λ-ORTHOGONALITY REGULARIZATION FOR COMPATIBLE REPRESENTATION LEARNING

Queen Mary University of London

MICC Media Integration and Communication Center

UNIVERSITÀ DEGLI STUDI FIRENZE
Da un secolo, oltre.

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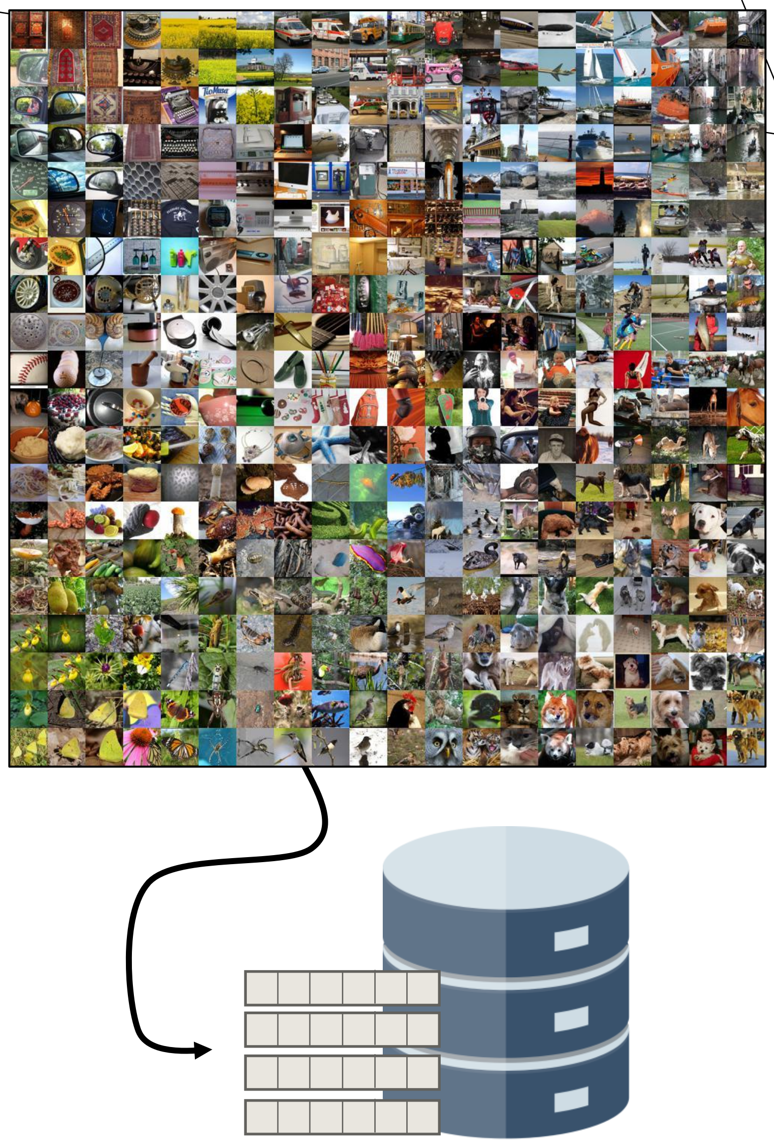
CONTEXT

Modern retrieval systems have **millions of images** indexed into embeddings to form a **Gallery Set.**

As time goes by, datasets grow and the quality of the embeddings improves with **newly trained models**.



