In [1]:
```
from zipfile import ZipFile
import pandas as pd
import os, time
import shutil
import sys
import cv2
import matplotlib.pyplot as plt
import tensorflow as tf
import numpy as np
from tensorflow import keras
import random
import csv
```

```
2022-12-13 02:37:40.030202: I tensorflow/core/platform/cpu_feature_guard.c
c:193] This TensorFlow binary is optimized with oneAPI Deep Neural Network
Library (oneDNN) to use the following CPU instructions in performance-criti
cal operations:  AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate
compiler flags.
2022-12-13 02:37:40.141978: W tensorflow/tsl/platform/default/dso_loader.c
c:66] Could not load dynamic library 'libcudart.so.11.0'; dlerror: libcudar
t.so.11.0: cannot open shared object file: No such file or directory; LD_LI
BRARY_PATH: /home/andrewsue/.local/lib/python3.7/site-packages/cv2/../../li
b64:/usr/local/lib:/opt/ros/melodic/lib:/usr/lib:/usr/share:/home/andrewsue
/open3d_install_v9/lib
2022-12-13 02:37:40.141998: I tensorflow/tsl/cuda/cudart_stub.cc:28] Ignore
above cudart dlerror if you do not have a GPU set up on your machine.
2022-12-13 02:37:40.185388: E tensorflow/tsl/lib/monitoring/collection_regi
stry.cc:81] Cannot register 2 metrics with the same name: /tensorflow/core/
bfc_allocator_delay
2022-12-13 02:37:40.817100: W tensorflow/tsl/platform/default/dso_loader.c
c:66] Could not load dynamic library 'libnvinfer.so.8'; dlerror: libnvinfe
r.so.8: cannot open shared object file: No such file or directory; LD_LIBRA
RY_PATH: /home/andrewsue/.local/lib/python3.7/site-packages/cv2/../../lib6
4:/usr/local/lib:/opt/ros/melodic/lib:/usr/lib:/usr/share:/home/andrewsue/o
pen3d_install_v9/lib
2022-12-13 02:37:40.817169: W tensorflow/tsl/platform/default/dso_loader.c
c:66] Could not load dynamic library 'libnvinfer_plugin.so.8'; dlerror: lib
nvinfer_plugin.so.8: cannot open shared object file: No such file or direct
ory; LD_LIBRARY_PATH: /home/andrewsue/.local/lib/python3.7/site-packages/cv
2/../../lib64:/usr/local/lib:/opt/ros/melodic/lib:/usr/lib:/usr/share:/home
/andrewsue/open3d_install_v9/lib
2022-12-13 02:37:40.817176: W tensorflow/compiler/tf2tensorrt/utils/py_util
s.cc:38] TF-TRT Warning: Cannot dlopen some TensorRT libraries. If you woul
d like to use Nvidia GPU with TensorRT, please make sure the missing librar
ies mentioned above are installed properly.
```

In [ ]:
```
'''def extract_zip(src, dest):
    '''
    #Extracts the contents downloaded from the URL
    '''
    zip_ref = ZipFile(src,'r')
    zip_ref.extractall(dest)
    zip_ref.close()

extract_zip('nyu_data.zip', '/content')'''
```

In [3]:
```
#Hyper params
split = 0.8
height, width = 240, 320
```

In [4]:
```
random.seed(0)
with open("training_set.csv", "w") as f:
    writer = csv.writer(f)
    for i in range(1999):
        if random.random() > 0.2:
            end = str(i) + ".png"
            dep = "saved_img_env1_5/depth_" + end
            rgb = "saved_img_env1_5/rgb_" + end
            row = [rgb, dep]
            # write a row to the csv file
            writer.writerow(row)

random.seed(0)
with open("test_set.csv", "w") as f:
    writer = csv.writer(f)
    for i in range(1999):
        randnum = random.random()
        if randnum > 0.1 and randnum <= 0.2:
            end = str(i) + ".png"
            dep = "saved_img_env1_5/depth_" + end
            rgb = "saved_img_env1_5/rgb_" + end
            row = [rgb, dep]
            # write a row to the csv file
            writer.writerow(row)

random.seed(0)
with open("validation_set.csv", "w") as f:
    writer = csv.writer(f)
    for i in range(1999):
        randnum = random.random()
        if randnum <= 0.1:
            end = str(i) + ".png"
            dep = "saved_img_env1_5/depth_" + end
            rgb = "saved_img_env1_5/rgb_" + end
            row = [rgb, dep]
            # write a row to the csv file
            writer.writerow(row)
```

In [5]:
```
#train_df = pd.read_csv('content/data/nyu2_train.csv',header=None)
#test = pd.read_csv('content/data/nyu2_test.csv',header=None).rename(columns

# using my custom dataset instead of NYU2
train_df = pd.read_csv('training_set.csv',header=None)
test = pd.read_csv('test_set.csv',header=None).rename(columns={0:'image', 1:

train_df = train_df.sample(frac=1).reset_index(drop=True).rename(columns={0:
train_split = int(len(train_df)*split)


train = train_df[:train_split]
validation = train_df[train_split:]
len(train), len(validation)
```

