Towards Unsupervised Remote Therapy for Individuals with Aphasia

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Abstract. This paper discusses the use of evolutionary algorithms in mobile computing in order to provide individuals with aphasia a means of self-guided and unsupervised speech and language therapy. Traditional speech and language therapy approaches necessitate significant time commitments and are resource intensive. By harnessing evolutionary computation, therapy sessions can be generated, which consider the best practices of a speech and language professional whilst factoring in the abilities and idiosyncrasies of the user. The primary goal of this research is the provision of a self-directed rehabilitative application targeted at aphasic individuals with writing difficulties (particularly dysgraphia).

Keywords: evolutionary computation, therapy, speech and language therapy, genetic algorithm, aphasia, dysgraphia.

1 Introduction

Aphasia can be defined as a degradation of the ability to comprehend or convey language in a coherent manner. Aphasia is most commonly associated with and caused by cerebrovascular accidents (CVA's), better known as 'strokes', though it can be caused by various injuries, which result in damage to the brain. Aphasia can affect an individual in terms of their spelling, reading, writing, articulation, recognition and expression of words or sentences. Dysgraphia is an issue commonly associated with aphasic individuals, whereby they experience difficulties in writing, most often with handwriting, but often in terms of their coherence. Individuals with dysgraphia tend to omit or substitute letters, whilst their handwriting exhibits frequent stylistic inconsistencies and functional issues, such as a lack of speed and composure. While numerous therapies exist which seek to rehabilitate individuals with aphasia, they often demand a significant time commitment from both a person with aphasia (PWA) and a speech and language therapist (SLT), not to mention family members and carers. Traditional forms of therapy are considered to be resource-intensive and as such it may not be possible for a PWA to participate in clinical therapy consistently. With this in mind, a mobile application has been developed, which harnesses artificial intelligence in order to enable self-guided continuous therapy.

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2 Related Work

2.1 Technology and Aphasia

van de Sandt-Koenderman (2011) [1] discussed the role of computer technology in aphasia rehabilitation, presenting the benefits and complexities associated with such technologies for PWA's. Greig et al. (2008) [2] presented the barriers and facilitators to mobile technology for aphasic individuals, claiming the physical attributes of modern mobile devices as being highly responsible for the alienation of users with aphasia. Katz (2010) [3] defined technologies related to aphasia by their intended usage, grouping them by the following; Alternative and Augmentative Communication (AAC), Computer-Assisted Treatment (CAT) and Computer-only Treatment (COT). Cherney & Halper (2008) [4] demonstrated the potential for computers to be used unassisted by aphasic patients with noticeable benefits. The authors employed a novel script training computer application in order to rehabilitate individuals with aphasia and concomitant cognitive deficits.

2.2 Traditional Therapy Forms

The work of Marshall et al. (1990) [5], Nettleton & Lesser (1991) [6] and Boyle & Coelho (1995) [7] among others targeted the reactivation and rehabilitation of aphasic patients word retrieval, employing semantic and or phonological approaches. Maher et al. (1998) [8] and Francis et al. (2001) [9] adopted reactivation and relearning approaches respectively to therapies focused on reading. As well as word retrieval/production and reading, a number of authors ([11] - [10]) have investigated the rehabilitation of writing using methods including writing to dictation, anagrams, participant cueing, etc. While the above have proven to be successful in their own regard, clinical therapy often necessitates a substantial and intense time commitment on the behalf of all associated individuals, whilst requiring the individual to be in close proximity to either a therapist or clinic. The developed system features a prompting framework, influenced by both Anagram and Copy Treatment (ACT) and Copy and Recall Treatment (CART). Beeson (1999) [12] chose both ACT and CART, whereby the studys participants were tasked with arranging anagrams and repeated word copying with and without professional assistance. Beeson et al. (2002) [10] demonstrated the potential for ACT and CART in rehabilitating individuals with aphasia and concomitant writing deficits.

3 Implementation

A mobile application has been developed, which enables PWA's to facilitate their own continuous therapy sessions. The application features a word identification task, presenting users with a target image and requiring them to identify and spell the associated word correctly. Throughout the application's use, the

user is supported via a cyclically presented cueing hierarchy. This hierarchy consists of semantic prompts (an easily understood sentence with the target word omitted/occluded), semantic prompts with the target word's initial grapheme presented and finally an interactive anagram. Therapy sessions are generated for users via a genetic algorithm (GA), assessing words based on criteria such as length, spelling regularity and frequency, whilst maintaining categorical similarity and significance and gradual increases in complexity.

The GA is solely responsible for selecting words for sessions, which are inkeeping with the user's capabilities. The GA chooses groups of words from the system's vocabulary, which consists of a sample of 1000 words, taken from WordNet [13]. WordNet is a vast lexical database, which not only offers a strong dictionary of indexed terms, but also provides valuable information for determining the difficulty of each individual term. WordNet arranges words in sets of cognitive synonyms known as synsets, as well as linking these synsets to one another conceptually. The GA leverages these conceptual linkages in order to select terms, which are categorically similar to one another, allowing the application to cater sessions to the interests of the individual. Words are represented by images selected from ImageNet, an image-based dataset, based on WordNet's hierarchy.

The GA first generates a large collection of potential sessions (the initial population). Each individual is analysed and assigned a fitness value via the GA's fitness function. Through roulette wheel selection and the application of genetic operators (mutation and crossover), fitter offspring are continually produced until a viable solution is found. Words are assessed based on word length, spelling regularity, frequency, imageability, presence of homophones and presence of embedded words. Viable individuals should generally place an emphasis on low word length, high frequency and high imageability, while secondary goals include the avoidance of homonyms, irregularly spelt words and the presence of embedded words. These criteria are subject to flexible weightings when being evaluated by the fitness function.

4 Future Work

Future evaluations of the GA's performance have been designed and will be implemented in the coming period. An early evaluation has already been carried out, which assessed the GA's ability to gauge the perceived spelling difficulty of words, in comparison to the expectation of SLT practitioners and SLT students. During this study, sessions were deliberately generated with a diverse level of difficulty among the individual terms and presented to the participants. The purpose of the study was to collate feedback related to the overall ability of the GA to define perceived difficulty. While the participants largely agreed with the choices made by the GA, some individuals cited issues with the initial weightings, specifically related to the weighting associated with spelling regularity.

5 Conclusion

A mobile application has been presented, which seeks to enable self-guided therapy for individuals with aphasia, particularly those with writing deficits. The application features a genetic algorithm, which generates sessions catered to the idiosyncrasies of individual users. The GA first and foremost assesses the perceived spelling difficulty of words, whilst placing an emphasis on maintaining enough categorical similarity so that sessions are in keeping with the interests of the user. The application features a cueing hierarchy influenced by traditional ACT and CART approaches to speech and language therapy. Further experiments have been planned and designed which will rigorously test the GA's ability to continuously provide suitable therapy sessions for individuals with aphasia, whilst adapting to the capabilities and interests of the individual in question.

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