BMW: **B**idirectionally **M**emory bank re**W**riting for Unsupervised Person Re-Identification

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Reformulate the memory bank rewriting procedure

- We rethink the procedure of memory bank rewriting in person ReID methods, and reformulate it as a gradient decent update supervised by objective functions.
- In this new formulation, existing memory bank update methods using the momentum mechanism with only positive samples equals to the gradient decent update only supervised by the intra-class constraint, neglecting the inter-class constraint.
- To handle the issue of partial constraint, we propose a unified memory bank rewriting mechanism, Bidirectionally Memory bank reWriting (**BMW**), to enhance the discrimination capacity.
- BMW uses two objective functions to constrain the memory bank rewriting, *i.e.*, reducing intra-class diversity and enhancing inter-class separability: $\mathcal{L}_{\mathcal{M}} = \lambda_{intra}\mathcal{L}_{intra} + \lambda_{inter}\mathcal{L}_{inter}$.

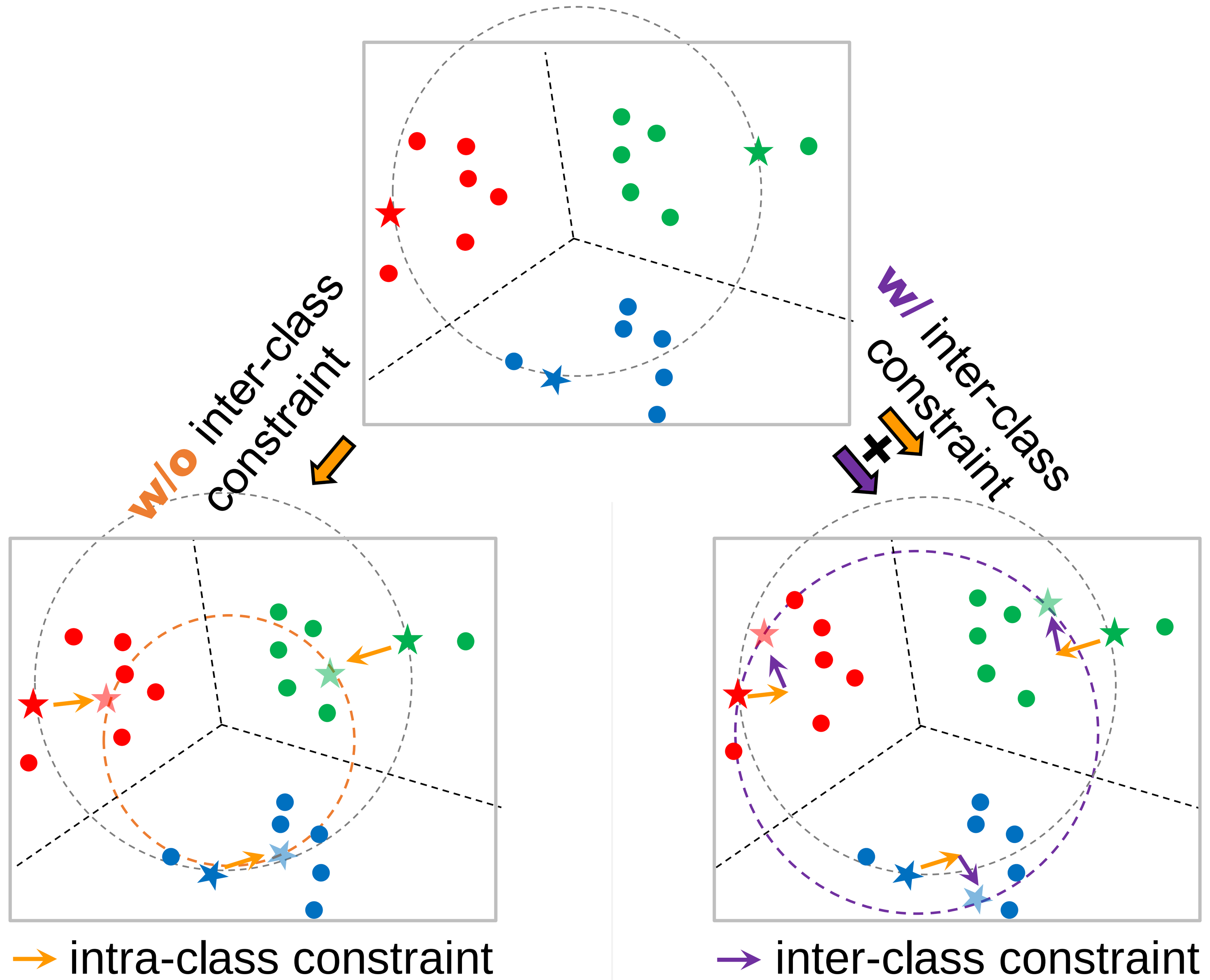


Illustration of memory bank updates **without** and **with** the inter-class constraint. Dots and stars denote samples and memory banks, respectively. Different colors denote different clusters.

- **Without** the inter-class constraint, memory banks are pulled to approach positive samples only (shown as yellow arrows).
- **With** the inter-class constraint, memory banks are also push away from each other (shown as purple arrows), thus enhancing their separability and discrimination capacity.

Redesign the inter-class objective function

To effectively enhance the separability of memory banks with limited update steps, we design a novel objective formulation for the inter-class constraint, more effective for one step update:

$$\mathcal{L}_{inter}(\mathcal{M}[i], \mathcal{M}[j]) = \frac{1}{2}||\mathcal{M}[i] + \mathcal{M}[j]||_2^2.$$

