NeXtVLAD: An Efficient Neural Network to Aggregate Frame-level Features for Large-scale Video Classification
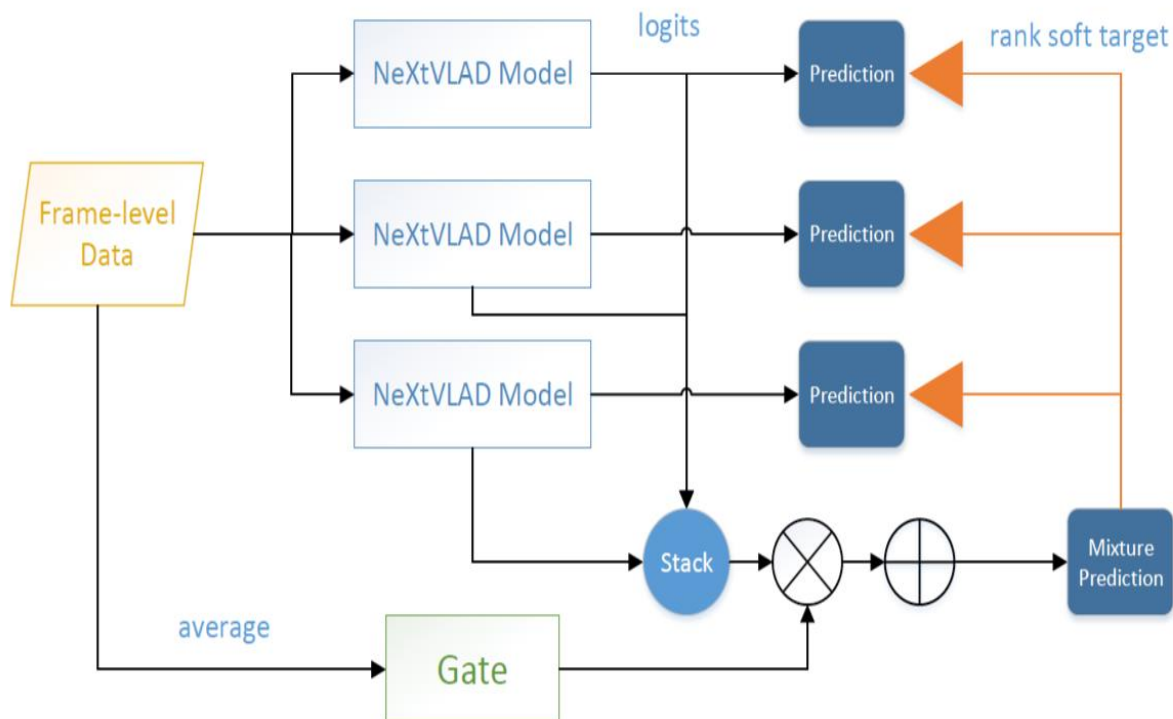
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Final solution overview:

[X. Lan 2018]

Individual loss

distillation loss

$$\mathcal{L} = \sum_{m=1}^{3} \mathcal{L}_{bce}^{m} + \mathcal{L}_{bce}^{e} + T^2 * \sum_{m=1}^{3} \mathcal{L}_{kl}^{m,e}$$

mixture loss

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Table 2. The GAP scores of submissions during the competition. All the other parameters used are (0.5drop, 112K, 2048H). The final submissions are tagged with *

Model	Parameter	Private GAP	Public GAP
single NeXtVLAD(460k steps)	79M	0.87846	0.87910
3 NeXtVLAD (3T, 250k steps)	237M	0.88583	0.88657
3 NeXtVLAD (3T, 346k steps)	237M	0.88681	0.88749
3 NeXtVLAD* (3T, 460k steps)	237M	0.88722	0.88794
3 NeXtVLAD* (3T, 647k steps)	237M	0.88721	0.88792

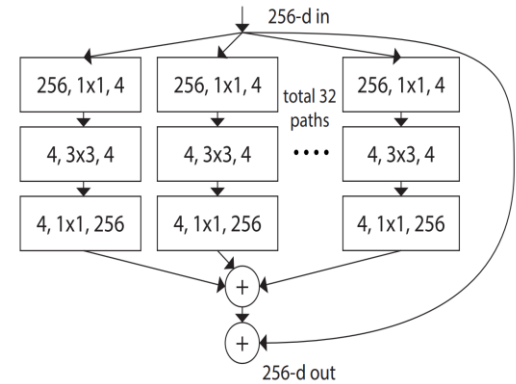- 79M parameters ≈ 316M storage using Float32
- 2 nvidia gtx 1080 TI GPUs
- 400+ examples/sec with SSD
- About 2 days to reach the final results

