

生体計測技術とその応用

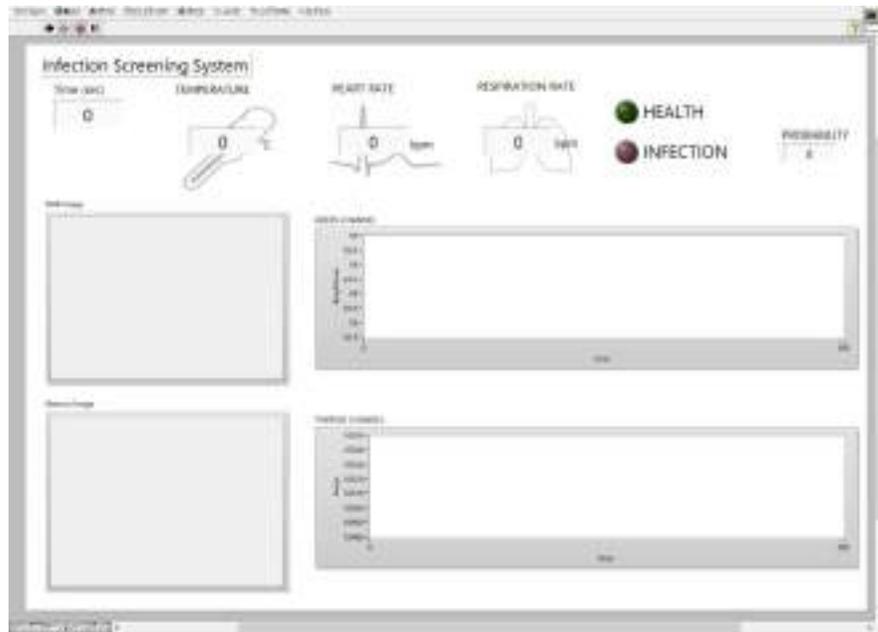
電気通信大学 大学院情報理工学研究科
機械知能システム学専攻
孫 光鎬

2024年11月28日

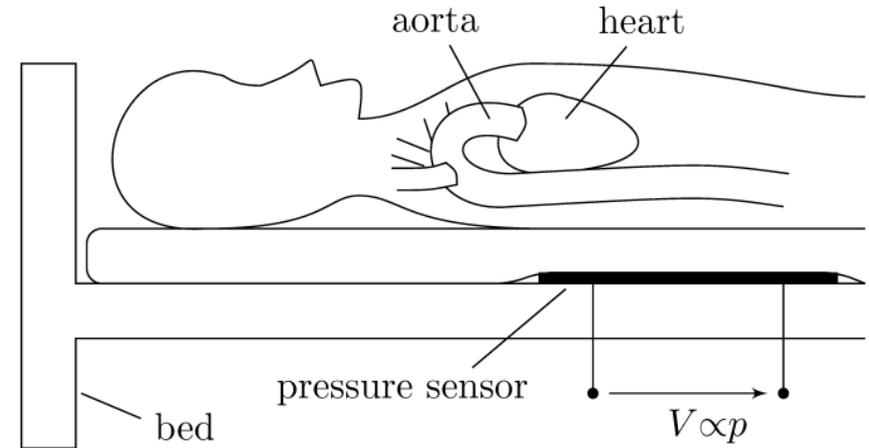
本日の内容

1. 非接触生体計測技術の最近の研究動向
2. CWレーダによる呼吸・心拍計測原理
3. 呼吸・心拍抽出のための信号処理法
4. 小児バイタルサイン計測への応用
5. 本技術の課題と展望

