CPSC 425: Computer Vision - Assignment 4: Texture Synthesis

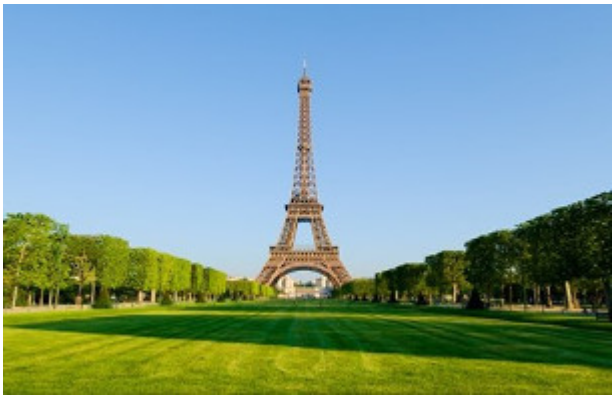
Tristan Rice, 25886145, q7w9a

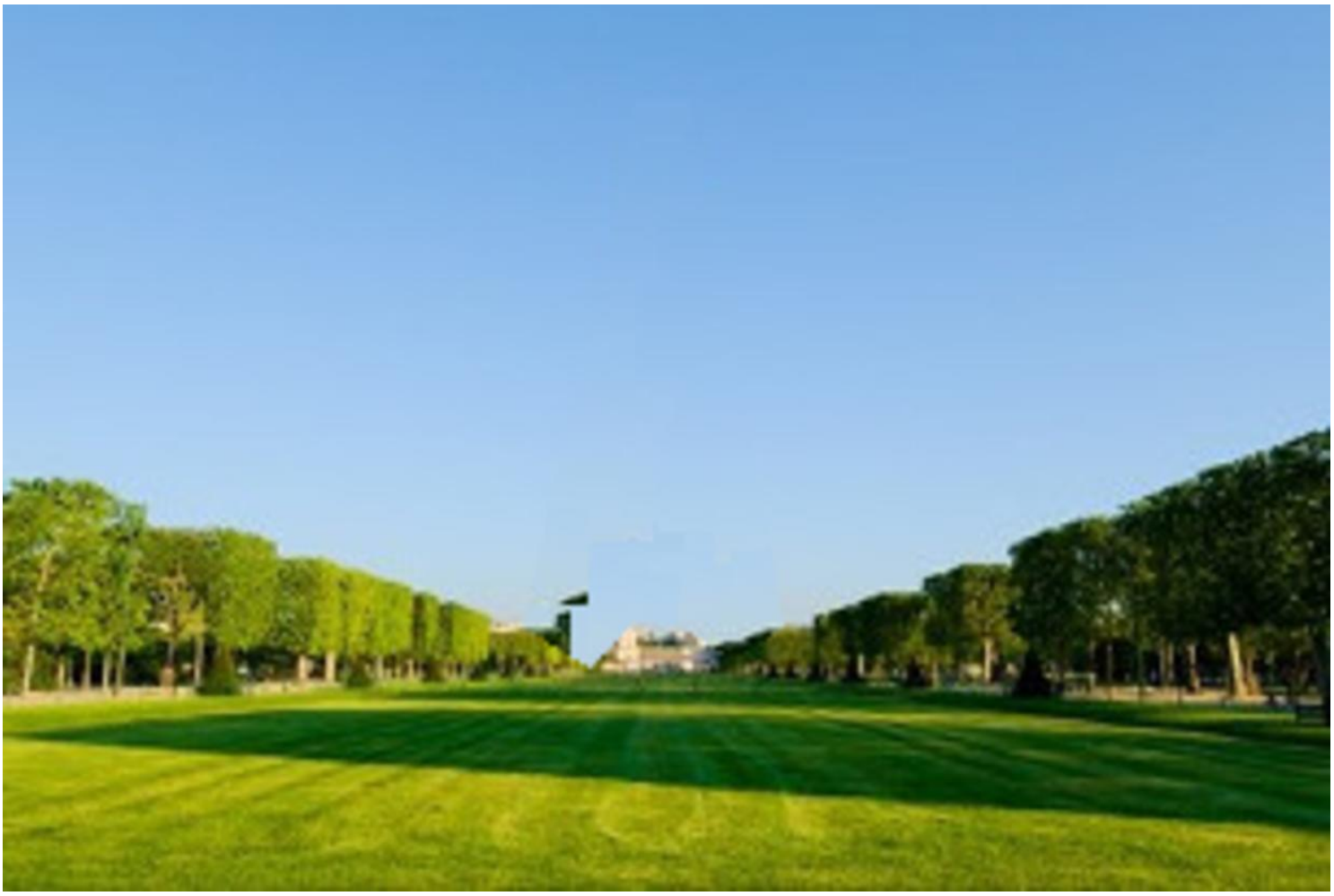
Question 5

Question 6

Umbrella

Eiffel Tower





This image performed poorly near the left base of the tower. This is because the sample region didn't have any good matches for what happens at the base.

Question 7

`randomPatchSD` is used to pick the patch to use. Since we don't want the texture to be too uniform when filling, this code uses `random.gauss(0, randomPatchSD)` to pick a number from a gaussian distribution with mean `0`, standard deviation `randomPatchSD`. This allows there to be some variation in the patches picked, while still favoring those with the lowest SSD. If `randomPatchSD` is too large, there will be a high variation in texture, and many patches chosen may be poor fits. If `randomPatchSD` is too small, there will be a very uniform (and possibly unnatural) fill.

`patchL` specifies how large the patches will be. The larger the `patchL` there is, the more it is able to match the surrounding context and repeat patterns. However, if `patchL` is too large, the patches will become noticeable since it will be copying full features of the image and not just the textures. If `patchL` is too small, it won't be able to accurately replicate the textures since it's looking for the best match at a too small of scale.

