```
!nvidia-smi

Wed May  1 22:42:00 2024
+-----------------------------------------------------------------------------
--------+
| NVIDIA-SMI 525.89.02    Driver Version: 525.89.02    CUDA Version:
12.0     |
|-------------------------------+----------------------
+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile
Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util
Compute M. |
|                               |                      |
MIG M. |
|
===============================+======================+===============
=======|
|   0  NVIDIA A100-PCI...  On   | 00000000:17:00.0 Off |
0 |
| N/A   26C    P0    31W / 250W |      0MiB / 40960MiB |      0%
Default |
|                               |                      |
Disabled |
+-------------------------------+----------------------
+----------------------+


+-----------------------------------------------------------------------------
--------+
| Processes:
|
|  GPU   GI   CI        PID   Type   Process name                  GPU
Memory |
|        ID   ID
Usage      |
|
=============================================================================
=======|
|  No running processes found
|
+-----------------------------------------------------------------------------
--------+

import os
import numpy as np
from PIL import Image as IM
import glob
import matplotlib.pyplot as plt
import os
```

```
import h5py  # Import HDF5 support
import keras
from keras import layers
import io
import imageio
from IPython.display import Image, display
from ipywidgets import widgets, Layout, HBox
import tensorflow as tf
from tensorflow.keras.utils import Sequence
```

```
2024-05-01 22:42:02.060762: I
tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow
binary is optimized with oneAPI Deep Neural Network Library (oneDNN)
to use the following CPU instructions in performance-critical
operations:  AVX512_VNNI
To enable them in other operations, rebuild TensorFlow with the
appropriate compiler flags.
2024-05-01 22:42:02.207850: I tensorflow/core/util/port.cc:104] oneDNN
custom operations are on. You may see slightly different numerical
results due to floating-point round-off errors from different
computation orders. To turn them off, set the environment variable
`TF_ENABLE_ONEDNN_OPTS=0`.
```

