Learning to map between ferns with differentiable binary embedding networks

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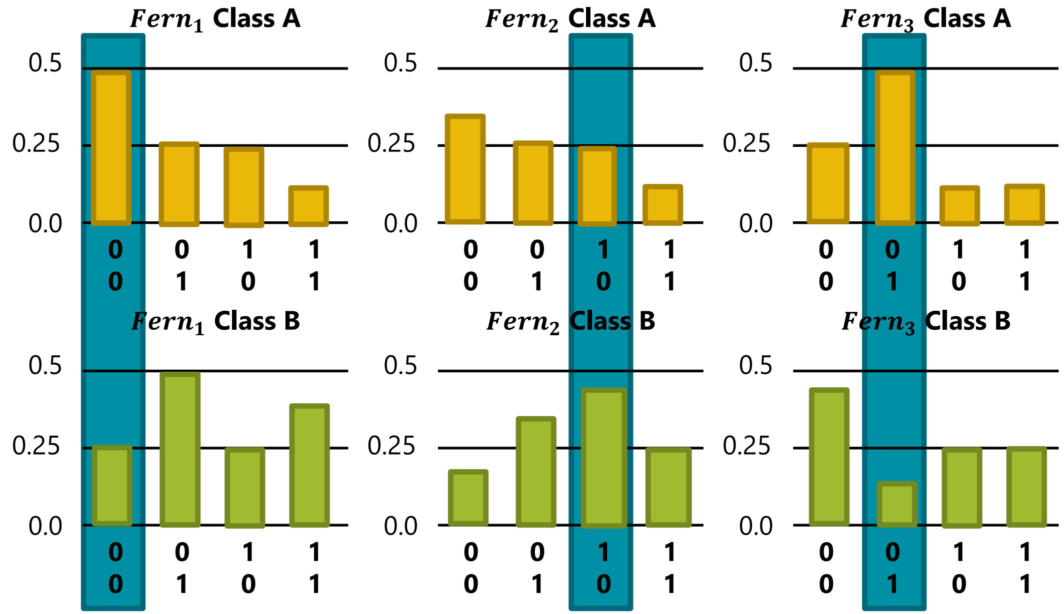
Random Fern Basics

Ozuysal, Mustafa, et al. "Fast keypoint recognition using random ferns." *IEEE transactions on pattern analysis and machine intelligence* 32.3 (2009): 448-461.

Dim	0	1	2	3	4	5
$feature\ \boldsymbol{f}$	+4	-2	+10	-6	+8	+1

depth $m = 2$	Dimension $\left(d_1^{Fern_k}, \dots, d_m^{Fern_k}\right)$	Threshold $\left(t_1^{Fern_k}, \dots, t_m^{Fern_k}\right)$	binary code $Fern_k(\boldsymbol{f})$	
$Fern_1$	$(1,2)$	$(-3,1)$	$-2 < -3\,?, +10 < 1?$	**00**
$Fern_2$	$(5,0)$	$(2,0)$	$+1 < +2\,?, +4 < 0?$	**10**
$Fern_3$	$(4,3)$	$(3,-1)$	$+8 < +3\,?, -6 < -3?$	**01**

