

Learning Fine-grained Image Similarity with Deep Ranking

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Let's start with defining similarity between images...

Similarity between images - Euclidean distance

$$D(p, q) = D(q, p) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \dots + (q_n - p_n)^2}$$

Squared Euclidean distance:

$$D(f(P), f(Q)) = \|f(P) - f(Q)\|_2^2$$

What do we care about image similarity?

Image Search



Query

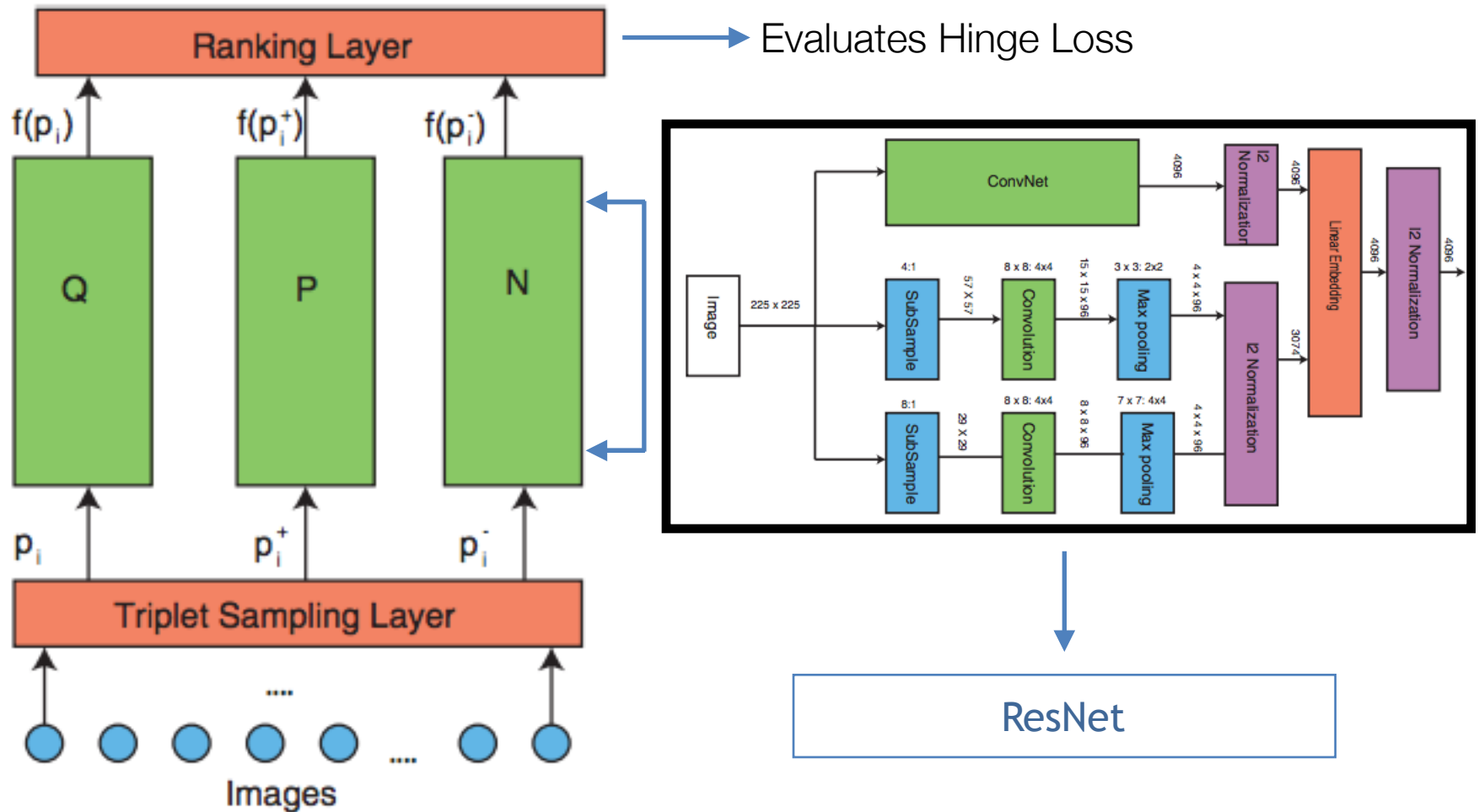
Ranked Results

Problem

- Learning image similarity is a challenging problem
- Most similarity models consider category-level similarity
 - For example, if a query image is a “black car”, we usually want to rank the “dark gray car” higher than the “white car”

We only care about category-level similarity!

