

Automatic disease detection using paralinguistic features

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I. INTRODUCTION

Voice is the main form of human communication. Vocal communication and its role is essential in all areas of life, both in a professional as well as in personal life. Humans use vocal communication for, amongst other things, expressing feelings, the transmission of knowledge and other day to day social interactions. Speech encodes both linguistic intent as well as paralinguistic information such as emotion, age and gender. [1]

People suffering from certain medical diseases can have great difficulty with using vocal communication. Often this difficulty is associated with respiratory, nasal, neural and larynx diseases. Therefore the study of Paralinguistics in vocal disorders have become an important medical procedure.

Paralinguistics, communicative vocal aspects that are typically not linguistic, contains extralinguistic- and paralinguistic. Extralinguistic features can be physical aspects such as age, gender or physical stress or mental aspects such as a depression. Paralinguistic features can be a broad range of affective states, feelings or emotions. [3]

This research proposal will explore the possibilities of developing a system for automatic disease detection using paralinguistic features.

II. BACKGROUND AND RELATED WORK

Related work has focused on the diagnosis of characteristic irregularities in voice patterns of patients with certain medical conditions. These features in voice patterns should form the basis for a system that tries to do an automatic detection and classification of medical diseases. Some research in the field of medical diseases and conditions such as Autism Spectrum Disorders, Alzheimers disease (AD) and Parkinsons disease (PD) will be discussed in this section. Research which has been conducted on the diagnosis using linguistic or text-based features will not be discussed.

A. Autism Spectrum Disorders

Autism is a group of mental disorders, collectively called autism spectrum disorder (ASD). An individual with an autism spectrum disorder can have a wide range of symptoms that can result in many impairments such as social interaction, behavioural and communication skills. [4] Hoque et. al. have shown that individuals with an autism spectrum disorder

produce speech with either high or low speech rate, and atypical pitch and/or amplitude affect (prosodic aspects). [5]

B. Alzheimers disease

Alzheimers disease is a common form of dementia. Common symptoms are: memory loss, confusion, irritability, aggression, trouble with language, and mood swings. While there is no known cure for this form of dementia, its effects can be delayed if therapy starts early. [6] Appell et. al. have proven that dementia and specifically Alzheimers disease affect human speech. [7] Satt et. al. describe an automatic classification technique using different focal features to classify different stages of Alzheimer's disease. Their research provides a classification accuracy of 87% for the classification between the control group and patients with Alzheimer's disease, providing evidence for potential use for automatic detection of very early dementia. [8]

In addition research by Weiner et. al. on speech-based detection of Alzheimers disease in conversational German shows a classification accuracy similar to the classification conducted by Satt et. al. in the English language. [9]

C. Parkinson's disease

Parkinson's disease is a chronic and progressive movement disorder. The cause is unknown, and although there is presently no cure, there are treatment options such as medication and surgery to manage its symptoms. [10] Parkinsons disease is strongly associated with voice changes. One of the symptoms of Parkinson's disease, tremor, is also apparent in an individual's voice. Voice tremor is linked to frequency/pitch and amplitude/loudness perturbation. [11]

Research by Villa-Canas et. al. explore a method for automatic detection of Parkinsons disease using a joint acoustic and modulation frequency representation. Their classification one by means of a Gaussian mixture model, shows that the approach can classify individuals between a control group and with Parkinson's disease with an accuracy of around 71%. [12]

III. PROBLEM STATEMENT AND MOTIVATION

For the medical diseases and conditions that were described, Autism Spectrum Disorders, Alzheimers disease (AD) and Parkinsons disease (PD), it is important that diagnosis of these diseases can happen as soon as possible. As an illustration: in the case of Alzheimers it is estimated that about half of

individuals suffering from the disease have not been diagnosed. [13] Furthermore the Alzheimer's association reports numerous benefits of an early diagnosis of Alzheimer's disease to help affected individuals and their families. [14]

A few problems however arise that in many cases prevent the early diagnosis of the described medical diseases and conditions. In many cases a large group of individuals would have to be examined at regular intervals for certain diseases such as Alzheimer's disease. Research for these diseases and conditions would not only be costly but would also require a large amount of time for medical professionals and other caretakers which are conducting all these examinations.

If research would indicate that an automatic disease detection system could accurately classify certain medical diseases and conditions it could be used as a system for an accurate pre-examination, therefore vastly decreasing the amount of examinations which have to be conducted by the medical professionals and other caretakers therefore reducing their workload and the overall costs of these examinations.

IV. RESEARCH QUESTIONS

The problem statement and motivation lead to the following research questions:

How can diagnosed paralinguistic features in speech be used to create automatic disease classification systems?

This question is answered with the support of the following questions:

- Is accurate disease detection merely based on paralinguistic features possible?
- What are sensible features that could be used in the automatic classification of a certain disease?
- How do such classification systems behave across different languages?

V. METHOD

To give an accurate answer the above mentioned research questions multiple different tasks have to be conducted.

One could argue if it is feasible to focus on all of the above mentioned medical diseases and conditions or if further research should narrow down on to one specific disease and merely focus on that disease. If it is decided to focus on one disease also the choice of this disease is important, a research study could be conducted to find the medical diseases or condition that has to most potential for an automatic disease detection system. Personal motivation could also play a role in the choice to choose a disease or condition to focus on for further research.

Furthermore an extensive literature study has to be conducted to establish a list of features which could be used for the classification of a disease or condition. Already some research in the field of medical diseases and conditions such as Autism Spectrum Disorders, Alzheimer's disease (AD) and Parkinson's disease (PD) have been mentioned in section II. Literature research could further expand into different diseases that have been linked to affect human speech. Furthermore based on the literature research, a table should be constructed with different

paralinguistic- and linguistic features and their success in accurately classifying diseases. Such a table could help answer the question if it is possible to classify a certain disease merely based on paralinguistic features or if also linguistic features are needed in this case.

After conducting an extensive literature study, selecting a disease or diseases to focus further research on and selecting fitting (para)linguistic features an automatic system could be created for the detection and classification. Different feature extraction, such as PCA or Mel-frequency cepstrum, and classification techniques will have to be examined and evaluated.

Finally accuracy of such a system should be evaluated preferably across different languages to get a good understanding of the effects that different languages, accents or cultural differences can have on such a classification system.

VI. SCIENTIFIC AND SOCIAL IMPACT

Research on the automatic disease detection using paralinguistic feature could have valuable impact both scientifically and socially.

Scientifically a literature review across multiple conducted research could provide valuable insight in different paralinguistic- and linguistic features and their success in accurately classifying diseases. Furthermore research in feature extraction and classification techniques could help future research on similar scientific problems.

Socially, if research would indicate that an automatic disease detection system could accurately classify certain medical diseases and conditions, a disease detection system could have a large impact. As has been stated in section VI, quality of life of patients could be drastically improved by an earlier diagnosis of some diseases. Furthermore the workload of medical professionals and other caretakers could be reduced as well as the overall costs associated with these diagnosis.

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