Statistical Analysis and Design Implication for Automatic Depression Detection and Support System

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ABSTRACT

Depression is a common but serious psychological phenomenon caused by a combination of genetic, biological, environmental, and psychological factors. Varied severity, frequency, and duration of symptoms along with lack of awareness make it difficult to detect and handle for both the suffering individual and psychologists. In this study, a statistical analysis has been provided to establish correlation between depression level and behavioral trends of individuals. Survey response from around 120 undergraduate students served as knowledge base of the study. In light of survey outcome, some design implications on an automated system of depression detection and support system has been proposed.

Keywords

Depression sensing; statistical analysis; mental health; behavioral trends.

1. INTRODUCTION

Depression is the most common psychological disorder, more than just sadness. Common sadness comes and passes by shortly; continues for a few hours or a day. But in cases of individuals with depressive disorder, it may persist for days, even years. 350 million people worldwide suffer from depression, which is 5% of the world's total population. Depression is the leading cause of disability worldwide, and is a major contributor to the overall global burden of disease[3]. At its worst, depression can lead to suicide, which causes one death every 40 seconds worldwide; statistically the second leading cause of death among 15-29 year olds globally in 2012 [11]. In addition, it is estimated that 10 to 15 percent of women experience postpartum depression after giving birth, which limits their capacity of childcare, ultimately resulting in poor growth and development of children [6].

Psychologists use standard scales to detect depression. But for that, the depressed person needs to be present before the psychologist. Recent study reveals that, depression is reflected in behavioral fluctuation of certain day-to-day activities. The goal of this study is to design wearable equipment that can detect depression automatically, and take initiative to provide necessary support to the depressed individual. To ensure effectiveness of the system, a survey has been conducted among 120 participants. The survey was designed to reflect the correlation between level of depression of the participants and behavioral fluctuation in their day-to-day activities. Based on the survey, we proposed some design implications on an automated system that will detect depression and will provide support to the individuals.

The rest of the paper is organized as follows. Depression, its causes, symptoms and remedies have been discussed in section 2. In section 3, some related works have been discussed. The survey outcome has been provided in section 4. Design of an automated depression detection and support system as been proposed in section 5. The paper has been concluded discussing future prospects in section 6.

2. DEPRESSION

In terms of psychology, **Depression** is a mood or emotional state that is marked by feelings of low self-worth or guilt and a reduced ability to enjoy life. According to American Psychological Association, people with depression may experience a lack of interest and pleasure in daily activities, significant weight loss or gain, insomnia or excessive sleeping, lack of energy, inability to concentrate, feelings of worthlessness or excessive guilt and recurrent thoughts of death or suicide [4]. On the basis of symptoms, it can be classified into a number of forms [5] including:

- **Major depression:** Severe symptoms that interfere with person's ability to work, sleep, study, eat, and enjoy life. An episode can occur only once in a person's lifetime, but more often, a person has several episodes.
- **Persistent depressive disorder:** A person diagnosed with persistent depressive disorder may have episodes of major depression along with periods of less severe symptoms, but symptoms must last for 2 years.
- **Psychotic depression:** It occurs when a person has severe depression in addition to some form of psychosis, such as having disturbing false beliefs or a break with reality (delusions), or hearing or seeing upsetting things that others cannot hear or see (hallucinations).
- **Postpartum depression:** Many women experience it after giving birth, when hormonal and physical changes and the new responsibility of caring for a newborn can be overwhelming. It is estimated that 10 to 15 percent of women experience postpartum depression after giving birth.
- **Seasonal affective disorder (SAD):** SAD is characterized by the onset of depression during the winter months, when there is less natural sunlight. The depression generally lifts during spring and summer. SAD may be effectively treated with light therapy, but nearly half of those with SAD do not get better with light therapy alone. Antidepressant medication and psychotherapy can reduce SAD symptoms, either alone or in combination with light therapy.

- **Bipolar disorder:** Bipolar disorder is characterized by cycling mood changes - from extreme highs (e.g., mania) to extreme lows (e.g., depression).

Various genetic, biological, social, financial factors have been reported as cause of depression. Individuals suffering from depression exhibit symptoms in a varied range of severity, frequency, and duration depending on their particular type of illness. In accordance, their treatment also differ, including combination of medication, psychotherapy, brain stimulations etc. But it is quite alarming that, only 50% of the population experiencing major depression receive treatment; in many countries, fewer than 10% [3]. Here comes the necessity of support from family, friends and near ones. Studies reveal that, isolation from social activities increases risk of depression while social interaction and support can go a long way to fight out the problem.

3. RELATED WORKS

A significant number of research have been conducted to sense psychological state of individuals on the basis of sensor data. Some of these systems involve active participation of users while the others passively collect data to determine mental state. In [1] the authors presented a smart phone based self monitoring and assessment system for bipolar patients that can replace the existing paper based system. Here users actively participate to update information on their daily activities which assist them to manage their psychological condition and also offer the clinicians an opportunity to keep an eye remotely on their patients.

