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BreathLive: Liveness Detection for Heart Sound Authentication with Deep Breathing

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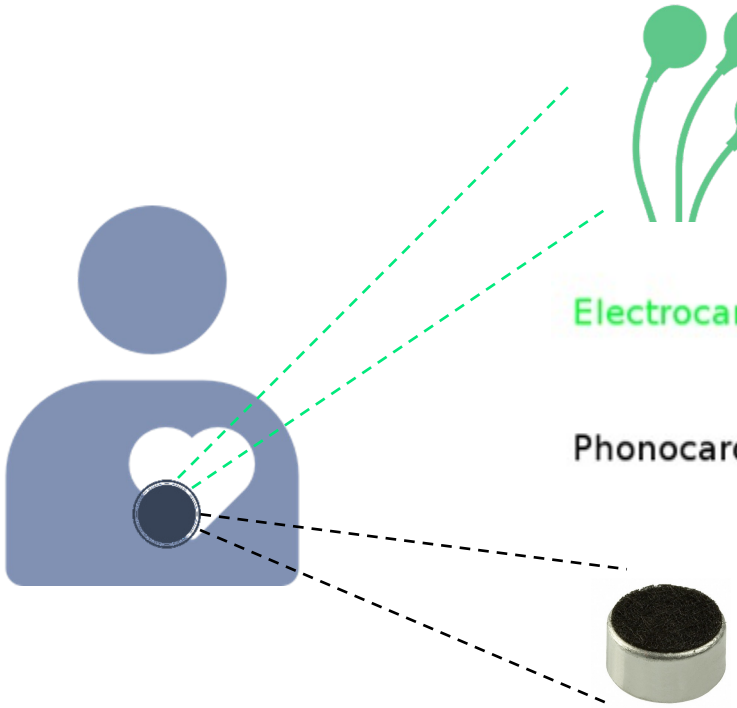
Heart Monitoring Wearables

- Purpose
  - Diagnostic aid
  - Fitness
- Privacy issue
  - The sensitive heart data need to be protected.

