StudyBuddy - A Smart Study Solution

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Abstract— **Procrastination is a serious issue while studying. With an overly extended duration of procrastination, students become more stressed due to lack of progress. As a result, we propose an interactive mobile healthcare system which can monitor study sessions and make effective recommendations to actively counter procrastination.**

I. INTRODUCTION

Due to the ubiquitous nature of smartphones, these devices have become the platform of choice for handling many aspects of everyday life, including time management. Within this domain, the aim of the Android application StudyBuddy is improving the effectiveness of study sessions for students via means of procrastination reduction. The obvious motivation for reducing procrastination is improving the academic performance of students while boosting their time management efficiency, but there is also a significant body of evidence [1], [2] . This suggests that there is a link between procrastination and stress, which provides additional medical incentive for reducing it.

Smartphone applications are a particularly suitable platform for targeting students, since 96% of them own such a device in the UK [3]. As described further in section III-A, there are several existing applications which target the same problem as ours, but to the best of our knowledge, none of them feature active monitoring of the student's activity during a session. By utilizing sensors from modern wearable devices, as well as the smartphone's built-in front camera and microphones, we aim to measure several quantities of interest that will enable us to analyze study behaviour independently of self-reported user feedback. Based on scientific evidence outlined in section III-B, we propose using the measured session data to infer the user's procrastination and stress levels. By measuring the statistics of these quantities, we aim to provide high-quality recommendations for further sessions by employing machine learning recommendation techniques. Furthermore, the application will provide an additional level of interactivity compared to competition by interpreting the input data stream suitably and offering real-time feedback and recommendations to the user.

This paper will firstly discuss and contrast competing solutions with ours in the background section. Then it will carry out a preliminary feasibility study in section III-B to justify the merits of our solution. Having presented evidence that our idea is sound, it will then describe the proposed system design and all of the major components that comprise it. Finally, in section V, it will describe our evaluation methodology and state how we will test the hypotheses that we have proposed.

II. HYPOTHESIS

Many students find themselves procrastinating and balancing their study and work load inefficiently. We believe that having an efficient counseling system that can appropriately help each student deal with and overcome the issues with procrastination [4] will reduce the great amount of stress that comes with an otherwise poorly timed schedule. As a result, we propose the following hypothesis:

"Following the correlation between Stress and Procrastination, we believe the StudyBuddy system can efficiently track, recommend and therefore reduce the amount of procrastination (that will be visually measured) amongst students and hence reduce the stress that would come with an otherwise poorly managed schedule."

III. RELATED WORK

A. Market Research

Several applications currently available on the market seek to prevent student procrastination. These often involve facilitating time management by automatically generating tailored timetables [5], [6], [7], recording and displaying productiveness in the form of useful and unuseful hours [6], [8], [9], or providing users with recommendations [6], [7], [10]. Applications which block access to selected webpages [8], [11], [12], and encourage students to focus for pre-set periods of time also tackle this problem [6], [7], [10].
StudyBuddy intends to enhance the user's studying experience by combining time-management and personalised recommendation tools, together with real-time focus estimation, to report quality of study session. An application combining all these features or performing student focus estimation is inexistent to the date.

B. Feasibility Study

a) Time-Management and Recommendations: Automatic timetables and recommendations can be generated via different Machine Learning techniques. With sufficient data in the database, StudyBuddy can utilize Collaborative filtering algorithms to find similarity between users and recommend the best fitting study plan.

b) Estimating User Attention: Lack of attention is tantamount to procrastination, hence estimating the former provides a suitable measure of the latter. Studies including [13] and [14] establish a strong correlation between an individual's visual attention and their eye movements. Moreover, [15] and [16] prove device-integrated cameras (in smartphones and tablets) are useful for the estimation of visual focus of attention

(VFOA). [16] discusses the issues arising when users' eyes cannot be seen at all times and hence; estimation of gaze from direct eye regions is not feasible [17]. Instead, the correlation between gaze and head pose can be exploited [18].
Following the outlined background research, we conclude that the use of a smartphone-integrated camera as a sensor for real-time attention level estimation is feasible.

c) Estimating Stress Levels: Assuming that wanting focus leads to stress, we seek to strengthen our estimation by measuring stress levels. These can be inferred from physiological indicators such as blood pressure, heart rate variability (HRV) and breathing rate [19]. All of these can be monitored in a non-invasive manner; by the means of a smart watch or a smartphone's integrated microphone.

IV. SYSTEM DESIGN

Figure 1 illustrates the Model-View-Controller (MVC) architecture behind the StudyBuddy application. All the key components will communicate via the controller. The data will be gathered through various peripherals, some directly built into the smartphone (camera and microphone) and some external (smartwatch). x

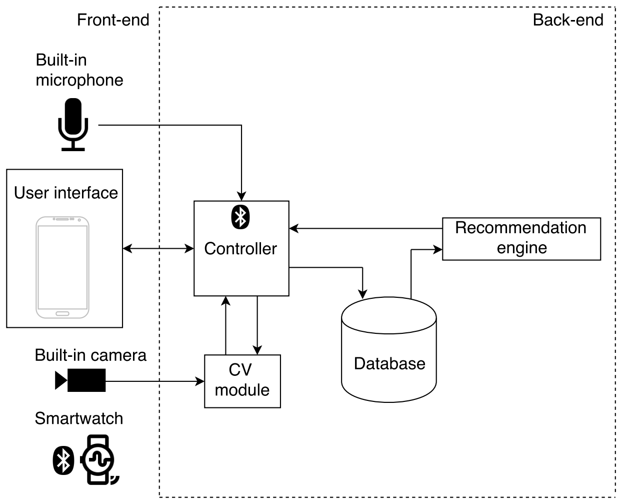


Fig. 1: System diagram

A. Hardware

In order to provide accurate statistics for individual study sessions, a wide array of data needs to be collected. We summarize the data of interest and relevant hardware below:

1) Smartphone
   - Attention levels: Using the front camera, estimation of student attention level becomes possible. The periods during which attention level is below a certain threshold are marked as "unproductive".
   - Noisy environment: Using the built-in microphone, noise levels are constantly assessed during a study session.
2) Smartwatch
   - Stress levels: Measuring HRV provides additional insight into the stress level of students. Together with attention level the data is further processed to generate recommendations for optimal study periods.

To aid computer vision algorithms, a simple stand to fix the phone's position with respect to the student's face is also part of the StudyBuddy system.

B. Computer Vision

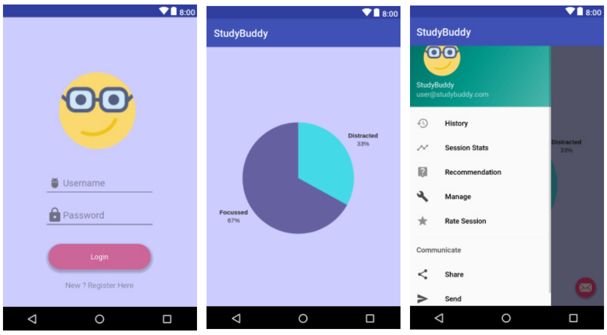
Since our solution will rely on Computer Vision algorithms for estimating user attention, it is important to identify a suitable CV library that can be readily integrated within our system given the project's limited time frame. Due to its high performance and portability, OpenCV [20] is a primary candidate for our framework of choice. This high-performance library can be integrated within Android applications relatively easily by employing existing wrappers such as JavaCV [21]. Other than providing an interface for OpenCV Java development, this framework supports several other computer vision and video processing libraries.

For the purposes of face detection, OpenCV has native support for detection based on Feature-based Cascade Classifiers [22]. To achieve a minimum viable product, we aim to perform coarse attention estimation using face detection, based on the assumption that the user will turn away once failing to concentrate. Implementing this feature will only entail integrating existing models into the system using well-tested frameworks, therefore we find this baseline solution relatively low-risk. To achieve higher accuracy, we plan to improve upon the OpenCV implementation if time permits it. By employing the Tensorflow [23] framework for on-device inference, we aim to replace the face detection model by a more accurate one based on a convolutional neural network (CNN).

As a final improvement, a more advanced eye-tracking algorithm could be implemented. A practical CNN-based system for eye tracking using mobile devices has already been demonstrated running in real time (10-15fps) [24]. In addition to pre-trained models, the authors provide a dataset with bounding boxes for faces as well as both eyes. While the original implementation was built for iOS, there exists a Tensorflow reimplementation that comes with a pre-trained model [25].

C. Database

Given the complex nature of the StudyBuddy application, a database is of paramount importance as it can help simplify the system design and bridge the gap between other components which would otherwise be taxed with too many functions. Users of StudyBuddy are expected to retrieve past information of their previous study sessions to help them understand more about their study routines and patterns. The StudyBuddy application would fare better in modular deployments (not restricted to a single cell phone) and lower consumption of the smartphones memory. Due to all of these considerations it is imperative that an external database be connected, interfaced and tallied with all of StudyBuddys components to create a robust system. Given that the Front-end design of the application will be done in Android Studio using a native Google Cloud Database would allow for easy integration of the 2 components. As a result the Firebase [26] database platform was selected. Firebase allows authenticated database calls which can privatize all the study sessions recorded on StudyBuddy and the Firebase platform performs real time synchronization of data which allows on the go access for users [27]. The Firebase platform is able to store large amounts of data which allow StudyBuddy to store training data that can be used for the recommender system (though this may be liable to change depending on the complexity of the recommender system).



(a) Login screen (b) Statistics (c) Navigation

Fig. 2: Different screens presented to the user.