CONTEXT

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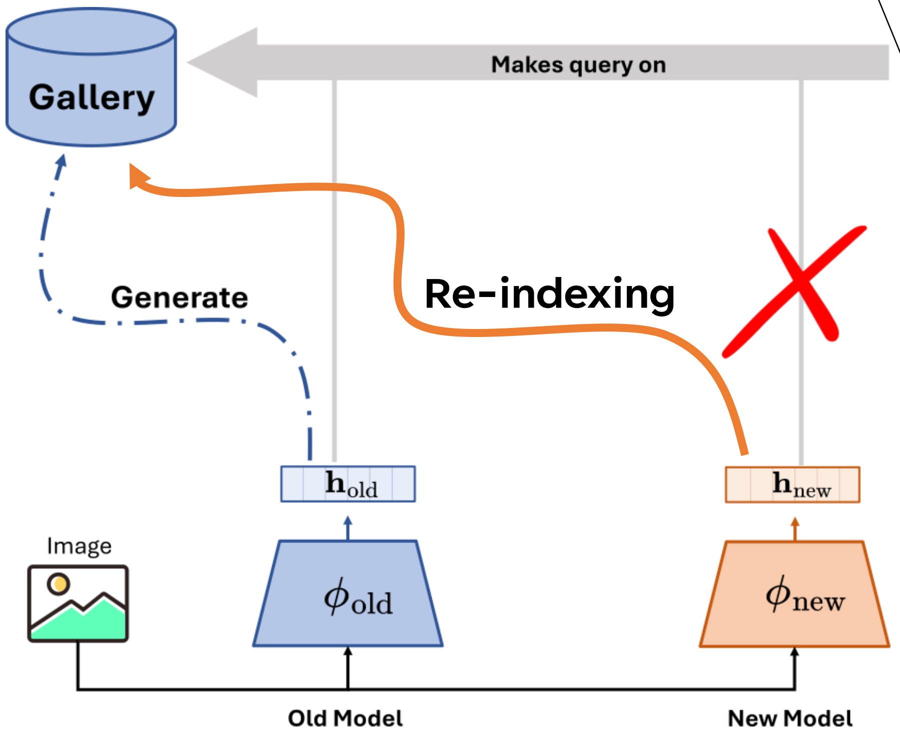
As time goes by, datasets grow and the quality of the embeddings improves with **newly trained models**.

Due to internal representation change, the updated model **can not directly make queries** on the Gallery Set.

To harvest the benefits of updating the model, a costly **re-indexing (backfilling)** process must be done to update old embeddings to new ones.

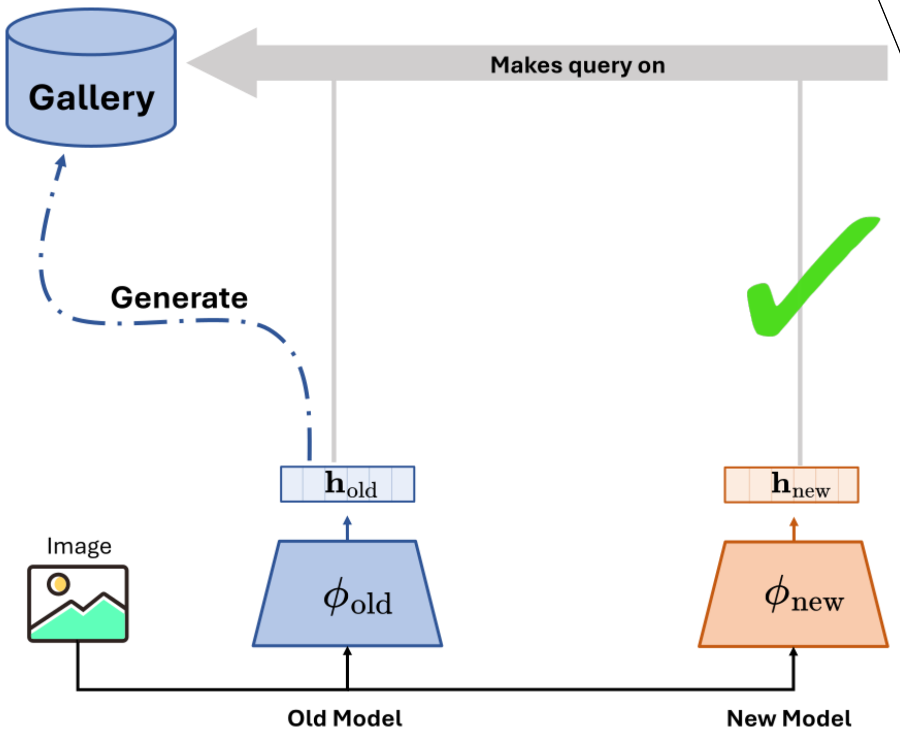


COMPATIBLE REPRESENTATION LEARNING

Visual search systems can **bypass** re-indexing of the Gallery Set when updating to improved models.