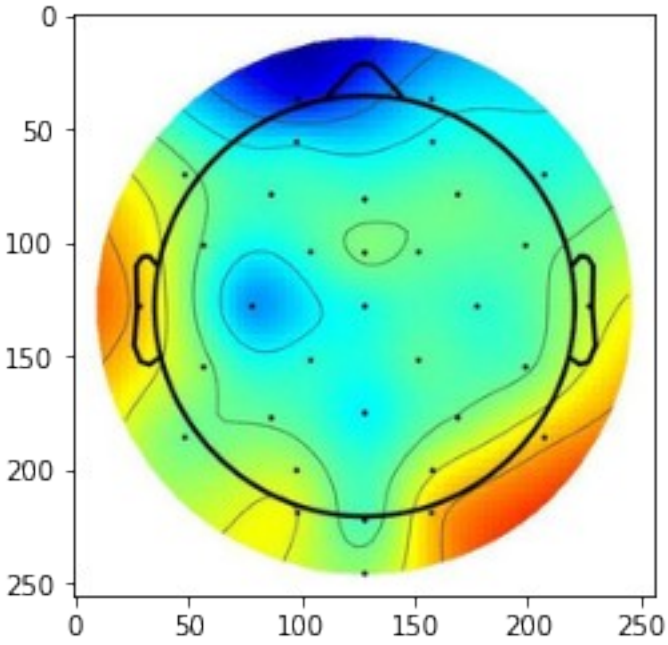
```
# fpath =
'/projects/academic/courses/cse676s24/dsingh27/CVIP/CNNLSTM/dataset/
dataset/preprocessed_data/preprocessed_dataResized100Frames.npy'
fpath =
'/projects/academic/courses/cse676s24/dsingh27/CVIP/CNNLSTM/dataset/
dataset/preprocessed_data/1003_500sec_8epoch.hdf5'
# dataset = np.load(fpath)

with h5py.File(fpath, 'r') as h5f:

    dataset = h5f['data'][:]

dataset.shape
```

```
(500, 8, 256, 256, 3)
```

```
# dataset = dataset[:100]

# # Generate an array of indices and shuffle it
# indicesTemp = np.arange(len(dataset))
# np.random.shuffle(indicesTemp)

# # Select the first 500 indices from the shuffled array
# selected_indices = indicesTemp[:400]

# # Create a new dataset with these selected indices
# datasetCopy = dataset[selected_indices]
```

```
plt.imshow(dataset[1][5])
```

```
<matplotlib.image.AxesImage at 0x14fffc890af0>
```




```
dataset.shape, dataset[0].shape
```

```
((500, 8, 256, 256, 3), (8, 256, 256, 3))
```

```
np.max(dataset)
```

```
1.0
```

```
# dataset = dataset.astype('float32') / 255.0
# batch_size = 25
# for start in range(0, dataset.shape[0], batch_size):
#     end = start + batch_size
#     dataset[start:end][:] = (dataset[start:end]
[:]).astype('float32') / 255.0

indexes = np.arange(dataset.shape[0])
np.random.shuffle(indexes)

train_index = indexes[:int(0.8 * len(dataset))]
val_index = indexes[int(0.8 * len(dataset)): int(0.9 * len(dataset))]
test_index = indexes[int(0.9 * len(dataset)):]

def create_shifted_frames(data):
    x = data[:, :-1, :, :, :]
    y = data[:, 1:, :, :, :]
    return x, y
```

```
# def create_shifted_frames(data):
#     x = data[:, :-8, :, :, :]
#     y = data[:, 8:, :, :, :]
#     return x, y

class DataGenerator(Sequence):
    def __init__(self, file_path, dataset_name, indexes,
batch_size=1):
        self.file_path = file_path
        self.dataset_name = dataset_name
        self.indexes = indexes
        self.batch_size = batch_size

    def __len__(self):
        # Return the number of batches per epoch
        return int(np.ceil(len(self.indexes) / self.batch_size))

    def __getitem__(self, index):
        # Generate one batch of data
        start = index * self.batch_size
        end = min((index + 1) * self.batch_size, len(self.indexes))
        batch_indexes = self.indexes[start:end]

        # Initialize arrays for X (features) and y (labels)
        x, y = [], []
        with h5py.File(self.file_path, 'r') as f:
            # Extract a batch of data using the specified indexes
            batch = f[self.dataset_name][batch_indexes]
            x, y = create_shifted_frames(batch)

        return np.array(x), np.array(y)

    def on_epoch_end(self):
        # Updates indexes after each epoch
        np.random.shuffle(self.indexes)

file_path2 =
'/projects/academic/courses/cse676s24/dsingh27/CVIP/CNNLSTM/dataset/
dataset/preprocessed_data/cleanedData500Best.hdf5'
data_name = 'cleaned_data'

# Save the dataset and indices to an HDF5 file
with h5py.File(file_path2, 'w') as f:
    # Create a dataset in the file for the main dataset
    f.create_dataset(data_name, data=dataset, compression='gzip')
    # Create datasets in the file for the indices
    f.create_dataset('train_index', data=train_index,
compression='gzip')
    f.create_dataset('val_index', data=val_index, compression='gzip')
```

```
    f.create_dataset('test_index', data=test_index,
compression='gzip')



# Load the indices from the HDF5 file
with h5py.File(file_path2, 'r') as f:
    train_index = f['train_index'][:]
    val_index = f['val_index'][:]
    test_index = f['test_index'][:]

# Instantiate the DataGenerators with the data name and indexes
train_generator = DataGenerator(file_path2, data_name, train_index,
batch_size=1)
val_generator = DataGenerator(file_path2, data_name, val_index,
batch_size=1)
test_generator = DataGenerator(file_path2, data_name, test_index,
batch_size=1)

# import tracemalloc

# # Start tracing the memory allocation
# tracemalloc.start()

# train_generator = DataGenerator(dataset[train_index], batch_size=1)
# val_generator = DataGenerator(dataset[val_index], batch_size=1)
# test_generator = DataGenerator(dataset[test_index], batch_size=1)

# snapshot = tracemalloc.take_snapshot()
# top_stats = snapshot.statistics('lineno')

# print("[ Top 10 ]")
# for stat in top_stats[:10]:
#     print(stat)

# # Stop the tracemalloc before ending the program
# tracemalloc.stop()

sample_batch_x, _ = train_generator[0]

import keras
from keras import layers
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping,
ReduceLROnPlateau

def train_model(train_generator, val_generator, sample_batch_x):

    inp = layers.Input(shape=(None, *sample_batch_x.shape[2:]))


    x = layers.ConvLSTM2D(
```

```
        filters=64,
        kernel_size=(5, 5),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(inp)
    x = layers.BatchNormalization()(x)
    x = layers.ConvLSTM2D(
        filters=64,
        kernel_size=(3, 3),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(x)
    x = layers.BatchNormalization()(x)
    x = layers.ConvLSTM2D(
        filters=64,
        kernel_size=(1, 1),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(x)
    x = layers.Conv3D(
        filters=3,
        kernel_size=(3, 3, 3),
        activation="sigmoid",
        padding="same"
    )(x)

    # Setup the model
    model = keras.models.Model(inputs=inp, outputs=x)
    model.compile(optimizer='adam', loss='mse')

    # Callbacks for saving the model and early stopping
    checkpoint_filepath = '/tmp/checkpoint'
    model_checkpoint_callback = ModelCheckpoint(
        filepath=checkpoint_filepath,
        save_weights_only=True,
        monitor='val_loss',
        mode='min',
        save_best_only=True)
    early_stopping_callback = EarlyStopping(monitor='val_loss',
patience=5, restore_best_weights=True)
    reduce_lr_callback = ReduceLROnPlateau(monitor='val_loss',
patience=3)

    # Train the model
    model.fit(
        train_generator,
        epochs=40,
```

```
        validation_data=val_generator,
        callbacks=[model_checkpoint_callback, early_stopping_callback,
reduce_lr_callback]
    )
    return model

# Usage of the function to train the model
model = train_model(train_generator, val_generator, sample_batch_x)
```

```
2024-05-01 18:42:40.892637: I
tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow
binary is optimized with oneAPI Deep Neural Network Library (oneDNN)
to use the following CPU instructions in performance-critical
operations:  AVX512_VNNI
To enable them in other operations, rebuild TensorFlow with the
appropriate compiler flags.
2024-05-01 18:42:41.313794: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1613] Created
device /job:localhost/replica:0/task:0/device:GPU:0 with 38422 MB
memory:  -> device: 0, name: NVIDIA A100-PCIE-40GB, pci bus id:
0000:17:00.0, compute capability: 8.0

Epoch 1/40

2024-05-01 18:42:54.866252: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:428] Loaded
cuDNN version 8600
2024-05-01 18:43:03.173714: I
tensorflow/compiler/xla/service/service.cc:173] XLA service
0x151bf6462970 initialized for platform CUDA (this does not guarantee
that XLA will be used). Devices:
2024-05-01 18:43:03.173802: I
tensorflow/compiler/xla/service/service.cc:181]   StreamExecutor
device (0): NVIDIA A100-PCIE-40GB, Compute Capability 8.0
2024-05-01 18:43:03.178549: I
tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:268]
disabling MLIR crash reproducer, set env var
`MLIR_CRASH_REPRODUCER_DIRECTORY` to enable.
2024-05-01 18:43:03.303684: I
tensorflow/compiler/jit/xla_compilation_cache.cc:477] Compiled cluster
using XLA!  This line is logged at most once for the lifetime of the
process.

400/400 [==============================] - 599s 1s/step - loss: 0.0181
- val_loss: 0.0793 - lr: 0.0010
Epoch 2/40
400/400 [==============================] - 580s 1s/step - loss: 0.0104
- val_loss: 0.0121 - lr: 0.0010
Epoch 3/40
400/400 [==============================] - 581s 1s/step - loss: 0.0093
```

```
- val_loss: 0.0143 - lr: 0.0010
Epoch 4/40
400/400 [==============================] - 612s 2s/step - loss: 0.0088
- val_loss: 0.0099 - lr: 0.0010
Epoch 5/40
400/400 [==============================] - 611s 2s/step - loss: 0.0085
- val_loss: 0.0188 - lr: 0.0010
Epoch 6/40
400/400 [==============================] - 618s 2s/step - loss: 0.0084
- val_loss: 0.0101 - lr: 0.0010
Epoch 7/40
400/400 [==============================] - 686s 2s/step - loss: 0.0081
- val_loss: 0.0118 - lr: 0.0010
Epoch 8/40
400/400 [==============================] - 607s 2s/step - loss: 0.0074
- val_loss: 0.0089 - lr: 1.0000e-04
Epoch 9/40
400/400 [==============================] - 606s 2s/step - loss: 0.0074
- val_loss: 0.0088 - lr: 1.0000e-04
Epoch 10/40
400/400 [==============================] - 607s 2s/step - loss: 0.0073
- val_loss: 0.0088 - lr: 1.0000e-04
Epoch 11/40
400/400 [==============================] - 600s 2s/step - loss: 0.0073
- val_loss: 0.0088 - lr: 1.0000e-04
Epoch 12/40
400/400 [==============================] - 603s 2s/step - loss: 0.0072
- val_loss: 0.0091 - lr: 1.0000e-04
Epoch 13/40
400/400 [==============================] - 609s 2s/step - loss: 0.0071
- val_loss: 0.0089 - lr: 1.0000e-05
Epoch 14/40
400/400 [==============================] - 617s 2s/step - loss: 0.0071
- val_loss: 0.0088 - lr: 1.0000e-05

path_to_save_weights = 'CNNLSTM100Samplesv4_8Frames.h5'

# Save the model weights
model.save_weights(path_to_save_weights)

---------------------------------------------------------------------
-----
NameError                                 Traceback (most recent call
last)
/scratch/15688973/ipykernel_363022/317367386.py in <module>
      2
      3 # Save the model weights
----> 4 model.save_weights(path_to_save_weights)

NameError: name 'model' is not defined
```

```
import keras
from keras import layers
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping,
ReduceLROnPlateau

def create_model(sample_batch_x):
    inp = layers.Input(shape=(None, *sample_batch_x.shape[2:]))

    x = layers.ConvLSTM2D(
        filters=64,
        kernel_size=(5, 5),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(inp)
    x = layers.BatchNormalization()(x)
    x = layers.ConvLSTM2D(
        filters=64,
        kernel_size=(3, 3),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(x)
    x = layers.BatchNormalization()(x)
    x = layers.ConvLSTM2D(
        filters=64,
        kernel_size=(1, 1),
        padding="same",
        return_sequences=True,
        activation="relu",
    )(x)
    x = layers.Conv3D(
        filters=3,
        kernel_size=(3, 3, 3),
        activation="sigmoid",
        padding="same"
    )(x)

    model = keras.models.Model(inputs=inp, outputs=x)
    model.compile(optimizer='adam', loss='mse')

    return model

# Load the model with the same architecture
# sample_batch_x = None  # Make sure to set this with the correct
shape that matches training
model = create_model(sample_batch_x)

# Path to your saved weights
path_to_saved_weights = 'CNNLSTM100Samplesv4_8Frames.h5'
```

```
# Load the weights
model.load_weights(path_to_saved_weights)

# Now your model is ready to make predictions
```

Direct Brain Map for Binaural prediction for 1 second from model weights

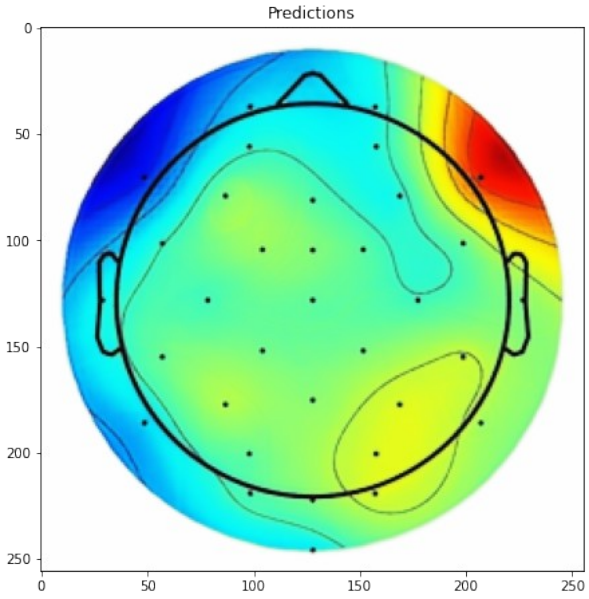
```
test_x, test_y = next(iter(test_generator))
predictions = model.predict(test_x)
```

