

FewShotBP

Towards Personalized Ubiquitous
Continuous Blood Pressure Measurement

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Presentation Info

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 - Session name: Human Sensing: Physio
 - Session date & time: 10/10/2023, 2:00:00 PM - 3:30:00 PM
 - Presentation Time: 8 Minutes

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Continuous Non-invasive Blood Pressure (CNIBP) is Crucial for Health Management

1 Introduction

- Demonstrates better value for clinical decision;
- Avoids the white coat effect;
- Benefits cardiovascular disease prevention and monitoring in community.

Achilles Heel of Current Deep Learning-Based CNIBP Approaches

1 Introduction



The connections between the physiological signals and the blood pressure readings are **complex** and **personalized**.

A large amount of personalized labeled data is required.
Frequent calibration with the cuff-based electronic blood pressure monitor is tedious.

Wearable devices have limited computation power.
Fine-tuning a deep net is impractical on wearable devices.

Key Differences with Previous Works

1 Introduction

- Few-shot personalization setting.
- Works in ubiquitous environment.
- Real-world user experiment.
- Strict domain splitting.

	Slapničar2019 ¹	Wang2022 ²	Leitner2022 ³	Ours
Source Domain	MIMIC-III	ImageNet	MIMIC-III	MIMIC-II*
Target Domain	MIMIC-III	MIMIC-II*	MIMIC-III	MIMIC-II*/user experiment
Personalization	Yes	N/A	Yes	Yes
Domains Splited Strictly?	No	Yes	Yes	Yes
Samples Required	additional 20%	N/A	50~3600	5~10

¹ G. Slapničar, N. Mlakar, and M. Luštrek, "Blood Pressure Estimation from Photoplethysmogram Using a Spectro-Temporal Deep Neural Network," Sensors, vol. 19, no. 15, Art. no. 15, Jan. 2019.

² W. Wang, P. Mohseni, K. L. Kilgore, and L. Najafizadeh, "Cuff-Less Blood Pressure Estimation From Photoplethysmography via Visibility Graph and Transfer Learning," IEEE Journal of Biomedical and Health Informatics, vol. 26, no. 5, pp. 2075-2085, 2022.

³ J. Leitner, P.-H. Chiang, and S. Dey, "Personalized Blood Pressure Estimation Using Photoplethysmography: A Transfer Learning Approach," IEEE Journal of Biomedical and Health Informatics, vol. 26, no. 1, pp. 218-228, 2022.

