Depression Diagnostic and Screening Tools Using Android OS Platform

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Abstract. Depression affects all walks of life and is a common form of mental health illness. Some of the common methods to diagnose depression are usually through a session with certified psychiatrist or with the aid of depression rating scales. This paper seeks to provide both clinicians and patients with an Android based mobile application that may store and calculate results based on depression rating scales i.e. DASS and MINI. A novel approach of combining both questionnaire statistics is proposed in one solution. As such, a tablet friendly application that uses a scoring algorithm and a series of psychiatric questionnaires as an indicator to a person's mental state or depression level is developed by means of an android platform.

Keywords: Mental depression level, Android application, Mobile depression questionnaire, Depression Rating Scale, DASS, MINI.

1 Introduction

Technology is aimed at making our lives easier. This in turn enables us to accomplish many things at once for multitasking purposes. Looking at the electronic gadgets for example, where the sizes are getting smaller, lighter and the processor's speed is faster. There are laptops, smartphones and the latest trend is tablets where miniaturizations take place. The electronics industry now is at its most competitive state, where a lot of companies are introducing their products into the market ever more quickly in order to get ahead in the industry. This scenario in turn makes other industries to adapt quickly to these latest of technology aiming to make our jobs easier and runs more efficiently.

The brain is one of the most hardworking organs we have. Our work efficiency is very much dictated by the state our mind, therefore it is monumental that the mind stays healthy. One of the common mental illnesses is depression, which can affect all walks of life. It can affect a person's ability to work, form relationships and destroy their quality of life. At its most severe state, depression can lead to suicide and is

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responsible for 850,000 deaths every year. New research published in BioMed Central's open access journal BMC Medicine compares social conditions with depression in 18 countries across the world [1]. There are many levels of depression and each has its own treatment; to name a few: Major Depressive, recurrent Major Depressive, and Major depressive with Melancholic features.

At present, depression is formally diagnosed by clinicians during therapy sessions and can also be aided by the use of depression rating scales. A depression rating scale consists of a series of psychiatric questionnaires with unique scoring algorithm, which indicates the severity of the depression symptoms. There are several depression rating scales available. In this paper, a hybrid approach of combining two types of depression rating scales i.e. Depression Anxiety Stress Scales (DASS) and Mini-international neuropsychiatric interview (MINI) is proposed. Although these rating scales are commonly used by clinician to indicate the severity of depression symptoms, however there are no tablet-friendly applications that will ease the process.

The tablet usage is growing rapidly over the past few years. The APPLE iPad had started off to rave reviews, and is expected to increase its volumes and further surpasses its competition. However other tablet computers, in particular those based on Google's Android operating system, are expected to erode its share of a fast-growing market [2]. Tablets are indeed a very versatile electronic device; it is light enough to be carried by hand in extensive periods, and large enough to be used as a display for daily use or even professional use. Hence it is practical to use the tablet as a platform to house the application. The application runs on Google Android, which is the first complete, open, and free mobile platform developed by Open Handset Alliance™ (OHA) [3].

The finished application prototype has achieved these three primary goals:

1. A working algorithm which calculate the results for DASS and MINI questionnaire
2. A database which housed psychiatrist and patient's profiles and questionnaires.
3. A successfully developed application using JAVA programming language with a user interface on Android platform for displaying user profiles and results history.

2 Related Work

Depression is regarded as a mental state or chronic mental disorder characterized by feelings of sadness, loneliness, despair, low self-esteem, and self-reproach; accompanying signs that include psychomotor retardation (or less frequently agitation), withdrawal from social contact, and vegetative states such as loss of appetite and insomnia. There have been a number of research studies addressing depression that includes depression screening and detection, data analysis and classification approach [4, 5] as well as study on the effects of depression [6].

Previous works that relate to depression screening system and detection however varies ranging from software-based to hardware-based, mostly integrating not only questionnaires response and text as a subject's input to the system but also images and voice as well. Similar research was conducted by Akan et. al. by having a pilot study that screens for depressed patients using a web based application called the

eScreening tool. This tool provides a graphical user interface, audio output and a database presenting the PHQ-9 and CAGE screening tests [7]. Arianti et. al. has developed a depression inventory system called the Beck Depression Inventory II Test that works as an assessment tool for the healthcare professional to diagnose depression level of a patient [8]. A different type of depression acquisition was reported by Moore et. al. using the self-rated mood data to forecast future depression ratings. The data used in the study have been collected using SMS text messaging and comprises one time series of approximately weekly mood ratings for each patient analyzed using forecasting method [9]. Some other related applications were proposed by Bevilacqua et. al [10] and Kipli et. al. [11] that presents depression detection tools using image and facial expression while Cohn et. al. [12] integrated both facial and vocal prosody in recognizing patient with depression. Another depression detection system focusing on hardware was also introduced by Leon et. al.[13] called the smart home-based detection for depressive disorder. Despite all the research works mentioned, there is no tablet-friendly application which integrates both MINI and DASS questionnaires for depression detection purposes.