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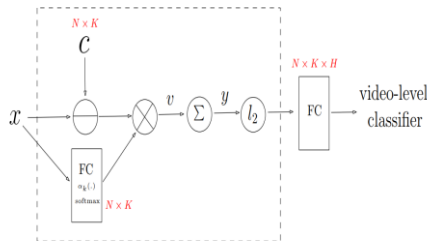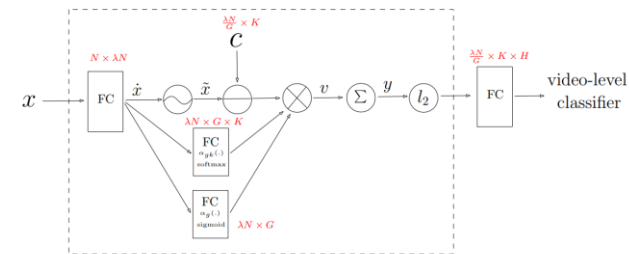# Motivations: feature groups for aggregation?

ResNet
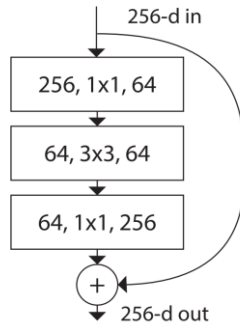
ResNeXt

NetVLAD

NeXtVLAD

NetVLAD: a learnable pooling approach

[R. Arandjelović, 2016]

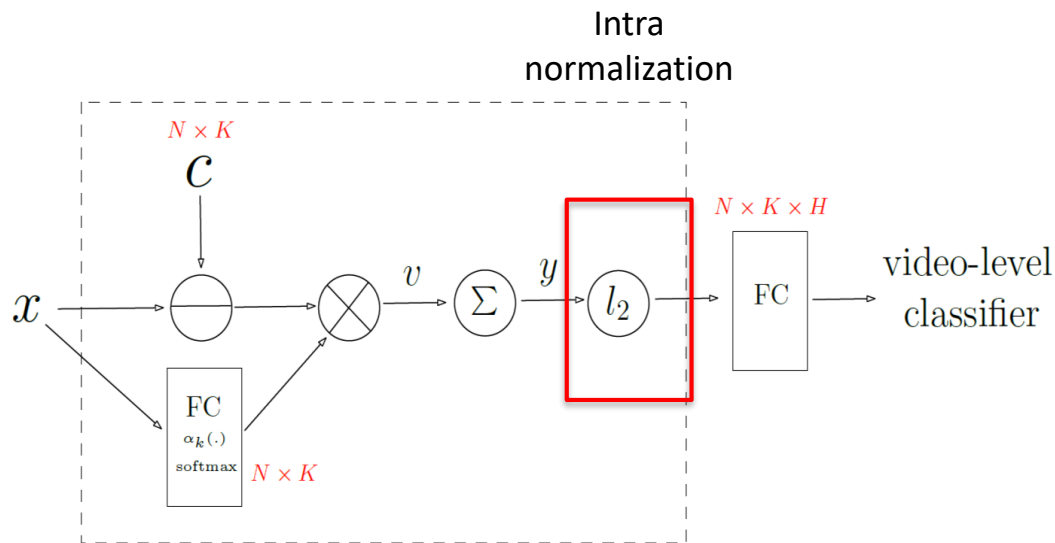Soft assignment of frame feature x_i to cluster k

$$y_{jk} = \sum_i \alpha_k(x_i)(x_{ij} - c_{kj})$$

Residual vector

Sum over all M frames in the video

$$\alpha_k(x_i) = \frac{e^{w_k^T x_i + b_k}}{\sum_{s=1}^{K} e^{w_s^T x_i + s_t}}$$

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NetVLAD: a learnable pooling approach

