System Architecture and Data Flow

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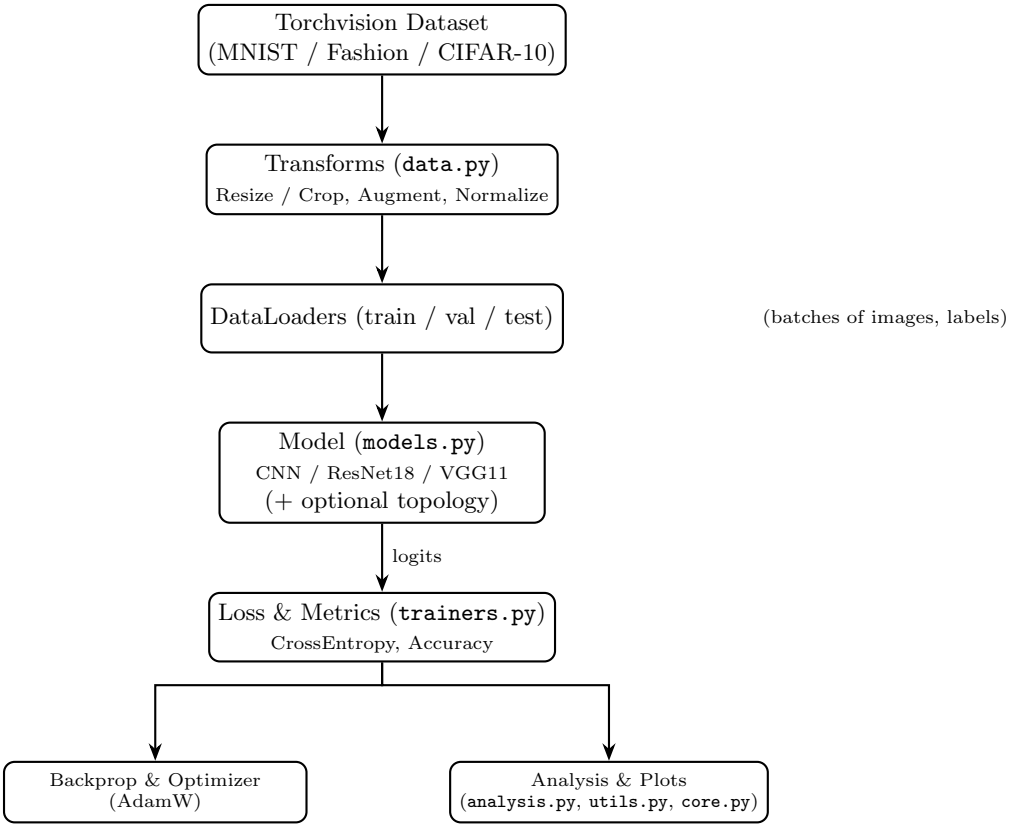
This document describes the architecture and data flow of the experimental image classification framework. It includes three core diagrams: (1) the high-level training pipeline, (2) the topology-enhanced model flow, and (3) the evaluation and robustness pipeline.

1. High-Level Pipeline

From raw datasets to training, optimization, and analysis.

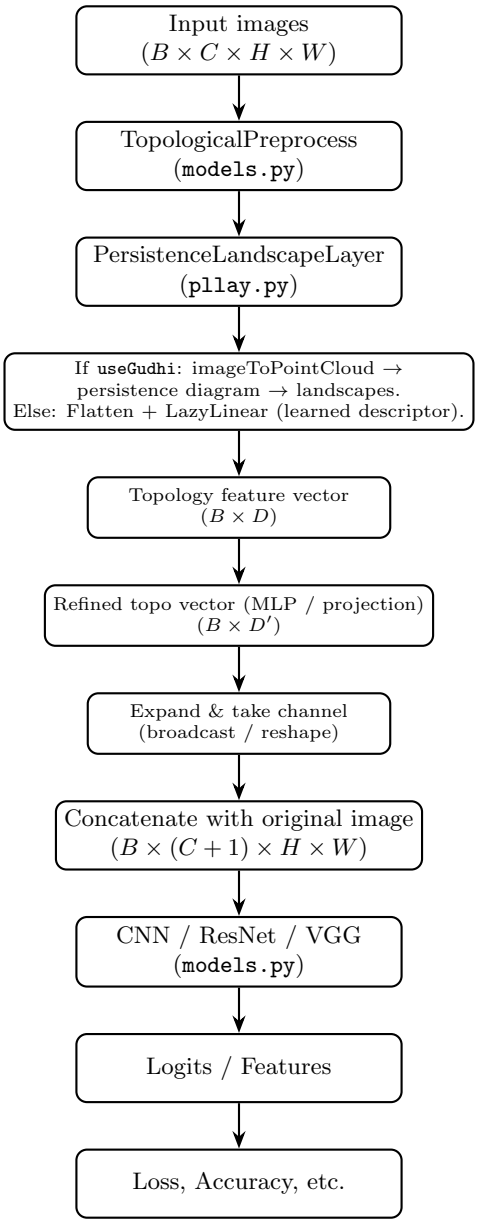


In this pipeline:

- Datasets are loaded from `torchvision` and preprocessed in `data.py`.
- `DataLoader` objects feed batches into the model defined in `models.py`.
- `trainers.py` computes loss and accuracy and performs backpropagation using AdamW.
- `analysis.py`, `utils.py`, and `core.py` log results and create figures such as learning curves and confusion matrices.

2. Topology-Enhanced Model Flow

Process showing how topological features (PLLay) are integrated into the model architecture.



In this topology-enhanced flow:

- `TopologicalPreprocess` calls `PersistenceLandscapeLayer` to compute topological descriptors.
- When `useGudhi` is enabled, `pllay.py` converts images to point clouds, computes persistence diagrams via Gudhi, and derives persistence landscapes.
- Otherwise, a learned global descriptor (Flatten + LazyLinear) is used as a fast approximation.
- The resulting topology vector is projected, reshaped, and inserted as an additional channel before passing into the backbone network.

3. Evaluation and Robustness Flow

In the evaluation and robustness stage:

- `evaluate.py` reloads the trained model checkpoint and the test split.
- `data.py` can add Gaussian noise via `applyEvalNoise` to test robustness.
- `trainers.py` computes loss and accuracy on noisy or clean data.
- `utils.py` and `analysis.py` generate confusion matrices, robustness curves, and save all metrics as JSON and plots.

Using saved checkpoints for evaluation, noise robustness, and visualization.