# Final Project 2

Pedram Agand (301400607)
pagand@sfu.ca

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Note: This project has been written with LaTeX.

## Exercise 1

- Set $\boldsymbol{x}$ to the observed values.
- Initialize $\boldsymbol{y}$ (1.random matrix or 2.Same as $\boldsymbol{x}$ or 3.Negative)
- Create an empty list for samples
- For $B + S$ steps:
  - For $i$ in $0 : N$ (rows)
    - For $j$ in $0 : M$ (columns)
      - Compute $2\eta \boldsymbol{x}_{ij} + 2\beta \sum_{\boldsymbol{y}_{i'j'} \in \boldsymbol{y}_{N(i,j)}} \boldsymbol{y}_{i'j'}$ by summing the values of each neighbor of pixel $(i, j)$.
      - Compute $p_{ij}$ using the $< calculate\_probability >$ function and applying the result from above with $\sigma$ function
      - Generate a random sample $r \sim Uniform(0, 1)$.
      - If $r \leq p_{ij}$, update $\boldsymbol{y}_{ij} = 1$. Otherwise, set $\boldsymbol{y}_{ij} = -1$.
- Return the $S$ samples $\boldsymbol{y}[\boldsymbol{s}]$ generated above.

## Exercise 2

On each iteration, I run the algorithm with three distinct initialization of $y_i j$. (1) same as $x_{ij}$, (2) negative of $x_{ij}$ and (3) random. The plot of these values are in Figure 1.

- Yes, the all seem to be converging around a same point, which is the optimal value. The energy for optimal values is around -190000.
- Yes it is adequate. Even in log-same and log-rand 50 seems to be even more than enough for burn in, as the sampling converges before that. It may be beneficial to increase the $B$.
- At the beginning and in a few first iterations, there are very fast chances which indicates that the model is going toward optimal values quickly. But among all, only in the "same" initialization there is enough mixing. For "rand" and "neg", however, it appears that the chain is not mixing as well. There is very little fluctuation after convergence is achieved. Hence, this means that we're sampling from a single mode, rather than the entire distribution over $p$.

## Exercise 3

- restoration error for image a : **0.0007249807658164171**
- restoration error for image b : **0.00380463107735835**

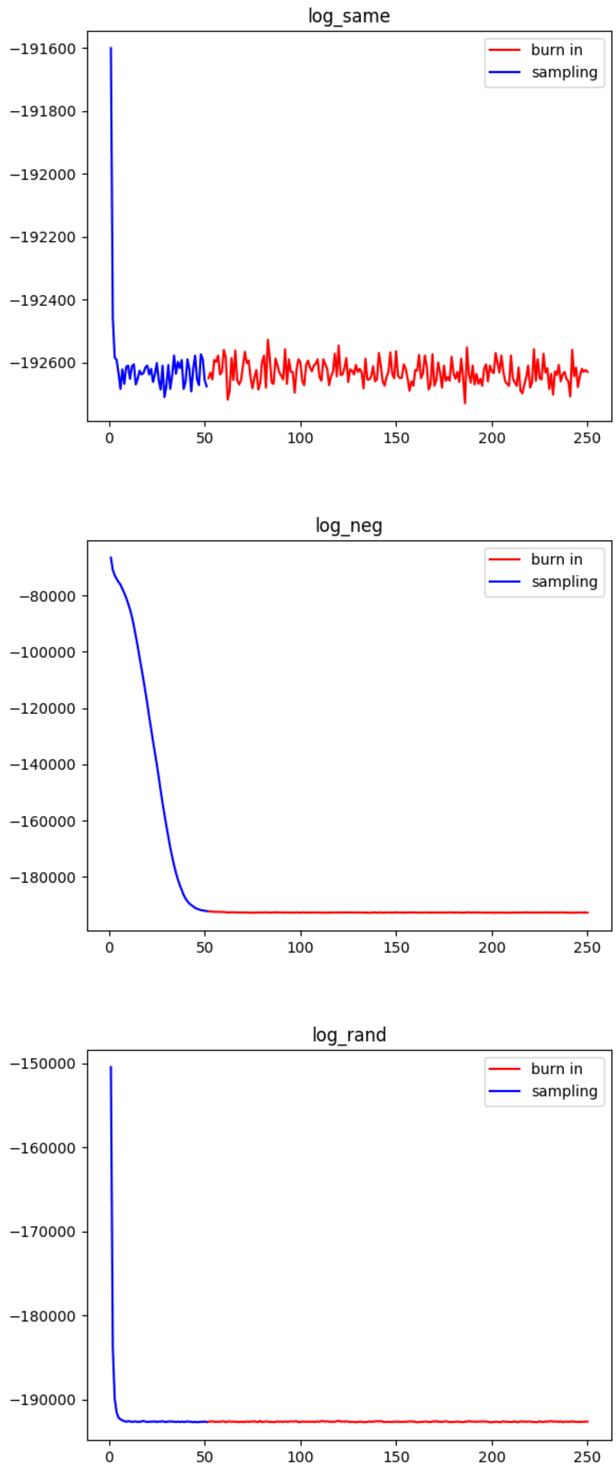
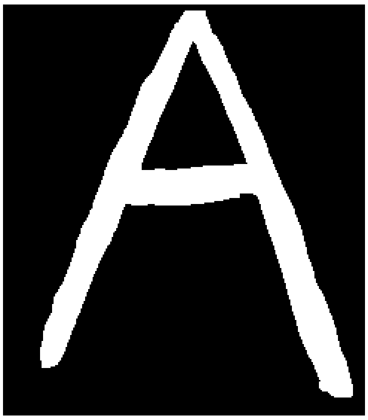