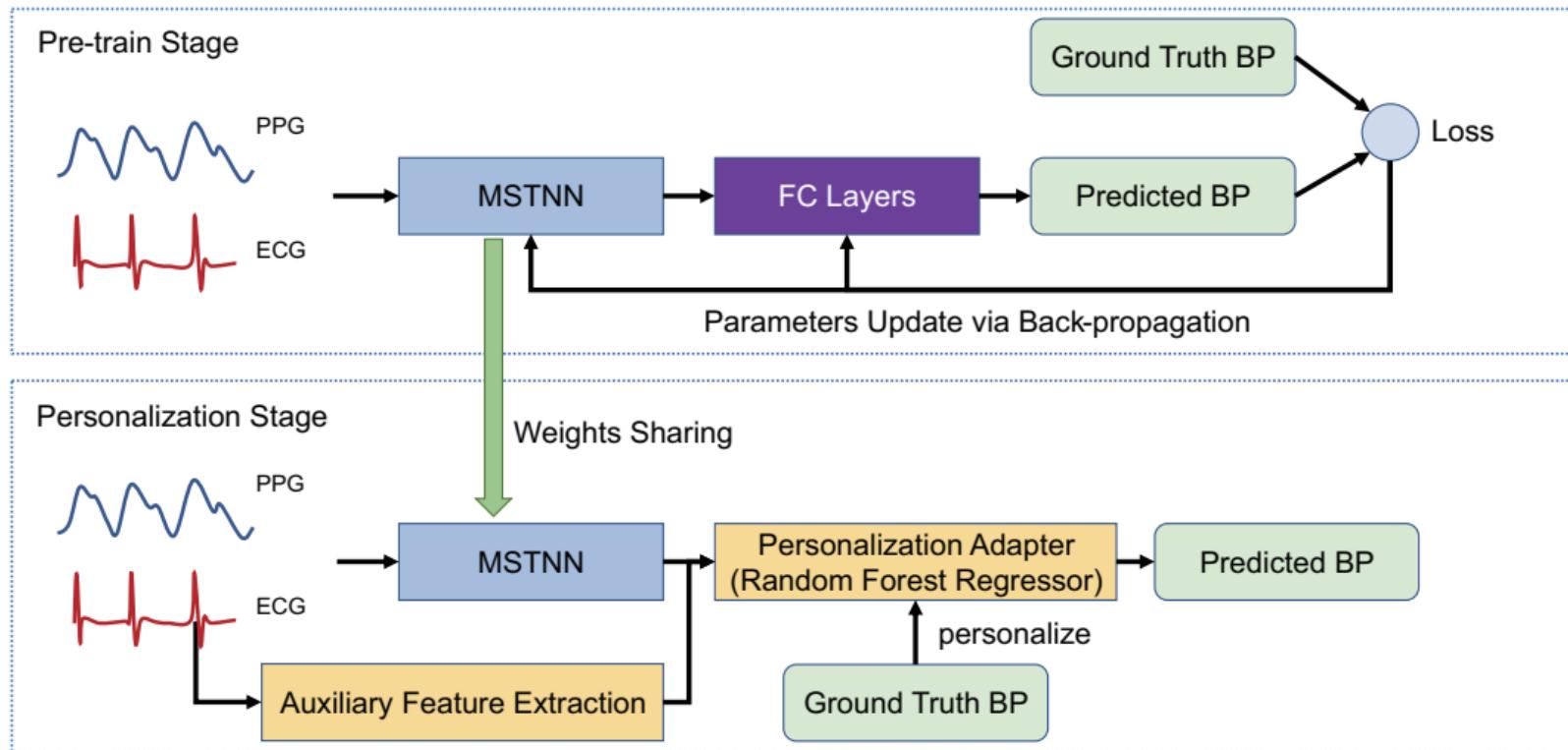
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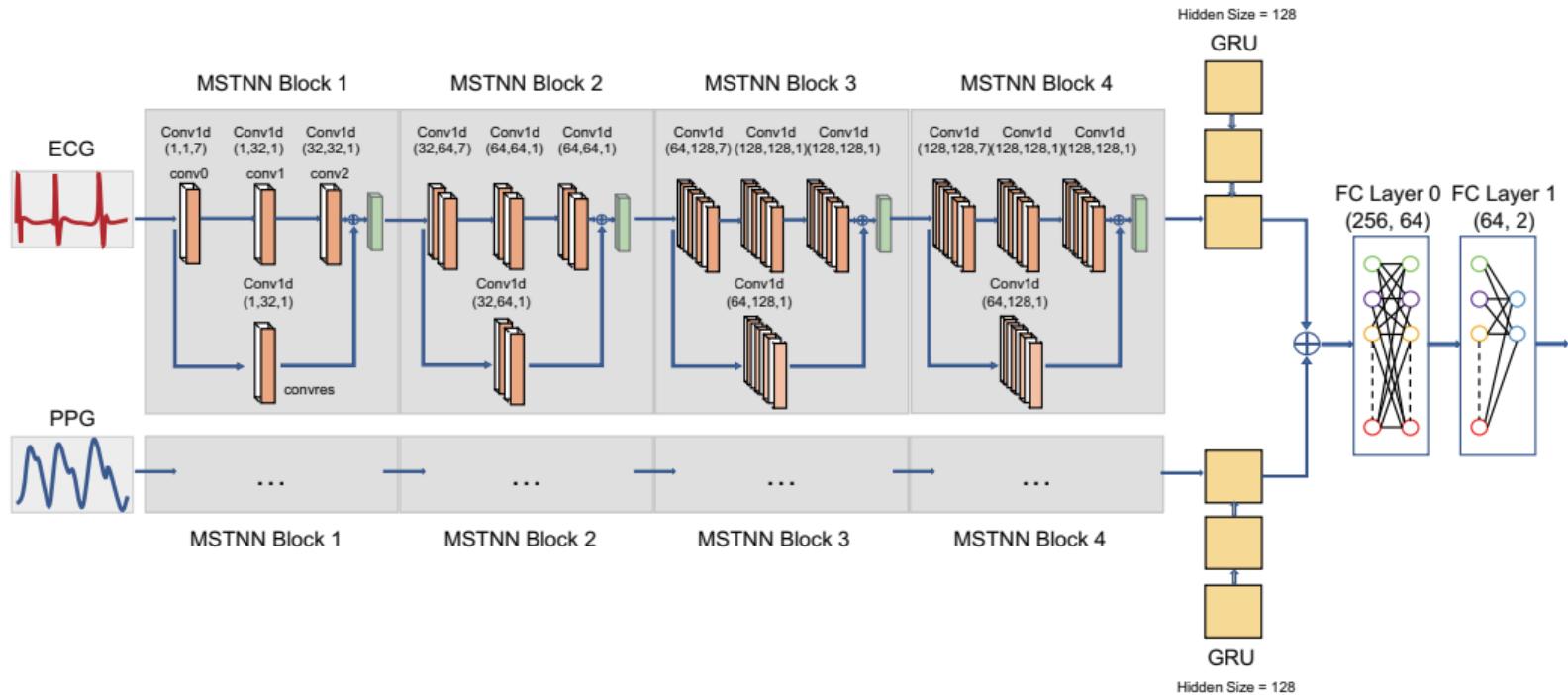
Transfer Learning Framework: A Network-based Approach

2 Methodologies



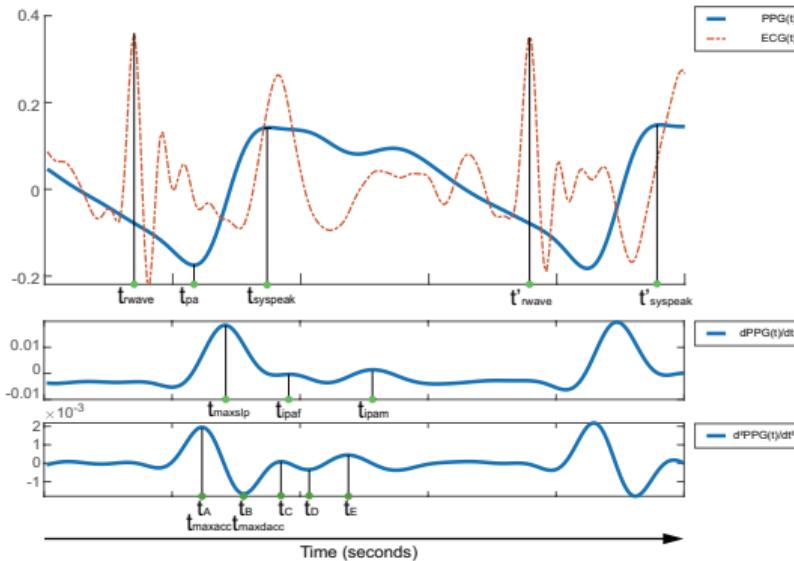
MSTNN: A ConvNextified Hybrid Network Structure

2 Methodologies



Personalization Adapter: Neural Features and Domain Expertise as Auxiliary Features

2 Methodologies



- Pulse Transit Time (PTT) variants and PPG morphological features are extracted as auxiliary features (AFs);
- Both AFs and *neural features* are fed into random regression tree for personalized blood pressure readings;
- The importance of AFs are evaluated later.

