

## Usage of DSIPTS

This repo collect some examples related to the use of dsipts. Using this repo you can train some DL models for timeseries forecasting using public datasets like Monash or six\_dataset used for benchmarking timeseries models. It is possible to use also the Venice dataset described here.

Here we report a complete approach using Hydra that allows to better manage multiple experiments.

This particular repo is structured for working with the six datasets (that are 9 because ethh has different resolution and periods): ['electricity', 'etth1', 'etth2', 'ettm1', 'ettm2', 'exchange\_rate', 'illness', 'traffic', 'weather']. The task is to predict y using past data and other past covariates for a variable number of steps depending on the paper used as reference.

## Installation

In a pre-generated environment install pytorch and pytorch-lightning (`pip install pytorch-lightning==1.9.4`) then go inside the lib folder and execute:

```
python setup_local.py install --force
```

Alternatively, you can install it from the package registry:

```
pip install --force dsipts --index-url https://dsipts:glpat-98SR11neR7hzy__SueG@gitlab.fbk.eu/api/v4/projects/4571/packages/pypi
```

## Configuration

- copy the folder `all_six_datasets` inside a data folder (in what follows `/home/agobbi/Projects/ExpTS/data`).
- place yourself in `bash_examples`
- train the models
- create the folders `csv` and `plots` in the `pathdir` in my case `/home/agobbi/Projects/ExpTS`

## Hydra

In you environment install hydra and the joblib launcher for the paralellization tasks:

```
pip install hydra-core
pip install hydra-joblib-launcher      ## if you have a big gpu
pip install hydra-submitit-launcher    ## if you are in a slurm environment
```

```
pip install hydra-optuna-sweeper      ## if you need optuna
```

The script used are: - **train.py** for training models - **inference.py** for inference - **compare.py** for comparing different models

This structure is a convenient way to deal with multiple experiments, feel free to adjust it as you prefer. There are some tricks for extracting runtime the hydra choices (and use informative names for the models). This can be ugly to see but it is easy to compare the same model with different parameters. If you want to use your own data with this schema you need to add your data processing pipeline in `load_data` and define your own timeseries object. For example in the following snippet we have 3 continuous variables: `Value`, `rain` `temp` that are assumed to be known also in the future while predicting `Value`. The month column will be created as categorical feature.

```
ts.load_signal(data_ex, past_variables = ['Value', 'rain', 'temp'], future_variables = ['rain', 'temp'], target_variables = ['Value'])
```

Remember also to modify also `train` and `inference` accordingly to your implemented function.

Hydra is used for composing configuration files. In our case most of the parameters can be reused among the different models and are collected under the general configuration file `config/config.yaml`. In what follows the `weather` dataset is used, and notice that this dataset has a frequency of **10 minutes**. The parameters here are the same described in the `dsitps` documentation but clearly some of them can not be modified since they depend on the selected time series. The configuration files related to this experiment can be found in `config_weather`; a generic config folder contains:

```
config_gpu.yaml          # containing the global configuration usually for gpu or local train, see below one example
config_slurm.yaml        # containing the global configuration for slurm training see below one example
compare.yaml             # instructions for comparing different models
architecture/            # the folder containing the configurations specific for all the models to test
config_used/             # this folder will be populated while training the models, and will be used in the comparison phase
```

The config file in the case of the weather dataset is reported and commented below.

```
dataset:
  dataset: 'weather'
  path: '/home/agobbi/Projects/ExpTS/data' ##path to data. In the folder data must be present the folder six_dataset

scheduler_config:
  gamma: 0.75
  step_size: 250

optim_config:
  lr: 0.0005
  weight_decay: 0.001
```

```

model_configs:
  past_steps: 16
  future_steps: 16
  quantiles: [0.1,0.5,0.9] #if you want to use quantile loss, otherwise set it to []
  past_channels : null      #dataset dependent  hydra expect you to set it anyway also if it depends on data
  future_channels : null    #dataset dependent
  embs: null               #dataset dependent
  out_channels: null       #dataset dependent

split_params:
  perc_train: 0.8
  perc_valid: 0.1
  range_train: null
  range_validation: null
  range_test: null
  shift: 0
  starting_point: null
  skip_step: 1
  past_steps: model_configs@past_steps      #this is a convinient what to reuse previous information, thx omegaconf
  future_steps: model_configs@future_steps

train_config:
  dirpath: "/home/agobbi/Projects/ExpTS"
  num_workers: 0
  auto_lr_find: true  ##this allows to pytorch lightening to find a suitable lr
  devices: [0]

inference:
  output_path: "/home/agobbi/Projects/ExpTS"
  load_last: true
  batch_size: 200
  num_workers: 4
  set: "validation"
  rescaling: false  #(sometimes you want to get the errors on normalized datasets)

