A Mixed-Domain Self-Attention Network for Multilabel Cardiac Irregularity Classification Using Reduced-Lead Electrocardiogram

Hao-Chun Yang[1*], Wan-Ting Hsieh[2*], Trista Pei-Chun Chen[2]

[1]National Tsing Hua University, Hsinchu, Taiwan
[2]Inventec Corporation, Taipei, Taiwan

Introduction

Electrocardiogram (ECG) is considered a powerful signal to detect cardiac irregularities, which cause 17.9 million annual deaths worldwide. In the spirit of the PhysioNet/Computing in Cardiology Challenge 2021 [1], we propose Mixed-Domain Self-Attention Resnet to identify cardiac abnormalities from reduced-lead ECG. Our approach achieves the score of 0.602 (54th), 0.593 (37th), 0.597 (38th), 0.591 (38th), and 0.589 (39th) on 12, 6, 4, 3, and 2 -lead ECG channels respectively.

Problems

▶ Domain Bias: The strategy of bridging the domain gap between train and test set is vital to ensure the generalizability of the proposed classifier.

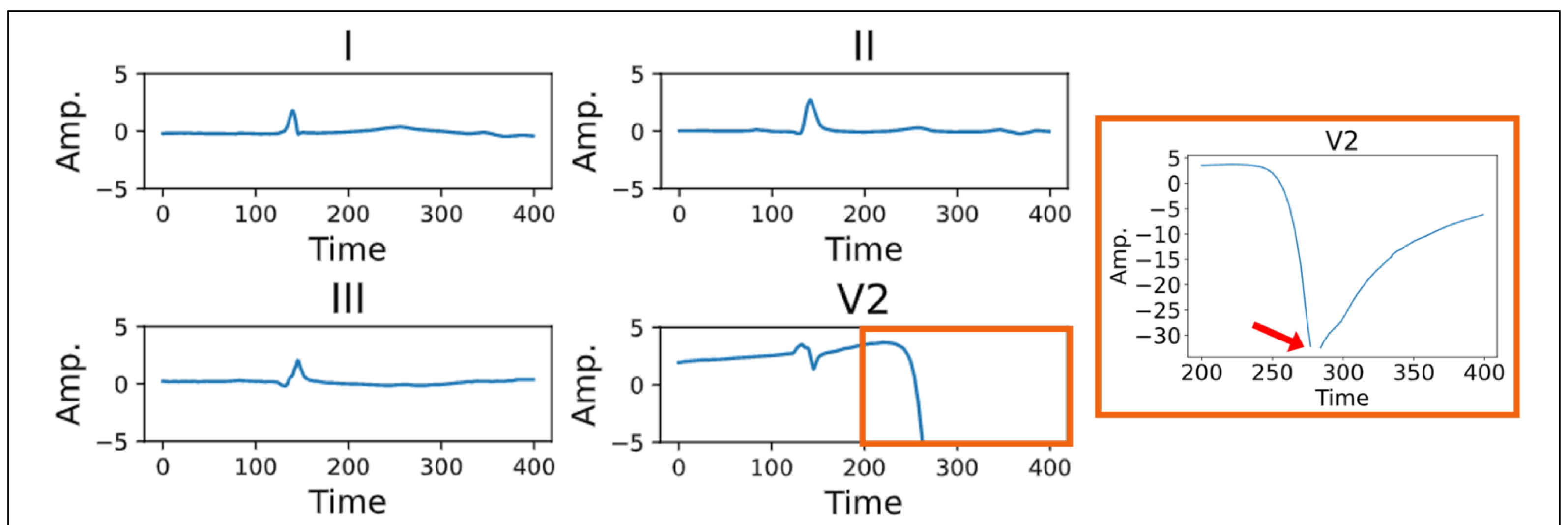

Fig 1. ECG Leads' Issue: The continuous non-numerical (NaN) fragments are found in lead V2 and V3 (red arrow area) with undesired dramatic amplitude variation .

