In [1]:

```
import numpy as np
from IPython import get_ipython
get_ipython().run_line_magic('matplotlib', 'inline')
from sklearn import datasets, linear_model, preprocessing, model_selection
import pickle
import tensorflow as tf
import keras
from keras.preprocessing.image import ImageDataGenerator
from keras import optimizers
from keras.models import Sequential
from keras.layers import Dropout, Flatten, Dense
from keras.layers import Conv2D
from scipy import misc
```

```
Using TensorFlow backend.
```

In [2]:

```
#basic settings
nrow = 162
ncol = 506
rgb = 3
```

In [3]:

```
#get X, y, process missing(deleted) X
y_dir = 'y.txt'
ss_dir = 'screenshot'

y = np.array(pickle.load(open(y_dir, "rb")))
data_num = len(y)
#data_num = 1000#only use part of samples, applied only on local PC
y = y[:data_num]
X = np.zeros((data_num, nrow, ncol, rgb), dtype=np.uint8)#this gives float
#X = np.array([[[[np.uint8(0) for i in range(rgb)] for i in range(ncol)] for i in range(nrow)] for i in range(1)])
```

In [4]:

```
#import X from elsewhere, pick put those have lost

lost = []
for i in range(data_num):
    if i%100 == 0:
        print(i, 'image capture attempts')
    try:
        fn = './' + ss_dir + '/' + str(i).zfill(5) + '.bmp'
        #X = np.vstack((X, misc.imread(fn)[None, ]))
        X[i] = misc.imresize(misc.imread(fn), (nrow, ncol))##############################scipy.misc.imresize
    except:
        lost.append(i)

#X = np.delete(X, 0, axis=0)
X = np.delete(X, lost, axis=0)
y = np.delete(y, lost, axis=0)
```

```
0 image capture attempts

/home/jiadong_chen18/.local/lib/python3.5/site-packages/ipykernel_launcher.py:10:
DeprecationWarning: `imread` is deprecated!
`imread` is deprecated in SciPy 1.0.0, and will be removed in 1.2.0.
Use ``imageio.imread`` instead.
  # Remove the CWD from sys.path while we load stuff.
/home/jiadong_chen18/.local/lib/python3.5/site-packages/ipykernel_launcher.py:10:
DeprecationWarning: `imresize` is deprecated!
`imresize` is deprecated in SciPy 1.0.0, and will be removed in 1.2.0.
Use ``skimage.transform.resize`` instead.
  # Remove the CWD from sys.path while we load stuff.
```

```
100 image capture attempts
200 image capture attempts
300 image capture attempts
400 image capture attempts
500 image capture attempts
600 image capture attempts
700 image capture attempts
800 image capture attempts
900 image capture attempts
1000 image capture attempts
1100 image capture attempts
1200 image capture attempts
1300 image capture attempts
1400 image capture attempts
1500 image capture attempts
1600 image capture attempts
1700 image capture attempts
1800 image capture attempts
1900 image capture attempts
2000 image capture attempts
2100 image capture attempts
2200 image capture attempts
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2400 image capture attempts
2500 image capture attempts
2600 image capture attempts
2700 image capture attempts
2800 image capture attempts
2900 image capture attempts
3000 image capture attempts
3100 image capture attempts
3200 image capture attempts
3300 image capture attempts
3400 image capture attempts
3500 image capture attempts
3600 image capture attempts
3700 image capture attempts
3800 image capture attempts
3900 image capture attempts
4000 image capture attempts
4100 image capture attempts
4200 image capture attempts
4300 image capture attempts
4400 image capture attempts
4500 image capture attempts
4600 image capture attempts
4700 image capture attempts
4800 image capture attempts
4900 image capture attempts
5000 image capture attempts
5100 image capture attempts
5200 image capture attempts
5300 image capture attempts
5400 image capture attempts
5500 image capture attempts
5600 image capture attempts
5700 image capture attempts
5800 image capture attempts
5900 image capture attempts
6000 image capture attempts
6100 image capture attempts
```

```
6200 image capture attempts
6300 image capture attempts
6400 image capture attempts
6500 image capture attempts
6600 image capture attempts
6700 image capture attempts
6800 image capture attempts
6900 image capture attempts
7000 image capture attempts
7100 image capture attempts
7200 image capture attempts
7300 image capture attempts
7400 image capture attempts
7500 image capture attempts
7600 image capture attempts
7700 image capture attempts
7800 image capture attempts
7900 image capture attempts
8000 image capture attempts
8100 image capture attempts
8200 image capture attempts
8300 image capture attempts
8400 image capture attempts
8500 image capture attempts
8600 image capture attempts
8700 image capture attempts
8800 image capture attempts
8900 image capture attempts
9000 image capture attempts
9100 image capture attempts
9200 image capture attempts
9300 image capture attempts
9400 image capture attempts
9500 image capture attempts
9600 image capture attempts
9700 image capture attempts
9800 image capture attempts
9900 image capture attempts
10000 image capture attempts
10100 image capture attempts
10200 image capture attempts
10300 image capture attempts
10400 image capture attempts
10500 image capture attempts
10600 image capture attempts
10700 image capture attempts
10800 image capture attempts
10900 image capture attempts
11000 image capture attempts
11100 image capture attempts
11200 image capture attempts
11300 image capture attempts
11400 image capture attempts
11500 image capture attempts
11600 image capture attempts
11700 image capture attempts
11800 image capture attempts
11900 image capture attempts
12000 image capture attempts
12100 image capture attempts
12200 image capture attempts
```

```
12300 image capture attempts
12400 image capture attempts
12500 image capture attempts
12600 image capture attempts
12700 image capture attempts
12800 image capture attempts
12900 image capture attempts
13000 image capture attempts
13100 image capture attempts
13200 image capture attempts
13300 image capture attempts
13400 image capture attempts
13500 image capture attempts
```