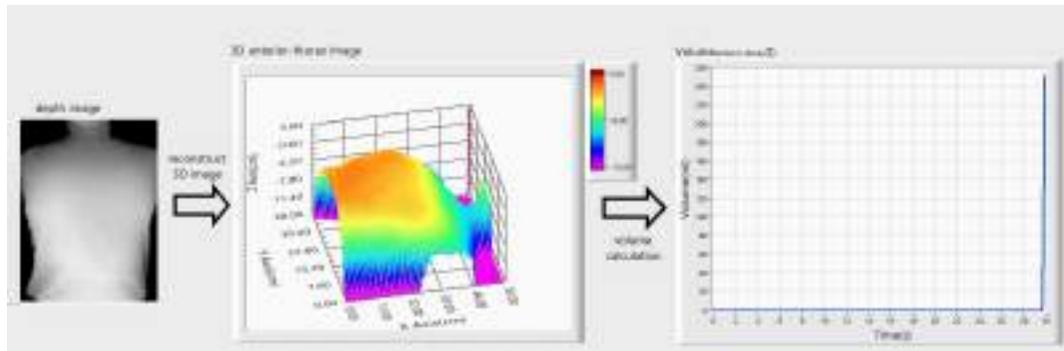
RGB/IR カメラ



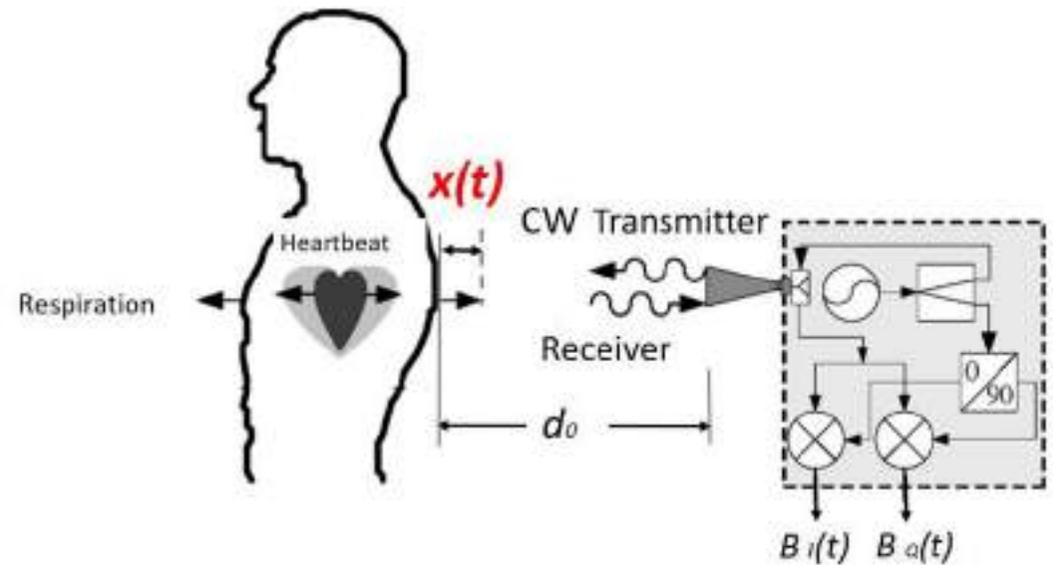
圧電センサ



Time of Flight センサ



電波センサ



高い

測定信頼性

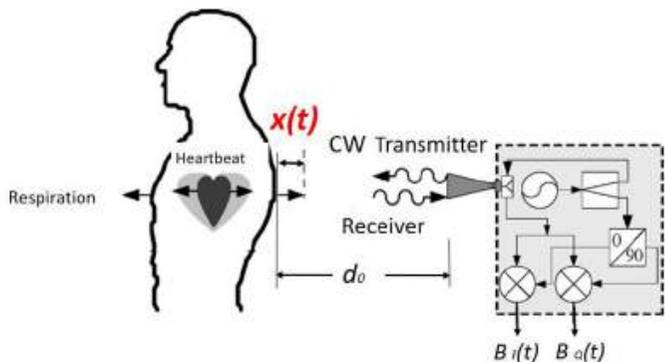
臨床用デバイス



ウェアラブル



非接触

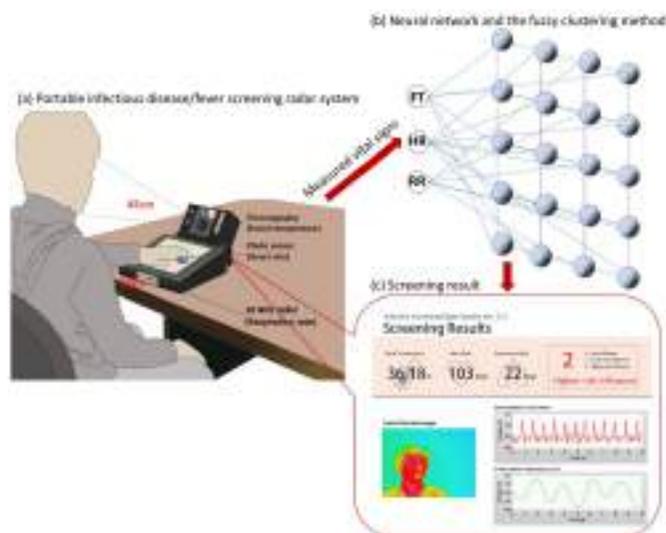


- ✓ 非接触
- ✓ 長時間連続モニタリング
- ✓ 無拘束
- ✓ 利用が簡便

患者への身体負担

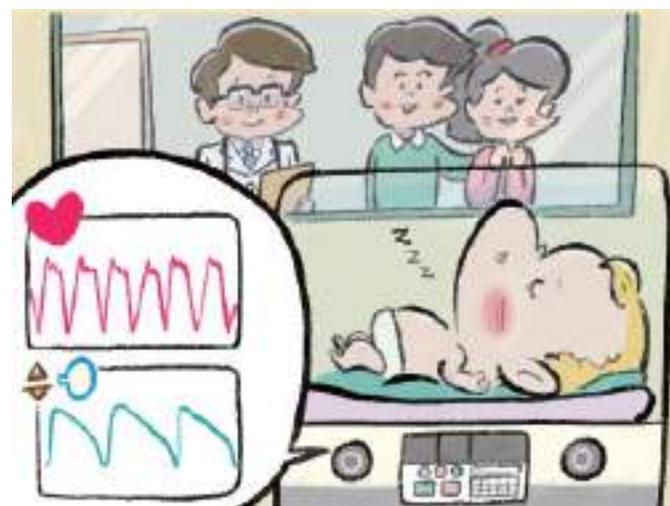
大きい

1、感染症のスクリーニング



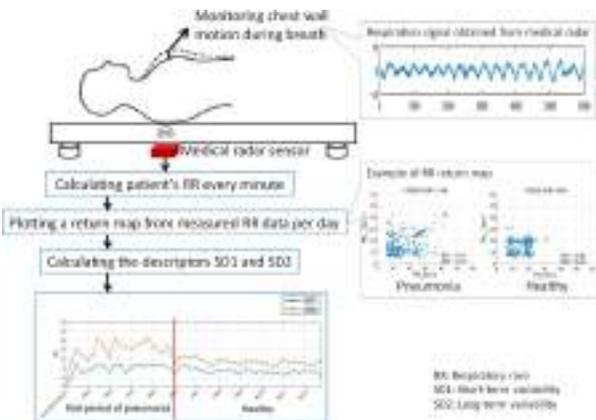
Sun G, et al, Journal of Infection (2015)

2、NICUモニタリング



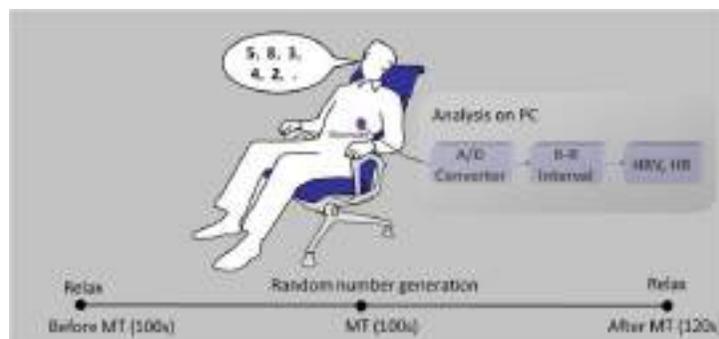
Sun G, et al, Computer Methods and Programs in Biomedicine (2022)
孫光鎬, 子供の科学 (2023)

3、高齢者見守り



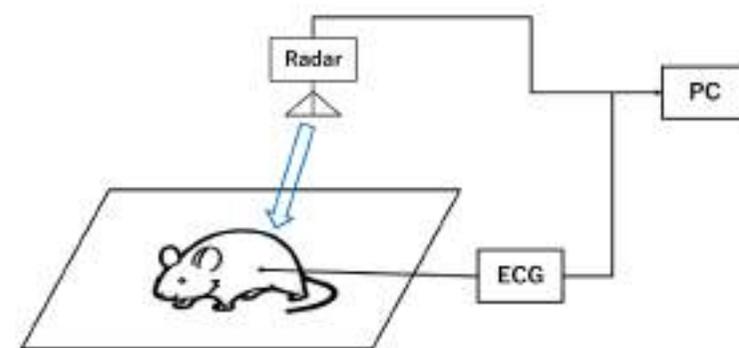
Sun G, et al, Clinical Case Reports (2019)

4、自律神経機能評価



Sun G, et al, Front Psychiatry. (2016)

5、実験動物モニタリング



Sun G, et al, Laboratory Animals. (2024)

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5. 本技術の課題と展望

呼吸・心拍抽出のための信号処理法



Contents lists available at ScienceDirect

Computer Methods and Programs in Biomedicine

journal homepage: www.elsevier.com/locate/cmpb

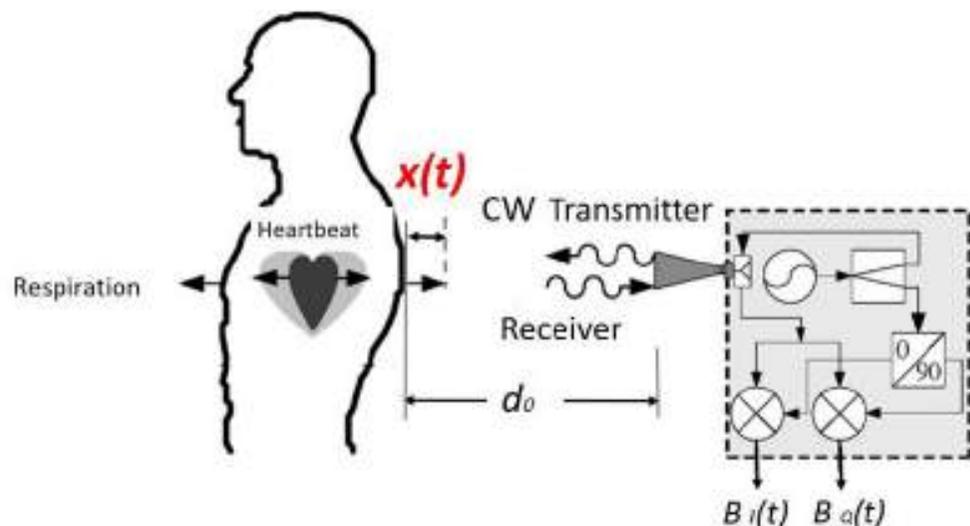


Remote sensing of vital signs by medical radar time-series signal using cardiac peak extraction and adaptive peak detection algorithm: Performance validation on healthy adults and application to neonatal monitoring at an NICU

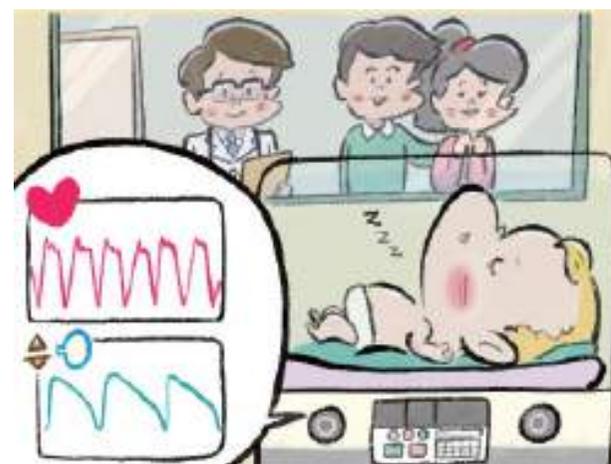


Keisuke Edanami^a, Masaki Kurosawa^a, Hoang Thi Yen^a, Takeru Kanazawa^b, Yoshifusa Abe^b, Tetsuo Kirimoto^a, Yu Yao^c, Takemi Matsui^d, Guanghao Sun^{a,*}

CWレーダによる呼吸・心拍計測原理



小児バイタルサイン計測への応用



Sun G, et al, Computer Methods and Programs in Biomedicine (2022)
孫光鎬, 子供の科学 (2023)

送信波

$$T(t) = A_T \sin(2\pi f t)$$



受信波

$$R(t) = A_R \sin \left[2\pi f \left\{ t - \frac{2(d_0 + x(t))}{c} \right\} \right]$$



ダウンコンバート

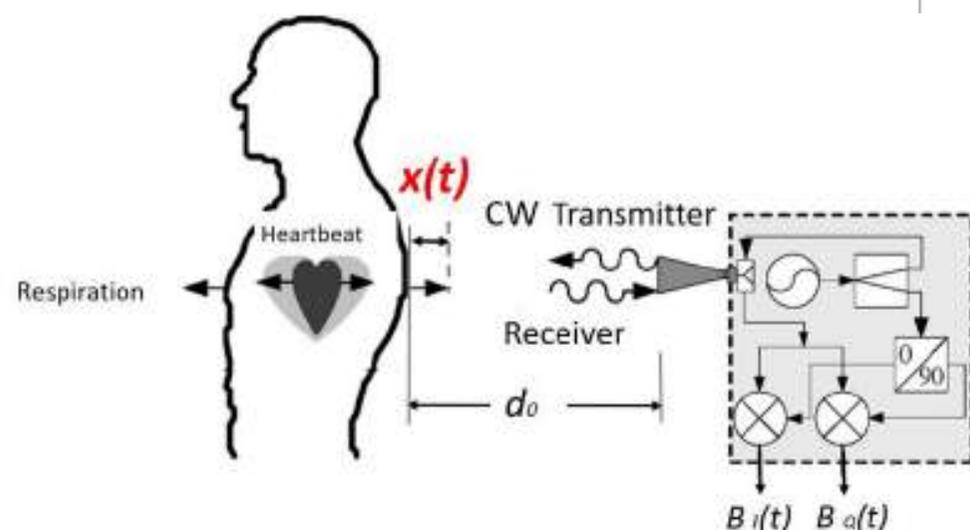
ベースバンド信号

$$B(t) = A_B \cos \left[\frac{4\pi f x(t)}{c} + \frac{4\pi f d_0}{c} \right]$$



I信号-同相成分(In-phase)

