Psychologist in a Pocket: Towards Depression Screening on Mobile Phones

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Abstract. Depression is the most prevalent clinical disorder and one of the main causes of disability. This makes early detection of depressive symptoms critical in its prevention and management. This paper presents and discusses the development of Psychologist in a Pocket (PiaP), a mental mHealth application for Android which screens and monitors for these symptoms, and–given the explicit permission of the user–alerts a trusted contact such as the mental health professional or a close friend, if it detects symptoms.

All text inputted electronically–such as short message services, emails, social network posts–is analyzed based on keywords related to depression based on DSM-5 and ICD criteria as well as Beck's Cognitive Theory of Depression and the Self-Focus Model. Data evaluation and collection happen in the background, on-device, without requiring any user involvement. Currently, the application is in an early prototype phase entering initial clinical validation.

Keywords. Depression; mHealth; Psychological Health

1. Introduction

Conventional mental health assessment involves a series of procedures primarily involving a clinician's direct interactions with patients. MHealth presents unique advantages in the field of mental health, particularly in assessment, by reducing or eliminating errors associated with perception, impression-formation and recall. It augments the traditional diagnostic evaluation and process and acts as an intermediate medium between patients and clinicians. Since it allows for ecological momentary assessment (EMA), the use of mobile technology prevents retrospective bias by capturing behavior at the moment of occurrence or closer in time to experience [1]. It makes it possible to study cognition and other processes via the analysis of everyday language used in text messages and social media [2]. Objectivity in gathering data is further enhanced with the ability of current smartphones to monitor additional physiological signals and correlates via sensors or external hardware devices. More importantly, assessments are private and entail no undue attention, thereby diminishing or eradicating the fear of being stigmatized.

This paper presents and discusses the development of Psychologist in a Pocket (PiaP), a mental mHealth app which screens and monitors for depressive symptoms. Text inputted electronically (such as short message services, Emails, social network posts) are analyzed based on keywords related to depression. Data evaluation and collection are on-device, with very minimal user involvement.

2. Related Work

A number of existing approaches use smartphones to monitor clients. BeWell [3], developed by Dartmouth University, checks user well-being of a user via passive sensing in three axes: sleep, physical activity and social activity. StudyLife and MoodRyhthm further extend BeWell. StudyLife assesses stress level among college students. MoodRhythm detects signs of bipolar disorder via self-reports, while encouraging healthy behavior. All of these applications use a cloud service for data analysis.

The MONARCA project developed a passive sensing system [4] for monitoring bipolar disorder by combining self-assessment with passive sensing. Patients use a website to display the evaluation of their measurements.

Finally, EmotionSense [5] is a framework for collecting data in human interaction studies based on mobile phones. It supports emotion detection and speaker recognition based on events logged through the phone's microphone and other sensors.

3. Depression as a Use Case

Depression is identified as the most prevalent clinical disorder [6] and is the main cause of disability [7]. This makes early detection of depressive symptoms critical in its prevention and management. However, factors such as lack of mental health professionals, insufficient awareness, misconceptions and cultural stigma, pose barriers to proper screening. Primary strategies used by clinicians in evaluating and diagnosing depression are interviews, behavioral observations, client-supplied data (e.g., self-reports), and reports by significant others [8]. Despite these, due to its complexity, depression may still be overlooked. Face-to-face interviews may elicit negative bias in recalling past events and rating scales may result to the overestimation of symptoms and levels of stress [9].

3.1. Mental Health and Psychologist in a Pocket

The Psychologist in a Pocket (PiaP) is an application that screens for depressive symptoms via text analysis. An advantage of this technique is that it is possible to observe and study negative schemas and self-focusing tendencies via negatively-valenced and self-focused text inputs. Since users hyper-communicate due to cognitive load [10], the presence of dormant or active negative schemas in depression-prone or depressed individuals may be revealed and confirmed.

We designed PiaP to employ the Experience Sampling Technique (ESM), a form of EMA [11]. This approach (a) measures transient variables (such as mood) [9]; (b) reduces recall bias by gathering real-time data; (c) captures a multitude of behavior

samples that detects fluctuations over time; (d) presents textured representation of behavior or experience; (e) gathers data on an individual's functioning in many situations; (f) adjusts measurement techniques specific to a group of users; and (g) allows for privacy.