In [5]:

```
#np.vstack((X, X1))
#np.hstack((y, y1))
print(X.shape)
print(y.shape)
```

```
(13529, 162, 506, 3)
(13529, 2)
```

In [6]:

```
#y preprocess
y = np.array([[i[0], 0] for i in y])
```

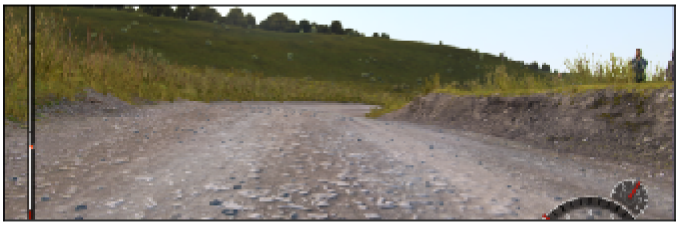
In [7]:

```
#get train and test, shuffle X and y

from random import shuffle
stay = [i for i in range(len(y))]
shuffle(stay)
X = np.array([x for _,x in sorted(zip(stay, X))])
y = np.array([x for _,x in sorted(zip(stay, y))])


data_num = len(stay)
train_ratio = 0.999
train_num = int(data_num*train_ratio)
test_num = data_num - train_num

x_train = X[:train_num]
x_test = X[train_num:]
y_train = y[:train_num]
y_test = y[train_num:]
```

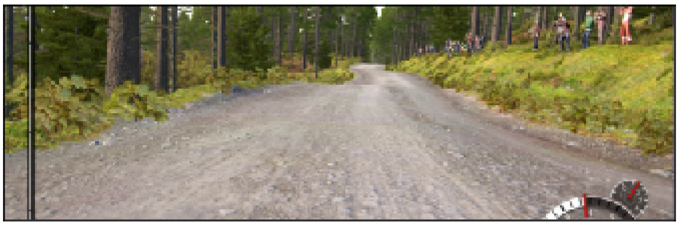
In [8]:

```
# Display the image
import matplotlib.pyplot as plt
def disp_image(im):
    if (len(im.shape) == 2):
        # Gray scale image
        plt.imshow(im, cmap=’gray’)
    else:
        # Color image.
        im1 = (im-np.min(im))/(np.max(im)-np.min(im))*255
        im1 = im1.astype(np.uint8)
        plt.imshow(im1)

    # Remove axis ticks
    plt.xticks([])
    plt.yticks([])
try:
    li
except:
    li = [i for i in range(len(X))]
shuffle(li)
for i in li[:8]:
    #plt.subplot(2, 4, i+1)
    disp_image(X[i])
    plt.title(’y = %s’ %y[i])
    plt.show()
```

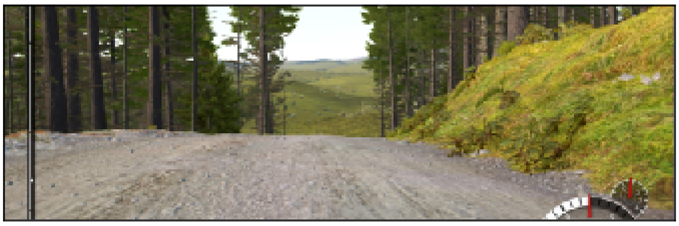
y = [-0.345 0.   ]



