

FTORCH: ENABLING ONLINE TRAINING FOR LARGE-SCALE FORTRAN MODELS

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Overview

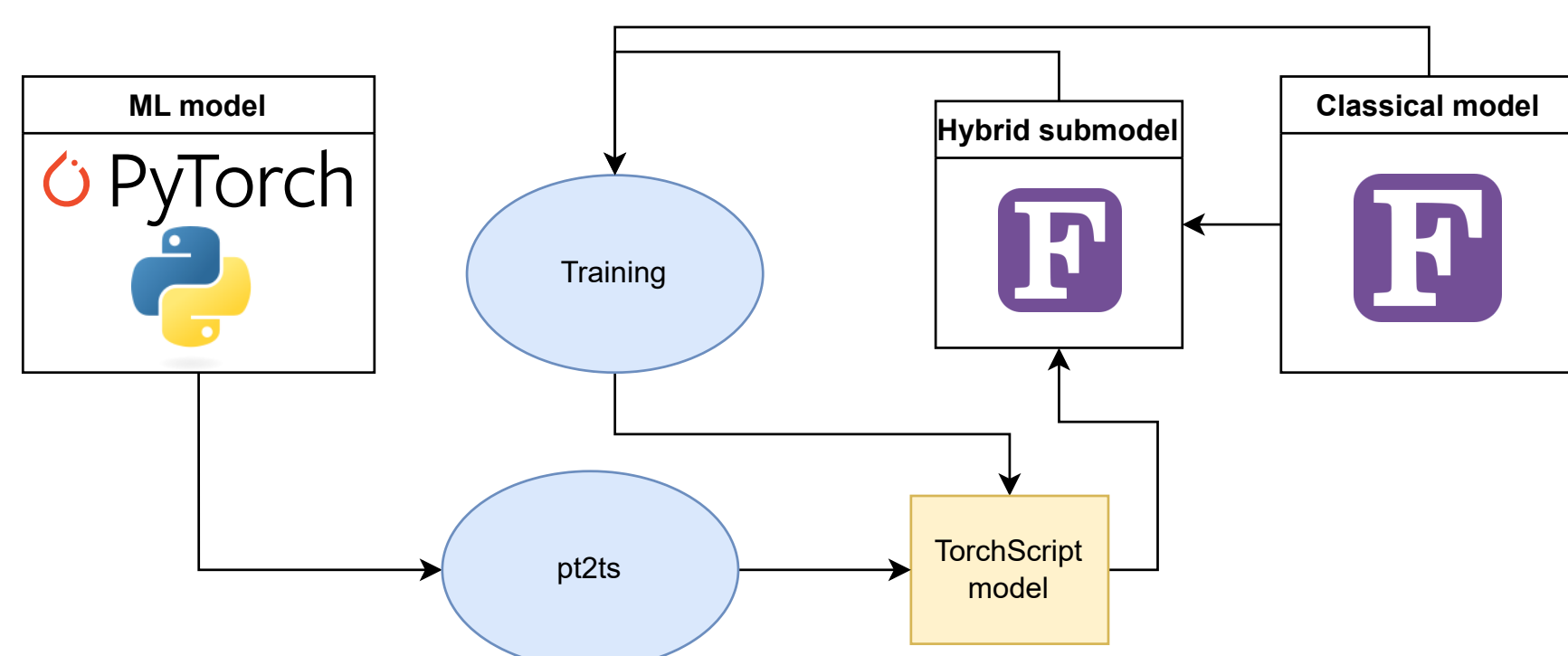
Scientific models in the climate domain are predominantly developed in Fortran for its high-performance and science-oriented nature. On the other hand, much of Machine Learning (ML) research is conducted in Python owing to its rich ecosystem of ML frameworks, e.g. PyTorch.

FTorch (Atkinson et al., 2025) is an open source library developed by ICCS allowing the user to do hybrid modeling by interfacing PyTorch ML models with Fortran code.

Features

- Binds Fortran to PyTorch's C++ backend (no runtime) via `iso_c_binding` module
- Provides a user-friendly Fortran API close to PyTorch API
- Enables *zero-copy* data transfer between languages
- Supports CPU and GPU (CUDA, XPU, MPS backends)
- Tested on UNIX and Windows operating systems

Proposed Online Training Workflow



Benefits:

- No -Fortran conversion overhead + direct integration

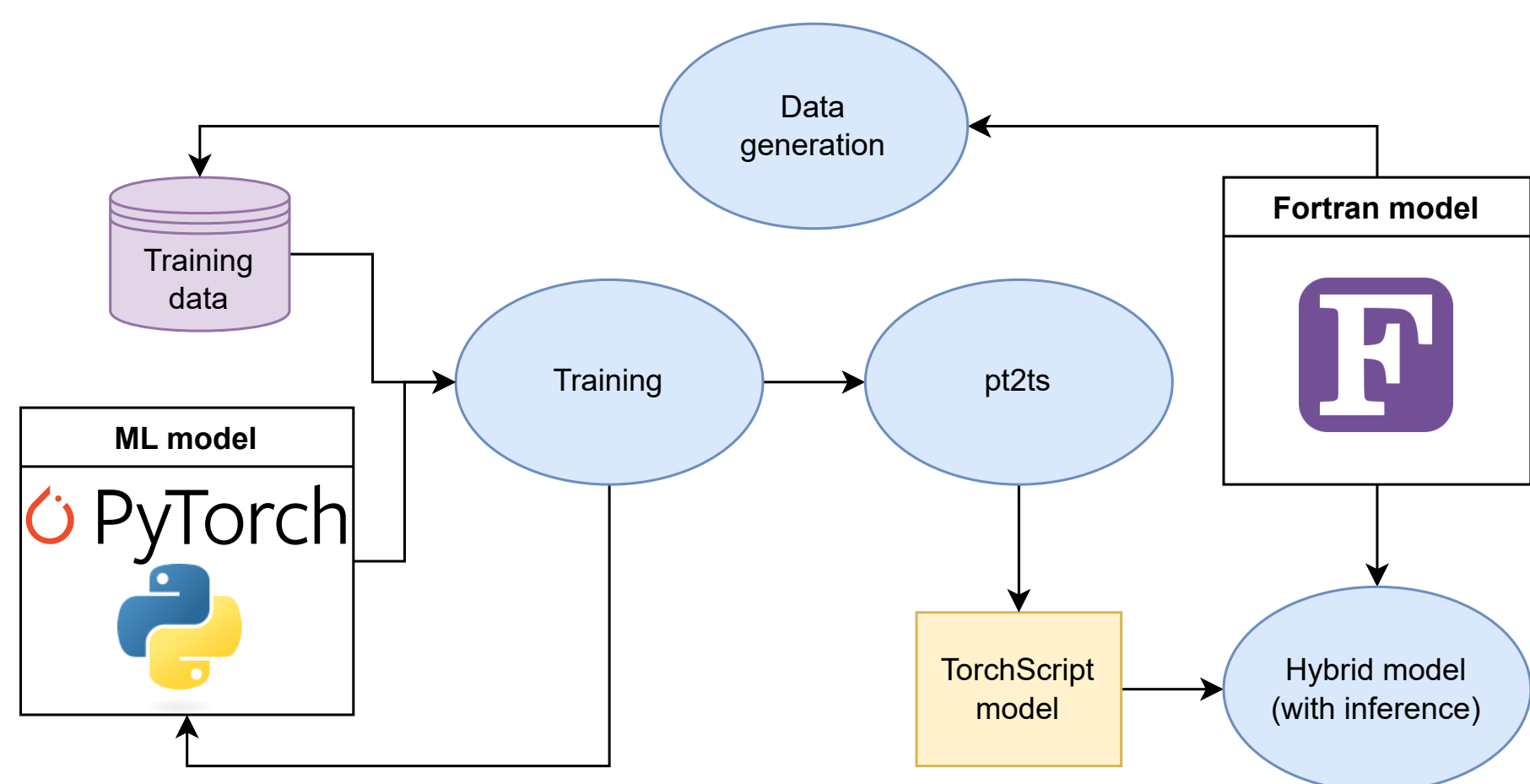
Current state:

- Tensor operator overloading, `requires_grad` support
- `torch_tensor_backward` (backpropagation) with gradient extraction and zeroing

In progress:

- Expose `torch::optim` algorithms and loss functions
- Expose components from `torch::nn::Module`

Hybrid Modeling Offline



- **Design the ML model in PyTorch** with PyTorch API
- **Dataset generation** for the ML model training via Fortran-based model runs
- **Train** the PyTorch model on generated data, optimizing for the specific predictive tasks
- **pt2ts** Convert trained models (`.pt`) to TorchScript (`.ts`)
- **Hybrid model** Integrate the TorchScript model with Fortran code using FTorch, enabling inference during runs

Links and Ongoing Work

- Currently working on coupling a *snow on sea ice emulator* of [SnowModel](#) with [Icepack](#) (column physics of CICE sea ice model)



- Docs: cambridge-iccs.github.io/FTorch
- GitHub: [Cambridge-ICCS/FTorch](https://github.com/Cambridge-ICCS/FTorch)
- See research done using FTorch [here](#)

References

Atkinson, Jack et al. (2025). "FTorch: A Library for Coupling PyTorch Models to Fortran". In: *Journal of Open Source Software* 10.107, p. 7602. DOI: [10.21105/joss.07602](https://doi.org/10.21105/joss.07602).

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