# Feasibility of Novel Non-Invasive Blood Pressure Sensor for Beat-to-Beat Measurement

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## INTRODUCTION

- Continuous, **non-invasive blood pressure (BP) monitoring** is critical across pre-hospital, emergency, critical care, perioperative, inpatient, and ambulatory settings for patient safety and effective management [1].
- **Piezoelectric nanofiber-based materials** offer flexibility, ease of integration, and strong potential for use in wearable, non-invasive BP devices [2].
- Work from the **Zhang Lab (Thayer School of Engineering)** has demonstrated that a **PVDF-TrFE polymer doped with 20 wt% barium titanate (BTO)** provides optimal piezoelectric performance.

### AIM

To develop a methodology that correlates the **signal output** from a PVDF-TrFE/BTO piezoelectric sensor with **blood pressure measurements** obtained from a reference BP device.

## METHODS

- Adults (≥18 yr) undergoing planned surgeries with invasive arterial monitoring at DHMC (n = 15).
- Exclusion: BMI > 40, radial artery depth > 1 cm, peripheral vascular disease, A-fib, silicone/tape allergy
- Radial artery depth measured via ultrasound prior to sensor placement.
- 4 **piezoelectric arterial pressure sensors** (PAS) placed over both left and right radial artery (2 parallel on each arm, 0.75 cm (Δd) apart)
- PAS voltage signals (4 total) recorded alongside reference voltage signal from invasive arterial catheter (standard)

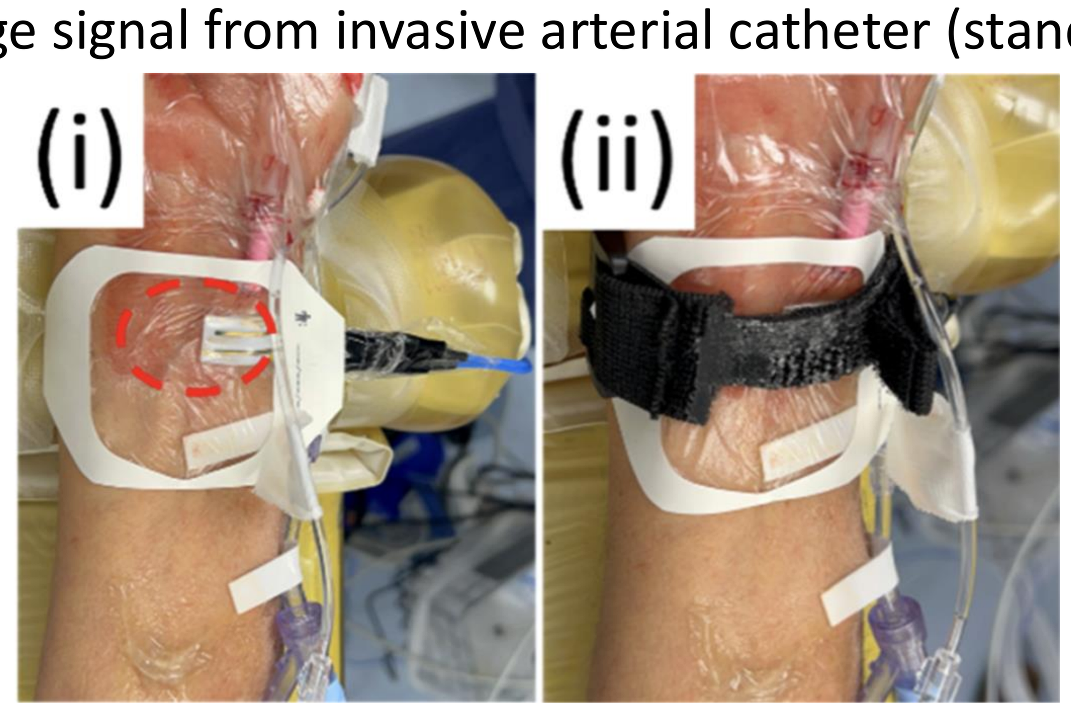
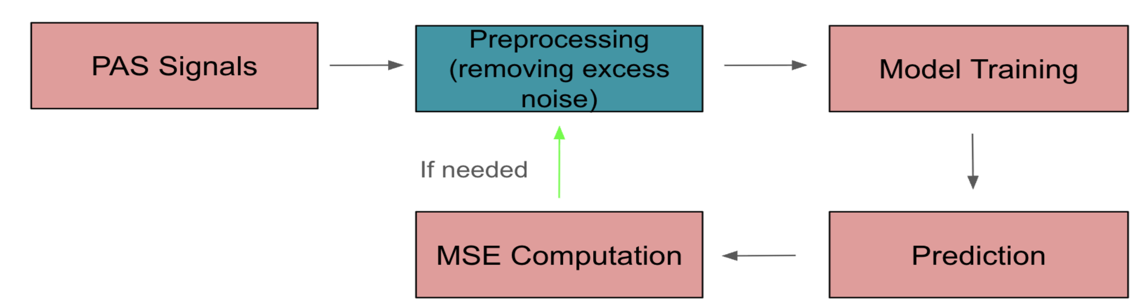



**Figure 1.** (i) Device setup with two sensors positioned over the radial artery. (ii) Setup with the same sensors and a wrist strap to maintain consistent pressure for optimal signal acquisition.

