HONGIK UNIVERSITY

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Lightweight DNN with Majority Voter

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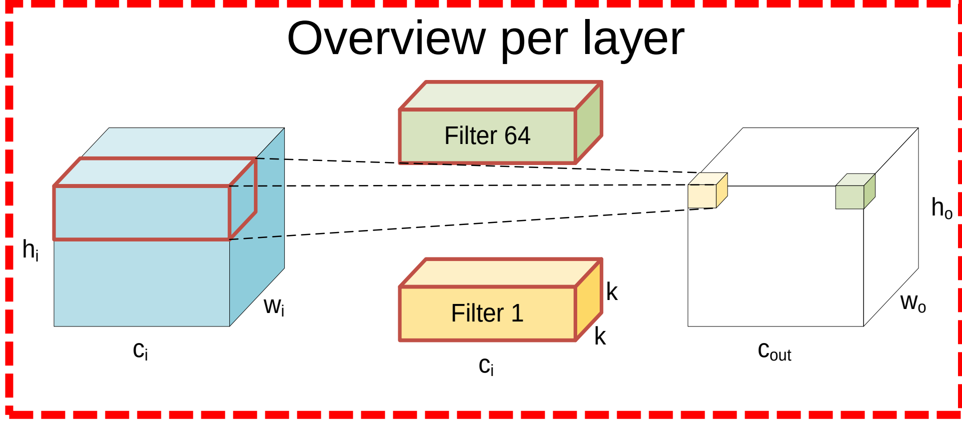
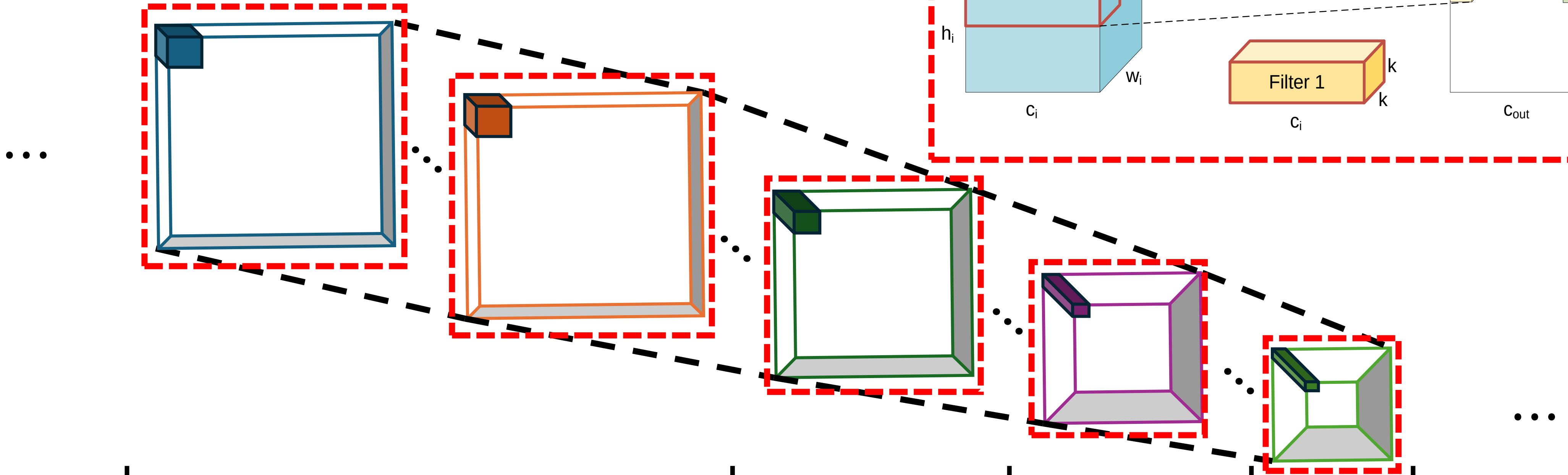
Progress

