Proficiency-Aware Systems: Adapting to the User's Skills and Expertise

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ABSTRACT
Everyday lives become increasingly reliant to digitally enhanced artifacts. Users expect that devices are easy to use. For technologies deployed in public spaces and for shared devices adaptation to the user is a key to achieve this. In this paper, we introduce the concept of *proficiency-aware systems*, that can dynamically adapt to the users' skills and expertise. Proficiency-aware systems have means to detect the users' proficiency relevant to the task and can adapt the user interface and the content accordingly. Such adaptation can be done locally and does not require to know the user, hence preserving the privacy while providing a customized user experience. Besides the definition, we elaborate on the idea by outlining a framework, describe requirements, and point to examples of proficiency-aware systems. The research challenge is in ubiquitous sensing techniques to infer users' proficiencies and to provide appropriate adaptations. We envision that for computing systems in public spaces this idea can lead to new interaction paradigms.

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Proficiency, Physiological Sensing, Interface Adaption.

INTRODUCTION
The number of digital devices around us is steadily increasing. This is not only true for our own devices, but also true for shared devices within our environment. Examples include ATMs, ticket vending machines and ordering kiosks at fast-food restaurants. Commonly, these systems are designed to be easy to operate. However, the background and knowledge of people differs substantially, due to cultural as well as individual differences. Hence, interfaces that aim for a one-size-fits-it-all approach will fail to address user-specific diversity that can impede operation.

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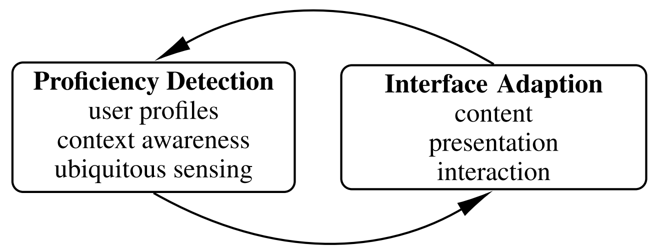

Figure 1. Abstract working state of a proficiency-aware interface.

The solution to this problem has been around for decades: "Know the user" [1]. The first principle in Hansen's list of user engineering principles for interactive systems is a simple idea, yet sometimes incredibly hard to achieve. In recent years, user profiles and context-awareness are popular methods to adapt interactive systems. With the proliferation of affordable sensing devices, researchers have started to leverage physiological sensing to infer user states automatically, alleviating the need for explicit user input.

We want to further elaborate on the idea of systems, that automatically detect the users' proficiency. Therefore, we introduce the term *proficiency-aware systems* which describes systems that adapt to a user's knowledge and skills. In this paper, we contribute a definition for proficiency awareness as well as a generic architecture for proficiency-aware systems and its implications and requirements for pervasive systems. Lastly, we point to examples of proficiency-aware systems.

PROFICIENCY AWARENESS – DEFINITIONS
In this section, we provide definitions that describe the idea of proficiency awareness.

Definition: Proficiency-Aware Systems are systems that can *sense a user's proficiency* and *adapt* the *content*, the *presentation*, and the *interaction*.

Hence, the term **proficiency-aware system** refers to a dynamic *interconnection* between system and user, that continuously *assesses* the *user's ability* to *interact with it* and *adapts* accordingly. Such adaptations will enable a user experience tailored to the specific users' proficiency. The proficiency hereby refers to the knowledge, skills, and abilities that are relevant for using the system, such as reading skills, background knowledge, motoric skills, and cognitive ability.

GENERIC ARCHITECTURE

Every proficiency-aware system is governed by a continuous cycle (cf. Figure 1) involving proficiency detection on the one side and appropriate adaption on the other side. Both sides mutually influence each other until an equilibrium is reached.

Interface Adaption

We have identified three main dimensions of adaptation. Firstly, an interface can adapt its **content**, in other words, it adapts towards the user's interest also taking the user's prior knowledge into account, e.g. on a public display distinguishing between a tourist and a local.

The second dimension is the **presentation** of the content. The interface may adapt to the user's preferred language, their current cognitive abilities by simplifying visualizations and choice of words or environmental conditions by changing screen brightness.

Lastly, the **interaction** itself can be proficiency-aware by taking into account the user's current abilities and environment to offer a suitable interaction method, e.g. hands-free interaction or replacing sounds with text in noisy environments.

Detecting Proficiency

On an abstract level, this module specifies whether adaption is needed to cope with the user's lack or abundance of proficiency. Detecting a user's proficiency can be done on multiple levels. The most static one being **user profiles**. The system recognizes a specific user and adjusts based on their pre-defined settings. This level allows for the highest degree of customization, yet requires profiles to be known beforehand, thus somewhat breaching personal privacy if profiles are stored using a cloud service.

In public spaces, a more realistic approach is to leverage the **surrounding context** for adaption. For example, changing presentation based on environmental conditions. A more invasive approach could possibly access a user's personal devices to infer necessary information, e.g. whether the user is on vacation or on a business trip. The basic concept of adaption to context is described in Schilit's seminal work [4]. We extend this work by a more fine-grained, per-user customization that takes additional dynamic properties of the user into account.

As a last level, we have identified detecting a user's proficiency using **ubiquitous sensing techniques**. Here, the system employs physiological sensing devices to infer the current state of the user, such as cognitive ability and motoric skills. Example modalities include face detection, tracking of eye and hand movements. Here, systems may enable proficiency detection down to individual users depending on the scenario and employed modality, while still providing robust and coarse detection if necessary as shown in the application section.

APPLICATIONS

In our work, we focus on the last two levels. Here, we addressed the user's language proficiency and leveraged robust gaze features to detect whether users were able to read the displayed language [3]. We showed that a binary detection, whether the user is able to read the language, can be done in under three second using one sentence only, allowing for quick adaption. Yet, it is not possible to "guess" a more suitable language since this type of proficiency does not entail any ordering. Hence, other adaption methods, e.g. displaying a language selection menu, have to be considered.

Contrarily, in EMGuitar [2], we opted for a fine-grained proficiency detection by leveraging Electromyography to infer a user's skills when playing the guitar. Here, we adapted the playback speed of our tutoring system, when the user is struggling to play correctly. The connection between low user proficiency and suitable adaption is known beforehand as decreasing the tempo will allow better play for a novice. By automatically adapting playback speed during sessions based on previous play correctness, we realized the cycle between detection and adaption for proficiency-aware systems as outlined before.

CONCLUSION

The techniques and methods behind what we classified as proficiency-aware systems have been the focus of research for a far longer time. In this work, we present a definition of proficiency-aware systems and a generic architecture for researchers to built upon. We believe that having a common understanding of requirements is necessary to advance further. Our own work entails the vision of ad-hoc adaptiveness when interacting with pervasive systems throughout our everyday life. Contrary to long-term user adaption based on context-awareness, we strive to realize short-term proficiency detection by leveraging ubiquitous sensing techniques. In this area, we address the challenge to infer users' proficiencies and to provide appropriate adaptations. Especially for computing systems in public spaces, our idea of proficiency awareness can lead to new interaction paradigms.

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