The aim is to learn a **new compatible model**, where new embeddings can be compared directly to old embeddings.

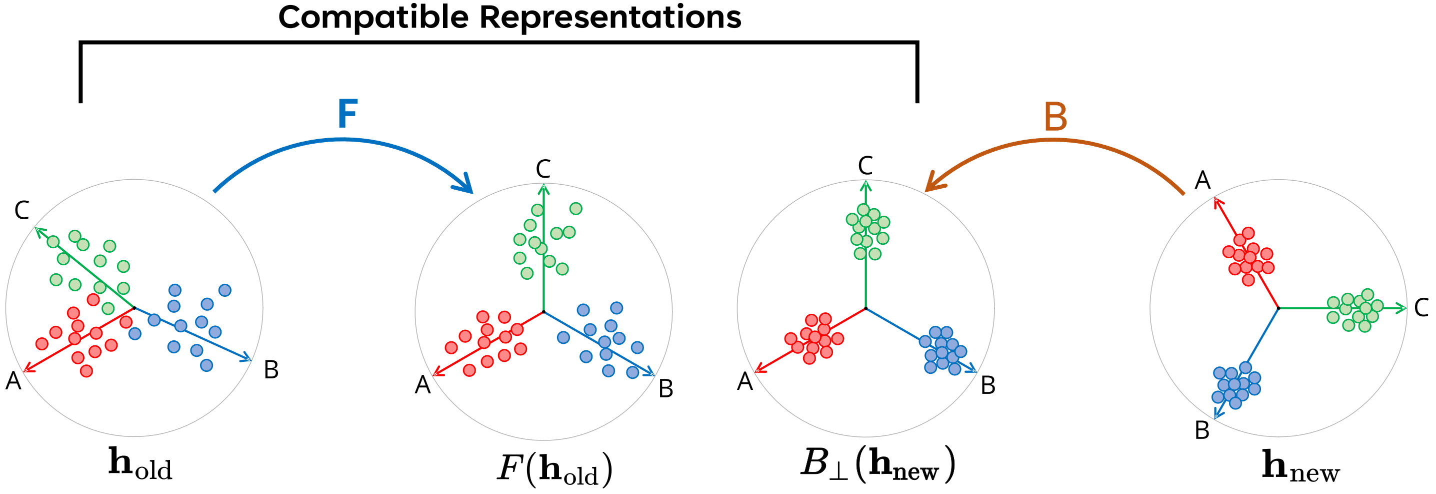
In compatible training strategies, the new model is typically trained with the **old model as reference** → the new compatible model performance **is lower** than independently trained one.