- Overview of ReActNet-18 with CIFAR-10

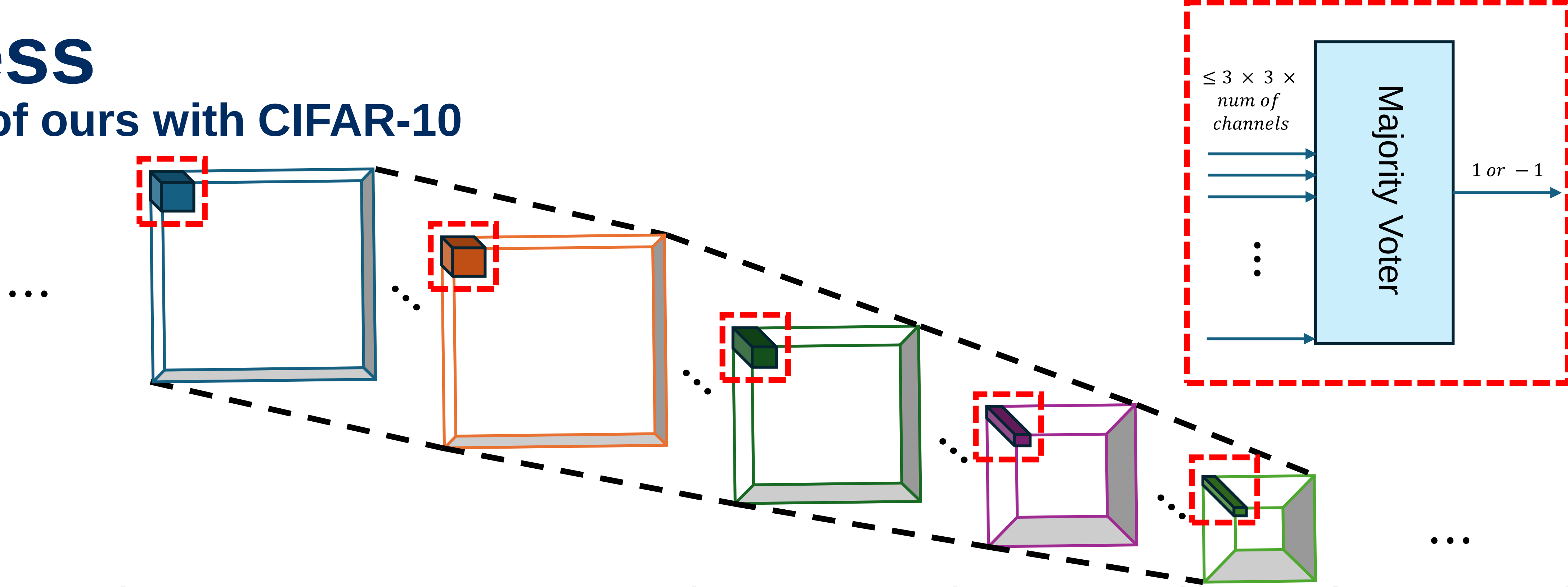




Num of channels	64	64	128	256	512	Pooling & FC
Operations	⊛	XNOR & Bit-Count				
Activations and weights	ℝ	ℝ (After BN) & Binarized values (1 or -1)				ℝ
# units of XNOR		$(c_i \times k \times k) \times (c_{out} \times h_o \times w_o)$				
# units of Popcount		$c_{out} \times h_o \times w_o$				

Progress

- Overview of ours with CIFAR-10



Num of channels	64	64	128	256	512	Pooling & FC
Operations	⊛	Majority Voter				
Activations and weights	ℝ	ℝ (After BN) & Binarized values (1 or -1)				ℝ
# units of XNOR		$\cancel{(c_i \times k \times k) \times (c_{out} \times h_o \times w_o)}$ → Majority Voter				
# units of Popcount		$\cancel{c_{out} \times h_o \times w_o}$ → Majority Voter				

Progress

- Results with CIFAR-10

Models	Top-1 Accuracy (%)	Top-5 Accuracy (%)
ReActNet-18	93.380	99.800
ReActNet-18 with Majority Voter	84.930	99.250
Bi-RealNet-18	88.770	98.250
Bi-RealNet-18 with Majority Voter	30.070	79.690

Progress
- Our strategy for retraining to increase accuracy…1

- A straightforward application of the Majority Voter results in a decline in accuracy. Therefore, to achieve our goal of enhancing inference speed, additional techniques must be incorporated.

