

CPSC532W: HOMEWORK 2

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1 Implementation

For my implementation I simply used the starter code and completed a few TODOs. Below I provide images of where I made modifications to the evaluator and SMC implementation. Firstly, I modified the observe case in the evaluator, ensuring that the log weight of the observed value is stored in sigma.

```
80     elif op == 'observe':
81         alpha = evaluate(args[0], env=env)
82         d = evaluate(args[1], env=env)
83         c = evaluate(args[2], env=env)
84         k = evaluate(args[3], env=env)
85         sigma = {'type' : 'observe',
86                 'logW' : d.log_prob(c)}
87     }
88     return k, [c], sigma
```

Next, I implemented the resample particles function

```
26 def resample_particles(particles, log_weights):
27
28     n_particles = len(particles)
29     new_particles = []
30
31     weights = [torch.exp(w).tolist() for w in log_weights]
32     d = dist.Categorical(torch.tensor(weights))
33
34     for i in range(n_particles):
35         sampled_idx = d.sample()
36         new_particles.append(particles[sampled_idx])
37
38     logZ = np.log(np.mean(weights))
39     return logZ, new_particles
40
41
```

Finally, I implemented the not-done case in the SMC algorithm, extracting the particles and their corresponding weights.

```

62     while not done:
63         print('In SMC step {}, Zs: {}'.format(smc_cnter, logZs))
64         for i in range(n_particles): #Even though this can be parallelized, we run it serially
65             res = run_until_observe_or_end(particles[i])
66             if 'done' in res[2]: #this checks if the calculation is done
67                 particles[i] = res[0]
68                 if i == 0:
69                     done = True #and enforces everything to be the same as the first particle
70                     address = ''
71                 else:
72                     if not done:
73                         raise RuntimeError('Failed SMC, finished one calculation before the other')
74             else:
75                 # pass #TODO: check particle addresses, and get weights and continuations
76                 particles[i] = res
77                 weights[i] = res[2]['logW']
78
79         if not done:

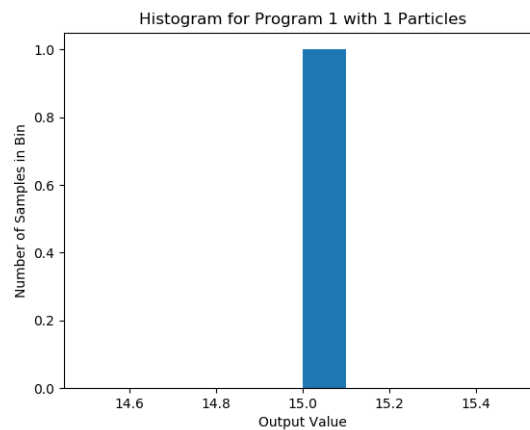
```

2 Program 1

For program 1 I note that the posterior distribution is equivalent to the prior distribution due to the fact that there are no observe statements in program 1. Consequently, I do not include the evidence estimate for any execution of SMC for program 1 as there are no observed random variables in program 1.

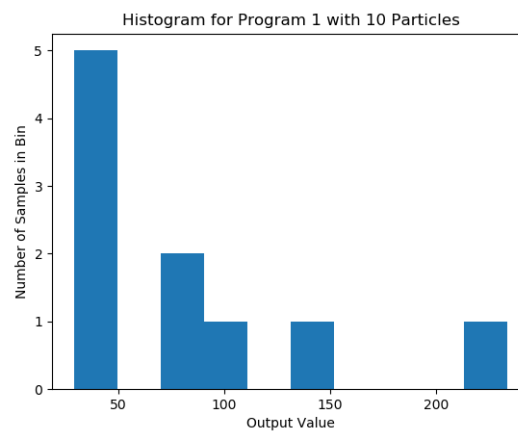
2.1 1 Particle

For my execution of SMC for program 1 with a single particle I obtained an estimate of 15.0 for the mean of the posterior. I omit the estimate of the variance of the posterior in this case of a single particle. Below is a histogram for this execution of SMC.