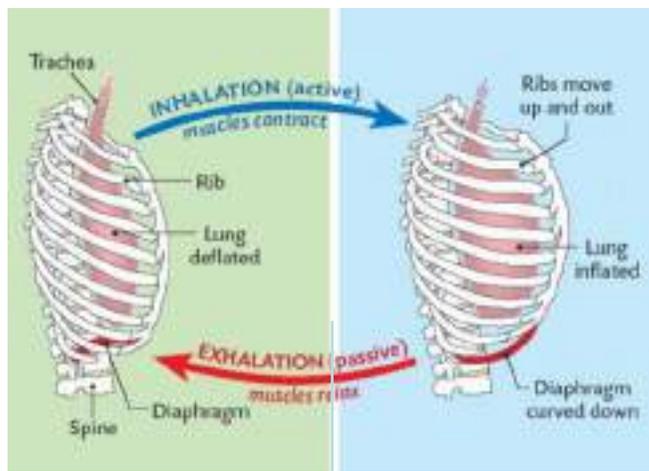
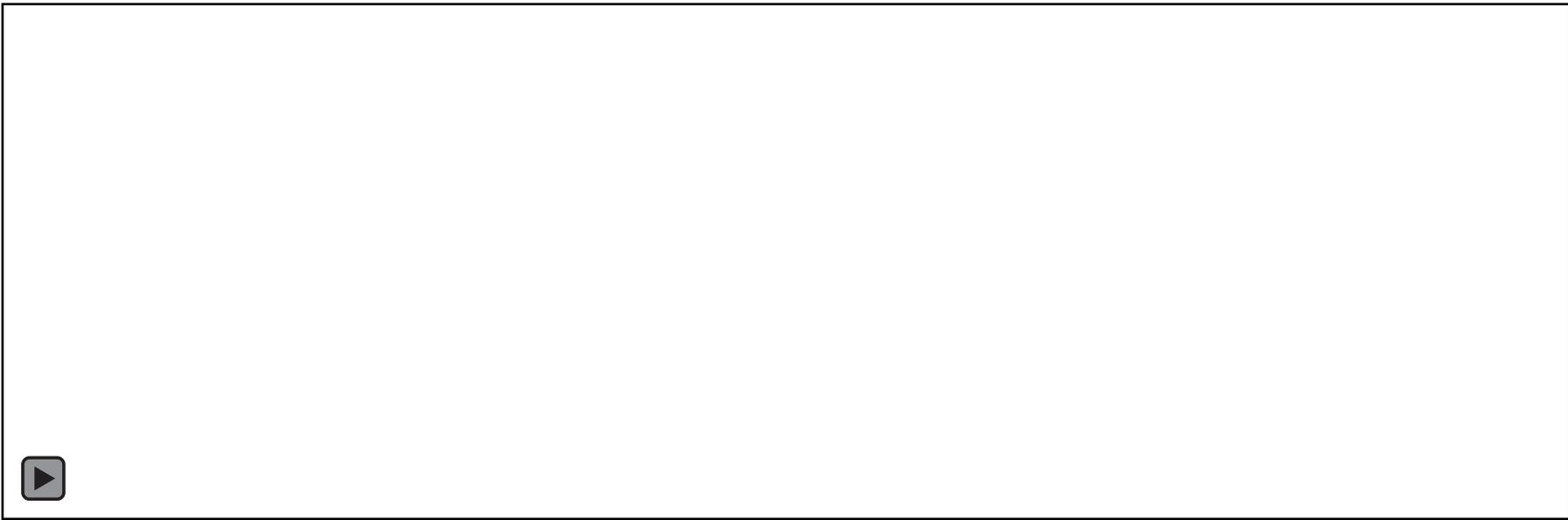
$$I(t) = A \cos \left(\frac{4\pi x(t)}{\lambda} + \phi \right)$$



90° 位相をずらす

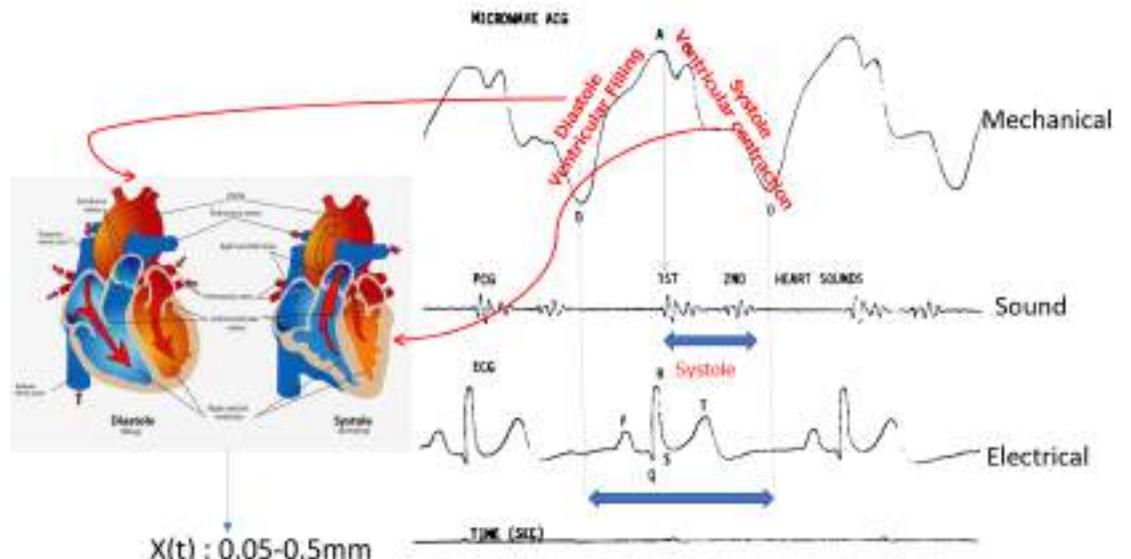
Q信号-直交成分(Quadrature-phase)

$$Q(t) = A \sin \left(\frac{4\pi x(t)}{\lambda} + \phi \right)$$



$X(t) : 5-15\text{mm}$

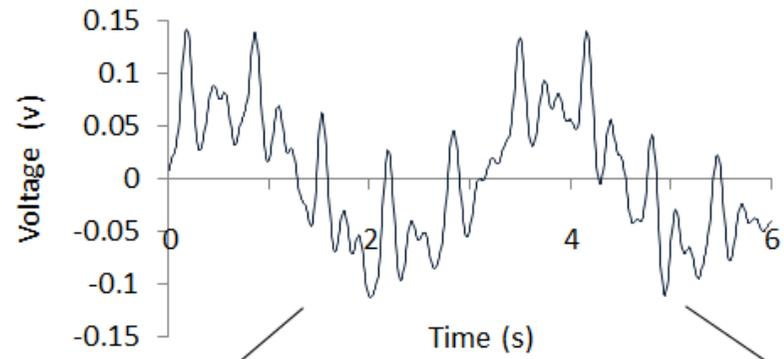
+



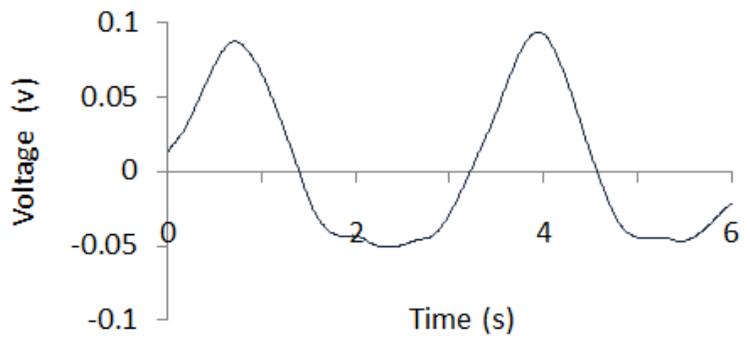
$X(t) : 0.05-0.5\text{mm}$

Lin J.C., et al, IEEE Trans. Microw. Theory Tech. (1979)

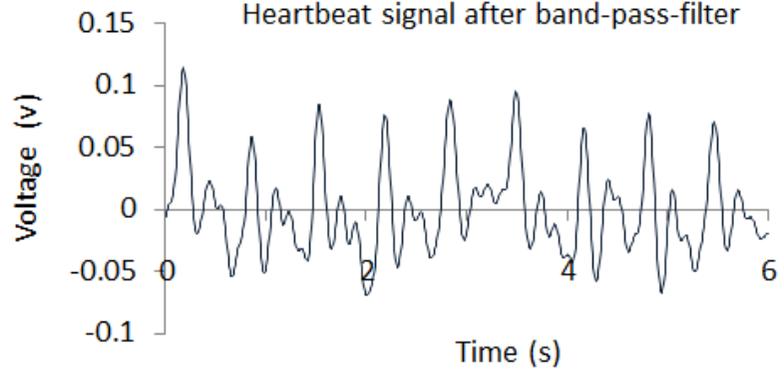
Signal obtained from microwave radar



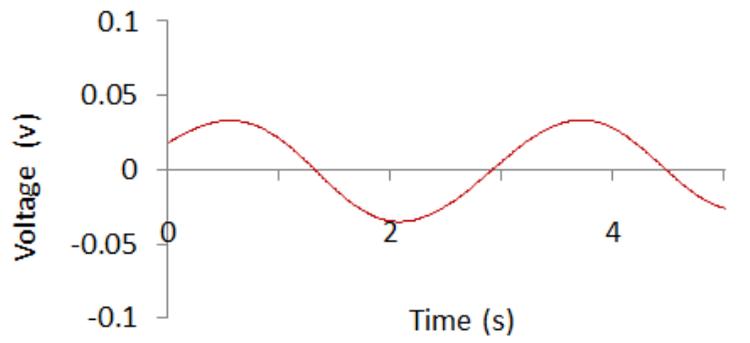
Respiration signal after band-pass-filter



