

Computational characterization of mental states: A natural language processing approach

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Abstract

Psychiatry is an area of medicine that strongly bases its diagnoses on the psychiatrists subjective appreciation. The task of diagnosis loosely resembles the common pipelines used in supervised learning schema. Therefore, we propose to augment the psychiatrists diagnosis toolbox with an artificial intelligence system based on natural language processing and machine learning algorithms. This approach has been validated in many works in which the performance of the diagnosis has been increased with the use of automatic classification.

1 Introduction

Psychiatry is an area of medicine that strongly bases its diagnoses on the psychiatrists subjective appreciation. More precisely, speech is used almost exclusively as a window to the patients mind. Few other cues are available to objectively justify a diagnostic, unlike what happens in other disciplines which count on laboratory tests or imaging procedures, such as X-rays. Daily practice is based on the use of semi-structured interviews and standardized tests to build the diagnoses, heavily relying on her personal experience. This methodology has a big problem: diagnoses are commonly validated a posteriori in function of how the pharmacological treatment works. This validation cannot be done until months after the start of the treatment and, if the patient condition does not improve, the psychiatrist often changes the diagnosis and along with the pharmacological treatment. This delay prolongs the patient's suffering until the correct diagnosis is found. According to NIMH, more than 1% and 2 % of US population is affected by Schizophrenia and Bipolar Disorder,

respectively. Moreover, the WHO reported that the global cost of mental illness reached \$2.5T in 2010 (Mathers et al., 2008).

The task of diagnosis, largely simplified, mainly consists of understanding the mind state through the extraction of patterns from the patient's speech and finding the best matching pathology in the standard diagnostic literature. This pipeline, consisting of extracting patterns and then classifying them, loosely resembles the common pipelines used in supervised learning schema. Therefore, we propose to augment the psychiatrists diagnosis toolbox with an artificial intelligence system based on natural language processing and machine learning algorithms. The proposed system would assist in the diagnostic using a patients speech as input. The understanding and insights obtained from customizing these systems to specific pathologies is likely to be more broadly applicable to other NLP tasks, therefore we expect to make contributions not only for psychiatry but also within the computer science community. We intend to develop these ideas and evaluate them beyond the lab setting. Our end goal is to make it possible for a practitioner to integrate our tools into her daily practice with minimal effort.

2 Methodology

In order to complement the manual diagnosis it is necessary to have samples from real patients. To collect these samples, we have ongoing collaborations with different psychiatric institutions from many countries: United States, Colombia, Brazil and Argentina. These centers provide us with access to the relevant patient data and we jointly collaborate testing different protocols in a variety languages. We have already started studies with two pathologies: Schizophrenia and Bipolar Disorder.

Regarding our technical setup, we are using and

developing tools to capture different characteristics of the speech. In all cases, we work with high-quality transcriptions of speech. Our experiments are focused on analyzing different aspects of the speech: 1) Grammatical-morphological changes based on topology of Speech Graphs. 2) Coherence Algorithm: Semantic coherence using proximity in semantic embeddings. 3) Changes in Emotional language and other semantic categories

3 Preliminary Results

Many groups have already validated this paradigm (Roark et al., 2011; Fraser et al., 2014; Resnik et al., 2013; Lehr et al., 2012; Fraser et al., 2016; Mitchell et al., 2015). First, Speech Graphs has been used in different pathologies (schizophrenic and bipolar), results are published in (Carrillo et al., 2014; Mota et al., 2014, 2012). In (Carrillo et al., 2014), the authors can automatically diagnose based on the graphs with an accuracy greater than 85%. This approach consists in modeling the language, or a transformation of it (for example the part of speech symbols of a text), as a graph. With this new representation the authors use graph topology features (average grade of nodes, number of loops, centrality, etc) as features of patient speech. Regarding coherence analysis, some researchers has developed an algorithm that quantifies the semantic divergence of the speech. To do that, they used semantic embeddings (like Latent Semantic Analysis(Landauer and Dumais, 1997), Word2vec(Mikolov et al., 2013), or Twitter Semantic Similarity(Carrillo et al., 2015)) to measure when consecutive sentences of spontaneous speech differ too much. The authors used this algorithm, combined with machine learning classifiers, to predict which high-risk subjects would have their first psychotic episode within 2 years (with 100% accuracy) (Bedi et al., 2015). The latter result was very relevant because it presented evidence that this automatic diagnostic methodology could not only perform at levels comparable to experts but also, under some conditions, even outperform experts (classical medical tests achieved 40% of accuracy). Dr. Insel, former director of National Institute of Mental Health cited this work in his blog on his post: Look who is getting into mental health research as one.

Regarding Emotional language, some researchers presented evidence of how some endocrine regulations change the language. This

methods are based on quantifying different emotional levels. This methodology has been used to diagnose depression and postpartum depression by Eric Horvitz (De Choudhury et al., 2013). Others researchers also have used this method to diagnose patients with Parkinsons disease(García et al., 2016).

4 Current Work

Currently, we are working on the coherence algorithm (Bedi et al., 2015), understanding some properties and its potential applications, such as automatic composition of text and feature extraction for bot detection. Meanwhile, we are receiving new speech samples from 3 different mental health hospitals in Argentina provided by patients with new pathologies like frontotemporal dementia and anxiety. We are also building methods to detect depression in young patients using the change of emotions in time.

5 Future work

The tasks for the following 2/3 years are: 1) Improve implementations of developed algorithms and make them open source. 2) Integrate the different pipelines of features extraction and classification to generate a generic classifier for several pathologies. 3) Build a mobile application for medical use (for this aim, Google has awarded our project with the Google Research Awards for Latin America 2016: Prognosis in a Box: Computational Characterization of Mental State). At the moment the data is recorded and then transcribed by an external doctor. We want a full automatic procedure, from the moment when the doctor performs the interview to the moment when she receives the results. 4) Write the PhD thesis.

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