Appendix_C

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Appendix C: Using PyMC3 for Approximate Parameter Estimation in Reporter Model A

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We will explore in this notebook how well parameter estimation can be performed using PyMC3 (rather bluntly).

1 Environment Setup

[1]:
```
%pylab inline
```

```
%pylab is deprecated, use %matplotlib inline and import the required libraries.
Populating the interactive namespace from numpy and matplotlib
```

[2]:
```
import arviz as az
import numpy as np
import warnings
warnings.filterwarnings("ignore")
import matplotlib.pyplot as plt
import graphviz
import os
import pymc3 as pm
from pymc3 import Model, Normal, HalfNormal, Bernoulli, Deterministic, Uniform
from pymc3 import find_MAP
```

[3]:
```
import scipy.stats as st
```

[4]:
```
from tqdm.notebook import tqdm
```

2 Experiment

Generate sample data.

[233]:
```
I = 20
T = 100
hidden_delta = np.random.uniform(high=0.5)
hidden_beta = np.random.uniform(size=I)
hidden_epsilon = np.random.uniform(size=I)
hidden_f_array = np.random.uniform(size=(T))<= hidden_delta
l = hidden_f_array.shape[0]
hidden_f = np.concatenate([hidden_f_array.reshape((l,1))]*I,axis=1)
hidden_alpha = np.random.uniform(size=(T,I)) <= hidden_beta.reshape(1,-1)
hidden_tau   = np.random.uniform(size=(T,I)) <= hidden_epsilon.reshape(1,-1)
hidden_r     = np.random.uniform(size=(T,I)) <= 0.5
observed_data = (hidden_tau*(hidden_alpha * hidden_f +␣
 ↪(1-hidden_alpha)*hidden_r) + 2*(1-hidden_tau))
```

[236]:
```
reporter_model = Model()
with reporter_model:
    delta = Uniform(name="delta", lower=0, upper=1)
    f = Bernoulli(name="f", p=delta,shape=T)
    beta = Uniform(name="beta", lower=0, upper=1, shape=I)
    epsilon = Uniform(name="epsilon", lower=0, upper=1, shape=I)
    alpha = Bernoulli(name="alpha", p=beta,shape=(T,I))
    tau = Bernoulli(name="tau", p=epsilon,shape=(T,I))
    r = Bernoulli(name="r", p=0.5,shape=(T,I))
    o = [Deterministic("o_"+str(t), tau[t,:] * (alpha[t,:] * f[t] + (1-alpha[t,:
 ↪])*r[t,:]) + 2*(1-tau[t,:])) for t in range(T)]
    X = [Normal("X_"+str(t),mu=o[t],sigma=0.01,observed=observed_data[t]) for t␣
 ↪in range(T)]
```

This next cell is handy for smaller models, but overwhelming for one of this size!

[ ]:
```
#pm.model_to_graphviz(reporter_model)
```

[237]:
```
with reporter_model:
    trace = pm.sample(1000)
```

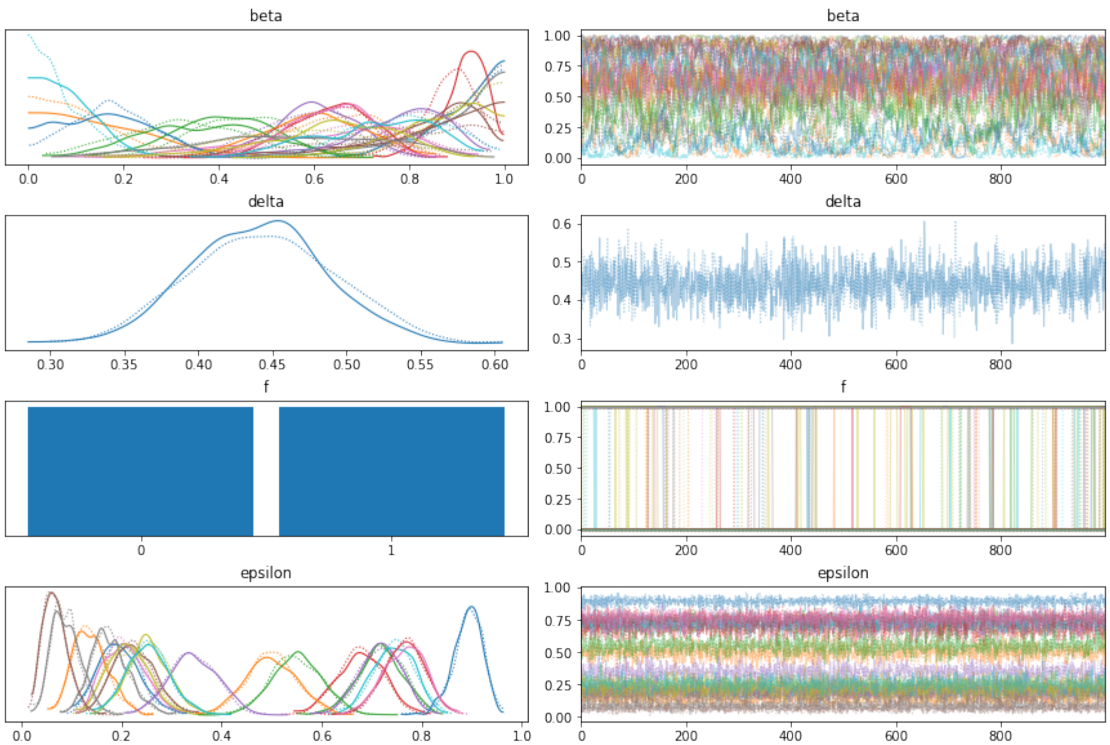
```
Multiprocess sampling (2 chains in 2 jobs)
CompoundStep
>NUTS: [epsilon, beta, delta]
>BinaryGibbsMetropolis: [f, alpha, tau, r]

<IPython.core.display.HTML object>

<IPython.core.display.HTML object>

Sampling 2 chains for 1_000 tune and 1_000 draw iterations (2_000 + 2_000 draws
total) took 5095 seconds.
The rhat statistic is larger than 1.4 for some parameters. The sampler did not
converge.
The estimated number of effective samples is smaller than 200 for some
```