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3 Experiment on Public Dataset

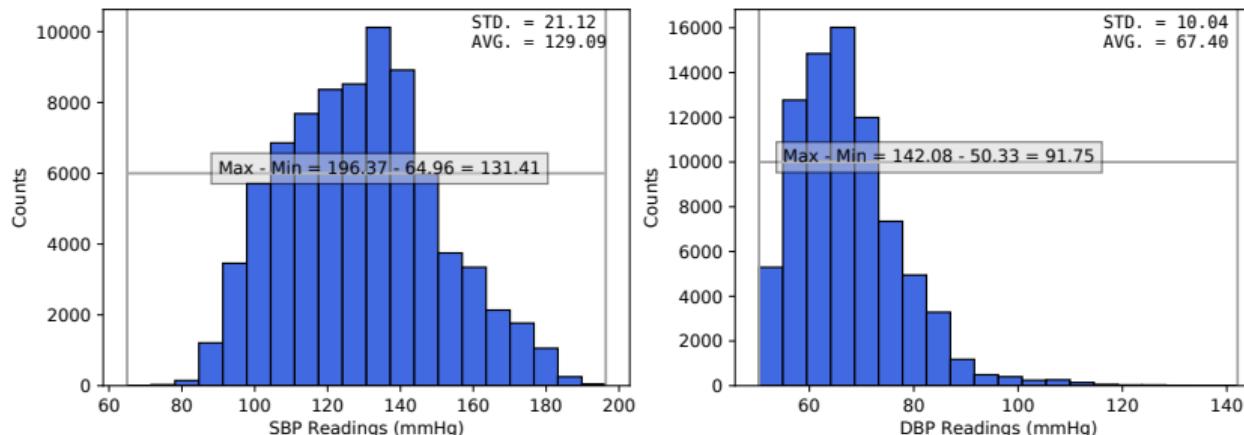
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Data Partition and Distribution

3 Experiment on Public Dataset

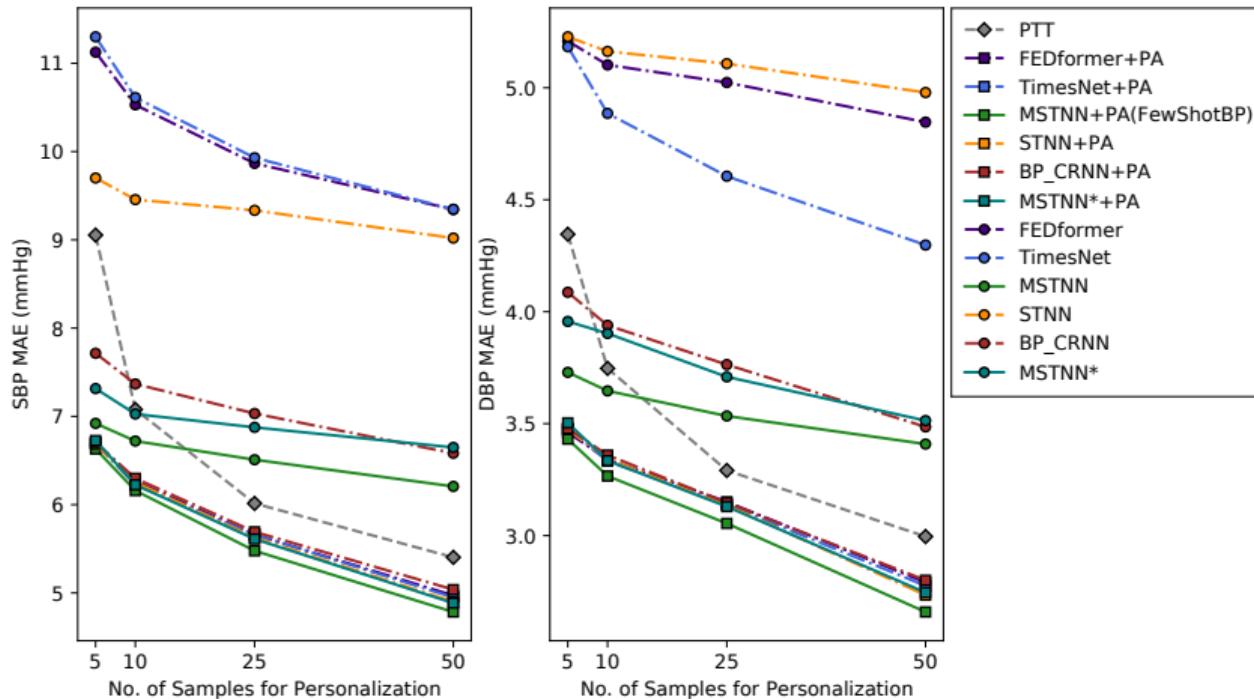
Table: The partition of public dataset.

	Total	Source Domain	Target Domain	Target Domain ("Short" Data Excluded)
No. of Subjects	9527	7621	1906	583
No. of Samples	540490	432080	106610	79371



Experiment Results

3 Experiment on Public Dataset



FEDformer, TimesNet, STNN, BP_CRNN and MSTNN w/o ECG modality (MSTNN*) are introduced as baseline networks architectures. All the architectures are evaluated with / without Personalization Adapter.