Difficulties in correlating natural expression with individual's mental state has been explored by Hoque et al. [9]. Their proposed system determines difference between natural smile and frustrated smile in accordance with context. In their extended research [8], they attempted to measure collective mood of an academic campus by Quantitative analysis of the interactions. This study also revealed periodic patterns (e.g., more smiles during the weekends) and strong correlation with campus events reflecting the emotional responses of a large community.

In [2] authors suggested that smart phone sensor data can be used to context-aware system that can automatically determine need of assistance for a patient suffering from major depressive disorder. Their suggestion paved the way to develop StudentLife [13], a continuous sensing application that assesses the day-to-day and week-by-week impact of workload on stress, sleep, activity, mood, sociability, mental well-being, academic performance on a group of students. Results from the StudentLife study show a number of significant correlations between the automatic objective sensor data from smart phones and mental health and educational outcomes of the students.

In addition to the existing system, we propose our smart phone and smart watch based context-aware automated depression detection system that will also be capable of triggering a support system when necessity arises.

4. SURVEY

As an initial step of this work we conducted an extensive survey among 120 participants, belonging to different academic departments, social class, age and gender. The views of the survey are:

- To understand behavioral change because of depression in perspective of our country
- To identify measurable parameters for depression detection
- To identify the target group requiring this sort of support

Depression Level	Number of participants	Percentage	Depression frequency	Average length of depression episode
Minimum	83	69.17	Once in a month	3 days
Mild	14	11.67	Once a week	2 days
Moderate	8	6.67	Twice a week	2 days
High	7	5.83	Once in a month	17 days

Table 1: Distribution of depression among participants

106 of our participants are undergraduate students, the rest are graduate students and faculty members. Average age of the participants is 21. 59 of them were male (50%). 101 of them use smart phone. 113 of the participants use social network in regular basis with an average of 241 friends on their profile. The level of depression the participants experienced in previous 7 days of the survey is given in Table 1.

Depression level of the participants was measured using an established scale [12]. From Table 1, it is evident that around 30% of the participants suffer from various levels of depression. As level of depression increases from minimum to mild or moderate, frequency of depression also increases. And though participants with high level of depression suffer less frequently, their length of depressive episode is evidently high, which justifies the underlying assumption of depressive disorders.

In Table 2 (last page) we present some observations that were included in our survey questionnaire with a view to shed light on our proposed system design. Among a few eye-catching observations, Table 2 shows that higher percentage of participants with at least mild level of depression prefer talking with friends while depressed. Individuals suffering from high level of depression use phone more frequently and for longer amount of time than others. Their higher need of support justifies this behavior. Though most of the participants avoid sending SMS while depressed, higher percentage of them send longer than usual SMS. A clear deviation is also found in Facebook chatting pattern at depression. Higher percentage of individuals chat less or do not chat at all while depressed, especially individuals with high level of depression show clear aversion to Facebook chatting (86% of individuals with high depression chat less or do not chat at all). Most of our participants prefer staying at home while depressed, but a notable percentage show interest in going out. It is also noticeable that most of the participants prefer classical music while depressed but in case of high depression, highest percentage of individuals refrains from listening to music of any kind.

5. PROPOSED SYSTEM OUTLINE

Our proposed depression detection and support system constitutes of three modules:

- Data Collection
- Data Analysis
- Support System

5.1 Data Collection Module

In the proposed system, data will be collected from sensors of wearable device. Users do not need to explicitly participate in data collection. The wearable device periodically collects data on several parameters including user's physical state, behaviour and so-

cial interaction. Sensors provided with these devices will provide data on:

- **Heart rate:** A study conducted by Harvard Medical School [7] shows that, cardiovascular system is directly affected by mind and mood. Psychological states like anxiety, depression etc. create a state of emergency readiness, which results in hormone levels rise, blood vessels constrict, and heartbeat speed up. If a person is seriously depressed or anxious, the emergency response becomes constant. Eventually it damages the blood vessels and makes the heart less sensitive to signals telling it to slow down or speed up as the body's demands change. Our proposed system will monitor these deviations and try to detect depression from the heart rate sensor data.

- **Sleep duration and quality:** Irregularity in sleep duration and quality is one of the key symptoms of depressive disorder. In [10] authors report that most of the patients suffering from depressive disorder first seek help due to insomnia or hypersomnia. Their study outcome state that 83% of depressed patients had at least one insomnia symptom which imply that we can potentially detect depression by monitoring sleep pattern of users.

- **GPS location:** Our survey outcome depicts that depression creates a significant change in movement pattern of individuals. Most of our survey participants prefer staying at home while depressed when they were supposed to be at their work place. Our system will be designed to track GPS location with a view to identify the change in movement pattern due to depression.

- **Communication through phone, email, social network:** As we discussed in our survey data analysis, depressed individuals largely deviate from their usual social interaction which can be a potential indicator for depression detection.

