rellis-exploration

February 21, 2022

1 RELLIS-3D Dataset Exploration

Exploring the RELLIS-3D dataset for VIPR project.

Notes:

- Rellis image dataset contains 3 image datasets which are derived from 5 different videos (mix of jpg and png files)
  - RGB images, label color images, label id images
  - RGB images contain every frame while the label color and id are every EVEN frame
  - Label color are the segemented ground truth images
  - Label ID a grayscale image that maps the pixel value to the class label (sky, tree, mud etc.)
- In this notebook I extracted each folder seperately and renamed them so there would be 3 separate folders
- If extracting all 3 folders (rgb, label color, and label id) in linux they will all be put in the Rellis-3D folder

1.1 Import libraries and define dataset file paths

[1]:
```
from IPython.display import display
import os
from pathlib import Path
from collections import Counter
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import matplotlib.patches as mpatches
```

[2]:
```
ROOT_DIR = os.getcwd() # notebook directory
RGB_DIR = os.path.join(ROOT_DIR,"../../datasets/rellis/Rellis-3D-rgb")
LABEL_COLOR_DIR = os.path.join(ROOT_DIR,"../../datasets/rellis/
 ↪Rellis-3D-label-color")
LABEL_ID_DIR = os.path.join(ROOT_DIR,"../../datasets/rellis/Rellis-3D-label-id")
LIDAR_DIR = os.path.join(ROOT_DIR, "../../datasets/rellis/
 ↪Rellis_3D_os1_cloud_node_color_ply/Rellis-3D") # LIDAR dataset
```

Check a file path to make sure we are looking in the correct folder

[3]:
```
print(os.listdir(RGB_DIR)) # check to see if in correct directory
print(os.listdir(LIDAR_DIR)) # check to see if in correct directory
```

```
['00002', '00001', '00003', '00004', '00000']
['00002', '00001', '00004', '00003', '00000']
```

1.2 Load Images

Displaying the size of each folder about and collect the image file paths to load the images.

[4]:
```
def folder_info(directory):
    """Find the number of frames per video in a folder (rgb, label color, label id)
    and return the file path for each frame. Also return the video id and number frames for plotting
    """
    subdirs = []
    num_files = []
    frame_file_paths = []
    for subdir, dirs, files in os.walk(directory):
        dir_name = subdir.split(os.path.sep)[-1]
        for file in sorted(files):

            image_path = os.path.join(subdir, file)
            if 'ipynb_checkpoints' not in image_path and Path(image_path).stem not in frame_file_paths:
                frame_file_paths.append(image_path)
        if dir_name != '.ipynb_checkpoints'and '.ipynb_checkpoints' not in files:
            subdirs.append(subdir.split(os.path.sep)[-1])
            num_files.append(len(files))

    #print("""{0:<21} - Video: {1} has {2:<5} frames, Video: {3} has {4:<5} frames, Video: {5} has {6:<5} frames,
    #                    Video: {7} has {8:<5} frames, Video: {9} has {10:<5} frames"""
    #                    .format(subdirs[0], subdirs[1], num_files[2], subdirs[3], num_files[4],
    #                    subdirs[5], num_files[6], subdirs[7], num_files[8], subdirs[9], num_files[10]))

    # Create list of video # and its number of frames, next sort the frames list based on the video # then sort the video # list
    videos = [subdirs[1], subdirs[3], subdirs[5], subdirs[7], subdirs[9]]
    num_frames = [num_files[2], num_files[4], num_files[6], num_files[8], num_files[10]]
    num_frames = [num_frames for _, num_frames in sorted(zip(videos, num_frames))] # sorting based on videos list
```