Out[5]: (1287, 322)

In [6]:
```
class DataGenerator(tf.keras.utils.Sequence):
    def __init__(self, dataframe, batch_size, shuffle=False, dim=(320,240)):
        # for reproducibility
        np.random.seed(43)
        # dataframe containing the subset of image and depth pairs
        self.df = dataframe
        # chosen Height and Width of the RGB image
        self.height, self.width = dim
        # choice of shuffling the data
        self.shuffle = shuffle
        self.batch_size = batch_size
        # unique set of RGB images
        self.ids = dataframe['image'].unique()
        # Map the image with depth maps
        self.imgtodpth = dataframe.set_index('image')['depth'].to_dict()
        self.on_epoch_end()

    def __len__(self):
        '''
        Returns the length of dataset.
        '''
        return len(self.df) // self.batch_size

    def on_epoch_end(self):
        '''
        Shuffles the data at the end of every epoch
        '''
        self.indexes = np.arange(len(self.ids))
        if self.shuffle:
            np.random.shuffle(self.indexes)

    def __getitem__(self,index):
        '''
        returns the batch of image and depth pairs
        '''
        # select the batch of pair indexes
        idxs = self.indexes[index*self.batch_size : (index+1)*self.batch_siz
        # randomly select whether to flip the image
        flip = np.random.choice([True, False])
        # select the image id's for the above indexes
        query_imgs = [self.ids[idx] for idx in idxs]
        # select corresponding depth pair for the image
        target_imgs = [self.imgtodpth[img] for img in query_imgs]
        # preprocess the image
        processed_query_img = self._preprocess_image(query_imgs, flip)
        # preprocess the depth map
        processed_depth_img = self._preprocess_depth(target_imgs, flip)
        return processed_query_img, processed_depth_img

    def _preprocess_image(self,images, flip):
        '''
        Resize, Normalize and randomly Augments the image set.
        '''
        # placeholder for storing the processed images
        processed = []
        for img in images:
```

In [23]:
```
train_generator = DataGenerator(train, batch_size=8, shuffle=True, dim=(640,
val_generator = DataGenerator(validation, batch_size=8, shuffle=False, dim=(
test_generator = DataGenerator(test, batch_size=16, shuffle=False, dim=(640,
print(len(train_generator), len(val_generator), len(test_generator))
```

```
160 40 11
```

In [27]:
```
runID = str(1) #str(int(time.time())) + '-n' + str(len(train_generator)) + '
outputPath = './models/'
runPath = outputPath + runID
import pathlib
pathlib.Path(runPath).mkdir(parents=True, exist_ok=True)
print('Output: ' + runPath)
```

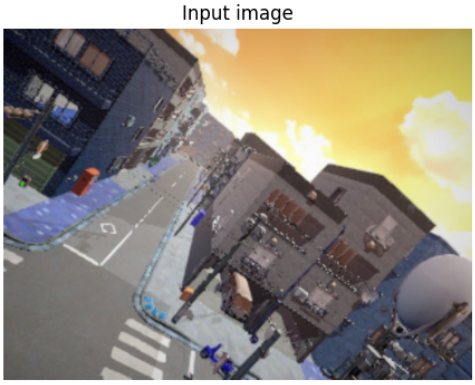
```
Output: ./models/1
```

In [8]:
```
images,depths = next(iter(val_generator))
print(images.shape, depths.shape)
```

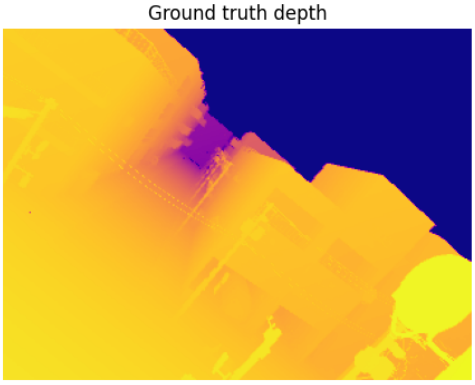
```
(8, 480, 640, 3) (8, 240, 320, 1)
/home/andrewsue/.local/lib/python3.7/site-packages/ipykernel_launcher.py:7
8: RuntimeWarning: invalid value encountered in true_divide
```

In [9]:
```
# visualize some example RGB + depth images from my Flightmare dataset
cmap = "plasma_r"
plt.figure(figsize=(15,9))
for i in range(0,4,2):
    image = images[i]
    depth = depths[i].squeeze(-1)
    plt.subplot(221+i)
    plt.axis('off')
    plt.imshow(image)
    plt.title('Input image')
    plt.subplot(222+i)
    plt.axis('off')
    plt.imshow(depth,cmap=plt.get_cmap(cmap))
    plt.title('Ground truth depth')
```