```

## Train

After declaring some stuff about the dataset and the enviroment we can train the model(s). Depending on the architecture (slurm or gpu/cpu) you need to add the following blocks to the main config:

For gpu/cpu:

```
defaults:
  - _self_                                # take all this configuration
  - architecture: null                    # and let the use specify the architecture to use (be aware that the filed here is the same
  - override hydra/launcher: joblib       # use joblib for multiprocessing allowing parallelization in case of multirun in a gpu/cpu envi

hydra:
  launcher:
    n_jobs: 2                             # parameters indicate the number of parallel jobs in case of multirun
    batch_size: 2                          #2 parrallel train session
    pre_dispatch: 4
    _target_: hydra_plugins.hydra_joblib_launcher.joblib_launcher.JoblibLauncher

  output_subdir: null                     # do not save any file
  sweeper:
    params:
      architecture: glob(*)               # this is a way to train all the models in the architecure folder
```

For a SLURM cluster:

```
defaults:
  - _self_
  - architecture: null
  - override hydra/launcher: submitit_slurm  ## use slurm launcher

hydra:
  launcher:
    submitit_folder: ${hydra.sweep.dir}/.submitit/%j
    timeout_min: 6000
    partition: gpu-V100                    ##partition to use REQUIRED
    mem_gb: 6                              ##gb requires          REQUIRED
```

```

nodes: 1
gres: gpu:1          ##number of GPU   REQUIRED
array_parallelism: 10  ##parallel process

name: ${hydra.job.name}
_target_: hydra_plugins.hydra_submitit_launcher.submitit_launcher.SlurmLauncher
setup:
  - conda activate tt  ##activate the conda environment first!

output_subdir: null
sweeper:
params:
  architecture: glob(*)

```

In the config\_weather/architecture folder there are the selected models that have the following structure:

```
# @package _global_  ##care this must be present!
```

```

#the specified parameters below overwrite the default configuration having a more compact representation
model:
  type: 'linear'
  retrain: true  ## overwrite the model with the same parameters

```

```

ts:
  name: 'weather'
  version: 1          # if you need to versioning a model
  enrich: ['hour']
  use_covariates: false  # if true all the columns of the dataset will be used as past features

```

```

## for more information about models please look at the documentation [here] (https://dsip.pages.fbk.eu/dsip\_dlresearch/timeserie)
model_configs:
  cat_emb_dim: 32          # dimension of categorical variables
  kernel_size: 5          # kernel size
  sum_emb: true           # if true each embedding will be summed otherwise stacked

```

```

hidden_size: 256          # hidden size of the fully connected block
kind: 'linear'           # model type
dropout_rate: 0.2        # dropout
use_bn: false            # use or not bn layers in the first layers
optim: torch.optim.Adam  # optimizer
activation: torch.nn.PReLU # activation between linear
persistence_weight: 0.010 # in case of loss different from l1 or mse it is used to weight a penalty score
loss_type: 'l1'          # loss

```

```

train_config:
  batch_size: 128
  max_epochs: 250
  gradient_clip_val: null          # pytorch lightening gradient clipping procedure
  gradient_clip_algorithm: 'norm' # pytorch lightening gradient clipping procedure

```

#####FINO A QUIEEEEEEEEEEEEEEEE Hydra allows us to train a specific model using if you are in a gpu environment

```
python train.py architecture=linear --config-dir=config_weather --config-name=config_gpu
```

or, if you are in a slurm gpu cluster

```
python train.py architecture=linear --config-dir=config_weather --config-name=config_slurm -m
```

The `-m` option is important because generally we would't lauch the script in the frontend. This shortcut allows hydra to use the multirun scheduler and lauch the process(es) in the required nodes. In the case of a single gpu machine it will lauch parallel process (careful to the used VRAM).

For example we can train two models on the same data using:

```
python train.py -m architecture=linear, dlinear --config-dir=config_weather --config-name=config_slurm
```

or all the implemented models:

```
python train.py -m --config-dir=config_weather --config-name=config_slurm
```

this because there is the option

```
params:
```

```
architecture: glob(*)
```

that compile the config files using all the models declared in the architecture folder.

