Data-driven Machine Perception

Probabilistic Modelling of Drift using Satellite Data

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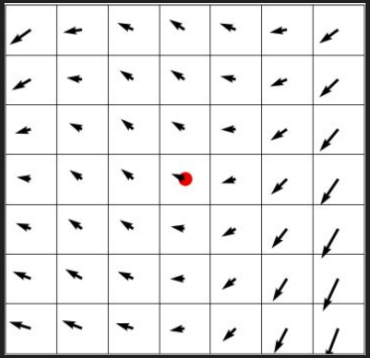
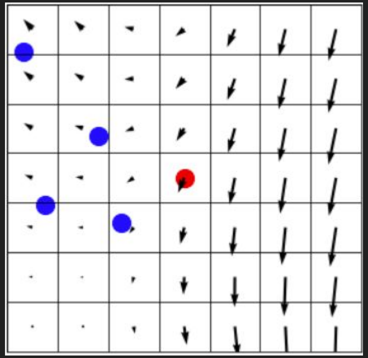
1. Introduction

Input
Velocity field + Object position



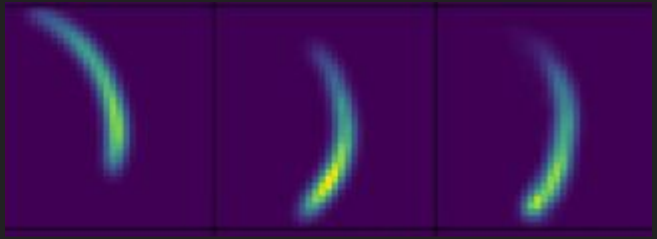
Lagrangian Model
Time (1 day)

Output
Next position?



Limitations:

- The images exhibit blurring.
- The summation of probabilities does not equal to 1.
- The models poorly predict drift over multiple days.



2. Software Improvement

NEW IMPLEMENTATIONS

- Definition of New Loss Functions for Training
- Model Evaluation using Multiple Loss Functions simultaneously
- Implementation of multi-day prediction
- Plotting of snapshot images with specific IDs for specific models
- Analysis of Training and Evaluation Outputs.

CODE REFACTORING

- Changing training loss function and probability loss weight from bash script
- Changing the drift prediction duration during evaluation from bash script
- Plotting of snapshot images from bash script

https://github.com/olanrewajufarooq/DriftModelling

3. Training

$$L_{total} = L_{regression}$$

$$L_{total} = \frac{1}{|O|} \sum_{x \epsilon O} \left| D_x - \overline{D_x} \right|$$

$$L_{regression} : MAE = \frac{1}{|O|} \sum_{x \epsilon O} \left| D_x - \overline{D_x} \right|$$

$$L_{regression} : MSE = \frac{1}{|O|} \sum_{x \epsilon O} \left| D_x - \overline{D_x} \right|^2$$

Models Trained:

- MAEProbDistrLoss
- MSEProbDistrLoss
- MAEProbDistrLoss_residual
- MSEProbDistrLoss_residual

● 4. Training Result

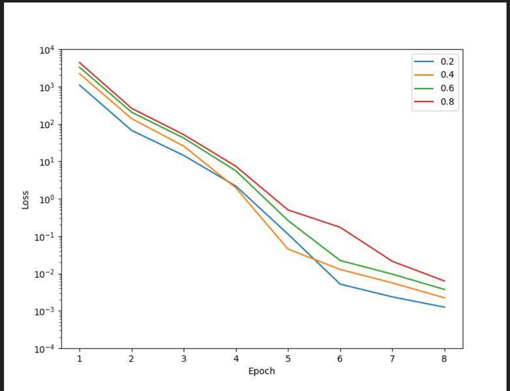


Figure 4.1: Training Loss for MAEProbDistrLoss Model

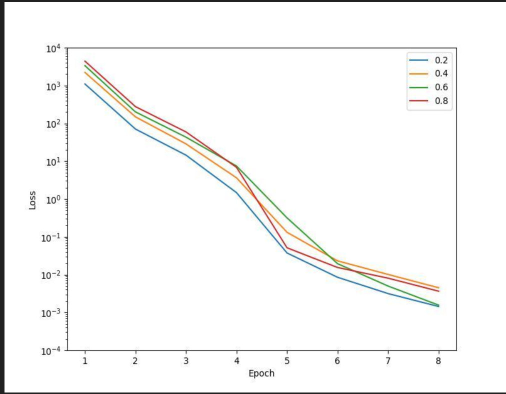


Figure 4.2: Training Loss for MSEProbDistrLoss Model

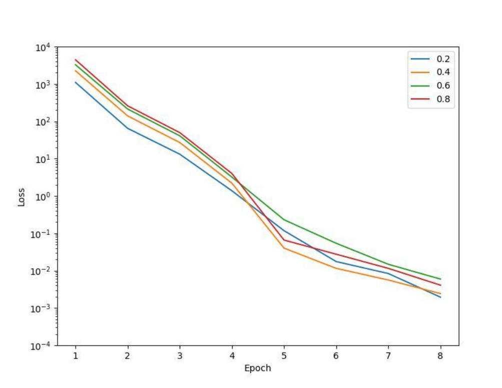


Figure 4.3: Training Loss for MAEProbDistrLoss Model with Residual

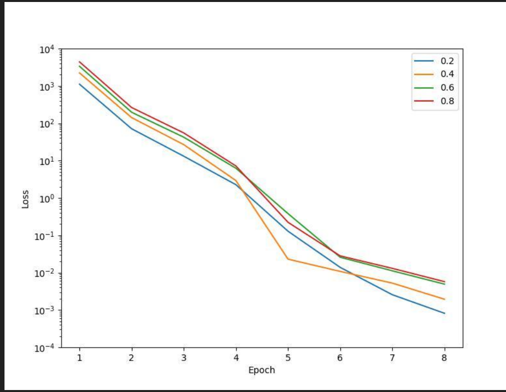


Figure 4.4: Training Loss for MSEProbDistrLoss Model with Residual

Observations

➔ The training loss decreases exponentially as the epoch.