Experiment Results

3 Experiment on Public Dataset

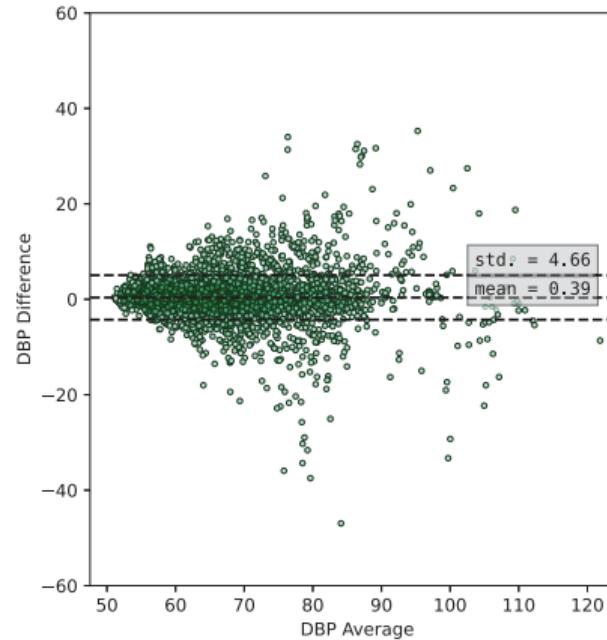
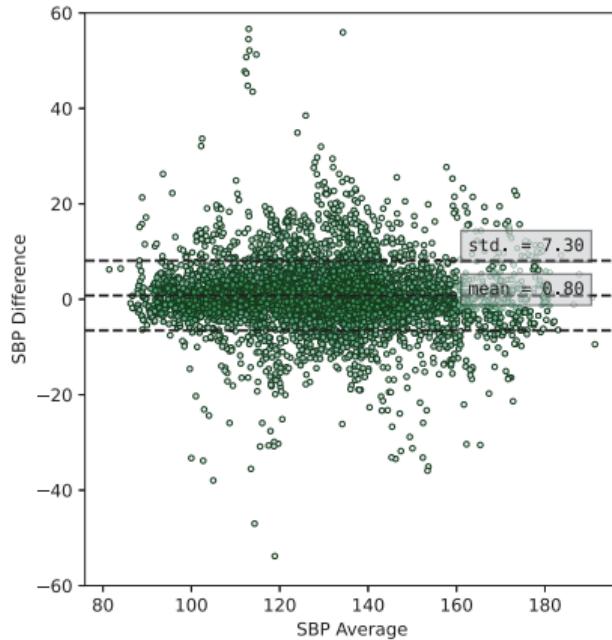


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Subject Demographics

4 Experiment on Subjects

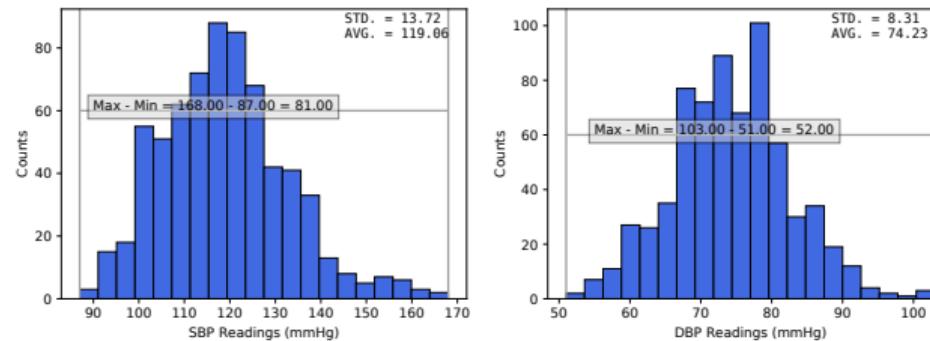


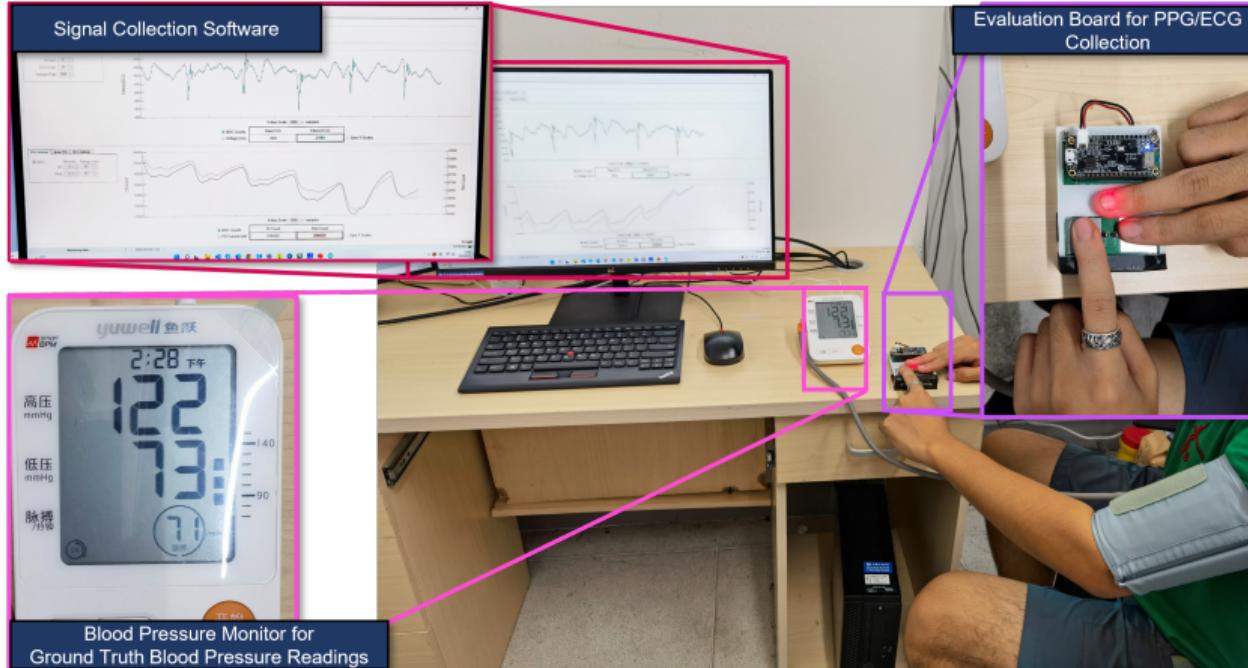
Figure: Distribution of Blood Pressure Readings in Real-world User Experiment

Table: Demographics of recruited subjects.