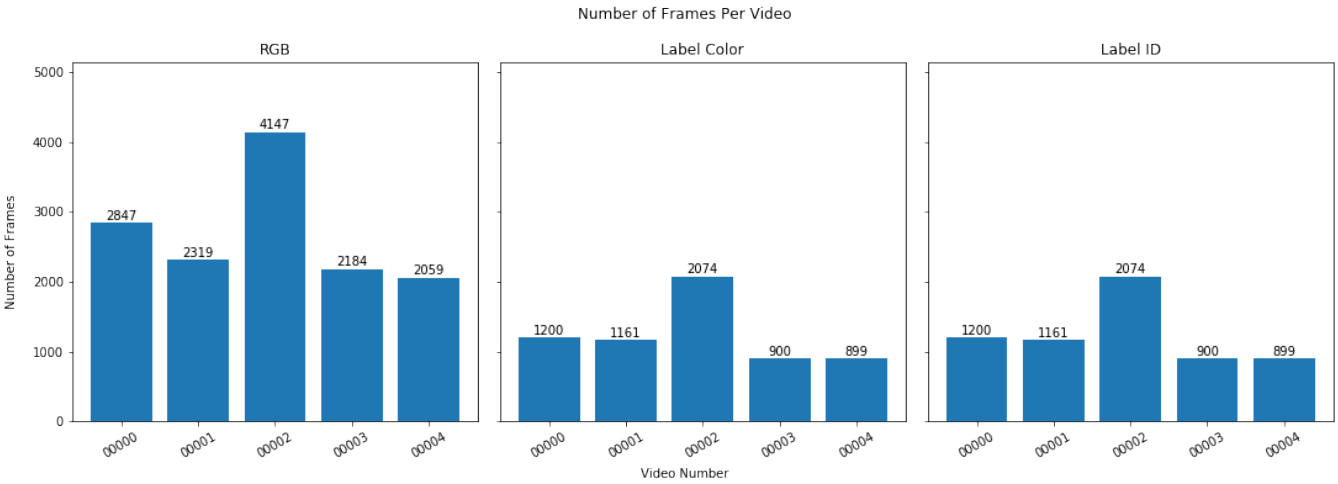
```
    videos = sorted(videos)

    return frame_file_paths, videos, num_frames
```

[5]:
```
def bar_subplots(X, y, row_num = 1, col_num = 3, titles = ['RGB', 'Label Color',␣
↪'Label ID']):
    """Create multiple bar plots using subplots sharing the same y axis and␣
↪contain bar labels"""
    # Define plot dimensions and size
    rows = row_num
    cols = col_num
    plot_size = 5
    # Create subplot and loop through the seperate axes
    fig, axes = plt.subplots(rows, cols, figsize=(plot_size * cols, plot_size *␣
↪rows), sharey=True)
    y_limit = np.amax(X) # get max value in 2D array
    for i in range(rows * cols):
        axes[i].bar(y, X[i])
        axes[i].set_xticks(y) # Specify labels to suppress xticklabel warning
        axes[i].set_xticklabels(y, rotation=30)
        axes[i].set_title(titles[i])
        axes[i].set_ylim([0, y_limit + 1000]) # increase y-axis to max value +␣
↪1000
        rects = axes[i].patches
        # Label bars with exact value
        labels = [f"label{i}" for i in range(len(rects))]
        for rect, label in zip(rects, X[i]):
            height = rect.get_height()
            axes[i].text(
                rect.get_x() + rect.get_width() / 2, height + 5, label,␣
↪ha="center", va="bottom"
            )

    fig.text(0.5, -0.01, 'Video Number', ha='center')
    fig.text(-0.01, 0.5, 'Number of Frames', va='center', rotation='vertical')
    fig.suptitle('Number of Frames Per Video',y=1.05)
    fig.tight_layout()
```

1.2.1 Number of files per video

[6]:
```
# File paths to each type of frame and number of frames
all_num_frames = []
rgb_frames = []
label_color_frames = []
label_id_frames = []
```

```
rgb_frames, video_number, num_frames = folder_info(RGB_DIR)
all_num_frames.append(num_frames)
label_color_frames, video_number, num_frames = folder_info(LABEL_COLOR_DIR)
all_num_frames.append(num_frames)
label_id_frames, video_number, num_frames = folder_info(LABEL_ID_DIR)
all_num_frames.append(num_frames)
bar_subplots(all_num_frames, video_number)
```



Remove duplicates and frames that do not have a ground truth. Because there are only labels for the even frames, this will probably remove most odd rgb frames. Duplicate names that have a different file extension will not be deleted and must be handled manually, these files will be printed out below.