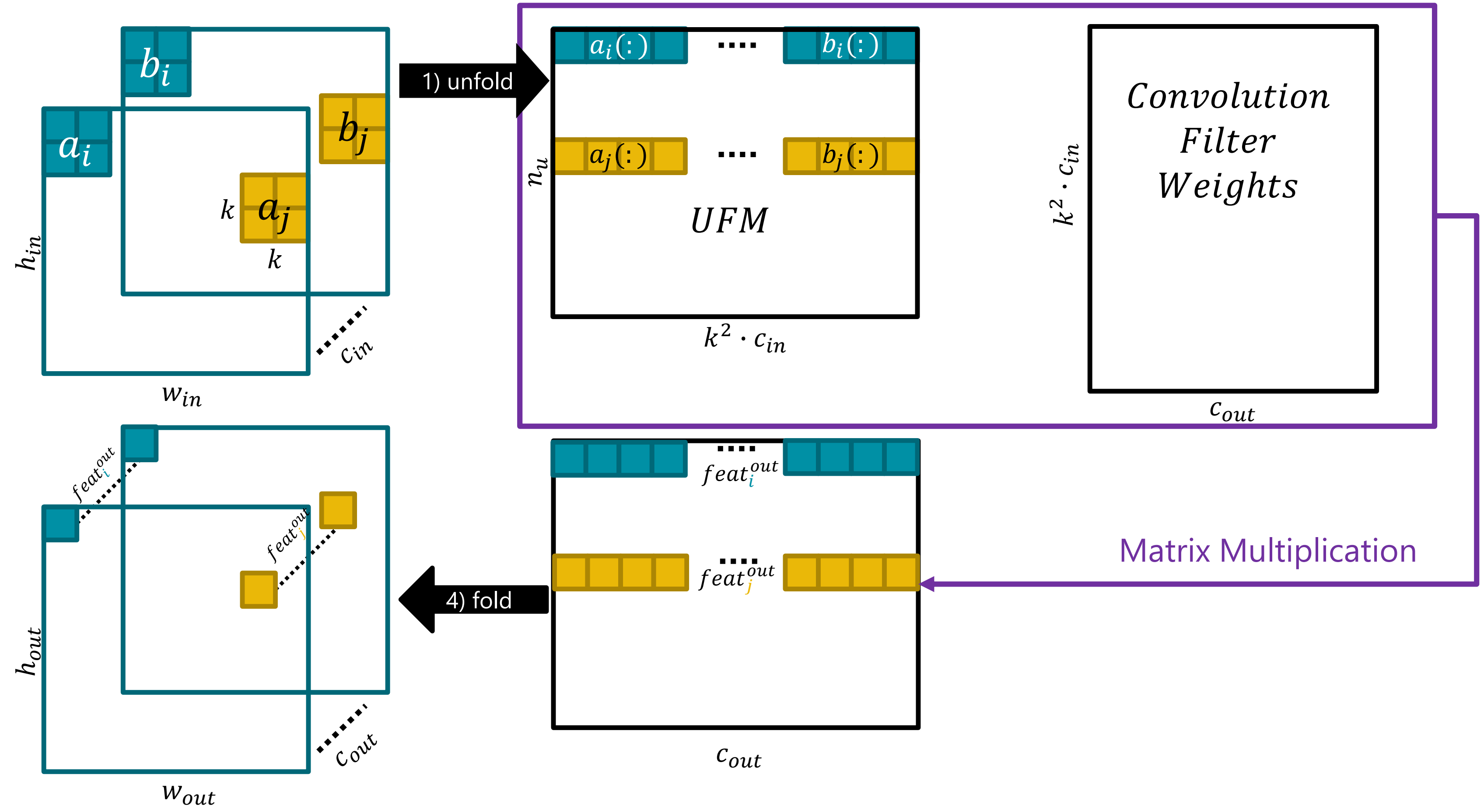


$$P(\boldsymbol{f}|A) = 0.5 * 0.25 * 0.5 = 0.0625$$

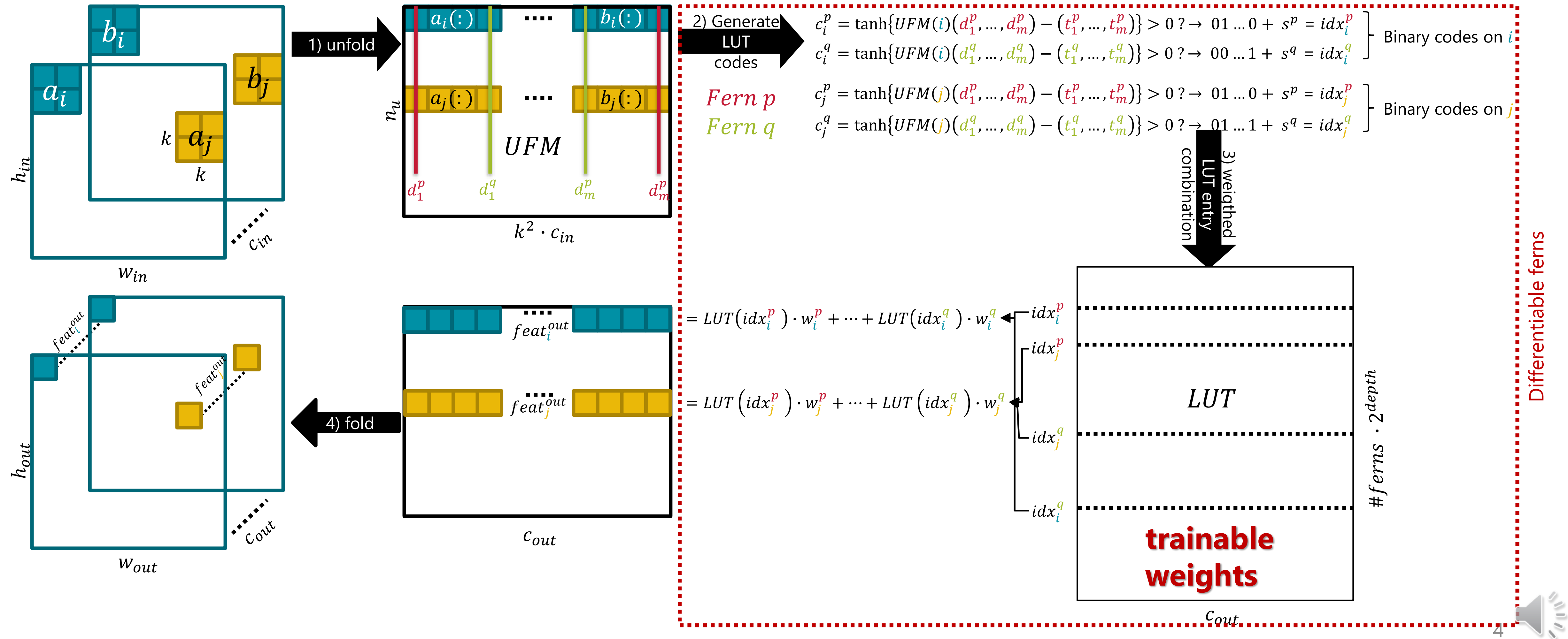
$$P(\boldsymbol{f}|B) = 0.25 * 0.4 * 0.125 = 0.0125$$

$$P(\boldsymbol{f}|A) > P(\boldsymbol{f}|B) \ \rightarrow classify\ \boldsymbol{f}\ as\ A$$

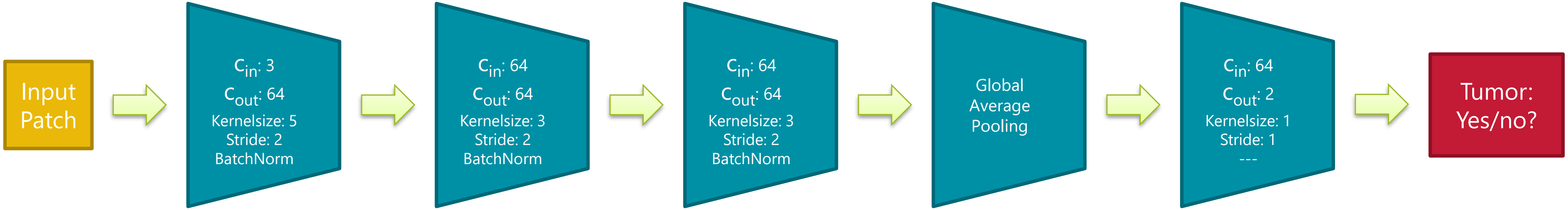
Standard convolution

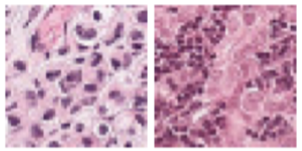


Drop-in replacement



Evaluation



Input Patches	Architecture	# Params	Energy consumption[1]	Accuracy
 [3]	XNOR net[2]	≈ 80k	$2.45\ \mu J$	82.66%
	Vanilla net	≈ 80k	$65.5\ \mu J$	**84.23%**
	Fern net (ours)	$\approx$ **40k**	$\mathbf{1.01}\ \mu J$	83.97%

[1] Hubara, Itay, et al. "Binarized neural networks." *Advances in neural information processing systems*. 2016.
[2] Rastegari, Mohammad, et al. "Xnor-net: Imagenet classification using binary convolutional neural networks." *European conference on computer vision*. Springer, Cham, 2016.
[3]Veta, Mitko, et al. "Predicting breast tumor proliferation from whole-slide images: the TUPAC16 challenge." *Medical image analysis* 54 (2019): 111-121.