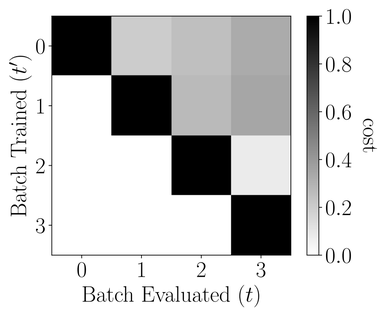
Cost-Aware Retraining for Machine Learning

Notations

- **Current Batch** t
- **Labeled Data** D_t
- **Unlabeled Queries** Q_t
- **Model** $M_{t'}$ **trained with** $D_{t'}$, $t' \leq t$
- **Parameters** θ
- **Decisions:**
  - `Keep` **model** $M_{t'}$
  - `Retrain` **model using** D_t

Cost Matrix C

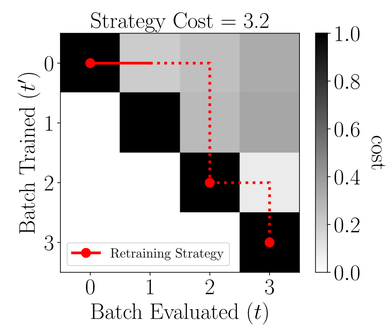
$$C[t', t] = \begin{cases} \textbf{Staleness Cost} & \textbf{if } t' < t \\ \textbf{Retraining Cost} & \textbf{if } t' = t \\ \infty & \textbf{otherwise} \end{cases}$$



Retraining Strategy S

- **Strategy is a set of decisions**
- **Cost of all decisions is strategy cost**
- **Aim is to minimize strategy cost**

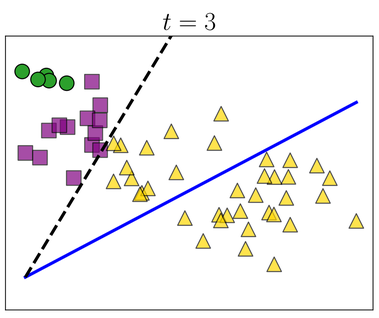
$S = \{\texttt{Keep}, \texttt{Keep}, \texttt{Retrain}, \texttt{Retrain}\}$

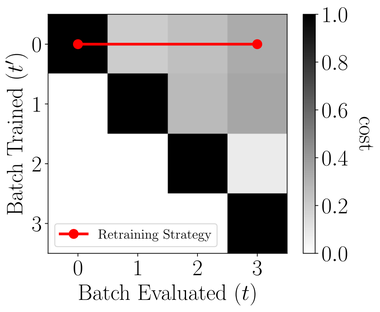


Staleness Cost $\overline{\Psi}_{t,t'}$

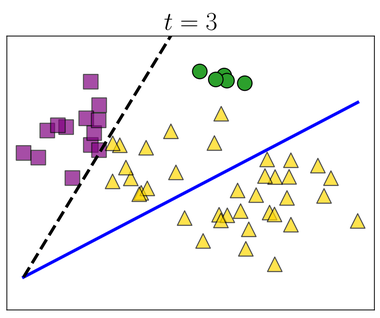
- **Cost of old model** $M_{t'}$ **at batch** t
- **Query-aware performance cost**
- **Scenario 1: Low staleness cost**
- **Scenario 2: High staleness cost**