[7]:
```
# Remove duplicates and unique frames (must be in all 3 lists)
rgb_frame_name = [Path(x).stem for x in rgb_frames] # return file name w/o the␣
 ↪extension to account for jpg and png files
color_frame_name = [Path(x).stem for x in label_color_frames]
id_frame_name = [Path(x).stem for x in label_id_frames]
# Find the frames that appear in all 3 folders
common_frames = list(set(rgb_frame_name).intersection(color_frame_name,␣
 ↪id_frame_name))

rgb_dupe_count = Counter(rgb_frame_name)
color_dupe_count = Counter(color_frame_name)
id_dupe_count = Counter(id_frame_name)

# Print duplicate file names w/ different extensions - to hard to handle through␣
 ↪code
rgb_dupes = [k for k in rgb_dupe_count if rgb_dupe_count[k] >= 2]
color_dupes = [k for k in color_dupe_count if color_dupe_count[k] >= 2]
```

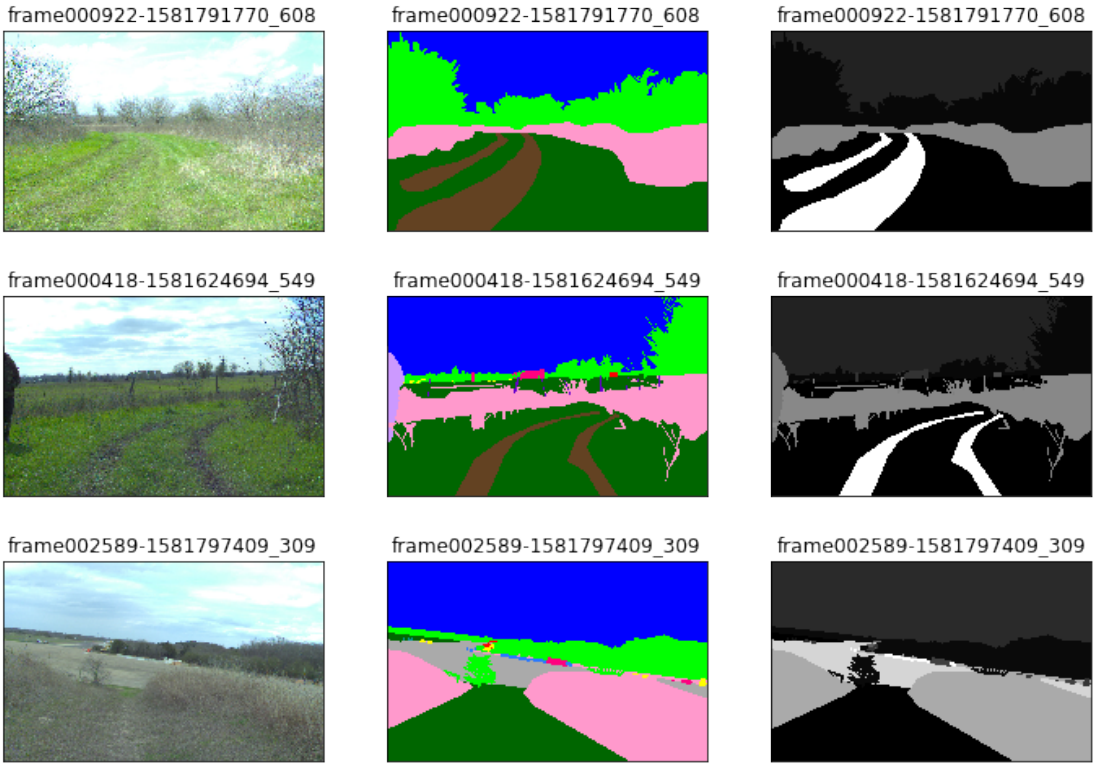
```
id_dupes = [k for k in id_dupe_count if id_dupe_count[k] >= 2]
if len(rgb_dupes) > 0:
    print("Warning: The RGB images contain the following duplicate images,␣
 ↪manually delete these: {}".format(rgb_dupes))
if len(color_dupes) > 0:
    print("Warning: The c images contain the following duplicate images,␣
 ↪manually delete these: {}".format(color_dupes))
if len(id_dupes) > 0:
    print("Warning: The color id images contain the following duplicate images,␣
 ↪manually delete these: \n{}".format(id_dupes))

# Remove frames from image list if they are not shared between all 3 image lists
for frame_file in rgb_frames[:]: # iterating through copy of the list
    frame_file_short = Path(frame_file).stem
    if frame_file_short not in common_frames:
        rgb_frames.remove(frame_file)
for frame_file in label_color_frames[:]:
    frame_file_short = Path(frame_file).stem
    if frame_file_short not in common_frames:
        label_color_frames.remove(frame_file)
for frame_file in label_id_frames[:]:
    frame_file_short = Path(frame_file).stem
    if frame_file_short not in common_frames:
        label_id_frames.remove(frame_file)

print("{} RGB frames".format(len(rgb_frames)))
print("{} Color frames".format(len(label_color_frames)))
print("{} ID frames".format(len(label_id_frames)))

# Sort final lists - they should already be sorted but for some reason they␣
 ↪aren't
#                   (I think its because the directories on returning in␣
 ↪different orders)
rgb_frames = sorted(rgb_frames)
label_color_frames = sorted(label_color_frames)
label_id_frames = sorted(label_id_frames)
```

```
6234 RGB frames
6234 Color frames
6234 ID frames
```