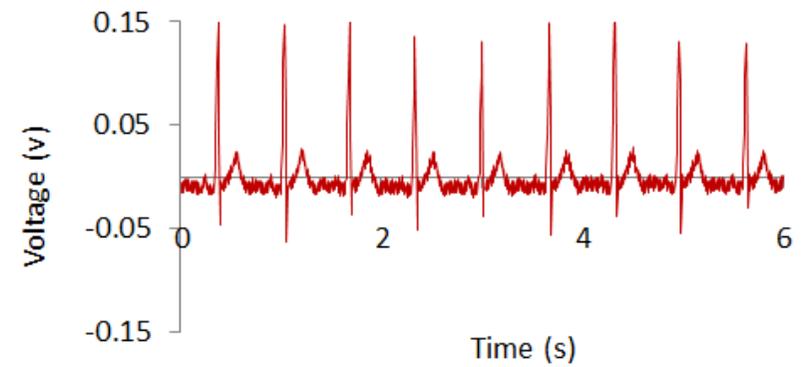
Heartbeat signal after band-pass-filter



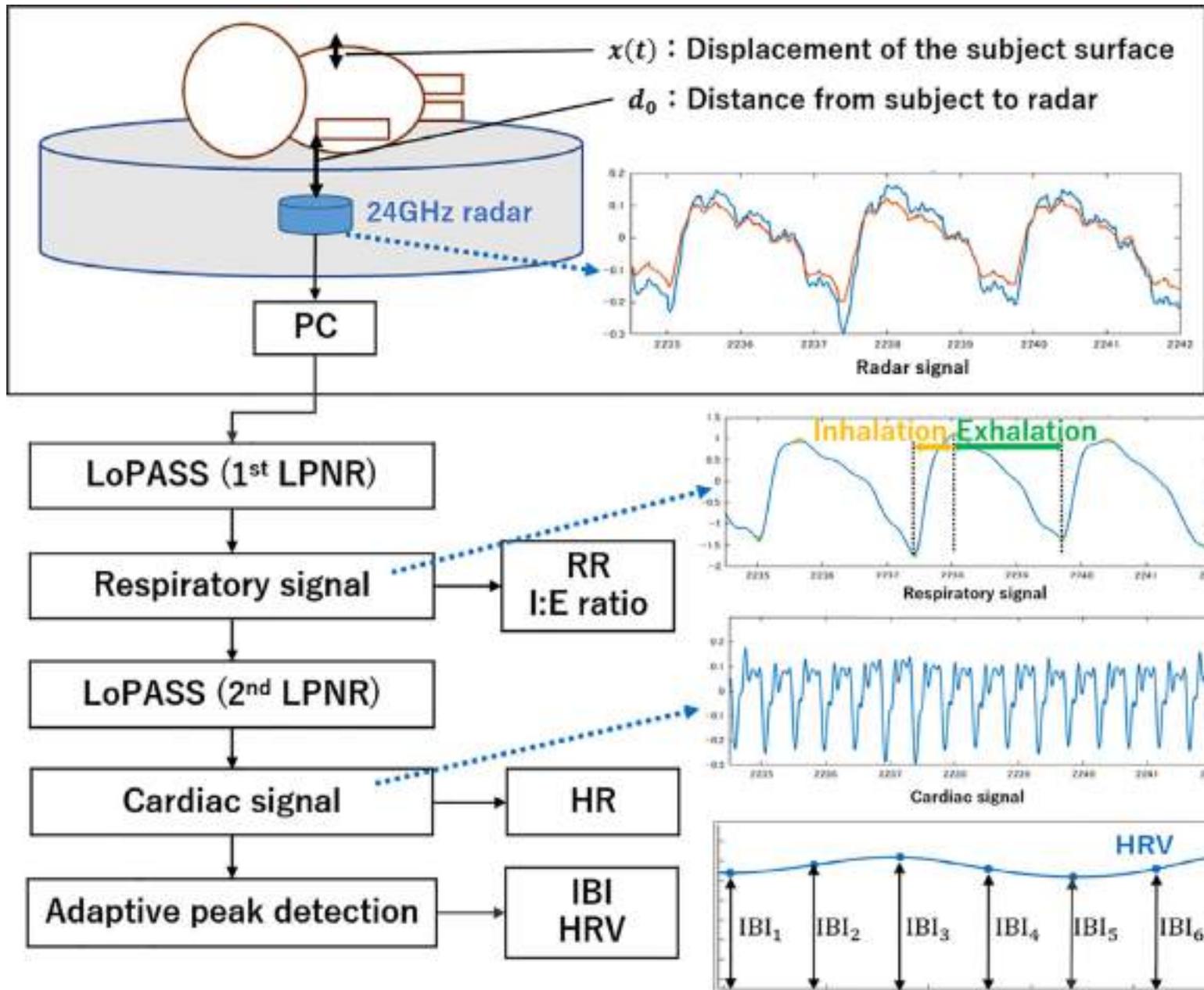
Respiration signal obtained from effort belt



Heartbeat signal obtained from ECG



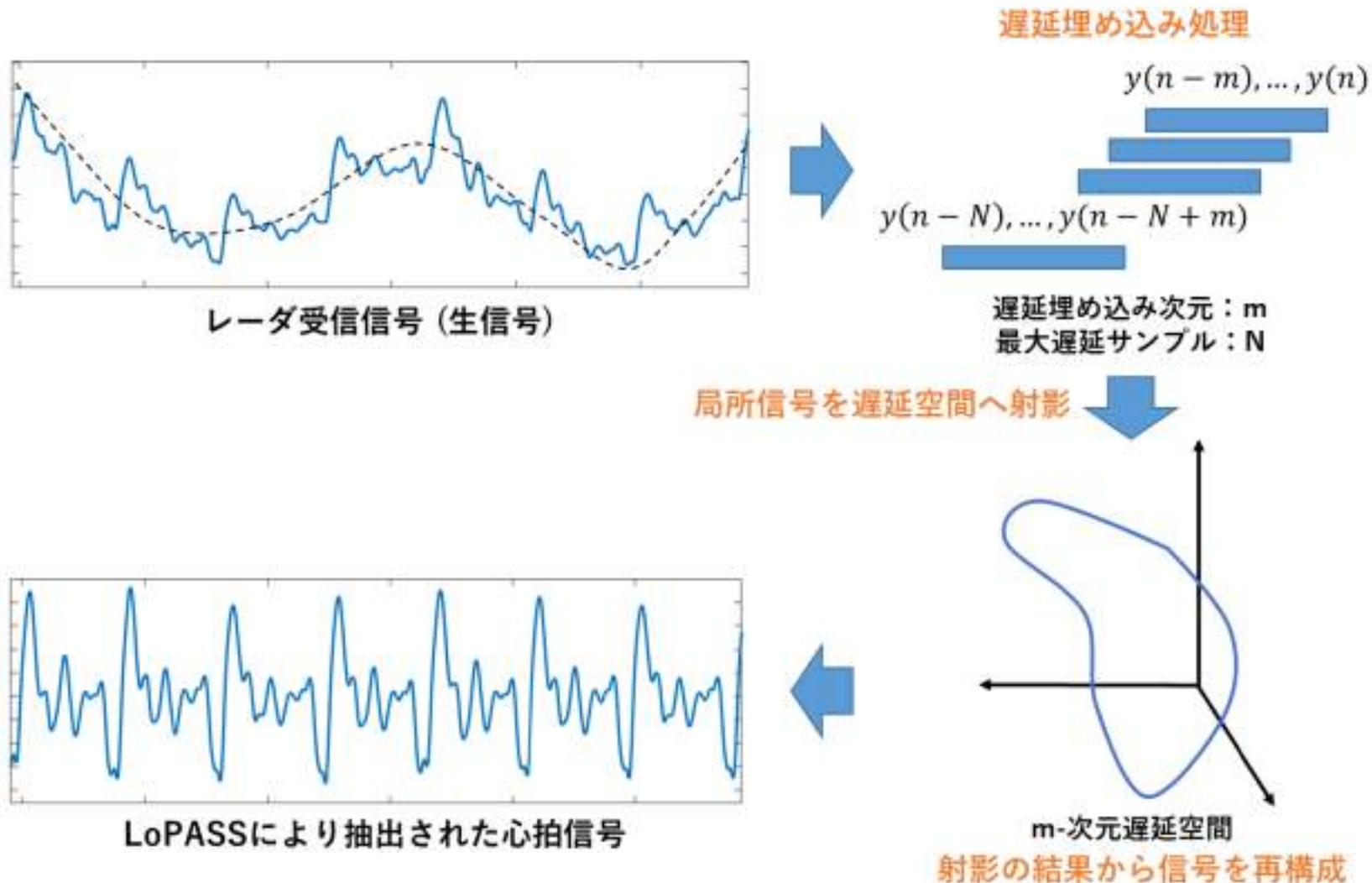
Sun. G, et al, Journal of Medical Engineering & Technology. (2015)



