Speech-Based Detection of Dementia in Spontaneous Conversational Speech

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Abstract

The worldwide population is aging. With a larger population of elderly people, the numbers of people affected by dementia are growing. Unfortunately, there is no known cure for Alzheimer's disease. The only way to alleviate it's serious effects is to start therapy very early before the disease has wrought too much irreversible damage. Current diagnostic procedures require a lot of time by specialists. In my PhD project I am working on automatic detection of dementia using spontaneous conversational speech in a longitudinal context in order to meet the demands for frequent mass screening required to mitigate the consequences of cognitive impairments on the global scale.

Index Terms: computational paralinguistics, dementia detection, cognitive impairment

1. Introduction

The population in developed countries such as Germany is aging rapidly. By 2050 the sixty-year-olds will be the most populous age group in Germany [1]. While dementia is a very rare condition for people younger than 60 years [2, p. 6], the prevalence of dementia is rising steadily from 1.6% at the age of 60 to nearly 40% at the age of 90 [2, p. 20]. Thus the increase in the elderly population will lead to a higher number of individuals affected by dementia. This will pose major challenges for these aging societies when worldwide, in 2015, 46.8 million individuals were already affected by dementia and health care costs incurred by the disease exceeded US$ 818 billion [2]. On a more individual level, the disease has major impacts on the lives of those affected by it, their relatives and their caregivers.

With up to 70 % of the cases, Alzheimer's disease is the most common form of dementia [3]. While there is no known cure for this form of dementia, its effects can be delayed if therapy starts early [2]. However, therapy can only start early if the disease is diagnosed early which requires frequent examinations of the cognitive status of the elderly age group. Typical examinations currently include a large number of neuropsychological tests such as the Mini Mental State Examination [4]. The results of these test are then used by psychiatrists to make a diagnosis. While this procedure produces reliable results, it is also very time consuming and expensive. In order to meet the challenges posed by the aging population, however, longitudinal cognitive status monitoring of the elderly age group has to be performed on a large scale. Therefore a method for diagnosing the disease needs to be found that is fast and cheap and can be made widely available.

2. Speech-Based Detection of Dementia

Alzheimer's disease and dementia of non-Alzheimer type affect human speech and language [5, 6]. In fact, these diseases cause significant changes to speech and language very early in their course [7]. Speech is therefore a promising candidate not only as a source of information for new approaches to diagnosing dementia, but also to diagnosing dementia as early as possible.

In recent years, features extracted from speech have already been used to automatically detect dementia. Most of this work concentrates on clinical environments in which patients are recorded while they carry out the same neuropsychological tests that psychiatrists use for their diagnosis of cognitive impairment [8, 9, 10, 11].

Requiring subjects to carry out neuropsychological tests, provides little improvement over the current diagnosis procedure in which psychiatrists analyze the results of the tests. Spontaneous speech, e.g. from interviews, requires less recording preparation, can be recorded by a person with minimal diagnostic knowledge, may provide subjects with a more comfortable situation and is also suitable for automatic detection of dementia [12].

In most of these these existing studies each subject was recorded and examined exactly once. If these systems were to be used in a longitudinal cognitive status monitoring of the elderly age group, they would miss one source of information: individual aging and progression of disease in individuals. This information is contained in longitudinal corpora for which each subject is recorded and examined multiple times. These corpora therefore enable research closer to the motivational idea that frequent longitudinal examinations of the elderly are required to mitigate the consequences of aging societies.

In my PhD project I am using spontaneous conversational German speech from a longitudinal corpus of biographic interviews to detect dementia as early as possible. I leverage automatic speech recognition techniques to assess both the spoken content of an utterance and the way it was uttered. The resulting system will be able to detect dementia from speech which can be recorded cheaply and easily. It will thus be tailored to the task of large scale longitudinal status monitoring in the elderly age group.

3. ILSE - a Longitudinal Corpus on Adult Development and Aging

For my experiments I use data from the *Interdisciplinary Longitudinal Study on Adult Development and Aging* (ILSE) [13]. ILSE is a collection of data on healthy and satisfying aging in middle adulthood and later life, not a database tailored specifically for the automatic detection of dementia. A group of 1,000 participants was recruited through community registers so that this group is representative for the sampled population: members of two birth cohorts that lived in two urban centers in Germany. The elder cohort were around 60 years old when the study began, while the younger cohort were around 40 years old. Over the course of more than 20 years these participants have contributed data to ILSE in four measurements.

The speech data in ILSE comes from biographic interviews that lasted several hours at each measurement. While some of the participants were very young to be examined for cognitive impairment when the study began, they have now reached the age where dementia occurs. Four different types of dementia occur in ILSE: aging-associated cognitive decline (AACD), Mild cognitive disorder (MCD), Alzheimers disease (AD), and Vascular dementia (VAD). The prevalence of dementia in each age group at each measurement [13] is in the range expected for that age group in Germany [2, p. 20]. This means that the data in ILSE provides me with a scenario that is very close to the conditions we would find in real longitudinal cognitive status monitoring in this country.

4. Three Tasks of Dementia Detection

4.1. Cross-Sectional Dementia Detection

Cross-sectional dementia detection [14] is the detection of the current cognitive diagnosis. In this task each measurement is treated as an independent sample: one person could contribute to both classes, cognitively healthy and cognitively impaired, if their cognitive diagnosis changed over the course of the study. This type of cross-sectional dementia detection in a longitudinal context has received little attention in the literature so far [15]. I will investigate both acoustic and linguistic features for dementia detection. Further I will investigate how long a speech recording needs to be to enable dementia detection and whether certain topics of the conversations are better suited for dementia detection than others.