- Our Majority Voter employs the same functionality as the Sign function used in ReActNet. Hence, we will leverage techniques such as the **Straight-Through Estimator (STE)** and **ApproxSign()**

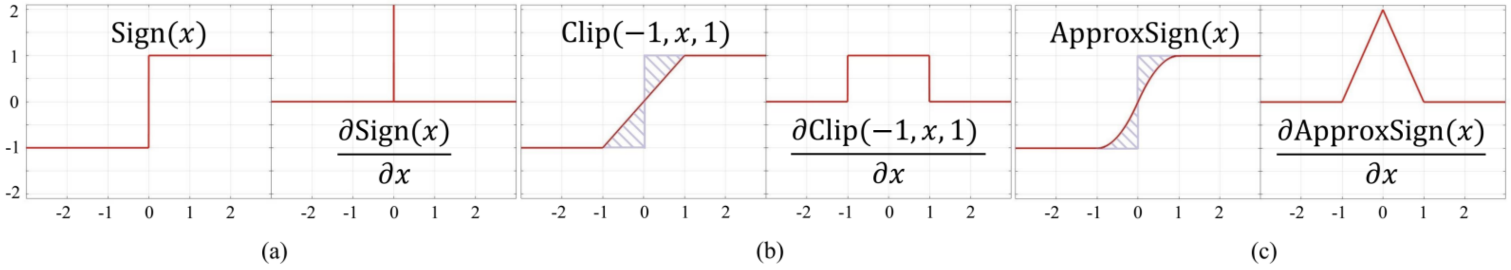
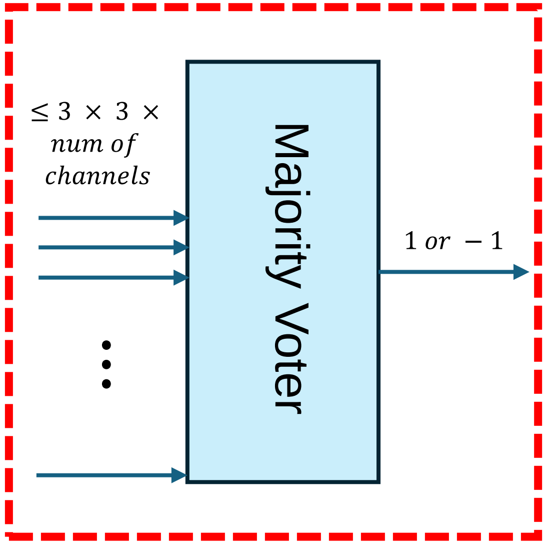


Fig. 5. (a) Sign function and its derivative, (b) Clip function and its derivative for approximating the derivative of the sign function, proposed in [7], (c) Proposed differentiable piecewise polynomial function and its triangle-shaped derivative for approximating the derivative of the sign function in gradients computation.

