



ML - Space Debris Motions

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Section 1

Poincaré Map

```
def fx(x0, y0, t0, h, eps):  
    y1 = y0 + h * (-eps * (np.sin(x0) + np.sin(x0 - t0)))  
    x1 = (x0 + h * y1) % TWOPI  
    t1 = t0 + h  
  
    return x1, y1, t1
```

```
# rotational motion
```

```
x0_a = PI  
y0_a = 1.4  
t0_a = 0
```

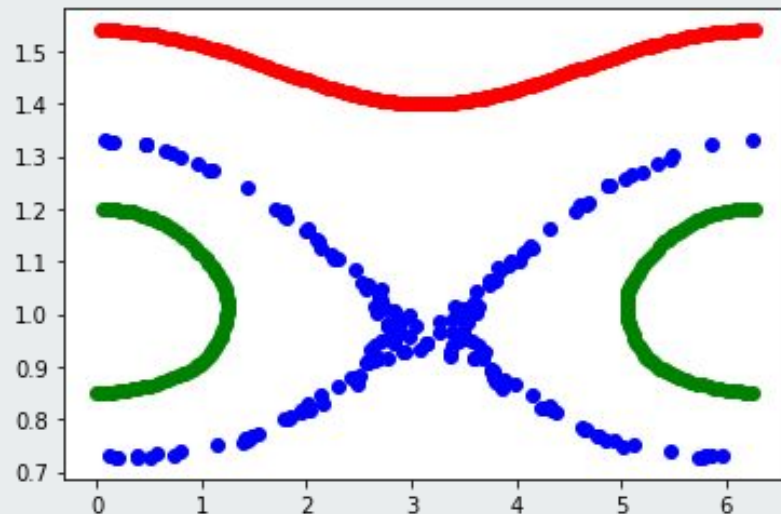
```
# libration motion
```

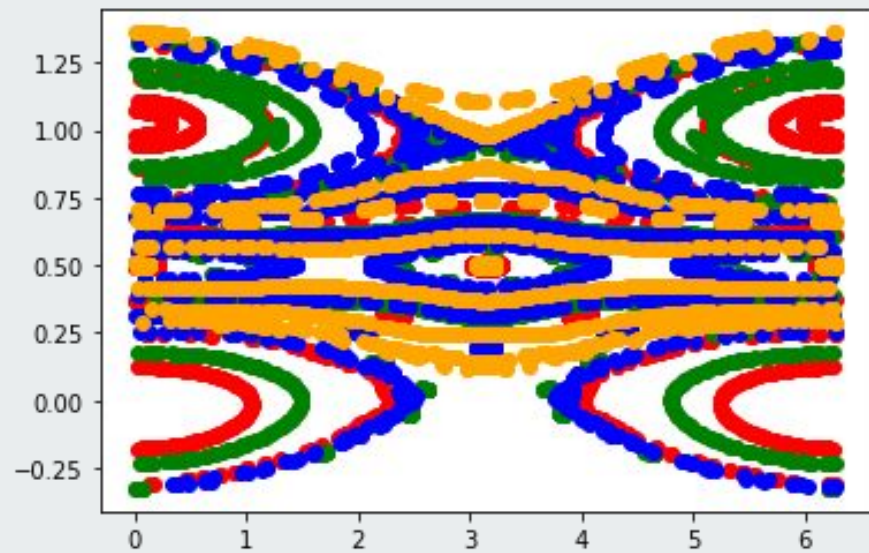
```
x0_b = 0.1  
y0_b = 1.2  
t0_b = 0
```

```
# chaotic motion
```

```
x0_c = PI  
y0_c = 0.945  
t0_c = 0
```

