# Chapter 6
# A Brief Survey on User Modelling in Human Computer Interaction

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## ABSTRACT

*This chapter presents a brief survey of different user modelling techniques used in human computer interaction. It investigates history of development of user modelling techniques and classified the existing models into different categories. In the context of existing modelling approaches it presents a new user model and its deployment through a simulator to help designers in developing accessible systems for people with a wide range of abilities. This chapter will help system analysts and developers to select and use appropriate type of user models for their applications.*

## INTRODUCTION

A model can be defined as "a simplified representation of a system or phenomenon with any hypotheses required to describe the system or explain the phenomenon, often mathematically". The concept of modelling is widely used in different disciplines of science and engineering ranging from models of neurons or different brain regions in neurology to construction model in architecture or model of universe in theoretical physics. Modelling human or human systems is widely used in different branches of physiology, psychology and ergonomics. A few of these models are termed as user models when their purpose is to design better consumer products. By definition a user model is a representation of the knowledge and preferences of users (Benyon & Murray, 1993).

Research on simulating user behaviour to predict machine performance was originally started during the Second World War. Researchers tried to simulate operators' performance to explore their limitations while operating different military hardware. During the same time, computational psychologists were trying to model the mind by considering it as an ensemble of processes or pro-

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grams. McCulloch and Pitts' model of the neuron and subsequent models of neural networks, and Marr's model of vision are two influential works in this discipline. Boden (1985) presents a detailed discussion of such computational mental models. In the late 70s, as interactive computer systems became cheaper and accessible to more people, modelling human computer interaction (HCI) also gained much attention. However, models like Hick's Law (Hick, 1952) or Fitts' Law (Fitts, 1954) which predict visual search time and movement time respectively were individually not enough to simulate a whole interaction.

The Command Language Grammar (Moran, 1981) developed by Moran at Xerox PARC could be considered as the first HCI model. It took a top down approach to decompose an interaction task and gave a conceptual view of the interface before its implementation. However it completely ignored the human aspect of the interaction and did not model the capabilities and limitations of users. Card, Moran and Newell's Model Human Processor (MHP) (Card, Moran, & Newell, 1983) was an important milestone in modelling HCI since it introduced the concept of simulating HCI from the perspective of users. It gave birth to the GOMS family of models (Card, Moran, & Newell, 1983) that are still the most popular modelling tools in HCI.

There is another kind of model for simulating human behaviour that not only works for HCI but also aims to establish a unified theory of cognition. These types of models originated from the earlier work of computational psychologists. Allen Newell pioneered the idea of unifying existing theories in cognition in his famous paper "You can't play 20 questions with nature and win" at the 1973 Carnegie Symposium (Newell, 1973). Since then, a plethora of systems have been developed that are termed as cognitive architectures and they simulate the results of different experiments conducted in psychological laboratories. Since these models are capable (or at least demanded to be capable) of simulating any type of user behaviour, they are also often used to simulate the behaviour of users while interacting with a computer. Gray et al. (1997) assert that cognitive architectures ensure the development of consistent models over a range of behavioural phenomena due to their rigorous theoretical basis.

So there are two main approaches of user modelling: the GOMS family of models was developed only for HCI while the models involving cognitive architectures took a more detailed view of human cognition. Based on the accuracy, detail and completeness of these models, Kieras (2005) classified them as low fidelity and high fidelity models respectively. These two types of model can be roughly mapped to two different types of knowledge representation. The GOMS family of models is based on goal-action pairs and corresponds to the Sequence/Method representation while cognitive architectures aim to represent the users' mental model (Carroll & Olson, 1990). The Sequence/Method representation assumes that all interactions consist of a sequence of operations or generalized methods, while the mental model representation assumes that users have an underlying model of the whole system.

There is a third kind of model in HCI that evaluates an interface by predicting users' expectations, rather than their performance, e.g., Task Action Language (Reisner, 1981), Task Action Grammar (Payne and Green, 1986) etc.). These models represent an interaction by using formal grammar where each action is modelled by a sentence. They can be used to compare users' performance based on standard sentence complexity measures; however, they have not yet been used and tested extensively for simulating users' behaviour (Carroll & Olson, 1990).

Finally, there was a plethora of systems developed during the last three decades that are claimed to be user models. Many of them modelled users for certain applications - most notably for online recommendation and e-learning systems.

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