Subject Harmonization of Multi-Modal Digital Markers: Improved Detection of Mild Cognitive Impairment Using Language and Facial Expression

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Background

- Mild Cognitive Impairment (MCI) is the prodromal stage of dementia, including Alzheimer's Disease (AD).
- **Language markers** extracted from verbal communications have shown diagnostic efficacy in detecting early MCI [1].
- **Facial expressions emotion** in communication can also be helpful in early MCI detection [2].
- Our hypothesis: multimodal learning combining language and facial expression will improve MCI detection performance.

Distribution Difference

- **Challenge:** One general challenge of digital biomarkers is that feature distributions are very distinct among subjects.
- **Solution:** We propose subject harmonization approach to mitigate that difference in distribution.
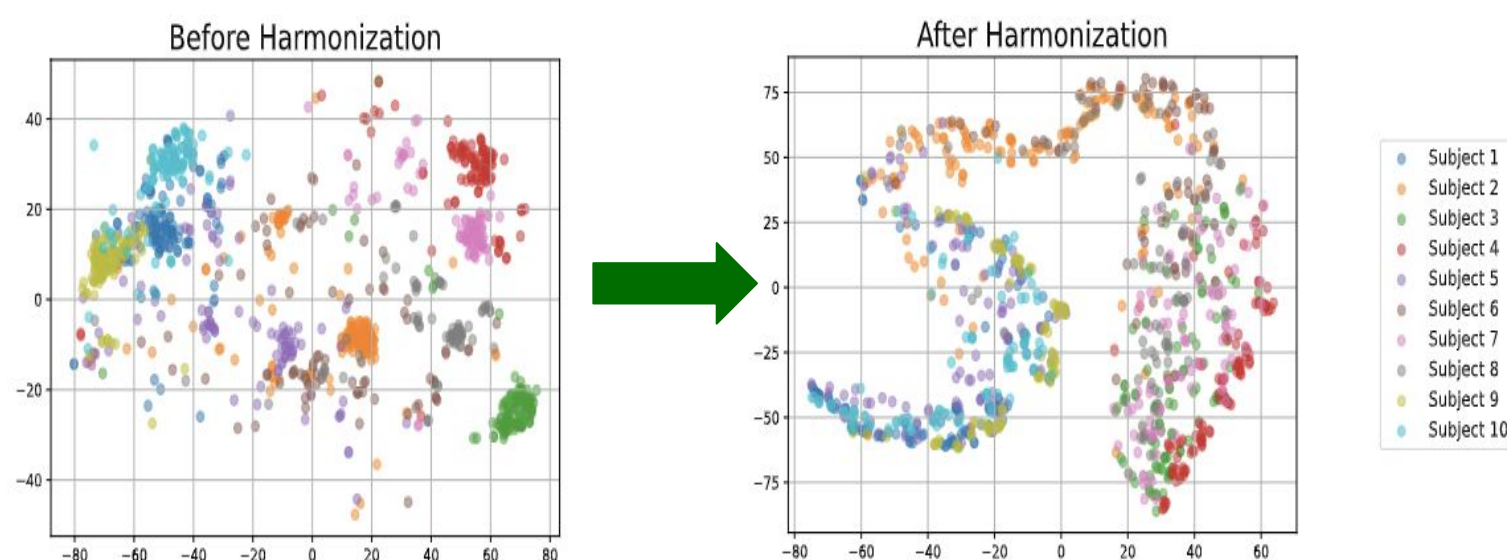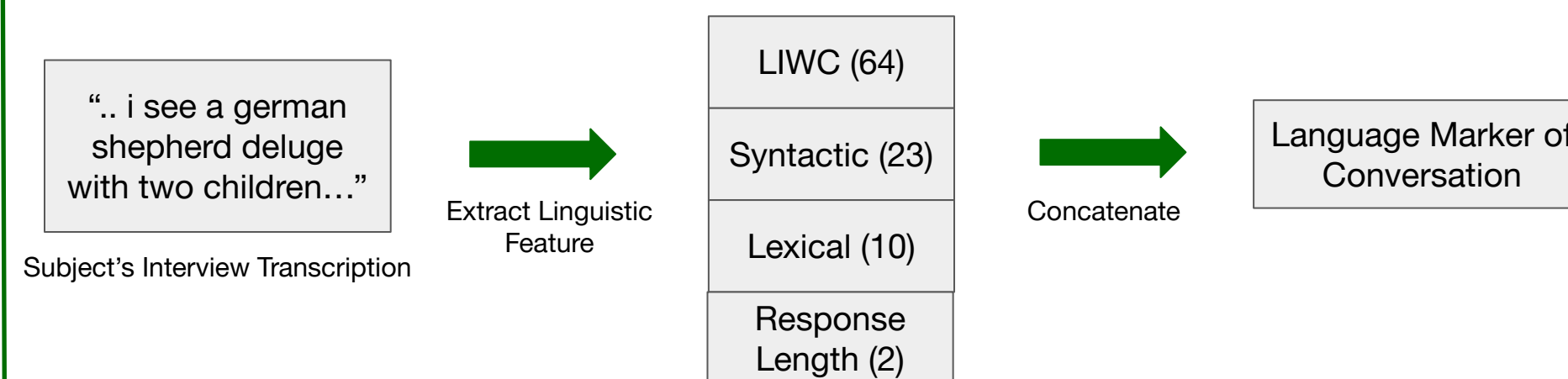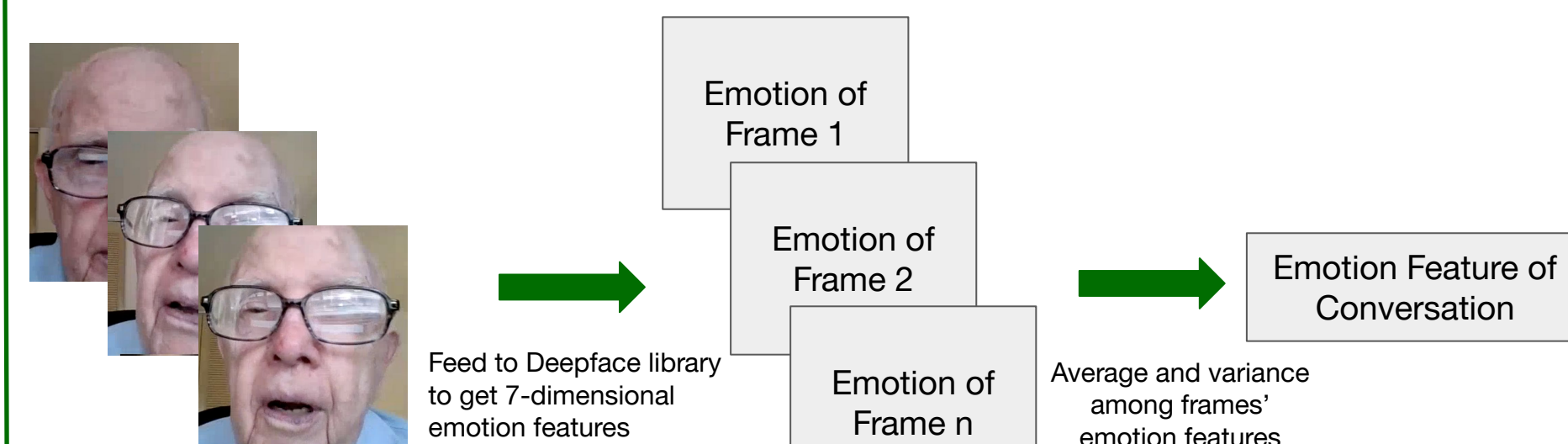

