

# Accompanying Depression with FINE – A Smartphone-Based Approach

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**Abstract.** Major depression is the most prevalent mental disorder and one of the main reasons for disability. To be successful in treating depression, it is necessary to have early identification and intervention. Therefore, it is important to design more objective and more efficient depression screening techniques. Such interventions provided by mobile apps shows promise due to their capabilities to support people in their everyday lives. Until very recently, the design of mental health apps that works effectively in the context of diagnostics had not been widely explored. For this reason, we have investigated potentially significant depression-correlated parameters derived from self reports, smartphone usage pattern and sensor data to specify our concept. Following the results of the requirement analysis, we developed the Android app 'Fine'. A feasibility check with a specific target audience has shown that the app can record most of the selected parameters reliably. It has also shown that the overall concept has been accepted positively with the target audience. Further work is planned to improve the functionalities and to adapt specific needs for depression attendance.

**Keywords.** Depression, smartphone, usage pattern, sensor data, apps

## 1. Introduction

Major depression is linked to a high level of strain for individuals and imposes a significant burden on society. Among the top ten causes of 'years lived with disability' (YLDs) until 2013, major depression ranks second [1]. Unlike organic dysfunctions, the diagnosis of mental disorders is neither clear nor trivial. In Germany, about 50% of depressive disorders are not diagnosed within routine screenings in primary care [2,3]. Therefore, only a minority of patients receive an adequate guideline based and punctual treatment [4]. Information technology is becoming increasingly important to psychiatry [5]. Especially smartphone apps have the potential to be beneficial for third party and self interventions for depression screening. As company in patient's everyday life, they can collect a variety of measurable objective parameters that may be pertinent to the severity of a contingent depressive disorder [6]. Therefore, the objective of this project cooperation between the University of Braunschweig and Braunschweig Medical Center is to develop and evaluate a concept for smartphone-based depression support. This paper reports on the design and the evaluation of the Android app 'Fine'.

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## 2. Methods

### 2.1. Requirement Analysis

Within the scope of a requirement analysis, functional demands for a depression app have been established. These requirements should comply with the need of patients and the need of physicians. Thus, the concept has been predicted on three approaches:

**Literature search** – An overview of smartphone-based features concerning depression recognition has been elaborated based on related researches available on PubMed and IEEE Xplore. Projects within the last three years that dealt with smartphone apps with outcome data related to major depression have been considered.

**Interviews with specialists** – Several interviews with physicians of the Braunschweig Medical Center took place. A prioritization of potential app features and measurable depression-correlated parameters have been worked out.

**Patient Survey** – A questionnaire to face the patients’ needs has been designed. It contains a list of potential app functions based on the literature search that patients should prioritize in matter of personal importance, benefit and compliance regarding the related data logging using the given 5-point Likert scale.

### 2.2. Conceptual Design

Based on the requirement analysis, functional demands have been translated into product functions and have been categorized according to topic (e. g. usage pattern or movement). As a second step, product functions have been prioritized in order to implement a prototype. Furthermore, non-functional requirements have been elaborated.

### 2.3. Depression App ‘Fine’

‘Fine’ has been designed and implemented as an Android app that collects numerous types of data that may reveal behavioral factors. The main part of data logging occurs in the background, thus there is no active user participation or specific triggering required. The graphical user interface (GUI) is kept simple and attempts to be intuitive.

‘Fine’ uses the embedded smartphone sensors to capture data with reference to depression-correlated parameters, such as usage pattern, communication, movement and depression-specific concerns (see Table 1).

**Table 1.** Overview of Fine’s collected sensor and usage data and their frequency

Category	Raw data	Frequency
Usage pattern	screen on/off	event-based
	display lock/unlock	event-based
	time on screen	event-based
	frequently used apps	event-based
Communication	incoming, outgoing and missed calls	event-based
	incoming and sent sms	event based
Movement	triaxial acceleration	every 0.2 seconds
	location	every 30 minutes
Depression-specific concern	mood diary	event-based
	mood self-assessment (PHQ-9)	event-based

For instance, a ‘display unlock’-event in the middle of the night might be a signal that the person is possibly not asleep. Similarly, a steady location combined with a low

movement profile and a high score of completed Patient Health Questionnaire-9 (PHQ-9) could be associated with an ongoing depressive behavior.

‘Fine’ uses SQLite databases to store data on the device and to calculate statistics towards usage pattern and communication as feedback to the user based on those records.

### 2.4. Feasibility Check

Four adults (age range: 27-46 years old) were recruited for the feasibility check. Three were under guidance of psychiatric therapy at the Braunschweig Medical Center and the fourth was an external patient. Major depression has been diagnosed in all of them.

Participants were provided with smartphones with ‘Fine’. They completed diary entries as well as self-assessments of mood (PHQ-9). Accelerometer data were investigated using the Signal Magnitude Area (SMA), a measure which correlates with physical activity and should be calculated every minute [7]. The execution period was one week. In a closing review, participants were interviewed regarding the usage experience with ‘Fine’.

### 3. Results

The number of active screen locks and unlocks were used to calculate the time spent on phone (see Figure 1). It is noticeable that participants used their phone more frequently at the beginning of the test period than at the end. The maximum time spent on the phone has been reached by participant 3 with a duration of 2:44h on the first day. Three participants showed no phone activity at four days each.