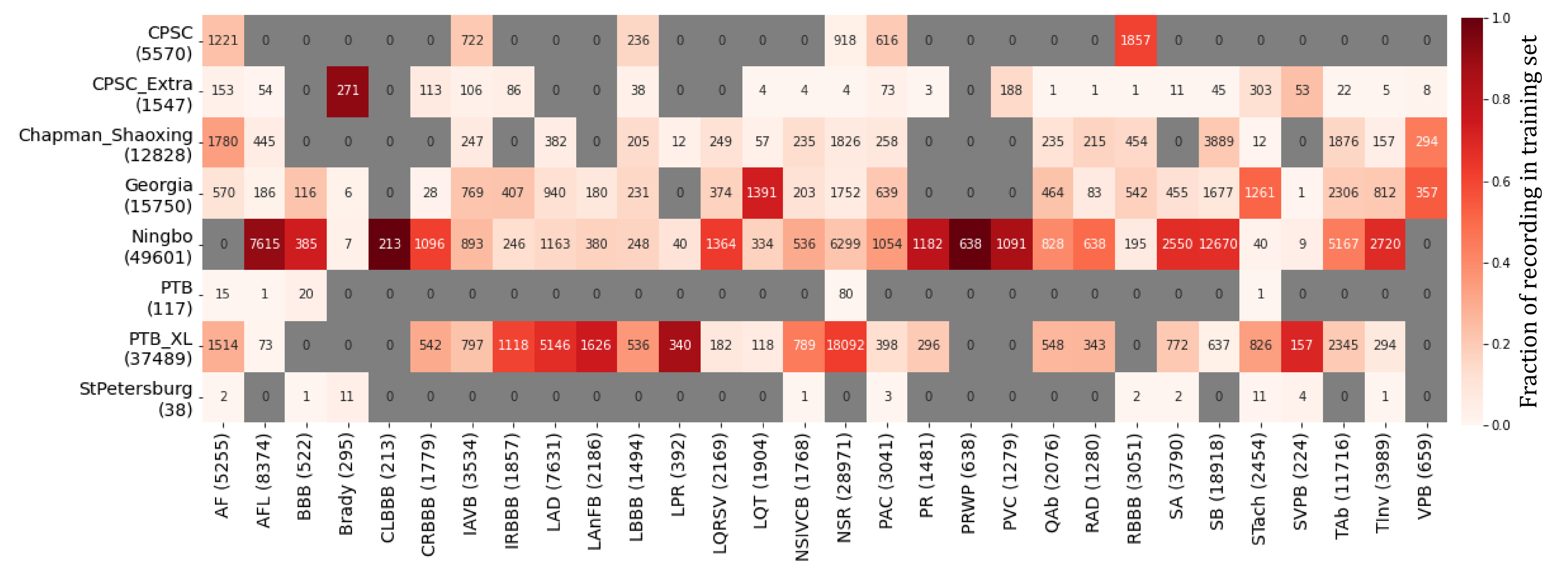

Fig 2. Domain Bias in multiple sources.

▶ ECG Leads' Issue: Complex relation between different ECG leads and CVDs requires a method to automatically learn the mapping of relation. Besides, the low-quality leads which contain continuous non-numeric fragments should be ignored since they will eventually hinder the model's performance.