3.2. Criteria for Detecting Depressive Symptoms

PiaP is anchored on two systems of classification: the DSM-5 criteria for Major Depressive Episode and the ICD-10 criteria for Depressive Episode.

In the Diagnostic and Statistical Manual of Mental Disorders (DSM) [12], Major Depressive Episode is an essential feature of Major Depressive Disorder. Symptoms usually develop from days to weeks, although before its onset, anxiety and mild depressive symptoms may be observed for weeks to months. To confirm an episode, at least 5 out of the 9 symptoms (depressed mood, significant decrease in interest or pleasure, significant weight loss, psychomotor agitation, psychomotor retardation, fatigue or loss of energy, feelings of worthlessness or excessive or inappropriate guilt, diminished ability to think or concentrate or indecisiveness, and recurrent thoughts of death and suicidal ideation) must be present for a period of at least 2 weeks causing distress and impairment in important areas of functioning.

The International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) [13] discusses three grades of severity of depression. It is characterized by depressed mood, loss of interest and enjoyment, reduced energy leading to increased fatigability and diminished activity, and marked tiredness after only slight effort. Other common symptoms are reduced concentration and attention, reduced self-esteem and self-confidence, ideas of guilt and unworthiness, bleak and pessimistic views of the future, ideas or acts of self-harm or suicide, disturbed sleep, and diminished appetite. Bodily symptoms include weight loss and marked loss of libido.   Mood change may also be masked by irritability, excessive alcohol consumption, histrionic behavior, and exacerbation of pre-existing phobic or obsessional symptoms, or by hypochondriacal preoccupations. At least 2 weeks is usually required for diagnosis, but shorter periods may be reasonable if symptoms are unusually severe and of rapid onset.

As an example, the user might input the sentence: "I feel blah" into his or her text messaging application. PiaP will detect the word *blah*, a keyword in the category *Depressed Mood*. In combination with the personal pronoun *I*, which reflects self-focused attention, our system can tally words and expressions indicative of different symptoms associated with depression.

4. Design

Foremost, PiaP is not designed to replace human mental health professionals, but to complement and assist them through additional monitoring and assessments. The final decision on diagnosis and treatment will stay with well-educated, empathetic professionals together with their clients.
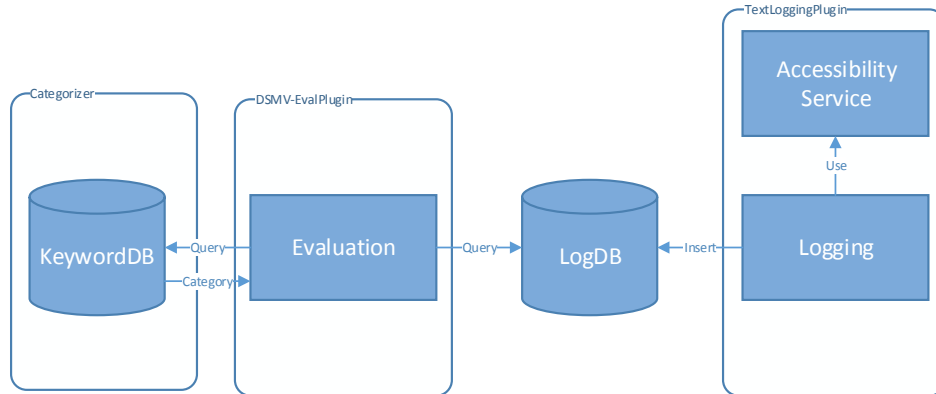
Figure 1. The Psychologist in a Pocket application logs all user input by registering to the phone as an accessibility service. It evaluates the recorded user input using a lexicon matching possible input to depression symptoms. Aggregating the detected symptoms it helps the assessment by a mental health professional.

On the technical side, PiaP [14] is an Android smartphone application, consisting of a plugin system with two main component types: (a) logging components and (b) evaluation components. The primary logging component implements an accessibility service to gather all text inputs from the user, such as SMS, Social Network Updates, and Web Searches. Additional logging component plugins for location and other sensors, for instance interfaces to fitness trackers and sleep detection, exist.