parameters.

[266]:
```
import pickle
with open("reporter.pkl","wb") as pfile:
    pickle.dump(trace, pfile)
```

[268]:
```
f = figure()
pm.traceplot(trace,var_names=["beta","delta","f","epsilon"]);
savefig("pymc3results.jpg",dpi=700)
```

<Figure size 432x288 with 0 Axes>



[242]:
```
trace['delta'].mean()
```

[242]: 0.4421892276331697

[243]:
```
hidden_delta
```

[243]: 0.3512355494942204

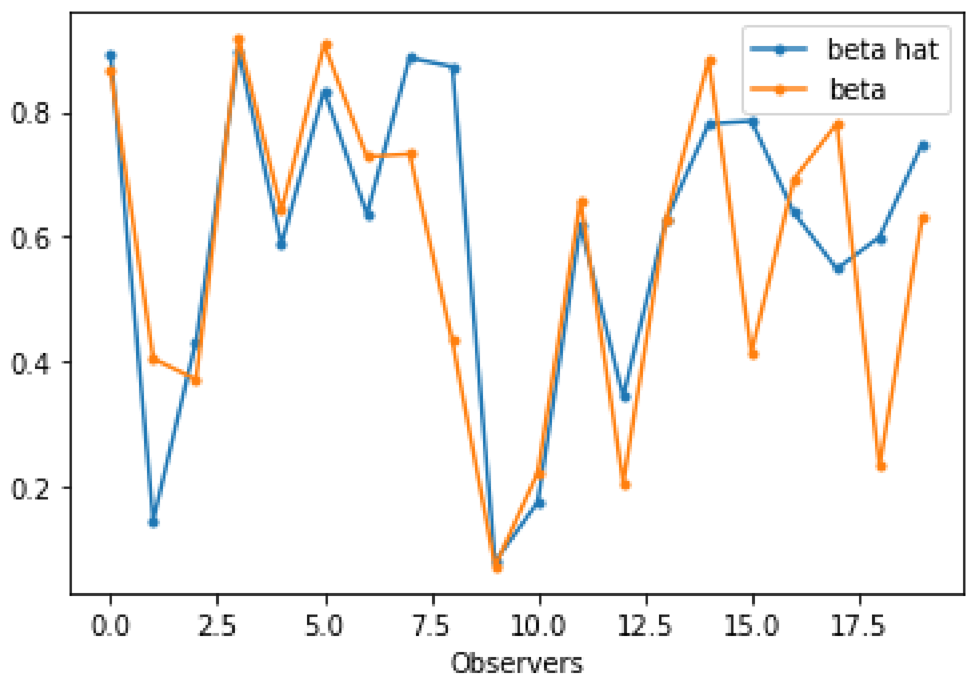
[265]:
```
trace['epsilon']
```

[265]: 0.4245300329268061

[244]:
```
print(trace['beta'].mean(axis=0))
print(hidden_beta)
```

```
[0.89283702 0.14631981 0.43258268 0.89590561 0.58804162 0.83438561
 0.63614918 0.88652525 0.87235246 0.07964526 0.1747446  0.61834232
 0.34392017 0.62604359 0.7805043  0.78534801 0.6383671  0.5485854
 0.5994691  0.74881558]
[0.86583519 0.40446965 0.37147047 0.91689329 0.64265487 0.90750678
 0.72799183 0.73231331 0.43312468 0.07210774 0.22201181 0.65898232
 0.20605286 0.62742296 0.882989   0.41511239 0.69260092 0.78093816
 0.23401369 0.63131669]
```

[280]:
```
f = figure()
plot(trace['beta'].mean(axis=0),'.-',label="beta hat")
plot(hidden_beta, '.-', label='beta');
xlabel("Observers")
legend();
savefig("betahat.jpg",dpi=700)
```



[262]:
```
f_accuracy = (st.mode(trace['f'])[0].flatten()==hidden_f[:,0].flatten()).sum()/
 ↪hidden_f.shape[0]xlabel
```

[263]:
```
print(f_accuracy)
```

```
0.98
```

[230]:
```
guessed_delta = trace['delta'].mean()
hist(trace['delta'],bins=30);
```