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Early Detection of Mental Health Problems

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ABSTRACT

A portion of psychiatric patients relapse when the treatment runs its course, or sometimes before. The psychiatric or psychological evaluation of patients is complicated by patients' frequent refusal to cooperate with medical specialists. Such clinical evaluations may also be unable to detect subtle changes in the patients' conditions or may not be timely enough. This disclosure describes techniques, implemented with appropriate permissions, for automatic monitoring of patients to detect changes in the patient behavior that predict a relapse or worsening of their mental health. Various sensors in user devices such as smartphones, smartwatches, or other wearables, as well as other devices such as smart speakers, home automation devices, etc. obtain sound, image, and body-parametric data of the patient and in their environment. The data is analyzed to test for changes in the patient's behavioral patterns over time (which can be a reflection of changes in the patient's health); to test if the patient's visual and aural fields have a basis in reality; to provide feedback to the patient; etc.

KEYWORDS

- Mental health
- Schizophrenia
- Psychosis
- Machine learning
- Virtual assistant
- Psychiatrist
- Psychologist
- Speech pattern
- Speech trigger
- Questionnaire
- Mood change

BACKGROUND

Patients diagnosed with schizophrenia receive medical treatment aimed at reducing or eliminating psychoses and other symptoms. Unfortunately, a significant fraction of patients relapse when the treatment runs its course, or sometimes before. Reasons for relapse include:

- Believing themselves to be healthy, patients stop medications.
- The medicinal dose is inadequate relative to the extent of the disease. Specifically, medicines known to have significant side effects are given at reduced dosages.

It is difficult to obtain sufficient data about the various aspects of a patient's recovery to learn from it, e.g., by applying machine learning models to determine the relative efficacy of different doses and treatments. Key clinical questions include:

- What is the duration of antipsychotic treatment and the risk of relapse after reduction or discontinuation of antipsychotic medications?
- What is the risk of relapse after a single episode of psychosis? Is the risk reduced with a longer treatment period?

Despite several studies assessing the risk of relapse after the discontinuation of antipsychotic medication, there is no consensus on the recommended duration of treatment. Reliable early warning signs of relapse are of great value in clinical settings, as they offer the opportunity of early intervention and prevention of florid relapse. Similar problems exist for mental diseases characterized by hallucinations or loss of touch with reality (these can also be due to drug overuse, closely associated with alcoholism and addiction).

Psychiatric or psychological evaluation of patients is complicated by patients' frequent refusal to cooperate with medical specialists, often leading to involuntary hospitalization. Such clinical evaluations may anyways be insufficient to detect subtle changes in the patients'

conditions or might not take place in a timely enough fashion to prevent worsening of mental health.

Chatbots that employ cognitive behavioral therapy to alleviate mental health issues require frequent interactions and don't work with incapacitated patients (such as those undergoing a schizophrenia episode) or uncooperative patients. Smartwatches can detect stress via galvanic skin response, but only provide a simple stress rating unrelated to mental health. Schizophrenia can possibly be detected from social media posts using supervised machine learning [1, 2], but the reliability of such detections is unknown.