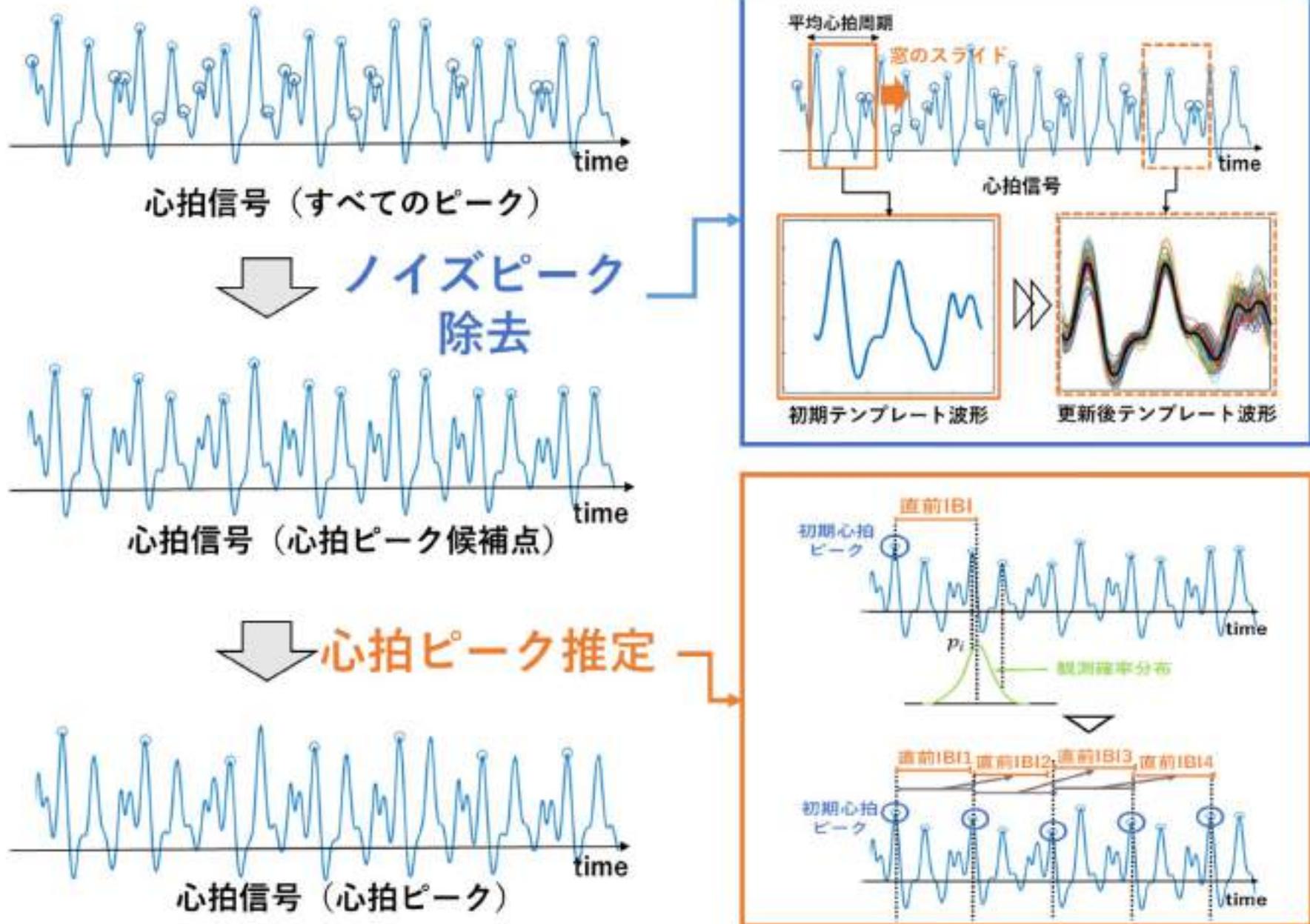
Edanami K. & Sun G, et al, Computer Methods and Programs in Biomedicine (2022)

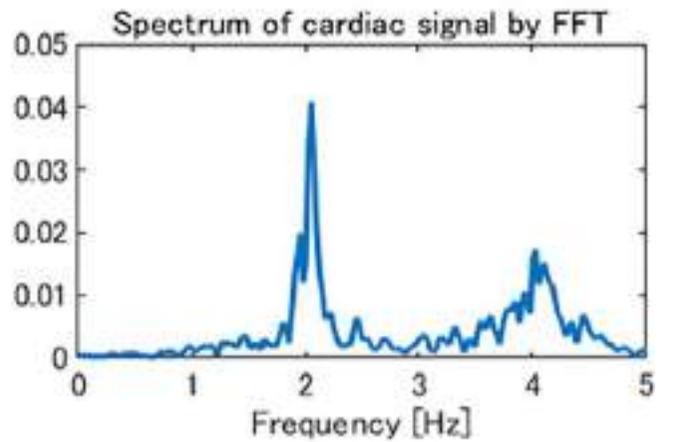
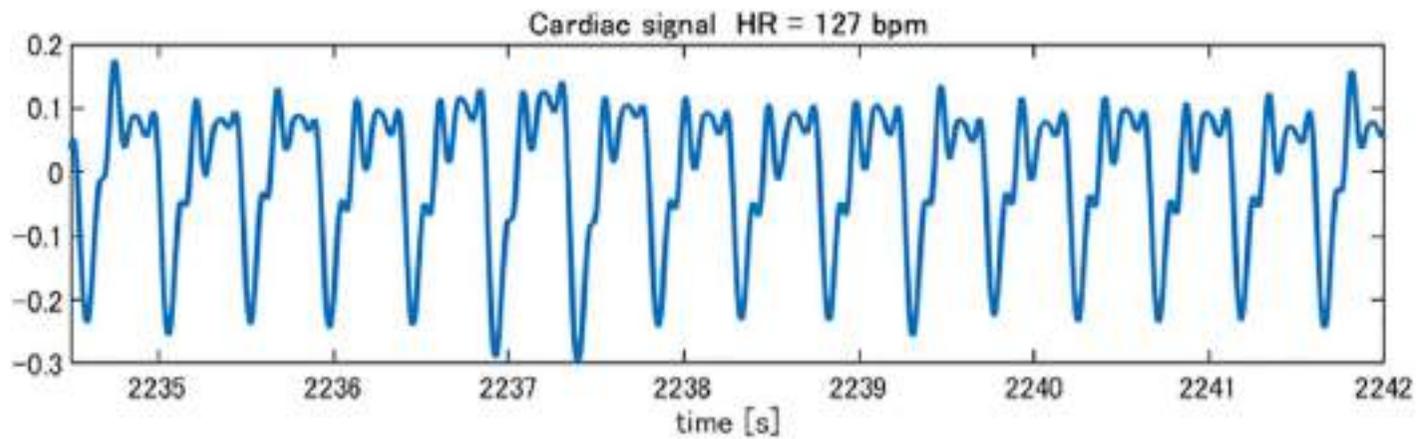
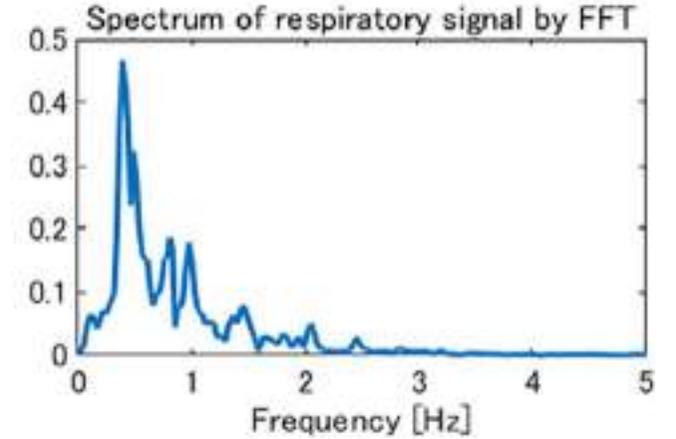
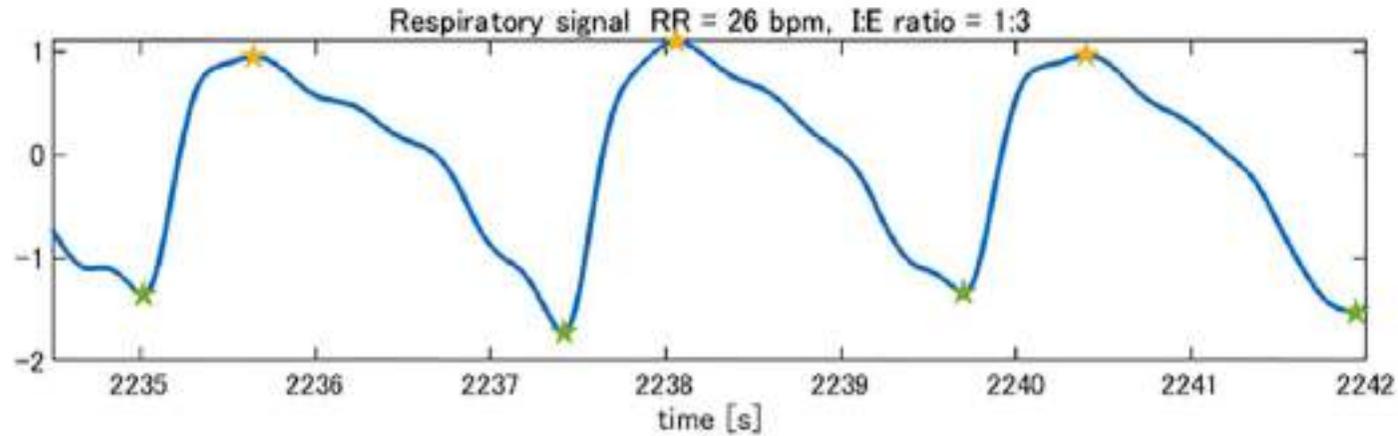
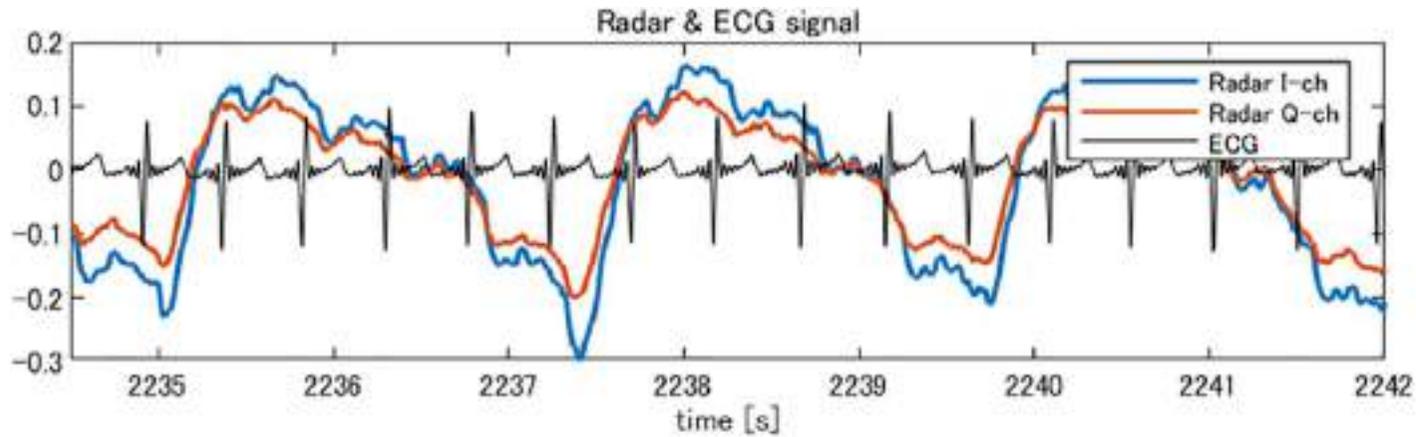
LoPASS: Locally Projective Adaptive Signal Separation