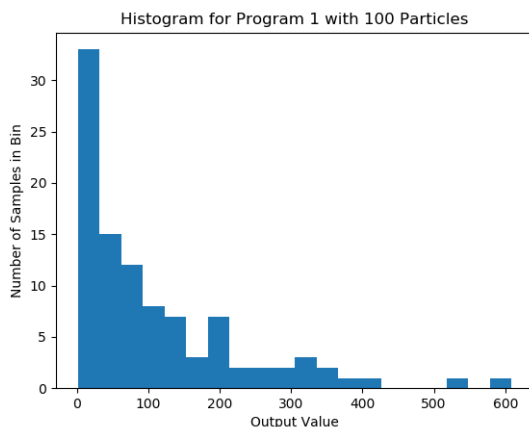
2.2 10 Particles

For my execution of SMC for program 1 with 10 particles I obtained an estimate of 81.0 for the mean of the posterior and an estimate of 4246.6665 for the variance of the posterior. Below is a histogram for this execution of SMC.



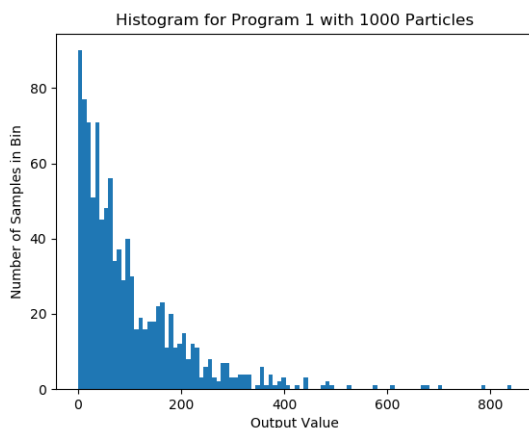
2.3 100 Particles

For my execution of SMC for program 1 with 100 particles I obtained an estimate of 106.87 for the mean of the posterior and an estimate of 14768.6396 for the variance of the posterior. Below is a histogram for this execution of SMC.



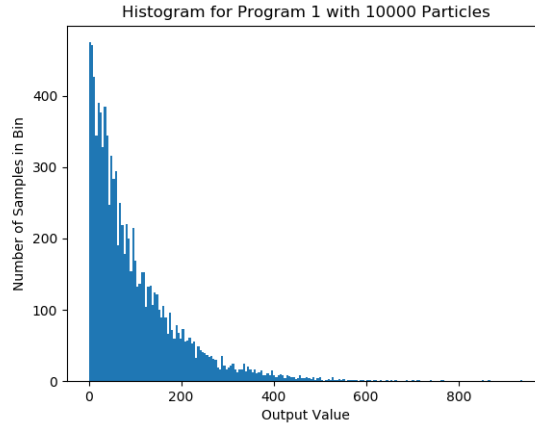
2.4 1000 Particles

For my execution of SMC for program 1 with 1000 particles I obtained an estimate of 100.79499 for the mean of the posterior and an estimate of 10735.7851 for the variance of the posterior. Below is a histogram for this execution of SMC.



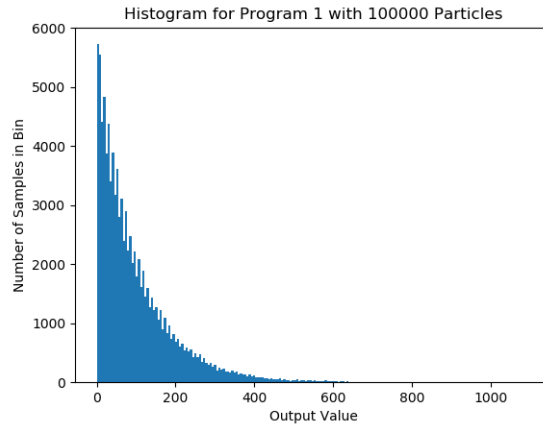
2.5 10000 Particles

For my execution of SMC for program 1 with 10000 particles I obtained an estimate of 99.2501 for the mean of the posterior and an estimate of 9853.4277 for the variance of the posterior. Below is a histogram for this execution of SMC.



2.6 100000 Particles

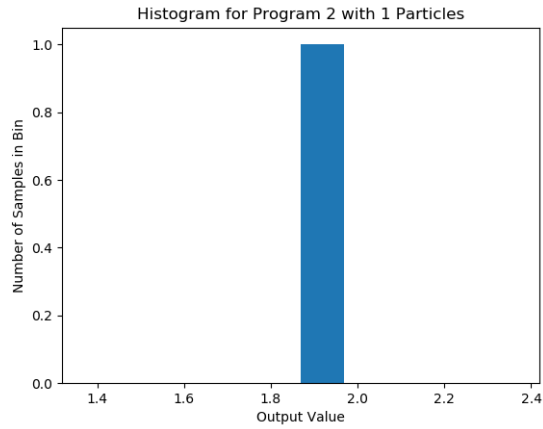
For my execution of SMC for program 1 with 100000 particles I obtained an estimate of 99.7467 for the mean of the posterior and an estimate of 10062.3925 for the variance of the posterior. Below is a histogram for this execution of SMC.