DESCRIPTION

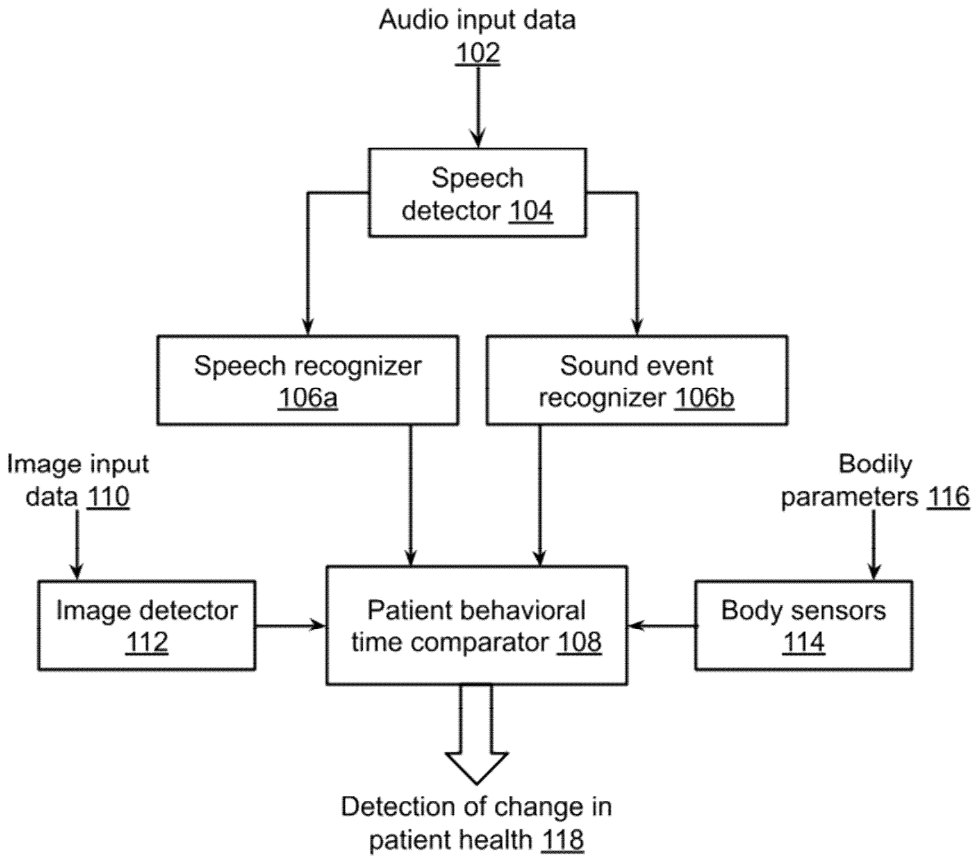

Fig. 1: Automatic detection of mental health problems

Illustrated in Fig. 1, this disclosure describes techniques for automatic monitoring of patients (with appropriate consent) to detect changes in the patient behavior that predict a relapse or worsening of their mental health. A speech detector (104) accepts audio input data (102) from the patient with permission from the patient. The speech detector can comprise a speech recognizer (106a), which recognizes speech in the form of language, and a sound event recognizer (106b), which recognizes environmental or patient origin sounds indicative of patient condition. Some examples of observations that prefigure a deterioration of mental health include:

- *Changes in speech patterns*: Some examples include more grammatical errors than usual; more (or less) pauses than usual; random speech; unfinished phrases; nonsensical statements; etc. Changes in speech patterns can be detected by a speech recognizer working in tandem with a machine learning model trained to differentiate between typical and atypical speech patterns. The speech recognizer and machine learning models operate on a mobile device, e.g., smartphone, or devices located around the patient such as smart speakers, home automation devices, voice-interactive devices, etc.
- *Speech triggers*: Some examples include suicidal statements, suggestions of violence, etc., detectable by a speech recognizer.
- *Changes in statistical characteristics of written or oral communication*: Some example statistics include the number of characters typed per minute; the number of words spoken per minute; etc.
- *Patient feedback on the kinds of sounds they hear*: An example of actionable feedback is a patient report of hearing environmental sounds (e.g., a barking dog) that are not detected by audio sensors around the patient, and therefore, likely have no basis in reality. In turn, haptic feedback can be provided to the patient using, e.g., a smartwatch,

vibratory bracelet, etc., if the patient's report of their audio field doesn't match sound events as detected by audio sensors. Further, sound events detected by audio sensors can be displayed on smartwatch or smartphone screens (e.g., "chirping birds") or can be indicated by device vibration to enable the patient to confirm that the sounds they apparently hear are in fact real. Another example of actionable feedback is a patient reporting the hearing of phrases consistently at variance with transcriptions by a speech recognizer. The patient's aural feedback can be analyzed to better understand the patient's mental health or changes therein.

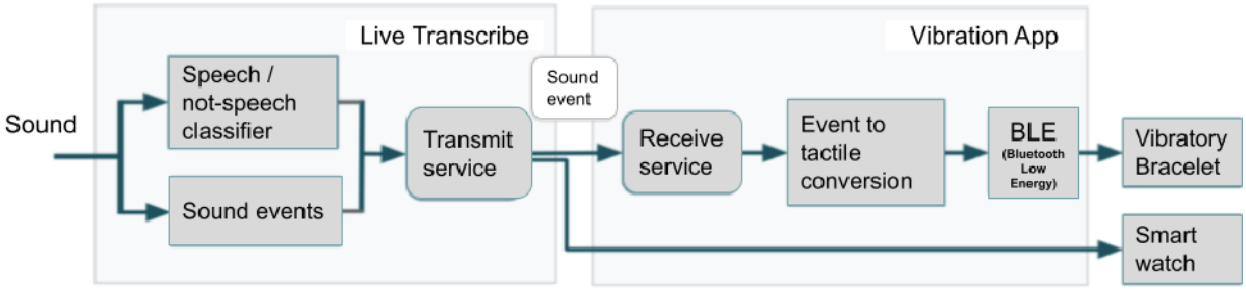

Fig. 2: An example of the use of speech and sound events to detect changes in a patient's health and of the use of haptic feedback to the patient