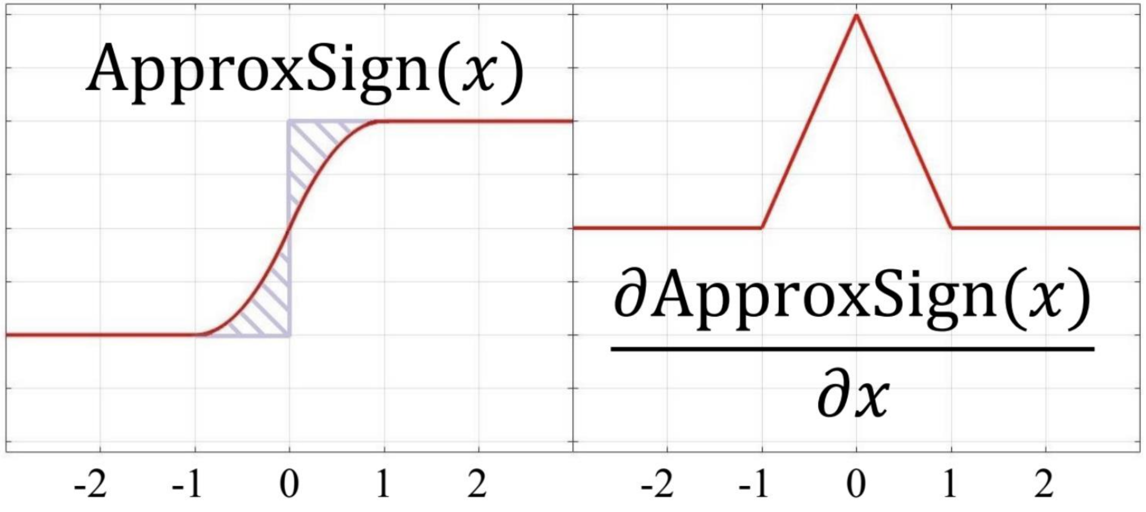
Bi-Real Net: Enhancing the Performance of 1-bit CNNs With Improved Representational Capability and Advanced Training Algorithm

Progress

- Our strategy for retraining to increase accuracy…2



Foward



$$F(a_r) = \begin{cases} -1 & \text{if } a_r < -1 \\ 2a_r + a_r^2 & \text{if } -1 \leqslant a_r < 0 \\ 2a_r - a_r^2 & \text{if } 0 \leqslant a_r < 1 \\ 1 & \text{otherwise} \end{cases}, \qquad \frac{\partial F(a_r)}{\partial a_r} = \begin{cases} 2 + 2a_r & \text{if } -1 \leqslant a_r < 0 \\ 2 - 2a_r & \text{if } 0 \leqslant a_r < 1 \\ 0 & \text{otherwise} \end{cases},$$