Final Code

Holefill.py

```
from PIL import Image, ImageDraw
import numpy as np
import random
import os.path
import pickle

################################################################################
#                        Functions for you to complete                         #
################################################################################

def ComputeSSD(TODOPatch, TODOMask, textureIm, patchL):
    # Create a 3D mask that can be applied to the patch. Need to go from 2d
    # to 3d since there are 3 channels per pixel.
    mask3d = np.zeros_like(TODOPatch)
    # For each channel set it to the mask.
    for i in range(3):
        mask3d[:,:,i] = TODOMask
    # Create the masked patch. This will allow us to use numpy vectorized
    # operations on only the data not masked.
    maskedPatch = np.ma.array(TODOPatch, mask=mask3d)
    # Coerce into a float.
    maskedPatch = maskedPatch*1.0

        # Compute number of rows, columns, as well as the final size of the SSD
    # output.
    patch_rows, patch_cols, patch_bands = np.shape(TODOPatch)
    tex_rows, tex_cols, tex_bands = np.shape(textureIm)
    ssd_rows = tex_rows - 2 * patchL
    ssd_cols = tex_cols - 2 * patchL
    SSD = np.zeros((ssd_rows,ssd_cols))
    # Compute SSD for each pixel.
    for r in range(ssd_rows):
        for c in range(ssd_cols):
            # Compute sum square difference between textureIm and TODOPatch
            # for all pixels where TODOMask = 0, and store the result in SSD
            #
            # ADD YOUR CODE HERE

            # Grab sub part of the image.
            subTexture = textureIm[r:(r+patch_rows), c:(c+patch_cols)]
            # Compute SSD for the target part of image and the
            # masked patch.
            SSD[r, c] = np.sum((maskedPatch - subTexture)**2)
    return SSD

def CopyPatch(imHole,TODOMask,textureIm,iPatchCenter,jPatchCenter,iMatchCenter,jMatchCenter,patchL):
    # Find the patch that will be copied into imHole.
    selectPatch = textureIm[iMatchCenter-patchL:iMatchCenter+patchL+1,jMatchCenter-patchL:jMatchCenter+patchL+1,:]
    patchSize = 2 * patchL + 1

    # For each pixel in selectPatch, copy it into the final output image.
    for i in range(patchSize):
        for j in range(patchSize):
            # Copy the selected patch selectPatch into the image containing
            # the hole imHole for each pixel where TODOMask = 1.
            # The patch is centred on iPatchCenter, jPatchCenter in the image imHole
            #
            # ADD YOUR CODE HERE
```

```
                    # Don't copy the pixel if it's outsize the masked
            # region.
            if TODOMask[i, j] == 0:
                continue

            # Compute the final x, y coordinates of the pizel in
            # imHole.
            dx = i - patchL
            dy = j - patchL
            # Copy the pixel to imHole.
            imHole[iPatchCenter+dx, jPatchCenter+dy] = selectPatch[i, j]
    return imHole

################################################################################