Deep Ranking Architecture



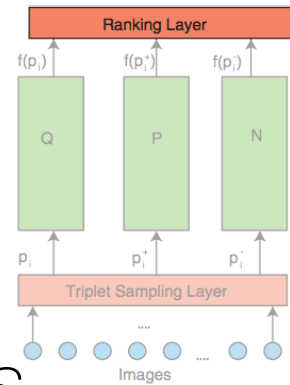
Deep Ranking Goal

- Learn an embedding function **$f(\cdot)$** that assigns smaller distance to more similar image pairs

$$D(f(p_i), f(p_i^+)) < D(f(p_i), f(p_i^-)),$$
$$\forall p_i, p_i^+, p_i^- \text{ such that } r(p_i, p_i^+) > r(p_i, p_i^-)$$

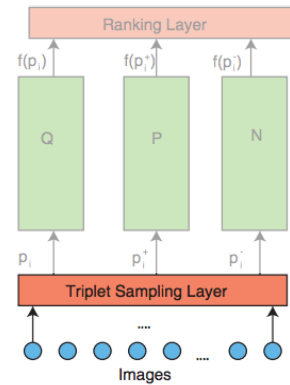
- Hinge loss for a triplet

$$l(p_i, p_i^+, p_i^-) =$$
$$\max\{0, g + D(f(p_i), f(p_i^+)) - D(f(p_i), f(p_i^-))\}$$



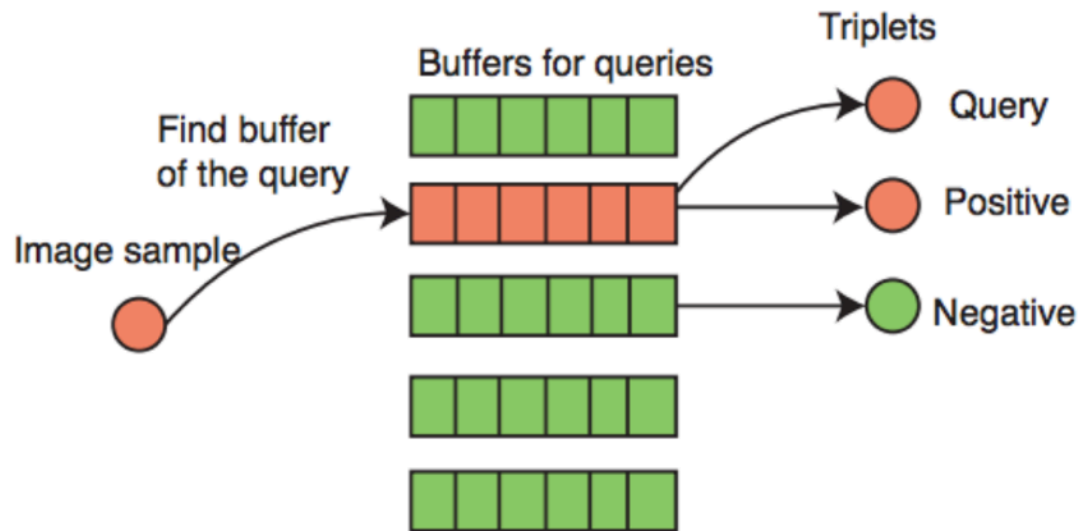
Triplet Sampling

- Need a large variety of images
 - Computationally prohibitive to use all the triplets
- Triplet sampling strategy crucial
 - Uniformly sampling sub-optimal
 - More interested in the top-ranked results returned by the ranking model



You can do uniform sampling for this project!

Triplet Sampling - Uniform sampling

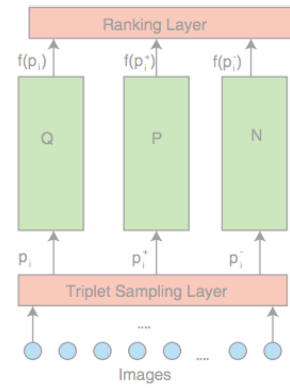


- **Query sample:** p_i is uniformly sampled from all images in the buffer of category c_j
- **Positive image sample:** uniformly sample p_i^+ from the same buffer as the query image
- **Out-of-class negative image sample:** draw a image p_i^- uniformly from all the images in the other buffers
- **In-class negative image sample:** not applicable for this homework

Training Data

- **First Dataset:**
 - ImageNet for ConvNet pretraining
- **Second Dataset:**
 - Tiny ImageNet for training and validation