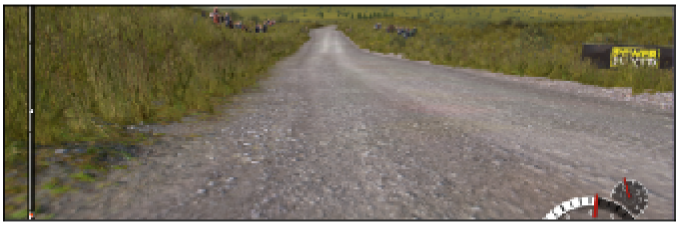
y = [0.355 0.   ]



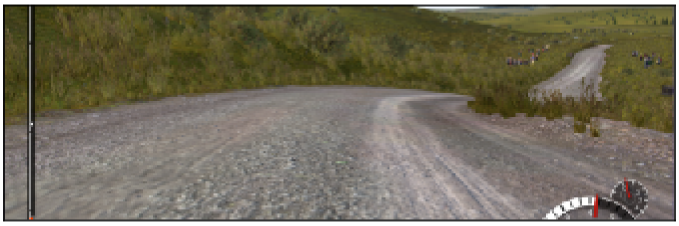
y = [0. 0.]



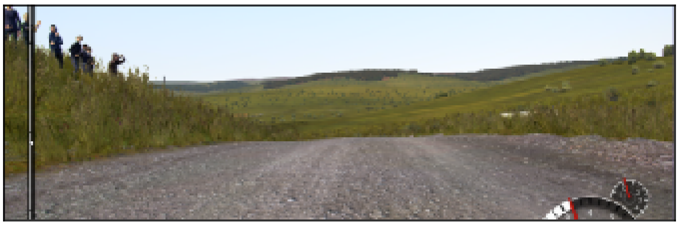
y = [-0.225 0.   ]

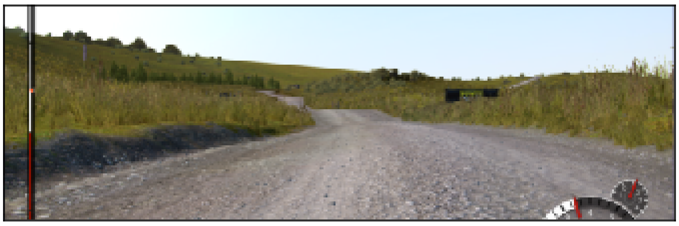


y = [0.37 0.]

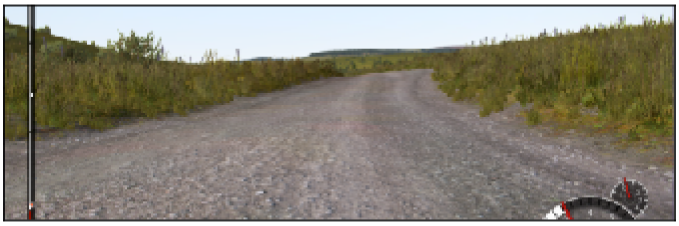


y = [0. 0.]





y = [0.31 0.]



y = [0.255 0.   ]

In [9]:

```
#get model
def create_model(keep_prob = 0.8):
    model = Sequential()

    # NVIDIA's model
    model.add(Conv2D(24, kernel_size=(5, 5), strides=(2, 2), activation='relu', input_shape= (nr
ow, ncol, 3)))
    model.add(Conv2D(36, kernel_size=(5, 5), strides=(2, 2), activation='relu'))
    model.add(Conv2D(48, kernel_size=(5, 5), strides=(2, 2), activation='relu'))
    model.add(Conv2D(64, kernel_size=(3, 3), activation='relu'))
    model.add(Conv2D(64, kernel_size=(3, 3), activation='relu'))
    model.add(Flatten())
    model.add(Dense(1164, activation='relu'))
    drop_out = 1 - keep_prob
    model.add(Dropout(drop_out))
    model.add(Dense(100, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(50, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(10, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(1, activation='softsign'))

    return model

def vgg16(keep_prob = 0.8):
    model = Sequential()

    # vgg16 model
    model.add(Conv2D(64, kernel_size=(5, 5), strides=(2, 2), activation='relu', input_shape= (nr
ow, ncol, 3)))
    model.add(Conv2D(128, kernel_size=(5, 5), strides=(2, 2), activation='relu'))
    model.add(Conv2D(256, kernel_size=(5, 5), strides=(2, 2), activation='relu'))
    model.add(Conv2D(512, kernel_size=(3, 3), activation='relu'))
    model.add(Conv2D(512, kernel_size=(3, 3), activation='relu'))
    model.add(Flatten())
    model.add(Dense(1164, activation='relu'))
    drop_out = 1 - keep_prob
    model.add(Dropout(drop_out))
    model.add(Dense(100, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(50, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(10, activation='relu'))
    model.add(Dropout(drop_out))
    model.add(Dense(1, activation='softsign'))

    return model
```