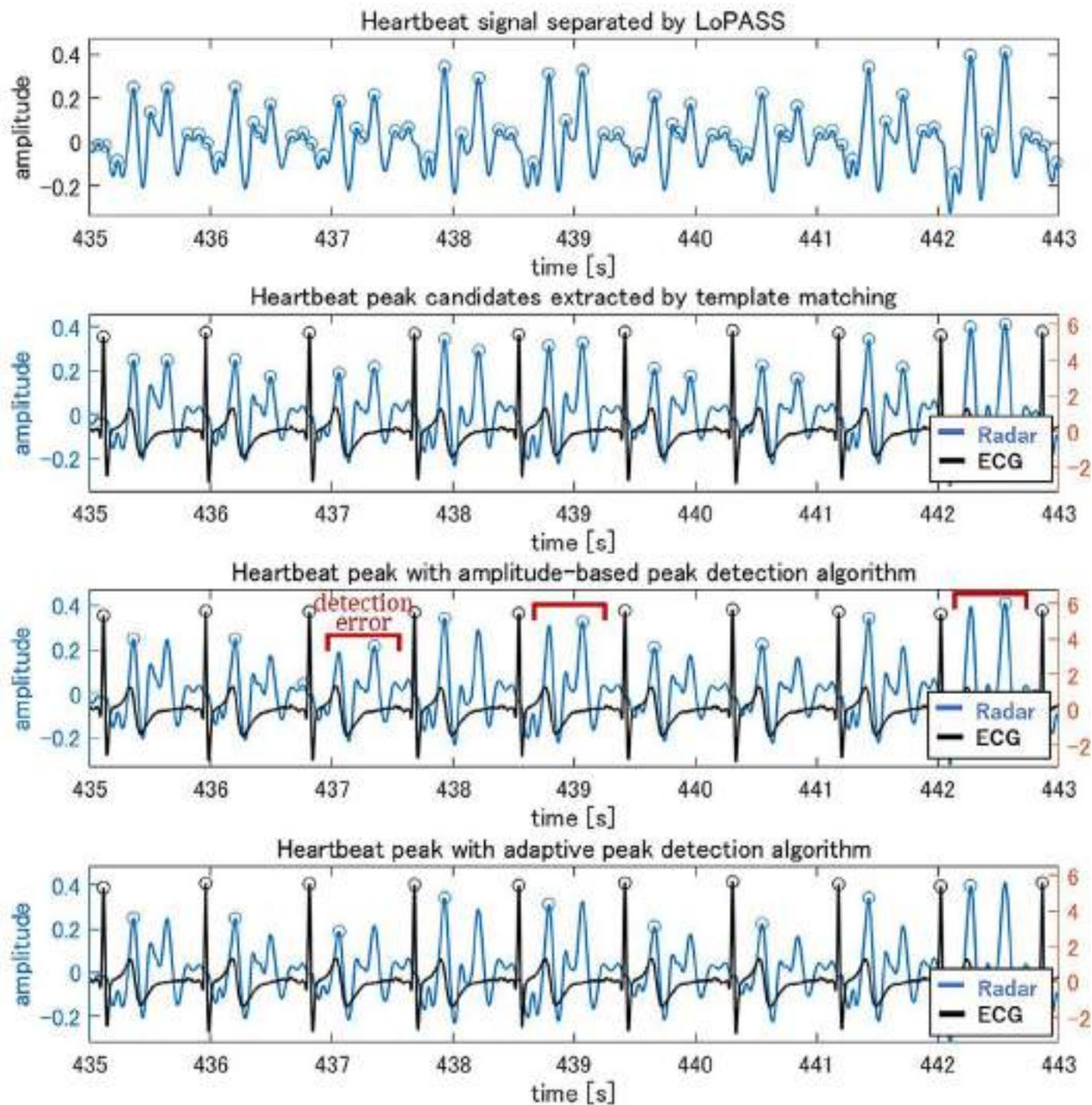
遅延空間への幾何学的射影を利用した非線形適応フィルタ手法



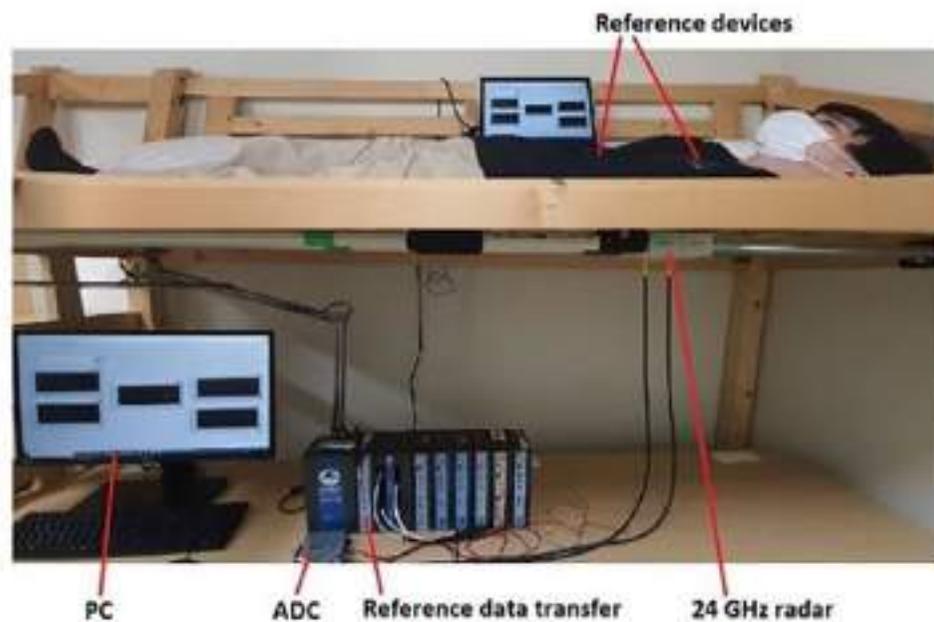
テンプレートマッチングの適応的な心拍ピーク推定法







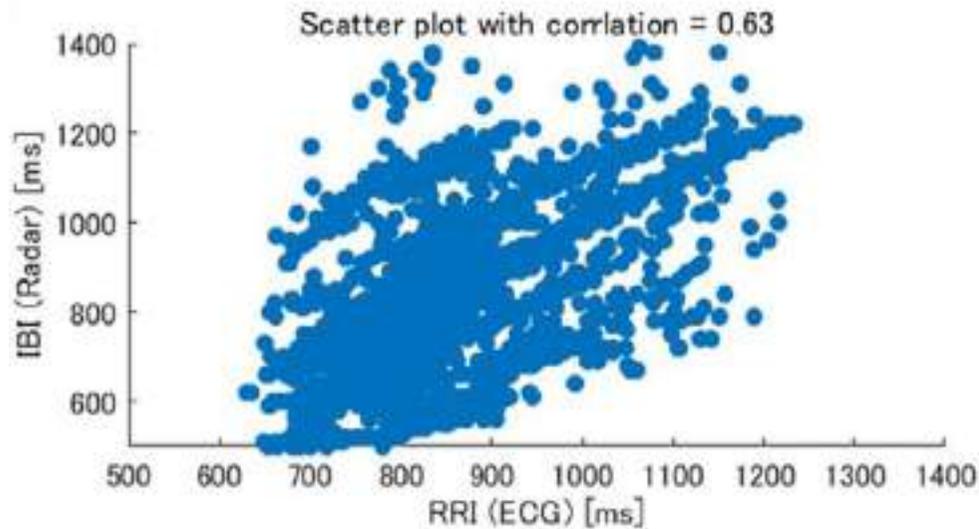
(a) System setup for healthy subjects in laboratory