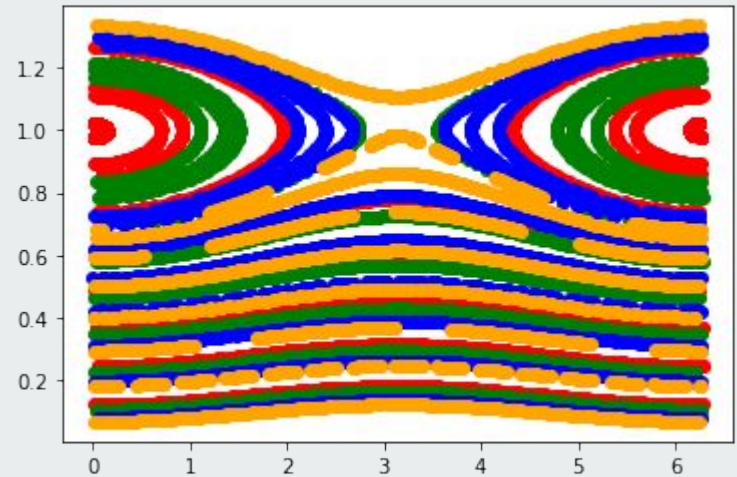
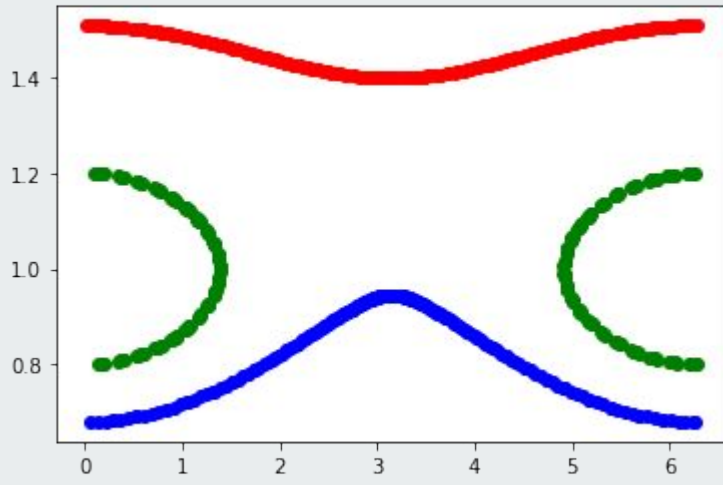
```
h = TWOPI / 1e3  
eps = 0.025  
xVec = []  
xVec.append(x0_a)  
yVec = []  
yVec.append(y0_a)  
tVec = []  
tVec.append(t0_a)  
poinMap_a = []  
poinMap_a.append([x0_a, y0_a])  
  
for ii in range(200000):  
    x1, y1, t1 = fx(xVec[-1], yVec[-1], tVec[-1], h, eps)  
    xVec.append(x1)  
    yVec.append(y1)  
    tVec.append(t1)  
  
    if ii % 1000 == 0:  
        poinMap_a.append([x1, y1])
```



