Advanced Silent Speech Interfaces: Unobtrusive EMG Electrode and Soft Magnetic Skin Approaches

MRS 3955000
Session SB05.03.06

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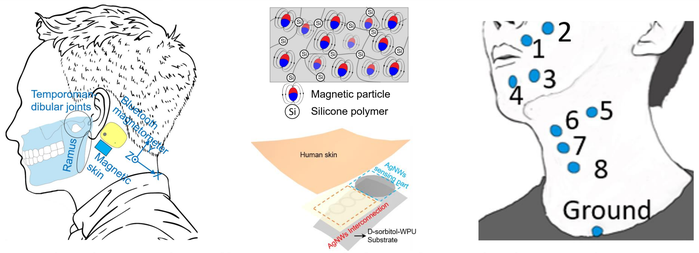
Smart Structures and Soft Electronics Lab

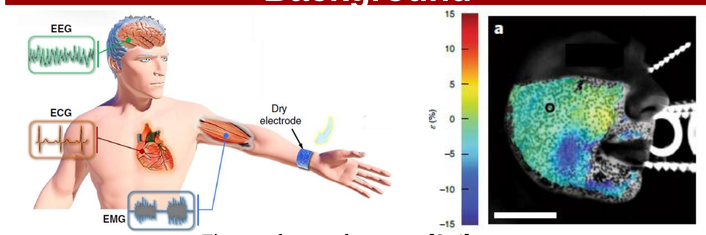
2023 MRS FALL MEETING & EXHIBIT

Project Objectives and Goals



Develop innovative **silent speech interfaces** by integrating functional materials, smart structures, and machine learning.[1-2]

Background

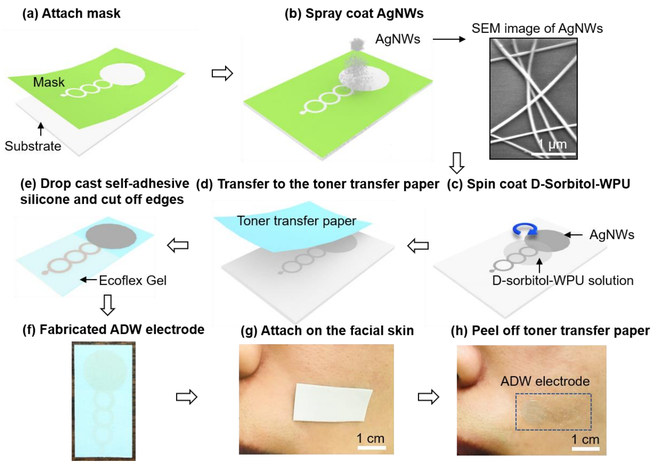


Figures from references [3-4]

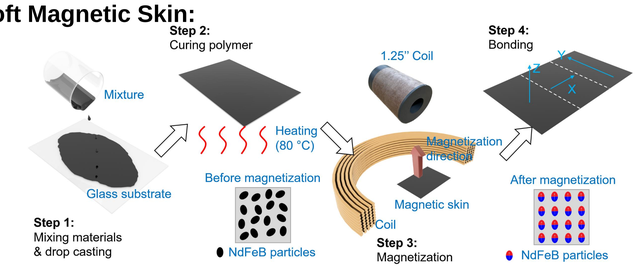
- The facial **Electromyogram (EMG)** and facial **skin deformations** exhibit a strong correlation with the content of silent speech.
- The **dry electrode** is an excellent choice for EMG data collection.
- The **magnetic skin** exhibits great sensitivity to skin deformation.

Sensor Fabrication

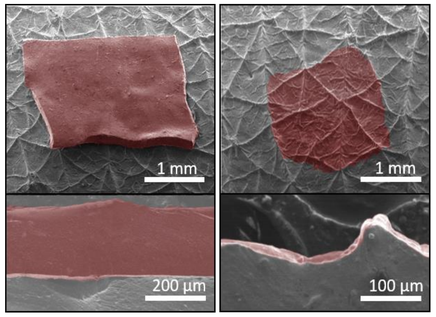
I. Unobtrusive Biopotential Electrode:

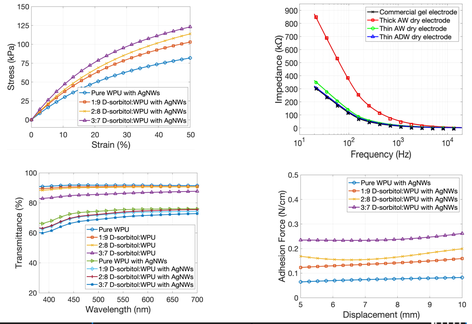


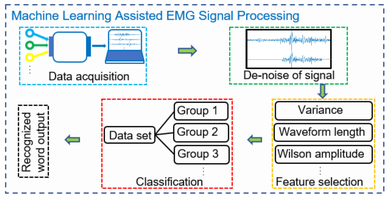
II. Soft Magnetic Skin:

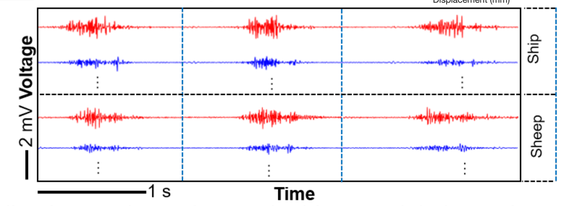


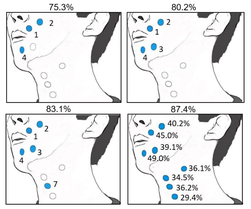
I. Results: Unobtrusive Biopotential Electrode





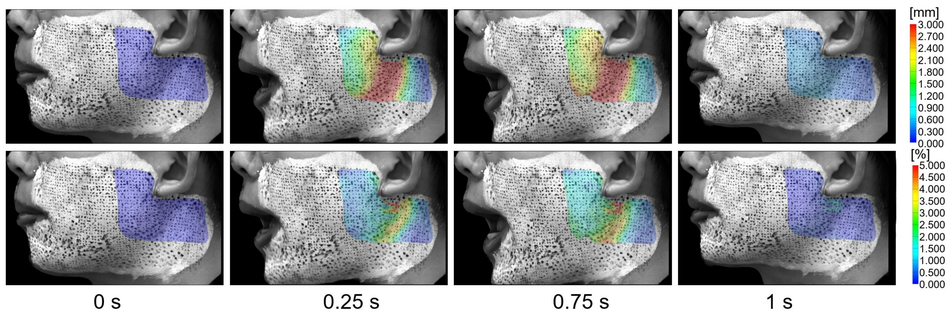


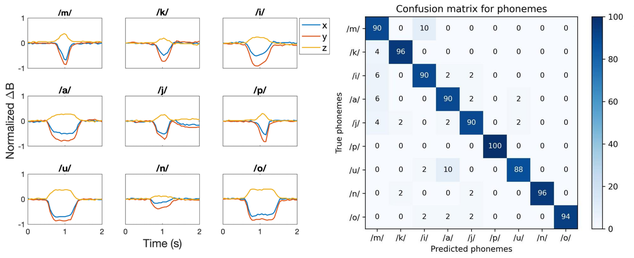




- The soft, adhesive, and translucent dry biopotential electrode forms a **conformal contact** with the skin, ensuring a low impedance and a high SNR.
- The **LDA** and **SVM** models demonstrate a high accuracy in classifying words with **similar pronunciations**.
- Various **sensing locations** make distinct contributions to the final accuracy.

II. Results: Soft Magnetic skin

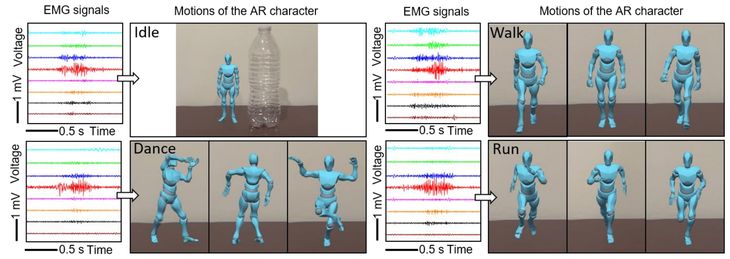


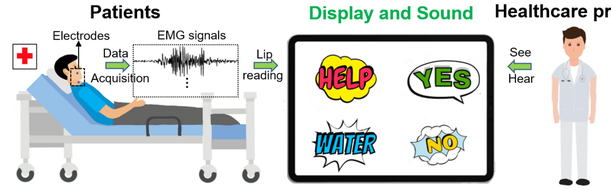


- The **DIC** technique is capable of measuring skin deformation, aiding in the identification of optimal sensing locations.
- Combining various **magnetization directions** can enhance signal quality

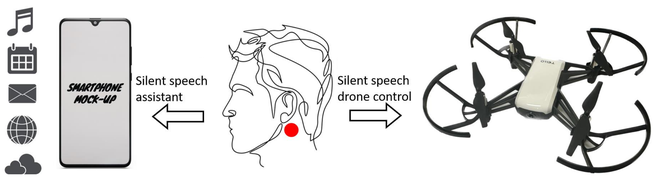
Applications

I. Application in Augmented Reality(AR) and Medical Service:





II. Application in Human-machine Interaction:



- Demonstrations are developed to illustrate the potential of the silent speech interfaces in **AR**, **medical services**, and **human–machine interactions**.

Conclusion and Future Study

- This project involves the development of two silent speech interfaces through thorough investigations into **materials**, **structural design**, **sensing locations**, **machine learning** methods.
- In the future, there is a need for the development of **phoneme-level** silent speech recognition algorithms.

Acknowledgement

The authors acknowledge NSF for financial support to this project from grants ECCS-2129673 and 2238363.

Publications

[1] Dong, P. et al. Electromyogram-Based Lip-Reading via Unobtrusive Dry Electrodes and Machine Learning Methods. *Small* 19, e2205058 (2023).

[2] Dong, P. et al. Decoding silent speech commands from articulatory movements through soft magnetic skin and machine learning. *Mater. Horiz.* (2023).

References

[3] Zhang, L. et al. *Nat. Commun.* 11, 4683 (2020).

[4] Sun, T. et al. *Nat. Biomed. Eng.* 4, 954-972 (2020).