Computer Vision

Approximate Nearest Neighbors Algorithms
Product Quantization

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Product Quantization

In this report, we cover results of our experiments with the Product Quantization index (in particular, IVFPQ[1]) [1] for the nearest neighbors search. The report includes the following:

- Showcase of IVFPQ performance on Oxford105K data (image descriptors with total number of samples N $=$ 104933 of dimension d $=$ 128);
- Comparison of IVFPQ with FLANN[2][2].

Technical Details

The implementation was performed using Python 3.7.7. The respective notebook is available on our GitHub page.

[1] We utilize Fair AI Similarity Search (faiss) library with fixed parameters of the index: `nlist`$=$ 100, m $=$ 16, `nbits`$=$ 8, and `nprobe`$=$ 32 of IVFPQ index.

[2] PyFLANN library is used.

NN Search with IVFPQ on Old Image Descriptors

Figure 1: 5 Nearest neighbors for the sample image. Not exhilarating performance on older image descriptors.

NN Search with IVFPQ on CNN-based Image Descriptors

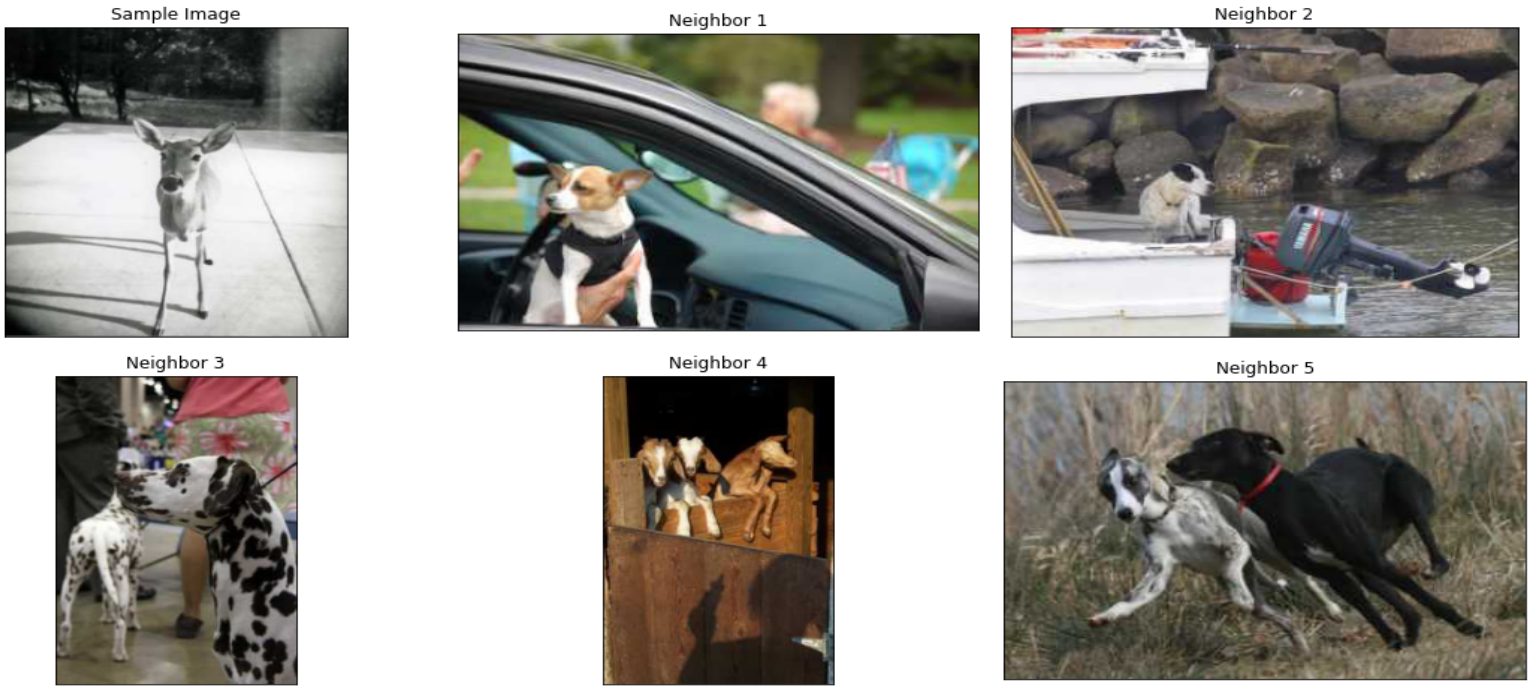

Figure 2: 5 Nearest neighbors for the sample image. Better performance on CNN-based image descriptors, as all images at least depict animals with common features.

Framework of the Experiment

- We compare performance of IVFPQ with the k-d-forest (FLANN-KDF), the priority search k-means tree (FLANN-KMT), and the auto-tuned FLANN with target precision set to 0.99 (FLANN-TARGET) by means of estimation of recall $R(k, K)$.[3]
- Recall is measured as the average fraction over 1000 queries (randomly selected images) of first k true nearest neighbors found during the search of K approximate nearest neighbors, $k \leq K$. Results for $K = 100$ can be viewed in Fig. 3.
- For each approach, we also measure the time to build the index and to perform the query. Results are presented in Tab. 1.