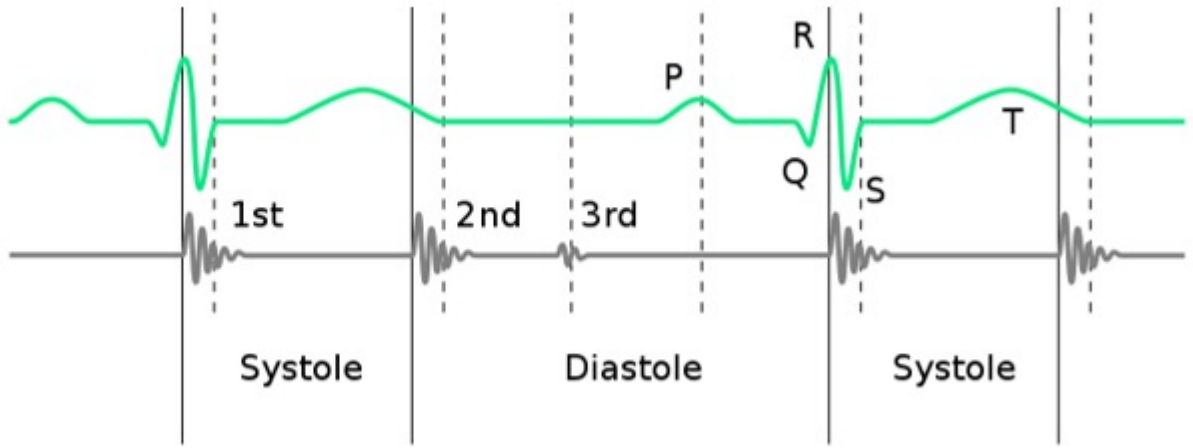
Electronic Stethoscope

Heart Rate Monitor

Heart Authentication



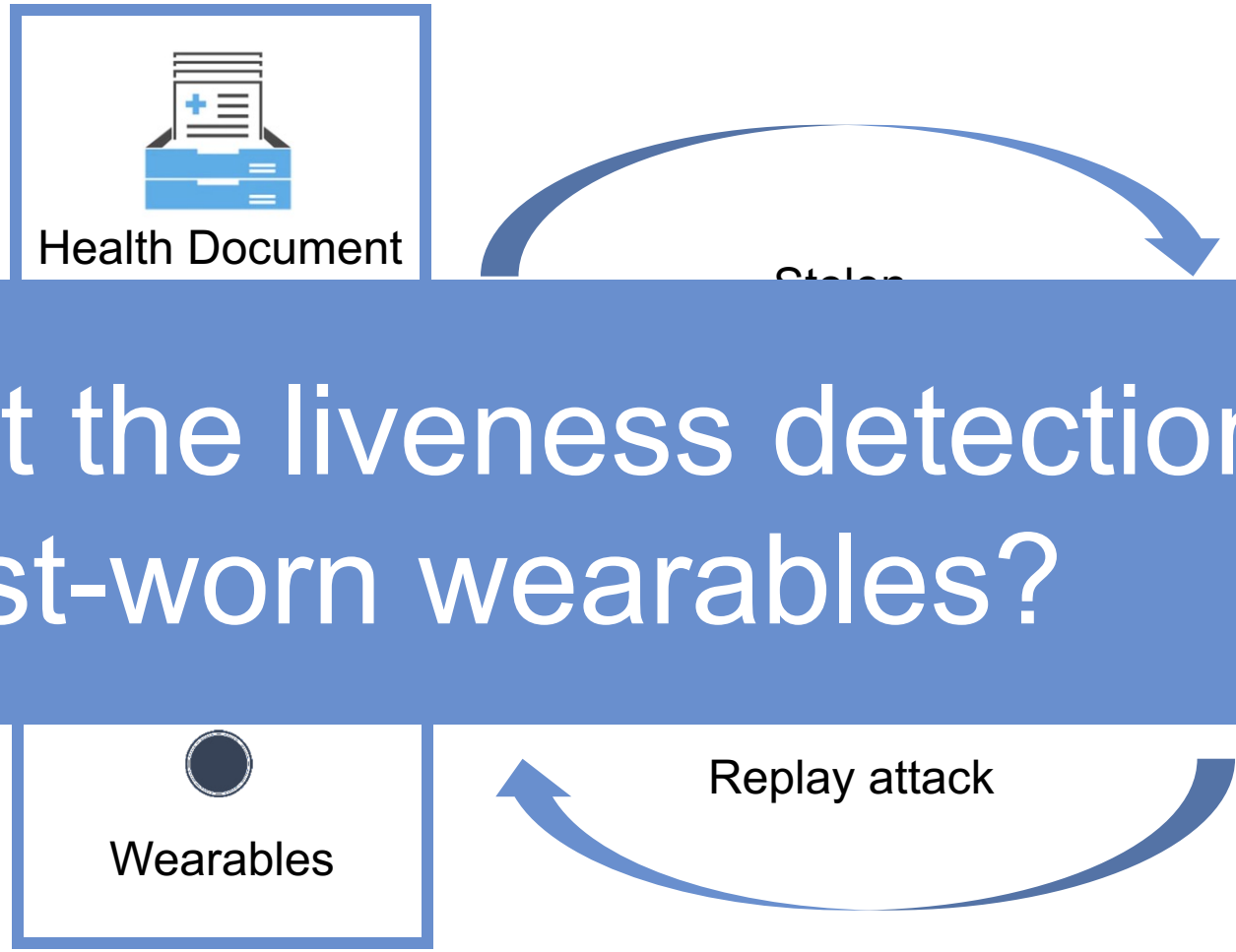
Microphone



- Different person have different ECG and heart sound

Replay attack

- Sound and ECG[1] authentication is vulnerable to replay attack.