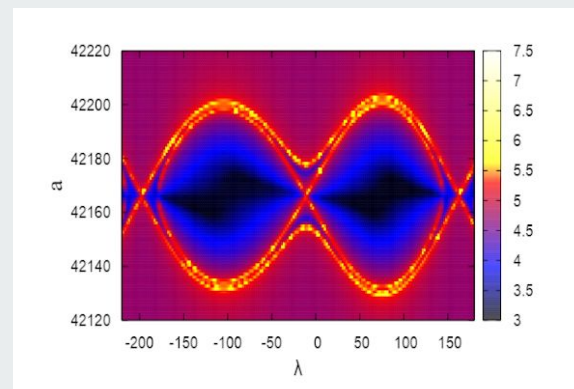
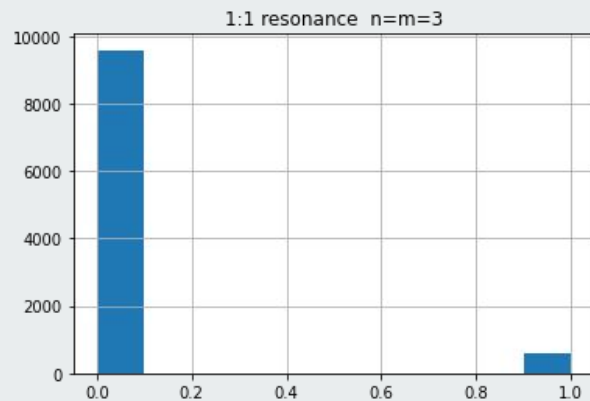
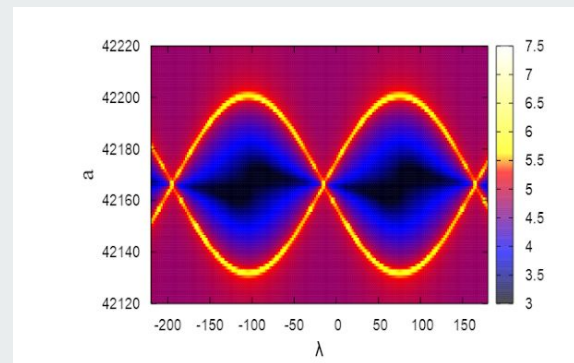
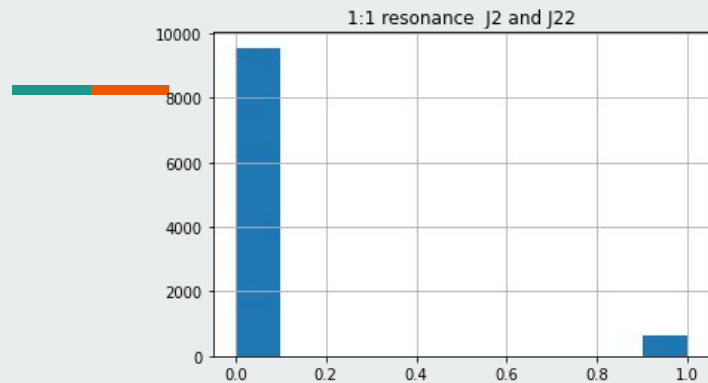


Section 1 - Playing with the Dynamics

```
def fx(x0, y0, t0, h, eps):  
    # y1 = y0 + h * (-eps * (np.sin(x0)))  
    y1 = y0 + h * (-eps * (np.sin(x0 - t0)))  
    x1 = (x0 + h * y1) % TWOPI  
    t1 = t0 + h  
  
    return x1, y1, t1
```

