Adaptive user interfaces for software supporting chronic disease

Wei Wang
Dept of Software Systems and Cybersecurity
Monash University, Melbourne, Australia
wei.wang5@monash.edu

Hourieh Khalajzadeh
School of Information Technology
Deakin University, Melbourne, Australia
hkhalajzadeh@deakin.edu.au

John Grundy
Dept of Software Systems and Cybersecurity
Monash University. Melbourne, Australia
john.grundy@monash.edu

Anuradha Madugalla
Dept of Software Systems and Cybersecurity
Monash University, Melbourne, Australia
anuradha.madugalla@monash.edu

***Abstract*—The rising prevalence of chronic diseases necessitates effective self-management strategies. mHealth interventions have shown promise in supporting self-management, but their under-utilization remains a challenge. Individuals with chronic diseases exhibit significant variations in their conditions, severity levels, and associated complications, highlighting the need for tailored approaches. Adaptive User Interfaces (AUIs) have emerged as a solution to address the diverse and dynamic needs of individuals with chronic diseases. Despite the potential, AUIs research in the health domain has primarily focused on health professionals, with a limited emphasis on involving end users in the early design stages. To bridge this gap, we have created an AUI prototype based on existing literature, incorporating presentation, content, and behaviour adaptation. Our user study employs a mixed research approach to gather insights from users through interacting with the prototype. The future plan of the study aims to utilise insights obtained from data analysis to automatically generate AUIs using a model-driven approach.**

***Index Terms*—adaptive user interface, chronic disease, mHealth applications, model-driven approach**

I. Introduction

The rising prevalence of chronic diseases is attributed to the reclassification of formerly fatal illnesses and the ageing population [1]. *Self-management*, has emerged as a critical aspect of chronic disease management [1], [2]. Patients now show a significant inclination towards acquiring skills and techniques to effectively manage their medical conditions. mHealth interventions have shown promise in promoting self-management by improving medication adherence and facilitating self-tracking capabilities [3]. However, studies indicate that individuals who could benefit the most from mHealth solutions tend to use them the least [4]. A key cause is the *one-size-fits-all* approach of most mHealth software, with little ability to tailor interfaces and care plans to specific individual preferences and needs.

What is required are mHealth applications that consider the diverse and dynamic nature of chronic diseases and the individuals who have them. Individuals with chronic diseases exhibit significant variations in their conditions, severity levels and associated complications [5], and are diverse in terms of age, culture, language ability, health knowledge, etc. To cater to this great variability, AUI has emerged as a potential solution. AUIs aim to enhance the interaction between users and their user interfaces by adapting to their current goals, needs and preferences [6].

With an increasing number of papers describing applications, approaches, tools and algorithms for AUIs, there is a lack of information on development processes during the early design stages involving end users [7]. Furthermore, the predominant evaluation approach commonly focuses on assessing the *overall effectiveness* of the application, making it difficult to draw specific conclusions about the implemented AUIs. We aim to address this by investigating the preferences of users with chronic diseases regarding different AUIs.

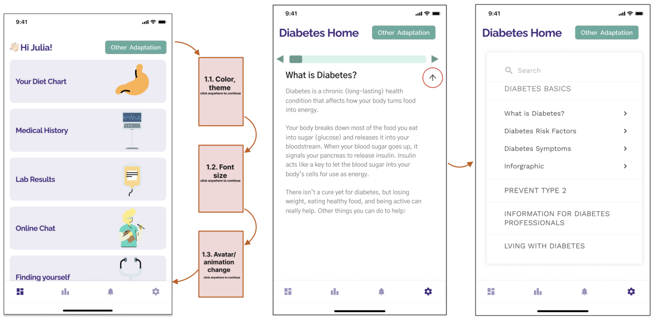
II. Related work

Existing research in the healthcare domain has predominantly focused on studying AUI issues among health professionals [8]–[10]. For instance, Eslami, Firoozabadi, and Homayounvala [8] employ interviews and observations to elicit user requirements in health information systems, primarily targeting health professionals. Similarly, some studies have examined AUI design issues in specific scenarios, such as the smart hospital context [10]. One study proposed an architecture for AUI with a particular emphasis on monitoring and reporting health-related information [12]. However, there is a noticeable research gap when it comes to AUIs for chronic disease-related applications.

III. Adaptive User Interface prototype

In our study, we leverage prior findings through a systematic literature review to inform the design of different types of adaptation [7]. The adaptation types presented below are derived from the literature in the domain of chronic diseases.