1.2.2 Display random images from the dataset - RGB, Color, ID

[8]:
```
rows = 3
cols = 3
plot_size = 4
```

```
image_type_iterable = [rgb_frames, label_color_frames, label_id_frames]
indices = np.random.choice(np.arange(len(rgb_frames)), rows)
indices = np.repeat(indices, cols) # repeat indices to align for 3 images

plt.figure(figsize=(plot_size * cols, plot_size * rows))
for i in range(rows * cols):
    index = indices[i]
    wrap_index = i % len(image_type_iterable) # index used to wrap around the␣
 ↪list
    image_data = mpimg.imread(image_type_iterable[wrap_index][index])
    #image_data2 = mpimg.imread(label_color_frames[index])
    #image_data3 = mpimg.imread(label_id_frames[0])
    ax = plt.subplot(rows, cols, i + 1)
    plt.imshow(image_data, cmap="gray")
    plt.title(Path(image_type_iterable[wrap_index][index]).stem)
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)

plt.subplots_adjust(hspace=-0.5)
```

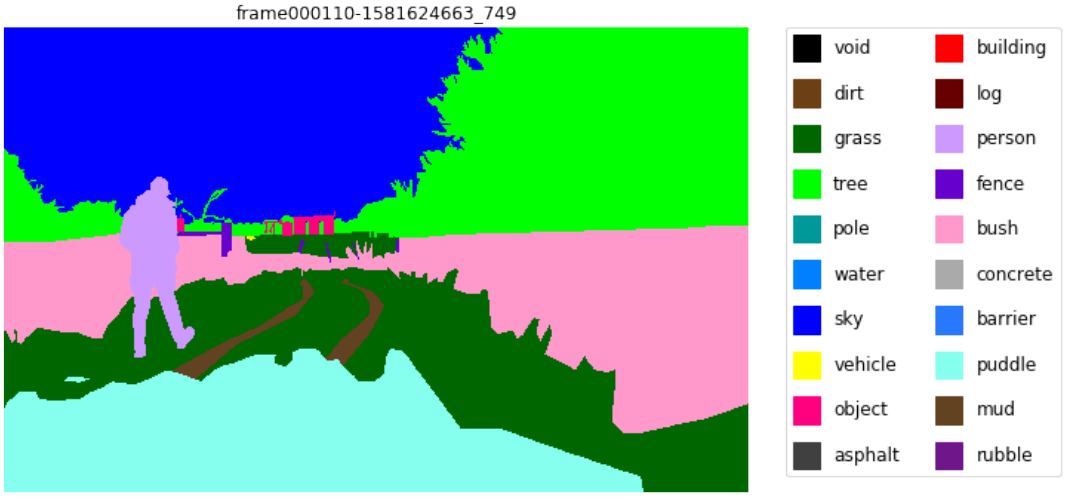


1.2.3 Display segemented image with classes

[9]:
```
# Taken from rellis github
color_palette = {
    0: {"color": [0, 0, 0],  "name": "void"},
    1: {"color": [108, 64, 20],   "name": "dirt"},
    3: {"color": [0, 102, 0],   "name": "grass"},
    4: {"color": [0, 255, 0],  "name": "tree"},
    5: {"color": [0, 153, 153],  "name": "pole"},
    6: {"color": [0, 128, 255],  "name": "water"},
    7: {"color": [0, 0, 255],  "name": "sky"},
    8: {"color": [255, 255, 0],  "name": "vehicle"},
    9: {"color": [255, 0, 127],  "name": "object"},
    10: {"color": [64, 64, 64],  "name": "asphalt"},
    12: {"color": [255, 0, 0],  "name": "building"},
    15: {"color": [102, 0, 0],  "name": "log"},
    17: {"color": [204, 153, 255],  "name": "person"},
    18: {"color": [102, 0, 204],  "name": "fence"},
    19: {"color": [255, 153, 204],  "name": "bush"},
    23: {"color": [170, 170, 170],  "name": "concrete"},
    27: {"color": [41, 121, 255],  "name": "barrier"},
    31: {"color": [134, 255, 239],  "name": "puddle"},
    33: {"color": [99, 66, 34],  "name": "mud"},
    34: {"color": [110, 22, 138],  "name": "rubble"}
}
```

[10]:
```
def plot_sample_image(label_array):
    """Plot random label color image with class labels"""
    index = np.random.choice(len(label_array))
    image = mpimg.imread(label_array[index])
    # Convert color palette to list of colors and labels
    colors = [ [value['color'][0] / 255, value['color'][1] / 255,␣
 ↪value['color'][2] / 255]
                for key, value in color_palette.items()]
    labels = [value['name'] for key, value in color_palette.items()]

    plt.figure(figsize = (9,9))
    ax = plt.imshow(image)