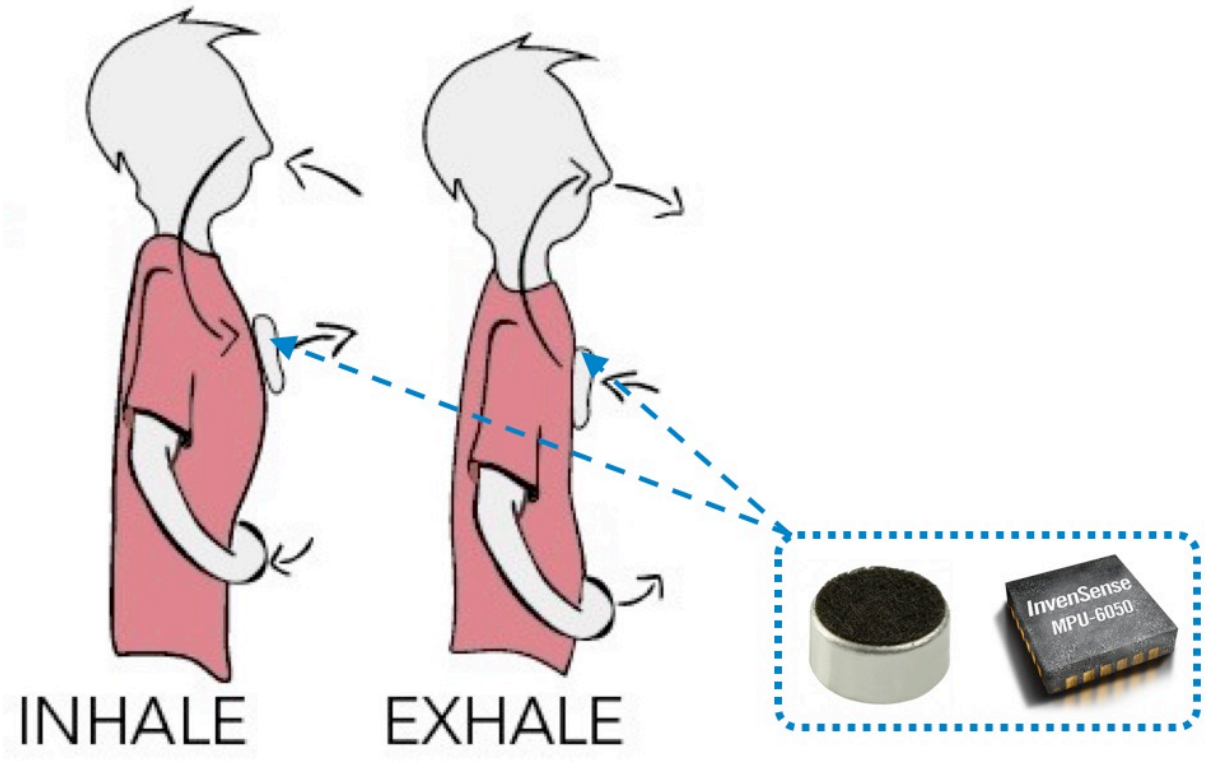
How to implement the liveness detection on these chest-worn wearables?

liveness detection for heart sound authentication