In [10]:

```
#model = vgg16()
model = create_model()
#from keras.models import load_model
#model = load_model('model.h5')
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 79, 251, 24)       1824
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 38, 124, 36)       21636
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 17, 60, 48)        43248
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 15, 58, 64)        27712
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 13, 56, 64)        36928
_________________________________________________________________
flatten_1 (Flatten)          (None, 46592)             0
_________________________________________________________________
dense_1 (Dense)              (None, 1164)              54234252
_________________________________________________________________
dropout_1 (Dropout)          (None, 1164)              0
_________________________________________________________________
dense_2 (Dense)              (None, 100)               116500
_________________________________________________________________
dropout_2 (Dropout)          (None, 100)               0
_________________________________________________________________
dense_3 (Dense)              (None, 50)                5050
_________________________________________________________________
dropout_3 (Dropout)          (None, 50)                0
_________________________________________________________________
dense_4 (Dense)              (None, 10)                510
_________________________________________________________________
dropout_4 (Dropout)          (None, 10)                0
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 11
=================================================================
Total params: 54,487,671
Trainable params: 54,487,671
Non-trainable params: 0
_________________________________________________________________
```

In [11]:

```
#mae

y_mean = np.mean(y[:, 0])
worst_mae = np.mean(abs(y[:, 0] - y_mean))
print('worst mae:', worst_mae)
```

```
worst mae: 0.22529522822
```

In [12]:

```
#background
import keras.backend as K
K.clear_session()

# Call the fit function
epochs = 7
batch_size = 50

model = create_model()
model.compile(loss='mean_squared_error', metrics=['mean_absolute_error'], optimizer=optimizers.A
dadelta())
model.fit(x_train, y_train[:, 0], batch_size=batch_size, epochs=epochs, shuffle=True, validation
_split=0.1)
#[:, 0]
model.save('model_20171216_dirt4.h5')




#X[:, :, :, None]for grey versionp
```

```
Train on 12163 samples, validate on 1352 samples
Epoch 1/7
12163/12163 [==============================] - 87s 7ms/step - loss: 0.1054 - mean_
absolute_error: 0.2291 - val_loss: 0.0522 - val_mean_absolute_error: 0.1754
Epoch 2/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0435 - mean_
absolute_error: 0.1567 - val_loss: 0.0344 - val_mean_absolute_error: 0.1398
Epoch 3/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0349 - mean_
absolute_error: 0.1393 - val_loss: 0.0331 - val_mean_absolute_error: 0.1363
Epoch 4/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0309 - mean_
absolute_error: 0.1309 - val_loss: 0.0410 - val_mean_absolute_error: 0.1575
Epoch 5/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0280 - mean_
absolute_error: 0.1253 - val_loss: 0.0344 - val_mean_absolute_error: 0.1425
Epoch 6/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0237 - mean_
absolute_error: 0.1157 - val_loss: 0.0370 - val_mean_absolute_error: 0.1467
Epoch 7/7
12163/12163 [==============================] - 65s 5ms/step - loss: 0.0207 - mean_
absolute_error: 0.1076 - val_loss: 0.0340 - val_mean_absolute_error: 0.1381
```

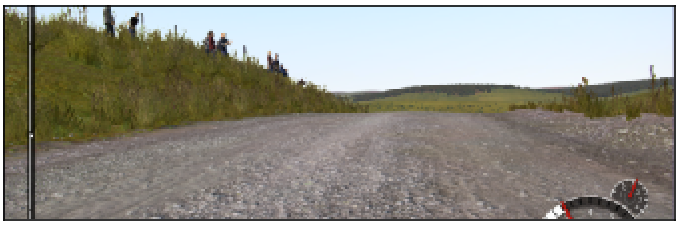
In [13]:

```
#model.fit(X, y[:, 0], batch_size=batch_size, epochs=1, shuffle=True, validation_split=0.1)
```