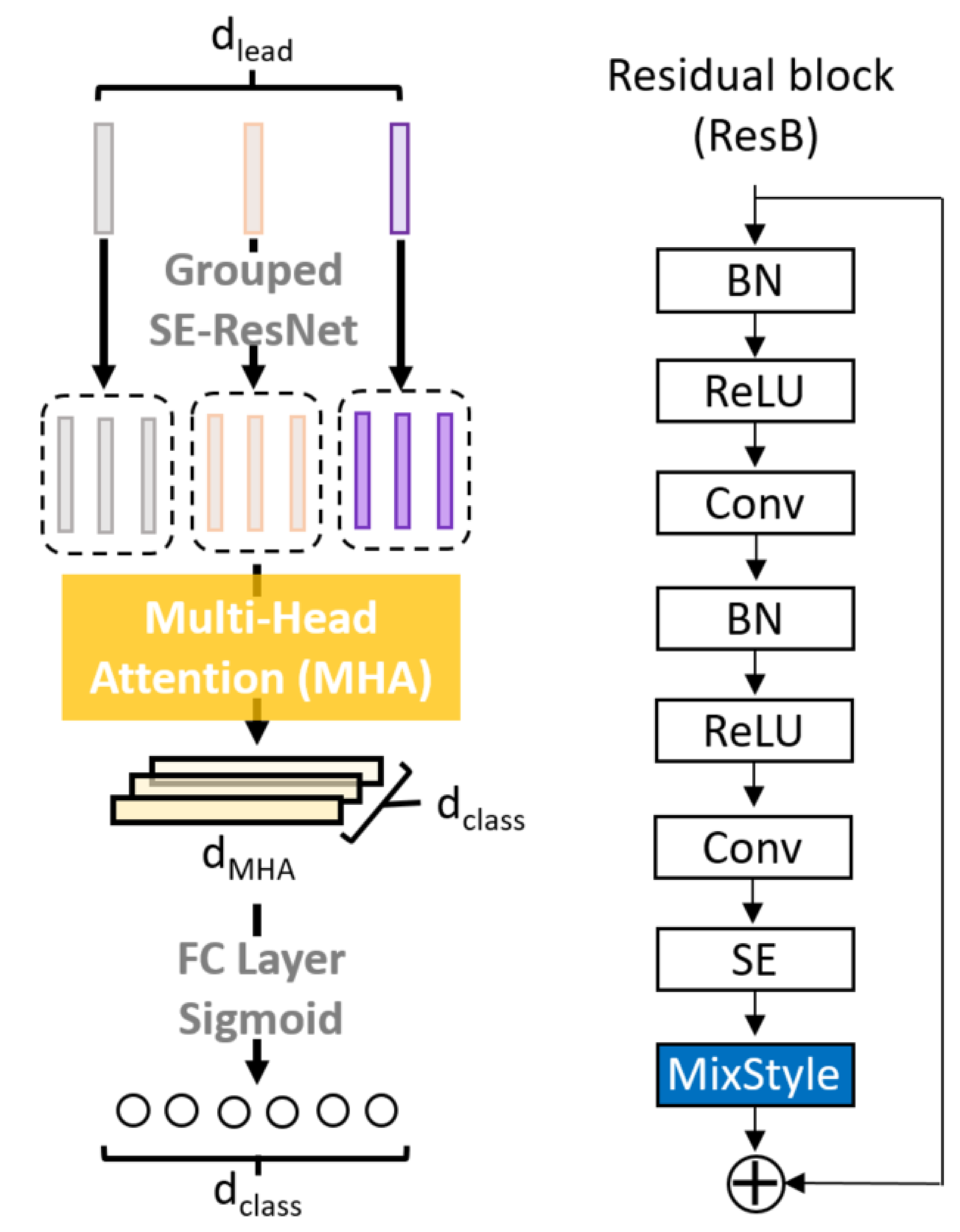

Fig 3. The schematic of our proposed framework .

Methodology

▶ MixStyle[2] to generalize for different domains.

$$\gamma_{mix} = \lambda\sigma(F) + (1-\lambda)\sigma(F')$$
$$\beta_{mix} = \lambda\mu(F) + (1-\lambda)\mu(F')$$
$$MixStyle(F, F') = \gamma_{mix} \odot \frac{F - \mu(F)}{\sigma(F)} + \beta_{mix}$$