#                            Some helper functions                             #
################################################################################

def DrawBox(im,x1,y1,x2,y2):
    draw = ImageDraw.Draw(im)
    draw.line((x1,y1,x1,y2),fill="white",width=1)
    draw.line((x1,y1,x2,y1),fill="white",width=1)
    draw.line((x2,y2,x1,y2),fill="white",width=1)
    draw.line((x2,y2,x2,y1),fill="white",width=1)
    del draw
    return im

def Find_Edge(hole_mask):
    [cols, rows] = np.shape(hole_mask)
    edge_mask = np.zeros(np.shape(hole_mask))
    for y in range(rows):
        for x in range(cols):
            if (hole_mask[x,y] == 1):
                if (hole_mask[x-1,y] == 0 or
                        hole_mask[x+1,y] == 0 or
                        hole_mask[x,y-1] == 0 or
                        hole_mask[x,y+1] == 0):
                    edge_mask[x,y] = 1
    return edge_mask

################################################################################
#                            Main script starts here                           #
################################################################################

#
# Constants
#

# Change patchL to change the patch size used (patch size is 2 *patchL + 1)
patchL = 10
patchSize = 2*patchL+1

# Standard deviation for random patch selection
randomPatchSD = 1

# Display results interactively
showResults = True

#
# Read input image
#
```

```
im = Image.open('umbrella.jpg').convert('RGB')
im_array = np.asarray(im, dtype=np.uint8)
imRows, imCols, imBands = np.shape(im_array)

#
# Define hole and texture regions.  This will use files fill_region.pkl and
#   texture_region.pkl, if both exist, otherwise user has to select the regions.
if os.path.isfile('fill_region.pkl') and os.path.isfile('texture_region.pkl'):
    fill_region_file = open('fill_region.pkl', 'rb')
    fillRegion = pickle.load( fill_region_file )
    fill_region_file.close()

    texture_region_file = open('texture_region.pkl', 'rb')
    textureRegion = pickle.load( texture_region_file )
    texture_region_file.close()
else:
    # ask the user to define the regions
    print("Specify the fill and texture regions using polyselect.py")
    exit()

#
# Get coordinates for hole and texture regions
#

fill_indices = fillRegion.nonzero()
nFill = len(fill_indices[0])                # number of pixels to be filled
iFillMax = max(fill_indices[0])
iFillMin = min(fill_indices[0])
jFillMax = max(fill_indices[1])
jFillMin = min(fill_indices[1])
assert((iFillMin >= patchL) and
        (iFillMax < imRows - patchL) and
        (jFillMin >= patchL) and
        (jFillMax < imCols - patchL)) , "Hole is too close to edge of image for this patch size"

texture_indices = textureRegion.nonzero()
iTextureMax = max(texture_indices[0])
iTextureMin = min(texture_indices[0])
jTextureMax = max(texture_indices[1])
jTextureMin = min(texture_indices[1])
textureIm   = im_array[iTextureMin:iTextureMax+1, jTextureMin:jTextureMax+1, :]
texImRows, texImCols, texImBands = np.shape(textureIm)
assert((texImRows > patchSize) and
        (texImCols > patchSize)) , "Texture image is smaller than patch size"

