        col = 0
        row += (patch_size - overlap)


    return output



def ssd_patch(template, mask, sample_image, guidance_im, alpha):
    """
    """
    b,g,r = cv2.split(sample_image/255)
    b_template, g_template,r_template = cv2.split(template)


    ssd_costb = ((mask*b_template)**2).sum() - 2 * cv2.filter2D(b, ddepth=-1, kernel = mask*b_template) + cv2.filter2D(b**2, ddepth=-1, kerne
    ssd_costg = ((mask*g_template)**2).sum() - 2 * cv2.filter2D(g, ddepth=-1, kernel = mask*g_template) + cv2.filter2D(g**2, ddepth=-1, kerne
    ssd_costr = ((mask*r_template)**2).sum() - 2 * cv2.filter2D(r, ddepth=-1, kernel = mask*r_template) + cv2.filter2D(r**2, ddepth=-1, kerne
    ssd_overlap = ssd_costb + ssd_costg + ssd_costr

    # SSD_guidance is the SSD between the input sample and the patch in the guidance/correspondence image at the same position as the output
    b,g,r = cv2.split(sample_image/255)
    b_guide, g_guide, r_guide = cv2.split(guidance_im/255)

    ssd_guideb = ((mask*b_guide)**2).sum() - 2 * cv2.filter2D(b, ddepth=-1, kernel = mask*b_guide) + cv2.filter2D(b**2, ddepth=-1, kernel=mas
    ssd_guideg = ((mask*g_guide)**2).sum() - 2 * cv2.filter2D(g, ddepth=-1, kernel = mask*g_guide) + cv2.filter2D(g**2, ddepth=-1, kernel=mas
```

```
    ssd_guider = ((mask*r_guide)**2).sum() - 2 * cv2.filter2D(r, ddepth=-1, kernel = mask*r_guide) + cv2.filter2D(r**2, ddepth=-1, kernel=mas
    ssd_guidance = ssd_guideb + ssd_guideg + ssd_guider

    total_cost = alpha*ssd_overlap + (1-alpha)*ssd_guidance
    return total_cost

def choose_sample(cost_image, tol, patch_size):
    """
    Finds the patch with the lowest cost
    :param cost_image: image where each pixel holds a cost
    :param tol: tells how many of the lowest cost patches to randomly choose from
    :param patch_size, int
    """
    rows = []
    cols = []
    height = cost_image.shape[0] - patch_size
    width = cost_image.shape[1] - patch_size
    image = cost_image[patch_size:height, patch_size:width]
    sorted_costs = sorted(image.flatten())
    sorted_costs = sorted_costs[0:tol]
    for row in range(0, cost_image.shape[0]):
      for col in range(0, cost_image.shape[1]):
        if (cost_image[row][col] in sorted_costs):
          rows.append(row)
          cols.append(col)
        if (len(rows) == tol):
          break
    choose =  random.randrange(0, len(rows))
    return rows[choose], cols[choose]
```

```
# load/process appropriate input texture and guidance images
texture_img =  cv2.cvtColor(cv2.imread("pancake_texture.jpg"), cv2.COLOR_BGR2RGB)
guidance_img = cv2.cvtColor(cv2.imread("smile.jfif"), cv2.COLOR_BGR2RGB)

plt.figure()
plt.imshow(texture_img)

plt.figure()
plt.imshow(guidance_img)

patch_size = 35
overlap = 11
tol = 1
alpha = 0.05
res = texture_transfer(texture_img, patch_size, overlap, tol, guidance_img, alpha)

plt.figure()
plt.imshow(res)
plt.show()
```