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From overload to Overlord: reducing cognitive load in a post app-pocalyptic world

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From Overload to Overlord: Reducing Cognitive Load in a Post App-pocalyptic World

ERF Paper

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Abstract

Mobile phones are ever-present and undoubtedly beneficial and useful devices, however the amount of information available can be at times overwhelming. Despite all of the benefits and conveniences they offer, the mobile computing environment has not entirely delivered on the promise of easy and simplified access to information. Approaching this problem space using a design science approach, this study addresses information overload of the mobile user as a result of duplicate application functionality and unnecessary screen transitions. Building on the myriad approaches to this problem, this research proposes a novel block-by-default GUI interface that performs automated data classification and aggregation in the background. Subscription functionality will hopefully evolve mobile computing into an attention-based revenue model where apps are rewarded for providing user utility as opposed to maximizing user time on app.

Keywords

Information Overload, Cognitive Load, Mobile HCI

Introduction

Mobile phones have helped people communicate and organize information in new ways since their introduction. The current mobile application ecosystem offers users the functionality of innumerable analog devices, and has incredible potential to make people's daily lives simpler and easier. Despite the myriad potential benefits, the mobile computing environment and its applications have not entirely delivered on the promise of simplified and easier lives. Frequent notifications and messages can interrupt and distract from task performance, and the volume of information and options available can result in confusion and stress. As time goes on, it is less apparent that time spent within the mobile computing environment is amplifying human capabilities.

Problem Description

People need a more effective way to process relevant information from their phones. As users download and install specific mobile applications (hereafter 'apps'), each app is an entry point to data and information users consume. Thousands of applications often compete within the same niches or functional categories and offer very small degrees of value propositions between them. The overwhelming amount of information available can inhibit our ability to effectively make decisions or take actions, and interruptions can increase the effort and time it takes to refocus on a task. This research focuses on reducing information overload of the mobile user as a result of duplicate application functionality and unnecessary screen transitions.

Theoretical Background

Research on working memory and human cognitive limits gained widespread interest after George Miller first proposed the infamous five plus or minus two rule for how many pieces of information people can store in working memory (Miller 1956). It has been further refined and studied to gain insight as to what design lessons can be learned (Sweller 1988). Research on human cognition has expanded to include the interactions between people and systems, specifically mobile devices, aimed at identifying the point of diminishing returns where information becomes too much information. Information overload, as it is deemed, has been found to have seven factors: quantity of information, characteristics of information, quality of information, information processing capacity, available time, task and the process parameters, and personal factors (Jackson & Farzaneh 2012).

This research utilizes a design science research approach, integrating cognitive psychology and dimensions of information overload with domain-specific lessons and knowledge according to DSR methodology to design and test a proposed solution (Hevner et al, 2004). The problem domain falls within what Hevner calls a "dancing landscape", where human agency and the technical artifact affect each other. The research is designed to complement the human-motivational side of overload (Aranda 2018) with a novel system designed to test the assumptions inherent in the underlying design of current mobile systems.

Research Questions

The project has the following research questions:

1. How can application data be de-duplicated and aggregated effectively?
2. How effectively can content aggregation and elimination of redundant information reduce cognitive load on the part of mobile phone users?
3. How effectively can deliberate system limitations reduce interruption overload?

Related Work

This section describes potential approaches to the problem of mobile app information overload, and where applicable specific examples are identified within each broad area.

Aggregators. Aggregators organize data within some specified boundary and present it in a central location. One example is the Apple Health app, which combines health and fitness information across Apple apps, selected third party apps, and medical record information from participating health providers (Apple Health). In terms of cognitive load, this approach leaves the user with a number of decision points: which apps to include, which metrics to include, and when to receive updates. Further, aggregators are typically unbounded in that they present reduced information but do not limit the overall amount of information presented. The IS community has attempted to address this - one example is the use of user-defined filters, or 'lenses', configured to filter and deliver information to inboxes (Sohn et al 2010).

Behavioral models (ML/AI). Such models record user behavior and modify communication and messaging based on past user interactions. This includes research into ideal times to deliver messages, including delaying messages until a context switch is detected (Okoshi et al 2019, Iqbal & Bailey 2005, Czerwinski et al 2016).

Network Traffic Analysis. This approach investigates where network data is sent, in an effort to classify what (and to whom) is being transmitted. The Haystack project provides access to network traffic along with local context to aid in analysis (Razaghpanah et al 2015). This type of analysis has the potential to augment behavioral approaches, including self-modifying behavior based on patterns.

Operating Systems. Mobile operating systems allow aggregation of information to varying degrees. System-wide functionality such as Apple's recent 'personal automation' feature is intended to reduce the friction that occurs throughout the day via automation. For example, it can start a specified

app when a certain trigger criteria is met, such as the user enters a specified geographic location. The onus is placed on the user to configure and manage triggers, and it is too early to tell what the overall impact will be (Apple iOS 13). These types of system-level approaches are promising as they are not app-based and are embedded directly in the functionality of the operating system itself.

Other Mobile Applications. There are a number of stand alone applications that attempt to assist with organization and productivity. These apps are mentioned for the sake of completeness, but did not impact the current research to a great extent.

System Overview

The Overlord system consists of two primary parts - a backend that will classify, sort, and aggregate application information, and a frontend GUI that will enable additional functionality including a hold-notices-by-default approach. Unique features of the artifact include a "limiting-by-default" functionality where unless a user explicitly indicates they are “available”, they will be assumed to be engaged in a cognitive task and application interruptions and notifications are held for later viewing. Additionally, the UI is a single screen that permits both user selection of functionality and data presentation.