D. Front-end

The Front-end of the application will be designed based on the concept of a user study session, as it effectively captures the concept of studying for a specified duration of time.

Following is a brief illustrative description of the Front-end workflow:

- The user begins by logging into the application. User authentication will be done using the database.
- This will lead the user to the next screen where the user may start a session by clicking on one of the buttons. This will trigger a countdown of ten to fifteen seconds in which the user can comfortably place the mobile on the provided stand. The Face Detector will ensure the users face is within a visible region and otherwise notify the user to place the mobile appropriately.
- On pressing the Start session button, a timer is initialized and displayed (in case the user wishes to pause the session and view the time elapsed).
- In the background, features extracted from the timer and Face tracking/eye detection are provided as input to the Recommender Engine. On pressing the Stop session button, the user is directed to a summary page where by default, a Pie Chart displaying results of inferences from the Face Tracking/Eye detection module is displayed.
- A navigation pane is provided on the sides of the screen to allow the user to:
  - View statistics: It lists the intervals of the study session the user was focused or distracted. These statistics will be an exploded view of the PieChart mentioned earlier.
  - Show recommendations provided by the Recommendation Engine as explained below.
  - Rate the current session. User feedback thus obtained will be stored in the database and used for further improving recommendations.
  - View sessions history with brief summary for each.

E. Recommendation Engine

The recommendation engine will be using data available from the StudyBuddy database to tailor the study session to each student's needs. There will be two types of recommendations given for different purposes.

1) Post and mid-session recommendations: If StudyBuddy detects a high stress level or lack of attention for extended periods, it will directly notify the user. After a session, an overview with potential tips for the future (eg. noise level was above average for the whole session, try to reduce it in the future) will be shown.
2) Long-term statistics: As enough data is collected, StudyBuddy will learn a custom model, for each user, recommending the optimal time for a session as well as the optimal length. This way, students can receive notifications based on their own habits and preferences that will improve their overall quality of life during demanding study periods.

V. TESTING & EVALUATION

A. System Evaluation

The team plans to utilise the initial market research to evaluate the effectiveness of StudyBuddy. Therefore, the main factors it will test is the reduction in distraction and stress, this will evaluate the StudyBuddys features.

StudyBuddy aims to reduce stress amongst its users by providing the recommendations listed above. There are well-documented links between procrastination and stress [28], consequently the StudyBuddy will aim to reduce stress indirectly by reducing procrastination. StudyBuddy will take steps to allow the individual to study in greater capacity and more efficiently, this leads to less procrastination and therefore less stress. Additionally, this will lead to the increase in health of the student as stress is linked to sickness, high blood pressure and many other diseases and disorders [19].

The main issue with testing the overall system is the requirement of a control group. Therefore, to test we will need to get data from people who are concentrating on their task and not distracted. A task that requires concentration and with little distraction permitted is chess, this will be played and since it requires a significant amount of concentration and can therefore act as a control.

To control for heart rate variability (HRV), we need to perform a relieving activity after using the study buddy. Some of the most effective destressing activities shown to lower HRV is listening to relaxing music, so this is how stress will be controlled [29]. To evaluate the functionality of the study buddy, the following experiment will be performed:

1) The study buddy camera will be turned on for 1 hour, but none of the features. Meaning distraction

will be measured but study buddy app its self will not send out any recommendations.
2) Then the solution and its features are now turned on. Therefore, distraction will be measured with the recommendation features turned on.

This experiment will enable us to determine whether the StudyBuddy is working correctly. Head movements and eye gaze movements will be measured and correlated with concentration level.

The three orders of evaluation are the following:

1) Self-Evaluation - This will be in the form a survey on the participants, it will ask what features of the solution were the most helpful and if the overall product was helped decrease stress.
2) Face distraction methods - Here the measurement criteria is how many times somebody is turning away from the computer screen and how many times an individuals eyes gazes away from the screen. Using this we will determine that the more an individuals face turns away the more distracted they are.
3) Heart Rate Variability - measure using a smart watch as this can be shown to correlate with stress [30].

Linking these quantitative metrics and qualitative survey results will help us gain an overall understanding, and will determine whether the solution is helping students or not. The different features of the study buddy will be evaluated, as some features will be deemed more effective than others. Therefore, each of the recommendations will be evaluated, meaning we will get an accurate view of which aspects of the StudyBuddy are effective.

VI. CONCLUSIONS

In this Design Report we have discussed the need for StudyBuddy as an interactive solution for students who become stressed from procrastination and mismanagement of time. We discussed our plan to measure numerous stress markers to isolate all factors that could directly lead to psychological stress. By using StudyBuddy to understand an optimal environment and maintain focus amongst the user we believe that the amount of time spent procrastinating while studying will decrease and consequently the stress that arises from time mismanagement will decrease as well.

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