## DATA ANALYSIS

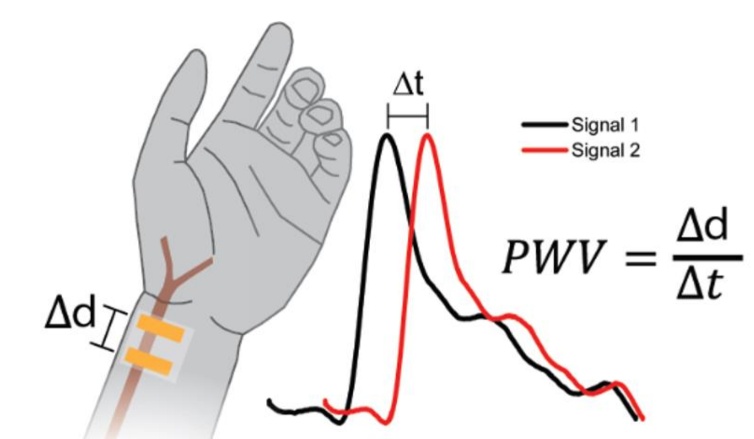
Machine Learning (ML)

- Use ML to map PAS voltage signals to reference voltage signals
- Correlate PAS signal segments with peaks and troughs of reference signals.
- Extract systolic and diastolic BP from identified peaks and troughs.




Pulse Wave Velocity

- Frequency Analysis to determine optimal preprocessing filters
- Pulse Wave Velocity (PWV) calculated by distance between sensors (Δd)/average delta time (Δt) between sensor peaks, where Δd is 0.75 cm
- Mean BP inferred using: $PWV = 4.62 - 0.13 * age + 0.0018 * age^2 + 0.0006 * (age * MBP) + 0.0284 * MBP$ [3]




## DISCUSSION

- PWV derived from the PAS sensor is feasible to estimate blood pressure
- ML approach showed overfitting, likely due to limited signal quality and homogenous data.
- Pulse information is identified within the 0.5–4 Hz frequency band
- Noisy sensor data can make peak detection challenging; improving hardware and sensor signal quality is a key step
- Current BP estimation equation relies on multiple assumptions (e.g., linear relationships, demographic, homogeneity)
- Accuracy of PWV-based BP estimation may vary with age, arterial stiffness, or cardiovascular disease; with these patient-specific data, more sophisticated BP models (Bramwell-hill equation) could be applied.
- Regression models using demographic and clinical variables may improve PWV-based BP estimation, and Bland–Altman analysis can assess agreement

## RESULTS

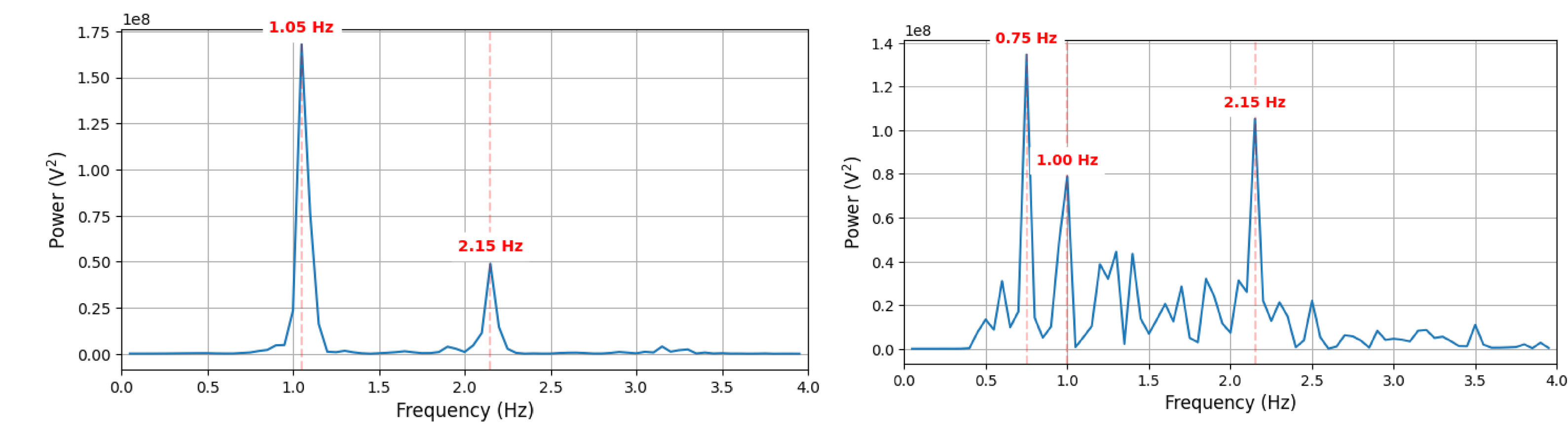



**Figure 2.** Frequency response of the reference signal (left) and the PAS signal (right). Both signals show peaks around 1 Hz and 2.15 Hz, likely corresponding to the pulse and its second harmonic, respectively.