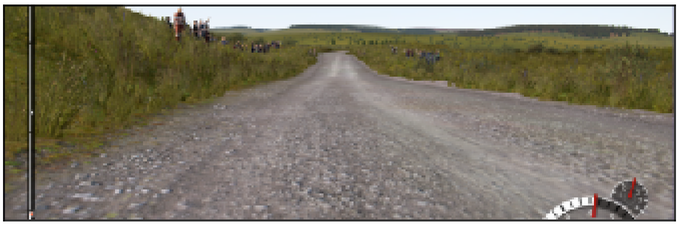
In [14]:

```
# Display the image with prediction result
import matplotlib.pyplot as plt
def disp_image(im):
    if (len(im.shape) == 2):
        # Gray scale image
        plt.imshow(im, cmap=’gray’)
    else:
        # Color image.
        im1 = (im-np.min(im))/(np.max(im)-np.min(im))*255
        im1 = im1.astype(np.uint8)
        plt.imshow(im1)

    # Remove axis ticks
    plt.xticks([])
    plt.yticks([])

for i in range(test_num):
    #plt.subplot(2, 4, i+1)
    disp_image(x_test[i])
    yhat = model.predict(x_test[None, i])[0]
    plt.title(’y = %s, yhat = %s’ %(y_test[i], yhat))
    plt.show()
```

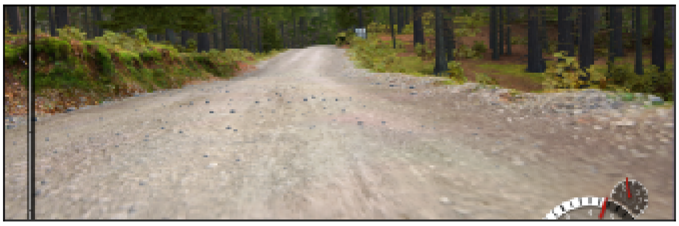
y = [0.27 0.], yhat = [0.43003002]



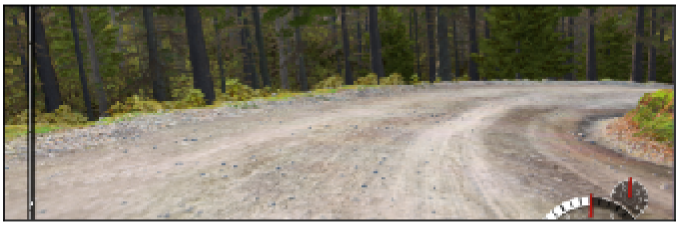
y = [0. 0.], yhat = [-0.00590411]



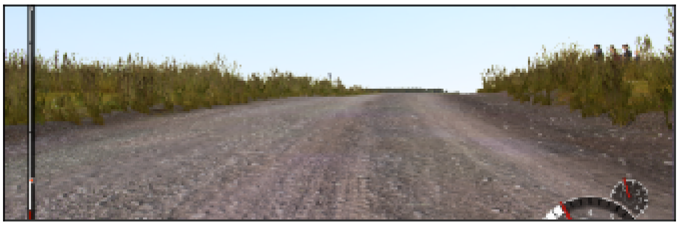
y = [0.025 0.   ], yhat = [-0.11889084]



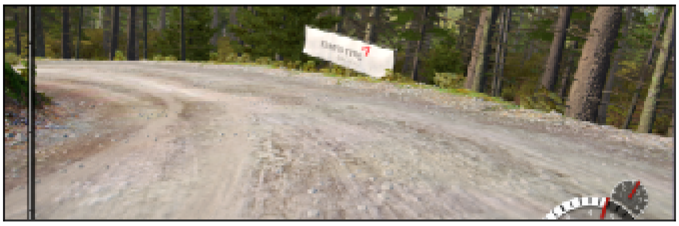
y = [0.8 0.], yhat = [0.47079498]



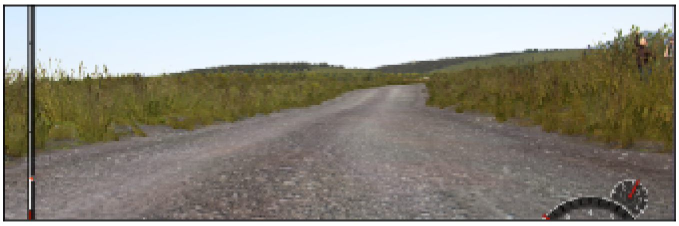
y = [0.395 0.   ], yhat = [0.15470238]