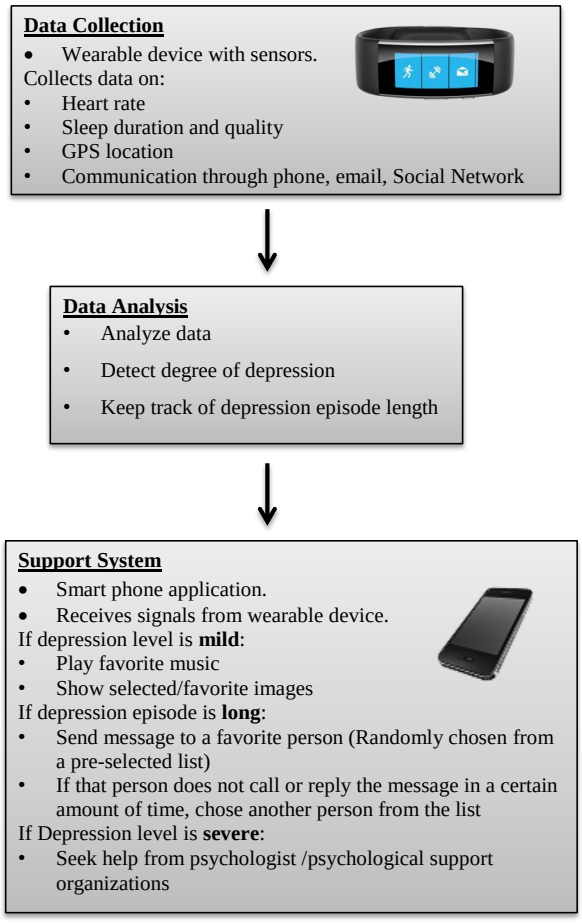

Figure 1: System Outline

5.2 Data Analysis Module

As the wearable device automatically collects data on several physical parameters and social interaction, these data will be sent to the synchronized smart phone periodically, where it will be analyzed to identify specific patterns indicating depression. Machine learning methodologies will be implemented to provide better personalized service to the user. Once the system detects depression, it will trigger supportive measures. At the same time the system will keep record of the length of depression episode to identify the severity of depression and initiate adaptive support mechanisms.

5.3 Support System Module

The support system will vary from person to person and might require rigorous calibration. An android application will be designed to act according to the level of depression.

1. **If depression level is mild:**
   - Play a music track from a pre-selected list
   - Show images of memorable events on phone screen, etc.
2. **If depression episode is long:**
   - Send message to a person, randomly chosen from a pre-selected list
   - If that person does not call or reply the message in a certain amount of time, the next person from the list will be notified
3. **If depression level is severe:**
   - Alert psychologist or psychological support organizations

6. CONCLUSION

In recent years, technology has been blamed to loosen the relational ties, though it has offered more versatile means of social communication than ever before. So now it is the responsibility of technical minds to direct the best usage of technological advancements in betterment of mankind. Ours is a small effort to find a way of using technology to understand who is in need of support around us. If succeeds, it will reveal a new dimension of interpersonal communication to prevent or cure these type of disorders.

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	Minimum	Mild	Moderate	High
Preferred way of conversation	**1.** Face to face (39.5%) **2.** None (34%)	None (53%)	None (50%)	**1.** Face to face (43%) **2.** Phone (43%)
Preferred company for conversation	**1.** Friends (54.6%) **2.** Family members (21%)	Friends (53%)	Friends (50%)	Friends (43%)
Average interval between phone call	11 hours (39% don't use phone while depressed)	53% don't use phone while depressed	10 hours (37% don't use pone)	6 hours
Average phone call duration	7 minutes	8 minutes	10 minutes	16 minutes
Average interval between SMS	40% avoid messaging over phone	Once in three hours	Once in three hours	43% avoid messaging over phone
Length of SMS	**1.** 32% send shorter sms **2.** 28% send longer sms	**1.** 60% send shorter sms **2.** 33% send longer sms	71% send longer sms	43% send longer sms
Interval between Facebook chatting	**1.** 30% chat less frequently **2.** 11% chat more frequently **3.** 28% don't chat at all	**1.** 33% chat more frequently **2.** 33% don't chat at all	**1.** 37% chat less **2.** 25% chat more frequently **3.** 25% don't chat at all	**86% chat less frequently or don't chat at all**
Duration of Facebook chat	**1.** 26% chat shorter than normal **2.** 16% chat longer	40% chat longer	**1.** 25% chat shorter **2.** 25% chat longer **3.** 25% don't chat at all	**86% chat shorter or don't chat at all**
Preferred place to stay while depressed	**1.** 35% prefers home **2.** 35% like to go out **3.** 22% prefers to stay with friends	**1.** 40% prefers home **2.** 40% like to go out	**1.** 37.5% prefers home **2.** 50% like to go out	**1.** 57% prefers home **2.** 28.6% likes to go out
Preferred type of music while depressed	**1.** 20% don't listen to music **2.** 45% listen to classical music **3.** 14% prefer rock music	66.7% listen to classical music	50% listen to classical music	43% don't listen to music

Table 2: Behavioral fluctuation due to depression

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