In case of parallel experiment you should see at display something like:

```
(tt) agobbi@frontend:~/Projects/timeseries/bash_examples$ python train.py --config-dir=config_weather --config-name=config_slurm -m
[2023-05-03 16:46:59,679][HYDRA] Submitit 'slurm' sweep output dir : multirun/2023-05-03/16-46-58
[2023-05-03 16:46:59,680][HYDRA]      #0 : architecture=attention
[2023-05-03 16:46:59,690][HYDRA]      #1 : architecture=d3vae
[2023-05-03 16:46:59,696][HYDRA]      #2 : architecture=dlinear
[2023-05-03 16:46:59,700][HYDRA]      #3 : architecture=gru
[2023-05-03 16:46:59,710][HYDRA]      #4 : architecture=informer
[2023-05-03 16:46:59,715][HYDRA]      #5 : architecture=linear
[2023-05-03 16:46:59,720][HYDRA]      #6 : architecture=lstm
[2023-05-03 16:46:59,733][HYDRA]      #7 : architecture=mymodel
[2023-05-03 16:46:59,738][HYDRA]      #8 : architecture=mymodel_v2
[2023-05-03 16:46:59,742][HYDRA]      #9 : architecture=mymodel_v3
[2023-05-03 16:46:59,747][HYDRA]     #10 : architecture=nlinear
[2023-05-03 16:46:59,757][HYDRA]     #11 : architecture=persistent
```

Hydra will create a folder called `multirun` with all the experiments launched nested as `date/time/x` where `x` indicates the id of the launched job. Inside `date/time/x` there will be a file called `train.log` containing all the information logged by the system and useful for debugging. Moreover, the error message and output messages generated by the `sbatch` slurm command can be found in the `date/time/.submitted/x` folder.

If the row `override hydra/launcher: joblib` is commented the train will be consecutive, otherwise in parallel. In the latter case the output in the terminal will be a mess but in the `multirun` folder you can find all the log files in the folder `0,1,...` based on the number of models you are training.

Last but not least: you can launch as many process as you want but only few will be active at the same time: if `slur` is used the keyword is `array_parallelism: 10` otherwise the combination of `batch_size:2` and `n_jobs: 2` for the single gpu pipeline.

## Inference

Once the models are trained, the relative full configurations are saved in `config_used` and can be used for inference or comparison:

```
python compare.py --config-dir=config_weather --config-name=compare
```

where the compare file is:

```
models: 'config_weather'          ## path to the main config folder or list of configuration files
dirpath: "/home/agobbi/Projects/ExpTS" ## where are store the models and where to put the results
```

```

set: 'test'                ## set to test
name: 'prova'
rescaling: false           ## sometimes want to get the MSE on the scaled data
batch_size: 32             ## batch size for the dataloader

```

or if you are in a slurm cluster remember to add the `-m` parameters also for the comparison step (otherwise the inference will be executed in the frontend)

```
python compare.py --config-dir=config_weather --config-name=compare_slurm -m
```

if you are in a SLURM cluster where the `compare_slurm.yaml` file must contain also something like:

```

defaults:
  - _self_
  - override hydra/launcher: submitit_slurm

```

```

hydra:
  launcher:
    submitit_folder: ${hydra.sweep.dir}/.submitit/%j
    timeout_min: 600
    partition: gpu-V100
    mem_gb: 6
    nodes: 1
    gres: gpu:1
    name: ${hydra.job.name}
    _target_: hydra_plugins.hydra_submitit_launcher.submitit_launcher.SlurmLauncher
  setup:
    - conda activate tt

```

In the `dirpath` folder `/home/agobbi/Projects/ExpTS/` there are three folders now: `weights` containing the model and the weights, `plots` containing some plots coming from the `compare` script and the `csv` folder containing the files.

A typical example of plot is displayed below and shows the MSE at different lags in the test set for different models:

The loss plot is currently broken on server, you can reproduce it from the notebook 4- `results` (see the notebook section)