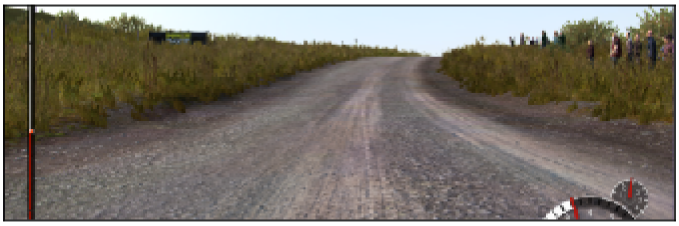
y = [-0.395 0.   ], yhat = [-0.37881956]



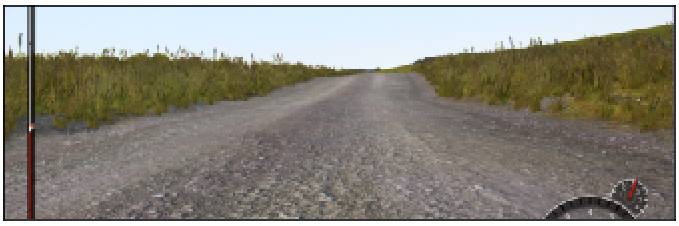
y = [0.015 0.   ], yhat = [0.09158894]



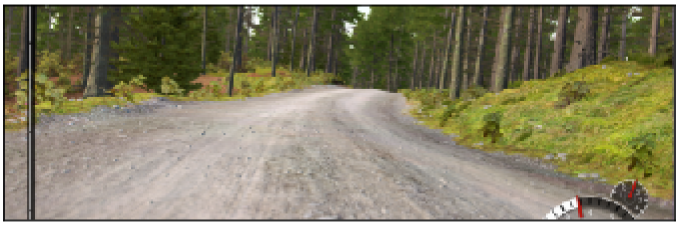
y = [0.27 0.], yhat = [0.228155]



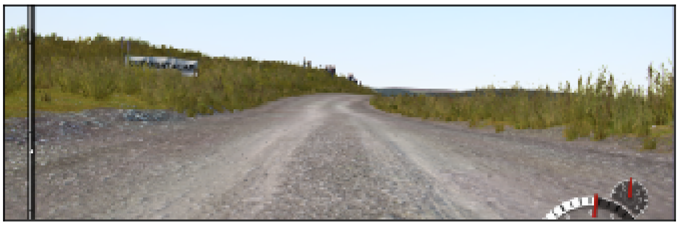
y = [0.21 0.], yhat = [0.01528017]



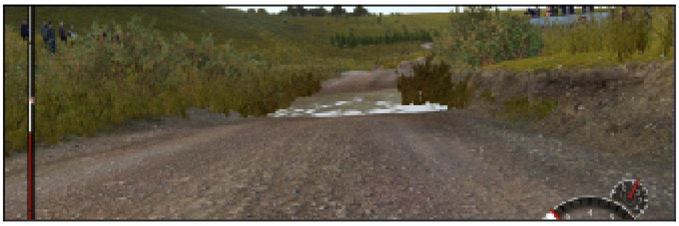
y = [0. 0.], yhat = [-0.22963995]

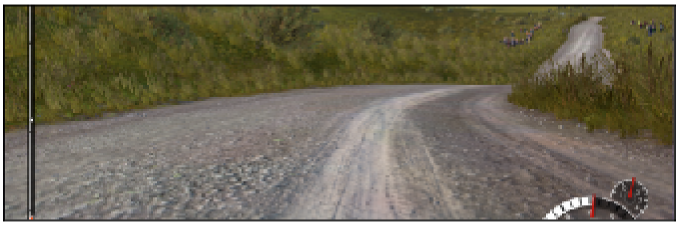


y = [-0.295 0.   ], yhat = [-0.23679118]

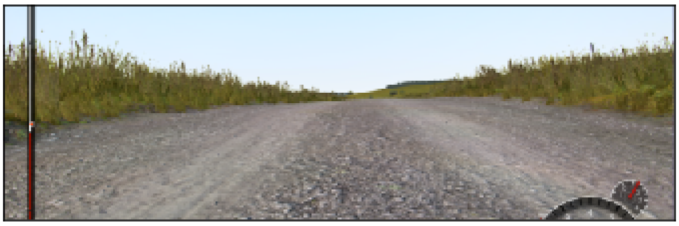


y = [0. 0.], yhat = [0.23385073]





y = [0.785 0.   ], yhat = [0.36670211]



y = [0. 0.], yhat = [0.11820682]