Norwegian University of Science and Technology

DT8122 **Project Assignment — Normalizing Flows**

PROBABILISTIC AI

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1 Tasks

The assignment consists of several tasks. You are expected to implement a few methods for normalizing flows. Each method should be evaluated using the provided data. A report with discussion and results should be delivered alongside the code.

1.1 Implementation

Implement the following methods in either Python or Julia. You may use packages such as TensorFlow, TensorFlow Probability, PyTorch, torchdiffeq, and Pyro. Many of these packages have these methods already implemented. You may *not* use those implementations.

1.1.1 Task 1: Normalizing Flows

First, we ask you to implement variational inference with two types of Normalizing Flows [3]. Any details not specified in the original literature, such as hyper parameters and model choice is up to you. The following flows should be implemented:

- Planar Flows [3],
- Real-NVP Flows [2].

You are to produce a plot such as or similar to the one shown in Figure 1 for each method and each dataset. You may present other plots or results that you find interesting. This figure shows scatter plots of the data $X \sim p(X)$, the inverse transform f, the forward transform g and the samples from the prior $\mathcal{N}([\begin{smallmatrix}0\\0\end{smallmatrix}],[\begin{smallmatrix}1&0\\0&1\end{smallmatrix}])$.
The report should include the following elements from this task:

- Plots for each method and each dataset.

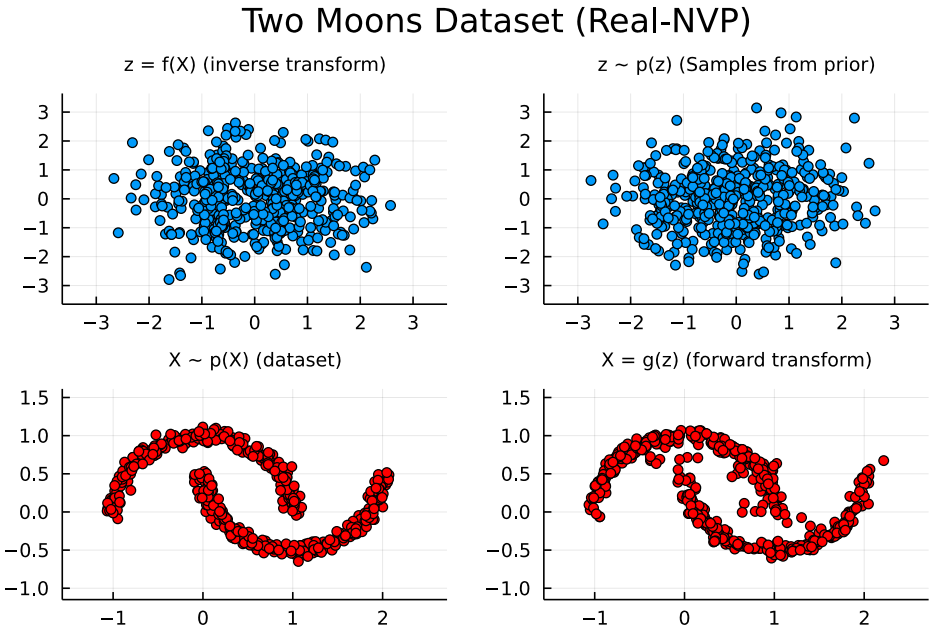

Figure 1. Example plot for Normalizing Flows task.

- A section discussing the differences between Real-NVP and Planar flows and how this is reflected in the results.
- Details about hyperparameters and model choice.
- Details about any assumptions or changes you might have made in your implementation.

1.1.2 Task 2: Continuous Normalizing Flows

The second task is to implement Continuous Normalizing Flows (CNF) [1] (Section 4).
The report should include the following elements from this task:

- Plots just like the ones from task 1.
- *.gif* files showing the transformation from the prior to the posterior over time.
- A short discussion on the advantages and disadvantages of continuous normalizing flows over coupling flows.
- Details about hyperparameters and model choice.
- Details about any assumptions or changes you might have made in your implementation.

2 Submission Requirements

We expect you to submit the following:

- **Code** with your implementation of task 1 and 2.
  - Your code should be readable and include any necessary comments.
  - You should make sure the code is not dependent on a system specific configuration. To make sure we can execute your code please provide a list of packages (such as a REQUIREMENTS.TXT file for Python or PROJECT.TOML/MANIFEST.TOML files for Julia). It should be detailed in a README.md file how to install the packages and reproduce the results in the report.
  - All or part of the code may be a Jupyter notebook. In that case, the code should be executed and produce all plots asked for in the report.
- **Gif** files from task 2. These should be in a separate folder in the repository.
- **Report** that should include the plots and discussions asked for in task 1 and 2. Max. 8 pages (including figures).
  - The report should be a cohesive text with discussion about methods and results. The report should not be a collection of plots and bullet points.
  - If you do any preprocessing or changes to the methods discuss those in the report.
  - Discuss the model and hyperparameter choices.

Both the code and report should be in a private git repository on GitHub. The repository should have a README.md file detailing how to install necessary packages and reproduce the results in the report. Before the deadline, add the following user as a collaborator: *DT8122*. Do not make any changes after the deadline. Making changes after the deadline will result in an automatic fail. After adding *DT8122* as a collaborator, submit the link to the repository on Blackboard. (If you are not on Blackboard, send an email with the link to dt8122@idi.ntnu.no.) **The deadline is 30 September 2022 AoE (Anywhere on Earth).**

References

[1] Ricky T. Q. Chen, Yulia Rubanova, Jesse Bettencourt, and David Duvenaud. Neural ordinary differential equations, 2018. URL `https://arxiv.org/abs/1806.07366`.

[2] Laurent Dinh, Jascha Sohl-Dickstein, and Samy Bengio. Density estimation using real nvp, 2016. URL `https://arxiv.org/abs/1605.08803`.

[3] Danilo Jimenez Rezende and Shakir Mohamed. Variational inference with normalizing flows, 2015. URL `https://arxiv.org/abs/1505.05770`.