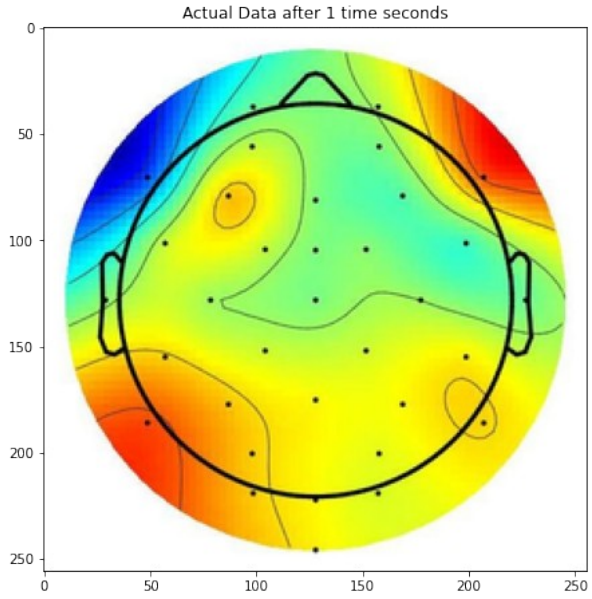
```
2024-05-01 22:57:37.319973: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:428] Loaded
cuDNN version 8600

1/1 [==============================] - 10s 10s/step
```

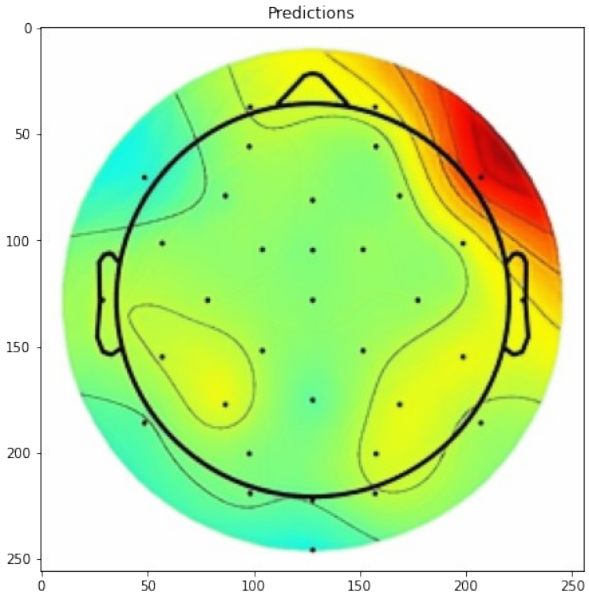
For the next time step the regenration of brain Map quality looks Good, but the contours are not as per the actual, but the quality becomes worse as we move forward to next timesteps

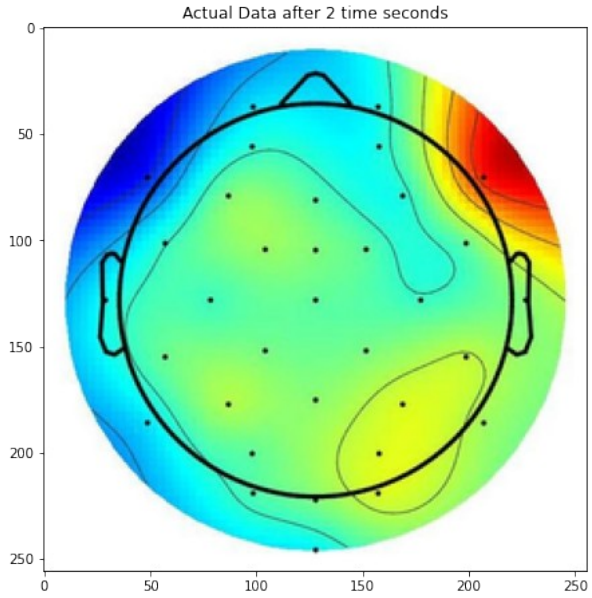
```
x = dataset[:, :-1, :, :, :]
y =  dataset[:, 1:, :, :, :]
reshaped_x = x[0].reshape((1, 7, 256, 256, 3))
reshaped_y = y[0].reshape((1, 7, 256, 256, 3))
pred = reshaped_x

for i in range(2):
    pred = model.predict(pred)
for i in range(7):
    fig, axs = plt.subplots(1, 2, figsize=(16, 8))

    axs[0].imshow(pred[0][i])
    axs[0].set_title('Predictions')

    axs[1].imshow(reshaped_y[0][i])
    axs[1].set_title(f'Actual Data after {i + 1} time seconds')


    plt.show()
```

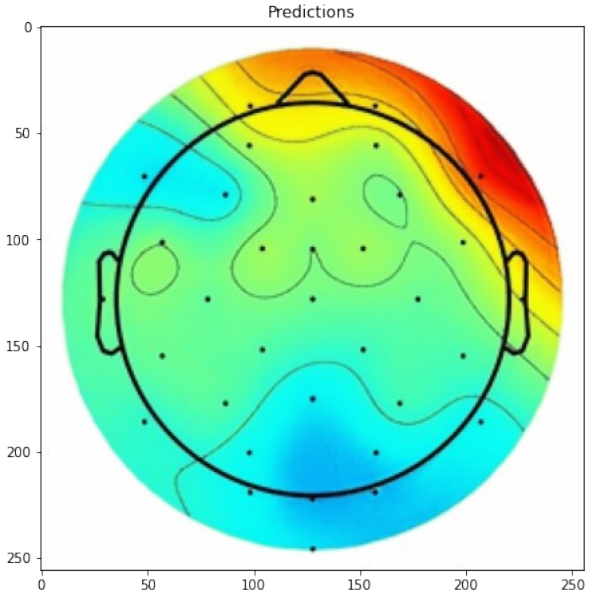
```
1/1 [==============================] - 0s 41ms/step
1/1 [==============================] - 0s 31ms/step
```