Inference



Inference

Query Image



Trained CNN

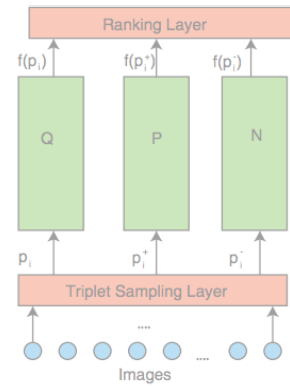
Query Feature Embedding

Training Images

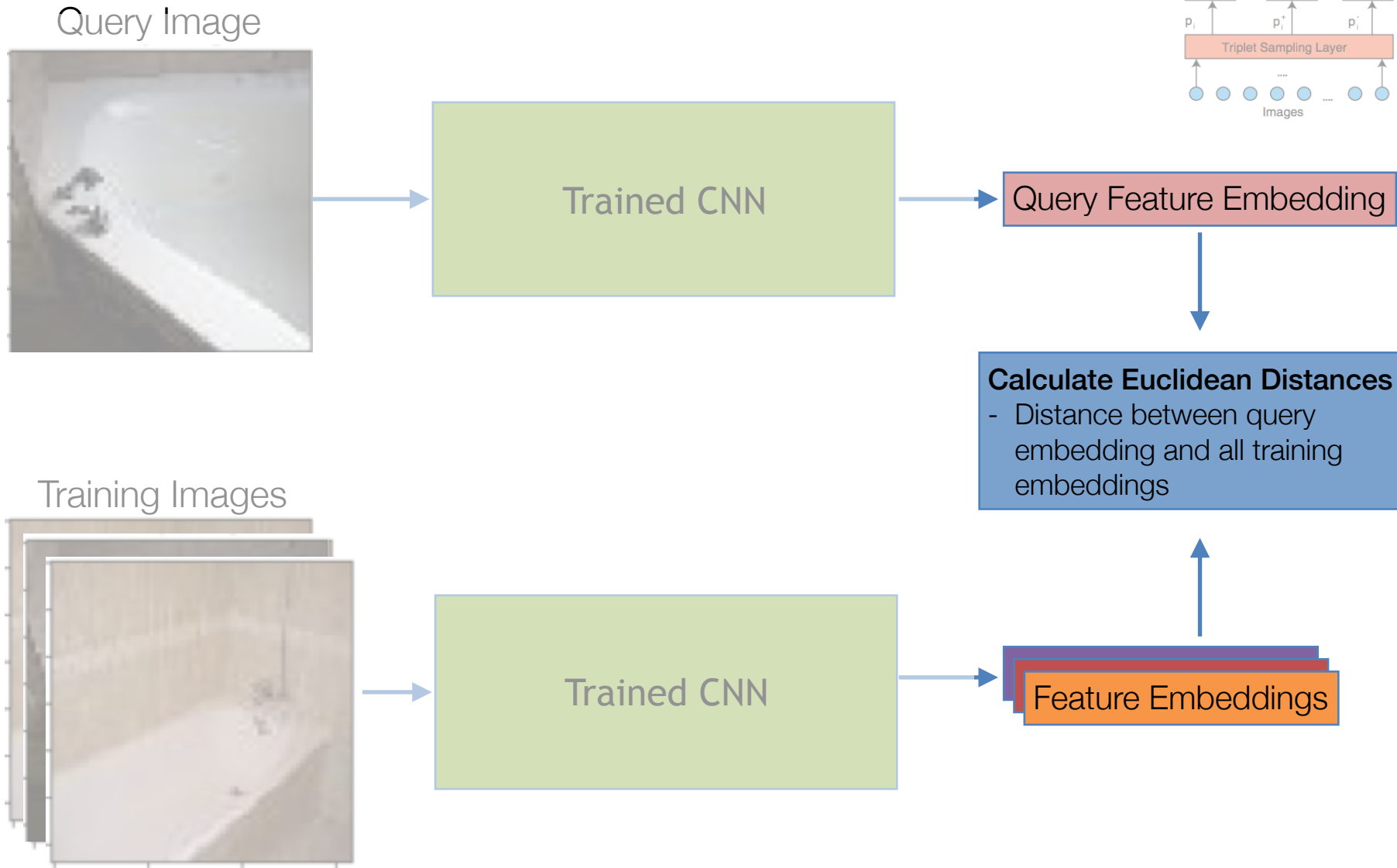


Trained CNN

Feature Embeddings



Inference



Quantitative Results - Evaluation Criteria

- Retrieve top 30 closest results for a query image
 - Closest in terms of Euclidean distance
- **Accuracy:** How many retrieved images belong to the same class as the query image?
- **Precision** at Top 30:
 - $\text{Precision} = \text{TPs} / (\text{TPs} + \text{FPs})$
 - Same as accuracy defined above

Qualitative Results

Query Image



Deliverables

- Code and Accuracy - Target accuracy: 60% or higher
- Describe your implementation
- Quantitative results
 - Plot of your training loss
 - Table of similarity precision for both your training and val
- Qualitative results
 - Sample 5 different images (from different classes) from the val set
 - Show the top 10 ranked results from your pipeline
 - Show the bottom 10 ranked results from your pipeline
- Describe at least one way in how you can improve the performance of your network