3 Android Operating System

Android Operating System is a software stack for mobile devices based on Linux with a Java programming interface. The Android SDK provides the tools, e.g. a compiler, debugger and a device emulator as well as its own Java Virtual machine (Dalvik Virtual Machine - DVM). Android OS supports 2-D and 3-D graphics using the OpenGL libraries and supports data storage in a SQLite database.

A smartphone pre-installed with Google Android SDK v2.3.6 (Gingerbread) is used to showcase this application prototype. Android applications are generally forward-compatible with new versions of the Android platform and higher Application Programming Interface (API) levels [14]. The application should be able to run on all later versions of the Android platform. Android operating system uses its own Virtual Machine called Dalvik Virtual Machine (DVM), which interprets and executes portable Java-style byte code after transforming it, which is optimized to operate on the mobile platform [15]. Android phones ship with a rich array of built-in activities (services), including email, a Web browser, and a map application [16].The platform embraces a replace-and-reuse philosophy, which lets users customize the phone [17].

3.1 Android Development Tools (ADT) for Eclipse Indigo IDE

Eclipse is an integrated development environment (IDE) for Java and its SDK is free and open source software [18]. Google provides the Android Development Tools (ADT) to develop Android applications with Eclipse. ADT extends the capabilities of Eclipse by enabling quick set up of new Android projects, creating application UI, adding packages based on Android Framework API, debugging applications using the Android SDK tools, and even export signed (or unsigned) ".apk" files in order to

distribute the application [19]. ADT also provides an Android device emulator (Android Virtual Device), so that Android applications can be tested without a real Android phone. The application is developed using Eclipse with ADT.

4 DASS Questionnaire

Depression Anxiety Stress Scale (DASS) is an example of a self-report instrument. Depression can be diagnosed through several methods. Traditionally, a qualified person in the psychiatric field may evaluate patient's mental state by having a one-to-one interview session. This is the commonly used method, however it is time consuming and not easily accessible by the medical practitioner since the patient's records are kept individually.

Another method in determining depression level of a person is through the use of psychiatric questionnaires. Although it is not used to ultimately decide whether a person is depressed, it is used to give advices to the patient to seek further help if needed. DASS scale is a set of three self-report scales designed to measure the negative emotional states of depression, anxiety and stress [20]. Table 1 depicts an example of DASS scoring which is used for this application.

5 M.I.N.I Questionnaire

The Mini-International Neuropsychiatric Interview (M.I.N.I.) is used during diagnostic interview. It was developed for DSM-IV and ICD-10 psychiatric disorders [21].Unlike DASS, MINI may be considered as a diagnostic tool for depressive disorders. The method of scoring and implying the questionnaire is also different to DASS which is a self-report instrument. MINI on the other hand, requires a licensed clinician to review and evaluate the patients. In order to calculate the scoring in the application, a slightly complex algorithm is required. All questions in the questionnaire must be rated by clinician who requires clinical judgment by the rater in coding the responses of either a Yes or No [21].

6 Methodology

6.1 Application Block Diagram

Fig.1 shows the general block diagram of the application. It shall have users profile and response from the questionnaire as an input. Users will be able to enter their profile information via a user's interface (UI). The output of the application is the results of the questionnaires taken and the scoring history for both depression rating scale i.e. DASS and MINI. The score history is managed by SQLite.

