Transforming Augmentative and Alternative Communications with AI to Empower People with Complex Communication Needs

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Background: As noted in the NJC Communication Bill of Rights (Brady et al., 2016, p.1), "All people with a disability of any extent or severity have a basic right to affect, through communication, the conditions of their existence." Access to speech-language therapies that promote optimal communication outcomes is also recognized as a fundamental right by the United Nations' Article 19 of the Convention on the Rights of Persons with Disabilities (2016). Yet many individuals with physical or intellectual disabilities have language limitations that prevent them from using speech as their primary mode of communication. For these individuals, assistive communication technologies (called augmentative and alternative communication, or AAC) offer an important set of supports. The late physicist Stephen Hawking is an example of someone who lost his speaking voice due to an acquired motor neuron disease, Amyotrophic Lateral Sclerosis (ALS), but was able to use synthesized speech from an AAC device. Without these assistive communication technologies, individuals like Dr. Hawking and over 5 million Americans with developmental or acquired communication disabilities could not have access to their fundamental human right to communication.

Problem: AAC technologies are applicable across a broad range of diagnostic conditions and can particularly benefit individuals with motor disabilities and concomitant cortical visual impairment (CVI) who struggle with ocular or cortical processing of visual information. However, current AAC systems are suboptimal for those with CVI and/or motor impairment due to reliance on the visual representation of vocabulary items (letters, words) and the crowded display of symbols that overwhelm visual processing for individuals with CVI. Additionally, access to these systems typically requires finger-pointing or limb movement, which often exceed the motor abilities of individuals with motor disabilities who rely on slower input devices like switches or eye gaze. Repetitive selections in these systems are challenging and fatiguing. For example, individuals with ALS who use eye gaze for typing communicate at a mere 10 to 20 words per minute (wpm), compared to a spoken speech rate of 180 wpm. Consequently, there is an urgent need to develop AAC technologies that minimize the visual and motor burdens for individuals facing challenges in vision and motor behavior.

Specific Aims: The overarching goal of this project is to transform access to AAC technologies through the development of human-centered AI algorithms and intelligent, interactive systems that are capable of sensing and interpreting specific communication messages in various forms of access that do not require advanced vision or repetitive motor movements. We specifically focus on touchscreen gestures and/or natural gestures, and aim to develop personalized, high-performance, and lightweight AI algorithms based on sensor fusion and few-shot learning, suitable for running on edge devices that will enable both AAC users and their care providers to easily create, configure, and tailor communication through a user-friendly, intelligent interface. As a result, the proposed AAC system will shift the burden of access from the users to the algorithms, interfaces, and sensors integrated into AAC devices. This transition would diversify access methods beyond repetitive movements, such as finger-pointing or limb movement, towards rapid, predictive interactions, and include a broader range of message preparation techniques, incorporating alternative touchscreen gestures and natural gestures like facial expressions, eye gaze, or head movements.