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Research-in-Progress

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Abstract

The advancement of mobile technology has transformed a phone from a simple communication tool to a powerful device for entertainment, socialization and work. The proliferation of mobile apps further changed people's way of living and working. However, more and more users experience excessive mobile phone dependence. The traditional method to identify dependence uses survey instruments and interview. However, this approach is labour intensive and hard to scale. To address the issue, this research-in-progress paper aims to identity users' phone usage pattern and propose an unobtrusive way of diagnosing users' mobile phone dependence. We have developed an app to track users' phone usage and preliminary analysis was performed based on the data collected over more than 20 days. Users showed different usage patterns over weekends and weekdays, and social app usage is a more significant indicator for mobile phone excessive dependence than general phone usage. Planned future analysis and potential contributions are discussed.

Keywords: Mobile phone excessive dependence, Usage patterns, Analytics.

Introduction

The advancement of mobile technology has transformed a phone from a simple communication tool to a powerful device for entrainment, socialization and work. According to a survey conducted in 2013, almost 20 billion people own a smartphone and this number is still increasing dramatically (O'Donoghue et al. 2016, Drumm and Johnston, 2015). More than 10 billion apps have been downloaded from the iOS app market in 2011 (iTunes, 2011), and the number is even larger when considering the downloads form other platforms (such as Android and other markets based on Android). The proliferation of the vast variety of mobile apps further changed people's way of living and working. However, the side effect is that more and more users become heavily dependent on their phones. Excessive dependence on mobile phone causes health problems such as mental issues and insomnia (Thomée et al. 2011). Mobile phone excessive dependence has also been found to affect people's working productivity and personal relationship (Salovaara et al. 2011). A survey conducted by Cisco in 2013 shows that more people are found to experience anxiety when they are separated from their phones (Ryan 2013).

The first step to provide timely intervention for people with mobile phone excessive dependence is to understand their usage, identify the symptoms and provide diagnosis. The traditional method used to

identify users' level of dependence usually involves psychiatrists to conduct an interview or ask the users to fill in a long list of questions. The instruments are usually adopted from the literature on substance addiction (Choliz 2010), games addiction (Grüsser et al. 2006), Internet addiction (Young 1998) and social network site (SNS) addiction (Schou and Pallesen 2014). However, this interview/survey based approach is labour intensive and not easy to scale to a wider population. The respondents may also hesitate to answer sensitive questions faithfully. To address the issue, researchers have proposed to diagnose users' level of mobile phone dependence unobtrusively using actual phone usage data (Shin and Dey, 2013). With the large amount of data generated by a single person every day, this approach is becoming more efficient and accurate.

Among the various parameters used to identity excessive dependence unobtrusively, frequency and duration of phone usage are found to be the most important ones (Shin and Dey, 2013). This is consistent with the literature on other substance addiction, as users' addictive and compulsive behaviour is related to more usage and longer usage. However, mobile phone dependence is a more complicated issue than substance addiction. Smart phones are used for many purposes, including health tracking, traffic guide, work-related tasks, and etc. It is hard to identify the boundary between mobile phone excessive dependence and the increasing need to use it. Among all types of apps and tools used on mobile phone, social network apps are usually believed to cause addictive behavior (Schou and Pallesen 2014). Drawn from the literature on addiction diagnosis and mobile phone excessive dependence, the study aims to (1) *understand users' mobile phone usage pattern, with special focus on social apps*, and (2) *propose an improved method of diagnosing excessive dependence on mobile phone*.