    plt.title(Path(label_array[index]).stem)
    plt.axis('off')
    patches = [ mpatches.Patch(color=colors[i], label="{l}".format(l=labels[i])␣
 ↪) for i in range(len(labels)) ]
    plt.legend(handles=patches, bbox_to_anchor=(1.05, 1), loc=2,␣
 ↪borderaxespad=0, ncol=2,
                handleheight=2, handlelength=1.5, labelspacing=1,␣
 ↪fontsize='large')
```

[11]:
```
plot_sample_image(label_color_frames)
```



1.3 Attempting to load all images

[12]:
```
def load_images_by_path(frame_path):
    image_list = []
    i = 0
    for image in rgb_frames:
        print(i)
        i += 1
        image_list.append(mpimg.imread(image))
# Jupyter crashes after loading anywhere from 2000-6000 images
#loaded_rgb_images = load_images_by_path()
```

2 LIDAR

Exploring the LiDAR data in this section.

There doesn't seem to be a good solution for veiwing lidar data on the palmetto.

[13]:
```
def lidar_info(directory):
    """Find the number of frames per video in a folder (rgb, label color, label␣
 ↪id)
    and return the file path for each frame. Also return the video id and number␣
 ↪frames for plotting
    """
    subdirs = []
    num_files = []
    frame_file_paths = []
```

```
    for subdir, dirs, files in os.walk(directory):
        dir_name = subdir.split(os.path.sep)[-1]
        for file in sorted(files):

            image_path = os.path.join(subdir, file)
            if 'ipynb_checkpoints' not in image_path and Path(image_path).stem␣
↪not in frame_file_paths:
                frame_file_paths.append(image_path)
        if dir_name != '.ipynb_checkpoints'and '.ipynb_checkpoints' not in files:
            subdirs.append(subdir.split(os.path.sep)[-1])
            num_files.append(len(files))

    #print("""{0:<21} - Video: {1} has {2:<5} frames, Video: {3} has {4:<5}␣
↪frames, Video: {5} has {6:<5} frames,
    #                    Video: {7} has {8:<5} frames, Video: {9} has {10:<5}␣
↪frames"""
    #                    .format(subdirs[0], subdirs[1], num_files[2],␣
↪subdirs[3], num_files[4],
    #                    subdirs[5], num_files[6], subdirs[7], num_files[8],␣
↪subdirs[9], num_files[10]))

    # Create list of video # and its number of frames, next sort the frames list␣
↪based on the video # then sort the video # list
    videos = [subdirs[1], subdirs[3], subdirs[5], subdirs[7], subdirs[9]]
    num_frames = [num_files[2], num_files[4], num_files[6], num_files[8],␣
↪num_files[10]]
    num_frames = [num_frames for _, num_frames in sorted(zip(videos,␣
↪num_frames))] # sorting based on videos list
    videos = sorted(videos)

    return frame_file_paths, videos, num_frames
```