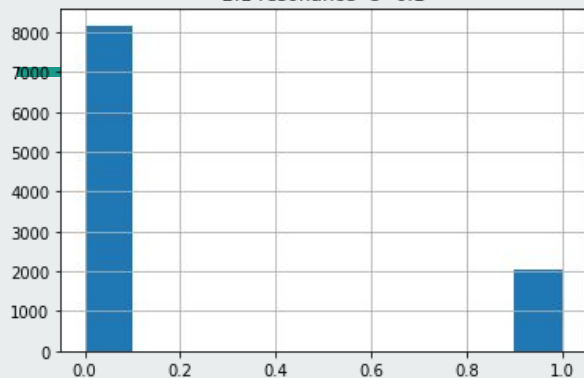


Regular vs Chaos - 1:1 Resonance

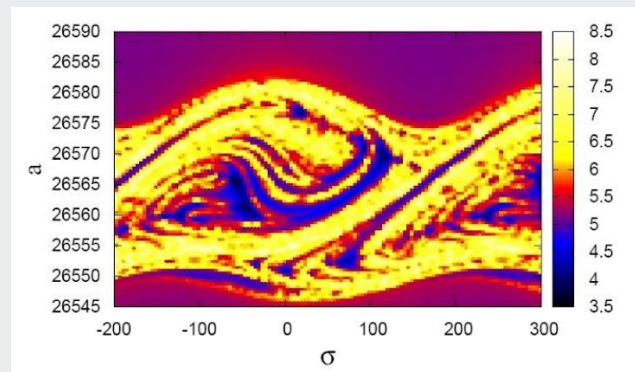
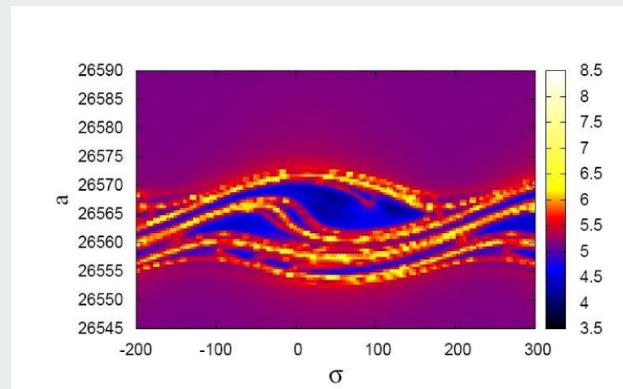
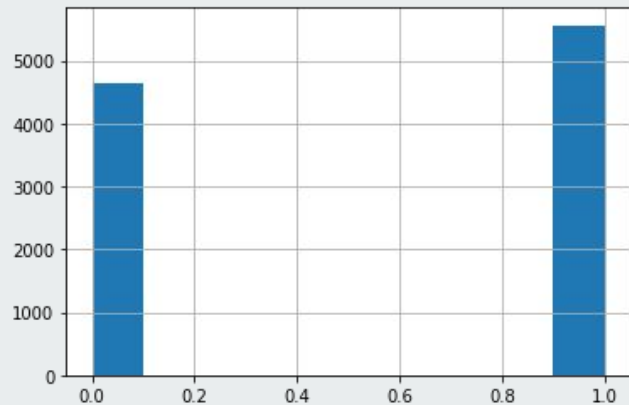


Regular vs Chaos - 2:1 Resonance

2:1 resonance $e=0.1$



2:1 resonance $e=0.5$





Training Design

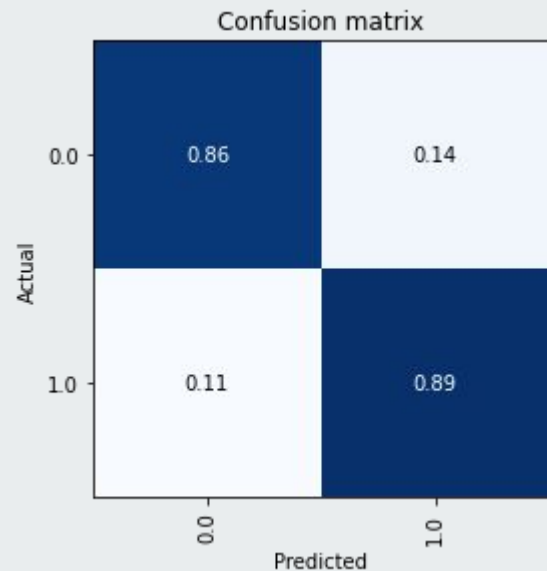
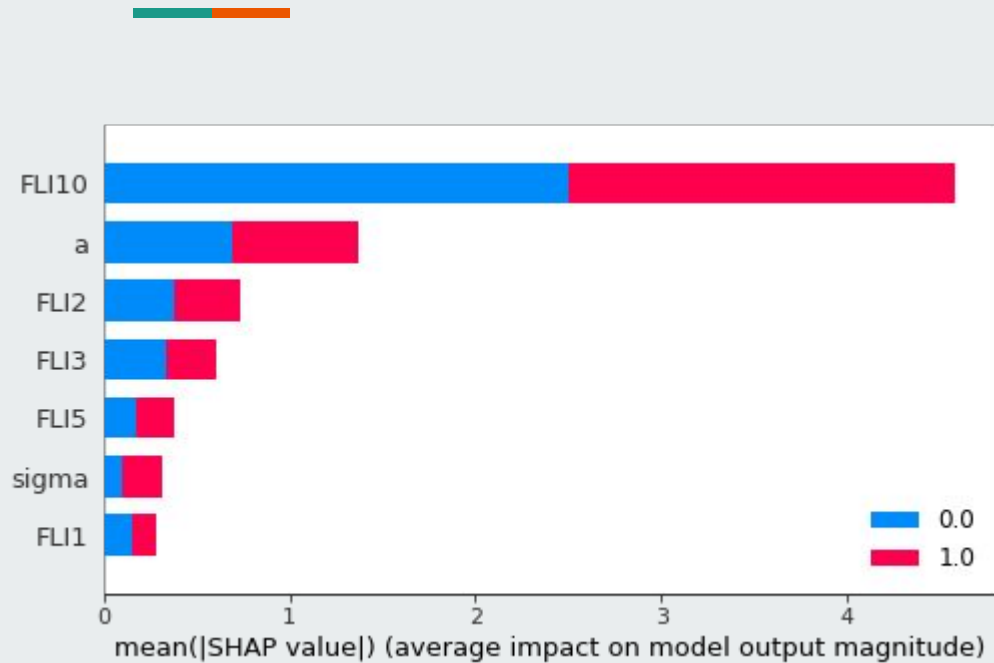
Batch size = 64. Reducing it leads to better results