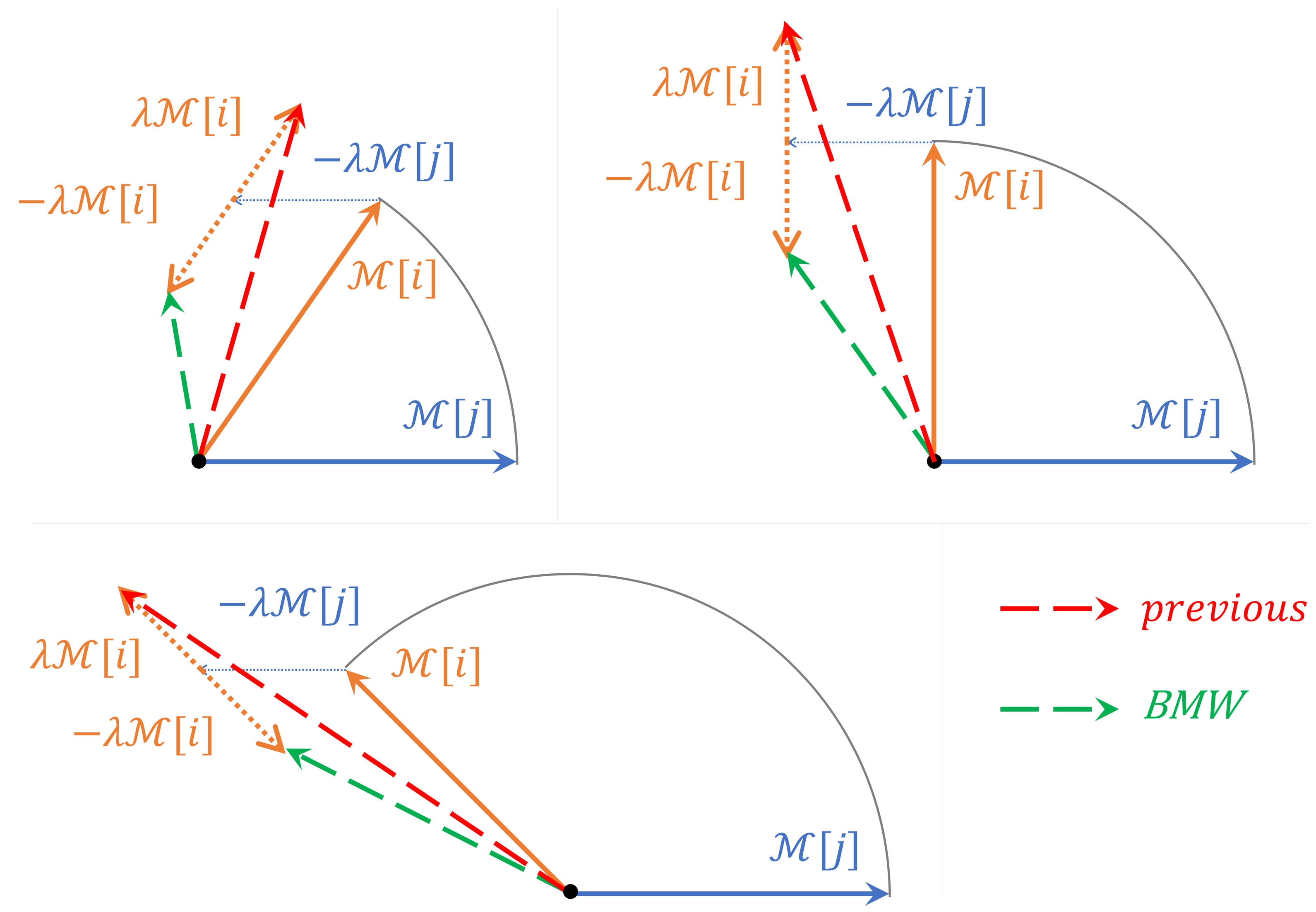


Illustration of the advantage in inter-class constraint of the proposed objective function in **BMW** over previous methods *w.r.t.* different angles between two memory banks (yellow and blue arrows). It can be observed that the proposed objective function in BMW is more effective in pushing different memory banks away within one step update.

