E²CM: Early Exit via Class Means for Efficient Supervised and Unsupervised Learning

Alperen Gormez†, Venkat R. Dasari§, Erdem Koyuncu†
†University of Illinois Chicago §CCDC US Army Research Laboratory
agorme2@uic.edu, venkateswara.r.dasari.civ@army.mil, ekoyuncu@uic.edu

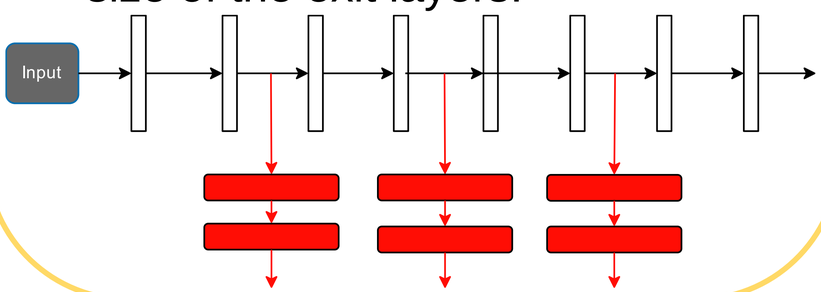
Motivation

- Idea of early exit: Not all examples need to traverse the entire neural network, simple examples should exit early from the network.

Classification Difficulty: **Easy**
Early Exit: **Yes**

Classification Difficulty: **Hard**
Early Exit: **No**

- Existing early exit methods are not suitable for the edge, because they:
  - Add exit layers that require gradient based training to the base network.
  - Train exit layers jointly with the base model.
  - Need additional hyperparameters such as the location, number and size of the exit layers.

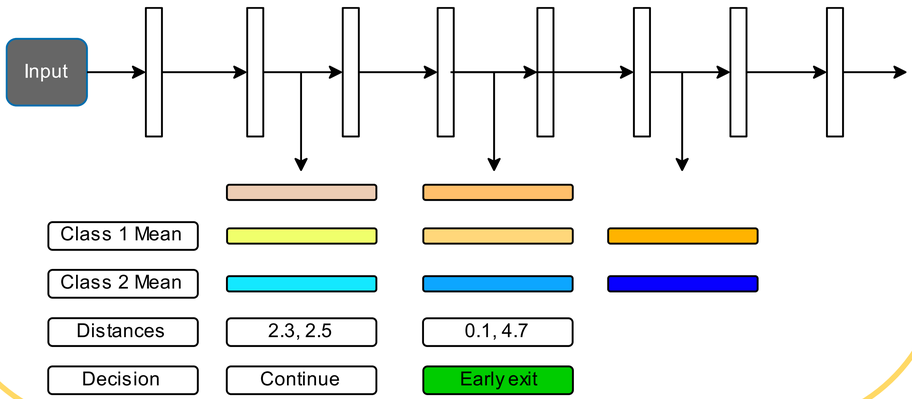


Our Contribution

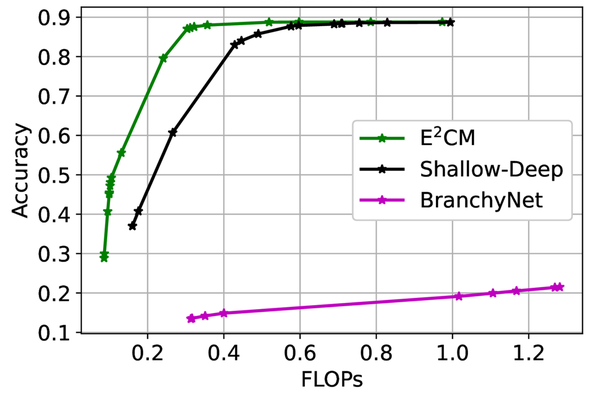
- **E²CM**: A simple, lightweight early exit method.
- E²CM does not add trainable layers, therefore it does not modify the base network.
- E²CM does not need gradient based training.
- E²CM does not need additional hyperparameters.

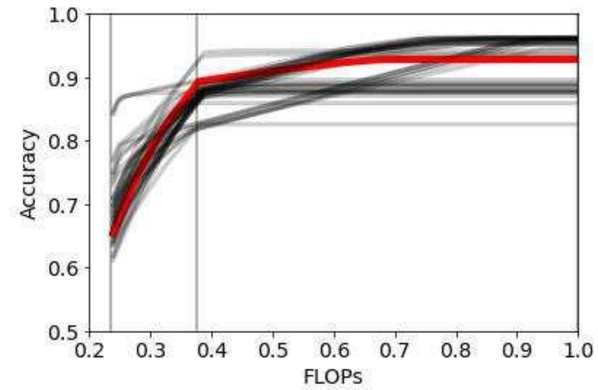
E²CM Algorithm

- E²CM calculates class means by averaging feature vectors at each layer for each class using training set examples.
- During prediction, E²CM calculates the distances between the feature vector and the class means. If the feature vector is close enough to a class mean, the sample exits early and that class is predicted. Otherwise, the sample moves forward to the next exit point.



Results





Model, Dataset	Method	Accuracy			
		$\phi=0.15$	$\phi=0.20$	$\phi=0.25$	$\phi=0.30$
ResNet-152, CIFAR-10	E²CM+SDN	**82.4%**	**86.4%**	**88.5%**	**88.8%**
	SDN	80%	86%	88.4%	88.8%
	BWDS	82%	84.1%	86%	87.7%
	BranchyNet	80%	80%	80%	80%

Conclusion

E²CM is a simple and lightweight early exit method that does not modify the base network and does not need gradient based training. It can be applied to both supervised and unsupervised learning tasks.