3 Program 2

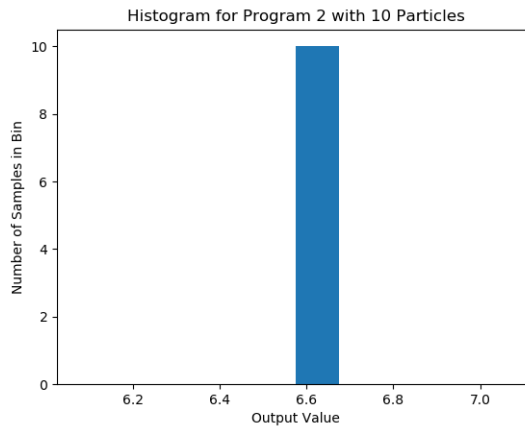
3.1 1 Particle

For my execution of SMC for program 2 with a single particle I obtained an estimate of 1.8688 for the mean of the posterior and an estimate of -24.6420 for the log evidence. I omit the estimate of the variance of the posterior in this case of a single particle. Below is a histogram for this execution of SMC.



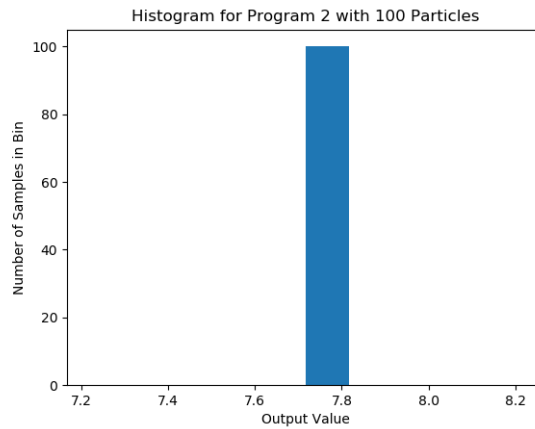
3.2 10 Particles

For my execution of SMC for program 2 with 10000 particles I obtained an estimate of 6.575 for the mean of the posterior, an estimate of 0.0 for the variance of the posterior, and an estimate of -6.8063 for the log evidence. Below is a histogram for this execution of SMC.



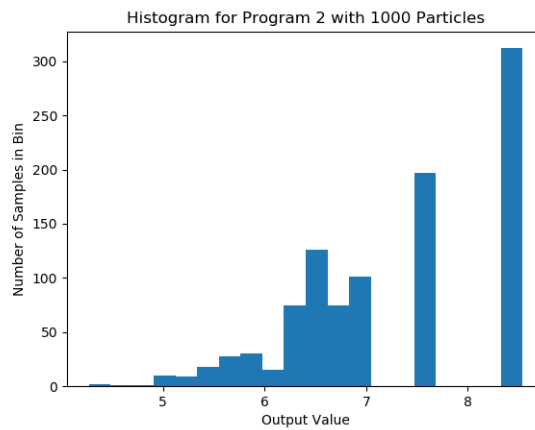
3.3 100 Particles

For my execution of SMC for program 2 with 10000 particles I obtained an estimate of 7.717 for the mean of the posterior, an estimate of 0.0 for the variance of the posterior, and an estimate of -7.7229 for the log evidence. Below is a histogram for this execution of SMC.



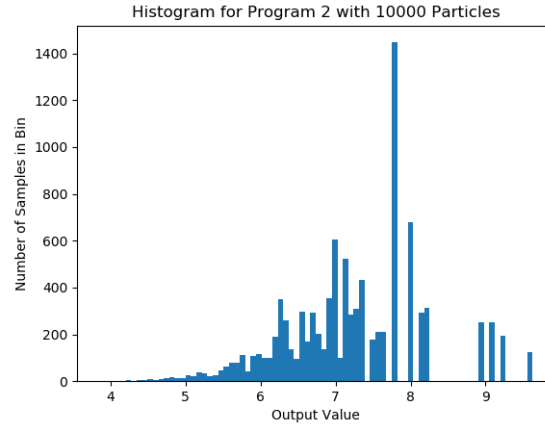
3.4 1000 Particles

For my execution of SMC for program 2 with 10000 particles I obtained an estimate of 7.2853 for the mean of the posterior, an estimate of 0.9801 for the variance of the posterior, and an estimate of -8.2321 for the log evidence. Below is a histogram for this execution of SMC.