(1) **Presentation adaptation** involves the adjustment of interface element parameters, such as colour, size, object positioning, and font size, to optimise the user experience (Figure 1). We further subdivide presentation adaptation into *graphic*



(a) Graphic design (b) Information architecture

Fig. 1: Presentation adaptation

design (Figure 1a) and *information architecture* (Figure 1b). *Graphic design* encompasses a range of techniques used to manipulate the visual aspects of the application by exercising control over elements such as theme, layout, and display. *Information architecture (IA)* revolves around the structural design of information within the system. For instance, directive tunnel IA guides users step-by-step towards specific goals, while hierarchical IA facilitates top-down navigation and access to relevant information.

(2) **Content adaptation** involves adjusting the content level of the interface by modifying the text, semantic content, images, or explanatory inscriptions (Figures 2-5). We propose two main categories of content adaptation. The first is *content complexity*, which focuses on simplifying the content to improve comprehension based on users' cognitive skills, educational background, or comprehension capabilities. Within *content complexity*, three subcategories have been identified: *easy-to-understand language* (Figure 3), *minimalist design* (Figure 4), and *text-to-image conversion* (Figure 5). Easy-to-understand language involves using clear and concise language to enhance comprehension. Minimalistic design streamlines the design to reduce visual clutter and present the content in a more concise manner. Text-to-image conversion transforms complex text into easily understandable visual representations. The second category is *interface elements rearrangement* (Figure 2), which involves reorganizing interface elements to improve the content presentation and accessibility. This includes adjusting element positions or selectively hiding less frequently used elements.

(3) **Behaviour adaptation** encompasses the modification of navigation type or structure, activation or deactivation of interface elements, and adjustment of interaction modalities within an application. This form of adaptation is characterised by its complexity, often requiring multiple steps to complete, and can encompass both content and presentation adaptation. We have categorised it into five subcategories. The first subcategory pertains to *navigation adaptation*, wherein the user's navigation permissions are modified or navigation to specific modules is suppressed. The second subcategory involves *add-on functions*, which entail the incorporation of new features into the application to enhance user assistance and improve application usability. The third subcategory focuses on the alteration of *pervasive strategies* used to motivate desired behavioural changes. This adaptation is tailored to different user types or statuses, fostering more effective behavioural transformations. *Multimodal interaction* represents another subcategory of behaviour adaptation, involving the adjustment of interface modalities based on diverse usage contexts. The adjustment of *difficulty levels* in certain health-related game applications constitutes the final subcategory. This adaptation entails modifying the difficulty level of games or exercises based on user motivation or performance, ensuring a balance between engagement and challenge.

Users with chronic diseases may benefit from various adaptations in user interfaces. The need for these adaptations depends on factors such as the users' knowledge, experience, health status, cognitive skills, physical and/or mental deterioration, etc.

IV. User Study Design

We are conducting a large user study involving a *quantitative survey* aimed at gathering data on participants' preferences regarding adaptive elements and a *qualitative study* designed to validate and evaluate the proposed adaptation types. A total of 86 survey responses have been collected to date. Moreover, five *focus group* sessions with three participants in each session, and six individual *interviews* have been run. The focus group and interview participants primarily include individuals with type 2 diabetes or mental health issues. Throughout these sessions, participants are given the opportunity to engage with the adaptation prototype, enabling them to gain hands-on experience with various adaptive features. Subsequently, discussions are conducted to elicit participants' opinions regarding different adaptations, identification of potential challenges, and recognition of any lacking features within the provided adaptation examples. The inclusion of multiple data collection methods, such as surveys, focus groups, and interviews, is essential to triangulate findings and enhance the robustness of our user study [11].

V. Future Steps

We are analysing the collected qualitative and quantitative data to gain insights into user preferences for adaptive elements for mHealth software supporting chronic diseases. We plan to employ a Model-Driven Approach to develop a tool capable of automatically generating AUIs for chronic disease-related applications. This tool aims to create AUIs that effectively cater to the unique needs and preferences of individuals with chronic diseases, thereby enhancing usability, adherence, and overall user experience. We will implement the tool using chronic disease-related applications as a practical example. User studies involving potential end-users will assess the acceptance and user-friendliness of generating AUIs and the impact of proposed adaptations.