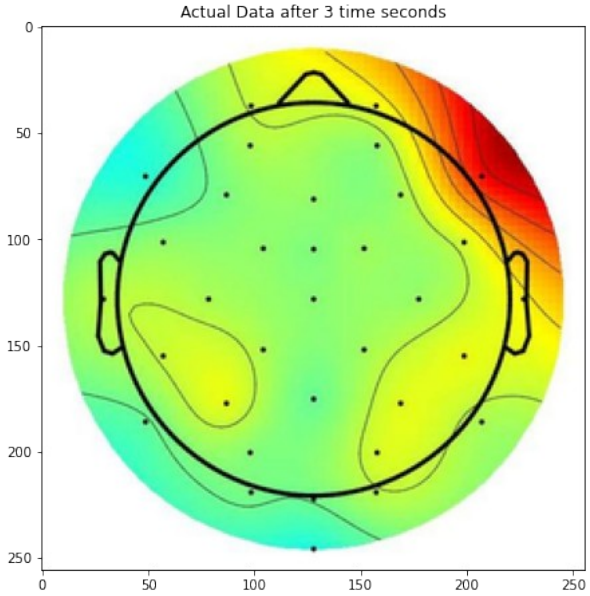


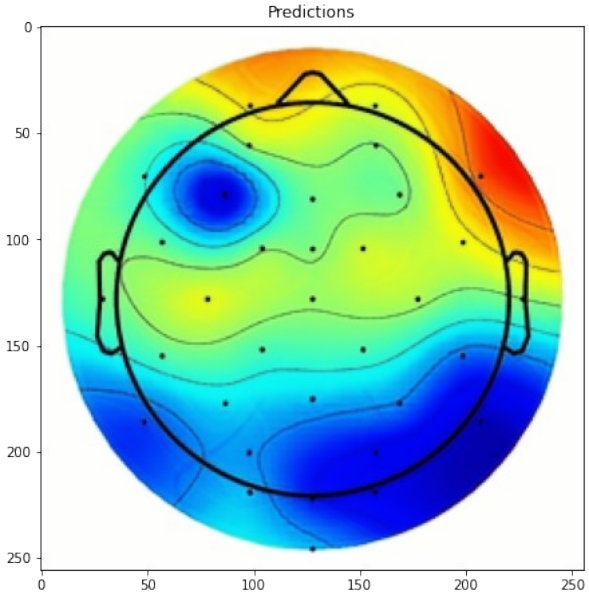


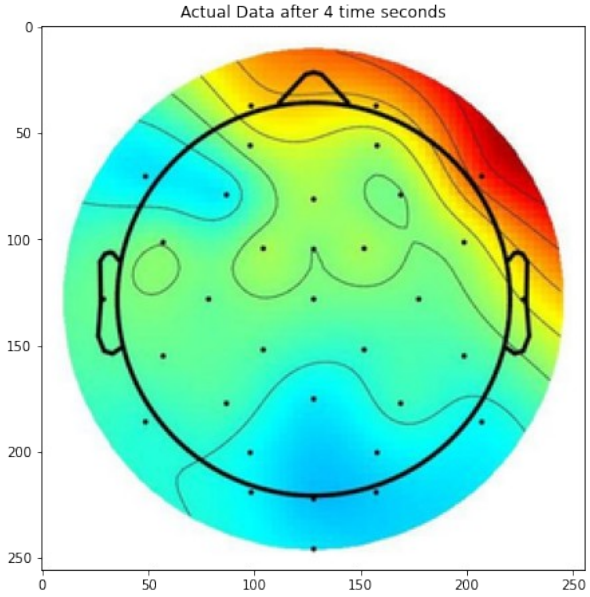


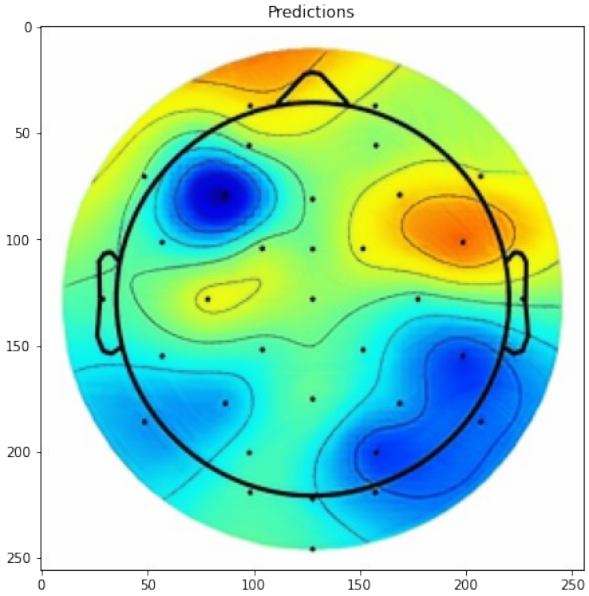


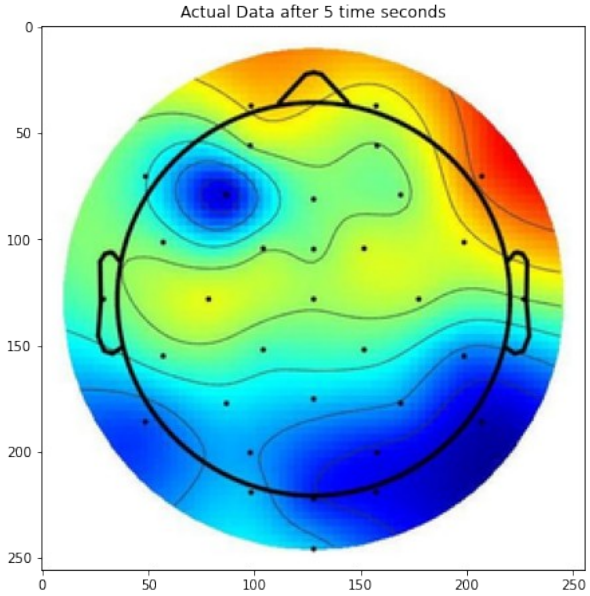

Predictions
0
50
100
150
200
250
0
50
100
150
200
250

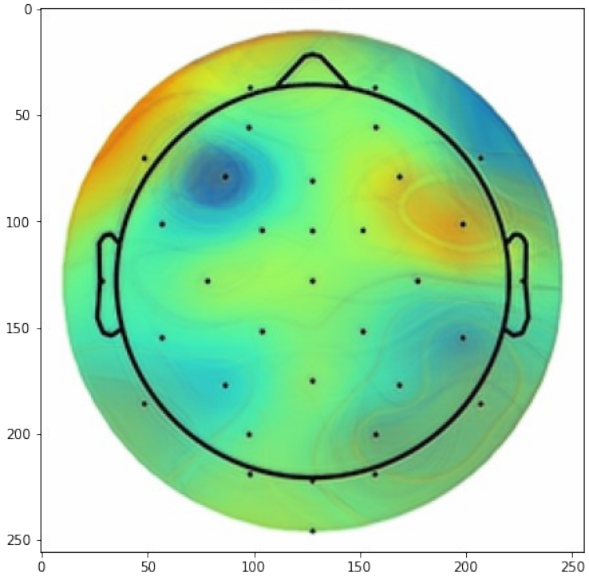

Actual Data after 3 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

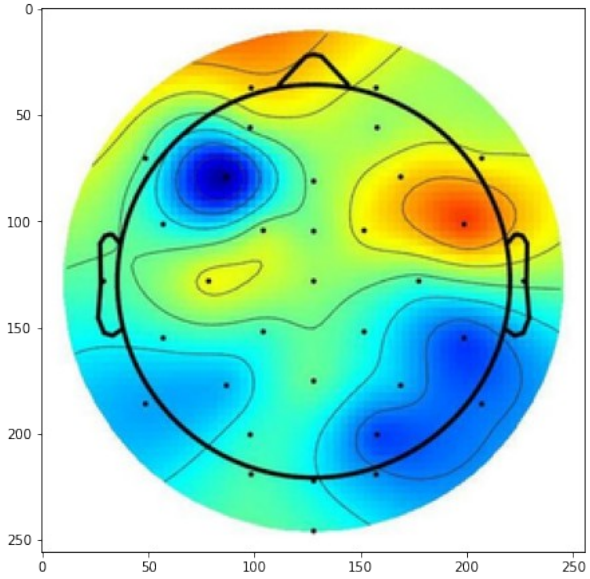

Predictions
0
50
100
150
200
250
0
50
100
150
200
250

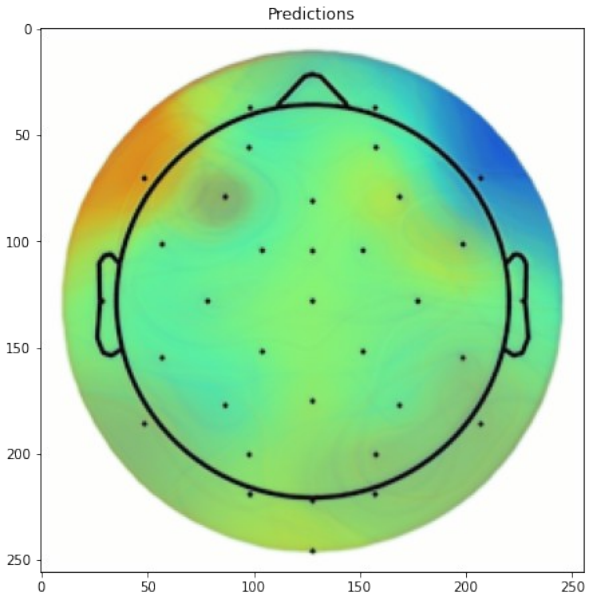

Actual Data after 4 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

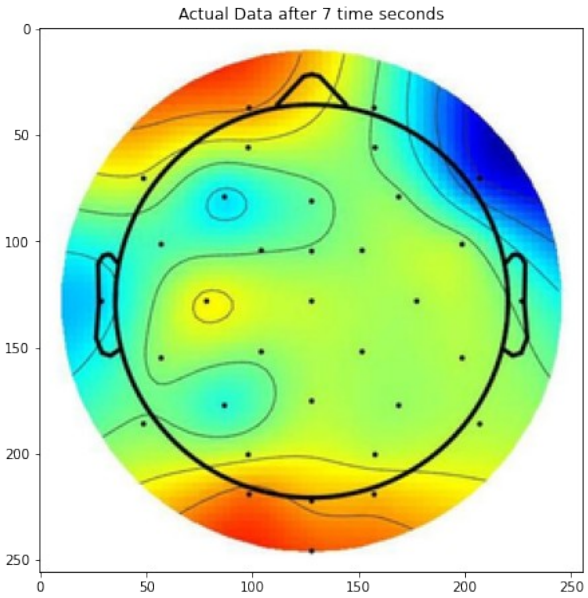

Predictions
0
50
100
150
200
250
0
50
100
150
200
250


Actual Data after 5 time seconds
0
50
100
150
200
250