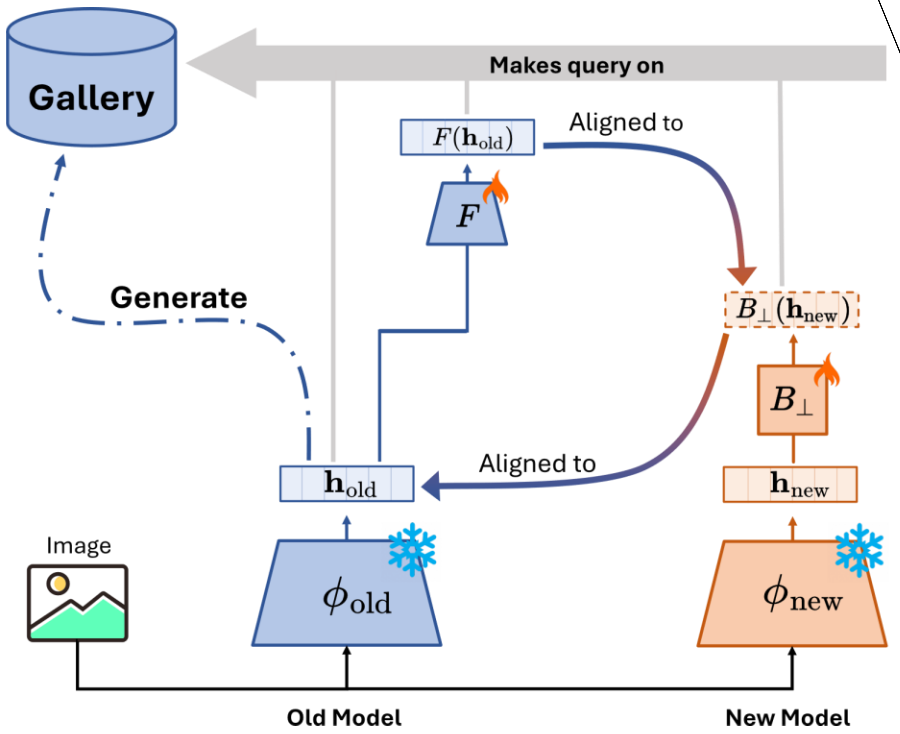


OVERVIEW OF THE PROPOSED APPROACH

A new independently trained model is aligned to the old representation space via an **orthogonal transformation B** (**geometry space preservation**).

A **forward transformation F** (**high adaptability**) maps the old embeddings to the backward-aligned representation of the new model ⟶ improving old embeddings.





λ-ORTHOGONALITY

A highly stable (**strict orthogonal**) constraint for **transformation B** is suboptimal when representations are adapted from models trained on different datasets (**downstream task**).

We aim for **slight adaptability** to different distributions, while preserving the geometrical structure.

Soft-Orthogonality: constraining the Gram matrix of the weight matrix to be close to the identity matrix.

$$\min_{W} ||W^T W - I||_F$$

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We aim for **slight adaptability** to different distributions, while preserving the geometrical structure.

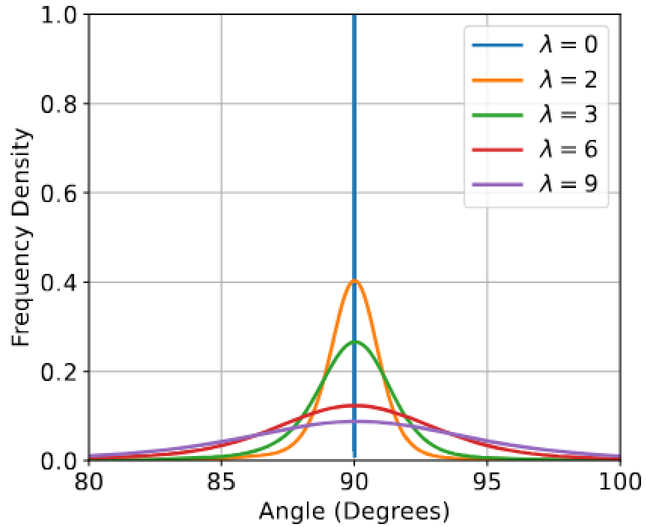
We constrains a transformation to **remain within a specified proximity** to the orthogonality condition.

$$\min_{W} ||W^T W - I||_F \quad \text{s.t.} \quad ||W^T W - I||_F \geq \lambda$$

To avoid the discontinuity in λ, we formulate the smooth **λ-Orthogonality Regularization**:

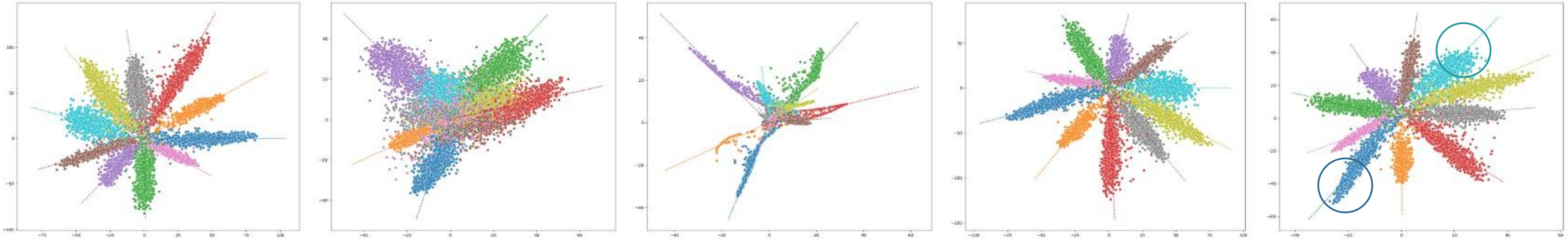
$$\mathcal{L}_\lambda = \sigma\left(\alpha\left(\|WW^T - I\|_F - \lambda\right)\right) \cdot \|WW^T - I\|_F$$

RELAXATION EFFECT



Higher λ values reduces the proximity to the orthogonal condition for the transformation.

Differing from strict orthogonality, λ-Orthogonality Regularization allows for small modifications within the representation space, which improves the overall alignment.



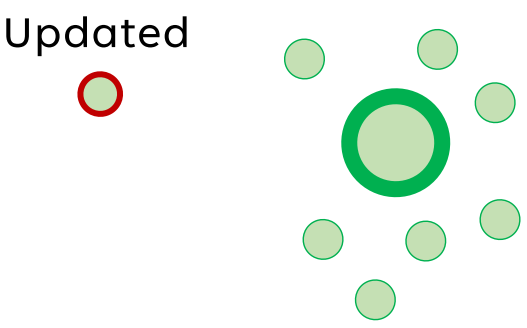
(a) Source space (b) Target space (c) Affine (d) Orthogonal (e) λ-orthogonality

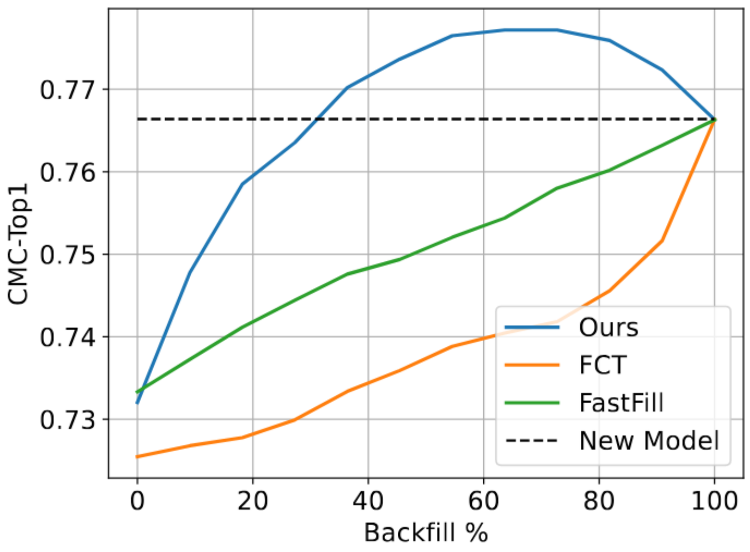
PARTIAL BACKFILLING

Determining an **effective ordering for backfilling** samples is critical for achieving the performance of the new independently trained model as efficiently as possible.

In retrieval systems, the most representative instances of a category are the embeddings **closest to their respective class mean.**

We propose a novel method for estimating a backfill ordering: the embeddings in the gallery that are **furthest from their respective class means** are prioritized for backfilling, as less informative.





NEURAL INFORMATION PROCESSING SYSTEMS

THANK YOU FOR YOUR ATTENTION

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