Intra normalization

$N \times K$

c

$N \times K \times H$

x

v

Σ

y

l_2

FC

video-level classifier

FC
$\alpha_k(.)$
softmax $N \times K$
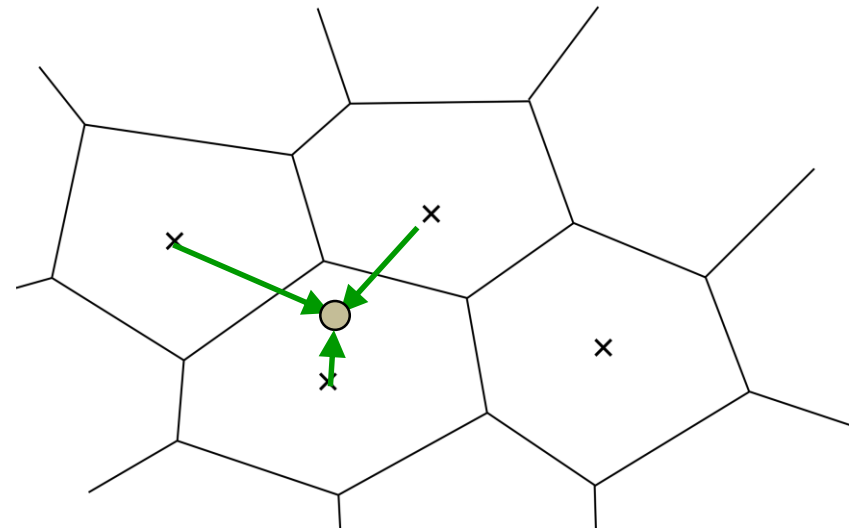
- Parameters Number:
  $N \times K \times (H + 2)$

- N(input dimension), K(cluster number), H(hidden size)

e.g. N = 1024, K = 256 H = 2048 will result in 537 millions parameters

Fig. 1. Schema of NetVLAD model for video classification. Formulas in red denote the number of parameters (ignoring biases or batch normalization). FC means fully-connected layer.

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# NeXtVLAD: a mixture of NetVLAD over group features

Attention function over groups

$$y_{jk} = \sum_g a_g(x_i) \sum_i \alpha_{gk}(x_i)(x_{ij}^g - c_{kj})$$

Sum over all groups

Group level NetVLAD aggregation

$$\alpha_g(x_i) = \sigma(w_g^T x_i + b_g)$$

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NeXtVLAD: a mixture of NetVLAD on group features

Feature expansion

Reshape operation

$N \times \lambda N$

$\frac{\lambda N}{G} \times K$

C

$\frac{\lambda N}{G} \times K \times H$

x — FC — $\tilde{x}$ — $\tilde{x}$ — $\otimes$ — v — Σ — y — l_2 — FC — video-level classifier