Reweight hard samples dynamically

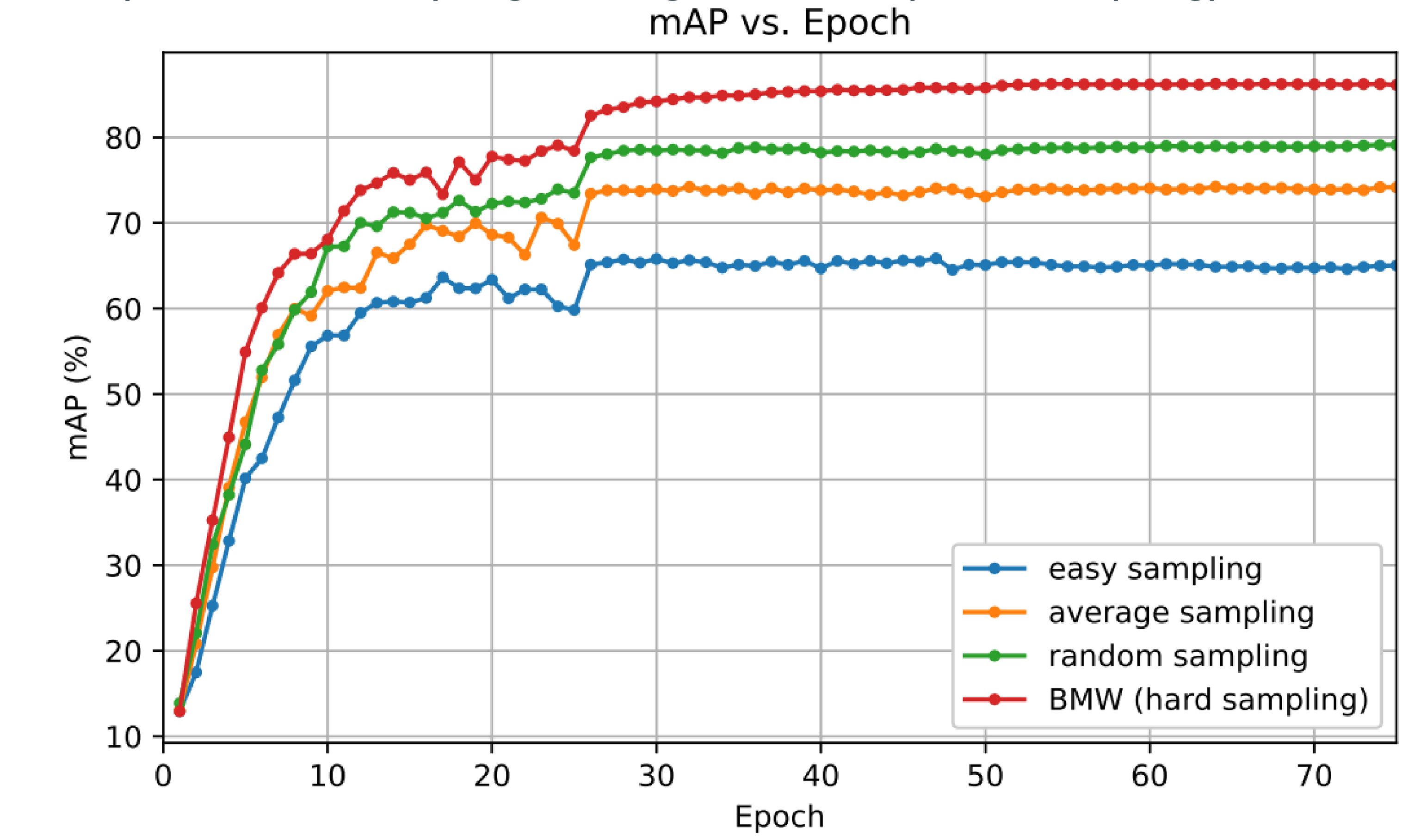
To make BMW aware of the importance of samples, we propose to dynamic weight these two constraints based on the idea that larger value of objective function corresponds to higher importance. After weighting, loss functions for intra- and inter- constraints are:

$$\mathcal{L}_{intra}(\mathcal{M}[c], f_i) = \frac{1}{8}||\mathcal{M}[c] - f_i||_2^4, \quad \mathcal{L}_{inter}(\mathcal{M}[i], \mathcal{M}[j]) = \frac{1}{8}||\mathcal{M}[i] + \mathcal{M}[j]||_2^4.$$

Gradients of these loss functions (update vectors) are simple:

$$\frac{\partial\mathcal{L}_{intra}(\mathcal{M}[c])}{\partial\mathcal{M}[c]} = (1 - \mathcal{M}[c]f_i)(\mathcal{M}[c] - f_i), \quad \frac{\partial\mathcal{L}_{inter}(\mathcal{M}[i])}{\partial\mathcal{M}[i]} = (1 + \mathcal{M}[i]\mathcal{M}[j])(\mathcal{M}[i] + \mathcal{M}[j]).$$

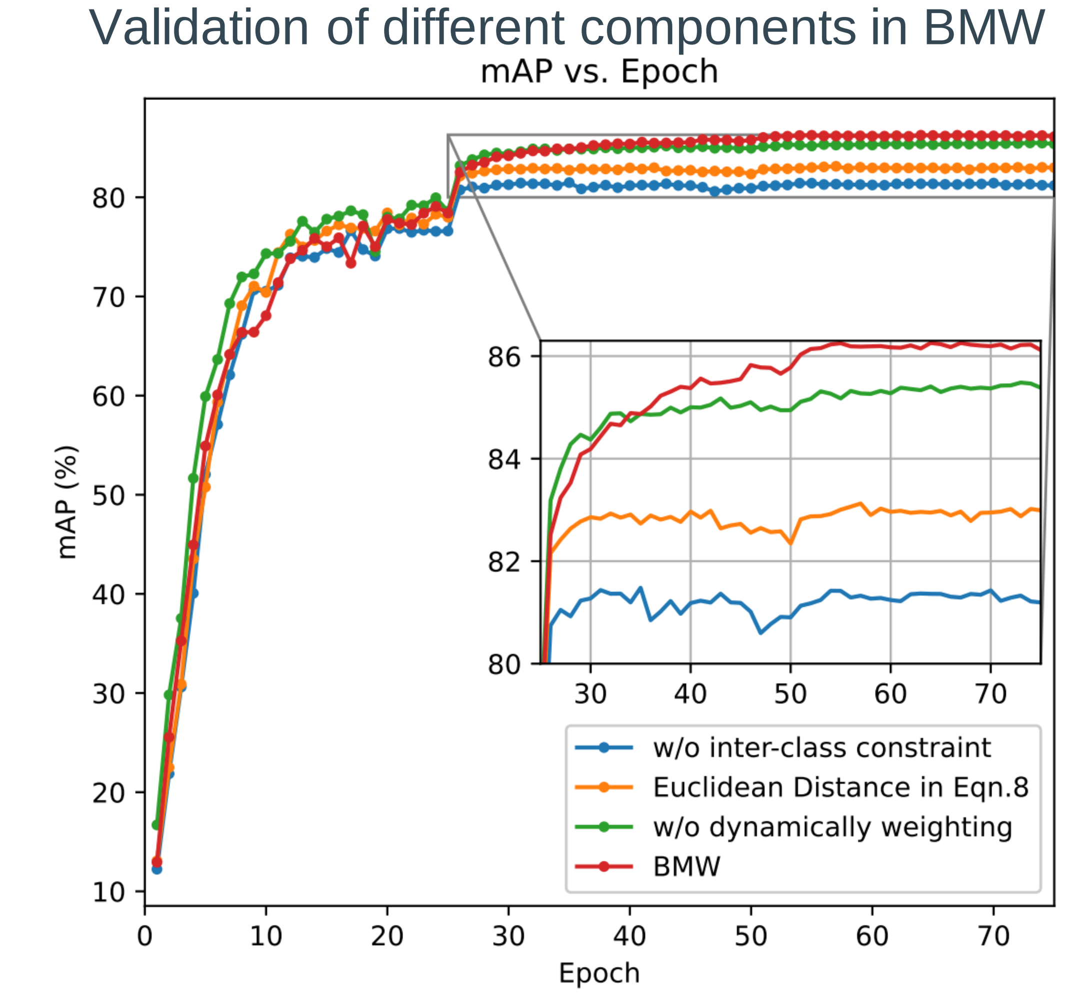
Comparison of sampling strategies. BMW (hard sampling) is the best