(b) System setup for infants in NICU

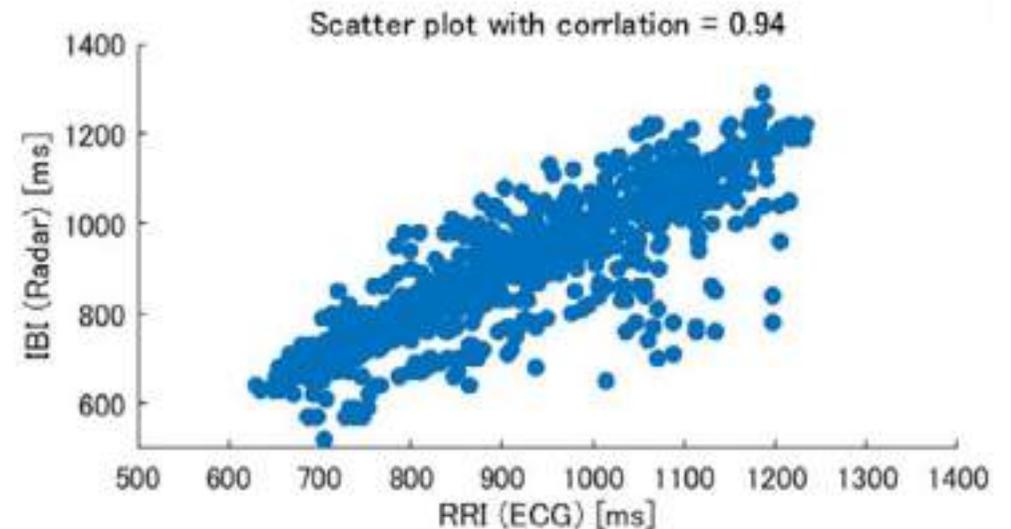


Conventional method

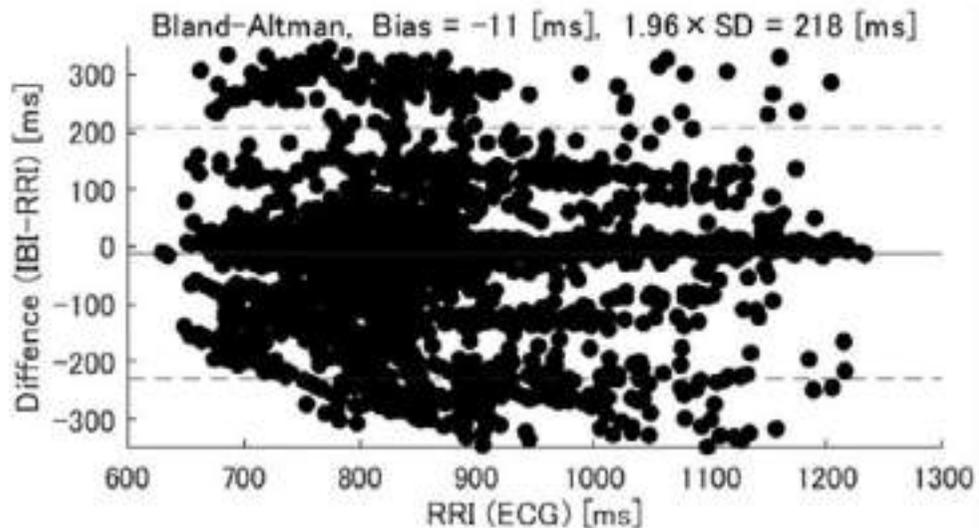


(a) Scatter plot

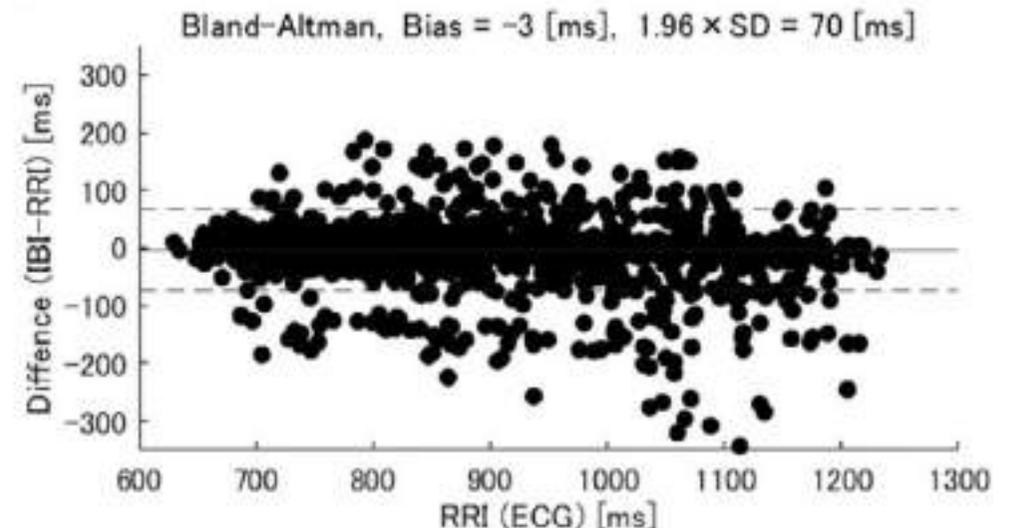
Proposed method



(c) Scatter plot

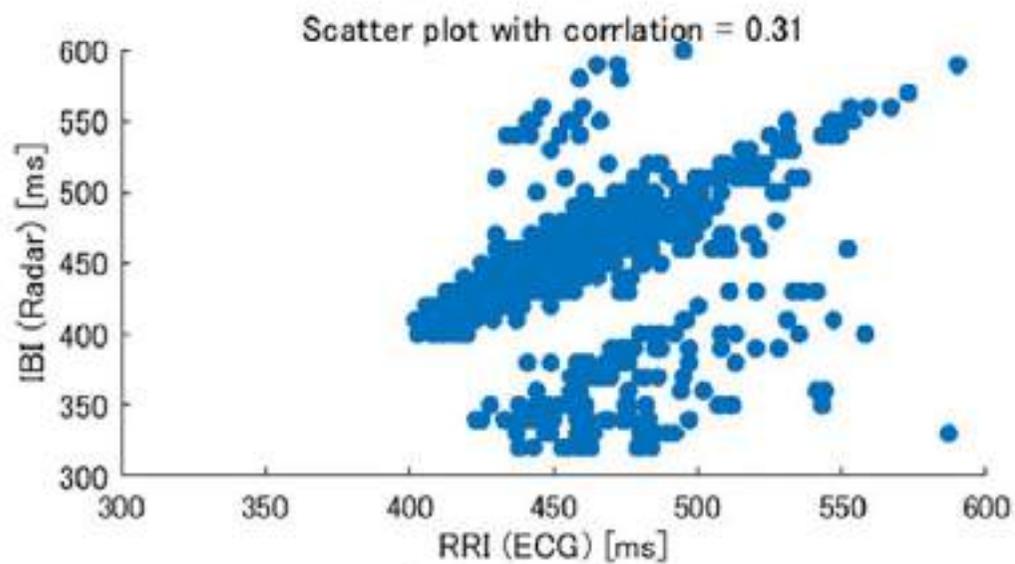


(b) Bland-Altman plot



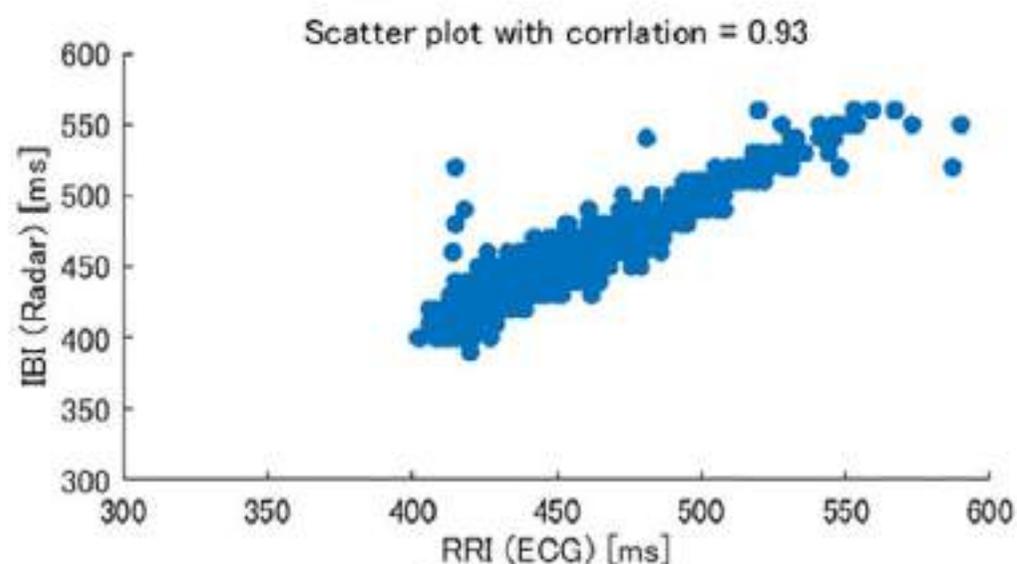
(d) Bland-Altman plot

Conventional method

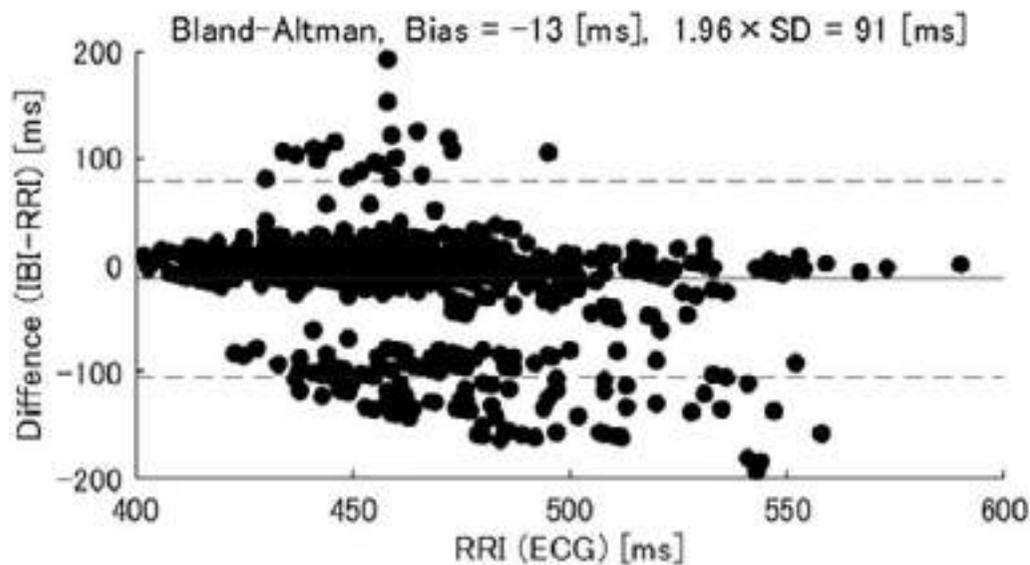


(a) Scatter plot

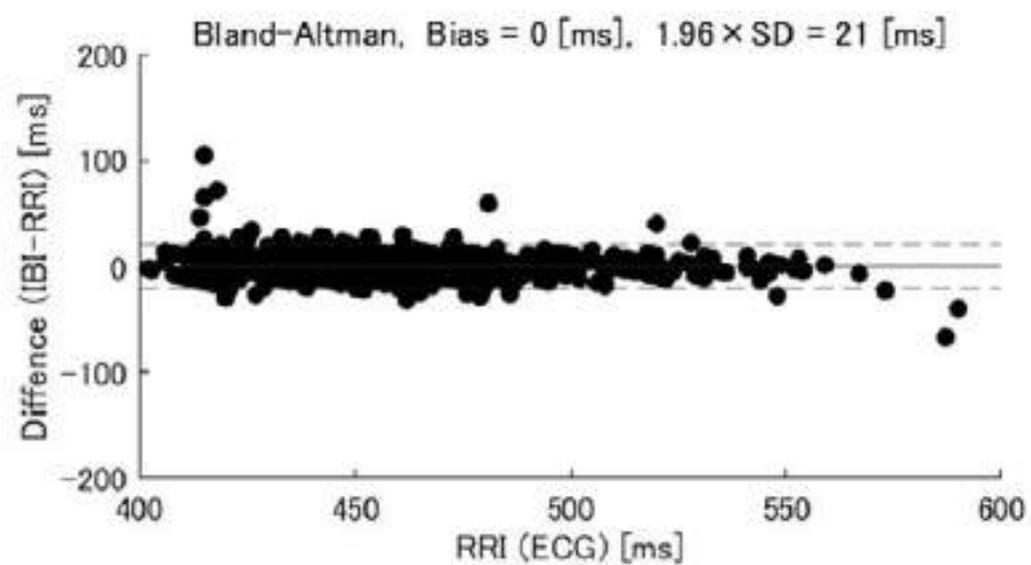