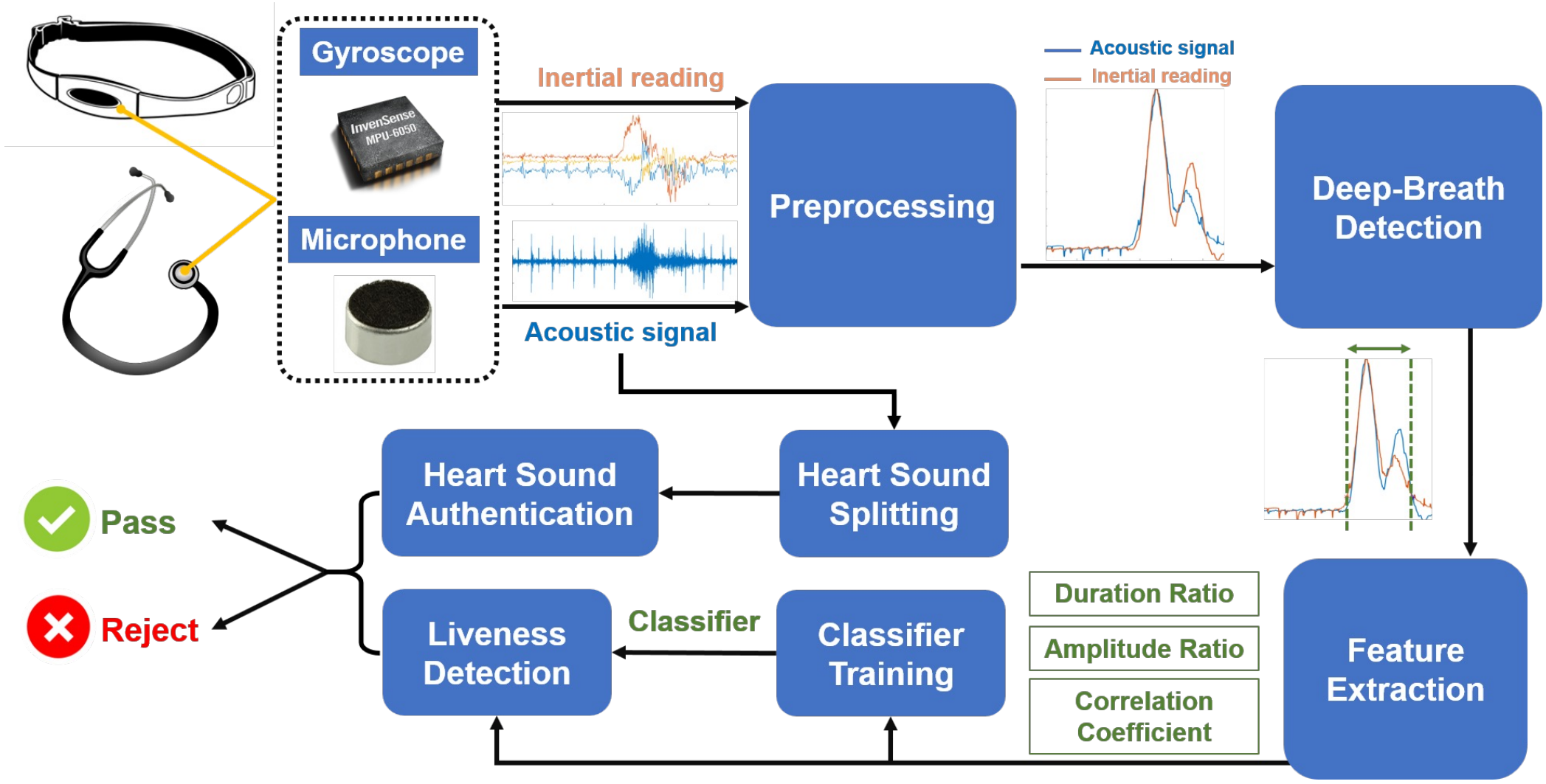
[1]Eberz, S., Patané, A., Paoletti, N., Kwiatkowska, M., Roeschlin, M. and Martinovic, I., 2017. Broken Hearted: How To Attack ECG Biometrics.

