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Attention-Preserving Technology

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Abstract

Smartphone overuse and internet addiction is strongly correlated with a sharp rise in mental health problems, reduced productivity and increased suicide rates. The applications responsible leverage techniques from behavioural science to appeal to our base human natures, causing us to form unconscious habits which lead to increased usage. This greatly detracts from an individual's productivity and ability to focus on difficult tasks.

Many attempts have been made to develop technologies which help individuals reduce these effects in the form of well-being apps. The most effective well-being apps aim to use the same techniques from behavioural science used to hook users to reverse their own effects. However, even these applications are outclassed by their opposites, which are developed by billion-dollar corporations with endless funding and developer man-hours. This project seeks to continue the work of one such well-being app, closing the gap in product quality and feature offerings by leveraging recent advancements in application development methods.

On top of enhancing the original product and its applications in behavioural rehabilitation with new features, the resulting work facilitates developer on-boarding, reduces development time and implements analytical methods for developers to quantitatively assess how effective new features are at helping users improve their focus and productivity.

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- My tight support circle of friends, whom without the guidance of I would have been lost in trying to navigate the process of building such an ambitious product within the short time span of 6 months.

Dedication

This work is dedicated to all my fellow procrastinators who set out on a a productive day only to lose time to an unplanned YouTube binge. It happens to us all, and we owe it to ourselves to be aware of how the subtle ministrations of powerful organisations are designed to influence our lifestyles for their profit.

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Chapter 1

Introduction

1.1 Motivation

1.1.1 Problem Statement

Internet addiction is not a new phenomenon. There is adequate scientific literature suggesting that the popularity and overuse of the smartphone and its applications may be the single largest change correlated to a rise in suicide, mental health problems and lower life satisfaction [1]. While many negative effects arise out of the overuse of devices and social media, in this report a particular focus is given to the negative effects it has on the individual's attention capacity, motivation and focus.

1.1.2 User attention as a commodity

Social media and gaming applications (henceforth abbreviated as "apps") generate profits by retaining the attention of a user. Social media apps might monetize this by generating advertising revenue off of a user's screen time, or offer the user additional premium features requiring an in-app transaction to unlock.

Gaming apps have evolved to follow this model of monetizing continued user engagement: games in the early 2000's delivered a full product on an upfront purchase, seeking to deliver an experience that would encourage users to buy a sequel, but modern games now attempt to monetize continued user playtime by offering "microtransactions" in the form of in-game cosmetics or bonuses on top of the base game purchase.

As of June 2020, of the 5 companies to have ever been valued over a trillion dollars, 4 of them are technology companies that profit off of user engagement with their products: Apple (\$1568b), Microsoft(\$1505b), Amazon(\$1337b) and Google(\$953b), leaving the winning business models of the decade before such as Walmart(\$337b) and Johnson & Johnson(\$366b) in the dust [2]. Even Facebook(\$629b), whose business revenues are almost purely from monetizing user attention, easily doubles the value of the winning business models of the past.

Twitter (a social media company whose revenue comes primarily from advertising) even goes so far as toting the metric of "monetizable daily active users" (mDAU) in investor press conferences [3], referring to users which the company may show ads to. Investors of such business models focus so heavily on such metrics that, despite beating traditional financial health indicators (such as earnings estimates) by a sound margin in the third fiscal quarter of 2020, Twitter lost 20% of its stock value in a single day simply on the announcement that they had only gained 1 million new users instead of the projected 9 million [4] [3].

Therefore, the new hot commodity of the 21st century is no longer gold, silver or oil, but user attention. The attention, engagement and growth of an app's user base is so lucrative for these companies that they have completely changed how their business models are evaluated and priced.

1.1.3 Consequences of addictive app design

Social media and gaming apps are therefore carefully designed with behavioural scientists to be highly addictive, aiming to capture the user's attention and keep them coming back to interact with the application. This is loosely referred to in the industry as a user's level of "engagement"

within the application. To increase and retain user engagement, techniques best described as "addictive software design" [5] are employed, including but not limited to:

- Variable rewards, as in gambling slot machines, maintaining an element of unpredictable positive reinforcement that keeps users coming back for more [5].
- "Bottomless" content with infinitely scrolling lists, experimentally proven to increase consumption [5].
- Ease of use and consistent user-interface elements across apps, allowing users to conveniently feel a sense of familiarity when accessing their apps across all platforms (PC, smartphone, tablets and wearables).
-

Such mechanisms are deliberately crafted to appeal to the primitive parts of the brain responsible for unconscious habitual compliance (the limbic system), rather than those associated with rational, forward and deliberate thought (the prefrontal cortex). What this results in is a subtle shift in the tendencies of an individual to prefer comfortable compliance over exercising motivated choice.

This is already a strong tendency for humans, but the subtle habit formation that apps ingrain into our lifestyles further reinforce this tendency to a point which can be extremely destructive.

With the onset of COVID-19 and the rise of the remote workplace, the line between work and play has grown even more vague and the screen time of individuals is higher than ever []. Smartphones and computers are key pieces of technology that are essential for connectivity and productivity in the age of remote work. The devices themselves do not pose a problem, but the access they give users to the attention-grabbing applications they contain have significant effects on the individual's ability to remain focused at work.

The exercise of willpower alone, while possibly yielding some results in the short term, is not the solution to the problem.

1.1.4 Present solutions

Therefore, many efforts have been made in the fields of neuroscience and psychology to raise awareness of the dangers of digital addiction. Similar addiction-based problems such as gambling and drug use may employ a "cold-turkey" approach, but depriving a modern worker of a smartphone and computer almost completely robs them of function in today's digital age. One approach to remedy device overuse is, paradoxically, the use of so-called well-being apps, which each attempt to address problems caused by internet addiction and overuse.

