CPAUG: REFINING COPY-PASTE AUGMENTATION FOR SPEECH ANTI-SPOOFING

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Abstract

Innovation

The proposed **CpAug** method represents a refined augmentation specifically for anti-spoofing.

① Unlike the conventional copy-paste that only concatenates utterances, CpAug also substitutes segments.

② Explore four blending strategies that consider the same / different speakers and spoofing attack types when creating augmented instances.

③ CpAug integrates basic signal processing to mitigate problems from directly concatenating signals.

④ Compare the performance of the proposed CpAug with now widely-used Rawboost, highlighting their synergistic benefits.

Results

① Compared with no data augmentation, the **CpAug** with *substitution* policy leads to relative improvements of **43%** and **38%** on the ASVspoof' 19LA and 21LA, respectively.

② The **CpAug** and Rawboost synergize effectively, achieving an EER of **2.91%** on ASVspoof' 21LA.

CpAug: Refing Copy-paste Augmentation

Methodology

- **The Conventional Copy-paste Augmentation**

$$X_{\mathrm{CP}} = f_{\mathrm{CP}}\left(X_1, X_2\right) = X_1 \oplus X_2$$

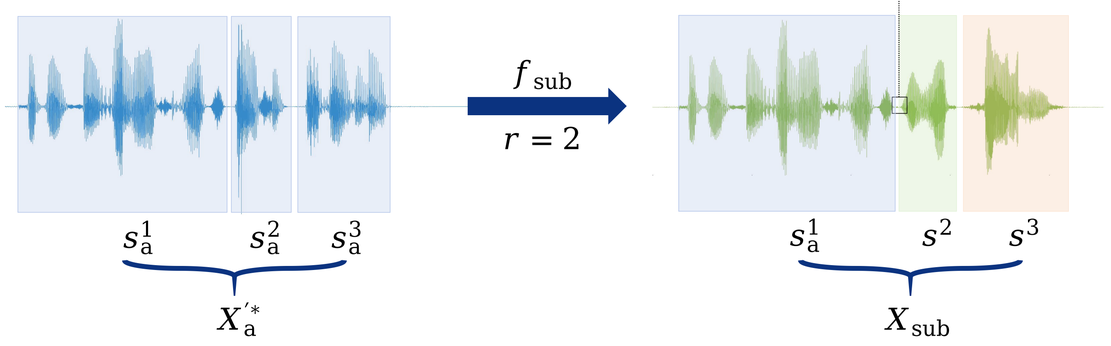
- **Substitution Policy**

$$X_{\mathrm{sub}} = f_{\mathrm{sub}}\left(X_{\mathrm{a}}'^{*}, \mathscr{S}, r\right)$$

$$= \left\{ s_{\mathrm{sub}}^{i} = \begin{cases} s^{j} & j \in R \quad \text{if} \quad i \in Q, \\ s_{\mathrm{a}}^{i} & \text{otherwise.} \end{cases} \right\}_{i=1}^{C}$$

$$\mathscr{S} \triangleq \left\{ s^{i} : i = 1, \ldots, M \right\}$$

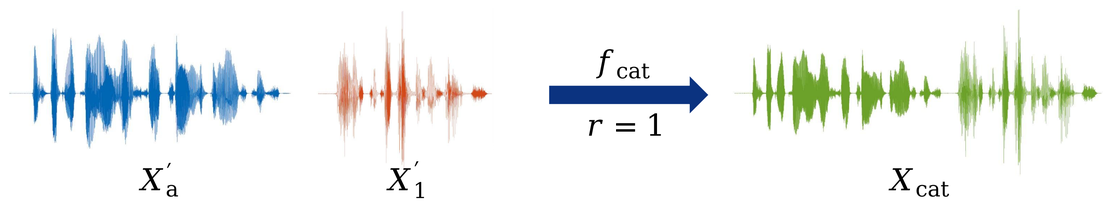
(cross-correlation, overlap-add)



- **Concatenation Policy**

$$X_{\mathrm{cat}} = f_{\mathrm{cat}}\left(X_{\mathrm{a}}', \mathscr{D}, r\right) = X_{\mathrm{a}}' \oplus X_1' \oplus X_2' \oplus \cdots \oplus X_r'$$

$$\mathscr{D} \triangleq \left\{ X_i' : i = 1, \ldots, K \right\}$$



Different Blending Strategies

Tab. 1. Details of the augmented datasets with four blending strategies.