	Age			Height (cm)			Weight (kg)		
	18~30	30~50	50~60	170-	170~180	180+	50-	50~70	70+
No. of Subjects	28	1	5	16	15	3	2	21	11

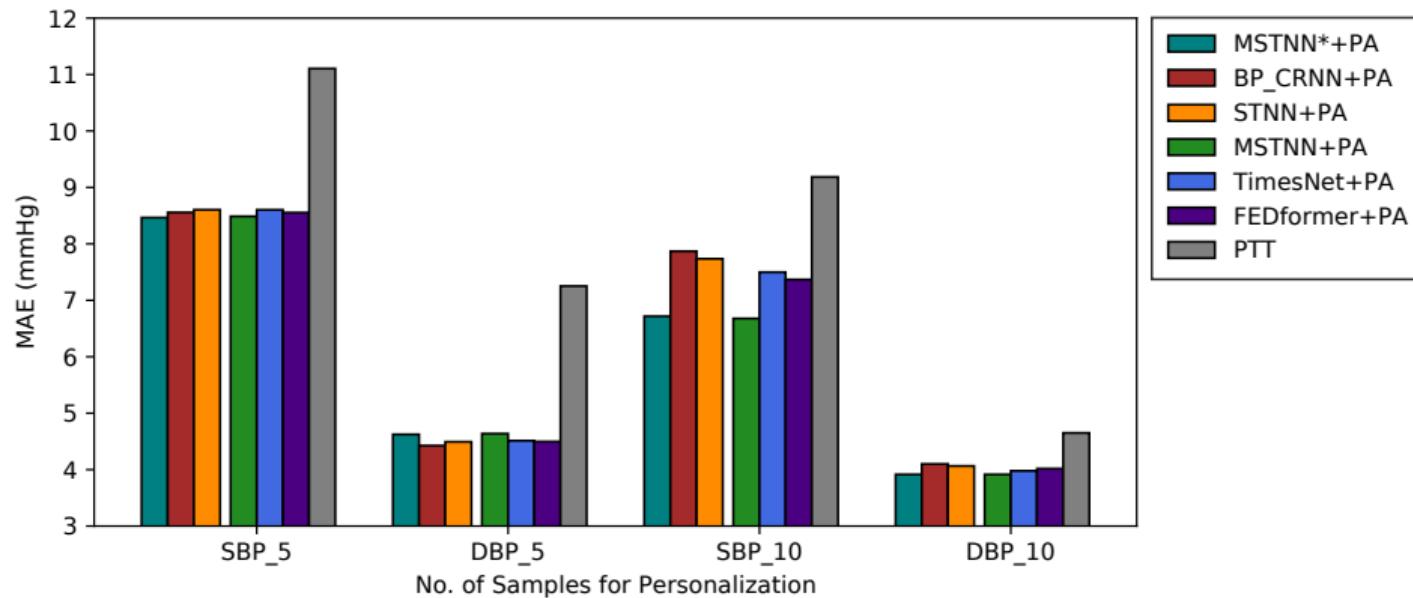
Experiment Settings

4 Experiment on Subjects



Experiment Results

4 Experiment on Subjects



Experiment Results

4 Experiment on Subjects

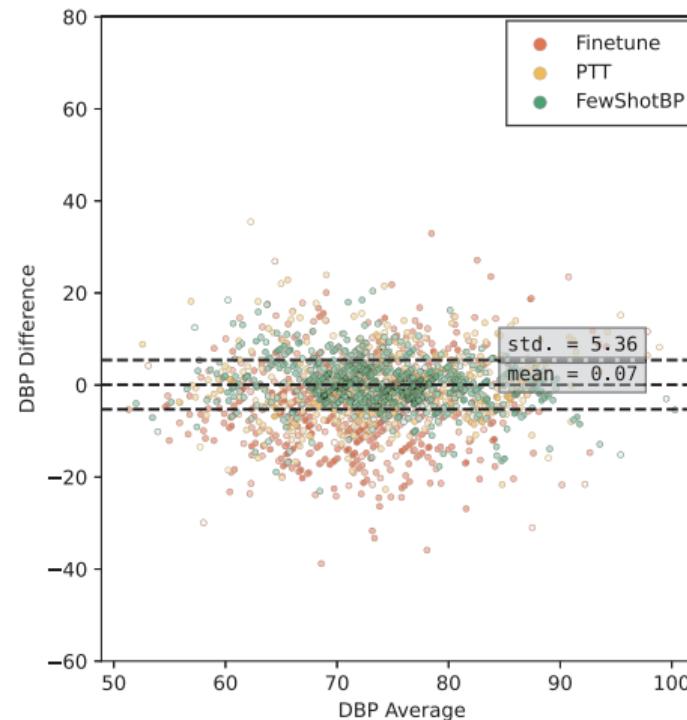
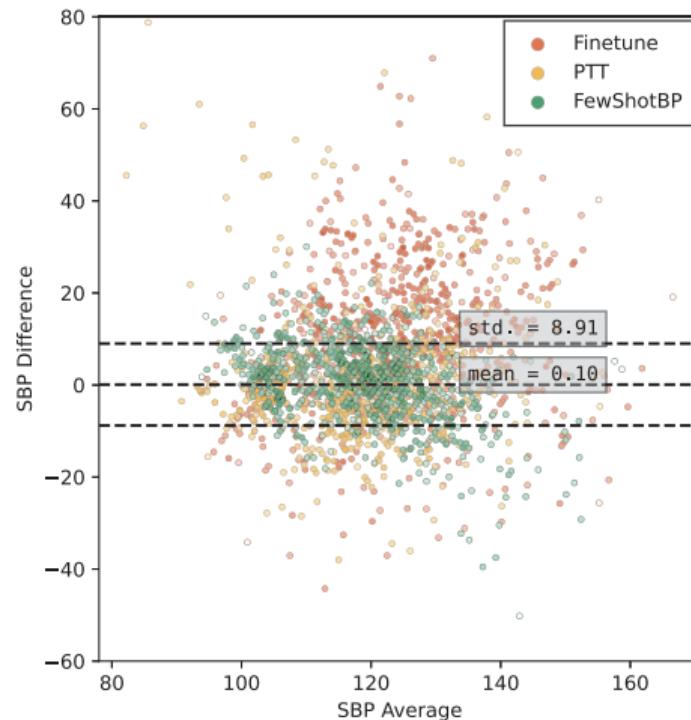