0
50
100
150
200
250


Predictions
0
50
100
150
200
250
0
50
100
150
200
250


Actual Data after 6 time seconds
0
50
100
150
200
250
0
50
100
150
200
250





7 timeseconds Brain Map prediction

```
test_x, test_y = next(iter(test_generator))
test_x.shape
```

```
(1, 7, 256, 256, 3)
```

```
test_y.shape
```

```
(1, 7, 256, 256, 3)
```

```
x = dataset[:, :-1, :, :, :]

reshaped_x = x[0].reshape((1, 7, 256, 256, 3))

reshaped_y = x[1].reshape((1, 7, 256, 256, 3))

pred = reshaped_x
# test_x, test_y = next(iter(test_generator))
# predictions = model.predict(test_x)
# pred = predictions
for i in range(1):
    pred = model.predict(pred)
```

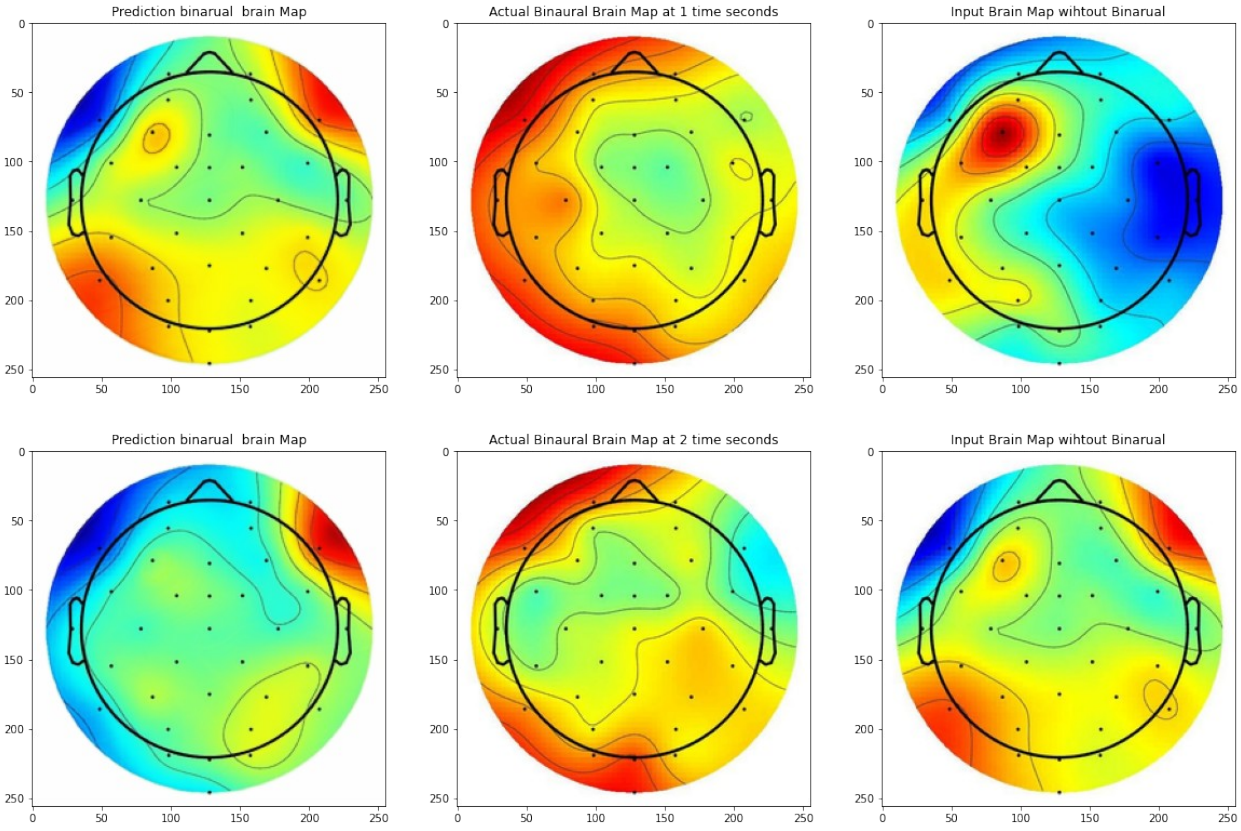
```
1/1 [==============================] - 0s 43ms/step
```