Theoretical Background

Mobile Phone Excessive Dependence and Addiction

Mobile phone excessive dependence refers to the excessive use of mobile phones and applications installed on the phone (Kwon et al., 2016). The discussion on excessive dependence will be built on prior research on addiction, which is an extreme type of excessive dependence. Addiction often refers to uncontrollable and irrepressible actions driven by the impulsion to fulfill one's pleasure regardless of the consequences (Pollak 1970). With the advancement of information technologies, many new forms of excessive dependence have emerged, including the excessive dependence on Internet, social network sites, computer games and mobile phone (Weinstein 2010; Kuss and Griffiths 2011; Ko et al. 2012; Kwon et al, 2016). Many studies believe that excessive dependence is a disease which requires psychological and psychiatric treatment (Pollak 1970). The mechanism of Internet excessive dependence is considered similar as drug or alcohol dependency (Kandell 1998). Social network sites dependence was found to have similar symptoms as substance dependence (Young 1999). Studies on constant game playing report that the activity will generate pleasure and reinforce the release of dopamine in the user's brain, which works as a reward system to further trigger the playing behaviours (Thalemann et al, 2007). In the context of medicine, mobile phone excessive dependence is also considered as a chronic mental disease triggered by the neurological predisposition (de la Puente et al, 2007). However, there is a group of researchers suggesting that excessive dependence on information technologies can be viewed as a rational choice made by individuals (Kwon et al, 2016). Thus, there a reason to believe that sometimes excessive phone usage is a rational choice of individuals. We predict that part of the excessive phone usage is driven by the need (e.g. work and communication need), while the rest of the excessive phone usage is driven by the urge in the brain (e.g. the actual addiction).

Diagnosis of Mobile Phone Excessive Dependence

The diagnosis of mobile phone excessive dependence was largely adopted from the literature on Internet addiction, game addiction (Lemmens et al., 2009) and social media addiction (Van den Eijnden et al. 2016). Like the diagnosis of these types of addiction, psychometric instrument is also the most widely used tool for the diagnosis of mobile phone excessive dependence (Lemmens et al., 2009; Van den Eijnden et al. 2016). The administration of the instrument usually requires the involvement of

physiatrists. The respondents may have high resistance to answer some of the sensitive questions, such as "Have you regularly lied to your parents or friends about the amount of time you spend on social media?" in the social media disorder scale (Van den Eijnden et al., 2016).

With the development of smart phones, the phone itself can work as a tool to collect users' activities and behaviours, which make it possible to have an unobtrusive way to describe and understand phone usage pattern. For example, number of apps used per day, the ratio of SMSs to calls, the number of apps used per event initiated session, and the length of non-event initiated sessions are found to be useful for detecting problematic usage (Shin and Dey 2013). Nonetheless, the current analytical methods tend to treat mobile phone usage as a whole. Given the fact that mobile phone is penetrating into individual's daily life and many people use it for work, health management and other purposes, those factors may not be effective in differentiating phone usage by need and phone usage by addiction.

Among all kinds of app that are used on mobile phone, social app is a major category that are likely to cause phone addiction. Social network addiction has long been identified as a major health threat in the digital age (Van den Eijnden et al. 2016). More than one-third of the world's population, which is 2.5 billion people, now access social media services via mobile devices each month (Kemp, 2017). Thus, it is important to consider the unique effect of using social apps on mobile phone dependence.

Methodology

In order to achieve the research aims of the study, an application was developed to capture users' mobile phone usage. Participants were invited to install the app onto their phone and fill in a pre-study questionnaire to commence the study. The pre-study questionnaire works as the ground truth of the analysis. System usage log will be analysed after four weeks' of participation. The details of the research method are discussed below:

The App Development

An Android app named PhoneTracker has been developed to capture users' phone usage data. It consists of three major units: data detection and collection, data storage unite, and Graphical User Interface (GUI). Data detection and collection unit mainly detects each data slot generated by the user's action and collecting the data in predefined form. It can also receive the data generated from the PhoneTracker user interface so that we could know how users navigate in our app. Data storage unit stores collected data locally and synchronize the data to online database in a predefined period. This is also the "backend" of the user interface. Each time the user inquires on the details of usage, it will query the storage unit first. Graphical User Interface is the part where users interact directly with the app via interface layer.