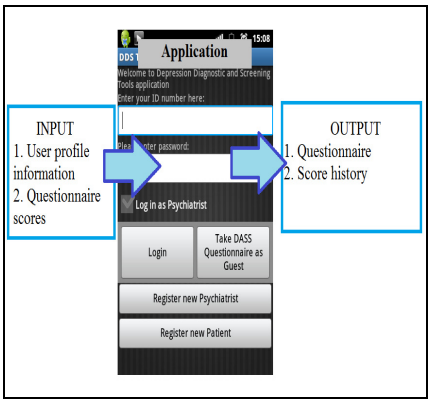


Fig. 1. System Block Diagram

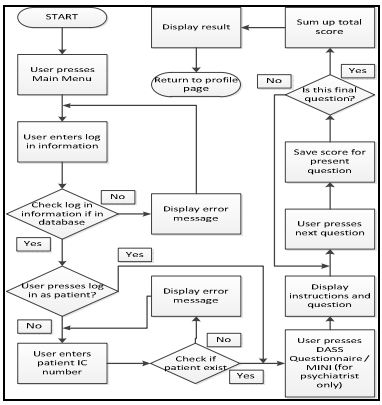


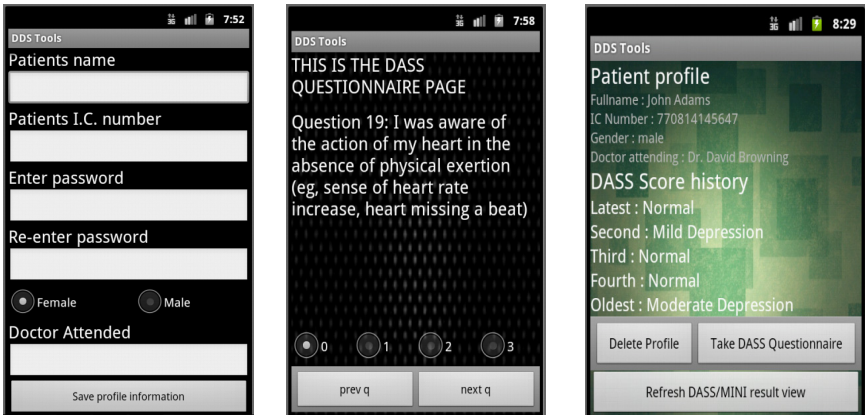
Fig. 2. Questionnaire flowchart

6.2 User Interface

There are two types of users i.e. patient or clinician. Both have different access level and user interface due to their different roles in applying the depression rating scales. DASS is a self-report instrument meanwhile MINI can only be administered by clinicians. Therefore, a patient type user will be able to take DASS questionnaire and view previous historical scores. Meanwhile, a clinician type user will have access to patient's historical records for e.g. DASS and MINI scoring history. Clinician type user will also be able to administer MINI for registered patients.

1) **Login Interface:** Prior to using the application, users are required to login at the register page which contains text fields for users to enter information such as user name and password. Fig. 3(a) illustrates the login interface.
2) **Questionnaire Interface:** This mobile application contains two types of depression rating scales i.e. DASS and MINI questionnaires. The style of presentation of the questions and its answer options for both rating scales are imperative due to the nature of Android devices, which are in the form of handheld devices. These handheld devices mostly have screens smaller than 10 inches diagonally. Thus, the interface should not be too cumbersome to navigate between questions and selecting answer options. Fig. 2 shows the designed flowchart for the graphical interface on the screen which shows one question at a time. The same interface will be reused for the next question and only the question element will change at the press of either next or previous question. This way, the screen is kept clean and simple. There are not too much activity going on the screen and therefore it is easy to navigate between questions. Score options uses radio type button in which only one can be selected at any time. This prevents multiple answers for any single question. The element for this interface is set to scrolling type, so that the questions may be viewed comfortably in horizontal view. Fig. 3(b) illustrates an example of questionnaire interface.

3) **Profile Interface:** Fig. 3(c) illustrates a sample of profile page interface for patient type user. It displays profile of the patient, the patient's DASS and MINI result history as well as questionnaires button. The view for patient's result history is toggled between DASS and MINI due to space limitations.



(a) (b) (c)

Fig. 3.

6.3 Scoring Algorithm

1) **DASS questionnaire scoring:** DASS questionnaire requires the patients to rate themselves a rating between 0-3. The number basically represents the score for each question. The scoring is done by summing up the total score and the corresponding depression classification based on the score as shown in Table 1.

2) **MINI questionnaire scoring:** Scoring for MINI questionnaire is more complex compared to the DASS scoring system. In MINI questionnaire, patient is given two answers to choose from: Yes or No. The MINI questionnaire has a total of 16 modules, but only relevant module i.e. Module A - Depression Rating Module is selected. In Module A, there are a total of 17 questions. The session may end at any point and not necessarily for all 17 questions to be answered if certain questions are answered "No". For instance, at question 2, if the patient answered question 1 and 2 with "No", the session shall end with the result being "No Major Depressive Episode". A rule-based approach is employed for the scoring algorithm.

Table 1. DASS scoring system

	Depression(D)	Anxiety(A)	Stress(SS)
Normal	0 – 9	0 – 7	0 – 14
Mild	10 - 13	8 – 9	15-18
Moderate	14 – 20	10 – 14	19 – 25
Severe	21 – 27	15 – 19	26 – 33
Extremely Severe	28+	20+	34+

7 Results

The scoring algorithm of the application is tested by conducting experiments to verify and validate its accuracy via functionality testing. Additionally, usability testing is conducted on eighteen users to analyze user's experience via an evaluation survey.