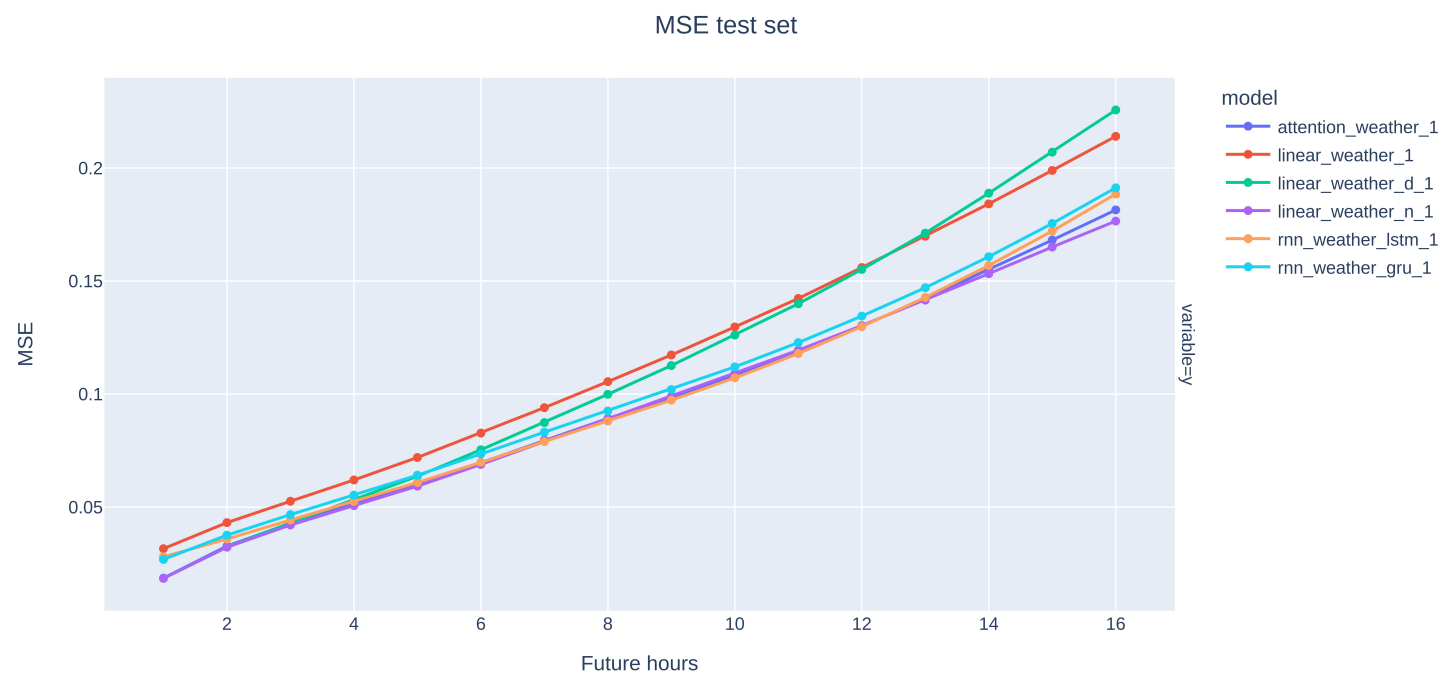


Figure 1: plot

## Testing

You can use the `config_test` for testing your models. In this case you can use smaller model with fewer epochs:

```
python train.py -m --config-dir=config_test --config-name=config_gpu
```

## Same model different parameters

It is possible also to perform a fine tuning procedure on a specific model, in this case:

```
python train.py --config-dir=config_weather --config-name=config_slurm -m architecture=mymodel model_configs.hidden_RNN=32,64,128
```

will spawn 3 parallel processes training the same model with three different values of `hidden_RNN`. In case of multiple parameters to test hydra will generate all the couples of possibilities. This approach can explode very quickly, for this reason it is possible to use `optuna` for exploring the space of the configurations (THIS FEATURE IS NOT MATURE):

```
python train.py --config-dir=config_weather --config-name=config_slurm_optuna -m
```

In this case the configuration file should include the following part:

```
defaults:
```

```
- _self_  
- architecture: null  
- override hydra/launcher: submitit_slurm #SLURM STUFF  
- override hydra/sweeper: optuna          ##OPTUNA SWEEPER
```

```
hydra: ##SLURM STUFFS
```

```
launcher:
```

```
submitit_folder: ${hydra.sweep.dir}/.submitit/%j  
timeout_min: 600  
partition: gpu-V100  
mem_gb: 6  
nodes: 1  
gres: gpu:1  
name: ${hydra.job.name}  
_target_: hydra_plugins.hydra_submitit_launcher.submitit_launcher.SlurmLauncher  
setup:  
- conda activate tt
```

```

output_subdir: null
sweeper:
  sampler: ##OPTUNA STUFFS
    _target_: optuna.samplers.TPESampler ## see https://optuna.readthedocs.io/en/stable/reference/samplers/index.html for other
    seed: 123
    consider_prior: true
    prior_weight: 1.0
    consider_magic_clip: true
    consider_endpoints: false
    n_startup_trials: 10
    n_ei_candidates: 24
    multivariate: false
    warn_independent_sampling: true
  _target_: hydra_plugins.hydra_optuna_sweeper.optuna_sweeper.OptunaSweeper
  direction: minimize
  storage: null
  study_name: tft
  n_trials: 3 ## put the number of maximun trials
  n_jobs: 3   ## parallel jobs

  params:
    architecture: mymodel                    #architecture you want to finetune
    model_configs.num_layers_RNN: choice(1,2,3) #parameters you want to explore, categorical
    model_configs.persistence_weight: range(0.1,0.9,0.1) #or continuous

```

## Results

Here you can find some plots comparing different models.

## Tips

- The folder `weights` can become very big. Try to remove all useless experiments.

- The folder `multirun` can become very crowded, not so big but it can be deleted sometimes
- The folder `config_used` contains all the trained models. The comparison step can be very time consuming (the models are evaluated sequentially). Please use only the models you need