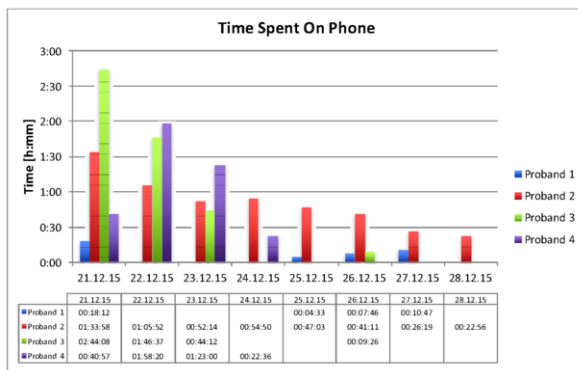
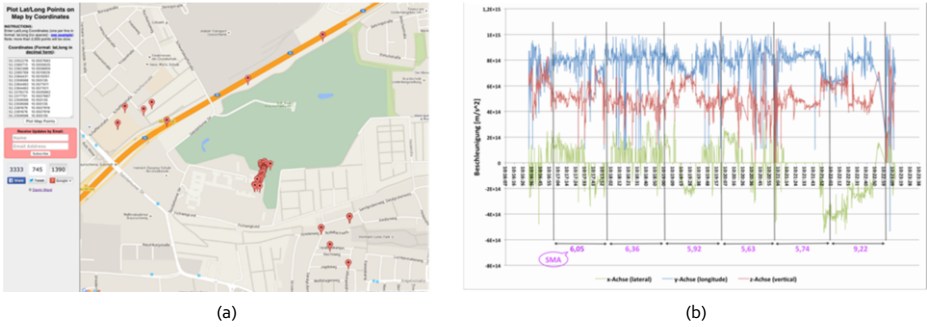


Figure 1. Comparison of time spent on phone of the four participants

GPS data has been plotted on Google Maps (see Figure 2a). The displayed participant stayed most of the time at the Medical Center and visited several places in its immediate surroundings. During the period displayed in Figure 2b, the SMA value fluctuated between 5-6 which correlates with a standing activity.



**Figure 2.** (a) Location data plotted on Google Maps, (b) Triaxial accelerometer data over a period of 6 minutes

Three out of four participants agreed to take part in the final review. All participants admit that they used the provided smartphone irregularly due to their strict agenda. Apart from the prototypical character of the current ‘Fine’ version, the overall concept served the participants well, especially the app name and the logo made a lasting impression. They would use a mature version as a substitute or supplement to their conventional treatment, provided that the recorded data and its further use is transparent to the user. In terms of functional implementation, the background logging was criticized because the user was not able to dis-/enable individual data recordings separately, such as GPS. Two participants raised concerns over the expressiveness of SMS recordings, thinking that instant messengers like ‘WhatsApp’ would be much more accurate and contemporary. Requests for upcoming versions of ‘Fine’ are further development of the (mood) diary, more feedback about the user in the form of statistics and words of encouragement to relieve the first step to seek for professional help.

## 4. Discussion

### 4.1. Comparison to Related Work

In comparison to related work, the ‘Fine’ project is still in its infancy. On a positive note, the results of the requirement analysis lead to similar parameters and features (i. e. usage pattern, location and self-assessment) as e. g. the ‘Purple Robot’ app by Saeb et al. [8]. Ben-Zeev et al. adopt a similar approach as well by investigating daily stress and changes in mental health using smartphone sensing (speech duration, geospatial and kinesthetic activity, sleep duration) and self-reports as indicators [9]. This accordance of chosen parameters reassures that the ‘Fine’ approach has a good starting position for further development in order to accompany depression.

### 4.2. Limitations

The prototype has been developed and evaluated on a LG Nexus 4 smartphone with Android 5.0. All features are tailored to this development environment. Besides, the SQL queries towards the usage statistics are adapted to the German date and time format. Hence, the compatibility of ‘Fine’ concerning another smartphone model, software version, language setting, screen size or the like cannot be guaranteed. ‘Fine’ stores recorded data locally on the device. In the current prototype version, data were

neither encrypted nor transmitted over the Internet. An elaborated security model is required, particularly due to managing of sensible personal data such as contact data, call log or diary entries. One could attempt to implement a local encryption algorithm and to provide a pseudonymization to face this problem. The feasibility check has given the evidence that the logging of the usage pattern, communication and location appears to work reliably. Unfortunately, the accelerometer data recording does not seem to maintain the aimed sampling rate. Moreover, the built-in accelerometer seems to be manufacturer-specific in its calibration. This causes problems by recalculating the Unix-timestamp to a human readable one. Nevertheless, the feasibility check needs to be seen in a nuanced light. The small number of recruited participants and the short execution period delimits the informative value. Another limiting factor is the circumstance that participants within the Medical Center were restricted using any smartphones during their therapy session(s).

#### 4.3. Conclusion

With the presented concept of ‘Fine’ a first step has been taken to support depression recognition and depression company. The results seem to be promising, but there is still a lot to be done. In two current projects, the prototype is going to be extended with a text screening function based on a text mining approach as well as speech analysis. Among others, the (mood) diary function should be refined and a security model needs to be added. With a mature version of ‘Fine’, it is planned to conduct a study to elaborate the users’ acceptance towards integrating such a mental app into their daily life and as part of their therapy. With the improvement of early (self-) interventions, the estimated number of unreported depression cases may be reduced.

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