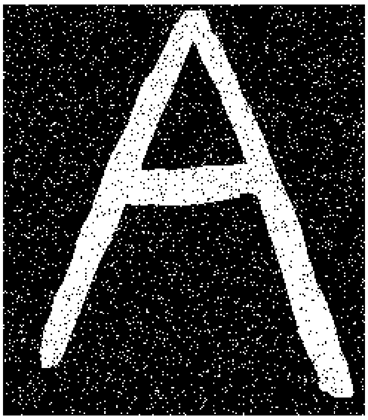

Figure 1: Energy value for three different initialization.

## Exercise 4

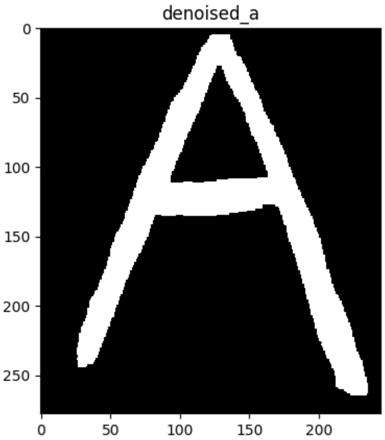
I did not measure it directly, but I think around 10 hours.



(a) Original

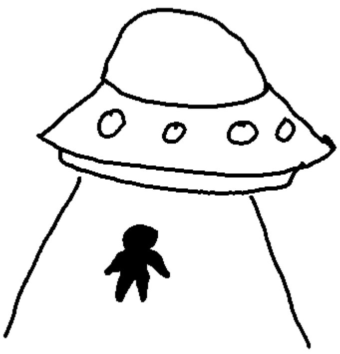


(b) Noisy

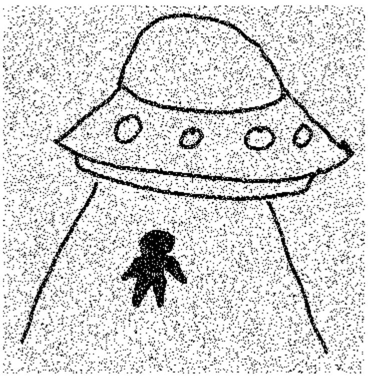



(c) Denoised

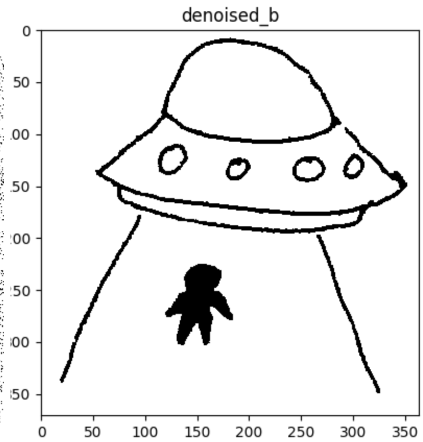
Figure 2: Results of denoising a noisy image a



(a) Original



(b) Noisy




(c) Denoised

Figure 3: Results of denoising a noisy image b