#
# Initialize imHole for texture synthesis (i.e., set fill pixels to 0)
#

imHole = im_array.copy()
imHole[fill_indices] = 0

#
# Is the user happy with fillRegion and textureIm?
#
if showResults == True:
    # original
    im.show()
    # convert to a PIL image, show fillRegion and draw a box around textureIm
    im1 = Image.fromarray(imHole).convert('RGB')
```

```
    im1 = DrawBox(im1,jTextureMin,iTextureMin,jTextureMax,iTextureMax)
    im1.show()
    """
    print("Are you happy with this choice of fillRegion and textureIm?")
    Yes_or_No = False
    while not Yes_or_No:
        answer = input("Yes or No: ")
        if answer == "Yes" or answer == "No":
            Yes_or_No = True
    assert answer == "Yes", "You must be happy. Please try again."
    """

#
# Perform the hole filling
#

while (nFill > 0):
    print("Number of pixels remaining = " , nFill)

    # Set TODORegion to pixels on the boundary of the current fillRegion
    TODORegion = Find_Edge(fillRegion)
    edge_pixels = TODORegion.nonzero()
    nTODO = len(edge_pixels[0])

    while(nTODO > 0):

        # Pick a random pixel from the TODORegion
        index = np.random.randint(0,nTODO)
        iPatchCenter = edge_pixels[0][index]
        jPatchCenter = edge_pixels[1][index]

        # Define the coordinates for the TODOPatch
        TODOPatch = imHole[iPatchCenter-patchL:iPatchCenter+patchL+1,jPatchCenter-patchL:jPatchCenter+patchL+1,:]
        TODOMask = fillRegion[iPatchCenter-patchL:iPatchCenter+patchL+1,jPatchCenter-patchL:jPatchCenter+patchL+1]

        #
        # Compute masked SSD of TODOPatch and textureIm
        #
        ssdIm = ComputeSSD(TODOPatch, TODOMask, textureIm, patchL)

        # Randomized selection of one of the best texture patches
        ssdIm1 = np.sort(np.copy(ssdIm),axis=None)
        ssdValue = ssdIm1[min(round(abs(random.gauss(0,randomPatchSD))),np.size(ssdIm1)-1)]
        ssdIndex = np.nonzero(ssdIm==ssdValue)
        iSelectCenter = ssdIndex[0][0]
        jSelectCenter = ssdIndex[1][0]

        # adjust i, j coordinates relative to textureIm
        iSelectCenter = iSelectCenter + patchL
        jSelectCenter = jSelectCenter + patchL
        selectPatch = textureIm[iSelectCenter-patchL:iSelectCenter+patchL+1,jSelectCenter-patchL:jSelectCenter+patchL+1,

        #
        # Copy patch into hole
        #
        imHole = CopyPatch(imHole,TODOMask,textureIm,iPatchCenter,jPatchCenter,iSelectCenter,jSelectCenter,patchL)

        # Update TODORegion and fillRegion by removing locations that overlapped the patch
        TODORegion[iPatchCenter-patchL:iPatchCenter+patchL+1,jPatchCenter-patchL:jPatchCenter+patchL+1] = 0
        fillRegion[iPatchCenter-patchL:iPatchCenter+patchL+1,jPatchCenter-patchL:jPatchCenter+patchL+1] = 0
```

```
        edge_pixels = TODORegion.nonzero()
        nTODO = len(edge_pixels[0])

    fill_indices = fillRegion.nonzero()
    nFill = len(fill_indices[0])

#
# Output results
#
if showResults == True:
    Image.fromarray(imHole).convert('RGB').show()
Image.fromarray(imHole).convert('RGB').save('results.jpg')
```