Comparison with SOTA methods. BMW is the best

Method	Backbone	Market-1501					MSMT-17				
		S. D.	mAP	Rank1	Rank5	Rank10	S. D.	mAP	Rank1	Rank5	Rank10
UTAL [41]	ResNet50	-	46.2	69.2	-	-	-	-	-	-	-
SpCL [17]	ResNet50	-	73.1	88.1	95.1	97.0	-	-	-	-	-
GCMT [37]	ResNet50	-	73.9	89.7	96.5	97.6	-	23.7	54.3	-	-
SSG‡ [43]	ResNet50	-	58.3	80.0	90.0	92.4	Market	13.2	31.6	-	-
CR_GAN[19]	ResNet50	Duke	54.0	77.7	89.7	92.7	-	-	-	-	-
PDA-Net [20]	ResNet50	Duke	47.6	75.2	86.3	90.2	-	-	-	-	-
DIM+GLO [18]	ResNet50	Duke	65.1	88.3	94.7	96.3	Market-1501	20.7	49.7	66.1	-
UDA [36]	ResNet50	Duke	53.7	75.8	89.5	93.2	-	-	-	-	-
MMT [38]	ResNet50-IBN	Duke	76.5	90.9	96.4	97.9	-	-	-	-	-
MEB-Net [39]	DeseNet121	-	76.0	89.9	96.0	97.5	-	-	-	-	-
MMT [38]	ResNet50	-	71.2	87.7	94.9	96.9	Duke	29.7	58.8	71.1	76.1
IIDS [65]	-	78.0	91.2	96.2	97.7	-	35.1	64.4	76.2	80.5	
PPLR [45]	ResNet50	-	81.5	92.8	97.1	98.1	-	31.4	61.1	73.4	77.8
PPLR“†” [45]	ResNet50	-	84.4	94.3	97.8	98.6	-	42.2	73.3	83.5	86.5
CaCL [2]	ResNet50	MSMT17	84.7	93.8	97.7	98.1	Market-1501	36.5	66.6	75.3	80.1
DCC [23]	ResNet50-IBN	-	58.8	94.3	97.6	98.6	-	36.6	64.9	74.9	78.5
IICS [66]	ResNet50	-	72.1	88.8	95.3	96.9	-	18.6	45.7	57.5	62.8
IICS [66]	ResNet50	-	72.9	89.5	95.2	97.0	-	29.9	56.4	68.8	73.4
O2CAP+FuseDSI [67]	ResNet50	-	83.4	93.3	97.2	98.3	-	44.2	73.7	83.6	86.7
ISE [68]	ResNet50	-	84.7	94.0	97.8	98.8	-	35.0	64.7	75.5	79.4
BMW	ResNet50	-	**86.3**	**94.2**	**97.7**	**98.4**	-	**44.6**	**75.5**	**86.3**	**87.1**

Validation of different components in BMW



Code