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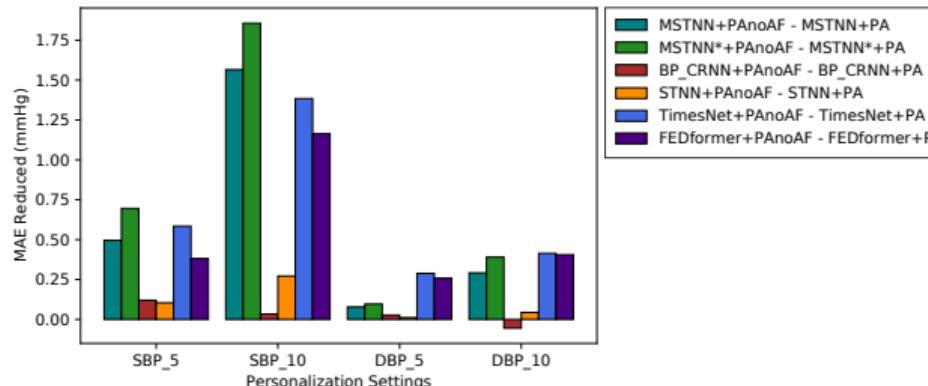
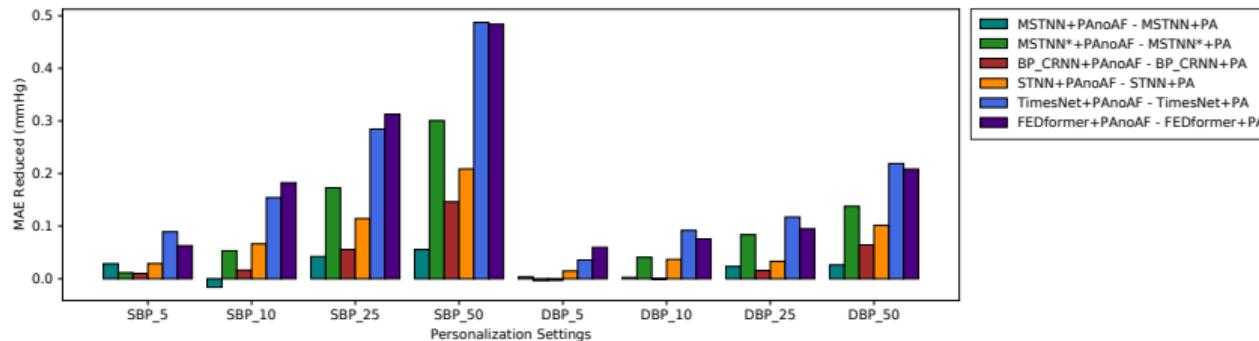
5 Major Findings

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The Auxiliary Features Do Help

5 Major Findings

We evaluate $\text{MAE}_{\text{Method+PA-AF}} - \text{MAE}_{\text{Method+PA}}$ to evaluate the contribution of auxiliary features.