Layers reduced to [100, 50] from [200, 100]. Faster and more stable training, less prone to overfitting.

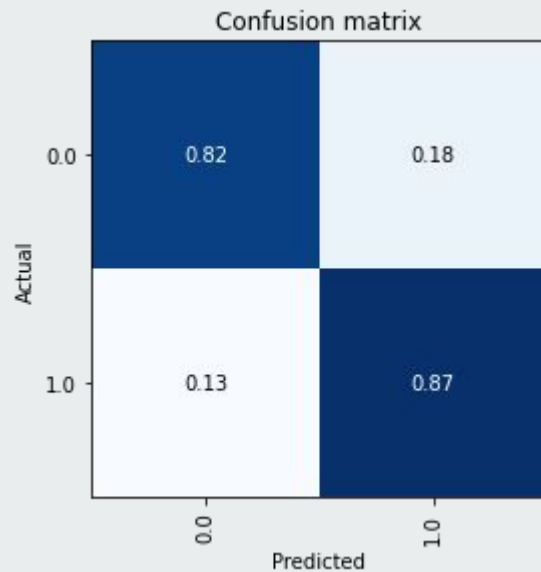
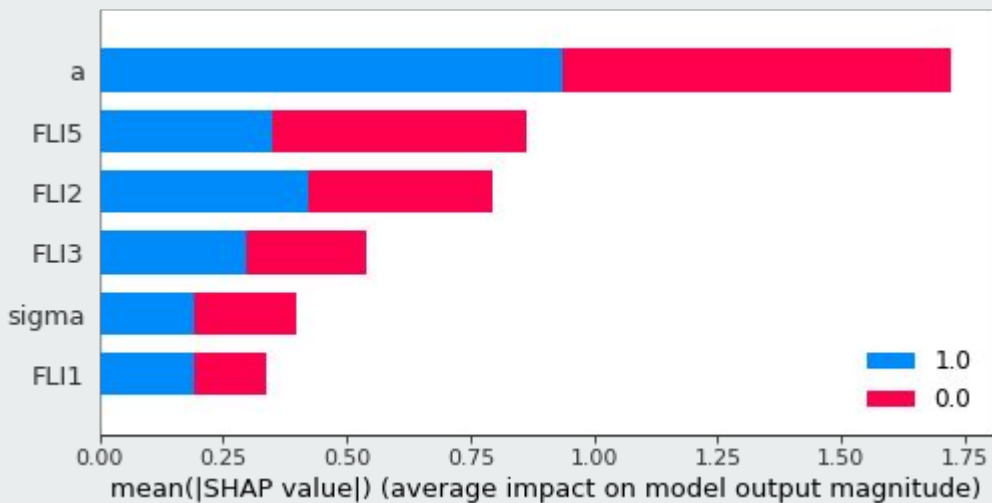
Steepest learning rate used.

5 epochs for training.