BreathLive

- Deep breathing can be utilized!
  - Black-Box property
  - Randomness property
- BreathLive
  - The inherent correlation between sounds and chest motion caused by deep breathing.



System Overview



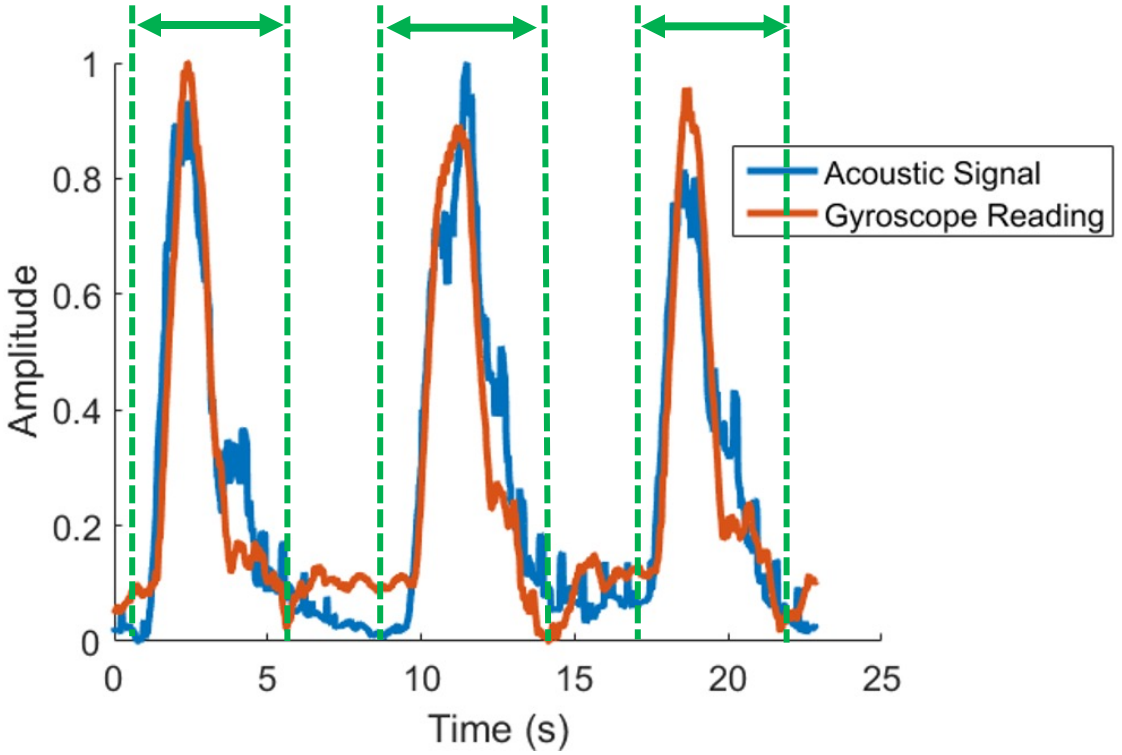
Preprocessing & Deep-Breath Detection

Preprocessing

- Bandpass Filter
- Short-term energy
- Synchronization

Deep-Breath Detection

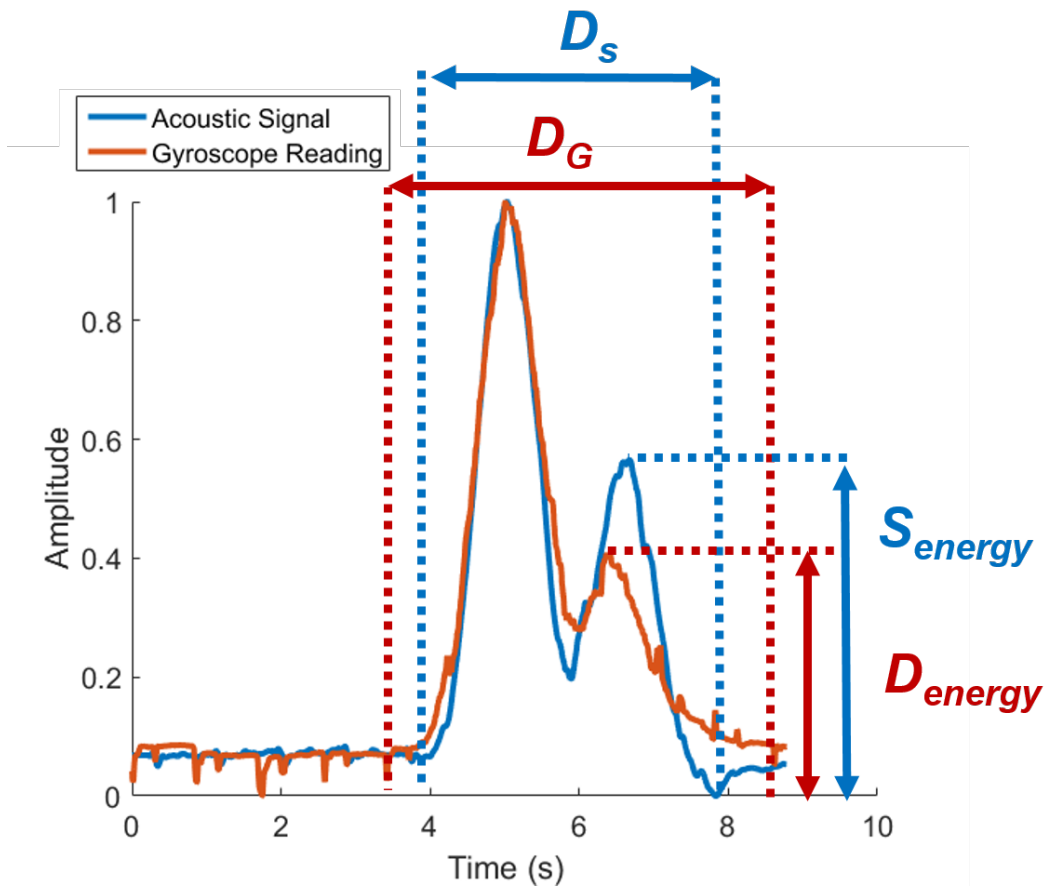
- Normalization
- Segmentation



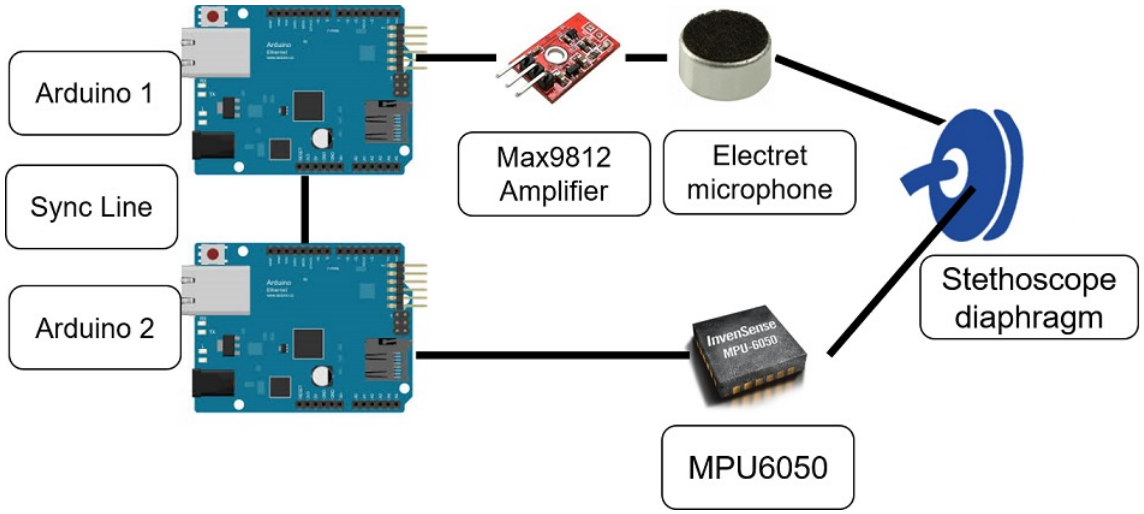
Feature Extraction & Classifier