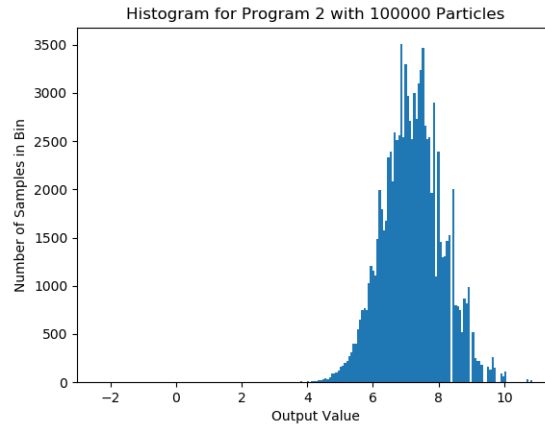
3.5 10000 Particles

For my execution of SMC for program 2 with 10000 particles I obtained an estimate of 7.2423 for the mean of the posterior, an estimate of 0.85123 for the variance of the posterior, and an estimate of -8.2732 for the log evidence. Below is a histogram for this execution of SMC.



3.6 100000 Particles

For my execution of SMC for program 2 with 10000 particles I obtained an estimate of 7.2006 for the mean of the posterior, an estimate of 0.82349 for the variance of the posterior, and an estimate of -8.2674 for the log evidence. Below is a histogram for this execution of SMC.



4 Program 3

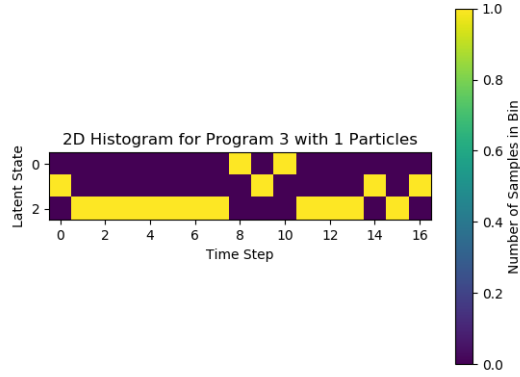
Note, my means and variances for program 3 are presented as a vector ordered from time step 1 to time step 17.

4.1 1 Particle

For my execution of SMC for program 3 with a single particle I obtained the following estimate of the mean of the posterior:

[1., 2., 2., 2., 2., 2., 2., 2., 2., 0., 1., 0., 2., 2., 2., 1., 2., 1.]

I omit the estimate of the variance of the posterior due to the use of a single particle. I obtained the following estimate of the log evidence: -48.953. Below is a histogram for this execution of SMC.



4.2 10 Particles

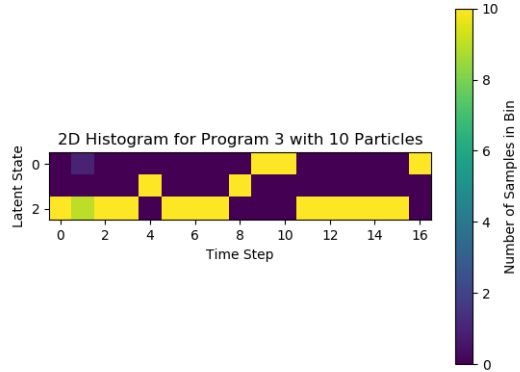
For my execution of SMC for program 3 with a 10 particles I obtained the following estimate of the mean of the posterior:

[2., 1.8, 2., 2., 1., 2., 2., 2., 1., 0., 0., 2., 2., 2., 2., 2., 0.]

I obtained the following estimate of the variance of the posterior:

[0., 0.4, 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.]

I obtained the following estimate of the log evidence: -44.3966. Below is a histogram for this execution of SMC.



4.3 100 Particles

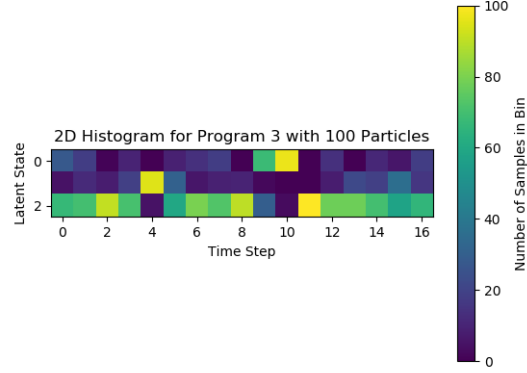
For my execution of SMC for program 3 with a 100 particles I obtained the following estimate of the mean of the posterior:

[1.39, 1.52, 1.9, 1.61, 1.05, 1.51, 1.66, 1.55, 1.9, 0.62, 0.06, 2., 1.64, 1.78, 1.59, 1.52, 1.48]

I obtained the following estimate of the variance of the posterior:

[0.8060, 0.6158, 0.1111, 0.4423, 0.0480, 0.4342, 0.5095, 0.6136, 0.0909, 0.8440, 0.1176, 0.0, 0.5156, 0.1733, 0.4666, 0.3733, 0.6158]

I obtained the following estimate of the log evidence: -44.2297. Below is a histogram for this execution of SMC.



4.4 1000 Particles

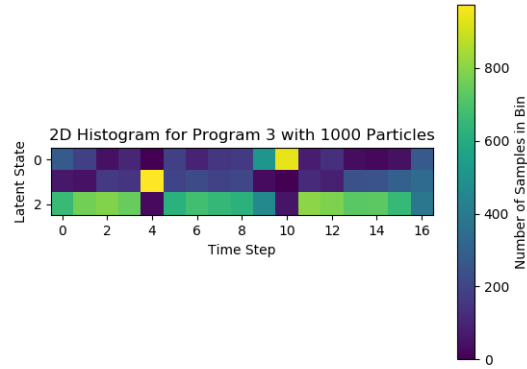
For my execution of SMC for program 3 with a 1000 particles I obtained the following estimate of the mean of the posterior:

[1.381, 1.582, 1.746, 1.643, 1.025, 1.437, 1.586, 1.495, 1.463, 0.9480, 0.1120, 1.7300, 1.653, 1.696, 1.708, 1.61, 1.113]

I obtained the following estimate of the variance of the posterior:

[0.7926, 0.6159, 0.2778, 0.4400, 0.0244, 0.6146, 0.433, 0.5625, 0.5792, 0.9683, 0.2117, 0.3515, 0.4871, 0.2739, 0.249, 0.3282, 0.6469]

I obtained the following estimate of the log evidence: -44.3568. Below is a histogram for this execution of SMC.



4.5 10000 Particles

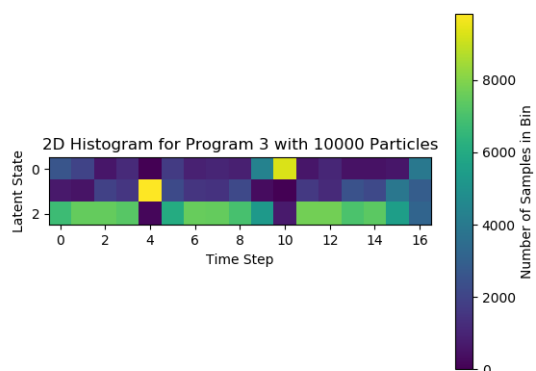
For my execution of SMC for program 3 with a 10000 particles I obtained the following estimate of the mean of the posterior:

[1.4168, 1.5557, 1.6935, 1.6121, 1.0157, 1.4365, 1.6653, 1.6493, 1.6108, 1.0968, 0.1392, 1.7129, 1.6679, 1.6603, 1.6883, 1.4934, 0.9226]

I obtained the following estimate of the variance of the posterior:

[0.7600, 0.6412, 0.3292, 0.4709, 0.0155, 0.5878, 0.4065, 0.4326, 0.4098, 0.9579, 0.2590, 0.3269, 0.4349, 0.3175, 0.3098, 0.3668, 0.7025]

I obtained the following estimate of the log evidence: -44.3738. Below is a histogram for this execution of SMC.



4.6 100000 Particles

For my execution of SMC for program 3 with a 100000 particles I obtained the following estimate of the mean of the posterior:

[1.4294, 1.5484, 1.6994, 1.5994, 1.0160, 1.4274, 1.6419, 1.6588, 1.6012, 1.0775, 0.1452, 1.6971, 1.6549, 1.6806, 1.6220, 1.5047, 0.9164]

I obtained the following estimate of the variance of the posterior:

[0.7549, 0.6526, 0.3249, 0.4719, 0.0180, 0.5958, 0.4315, 0.4238, 0.4245, 0.9510, 0.2642, 0.3421, 0.4476, 0.3124, 0.3457, 0.3225, 0.6870]

I obtained the following estimate of the log evidence: -44.41369. Below is a histogram for this execution of SMC.