The Pre-study Questionnaire

The pre-study questionnaire was designed to collect users' demographic information and self-assessed phone usage behaviour. There are two instruments used to understand participants' phone usage pattern. Section one stands for the overall usage of smartphones. The questions were adapted from game addiction scales (Lemmens et al., 2009). The participants were asked during the last six months, how often they "think about using the phone all day long" "spend increasing amounts of time on mobile phones" and other five questions related to general phone usage. The answer to each question is rated over five values: never (value 0), rarely (value 0), sometimes (value 1), often (value 1), and very often (value 1). If the total score is equal or higher than four, the participant is considered as having a mobile phone excessive dependence.

Section two of the pre-survey questionnaire asked for self-evaluation on social app dependence. The questions were adapted from social media disorder scale (Van den Eijnden et al. 2016). The participants were asked that during the last six months, whether they "regularly found that they can't think of anything else but the moment that they will be able to use mobile phone again", "had serious conflict with their parents, brother(s) or sister(s) because of the mobile phone use", "regularly had arguments with others because of the mobile phone", "regularly lied to parents or friends about the amount of time spend on mobile phone", "often use mobile phone to escape from negative feelings", regularly felt dissatisfied because you wanted to spend more time on mobile phone", "often felt bad when they could

not use mobile phone", "tried to spend less time on mobile phone, but failed", "regularly neglected other activities (e.g. hobbies, sport) because they wanted to use mobile phone". Each item represents a personality trait of a person and the participant only needs to answer "Yes" or "No" to each question. Participants will be diagnosed as mobile social app addiction if at least five or more criteria are met.

Participant Recruitment

University students were invited to participate in the study through various channels, including emails and notice board. Interested participants were required to fill-in the pre-study questionnaire before installing the app. Participant consent form and participant information statement were given to them before the start of the study. They were requested to stay in the study (with the app installed) for a month.

Data Analysis and Preliminary Results

The current study is still in-progress with ten users participating in the study. However, the analysis presented in this research-in-progress paper was based on the data collected from the first four users as the rest don't have complete data for two weeks. Descriptive statistics of the results are presented in this section.

Participants Information

The demographics of the users are summarized in Table 1 below. The users were coded as excessive dependence or non-excessive dependence based on the survey results. Only users who exceed the threshold for both section one and section two are coded as excessive dependence.

Table 1. General Information on the Participants

	Age	Gender	Record Numbers	Duration	Mobile phone dependence? (Yes = 1; No = 0)	Mobile social app dependence? (Yes = 1; No = 0)
User 1	22	Male	19613	29 day	1	1
User 2	23	Male	5728	20 days	0	0
User 3	22	Female	2564	21 days	0	0
User 4	21	Male	9344	22 days	0	1

Descriptive statistics

Parameters

Based on users' log data on phone usage, we have calculated four parameters related to general usage and social app usage. Mobile social apps refer to the smartphone applications used for social communication and social entertainment, such as Facebook, Twitter, Instagram, Youtube and etc. The definition of the social app is obtained from the office Android application market. In the Android application market, each app has its category (e.g. tool, communication, game etc.) marked under the app name. This is also used as a basis for coding the app. The parameter names and description are summarized in Table 2 below.

Table 2. Usage Parameters

Parameter Name	Description
General Usage	
Screen on/off frequency (time)	Number of screen unlocks in certain time period
Screen session (second)	Time duration from consecutive screen on to screen off
Social App Usage	
Social app frequency (time)	Number of social apps used in certain time period
Social app session (second)	Time duration of social apps used in certain time period

Usage patterns: Weekend/Weekday Social App Usage

Figure 1 describes every participants' total social app screen session everyday. The data on weekends have been highlighted. All users seem to access the social apps for longer duration over the weekends. User 1, who is coded as excessive dependence user according to pre-study survey, also uses social apps for longer duration during the weekdays. There is no consistent pattern being identified for the general phone usage.
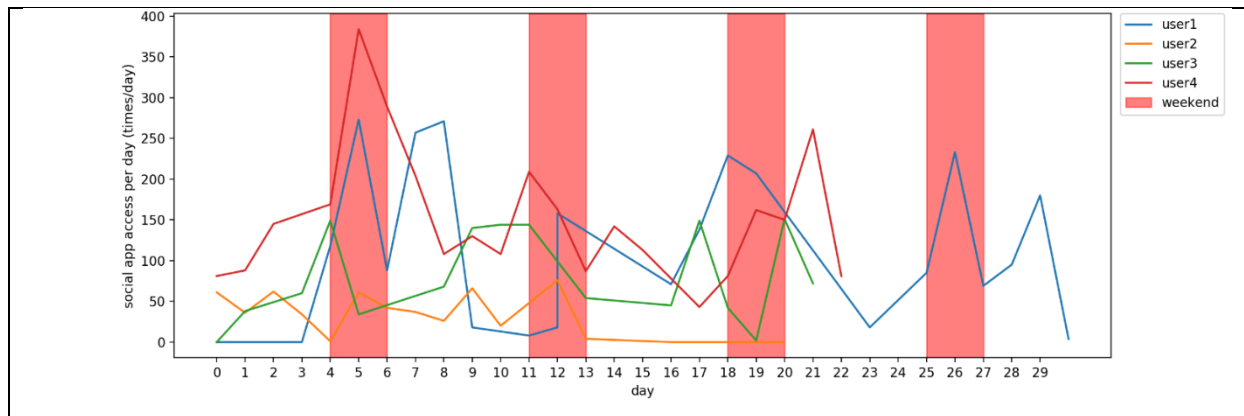

Figure 1. Weekend/Weekday Social App Usage Duration

Usage patterns: Day/Night Social App Usage

Besides the daily usage pattern, hourly data is also plotted to have an understanding on the detailed usage level of the phone from 0:00 to 23:59 on average. The plots for users' daily social app usage by hour shows that all users tend to use social apps on phone more frequently during 12:00 – 14:00 every day (Figure 2). Figure 2 also shows that user1 uses social apps more frequently during midnight, especially between 0:00 to 5:00 (Figure 2). User 1 is also found to use social apps for longer duration during midnight (Figure 3).
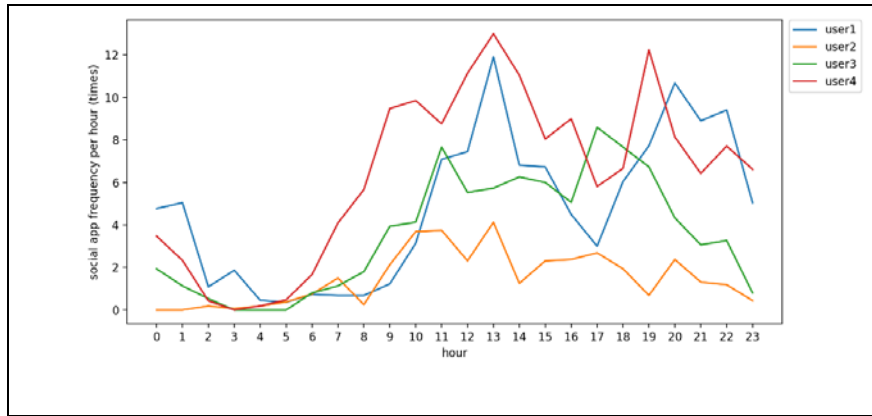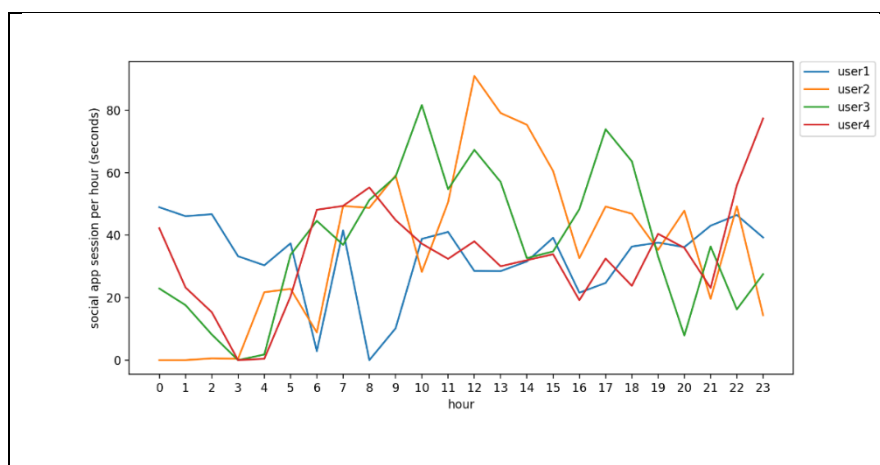
Figure 2. Daily Social App Usage Frequency