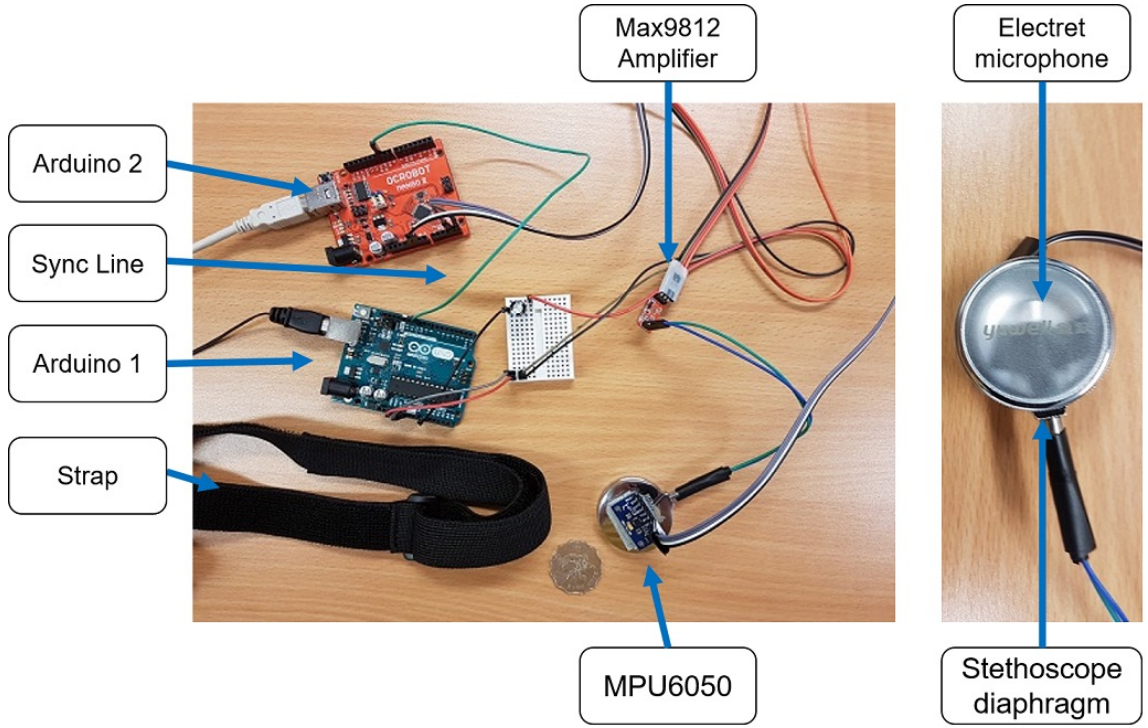
- Feature Extraction
  - Correlation Coefficients
  - Mean, standard deviation, min and max of amplitude ratio
  - Duration Ratio

- Classifier
  - Logistic Regression(LR)
  - Support Vector Machine(SVM)
  - Multilayer Perceptron(MLP)



Implementation





Evaluation Setup

- 16 volunteers

- Three phases
  1. Daily usage
  2. Security analysis
  3. Context Experiment

- Threat model
  - Simple Replay Attack
  - Gyroscope Injection Attack
  - Random Impersonation Attack
  - Advanced Impersonation Attack
  - Advanced Replay Attack

