End-to-end Keyword Spotting using Neural Architecture Search and Quantization

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ICASSP 2022

Abstract

- We introduce neural architecture search (NAS) for the automatic discovery of *end-to-end* keyword spotting (KWS) models for limited resource environments.
- We employ a *differentiable NAS approach* to optimize the structure of convolutional neural networks (CNNs) operating on *raw audio waveforms*.
- Different methods for *weight and activation quantization* are considered to reduce the memory footprint.
- ⇒ *State-of-the-art accuracy* of 95.55% is obtained on the Google Speech commands dataset using only 75.7k parameters and 13.6M operations.

Methods

Neural Architecture Search (NAS)

- *Multi-objective NAS* using ProxylessNAS [1]
- *Optimize the structure of CNNs* for keyword classification
- *Tradeoff parameter* β to establish a tradeoff between accuracy and number of operations [2]

Methods

Neural Network Model

Stage	Type	Kernel Size	Stride	Channels	Layers
(i)	SincConv	400	160	1	1
(ii)	Conv	3x3	2, 2	10	1
(iii)	MBC[e] / Identity	$[k]\times[k]$	2, 2	20	3
(iv)	MBC[e] / Identity	$[k]\times[k]$	2, 2	40	3
(v)	Conv	1×1	1, 1	80	1
	Global Avg. Pooling	-	-	-	1
	Fully connected	-	-	-	1

Expansion rates $e \in \{1, 2, 3, 4, 5, 6\}$
Kernel sizes $k \in \{3, 5, 7\}$

Methods

Weight and Activation Quantization

- Quantization-aware training is performed.
- We compare fixed bit-width quantization and trained bit-width quantization.

Feature Extraction using SincConvs

- SincConv is used as a replacement for the 1D-Conv. [3]

Experimental Setup

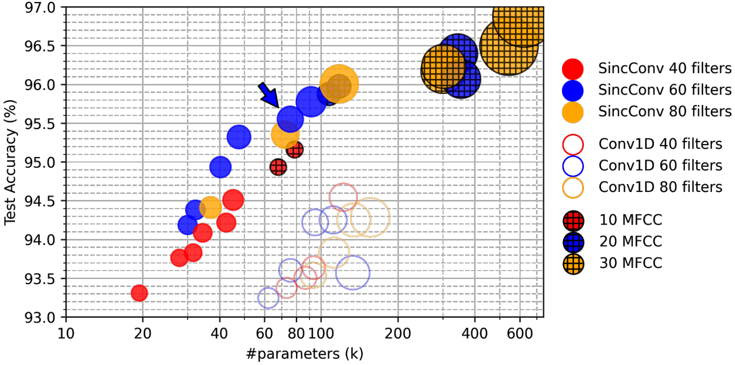
Google Speech commands dataset [4]:

- 65,000 1-second long audio files
- 12 classes (10 keywords, silence, unknown)

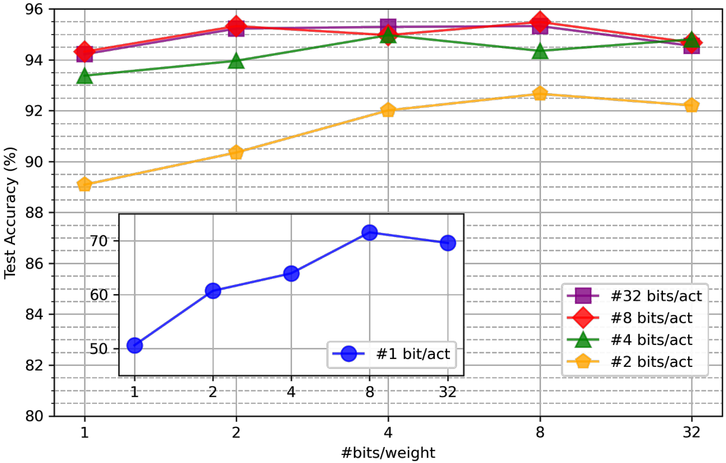
Augmentation:

- Random time shift
- Background noise

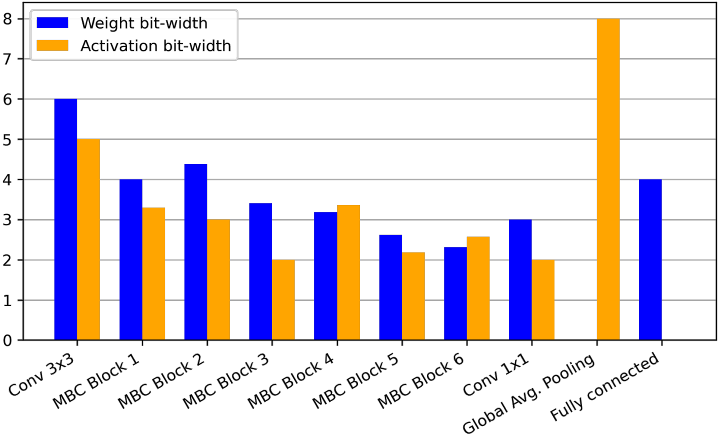
KWS from Raw Audio Waveforms using NAS



Fixed Bit-width Quantization



Trained Bit-width Quantization



Conclusion

- Resource-efficient DNNs are the *key components* in modern keyword spotting (KWS) systems.
- Neural architecture search (NAS) can be used to obtain efficient end-to-end convolutional neural networks (CNNs) for keyword spotting *without compromising classification accuracy*.
- Weight and activation quantization is a viable option to *reduce the memory footprint* for storing the CNN weights.

References

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