4.2. Longitudinal Dementia Detection

Longitudinal dementia detection [16] is the detection of intra-personal development of dementia: using speech data from two examinations we detect subjects that were cognitively healthy during one examination and cognitively impaired during a later examination. This detection task takes into account individual aging and progression of dementia in individuals. Together with the real world prevalence of dementia in the ILSE corpus, this task models a longitudinal cognitive status monitoring in the elderly population.

4.3. Dementia Prediction

The absence of a cure for dementia means that the earlier therapy starts, the more cognitive abilities can be saved. Since speech occurs very early in the course of dementia, I will investigate how early dementia can be detected. The aim of this task is to detect dementia earlier in its course than the state of the art in neuropsychological examination.

5. Conclusion

In my PhD project I investigate automatic detection of dementia from speech: Is early automatic detection of dementia possible using spontaneous conversational interview speech? I am working on this research question in three tasks: cross-sectional dementia recognition, longitudinal dementia recognition and dementia prediction. The goal is to enable longitudinal cognitive status monitoring of the elderly population as one contribution to mitigating the consequences of our aging society.

6. References

[1] Statistische Ämter des Bundes und der Länder, "Bevölkerungs- und Haushaltsentwicklung im Bund und in den Ländern." *Demografischer Wandel in Deutschland*, vol. 1, 2011.

[2] M. Prince, A. Wimo, M. Guerchet, G.-C. Ali, Y.-T. Wu, and M. Prina, *World Alzheimer Report 2015. The Global Impact of Dementia: an Analysis of Prevalence, Incidence, Cost and Trends*. London: Alzheimer's Disease International, 2015.

[3] World Health Organization and Alzheimers Disease International, *Dementia: a public health priority*. World Health Organization, 2012.

[4] M. F. Folstein, S. E. Folstein, and P. R. McHugh, ""Mini-mental state": a practical method for grading the cognitive state of patients for the clinician," *Journal of psychiatric research*, vol. 12, no. 3, pp. 189–198, 1975.

[5] J. Appell, A. Kertesz, and M. Fisman, "A study of language functioning in Alzheimer patients," *Brain and language*, vol. 17, no. 1, pp. 73–91, 1982.

[6] J. Reilly, A. D. Rodriguez, M. Lamy, and J. Neils-Strunjas, "Cognition, language, and clinical pathological features of non-alzheimer's dementias: An overview," *Journal of Communication Disorders*, vol. 43, no. 5, pp. 438 – 452, 2010.

[7] R. Bucks, S. Singh, J. M. Cuerden, and G. K. Wilcock, "Analysis of spontaneous, conversational speech in dementia of Alzheimer type: Evaluation of an objective technique for analysing lexical performance," *Aphasiology*, vol. 14, no. 1, pp. 71–91, 2000.

[8] A. Satt, R. Hoory, A. König, P. Aalten, and P. H. Robert, "Speech-based automatic and robust detection of very early dementia." in *INTERSPEECH 2014 – 15th Annual Conference of the International Speech Communication Association*, 2014, pp. 2538–2542.

[9] F. Espinoza-Cuadros, M. A. Garcia-Zamora, D. Torres-Boza, C. A. Ferrer-Riesgo, A. Montero-Benavides, E. Gonzalez-Moreira, and L. A. Hernandez-Gómez, "A spoken language database for research on moderate cognitive impairment: design and preliminary analysis," in *Advances in Speech and Language Technologies for Iberian Languages*. Springer, 2014, pp. 219–228.

[10] L. Tóth, G. Gosztolya, V. Vincze, I. Hoffmann, and G. Szatlóczki, "Automatic detection of mild cognitive impairment from spontaneous speech using asr," in *INTERSPEECH 2015 – 16th Annual Conference of the International Speech Communication Association*, 2015, pp. 2694–2698.

[11] M. Lehr, E. T. Prud'hommeaux, I. Shafran, and B. Roark, "Fully automated neuropsychological assessment for detecting mild cognitive impairment." in *INTERSPEECH 2012 – 13th Annual Conference of the International Speech Communication Association*, 2012, pp. 1039–1042.

[12] A. Khodabakhsh, F. Yesil, E. Guner, and C. Demiroglu, "Evaluation of linguistic and prosodic features for detection of Alzheimer's disease in Turkish conversational speech," *EURASIP Journal on Audio, Speech, and Music Processing*, vol. 2015, no. 1, pp. 1–15, 2015.

[13] J. Weiner, C. Frankenberg, D. Telaar, B. Wendelstein, J. Schröder, and T. Schultz, "Towards Automatic Transcription of ILSE – an Interdisciplinary Longitudinal Study of Adult Development and Aging," in *Proceedings of the Tenth International Conference on Language Resources and Evaluation (LREC'16)*, 2016.

[14] J. Weiner, C. Herff, and T. Schultz, "Speech-Based Detection of Alzheimer's Disease in Conversational German," in *INTERSPEECH 2016 – 17th Annual Conference of the International Speech Communication Association*, 2016.

[15] B. Yu, T. F. Quatieri, J. R. Williamson, and J. C. Mundt, "Cognitive impairment prediction in the elderly based on vocal biomarkers," in *INTERSPEECH 2015 – 16th Annual Conference of the International Speech Communication Association*, 2015, pp. 3734–3738.

[16] J. Weiner and T. Schultz, "Detection of Intra-Personal Development of Cognitive Impairment From Conversational Speech," in *Proceedings of the 12th ITG Conference on Speech Communication*, 2016.