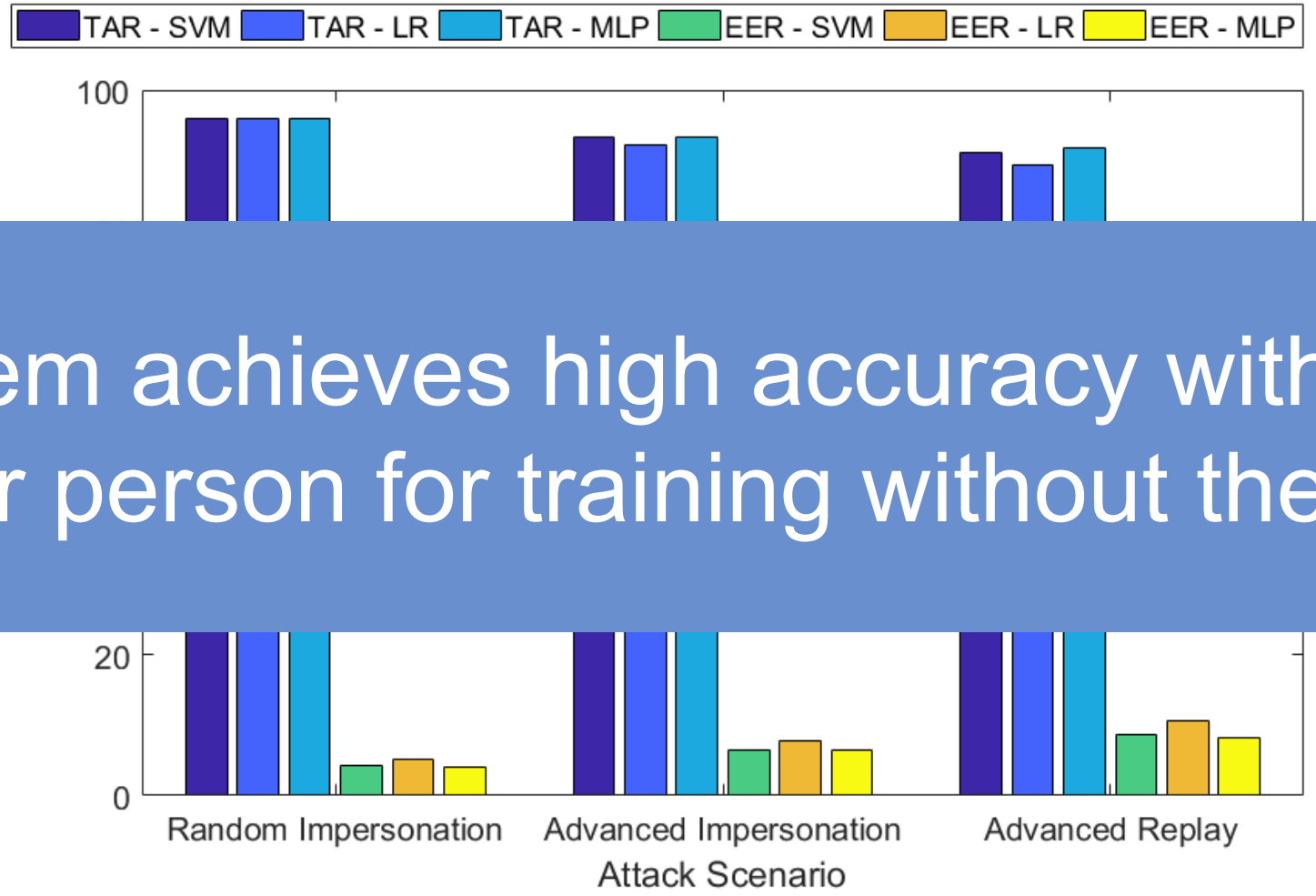
Phase 1: Daily Usage

- Act as normal users

- 3 sessions, each contains 10 deep breathings.
  - First 2 sessions for training, rest for testing.