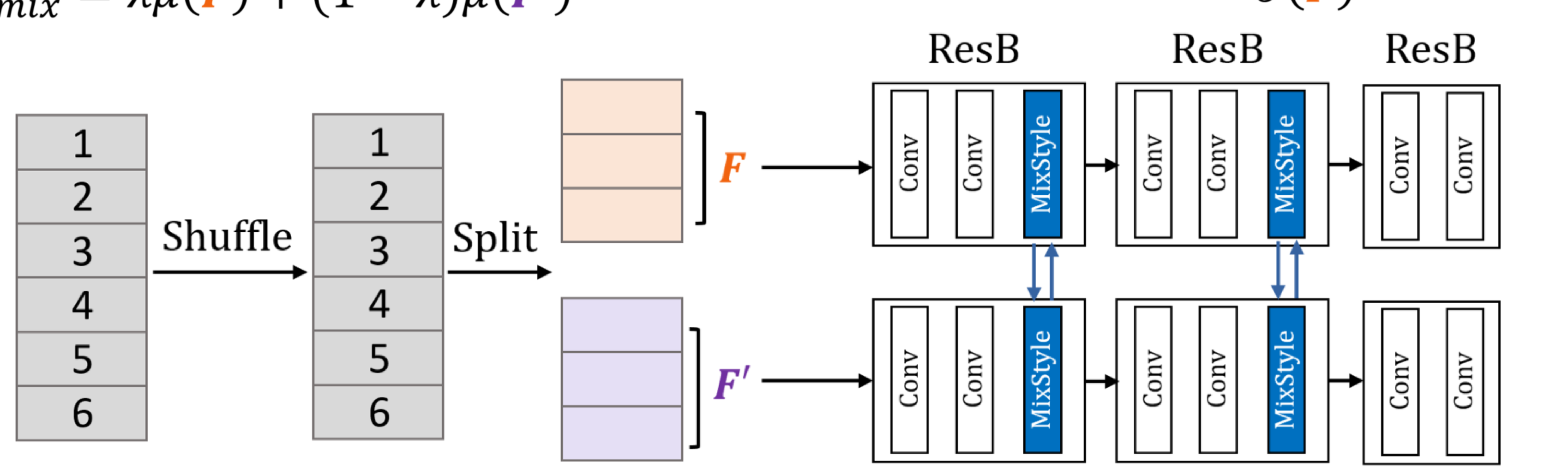

Fig 4. MixStyle training strategy.

▶ Multihead Attention layer (MHA) with valid-lead mask to ignore low-quality ECG leads and attend on the rest of leads.

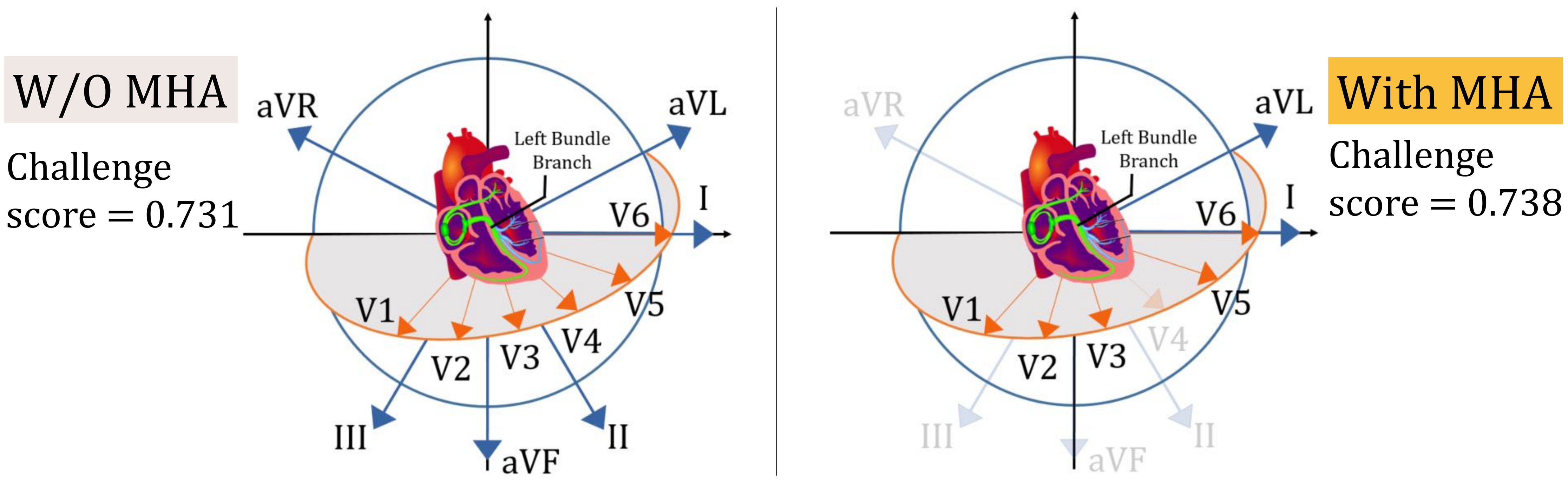

Fig 5. The Schematic and performance of MHA.

Model	SERsn+M					SERsn+M+A				
Leads	12	6	4	3	2	12	6	4	3	2
Training	0.731	0.709	0.711	0.713	0.705	**0.738**	**0.71**	**0.723**	**0.719**	**0.707**
Validation	**0.602**	**0.593**	**0.597**	**0.591**	**0.589**	0.525	0.506	0.511	0.503	0.499

Table 1. Challenge scores of different models. M: with MixStyle block, A: with the MHA layer.

[1] Reyna MA, Sadr N, Perez Alday EA, Gu A, Shah A, Ro-bichaux C, et al. Will Two Do? Varying Dimensions in Electrocardiography: the PhysioNet/Computing in Cardiology Challenge 2021. Computing in Cardiology 2021;48:1–4

[2] Zhou K, Yang Y, Qiao Y, Xiang T. Domain generalization with mixstyle. CoRR 2021;abs/2104.02