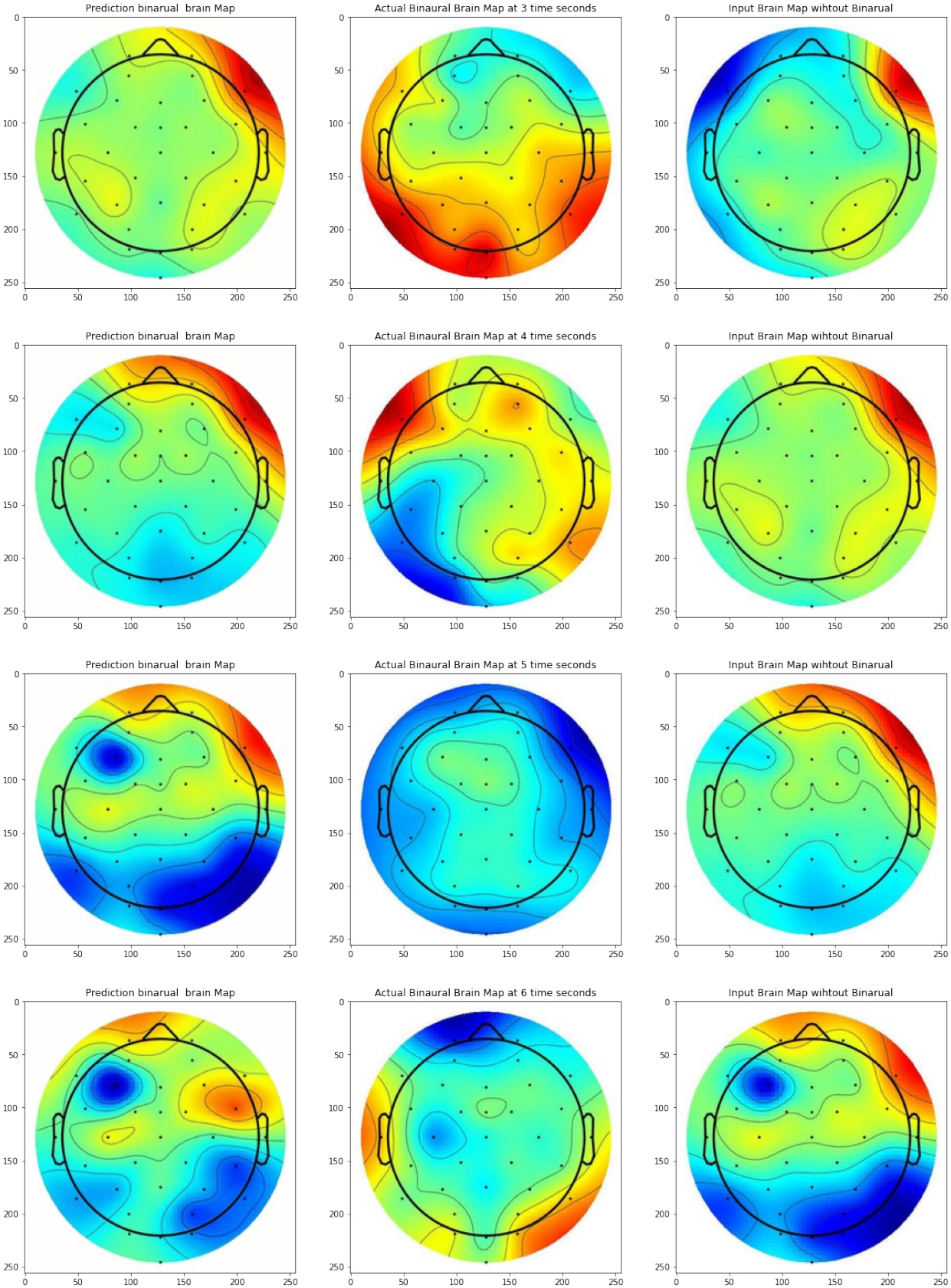
```
pred.shape
```

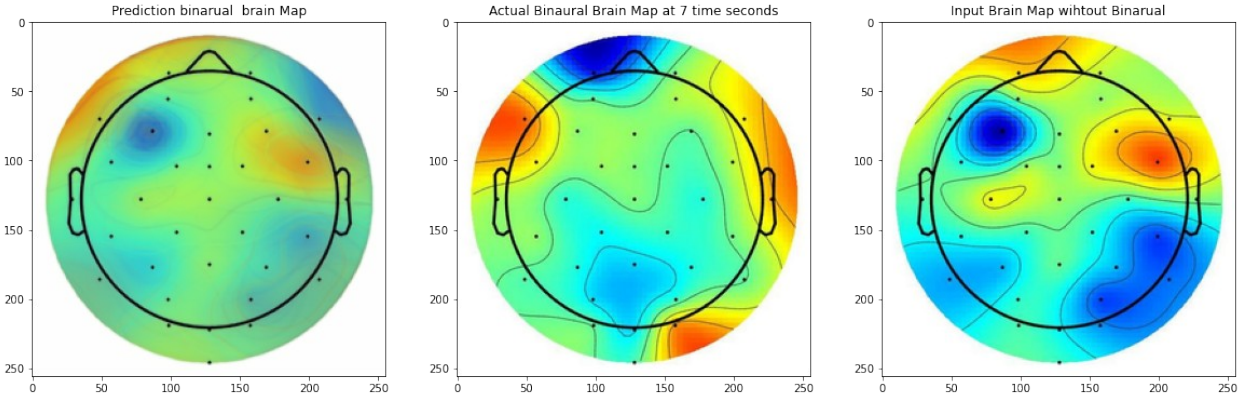
```
(1, 7, 256, 256, 3)
```

```
for i in range(7):
```

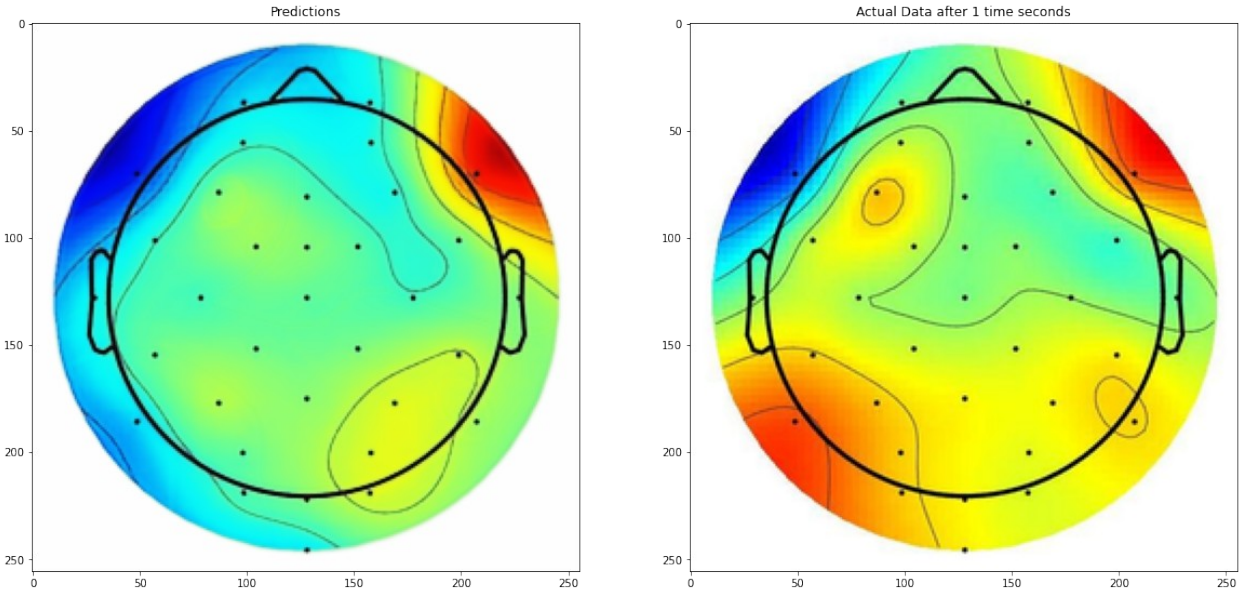
```
    fig, axs = plt.subplots(1, 3, figsize=(20, 10))  # Increase figure
size here

    # Plot the first image (prediction) on the left
    axs[0].imshow(pred[0][i])
    axs[0].set_title('Prediction binarual  brain Map')

    # Plot the second image (actual data) in the middle
    axs[1].imshow(reshaped_y[0][i])
    axs[1].set_title(f'Actual Binaural Brain Map at {i + 1} time
seconds')

    # Plot the third image (input data) on the right
    axs[2].imshow(reshaped_x[0][i])
    axs[2].set_title('Input Brain Map wihtout Binarual')

    plt.show()
```

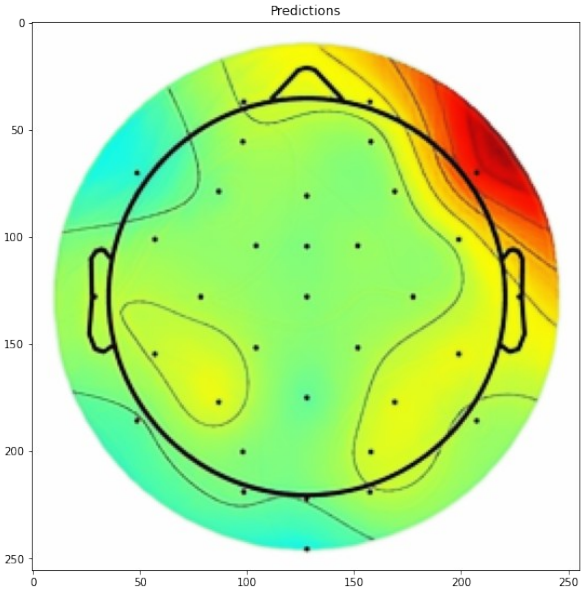


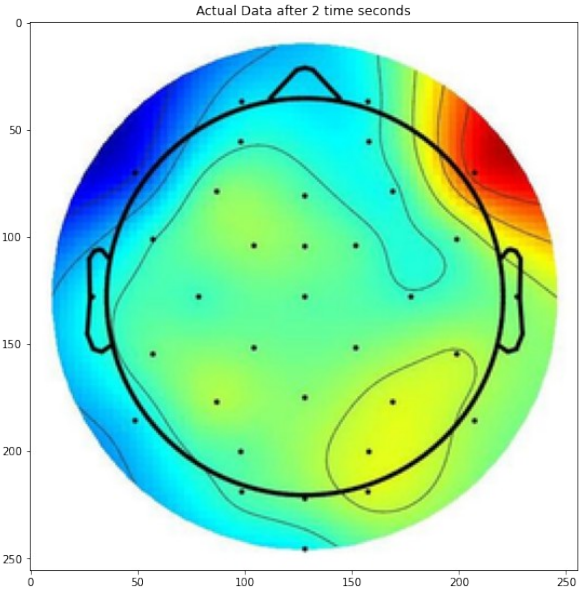

Prediction binarual brain Map
Actual Binaural Brain Map at 3 time seconds
Input Brain Map wihtout Binarual
Prediction binarual brain Map
Actual Binaural Brain Map at 4 time seconds
Input Brain Map wihtout Binarual
Prediction binarual brain Map
Actual Binaural Brain Map at 5 time seconds
Input Brain Map wihtout Binarual
Prediction binarual brain Map
Actual Binaural Brain Map at 6 time seconds
Input Brain Map wihtout Binarual