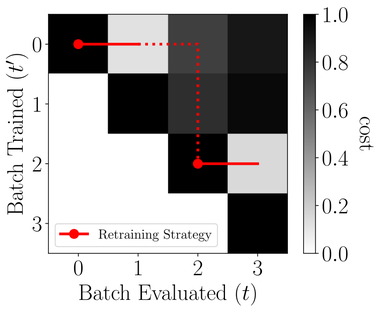
Scenario 1

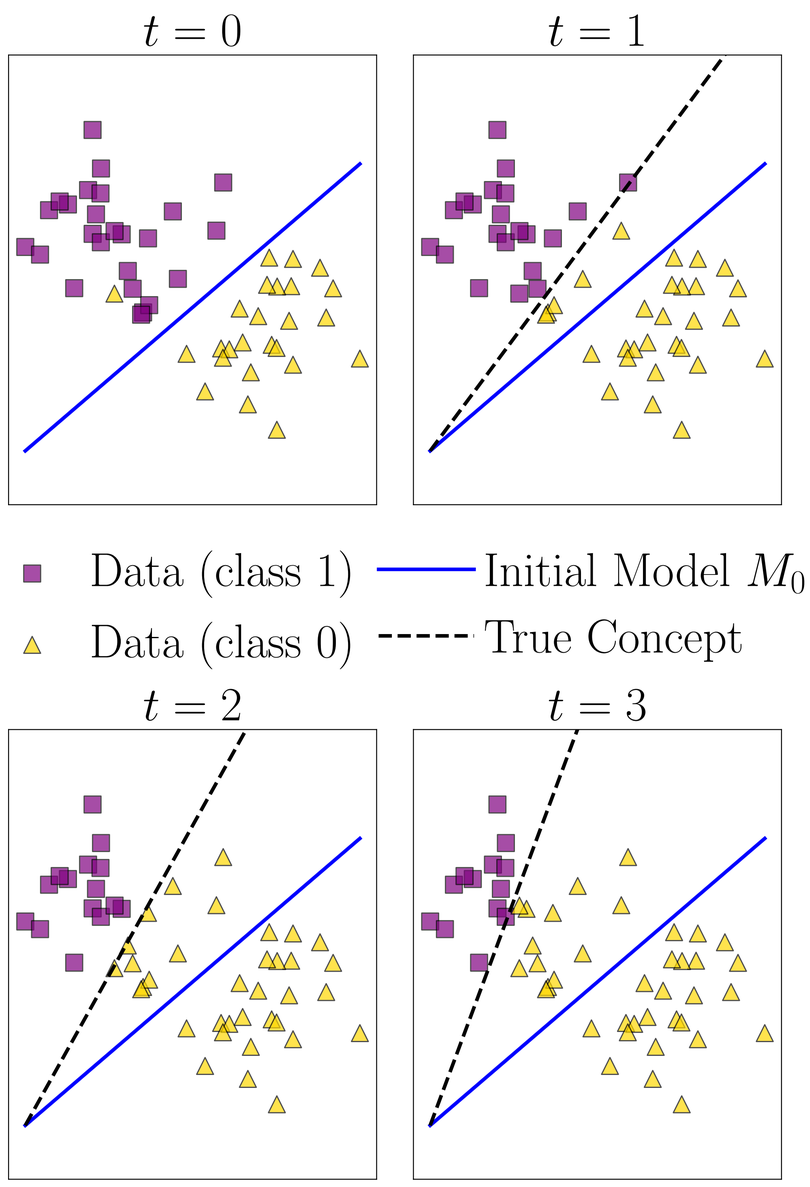




Scenario 2



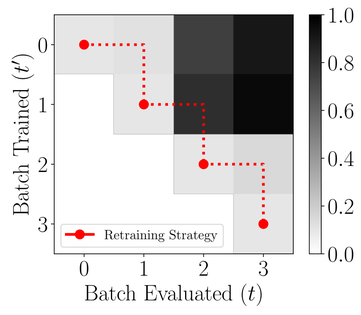




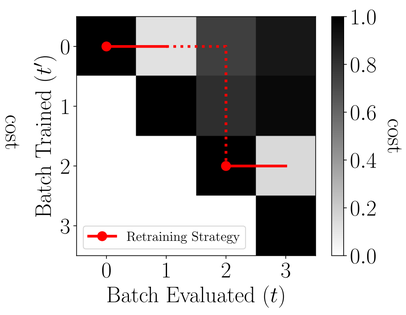
Retraining Cost κ

- **Trade-off parameter**
- **Between resources & performance**
- **Low** κ**: performance is important**
- **High** κ**: resources are important**

Low κ



High κ



Retraining Algorithms

Oracle

Retrospective Optimal Strategy

Cara

Parameterized Online Strategy

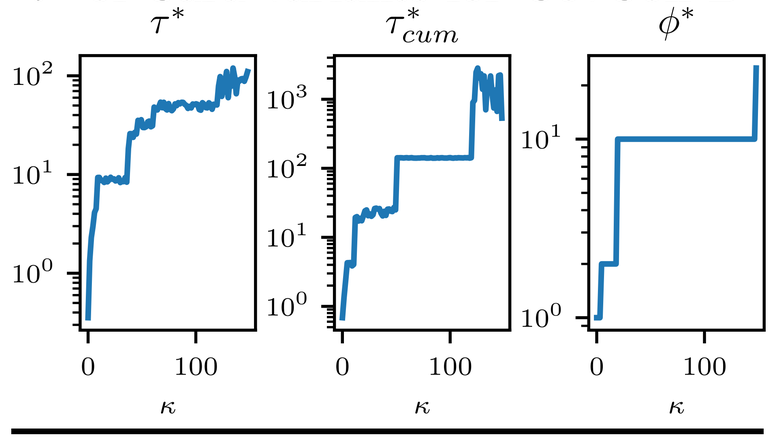
1. **Offline Phase:**
   - **Finds optimal parameters** θ^* **for retraining cost** κ
2. **Online Phase:**
   - **Computes staleness cost** $\overline{\Psi}_{t,t'}$
   - `Retrain` **or** `Keep` **using** θ^*

Cara Variants

1. Cara-T
   - θ **is a threshold** τ
   - **If staleness cost** $> \tau$ **then** `Retrain`
2. Cara-CT
   - θ **is a cumulative threshold** τ_{cum}
   - **Tracks cumulative staleness cost**
   - **If larger than** τ_{cum} **then** `Retrain`
3. Cara-P
   - θ **is a periodicity** ϕ
   - `Retrain` **decision after every** ϕ **batches**

Results

θ^* of Cara variants for CovCon-D



Algo	Strategy Cost	# `Retrain`
Oracle	1170	11.20
Cara-T	1507	13.89
Cara-CT	1368	13.33
Cara-P	1248	10.75

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