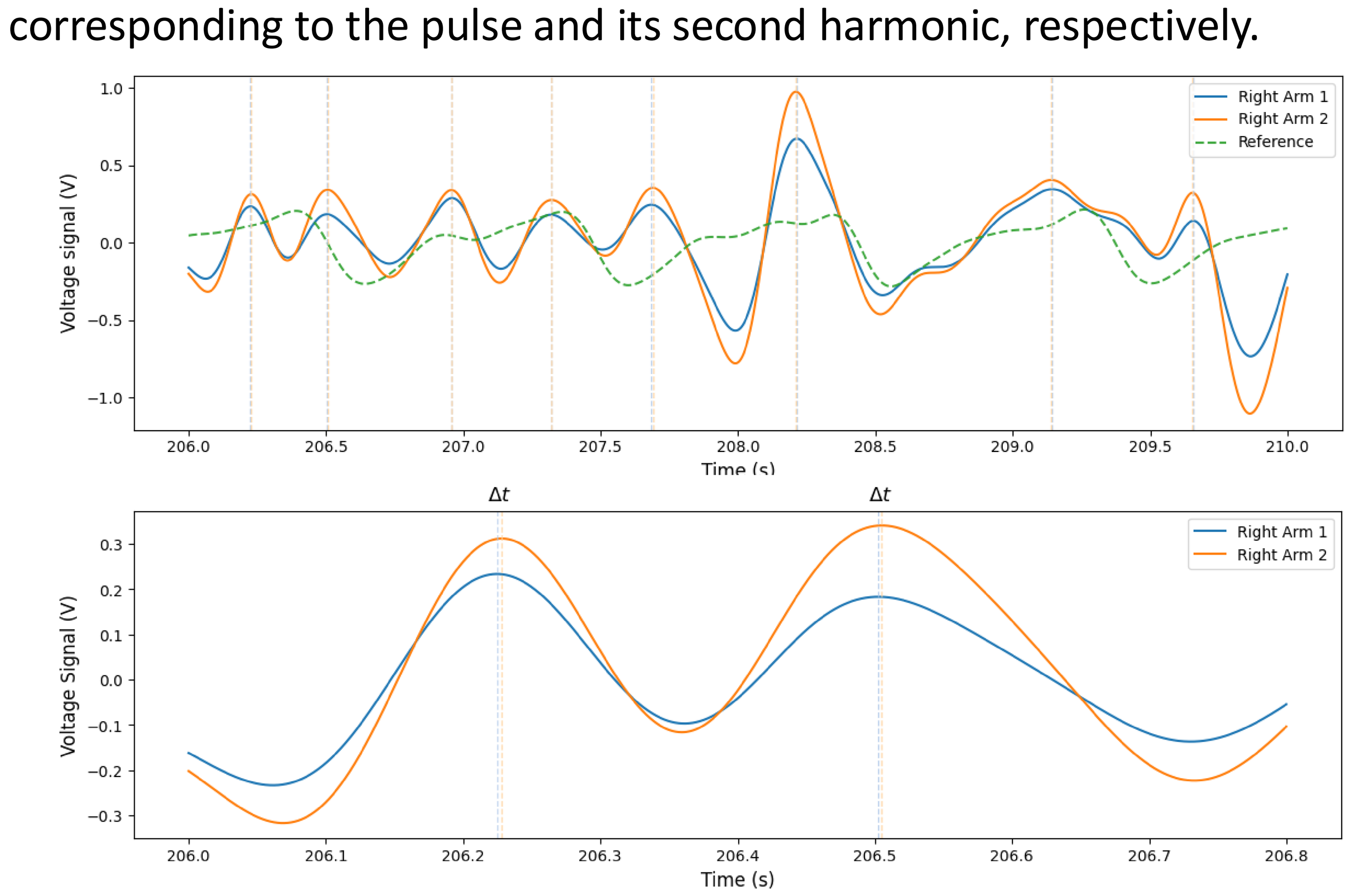



**Figure 3.** Right arm sensor 1 (blue), sensor 2 (orange), and reference (green) signals after applying a 0.5–4 Hz bandpass filter for 4-second segment (top) and 1-second segment (bottom). Peaks are marked with dashed lines, and the delta time between peaks is shown.

| Sample Patient Δt, PWV, derived MBP | | |
|---|---|---|
| AVERAGE DELTA TIME | PULSE WAVE VELOCITY | DERIVED MEAN BLOOD PRESSURE |
| 0.786 ms | 9.54 m/s | 85.5 mmHg |

**Table 1.** Sample of patient's hemodynamic measurements, with **Average delta time (Δt), Pulse wave velocity (PWV)**, and **derived mean blood pressure (MBP)**

### CONCLUSIONS

PWV from PAS sensors is a feasible method to estimate blood pressure.
Accurate peak detection and signal quality are critical for reliable measurements.
Models need refinement and validation across populations for clinical use

REFERENCE