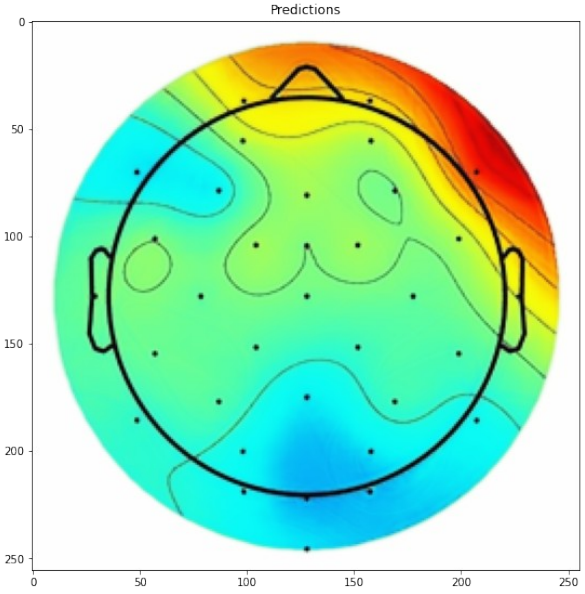


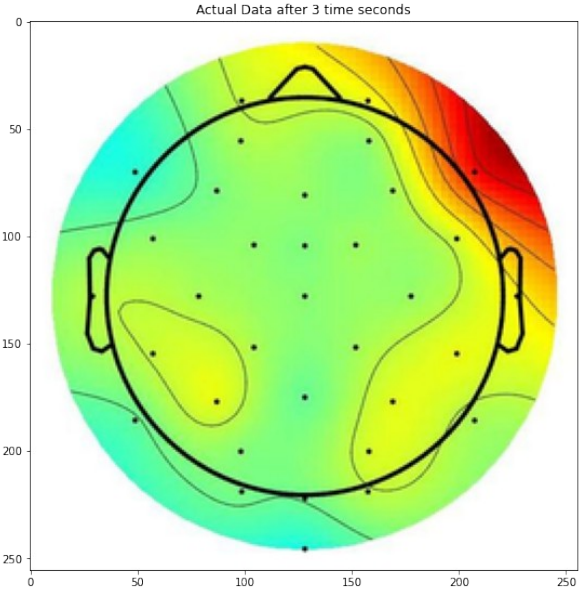

```
1/1 [==============================] - 0s 40ms/step
1/1 [==============================] - 0s 32ms/step
```