There are many more well-explored examples of insidious software design and behavioural manipulation to exacerbate internet overuse [6], but the arguments proposed so far sufficiently motivate the creation of a solution that does not require the complete abstinence of smart-device usage.

Many examples of so-called well-being apps have been made, in a paradoxical attempt to design apps that would enhance users' productivity or state of mental health. However, [6] highlights that the such apps do not employ the same behavioural "hooks" that social media and gaming apps use. They often yield a short period of initial use, propelled by motivation, and then fall out of favour of their users within a few months.

Therefore, the work previously done in [6] proposes the concept of attention-preserving technology, which leverages the same behavioural science and software engineering techniques from addictive apps to help users stop using them and reverse their detrimental effects. The authors also produced a proof-of-concept: a well-being app called Sage. In summary, their work uses the development of Sage to highlight the failings of the well-being apps that came before it, proposing a set of design principles for future effective attention-preserving app design.

The Sage application helps users regain their focus and productivity through task and time-tracking features. However, given the short development time, it currently exists only as a minimal Android application with limited functionality. Despite this, an initial round of evaluation on the alpha release yielded positive reviews from testers, claiming that it improved their awareness of their own productivity and that they would continue using the application.

1.2 Objectives

The work documented in this report thus seeks to extend Sage with the following objectives:

- Engineering objective: Re-implementing the code base with methods that would be more suitable for lean development teams to continue their work, as well as adding infrastructure for quantifiable measurement of how well the application achieves its objective.
- Paradoxical social objective: Since Sage did not get a lot of development time and only implemented basic features, this project seeks to further explore how to further leverage the technologies and methods that cause the problem of digital addiction to reverse the problem.
- Application objective: Creating a product that may prove useful in prevention and rehabilitation of attention deterioration as a result of device overuse. This could even see use as a commercial product for companies wanting to help their employees improve their focus at work.

In summary, this run of the project aims to improve the current implementation of Sage. The application will be made available to a much larger user base by re-implementing the code base using cross-platform development frameworks. The user interface is then to be given a complete overhaul to improve the smoothness of the user experience and increase user engagement. More features will be proposed and implemented. Finally, an attempt will be made to create and implement quantitative evaluation methodologies that allow the product team to identify which features are most effective at helping users improve productivity and reduce screen time.

Chapter 2

Background

2.1 Iterative Software Development

2.2 User Experience Design

2.3 Cross-platform Development

2.4 The Existing Sage Application

2.4.1 Functional overview

After granting the app permissions for notification access in an onboarding sequence, the app starts up and offers its core functionality: a task list. Users may create and edit tasks. Each task may be recurring daily, and may block notifications. Users may then at any time start working on a task, triggering a running timer which may block all incoming notifications while active. A task can be completed, or returned to any time later with a break. All this activity is stored within the client and can be displayed to the user through graphs as a form of feedback on their productivity.

2.4.2 Limiting issues

However, there are several issues and limiting features with the current implementation of Sage.

- Does not fully block notifications. Certain edge cases allow notifications to still slip through.
- Currently implemented as an Android app, no extensibility to iOS or desktop users.
- Completely local: no data backups or export, no online cloud synchronisation.

2.5 Project (Re-)specification

Proposing a re-implementation software project naturally begs the following questions: - What advantages will the effort yield, and is it worth the effort? - Will it perform as before, or are there be any compromises as a result of the move?

As such, some initial research had to be conducted to address the concerns. Studying the existing codebase and Android developer documentation

As in any other software engineering problem, the first step is to gather an initial list of requirements that will form the specification of what the final product must achieve.

The re-implementation of the Sage application thus should fulfill the following set of requirements in its MVP:

Functional Requirements

- Re-implement the full feature set of the existing application.
- Fix notification blocking functionality with the use of *Do not Disturb* mode, instead of the current implementation.
- Add online cloud storage and synchronisation of user data.

Non-functional Requirements

- Must be performant without excessive jank, jitter or loading delay.
- In the event of a crash, the application should recover gracefully and inform the user of any inconsistencies in their data caused by the crash (interrupting a focus period, etc).

2.6 Implementation Plan

2.7 Evaluation Plan

2.8 Ethical, Legal and Safety Plan

Chapter 3

Engineering Rationale

3.1 Cross-Platform Frameworks

3.1.1 Flutter

3.1.2 React Native

3.1.3 Xamarin

3.2 Platform Mechanics

3.2.1 Android

3.2.2 iOS

3.3 Cloud Hosting Vendors

3.3.1 Firebase

3.3.2 DigitalOcean

3.3.3 Heroku

Chapter 4

Implementation

4.1 Re-implementing the existing product

Chapter 5

Evaluation

5.1 The Sage platform

Chapter 6

Conclusion

6.1 Summary of Thesis Achievements

Summary.

6.2 Applications

Applications.

6.3 Future Work

Future Work.

Bibliography

- [1] Canadian, “Smartphones, social media use and youth mental health,” *Canadian Medical Association Journal*, vol. 192, no. 6, pp. E136–41, 2020.
- [2] PwC, “Global top 100 companies by market capitalization.”
- [3] T. M. Fool, “Twitter inc (twtr) q3 2020 earnings call transcript.”
- [4] CNBC, “Twitter shares sink amid slowing user growth and ad uncertainty.”
- [5] C. J. Neyman, “A survey of addictive software design,” 2017.
- [6] J. P. L. Wiederkehr, K. Bruzda and T. Dannhauser, “Attention enhancing technology: A new dimension in the design of effective wellbeing apps,” vol. 192, no. 6, pp. E136–41, 2020.