The evaluation component runs once a day, when the phone connects to a power source or on explicit user request to derive a conclusion from the logged inputs. It iterates through all the previously logged inputs of the user and sends the logged words and sentences to a rule-based classifier. Here, the words are matched against a language specific depression lexicon to check if the user input matches a specific category of depressive symptom. Thus, for a word or sentence, a list of matching categories is returned (Figure 1). Using DSM and ICD guidelines, the depressive symptoms are aggregated for possible assessment by a mental health professional.

5. Discussion

Designing a mobile mental health application poses a number of challenges. In the following, we will discuss key aspects.

5.1. Privacy

A primary concern of using of mobile technology for mental health care is privacy. People tend to be wary of cloud services handling personal health-related data. However, as smartphones are becoming more powerful, analysis of the data on-device–without using an Internet or cloud service–becomes possible.

People are often hesitant to share information like visited locations even with close friends, using white lies to cover it up. If an application logs their visited locations, safety and security risks may arise for the person if this data is leaked. This problem is aggravated when dealing with very personal–especially health and mental health–data.

For this reason, we made the design decision for PiaP to not require any Internet connectivity, in particular not even the permission to access the Internet. Health, location and user input data will never be uploaded to a cloud service, unless PiaP is given explicit consent from the user to do so. To enforce this, if the user wishes to automatically alert a trusted third party of a possibly deteriorating health status, he has to install an optional plugin. Only this plugin has Internet or SMS permissions. This avoids security risks, associated with the transmission and storage in a cloud service. The data gathered by PiaP is gathered and evaluated only on the local device.

Furthermore, participants in focus group discussions have raised concerns about another person–a friend or family member temporarily using their mobile phone–potentially being able to see their private data in the application [15]. Therefore, we require the user to enter a password before access to any possibly sensitive information is granted. In order to minimize the uncertainty a user has with regard to what the application is doing with his or her personal data, he or she can inspect every piece of logged data.

5.2. Extensibility

A smartphone application monitoring depression may make use of several data sources in order to be able to accurately evaluate the mental state of a user. As an example, restricting it to only consider sleep monitoring might lead to false positives, as the user might also have poor sleeping habits due to a stressful job.

However, utilizing a large number of features to assess the situation bears the risk that the client might not be comfortable with specific features. As an example, users might have reservations of their location being monitored for signs of depression, such as not leaving the house for extended periods of time. To avoid that a user decides against using the application altogether, we designed PiaP to use plugins for specific functionality that can be installed and uninstalled separately, so that only the functionality a user actually wants is available on the device. In this example, the user could uninstall the location monitoring, allowing a slightly degraded evaluation quality.

Furthermore, by using a plugin architecture, permissions which might make the user uncomfortable can be separated to a specific plugin of PiaP. The user can decide for himself or herself, if he or she wants to install the plugin from the app store in order to use the feature requiring this permission.

Finally, PiaP attempts to integrate with third party applications as seamlessly as possible. Third party plugins may provide custom features or use specific subparts through an API. Classifying words or sentences into specific categories might for instance be also useful to other applications. This service is therefore available for other applications through the use of a ContentProvider.

5.3. Bases for the Depression Lexicon

Items, such as keywords, are primarily based on the DSM and the ICD. Theoretical theories, such as Beck's Cognitive Theory of Depression and the Self-focus Model, represent related sources. Additional items are derived from focus group discussions with college students, interviews with mental health professionals and blogs and social network sites. We are developing depression lexicons for English and Tagalog. This lexicon undergoes analysis and testing via the Tripartite Model of Test Construction to establish its reliability and validity for detecting depressive symptoms.

5.4. Future Research Direction

We are currently testing content validity with 10 subject matter experts in the fields of clinical psychology, guidance and counseling and psychiatry in the Philippines. Afterwards, we will run the research version of PiaP with high school and college students. Finally, we aim to establish norms, to serve as interpretation guides.

Furthermore, we are looking into analyzing voice features as an additional measure for mood, as well as machine learning for automatic categorization of user input.

6. Conclusion

In this paper, we introduced PiaP as a mobile mental health application with a focus on monitoring depression. We discussed design decisions, such as on-device evaluation to ensure user privacy. Furthermore, we presented the next steps including clinical validation and possible technical extensions.

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