Backpropagation

Progress

- Results with CIFAR-10

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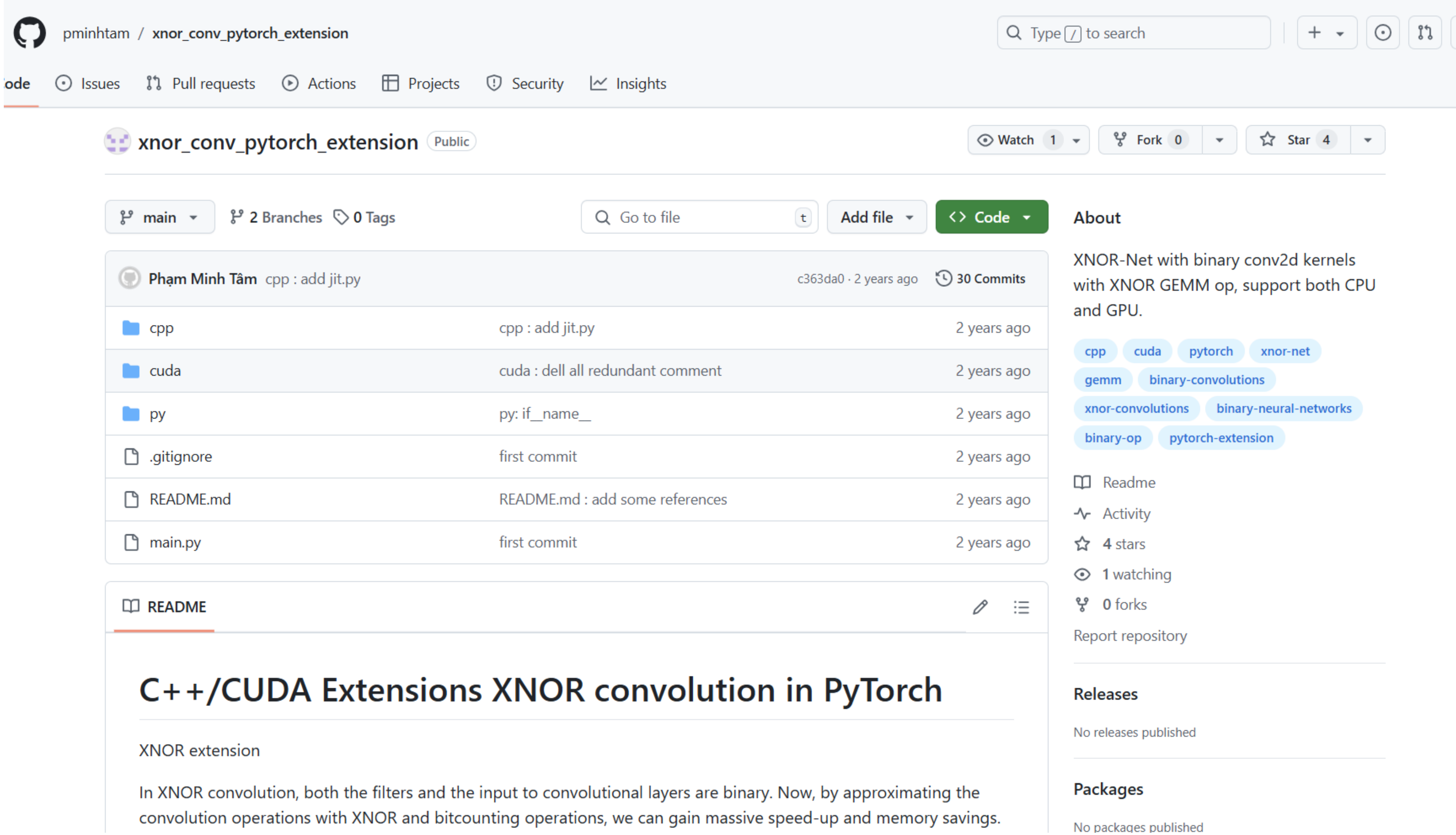
ReActNet-18 with Majority Voter	84.930	99.250
Our RaActNet-18	92.090	99.610
Bi-RealNet-18	88.770	98.250
Bi-RealNet-18 with Majority Voter	30.070	79.690
Our Bi-RealNet-18	87.660	98.720

Update about plans

- PyTorch Modeling



Update about plans

- PyTorch Modeling

~~1. BNN based on XNOR and **Popcount**~~

~~- Implementing **actual** XNOR and Popcount operations within hardware (GPU) using PyTorch and CUDA~~

~~2. BNN based on XNOR and **Majority Voter**~~

~~- Apply majority voter to standard convolution.~~

3. BNN based on XNOR and **Hierarchical Majority Voter**

   - Example) M512 ~= M4 (M128, M128, M128, M128)

Thank you

Progress
- Appendix

Table 2. Comparison of the top-1 accuracy between the three variants (i.e., BN, w/o BN, BN-Free) of binary networks on CIFAR-10 and CIFAR-100. All networks are modified from ResNet-18 except for ReActNet-A, which is constructed from MobileNetv1.

Binary Network	CIFAR-10 (%)			CIFAR-100 (%)		
	BN	w/o BN	BN-Free	BN	w/o BN	BN-Free
XNORNet-18	90.21	71.75	79.67	65.35	45.30	53.76
Bi-RealNet-18	89.12	71.30	79.59	63.51	47.72	54.34
ReActNet-18	92.31	90.33	92.08	68.78	62.60	68.34
ReActNet-A	82.95	77.60	**83.91**	50.30	39.37	**55.00**

“BNN - BN = ?”: Training Binary Neural Networks without Batch Normalization