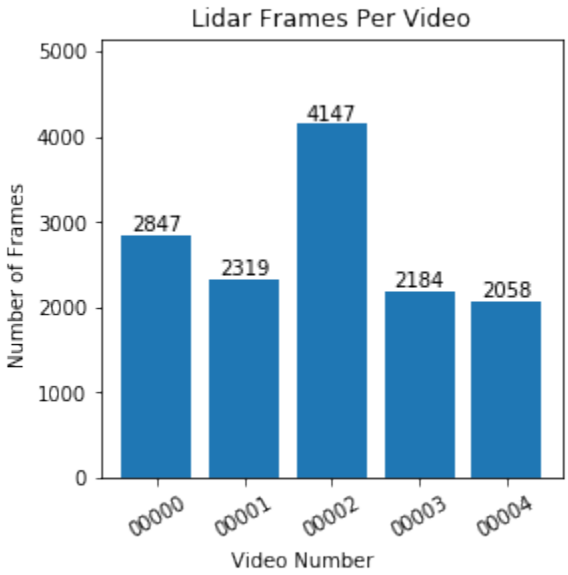
[14]:
```
def bar_plot(X, y, row_num = 1, col_num = 3, title = "Lidar Frames Per Video"):
    """Create a single bar plot with bar labels"""
    # Define plot dimensions and size
    rows = row_num
    cols = col_num
    plot_size = 4

    fig, ax = plt.subplots(rows, cols, figsize=(plot_size * cols, plot_size *␣
↪rows), sharey=True)

    # Create subplot and loop through the seperate axes
    #fig, axes = plt.plot(rows, cols, figsize=(plot_size * cols, plot_size *␣
↪rows), sharey=True)
    y_limit = np.amax(X) # get max value in 2D array
```

```
    ax.bar(y, X)
    ax.set_xticks(y) # Specify labels to suppress xticklabel warning
    ax.set_xticklabels(y, rotation=30)
    ax.set_title(title)
    ax.set_ylim([0, y_limit + 1000]) # increase y-axis to max value + 1000
    rects = ax.patches
    # Label bars with exact value
    labels = [f"label{i}" for i in range(len(rects))]
    for rect, label in zip(rects, X):
        height = rect.get_height()
        ax.text(
            rect.get_x() + rect.get_width() / 2, height + 5, label, ha="center",␣
↪va="bottom"
        )

    fig.text(0.5, -0.01, 'Video Number', ha='center')
    fig.text(-0.01, 0.5, 'Number of Frames', va='center', rotation='vertical')
    #fig.suptitle('Number of Frames Per Video')
    fig.tight_layout()
```

[15]:
```
# File paths to each type of frame and number of frames
all_num_frames = []
lidar_frames = []

lidar_frames, video_number, num_frames = folder_info(LIDAR_DIR)
all_num_frames.append(num_frames)
```

2.1 Number of files per video

[16]:
```
bar_plot(all_num_frames[0], video_number, row_num=1, col_num=1)
```



[17]:
```
# Remove duplicates just in case - assuming they all have .ply extension
print(len(lidar_frames))
lidar_frames = list(set(lidar_frames))
print(len(lidar_frames))
```

```
13555
13555
```

Viewing lidar data in jupyter on the palmetto is too difficult so this will be continued in matlab

[18]:
```
#import open3d as o3d
#plt.set_loglevel('WARNING') # suppress warning caused by open3d
```

Installing open3d on palmetto:

```
pip3 install --ignore-installed PyYAML
pip3 install open3d
```

[19]:
```
#index = np.random.choice(len(lidar_frames))
#print(Path(lidar_frames[index]).stem)
#pcd = o3d.io.read_point_cloud(lidar_frames[index]) # Read the point cloud
#mesh = o3d.io.read_triangle_mesh("../../TestData/knot.ply")
#print(pcd)
#o3d.io.write_triangle_mesh("copy_of_knot.ply", mesh)
#o3d.visualization.draw_geometries([pcd])
```