t-SNE plot of language markers

References

[1] Liu G, Xue Z, Zhan L, Dodge HH, Zhou J. Detection of Mild Cognitive Impairment from Language Markers with Crossmodal Augmentation. Pac Symp Biocomput. 2023;28:7-18.
[2] Sun, J., Dodge, H. H., & Mahoor, M. H. (2024). MC-ViViT: Multi-branch Classifier-ViViT to detect Mild Cognitive Impairment in older adults using facial videos. In Expert Systems with Applications (Vol. 238, p. 121929). Elsevier BV. https://doi.org/10.1016/j.eswa.2023.121929
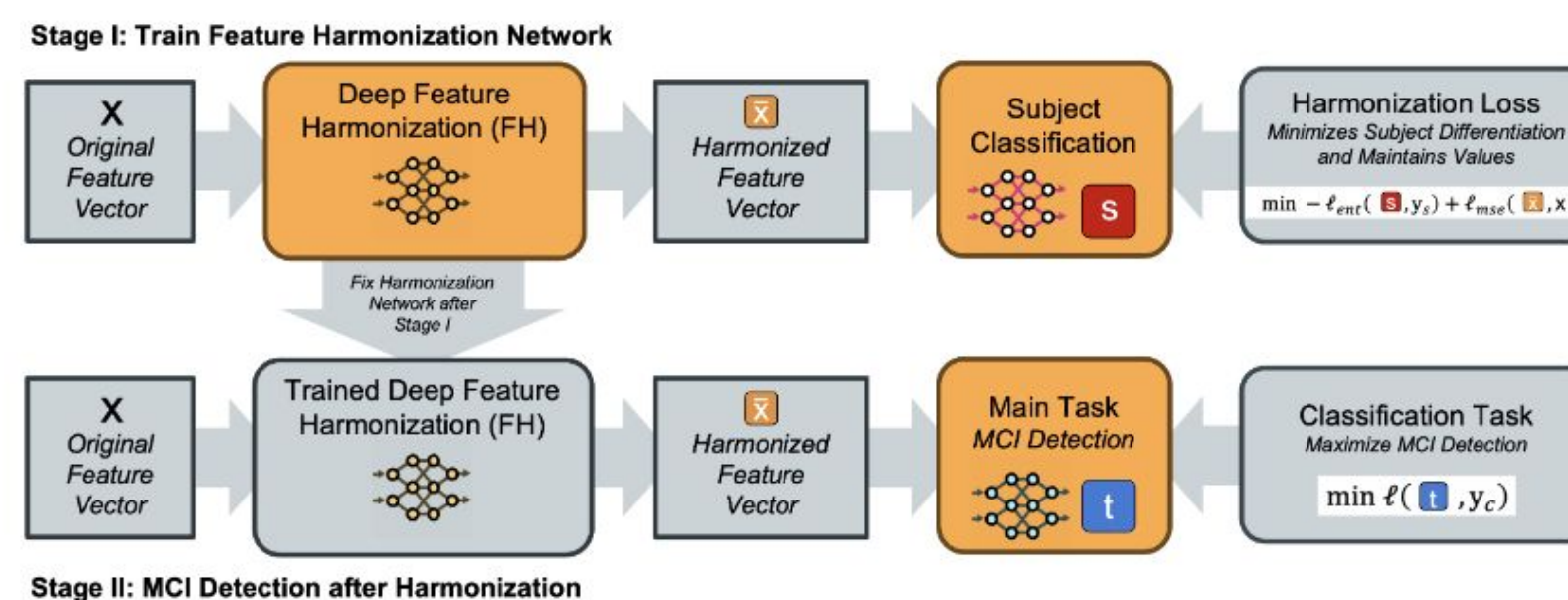
Pipeline

"..i see a german shepherd deluge with two children…"

Subject's Interview Transcription

Extract Linguistic Feature

LIWC (64)
Syntactic (23)
Lexical (10)
Response Length (2)

Concatenate

Language Marker of Conversation

Language marker extraction pipeline

Subject's Interview Frames

Feed to Deepface library to get 7-dimensional emotion features

Emotion of Frame 1
Emotion of Frame 2
Emotion of Frame n

Average and variance among frames' emotion features

Emotion Feature of Conversation

Emotion feature extraction pipeline

Subject Harmonization pipeline

Experimental Results

- We used 3,501 conversations from 69 participants from the Internet-Based Conversational Engagement Clinical Trial (I-CONECT) (NCT02871921)
- We built a neural network for MCI detection.

Performance on Different Feature Combinations		
Language	Emotion	MCI detection AUC
Non-harmonized	x	0.642±0.134
Harmonized	x	0.652±0.112
x	Non-harmonized	0.602±0.123
x	Harmonized	0.502±0.160
Non-harmonized	Non-harmonized	0.671±0.115
Harmonized	Harmonized	0.655±0.125
Harmonized	Non-harmonized	**0.701±0.121**
Non-harmonized	Harmonized	0.665±0.115

Conclusion

- Our study has shown the additional benefits of emotion variables to augment language variables in the early detection of MCI.
- Multimodality analyses need careful selection of harmonization: harmonization strategy should be chosen for individual modalities rather than uniformly applying it to all modalities.

Acknowledgement