A Framework for the Development of a Dynamic Adaptive Intelligent User Interface to Enhance the User Experience

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ABSTRACT

The aim of this paper is to present PhD research that aims to enhance the User Experience by proposing a framework that combines the three core components of: dynamic interfaces; adaptive interfaces; and intelligent interfaces. Initial research into the field has identified a gap at the intersection of these types of interaction. A dynamic interaction understands the user, their device and their physical environment to provide a basic User Experience. An adaptive interaction understands the user's capabilities further to implement an enhanced experience via usability and accessibility whilst recognising the flow of the user and their pipeline. The intelligent interaction builds further upon this through the incorporation of Machine Learning algorithms that assist in making the interface intelligent and provide a personalised experience for each user based upon their end goal. This in turn will reduce a user's cognitive load and enhance their interactive experience with an interface.

CCS CONCEPTS

• Human-centered computing~Human computer interaction (HCI) • Human-centered computing~Usability testing • Computing methodologies~Machine learning

KEYWORDS

Big Data, Data Visualization, Dynamic, Adaptive, Intelligent, User Experience, Parameters, Machine Learning, Human Computer Interaction, Data Science.

1 Introduction

The following paper highlights research that has been completed within the first year of the PhD process. This PhD began by researching the fundamentals of big data, analyzing the variety of visualizations that could be used to obtain value from the data efficiently and identified how the User Experience (UX) of an interface could be enhanced for general users.

Documenting data has been around for some time and it is growing every day, big data covers aspects such as volume, velocity, variety and veracity [1]. Volume is the amount of data, velocity is the speed data is being processed, variety is the diversity of data and veracity refers to the source of the data [1]. In addition to the four v's, the main objective of big data is to obtain value and a visualization can assist this by displaying information in a meaningful way [1].

Visualizations allow a user to absorb information easily as its purpose is to make the decision-making process accessible [1]. Visualizations can be enhanced by incorporating the "Visual Information-Seeking Mantra", this allows for visualization manipulation and interrogation via: an overview; zoom and filter;

and details on demand. It helps to reduce the users cognitive load and allow for information to be retained [2] [3].

Visualizations are normally integrated to an applications interface, the interface itself has been made to respond to specific devices such as desktop, tablet and mobile through CSS3 media queries [4]. As the amount and type of devices increase this makes it difficult to keep up with the ever changing device specifications, to overcome this an interface that adapts towards the user and a range of yet unknown informative parameters would be beneficial [3]. For this to be achieved, an Intelligent User Interface (IUI) would be developed to work in conjunction with Machine Learning (ML) algorithms to tailor the UX towards each user, this will reduce the users cognitive load and provide a better user journey [3].

This paper will be structured as follows: section 2 background; section 3 challenges; section 4 provides a methodology; section 5 is current studies and future plans; and section 6 concludes this paper.

2 Background

Every-day web applications are accessed by a variety of users and each user has a different purpose as to why they use a particular application. Apart from the user the application has an end goal and this may influence the user's journey. This has been identified as an individual experience. Within an individual experience it is important to understand three parameters that are key to the individual and their pipeline:

- **Goals:** Everyone has an objective as to why they carry out a task, the same perspective is described within a web application, each user is unique and has an end goal: browse products; obtain information; or to make a purchase [5];
- **Contextual Information:** Information surrounding the user: time of day, location and device [5]. Contextual information can also influence the user's end goal for using the application; and
- **Capability:** Does the user have accessibility issues that may influence their interaction with the application for example, an elderly user with shaky hands [6].

A cohort experience is a group of users that are categorized based upon their behavior whilst using the application such as: browsing, searching or knowledge-building customers based upon an E-Commerce situation [7]. To create a framework, it is important to incorporate all three components detailed in the figure below to produce a Dynamic Adaptive Intelligent User Interface (DAIUI).

- **Dynamic:** In addition to the parameters previously mentioned, the dynamic component is the bases of contextual information due to a change in activity. Its main goal is to understand the user in greater detail through the following subjects: user, device and physical environment. The user subject contains parameters such as gender, age, job role and their goals [8] [9], the device subject contains the device type, bandwidth available and battery [8] [9] and physical environment is the user's location, the weather, time of day and noise level [8] [9]. During the research phase, a variety of dynamic approaches had been identified within various examples detailed in Figure 1, these include: understanding the user's behaviour through page-to-page click stream data and navigational patterns, this helps to classify what category a user belongs to and provide context as to what elements users are, or not fully interacting with. Gamification strategies help keep the user focused and have a task to work towards, this allows the application to understand the user through Human Computer Interaction (HCI) which affects the UX [7];
- **Adaptive:** This relates to the user and their capabilities. By understanding the user through HCI, it allows for a UX to become enhanced over time based upon their capabilities [10]. The main goal of this component is to strengthen the UX from the previous component by including new parameters for the system to learn and anticipate their capabilities to adjust the interface accordingly [10]. Within the dynamic adaptive intersection, examples such as E-Learning, E-Commerce and iMeAid made use of a user model to store information about a user and their preferences [6]. The interface within iMeAid adapted towards the user and their interactions: visual, hearing and touch capabilities. This helped establish what cohort a user belonged to base upon their capabilities, in addition to their contextual information [6]. By granting technology

the ability to learn about each end user via interaction methods allows for specific cohorts to be established which will help to provide greater independence for that cohort for example, the elderly; and

- **Intelligent:** This component adapts and renders elements of an interface through the use of ML algorithms by understanding the user's goal [11]. Within the adaptive and intelligent intersection, a variety of applications illustrated the use of ML algorithms by displaying content relevant to that particular user based on their previous interactions, this includes E-Commerce and Gaming. As the user progresses through each level of the game, it stores and learns their interactions to help predict and deliver an interface and components applicable to them intelligently through the use of ML algorithms.