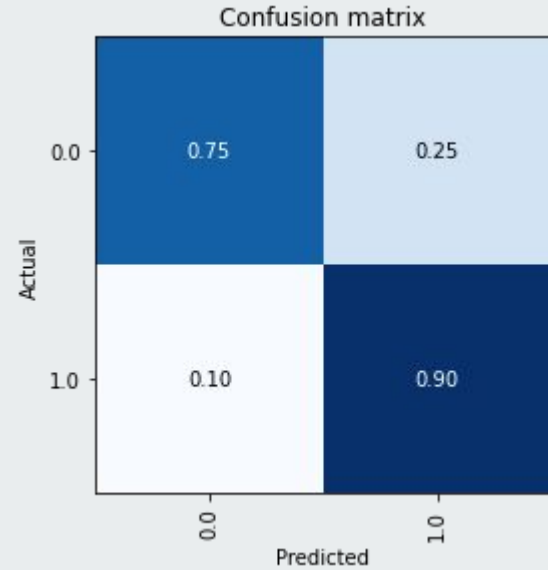
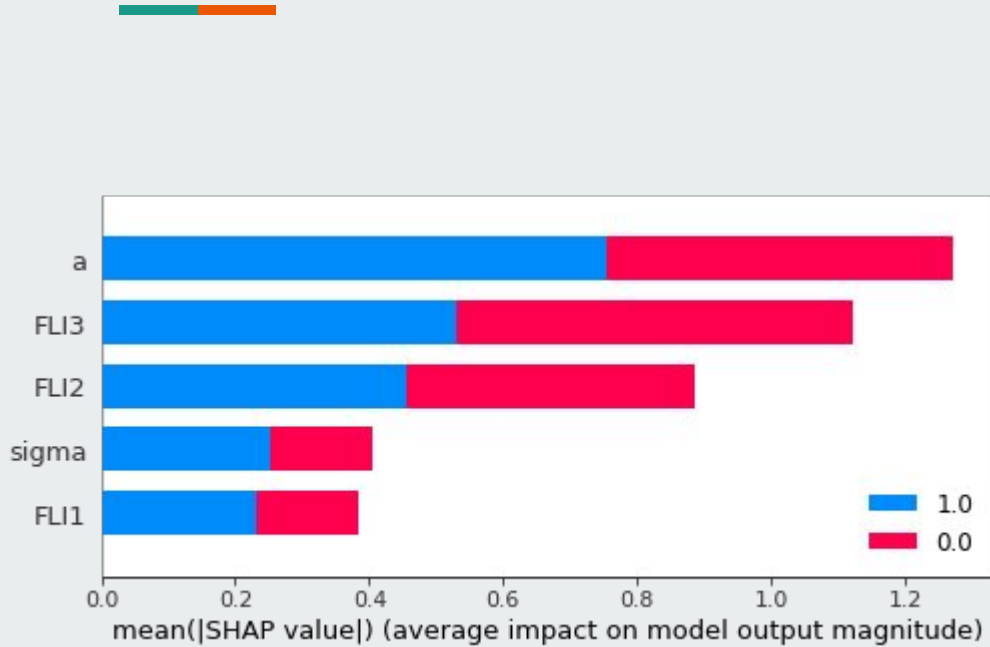
All parameters