Figure 3. Daily Social App Usage Duration

Diagnostic analysis (to be conducted)

Based on the descriptive analysis, we predict that social app usage would be a better predictor for mobile phone excessive dependence than the total usage. Users have demonstrated clearly pattern of usage for weekday/weekend and day/night difference. We will consider all the factors and apply them as predictors to four candidate data mining models (Support Vector Machine, Logistic Regression, Naïve Bayes, and Decision Tree) to find out the best algorithm explaining the data well. Feature selection/reduction techniques will be applied to find the best predictor(s) describing the data set as well.

Discussions

This research-in-progress study contributes to a better understanding on people's mobile phone usage pattern. The preliminary finding from the data analysis shows that social app usage would be an important predictor for mobile phone excessive dependence. As we have discussed, the mobile phone usage is penetrating to people's daily life, people not just use it for communication and entertainment, they also use it for work, health and well-being management and many other purposes (Kemp, 2017). The finding of our study calls for an updated definition and diagnosis method for the excessive use of mobile phone.

Based on the descriptive data, we also predict that the frequency of screen unlock might also be an important predictor for excessive dependence. This is in line with the literature on substance addiction,

where people having severe dependence on the substance keep thinking of it and want to access/use it (Kown et al, 2016).We see patterns emerged based on weekday usage and weekend usage. Students and working adults usually have more leisure time over the weekends. If their phone usage during weekdays is as frequent as on weekends, there might be an issues with excessive dependence. We also see users use mobile phone for longer duration and higher frequency in the evening. If people use their phone more often during day night or in midnight, it might also be an indicator for phone dependence.

Limitations

As a research-in-progress paper, there is a few limitations that we are trying to address in the next phase of the study. In this project, we developed an Android operating system application to collect the smartphone usage data. The app offered a lightweight platform to gather and store data regardless of the place and time. Besides data collection, it has several user-friendly pages helping users to inspect the details of their device using patterns. The app runs perfectly on original Android OS but not modified Android system. Some of the smartphone manufacturers (such as VIVO) changed the default behaviour of the Android system which brought lots of troubles on installing and running the app. For instance, Huawei system consists of a smartphone manager, which constantly blocks the app, resulting in data lose during collection. We are currently trying to address the compatibility issues and implementing iOS version in order to collect more data.

The data size imposes some constraints when interpreting the results of the study, although there are thousands of results generated for each user. Besides the device data, we collected detailed smartphone use habit by each user via paper-based questionnaire. Some users (such as user3) have generated a large amount of data in general usage, in contrast, other users (such as user4) shown a clear preference for social apps. However, only user1 had a strong desire on general and social app usage. Based on this survey result, user1 was marked with excessive dependence user. There may be bias in the result if the dependence behaviour is only analysed based on one single user. Future study will definitely recruit more people and verify the results based on a large sample.

Future Plan and Conclusion

The study aims to understand mobile phone excessive dependence using actual phone usage data. An Android application was developed to collect smartphone usage data. Based on the records collected from the app, the data had been plotted into line charts to show the hourly and daily usage pattern. Different patterns have been observed for high dependence and low dependence users. Data mining algorithms were proposed to identify the pattern and analyse the data. The study contribute to the advancement of unobtrusive diagnosis method of mobile phone excessive dependence. In the future, the study will be extended to include analysing mobile game usage and other categories of app usage to have a better understanding on mobile phone excessive dependence. Additional parameters (e.g. location and phone calling) will also be taken into consideration for discovering the latent pattern.

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