	Names	Blending Strategies		Ave_ Dur (s)	Ratio (%)
		Attack	Speaker		
Concatenation	cat-satt-sspk	same	same	6.62	52.14
	cat-datt-sspk	different	same	6.67	51.91
	cat-satt-dspk	same	different	6.62	52.14
	cat-datt-dspk	different	different	6.66	51.83
Substitution	sub-satt-sspk	same	same	3.23	45.88
	sub-datt-sspk	different	same	3.25	45.20
	sub-satt-dspk	same	different	3.23	45.78
	sub-datt-dspk	different	different	3.23	45.06

Experimental Results

Tab. 2. Performance in EER (%) and t-DCF on 19LA test set with different policies.

DA	r	Back-end	EER	t-DCF
No	0		0.93	0.0285
conve CP	1		1.22	0.0410
cat-satt-dspk	1	AASIST	**0.86**	**0.0253**
sub-satt-dspk*	1		0.90	0.0292
sub-satt-dspk	[1,16]		0.88	0.0270
No	0		1.35	0.0425
conve CP	1		1.40	0.0440
cat-satt-dspk	1	Rawformer	1.09	0.0341
sub-satt-dspk*	1		1.02	0.0332
sub-satt-dspk	[1,16]		**0.77**	**0.0253**

Tab. 3. EER (%) and t-DCF on 19LA and 21LA tests with different blending strategies using Rawformer.

DA	r	19LA		21LA	
		EER	t-DCF	EER	t-DCF
No	-	1.35	0.0425	6.38	0.3328
cat-satt-sspk	1	1.16	0.0355	**4.41**	**0.3019**
cat-datt-sspk	1	1.22	0.0386	5.22	0.3309
cat-satt-dspk	1	**1.09**	**0.0341**	4.85	0.3086
cat-datt-dspk	1	1.28	0.0431	5.76	0.3380
sub-satt-sspk	[1,16]	0.88	0.0288	**3.93**	**0.2851**
sub-datt-sspk	[1,16]	1.02	0.0336	4.23	0.2909
sub-satt-dspk	[1,16]	**0.77**	**0.0253**	4.36	0.2993
sub-datt-dspk	[1,16]	1.12	0.0371	5.13	0.3086

- **conve CP:** the conventional copy-paste augmentation
- ***r*:** the number of concatenated utterances or substituted segments

- sub-satt-sspk (Rawboost): Rawboost augmentation before 'sub-satt-sspk'
- Rawboost (sub-satt-sspk): Rawboost augmentation after 'sub-satt-sspk'
- Rawboost,sub-satt-sspk: independent augmentation using Rawboost and *substitution* strategies, separately

Tab. 4. Performance of combining the CpAug and Rawboost on the 21LA test set.

DA	Back-end	EER	t-DCF
No	AASIST	10.51	0.4884
Rawboost		7.60	0.2601
sub-satt-sspk		7.31	0.2488
sub-satt-sspk(Rawboost)		8.59	0.2853
Rawboost(sub-satt-sspk)		**5.56**	**0.1776**
Rawboost,sub-satt-sspk		5.60	0.1850
No	Rawformer	6.38	0.3328
Rawboost		4.02	0.2918
sub-satt-sspk		3.93	0.2851
sub-satt-sspk(Rawboost)		3.98	0.2740
Rawboost(sub-satt-sspk)		**2.91**	**0.2617**
Rawboost,sub-satt-sspk		3.61	0.2825

https://github.com/zlin0/CpAug

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Conclusions

✓ We proposed the **CpAug** tailored for anti-spoofing using *concatenation* and *substitution* policies and found it performs well on the ASVspoof' 19LA and 21LA tests.

✓ We explored four different blending strategies and found that using the same spoofing attack type achieves the best performance.

✓ The proposed **CpAug** and Rawboost work well together, with the Rawboost(sub-satt-sspk) giving the best results.

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