7.1 Functionality Test

The questionnaires were administered to ten subjects. At the end of the questionnaires, the total score is summed up and compared to the scale to determine the level of depression it represents. The subject's responses were then fed into the application. The results for both types of manual and application scorings are compared against each other. It was found that the scores for DASS questionnaire completed manually using forms were identical to the scores for DASS questionnaire fed to the application for all ten patients. This is true for MINI questionnaire as well. Hence it can be concluded that the accuracy of the scoring algorithm of the application is therefore verified.

7.2 Usability Test Evaluation

A usability evaluation is administered to eighteen users. It was found that 81% of the users found that the application is nicely designed. More than 93% agreed that it was easy to navigate between pages, which is quite important since navigating between questions is the core feature of the application. The placement of the texts, buttons and boxes also plays a role in ensuring that the user experience is pleasant by making it easier for user selections and user inputs. The theme of colour used in the application is deemed suitable and appropriate by 93% of the respondent. The right choice of colour is important as it could affect the mood of the user and may have an impact on users' experience. It seems that 87.5% of users agreed that the questions were appropriately presented in such a way that it is easy to read through. The choice of font type and size for the questions also plays a role. The questions are fairly easy to understand as 77% users agreed to it. Almost 94% of the users felt the scoring method used in the application is convenient. More than 75% user prefers to take the questionnaire electronically as compared to the conventional way of using pen and paper. In conclusion, users agree that the application were easy to use. This was reflected by the fact that more than 88% of users are satisfied with the overall experience in using the application as illustrated by Fig. 4. Meanwhile, Fig. 5 shows a comparison of user's self-rating prior to using the application and user's depression level analysed by the application. The result compares well which shows that the application serves its purpose in detecting depression levels.

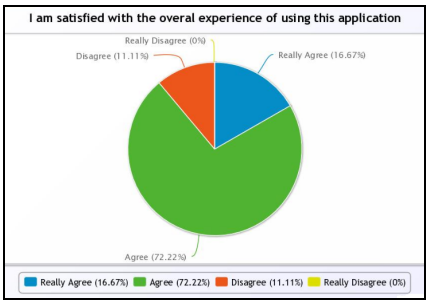


Fig. 4. User Satisfaction

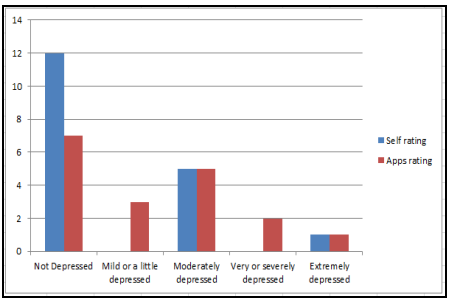


Fig. 5. Apps v/s Self Rating Comparison

8 Conclusion

The depression diagnostic and screening tool application has been successfully developed. The Android application were created using JAVA Eclipse IDE with Android ADT plugin. It has a user-friendly graphical interface for registering profiles, answering DASS or MINI questionnaires, and viewing score history. This application has the ability to store user profile information for both patients and psychiatrist. This is done through creating and managing databases using the SQLite library. The database is stored locally on the device where the information is secured.

The application successfully replicates both DASS and MINI scoring schemes. The scoring algorithm developed based on DASS and MINI questionnaire is able to correctly classify the level of depressions. Additionally, MINI questionnaire scoring algorithm provides an extra assistance during the interview session as it automatically navigates through the questionnaire as it progresses. There are some questions that can be skipped after a certain condition is met hence cutting down processing time to administer the MINI depression rating scales significantly. This certainly eases the whole interview process. Moreover, an automated system using the Android application reduces the chances of human error while computing the results. Most importantly, the application may also serve as a mobile patient management and monitoring system as it helps clinicians to monitor patients' depression level effectively over time. The mobile application is also robust enough to be upgraded with additional features for future reference. Usability testing on real-life user shows that majority of the user is satisfied with the overall experience while using the application.

Future work calls for further development to upgrade the stand alone application to a server based application. As such, an online mobile patient monitoring and management system with extended features is to be developed. This requires online connections to the server. Clinicians shall have access to patient's records in the database anywhere and everywhere internet is available.

In conclusion, throughout the paper it is shown that a mobile device may assist in diagnosing and screening depressive disorder. It is hoped that this prototyped mobile application shall further assist the clinicians in the field of mental health for depression diagnostic and screening tool that can be used on a more widely available platform.

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