Fig. 2 illustrates an example of the use of speech and sound events to detect changes in a patient's health and the use of haptic feedback. With appropriate permission, image input (110) is accepted by an image detector (112) in proximity to the patient, e.g., a camera embedded within smart glasses or augmented reality glasses, home automation devices, or other devices. Hallucination events can be detected by comparing a patient's report on their visual field with objects, people, and scenes detected within the camera feed.

Further, with appropriate permissions, body parameters (116), e.g., pulse, breath-patterns, body humidity, temperature, etc., can be measured using body sensors (114, e.g., as found in smartwatches) and can be used to detect mood changes. These in turn can be indicative of the

onset of depression, anxiety, panic, paranoia, etc. With patient permission, mood changes can also be detected by analyzing voice patterns, face expressions, walking patterns (e.g., repeatedly walking in circles), etc.

A patient behavior comparator (108) accepts outputs from the speech recognizer, sound event recognizer, image detector, body sensors, etc., and uses on-device machine learning models to detect changes in the patient's behavior that are indicative of mental health problems (118).

To delay or eliminate disease onset, better manage the disease, and inculcate healthy habits, such analyses can also provide the patient with immediate feedback. For example, if a patient hears sounds but feels no corresponding haptic feedback, they can determine that the heard sound is in fact an auditory hallucination. This knowledge can enable the patient to better understand and control their mental state. As another example of feedback to the patient, calming media (e.g., haptic tones, music, etc.) can be provided upon the detection of the onset of a depressive episode. Feedback can also constitute directing the patient to a psychiatrist or psychologist (either in-person or via remote call), chat bot, medical service, etc.

Questionnaires can be used to develop baseline data about patient conditions, such that changes can be detected during operation by comparison with the baseline data. For example, a patient can be requested to write a paragraph that can be used to detect statistical changes (number of grammar errors per page, etc.) in later writings of the patient. Another example is to provide texts with varying levels of nonsense (on a scale of 1 to 10, where 1 is meaningful and coherent text and 10 is meaningless and disjointed text). Periodically asking the patient to evaluate the meaningfulness or coherence of a piece of text can enable an understanding of the patient’s grasp of reality, and how that grasp changes with time. Periodic questionnaires can

themselves be used to detect changes in patient mental health. It is usually difficult to obtain data from patients to train machine learning models to detect, for example, if a patient's speech has grown odd or bizarre. Questionnaires (and the patients' answers to them) can be used to train machine learning models to detect changes in patient behavior.

The described techniques are implemented with appropriate user permissions and in compliance with laws and regulations related to collection and use of data. The techniques are implemented locally on user devices. The techniques are implemented in consultation with appropriate medical practitioners. Detection of changes in mental health based on such parameters is complementary to regular medical screenings and can assist the medical professional through early alerts and/or more granular data on patient behavior.

Further to the descriptions above, a user (e.g., the patient, a family member, a caregiver and/or other medical professional, as appropriate) may be provided with controls allowing the user to make an election as to both if and when systems, programs, or features described herein may enable the collection of user information (e.g., information about a user's physical environment including audio and/or video, body parameters, a user's speech or actions, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data are treated in one or more ways before it is stored or used so that personally identifiable information is removed. For example, a user's identity is treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level) so that a particular location of a user cannot be determined. Thus, the user has control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques, implemented with appropriate permissions, for automatic monitoring of patients to detect changes in the patient behavior that predict a relapse or worsening of their mental health. Various sensors in user devices such as smartphones, smartwatches, or other wearables, as well as other devices such as smart speakers, home automation devices, etc. obtain sound, image, and body-parametric data of the patient and in their environment. The data is analyzed to test for changes in the patient's behavioral patterns over time (which can be a reflection of changes in the patient's health); to test if the patient's visual and aural fields have a basis in reality; to provide feedback to the patient; etc.

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