➔ In general, loss reduces better with lower values of probability loss weight.

➔ Models with **α** = 0.2 and 0.4 are generally better.

Note

➔ Models are named with training loss functions

5. Evaluation Results

Table 5.1: Results of the model evaluation with different loss functions

Model	Alpha	MAE	MSE	MAEwProb	MSEwProb
Pretrained		0.000002	2.968042e-09	6.166436	6.166435
Pretrained with Residual		0.000038	1.486365e-07	9.453541	9.453514
MAEProbDistrLoss	0.2	-	-	-	-
	0.4	-	-	-	-
	0.6	0.000016	1.416063e-07	0.032711	0.032699
	0.8	0.000016	1.452545e-07	0.133818	0.133806
MSEProbDistrLoss	0.2	0.000016	1.416093e-07	0.034826	0.023210
	0.4	0.000016	1.416738e-07	0.043249	0.028825
	0.6	0.000016	1.416072e-07	0.043311	0.028867
	0.8	0.000016	1.416424e-07	0.083172	0.055440
MAEProbDistrLoss_residual	0.2	0.000017	1.432288e-07	0.117095	0.117083
	0.4	0.000016	1.416063e-07	0.033467	0.033455
	0.6	0.000017	1.452379e-07	0.140218	0.140207
	0.8	0.000016	1.417097e-07	0.072271	0.048173
MSEProbDistrLoss_residual	0.2	-	-	-	
	0.4	0.000016	1.416591e-07	0.058822	0.058811
	0.6	0.000016	1.416059e-07	0.037684	0.037673
	0.8	0.000016	1.416062e-07	0.036429	0.024278

6. Multi-Day Drift Prediction

Table 6.1: Evaluation of Models on the prediction of a 2-day drift

Model	MAE	MSE	MAEwProb	MSEwProb
pretrained	2.08E-05	1.75E-07	6.17E+00	6.17E+00
pretrained_residual	-	-	-	-
MAEProbDistrLoss	1.61E-05	1.31E-07	2.78E-02	2.78E-02
MSEProbDistrLoss	1.61E-05	1.31E-07	3.81E-02	2.54E-02
MAEProbDistrLoss With Residual	1.63e-05	1.34e-07	1.37e-01	1.37e-01
MSEProbDistrLoss With Residual	1.60E-05	1.31E-07	5.56E-02	5.56E-02

Table 6.2: Evaluation of Models on the prediction of a 3-day drift

Model	MAE	MSE	MAEwProb	MSEwProb
pretrained	-	-	-	-
pretrained_residual	0.003961	0.000029	1666.447212	1666.444442
MAEProbDistrLoss	1.59E-05	1.23E-07	3.03E-02	3.03E-02
MSEProbDistrLoss	1.59E-05	1.23E-07	3.66E-02	2.44E-02
MAEProbDistrLoss With Residual	1.60e-05	1.26e-07	1.30e-01	1.30e-01
MSEProbDistrLoss With Residual	1.58E-05	1.23E-07	5.44E-02	5.44E-02

Table 6.3: Evaluation of Models on the prediction of a 4-day drift

Model	MAE	MSE	MAEwProb	MSEwProb
pretrained	2.70E-05	2.29E-07	6.18E+00	6.18E+00
pretrained_residual	1.49e-05	1.16E-07	2.90E-01	2.9E-01
MAEProbDistrLoss	1.16E-07	1.16E-07	3.23E-02	3.23E-02
MSEProbDistrLoss	1.57E-05	1.16E-07	3.57E-02	2.38E-02
MAEProbDistrLoss With Residual	1.58e-05	1.19e-07	1.24e-01	1.24e-01
MSEProbDistrLoss With Residual	1.56E-05	1.16E-07	5.48E-02	5.48E-02

Table 6.4: Evaluation of Models on the prediction of a 5-day drift

Model	MAE	MSE	MAEwProb	MSEwProb
pretrained	2.77E-05	2.32E-07	6.21E+00	6.21E+00
pretrained_residual	0.000752	0.000001	313.017980	313.017453
MAEProbDistrLoss	1.55E-05	1.10E-07	3.48E-02	3.48E-02
MSEProbDistrLoss	1.55E-05	1.10E-07	3.56E-02	2.38E-02
MAEProbDistrLoss With Residual	1.56e-05	1.13e-07	1.2e-01	1.21e-01
MSEProbDistrLoss With Residual	1.60E-05	1.10E-07	4.60E-02	4.60E-02

7. Result Highlights & Future Work

Results Discussion

- ➔ The new models perform better in enforcing that summation of probabilities = 1.
- ➔ Lower weight for probability distribution loss gives a better model.
- ➔ Multi-day prediction is generally better with a model trained with probability loss consideration.
- ➔ Models not trained on residuals are better on evaluation.

Future Works

- ➔ Further physical considerations such as conservation of mass or volume.
- ➔ Implementing new CNN backbone for the model.

Thank You for Listening

Questions?