System Design

Backend. The backend will perform the necessary data sorting and aggregation. Data specifications will be outlined such that application developers can enable/add compatibility with the system for inclusion in the data summary screens.

Aggregation will be based on general application categories and will only be offered for a selected set of predefined categories. The number of categories actively available to users at any one time is five. These constraints are imposed for a couple reasons: first, there are only certain categories that are amenable to be aggregated. Games, for example, are unable to be aggregated in any meaningful way - you are either engaged in the game or you are not. Second, there is a strong desire to limit the decisions that a user needs to make, and by restricting the total number of categories available the decision space is reduced. Categories were selected based on prior research into the dimensions of information overload by Jackson and Farzaneh (2012); each category was assigned a score for each dimension and only those identified as prime for aggregation were included in the design, resulting in the following set of initial categories: health/medical, finance, news, energy & utilities, social, travel/weather, external devices.

Frontend. The GUI design is a single split-screen approach (split horizontally), with a rotary style selection of icons on the top half of the screen and the bottom half presenting relevant information for the active category. User options and configurations are intentionally limited in order to reduce cognitive load. The screen will show a maximum number of categories at any one time and the number of data points presented within each category will be limited as well. The rationale throughout the design is to enforce constraints in order to reduce the cognitive load on users.

The number of options presented at any one time is six: five data category icons along with a sixth “available” icon. The “available” icon, when selected, will not block any communication or messaging; all other category icons will block messaging by default, allowing message viewing upon a category switch. The purpose of the block-by-default functionality is to enable focus on the category being viewed and to prevent context switching; research has indicated that cognitive overload is more acute within tasks than between them, and greater for similar than dissimilar tasks (greater care and attention is required to differentiate important information) (Mulder et al 2006). The novel use of the “available” option is intended to allow completion/focus on a task, and stage delivery of interruptions for context switches. The presentation of the “available” option as a category instead of as an on/off toggle switch clearly articulates the choice the user is making to either be available or to be engaged in a task.

The primary benefits of the system can be summarized as follows:

- Reduction in screen/context switching: various categories are available on one screen reducing the need to go to individual apps
- Reduction in information flow: aggregation of data
- Improved efficiency of information flow: removal of redundant information

- Reduction in cognitive load: limit by default allows user to preserve intention and view only relevant data
- Reduction in interruption load: messages occur only at category changes

Evaluation

Evaluation will be conducted using a mixed-methods approach blending quantitative and qualitative survey responses with observed experimentation utilizing the system. For the experimentation portion, a student's t-test will be used to determine if there are significant differences between experimental groups. Participants will be recruited to test the system under observation in a computer-lab type setting with a follow-up survey immediately after the system use. Participants will be selected utilizing purposive sampling from among university students based upon responses to an initial questionnaire in order to include individuals who indicate varying degrees (including absence of) a sense of information overload prior to the research. Experimental conditions during observation will vary along two dimensions: type of mobile environment (standard, unmodified mobile phone or modified Overlord-like system) and interruptions (no messages sent to phone or messages sent to phone). Under each of the four combinations of conditions users will be asked to complete a variety of tasks that includes transcribing a document into digital form and checking vital signs and reporting them via email. Prior to the tasks, a short typing assignment will be given to measure typing proficiency. Metrics to be measured include time to completion for each task, time spent on phone, number of apps used on phone, error rates (typographical errors), and self-assessed cognitive load.

RQ1: How can application data be de-duplicated and aggregated effectively? Research question 1 will be addressed by purely technical/objective measures - namely the percentage of data able to be aggregated along with the percentage that was classified correctly.

RQ2: How effectively can content aggregation and elimination of redundant information reduce cognitive load on the part of mobile phone users? Research question 2 will be addressed by the observed use and post-use questionnaire regarding perceived effectiveness of aggregation and level of cognitive strain during task completion.

RQ3: How effectively can deliberate system limitations reduce interruption overload? Research question 3 will be addressed via the observed use (various screen checks) along with post-use questionnaire regarding perceived level of interruptions and effectiveness of the artifact.

Contributions

Theory. The current work applies Sweller's Cognitive Load theory (Sweller 1994) to mobile app overload, and assesses interruptions in order to determine the potential impacts of reducing information and interruption overload. Demonstration of a system that effectively reduces cognitive load and interruption overload based on Jackson and Farzaneh's model would further validate the model and demonstrate how it can be applied to categories of information.

Practice. If successful, the Overlord system will demonstrate that systems do not have to become increasingly complex in order to convey information effectively, and that single-screen apps can effectively present information. This will also promote alternatives to the increasing fragmentation of the mobile app environment.

Future Work

The approach used in the development and testing of Overlord is of interest to anyone developing mobile applications as well as researching information and/or interruption overload. Drawing upon work done across a number of approaches, we hope to support the evolution of a more user-friendly environment that truly enhances human abilities. Due to time and resource constraints, Overlord is currently under development as an application. The current study is intended to serve as a proof of concept and pilot study, with future work focusing on directly integrating the functionality into a mobile OS.

Summary

The mobile computing environment is quickly becoming a dominant mode of interaction between individuals and information systems, and prevailing trends have solidified a computing environment that prioritizes user attention over user utility. In this environment, it is no surprise that individuals are often unable to effectively process the incredible amounts of information at their fingertips.

The goals of Overlord are to aggregate information and present it in ways that both reduce information overload as well as provide a reduced interruption environment. By building on many of the existing approaches to tackle this problem, Overlord implements a novel block-by-default GUI interface that performs automated data classification and aggregation in the background.

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