Input image



Ground truth depth



Input image

Ground truth depth

In [30]:
```
# Model
import tensorflow as tf
from tensorflow.keras.applications import DenseNet169
from tensorflow.keras.layers import Conv2D, UpSampling2D, MaxPool2D, Dropout
from tensorflow.keras.layers import LeakyReLU, concatenate, Concatenate, Inp
from tensorflow.keras import Model

def upsampling(input_tensor, n_filters, concat_layer):
    '''
    Block of Decoder
    '''
    # Bilinear 2x upsampling layer
    x = UpSampling2D(size=(2,2), interpolation='bilinear')(input_tensor)
    # concatenation with encoder block
    x = concatenate([x,concat_layer])
    # decreasing the depth filters by half
    x = Conv2D(filters=n_filters, kernel_size=(3,3), padding='same')(x)
    x = BatchNormalization()(x)
    x = Conv2D(filters=n_filters, kernel_size=(3,3), padding='same')(x)
    x = BatchNormalization()(x)
    return x

# Layer name of encoders to be concatenated
names = ['pool3_pool', 'pool2_pool', 'pool1','conv1/relu']
# Transfer learning approach without the classification head
encoder = DenseNet169(include_top=False, weights='imagenet', input_shape=(48
for layer in encoder.layers:
    layer.trainable = True
inputs = encoder.input
x = encoder.output
# decoder blocks linked with corresponding encoder blocks
bneck = Conv2D(filters=1664, kernel_size=(1,1), padding='same')(x)
x = LeakyReLU(alpha=0.2)(bneck)
x = upsampling(bneck, 832, encoder.get_layer(names[0]).output)
x = LeakyReLU(alpha=0.2)(x)
x = upsampling(x, 416, encoder.get_layer(names[1]).output)
x = LeakyReLU(alpha=0.2)(x)
x = upsampling(x, 208, encoder.get_layer(names[2]).output)
x = LeakyReLU(alpha=0.2)(x)
x = upsampling(x, 104, encoder.get_layer(names[3]).output)
x = Conv2D(filters=1, activation='sigmoid', kernel_size=(3,3), padding='same

model = Model(inputs=inputs, outputs=x)
#model.summary()
```

In [ ]:
```
from tensorflow.keras.callbacks import LearningRateScheduler
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.regularizers import l2
import tensorflow.keras.backend as K
import tensorflow_addons as tfa

def loss_function(y_true, y_pred):
    #Cosine distance loss
    l_depth = K.mean(K.abs(y_pred - y_true), axis=-1)

    # edge loss for sharp edges
    dy_true, dx_true = tf.image.image_gradients(y_true)
    dy_pred, dx_pred = tf.image.image_gradients(y_pred)
    l_edges = K.mean(K.abs(dy_pred - dy_true) + K.abs(dx_pred - dx_true), ax

    # structural similarity loss
    l_ssim = K.clip((1 - tf.image.ssim(y_true, y_pred, 1.0)) * 0.5, 0, 1)

    # weightage
    w1, w2, w3 = 1.0, 1.0, 0.1
    return (w1 * l_ssim) + (w2 * K.mean(l_edges)) + (w3 * K.mean(l_depth))



#optimizer
#opt = tfa.optimizers.AdamW(learning_rate=0.0001, weight_decay=1e-6,amsgrad=
#opt = tf.keras.optimizers.experimental.AdamW(learning_rate=0.0001, weight_d
from tensorflow.keras.optimizers import Adam
opt = Adam(lr=0.0001, amsgrad=True)

# accuracy function
def accuracy_function(y_true, y_pred):
    return K.mean(K.equal(K.round(y_true), K.round(y_pred)))

# save model frequently for later use.
checkpoint = tf.keras.callbacks.ModelCheckpoint('/content/drive/MyDrive/proj
                                                save_best_only=True,
                                                verbose=1)
# Learning rate scheduler
def polynomial_decay(epoch):
    max_epochs = 10
    base_lr =  0.0001
    power = 1.0
    lr = base_lr * (1 - (epoch / float(max_epochs))) ** power
    return lr

callbacks = [LearningRateScheduler(polynomial_decay, verbose=1), checkpoint]
```

In [ ]:
```
```

In [ ]:
```
for layer in encoder.layers:
    layer.trainable = True
    print(layer.trainable)
```

In [28]:
```
model.compile(optimizer=opt, loss=loss_function, metrics=[accuracy_function]
history = model.fit(train_generator, validation_data=val_generator, epochs=1
```

In [ ]:
```
## The above step results in a loss of NaN and accuracy of 0
```

In [ ]:
```
model.evaluate(test_generator)
```

In [ ]:
```
images,labels = next(iter(test_generator))
preds = model.predict(images)
```

In [ ]:
```
cmap = "plasma_r"


for i in range(len(images)):
    plt.figure(figsize=(19,10))
    pred = preds[i]
    pred = np.squeeze(pred, axis=-1)
    plt.subplot(1,3,1)
    plt.axis("off")
    plt.imshow(pred, cmap=plt.get_cmap(cmap))

    plt.subplot(1,3,2)
    plt.axis("off")
    img = labels[i]
    img = np.squeeze(img, axis=-1)
    plt.imshow(img, cmap=plt.get_cmap(cmap))

    plt.subplot(1,3,3)
    plt.axis("off")
    img1 = images[i]
    plt.imshow(img1)

    plt.show()
```

In [ ]:

In [ ]: