Deep kNN for Medical Image Classification

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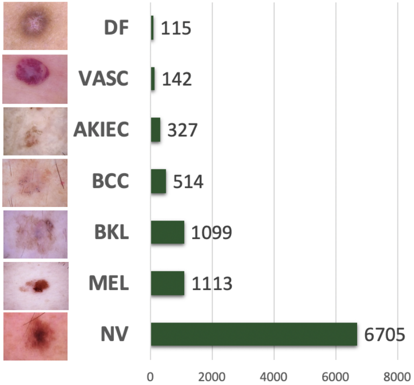
Motivation



Data imbalance is common in medical diagonsis.

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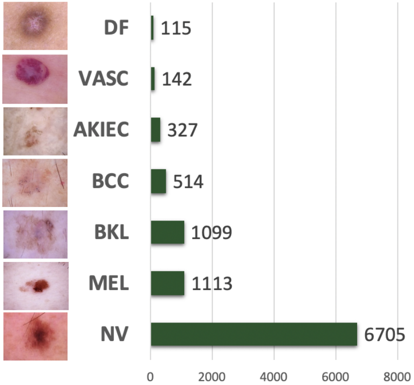

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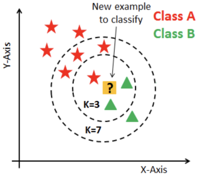

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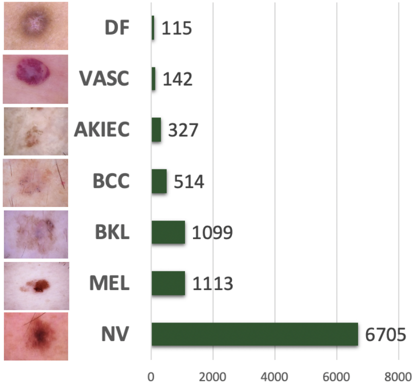

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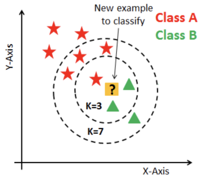
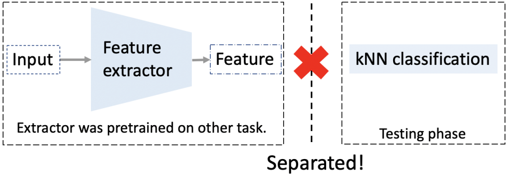


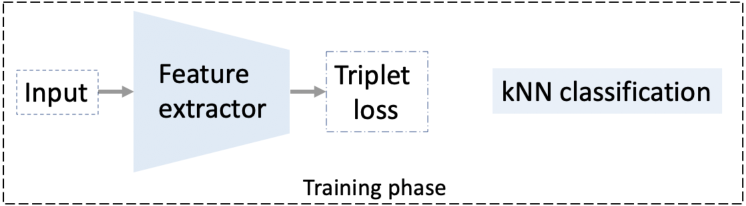


Task irrelevant feature will degrade the performance of kNN.

Related work

- Feature learning for kNN:
  - Traditional metric learning methods: Neighborhood Component Analysis, Large Margin Nearest Neighbor methods.
  - Pretrained Model as feature extractor, such as VGG, ResNet.
  - Triplet based methods.
- Alleviate data imbalance:
  - Oversampling, augmentation.
  - Transfer learning, ensemble model.
  - Class Weighting (cost sensitive learning), instance weighting.

Framework of deep kNN (training)



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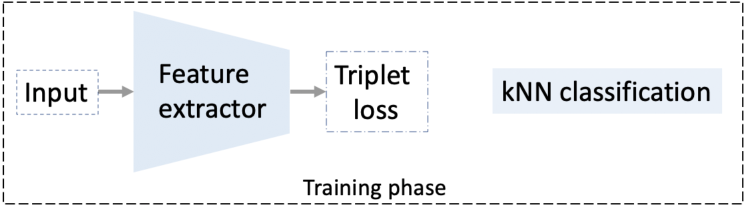

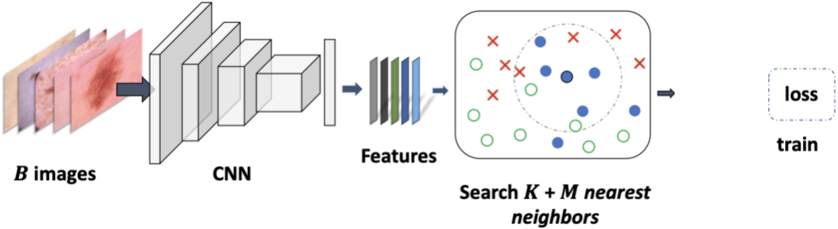

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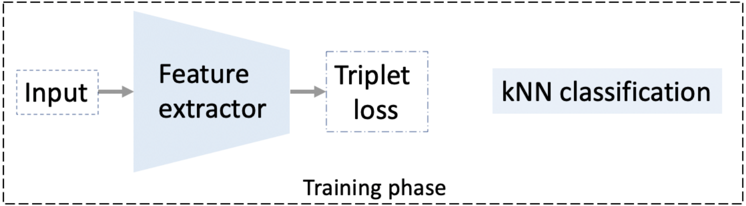
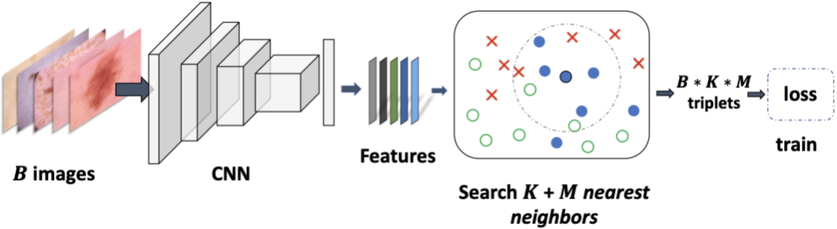
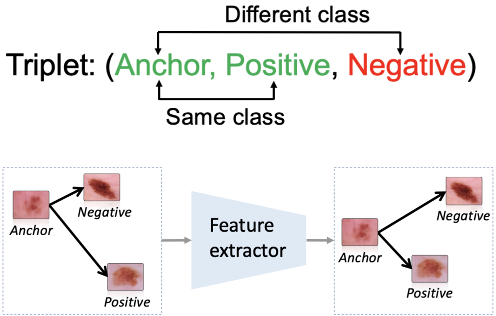




Search $K + M$ nearest neighbors



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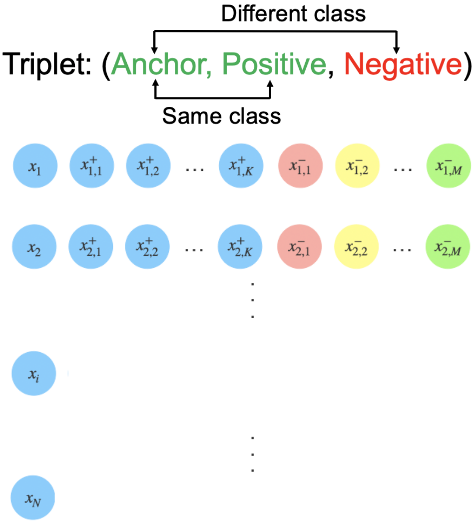

Generate triplets for $\mathbf{x}_i$:

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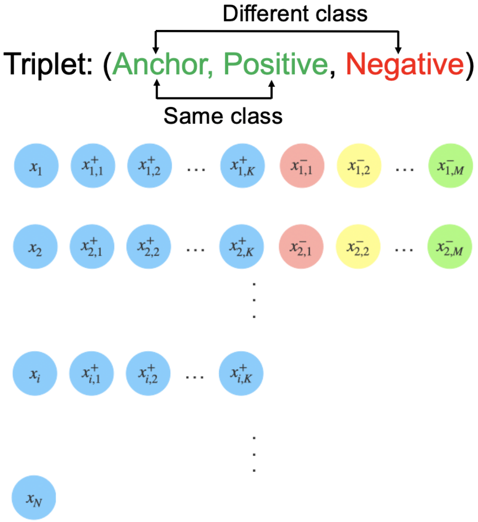

Generate triplets for $\mathbf{x}_i$:

- K nearest neighbors $\{\mathbf{x}^+_{i,k}\}$ of the same class.

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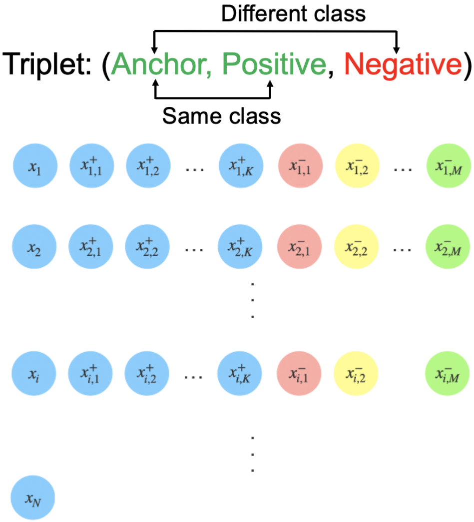

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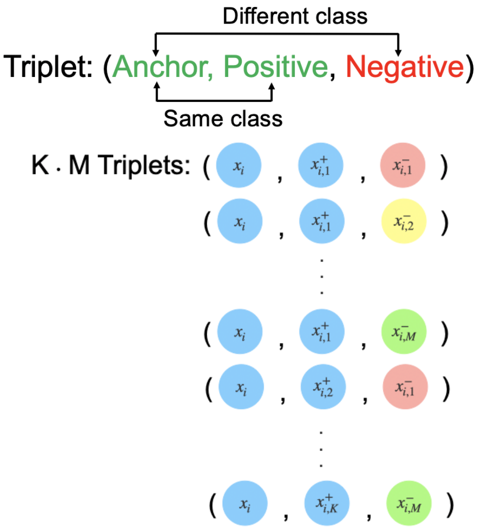

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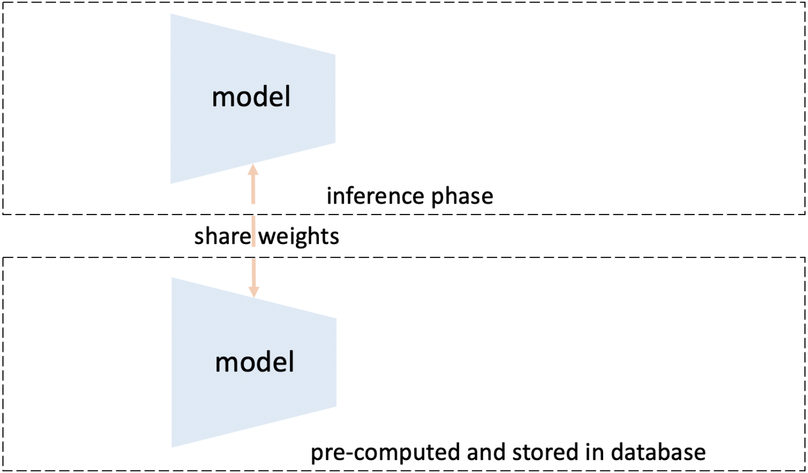
- K nearest neighbors $\{\mathbf{x}^{+}_{i,k}\}$ of the same class.
- M nearest neighbors $\{\mathbf{x}^{-}_{i,m}\}$ from all other classes.
- K and M neighbors are used to generate $K \cdot M$ triplets.

Framework of deep kNN (inference)



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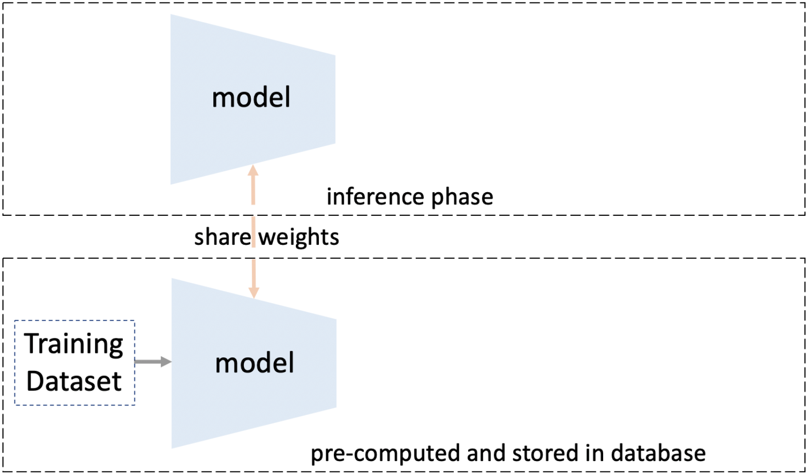

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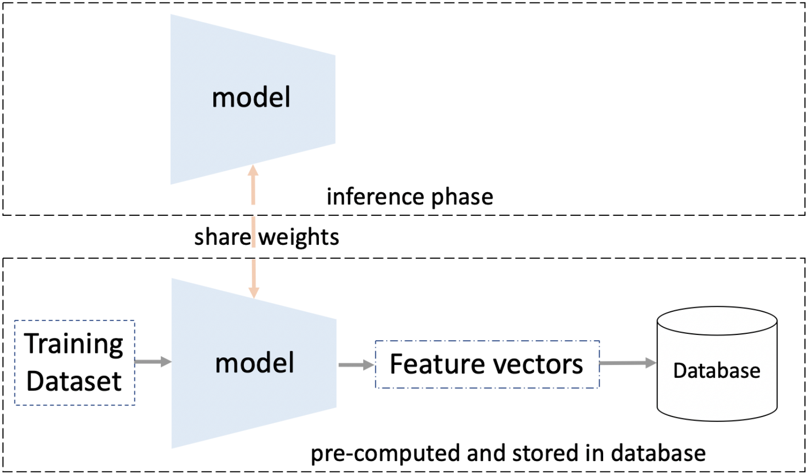

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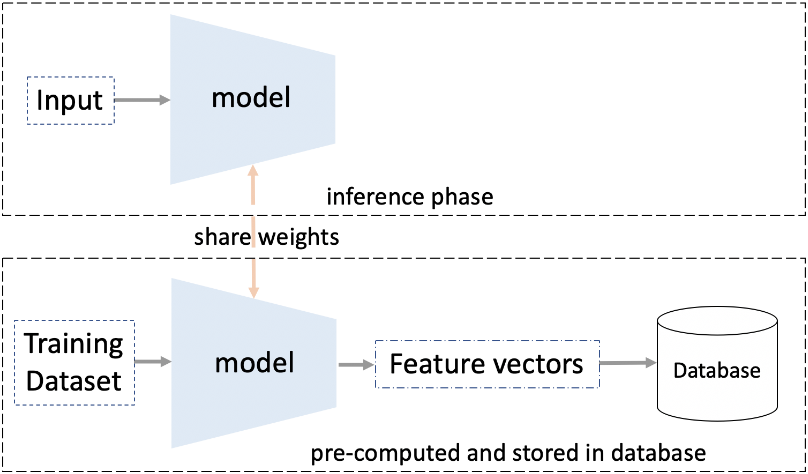

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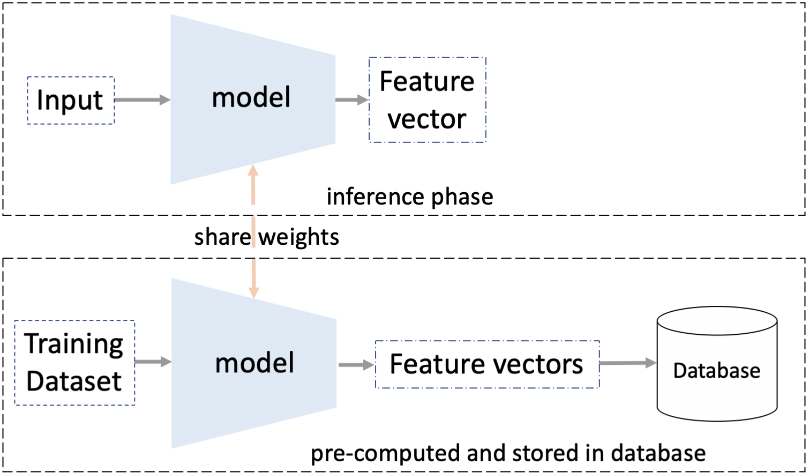

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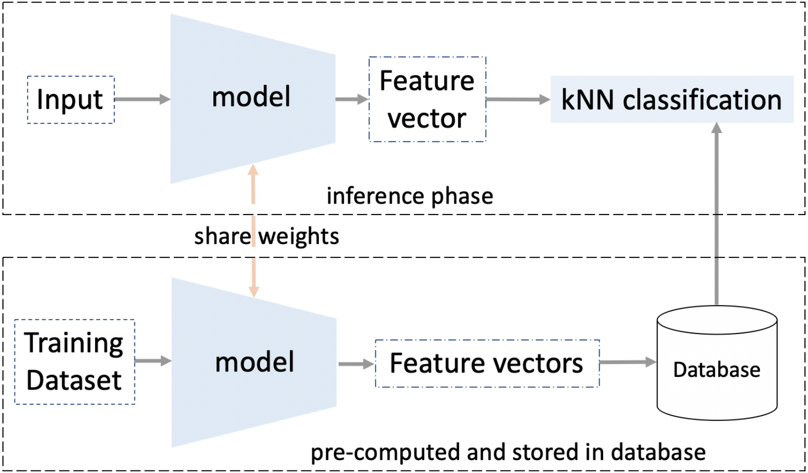