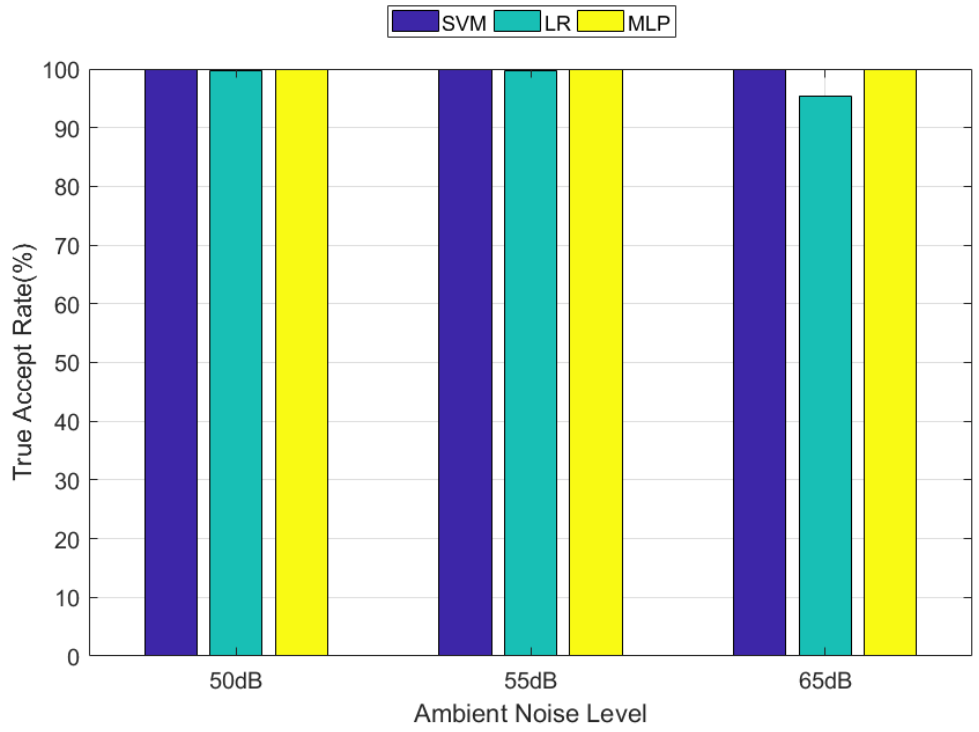
	LR	SVM	MLP
True Accept Rate	96.3%	99.3%	99.3%

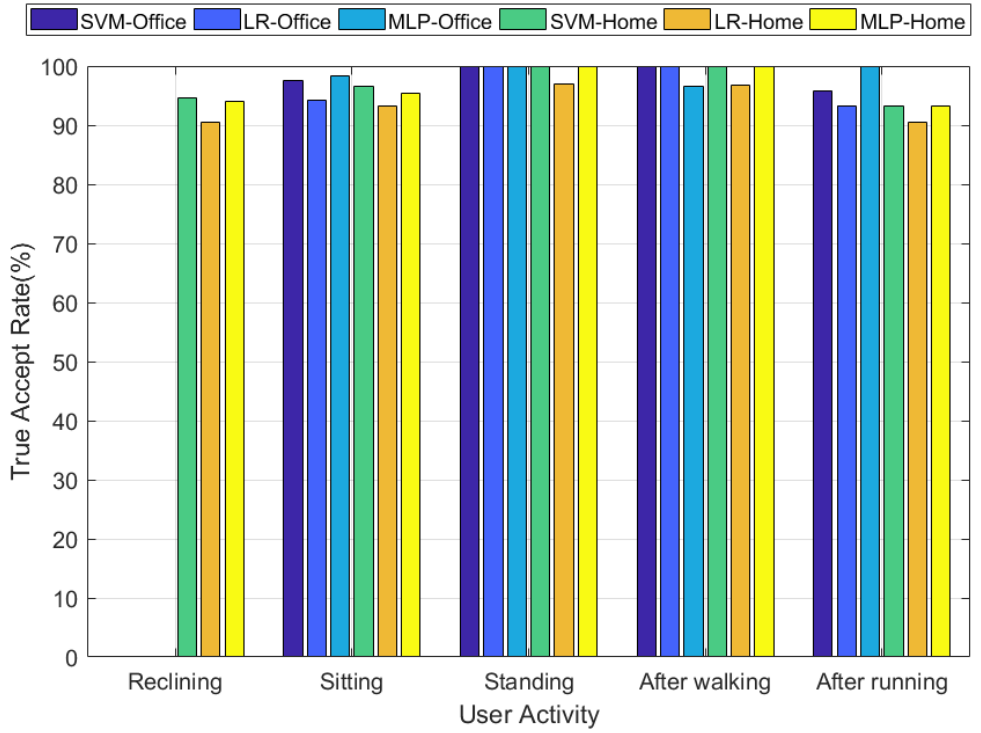
Phase 2: Security Analysis



The system achieves high accuracy with only three to four person for training without the owner.

Phase 3: Context Experiment





Future Work & Conclusion

- Future Work
  - Liveness detection for ECG authentication

- Conclusion
  - We showed the potential of deep breathing for liveness detection
  - We proposed a liveness detection system, BreathLive, for heart sound authentication on a chest-worn device.
  - We implemented our system and tested it under various threat models and contexts. It achieves a high accuracy with a small training set

Thanks.
Q&A

BACKUP

Impact of the Training Set