Proposed method



(c) Scatter plot

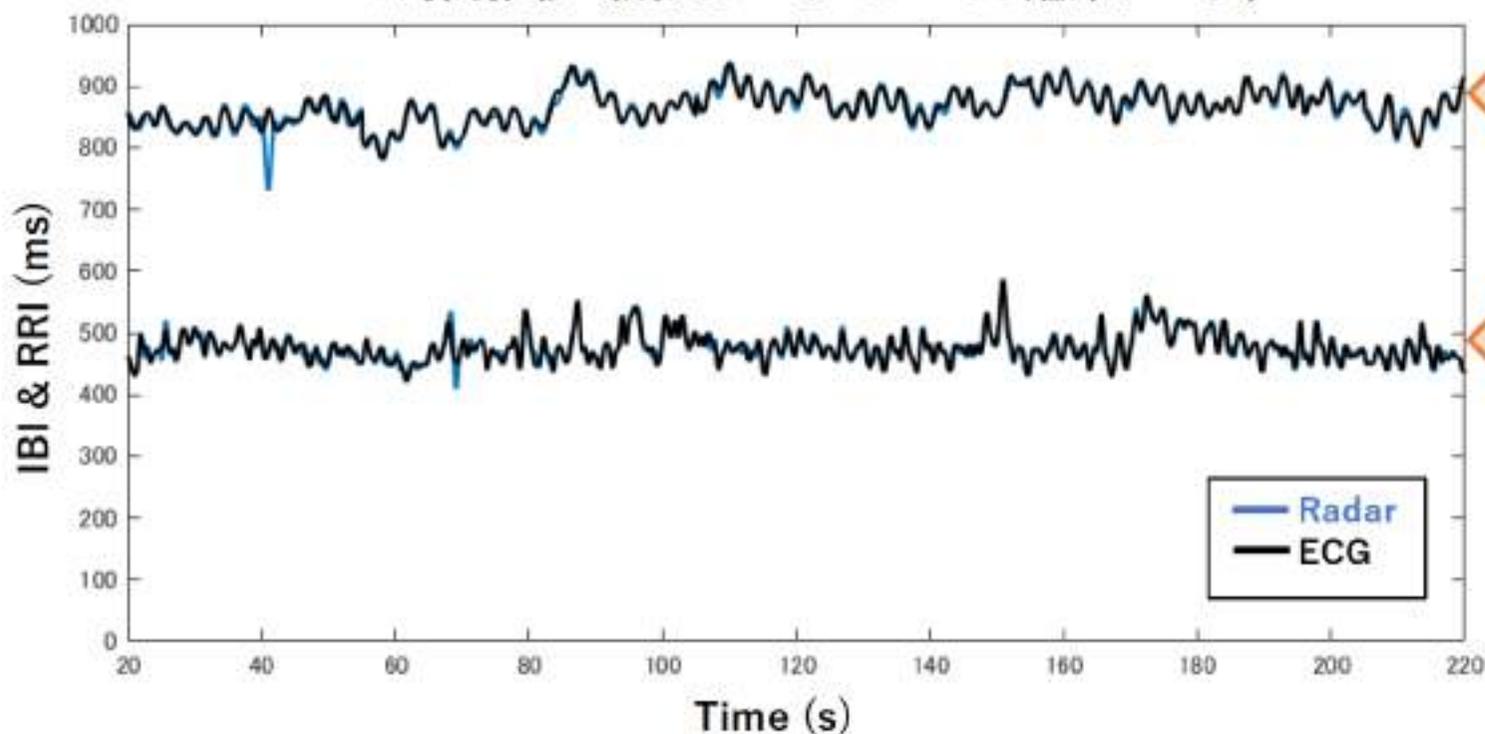


(b) Bland-Altman plot



(d) Bland-Altman plot

HRVの時間推移 (成人データ & NICU臨床データ)



成人の標準値

心拍数: 60 ~ 80 (bpm)
心拍間隔: 800 ~ 1000 (ms)

乳幼児の標準値

心拍数: 100 ~ 150 (bpm)
心拍間隔: 400 ~ 600 (ms)



電気的な活動

脱分極



ECG信号 (ECG)

時間間隔が一定

機械的な活動

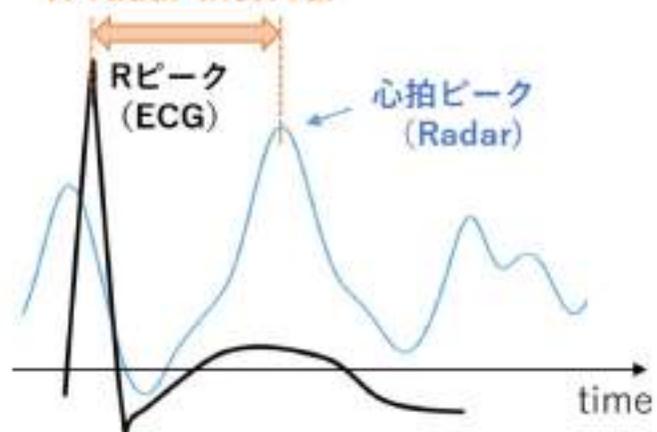
心室収縮



心拍信号 (Radar)

生理学的な心臓の活動

R-radar interval



生体信号計測

企業への期待

生体モニタリングの技術を持つ、企業との共同研究を希望。

本技術の導入にあたり必要な追加実験を行うことで科学的な裏付けを行うことが可能。

本格導入にあたっての技術指導