Experiments on baseline

Deep kNN outperforms baselines

Experiments on baseline

Deep kNN outperforms baselines particularly on small classes with a large margin

Datasets	Skin-7			Pneumonia			SD-198		
Methods	Acc	MCR	RS	Acc	MCR	RS	Acc	MCR	RS
kNN (VGG19, $K_p = 5$)	70.72	30.77	10.34	55.42	55.71	44.97	15.12	13.28	4.17
kNN (ResNet50, $K_p = 5$)	74.41	37.53	34.48	55.52	54.66	39.65	19.11	17.45	12.50
Triplet(ResNet50,$K_p = 5$)	84.29	68.31	67.34	70.00	68.73	66.32	60.17	60.02	47.21
deep kNN (ours, $K_p = 5$)	**89.1**	**78.9**	**77.3**	**71.1**	**69.4**	**69.0**	**65.1**	**64.3**	**48.3**
Weighted-CE(ResNet50)	88.02	80.21	76.60	71.12	69.11	70.05	61.90	62.40	47.67
deep kNN* (ours, $K_p = 5$)	**90.3**	**81.0**	**80.4**	**71.6**	**71.1**	**70.9**	**66.4**	**66.4**	**51.5**

Advantages of deep kNN

Works with Multilayer perceptron structure

Methods	kNN-basic	NCA	LMNN	MLP+triplets	MLP+CE	MLP+deep-kNN
Acc	64.53	75.06	81.85	77.13	78.85	**85.09**
MCR	34.49	36.39	61.78	62.22	63.11	**66.08**
RS	10.34	27.59	62.07	63.43	64.21	**67.30**

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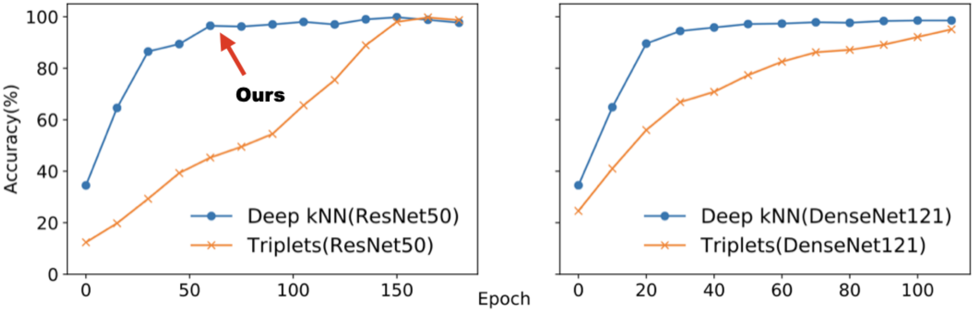

Left: ResNet50 on SD-198; Right: DenseNet121 on Skin-7.

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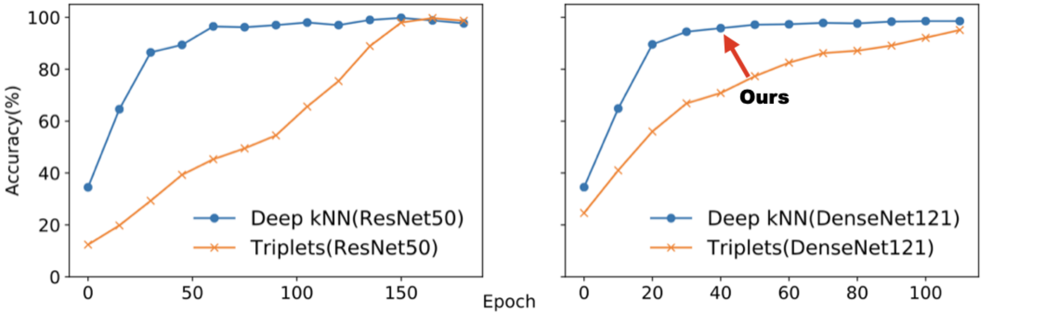

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Flexibility with Different Architecture

Models	VGG19		ResNet50		Dense121		SE-ResNet50	
	kNN	deep kNN	kNN	deep kNN	kNN	deep kNN	kNN	deep kNN
Acc	59.16	**61.51** +2.35↑	60.17	**65.12** +4.95↑	60.54	**64.02** +3.48↑	61.85	**62.79** +0.94↑
MCR	56.33	**61.93** +5.60↑	57.35	**64.34** +6.99↑	60.12	**65.11** +4.99↑	59.32	**62.27** +4.99↑
RS	43.12	**45.43** +2.89↑	46.01	**48.31** +2.30↑	50.42	**52.21** +1.79↑	50.01	**53.12** +3.11↑

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Acknowledgement

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