Method	Time to build the index, [s]	Time to perform the query, [s]
IVFPQ[4]	5.64 + 0.584	0.104
FLANN-KDF	4.24	0.1
FLANN-KMT	28.4	0.0582
FLANN-TARGET	28.2	0.0544
Exact NN	-	26

Table 1: Timings of ANN methods to perform 1000 queries for 100 nearest neighbors.

[3] FLANN parameters we used are available in the appendix (see Tab. 2 and Tab. 3).

[4] Timings for both training on all data points and the point insertion are given.

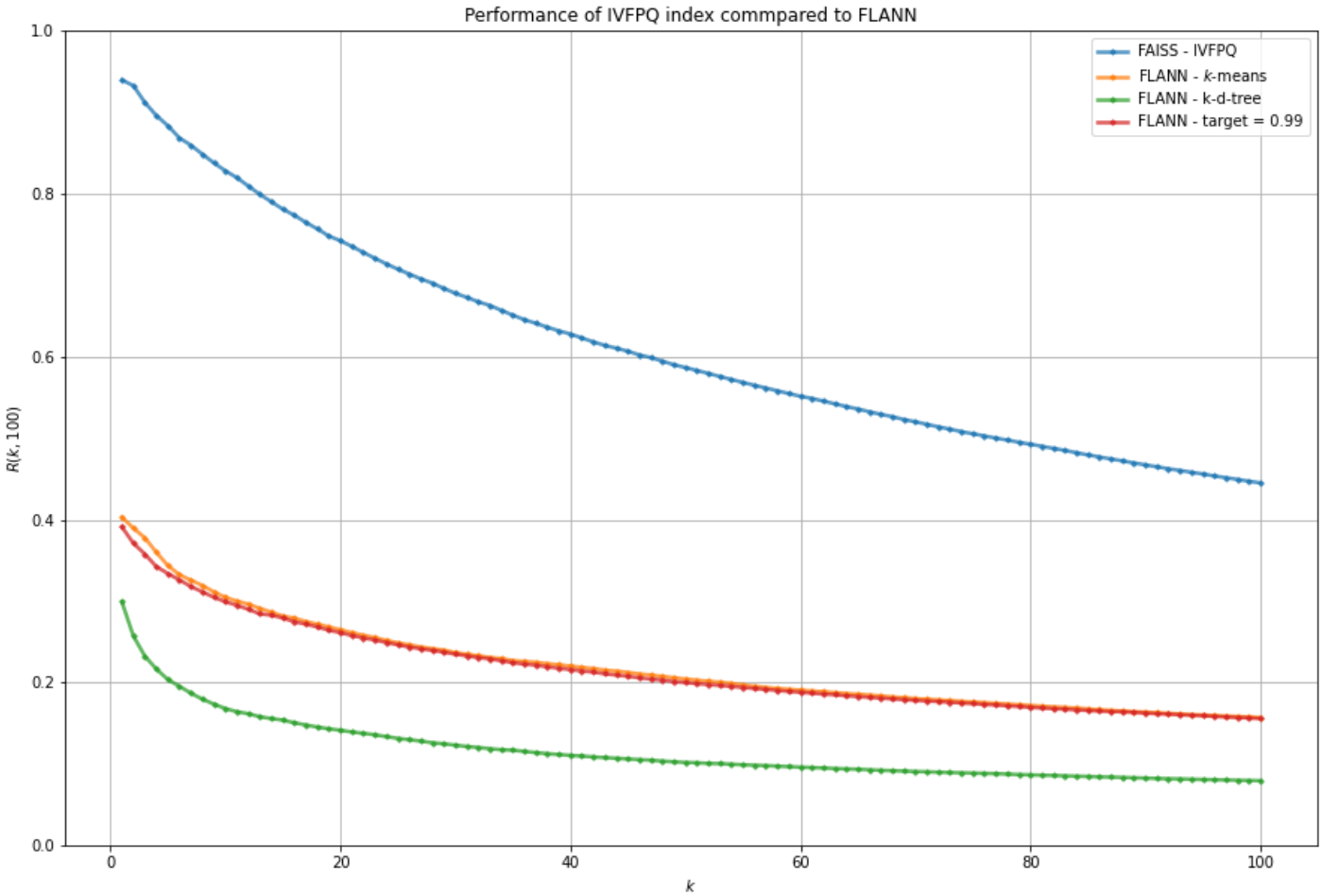

Figure 3: Values of $R(k, 100)$. In terms of recall, IVFPQ demonstrates superior performance to FLANN.

Appendix

FLANN Parameters in Our Experiments

- FLANN-KDF (T - number of randomized trees, C - number of leaves to check in one search):

T	C
32	32

Table 2: FLANN-KDF parameters.

- FLANN-KMT (B - branching factor for k-means tree construction, I - number of iterations for the tree construction, CB - cluster boundary index for the search in the tree, C - number of leaves to check in one search):

B	I	CB	C
100	20	0.2	32

Table 3: FLANN-KMT parameters.

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IEEE Trans. Pattern Anal. Mach. Intell., 33(1):117–128, 2011.

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