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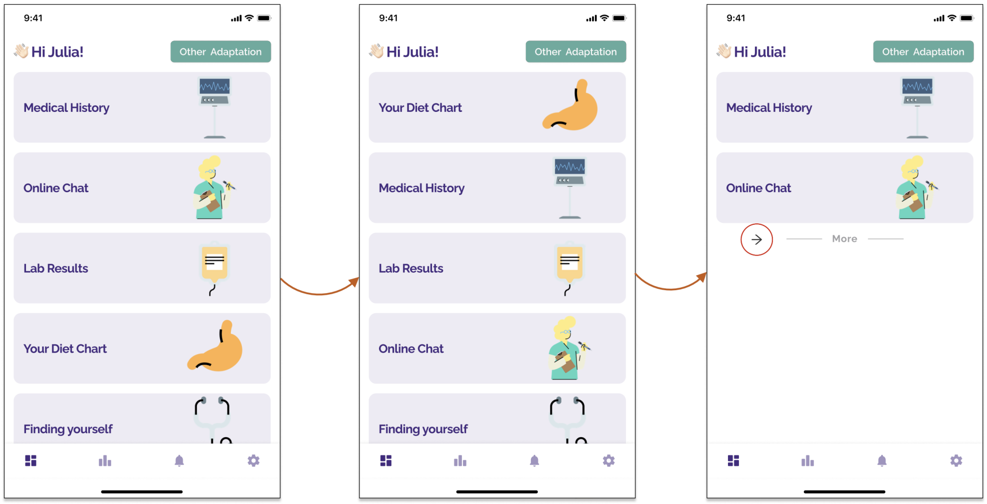

Fig. 2: Interface elements rearrangement

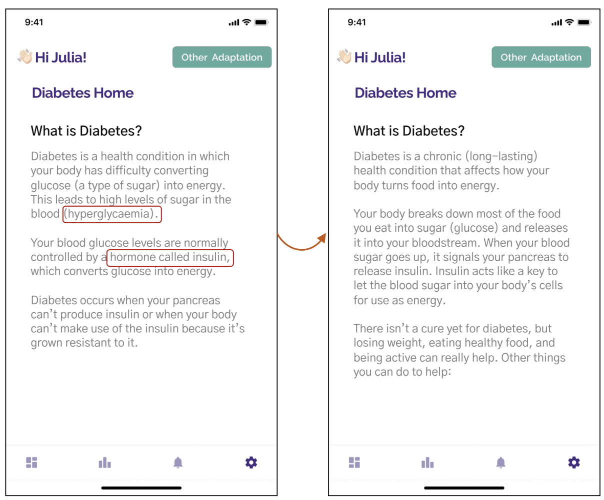

Fig. 3: Content complexity-Easy-to-understand language

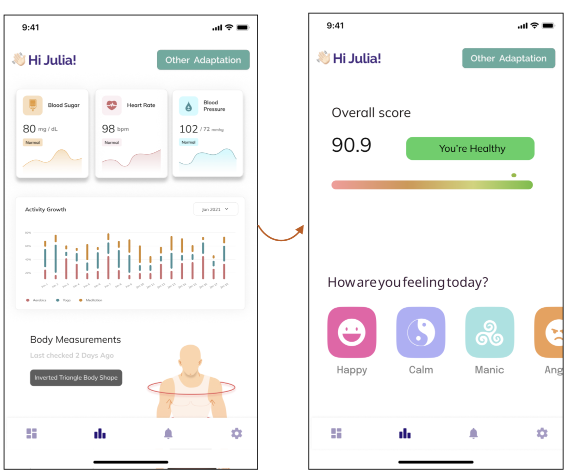

Fig. 4: Content complexity-Minimalist design

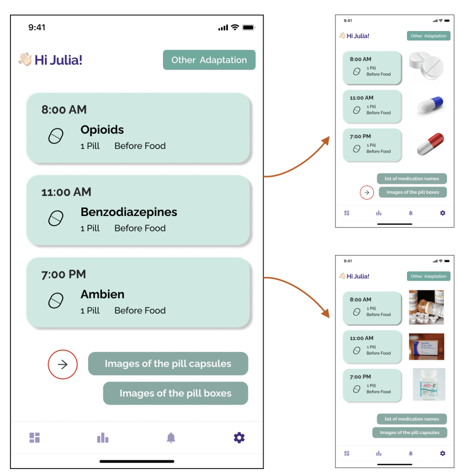

Fig. 5: Content complexity-Text-to-image conversion

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