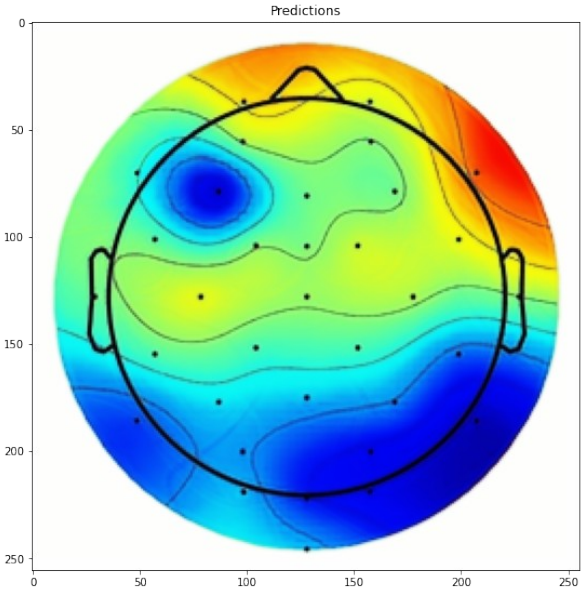


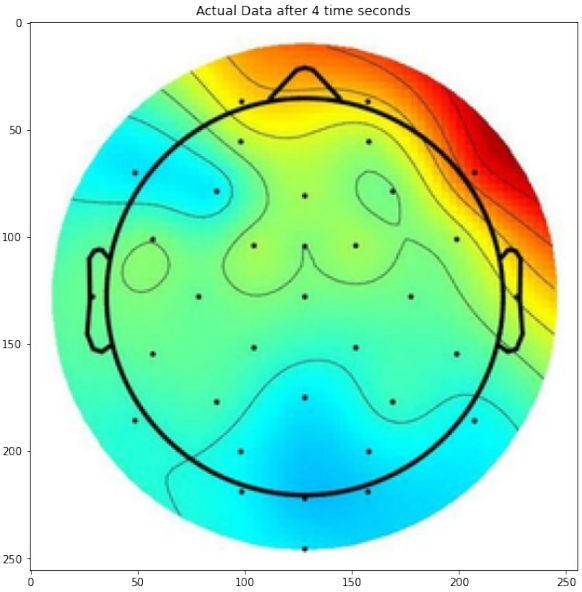

Predictions
0
50
100
150
200
250
0
50
100
150
200
250

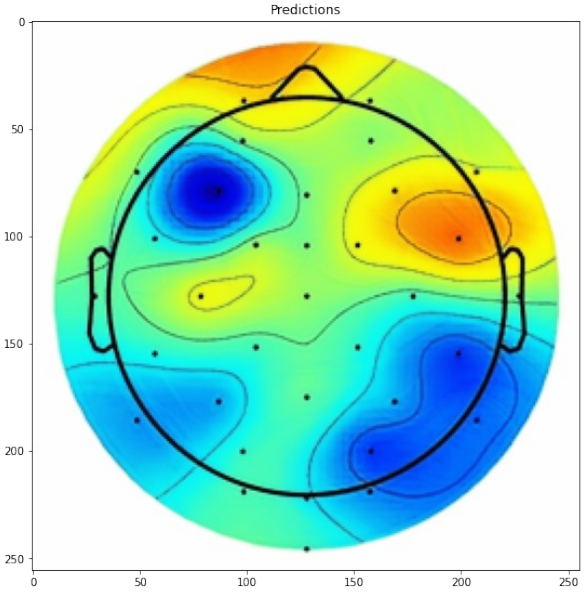

Actual Data after 2 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

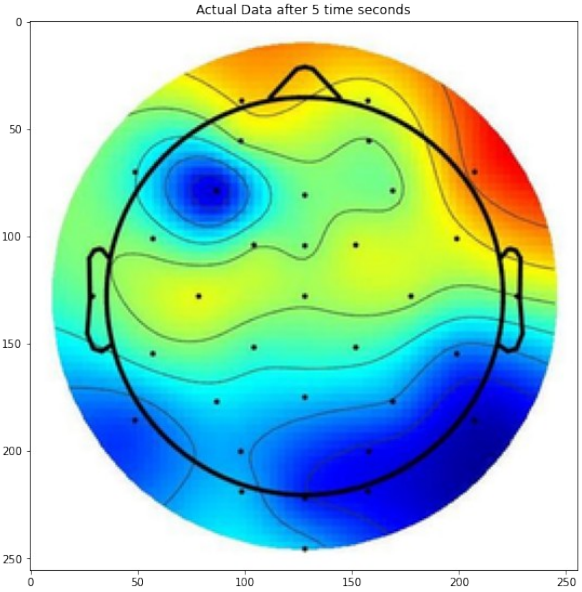

Predictions
0
50
100
150
200
250
0
50
100
150
200
250

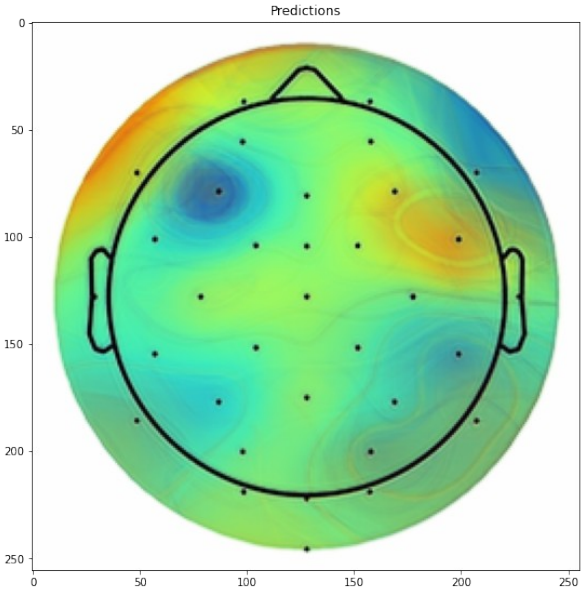

Actual Data after 3 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

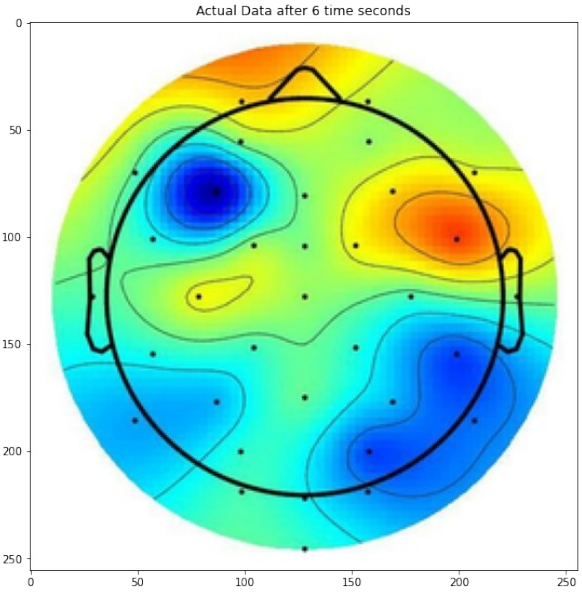

Predictions
0
50
100
150
200
250
0
50
100
150
200
250

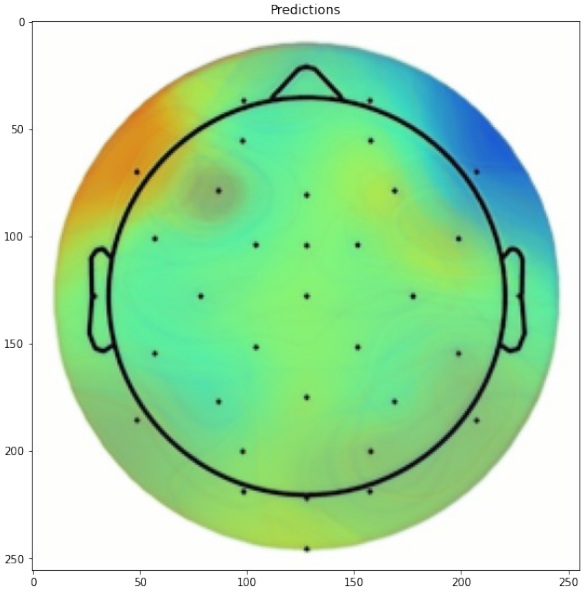

Actual Data after 4 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

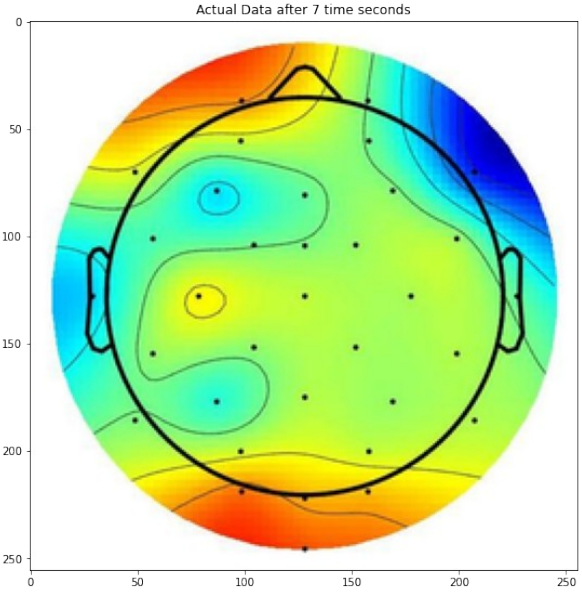

Predictions
0
50
100
150
200
250
0
50
100
150
200
250


Actual Data after 5 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

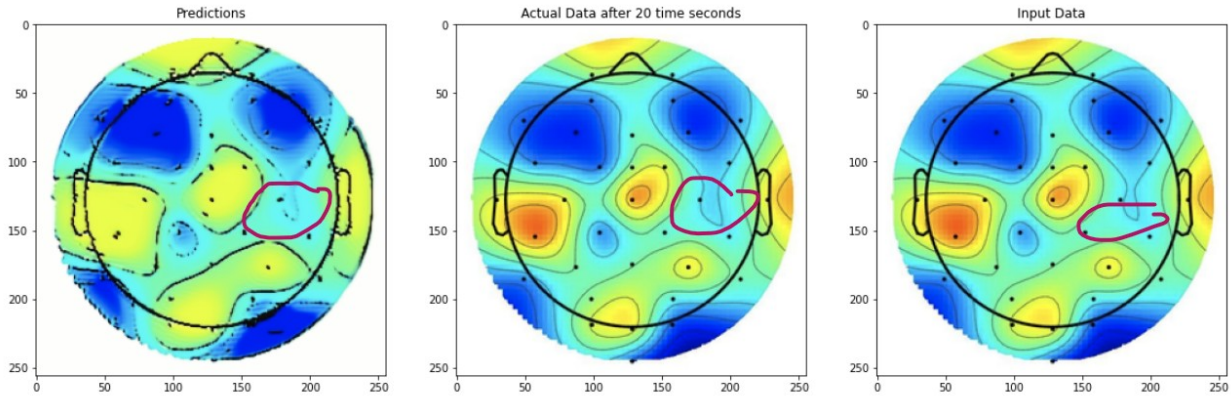

Predictions
0
50
100
150
200
250
0
50
100
150
200
250


Actual Data after 6 time seconds
0
50
100
150
200
250
0
50
100
150
200
250


Predictions
0
50
100
150
200
250
0
50
100
150
200
250

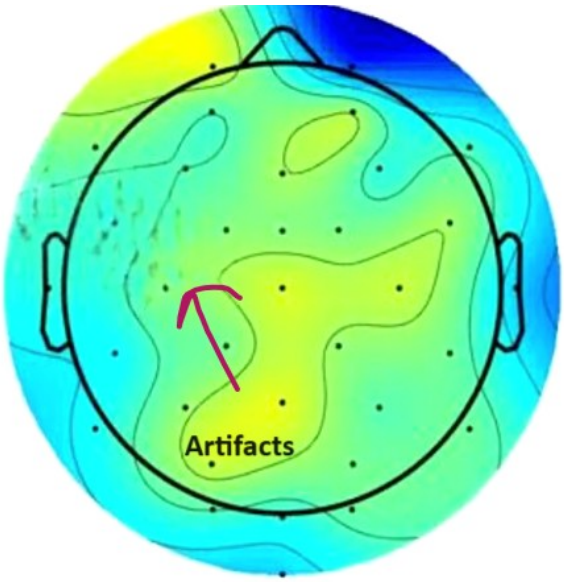

Actual Data after 7 time seconds
0
50
100
150
200
250
0
50
100
150
200
250

Now looking closely at the below image, it can be seen that the model is predicting the same frame (look at the contour, the contour mapping is neraly same as the input Data), instead of predicting future timestamps. Major reason for this is that brain Map donot change significantly over time

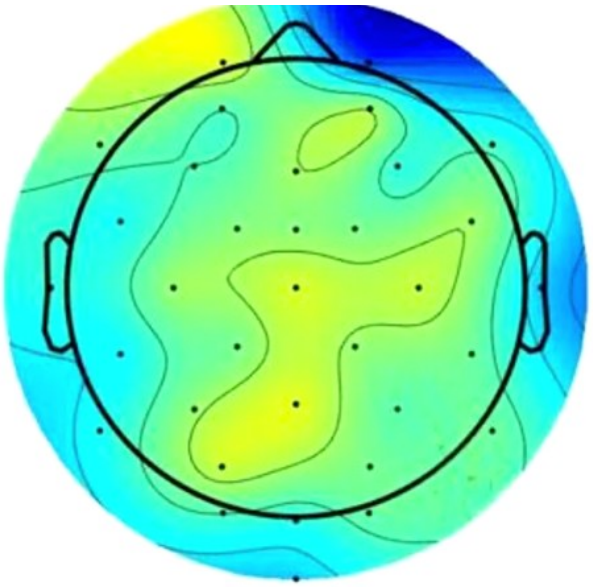


We Tried implementing the same model by leveraging the Condtional GAN version referring to below paper. We observed the same issue that the image generated for next timestep remained same. Also there were significants artifacts getting generated in the model.

https://medium.com/@jctestud/video-generation-with-pix2pix-aed5b1b69f57



Frame generated at T+0 timestep



Frame Generated at T+15 timestep/ second