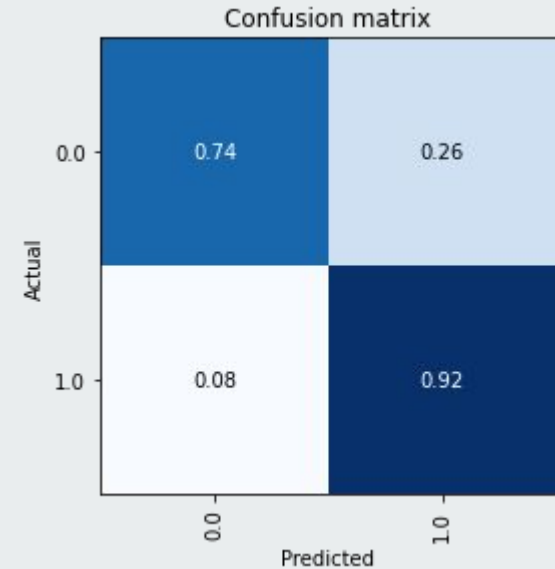
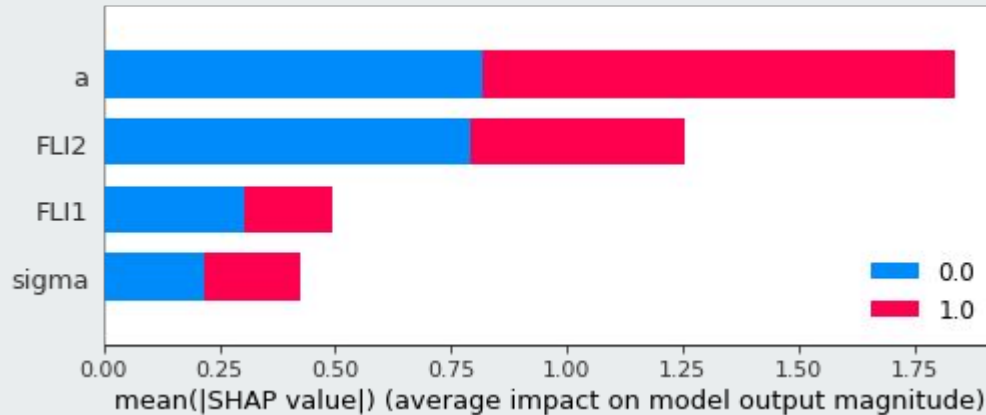
Drop FLI10



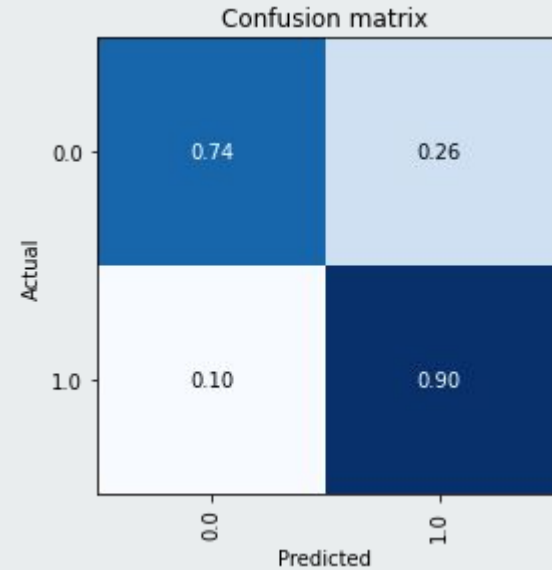
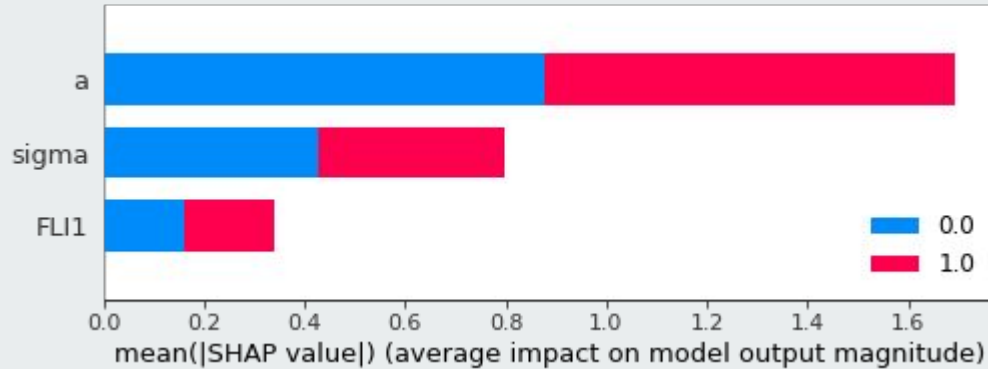
Drop FLI10 & FLI5



Drop FLI10, FLI5 & FLI3 (the most problematic)



Drop FLI10, FLI5, FLI3 & FLI2



Drop FLI10, FLI5, FLI3, FLI2 & FLI1