The Structure to be Optimized is Pivotal: I

5 Major Findings

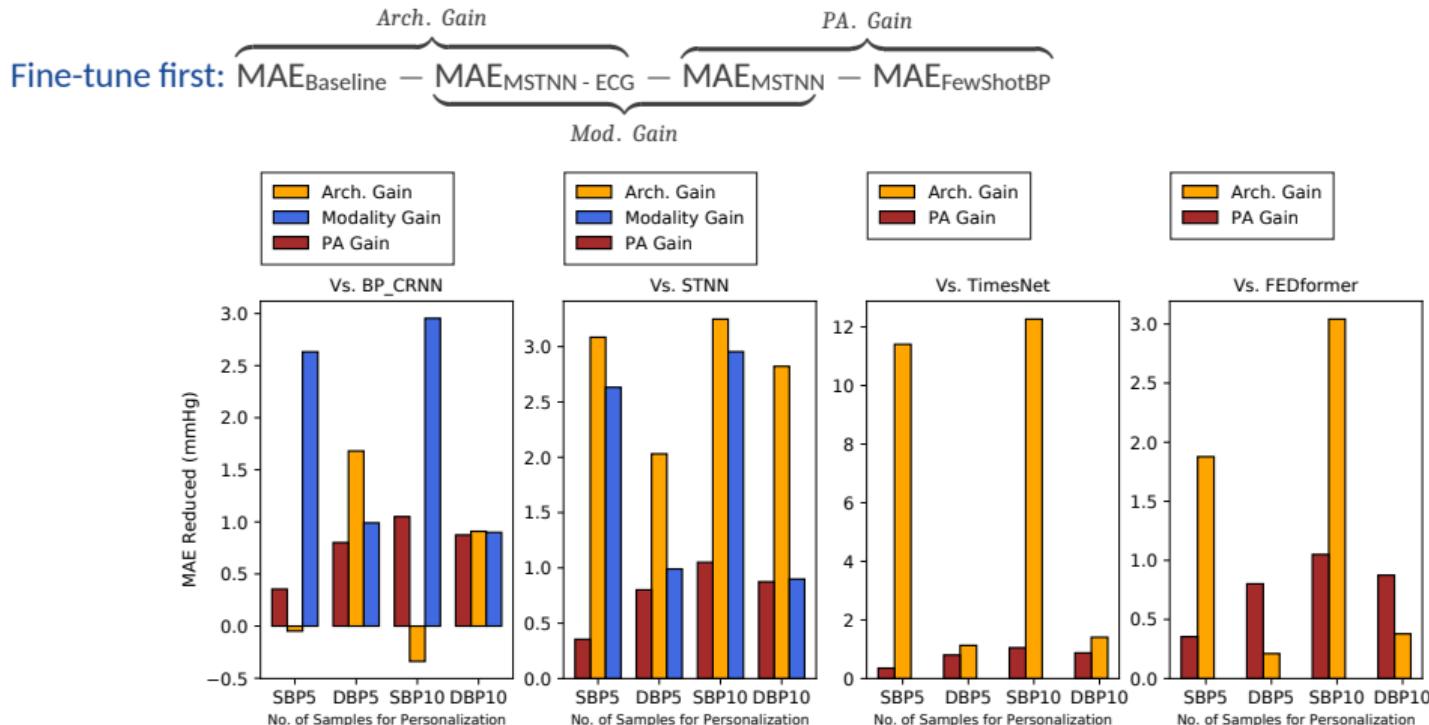


Figure: Vs. baselines under “fine-tune first” setting

The Structure to be Optimized is Pivotal: II

5 Major Findings

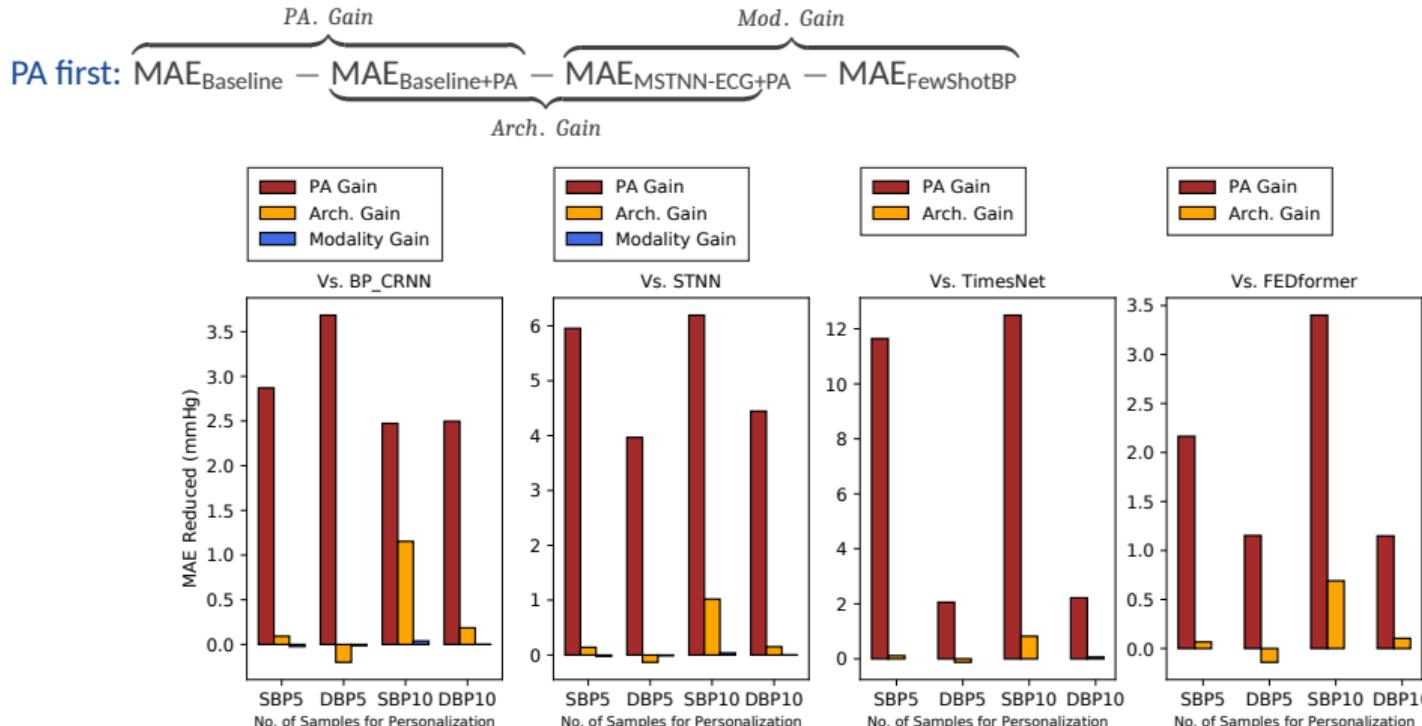


Figure: Vs. baselines under “PA first” setting

Less Backpropagation, Faster Personalization

5 Major Findings

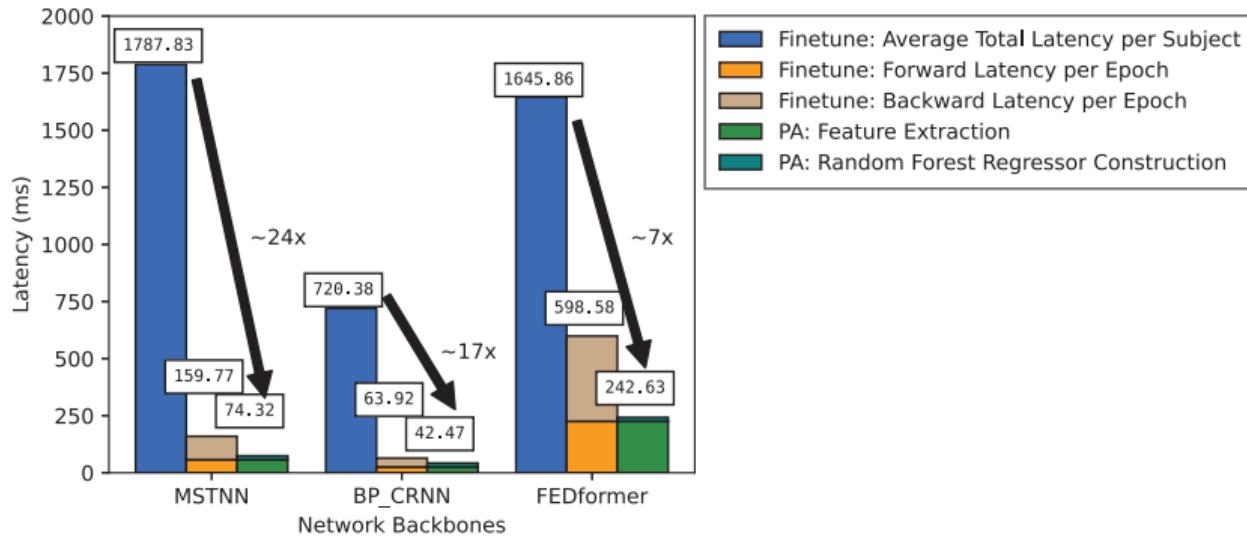


Figure: Estimation of cNIBP model personalization latency.

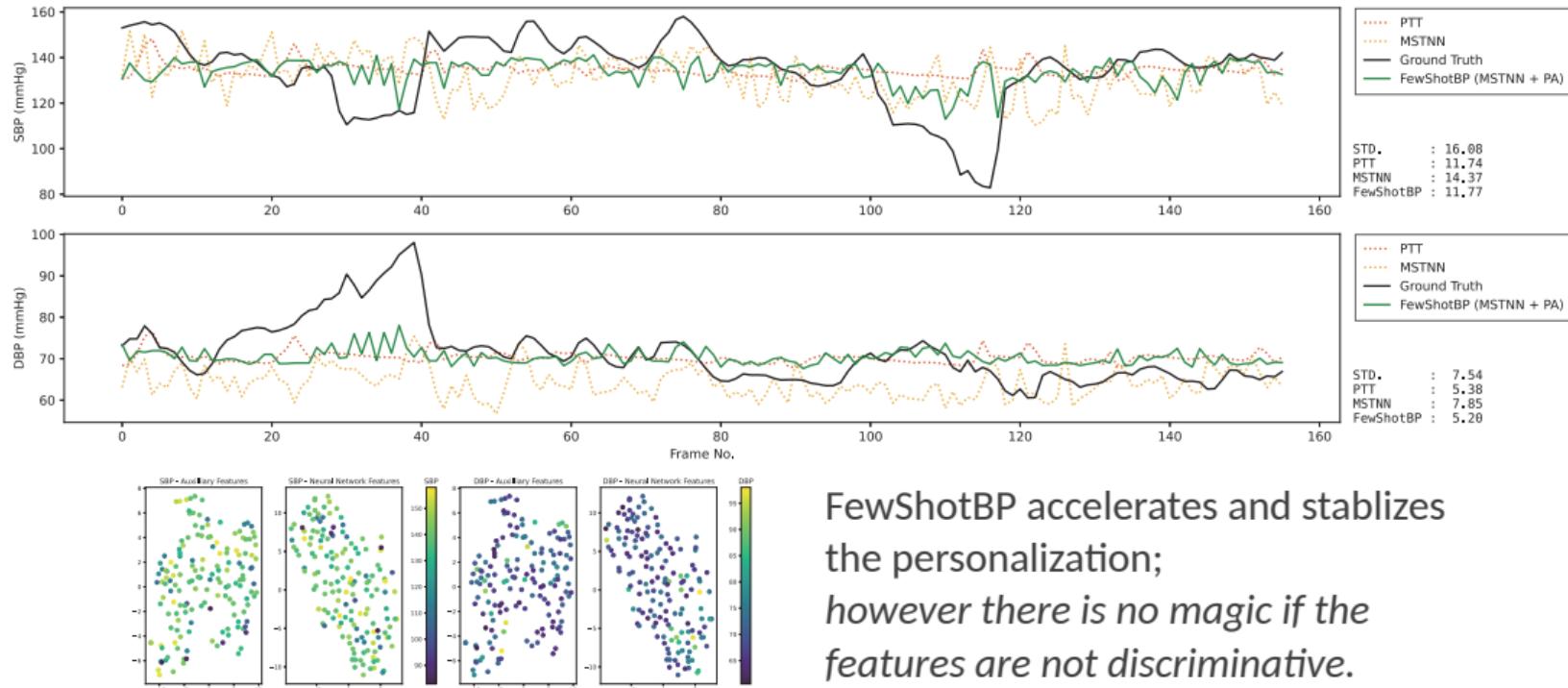
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FewShotBP is No Magic

6 Limitations



The Limitations of the Conducted Experiments

6 Limitations

- Subjects are insensitive of cold pressor test:
 - lower variation in features and labels;
 - the blood pressure may correlate with the heart rate .
- The accuracy of electronic home blood pressure monitor leads to noisy labels;
- The long-term changes in cardiovascular system are not taken into consideration.

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- ConvNextified network architecture (MSTNN): reduced number of parameters, enhanced generalizability.
- Personalization Adapter (PA) with auxiliary features: better few-shot personalization performance, less computation burden.
- The structure being optimized in the process of personalization is the paramount factor influencing accuracy. In this study, we employ a random forest regressor.
- Future work should focus on obtaining better representation on intra-subject blood pressure variations.

FewShotBP

Thank you for listening!