$\lambda N \times G \times K$

FC $\alpha_{gk}(.)$ softmax

FC $\alpha_g(.)$ sigmoid $\lambda N \times G$

Fig. 2. Schema of our NeXtVLAD network for video classification. Formulas in red denote the number of parameters (ignoring biases or batch normalization). FC represents a fully-connected layer. The wave operation means a reshape transformation.
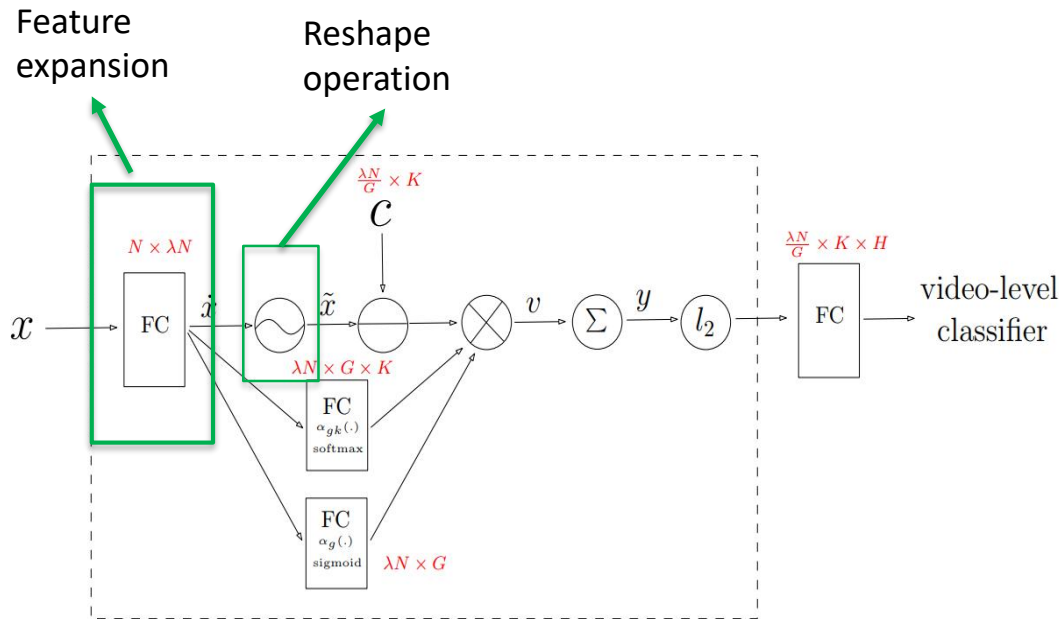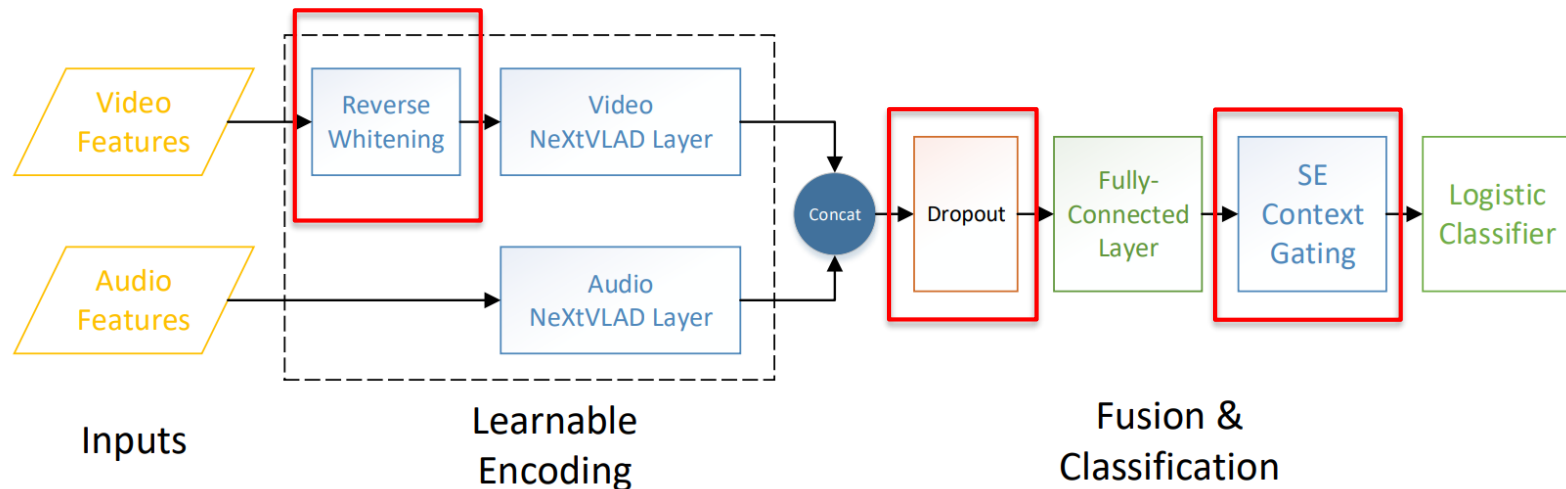
- Parameters Number:

$$\lambda N \times \left(N + G + K \times \left(G + \frac{H+1}{G} \right) \right)$$

- N(input dimension), G(group number), K(cluster number), H (hidden size), λ(expansion factor)
- About $\frac{G}{\lambda}$ times smaller than NetVLAD with same cluster number, input and output dimension
- e. g. N=1024, G=8, K=256, H=2048, λ = 2 will results in about 140 million parameters

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Overview of the NeXtVLAD model used in the challenge

[A. Miech 2017]