3 Challenges

In order for the framework to be created there are challenges to consider. The main challenge being the type of ML algorithms that would work across more than one domain. Currently the domains of interest include: Education and Healthcare.

Whilst researching, it was discovered that there has been limited research into how ML algorithms could assist the adaptive layout of an interface along with user flow, usability and functionality aspects. This will be researched further, as it will help build a foundation for the cohorts of users. Identifying a user and their journey throughout via their capabilities and the device they are using is important.

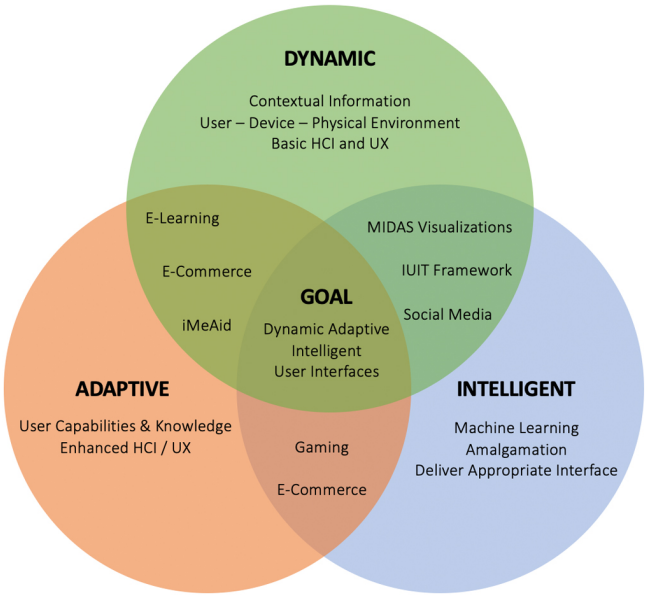

Figure 1: The Intersections of Dynamic, Adaptive and Intelligent Interfaces with Examples. Fig. 1 © Vivien Johnston, Jonathan Wallace and Michaela Black.

The collection of data parameters is another area to consider. Depending on the device, data collection could be through sensors, microphones or the user's pipeline of interactions and events that are stored through cloud platforms such as AWS ML, this will help in relation to security and ML performance. Previous papers suggest that in order to store parameters and understand the user in greater detail, User Modeling (UM) may be effective, this is an area to research further [12]. As the research progresses, additional parameters will be identified and this will advance other areas that are currently underdeveloped such as gamification [7].

Gamification refers to game mechanics that are incorporated into other domains. It engages the user by providing them with a challenging environment, whilst providing an enjoyable and sociable experience when interacting with the interface. As mentioned, each user has a goal and by providing game mechanics

such as feedback it will encourage effective engagement [7]. It is key to incorporate this across both Education and Healthcare domains, as not only will it keep the user interested and engaged for extended periods of time, but it will give the framework time to understand the user and enhance the UX, to help the user achieve their end goal.

The goal of this PhD is to contribute towards the lack of a framework that provides a dynamic, adaptive, intelligent and engaging UX. The framework will be developed and tested across at least two domains namely Education and Healthcare.

4 Methodology

After reviewing the challenges, the following section proposes a solution - a framework for the creation of a DAIUI. Its main objective is to make use of all three components that have been previously identified (Figure 1): dynamic, adaptive and intelligent. By incorporating these components, it will help determine a cohort the user belongs to and produce a UX tailored to the cohort. In order for the framework to progress, it is important to analyze a variety of users, any available parameters, their flow towards their overall goal and their capabilities to make an interface tailored towards the individual rather than the cohort at large and ensure their needs are met to permit them to reach their end goal efficiently.

Once the framework has been created, an important aspect will be to test it via usability testing. To understand and monitor the user being tested, the equipment below should be taken into consideration:

- **Gaze and Eye Tracking:** An eye tracker can detect gaze and eye movements as the end user progresses through an interface. This form of sensor technology can help detect the duration an end user stares at a point of interest, detect drowsiness and additional mental states [13];
- **Heart Rate Variability:** A chest strap with a heart rate monitor attached can help detect interaction between each heartbeat. This may be of interest during the end users interactions with a task [14];
- **Galvanic Skin Response:** An electrode is attached to the end users fingers to identify signals that are transmitted through sweat gland activity. This could help to detect where on the end users journey they find it difficult to proceed [15]; and
- **Electroencephalography (EEG):** This is in relation to brain activity, small sensors are attached to the scalp of the end user to identify electrical signals transferred to and from brain cells [16].

5 Current Studies and Future Plans

To date an in-depth literature review detailing how each application fits within a component of the framework. They were examined thoroughly and gaps have been analyzed, followed by a proposed solution. Once relevant datasets are received three studies have been outlined each for the duration of 6 months. Each study is specific to a domain of interest and its unique dataset: Education and Healthcare are the primary focus due to availability of data and if time permits an E-Commerce dataset will be the third domain. Testing is part of each study and will use equipment that has already been identified within this paper.

6 Conclusion

The work presented here describes initial research into the area of IUIs and has illustrated gaps. In addition, a framework has been described to address the gaps and a variety of testing equipment has been identified that will assist each study.

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