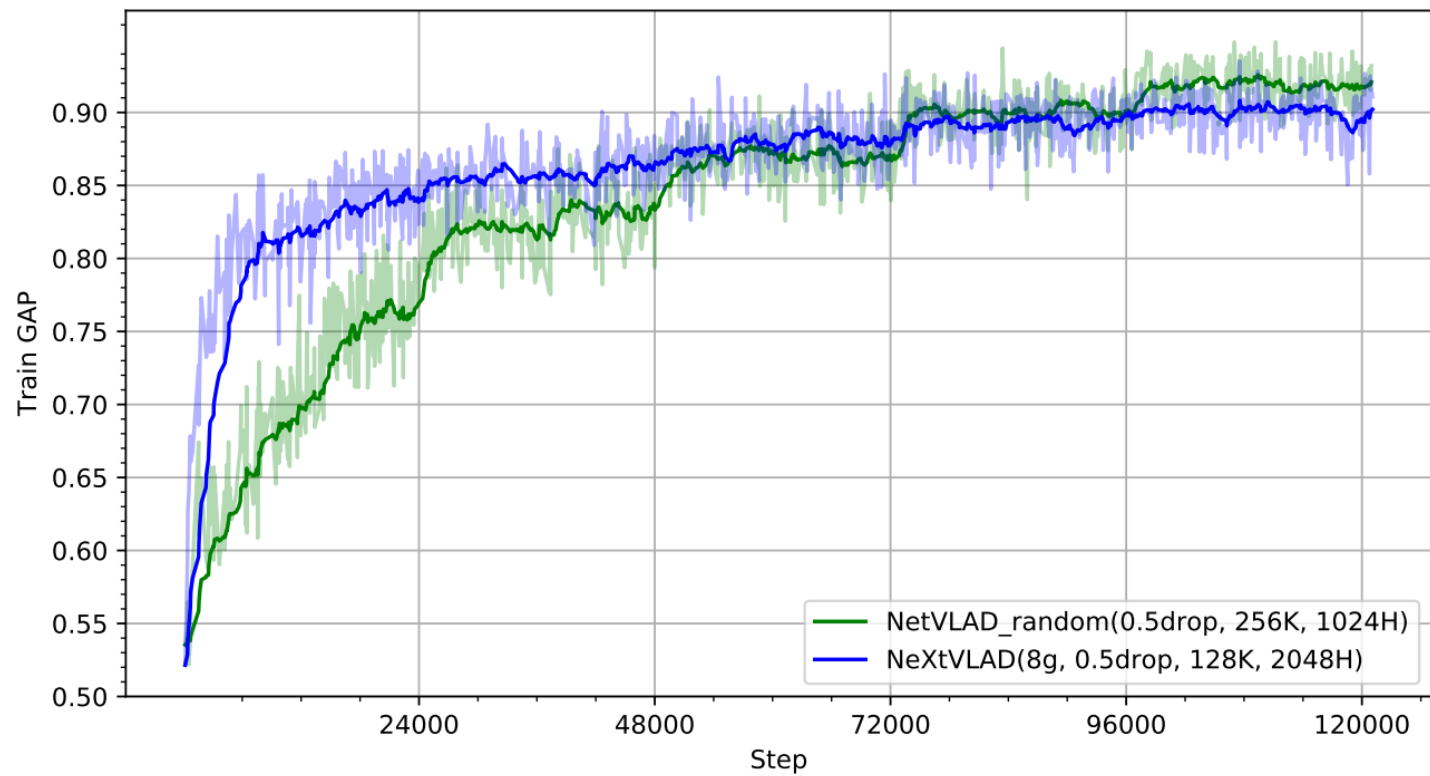- Reverse whitening: $\hat{x}_{ij} = x_{ij} * \sqrt{e_j}$
- SE Context Gating:
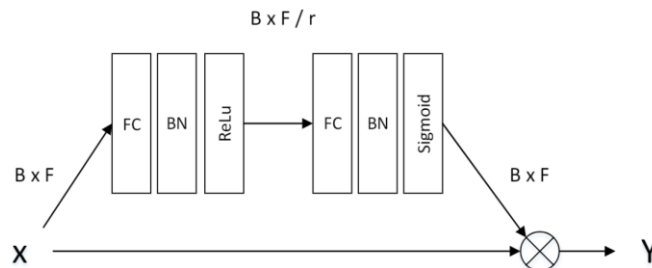
Fig. 6. Training GAP on Youtube-8M dataset. The ticks of x axis are near the end of each epoch.

Single model performance comparison

Table 1. Performance (on local validation partition) comparison for single aggregation models. The parameters inside parenthesis represents (group number G, dropout ratio, cluster number K, hidden size H)

Model	Parameter	GAP
NetVLAD (-, 0.5drop, 128K, 2048H)	297M	0.8474
NetVLAD_random (-, 0.5drop, 256k, 1024H)	274M	0.8507
NetVLAD_small (-, 0.5drop, 128K, 2048H)	88M	0.8582
NeXtVLAD (32G, 0.2drop, 128K, 2048H)	55M	0.8681
NeXtVLAD (16G, 0.2drop, 128K, 2048H)	58M	0.8685
NeXtVLAD (16G, 0.5drop, 128K, 2048H)	58M	0.8697
NeXtVLAD (8G, 0.5drop, 128K, 2048H)	89M	0.8723

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Questions & More Details - - >
https://www.kaggle.com/c/youtube8m-2018/discussion/63223
Code -- >
https://github.com/linrongc/youtube-8m