Chapter 7
Evolutionary Based Adaptive User Interfaces in Complex Supervisory Tasks

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ABSTRACT
In this chapter, the author proposes a novel idea based on evolutionary algorithm for adaptation of the user interface in complex supervisory tasks. Under the assumption that the user behavior is stationary and that the user has limited cognitive and motor abilities, the author has shown that a combination of genetic algorithm for constrained optimization and probabilistic modeling of the user may evolve the adaptive interface to the level of personalization. The non-parametric statistics has been employed to evaluate the feasibility of the ranking approach. The method proposed is flexible and easy to use in various problem domains. The author has tested the method with an automated user and a group of real users in an air traffic control environment. The automated user, implemented for initial tests, is built under the same assumptions as a real user. In the second step, the author has exploited the adaptive interface through a group of real users and collected subjective ratings using questionnaires. The author has shown that the proposed method can effectively improve human-computer interaction and his approach is pragmatically a valid design for the interface adaptation in complex environments.

INTRODUCTION
Humans and computers form teams in complex environments such as in aviation, glass cockpit, nuclear power plants, manufacturing lines, and command and control scenarios. The computers generally undertake the automation part while the human is responsible for the supervision of the overall task or interrupts the process at the higher level. Task sharing is generally done at design time, using Fitts list (Fitts, 1951). Automation was thought to be the remedy to the problems resulting from human errors.

DOI: 10.4018/978-1-60566-798-0.ch007
However, Billings has argued that automation in aviation, for example, has not put an end to the accidents (Billings, 1997). It is commonly believed that as the tasks allocated to the computer increase, the cognitive load of the human (supervisor) grows, hence causing inevitable errors.

One of many reasons for the errors under automation is the reduced situation awareness, which is defined as “the perception of the elements in the environment within a duration of time, the comprehension of their meaning, and the projection of their status” by Endsley (1988). Endsley has also developed Situation Awareness Global Assessment Technique (SAGAT), a questionnaire to measure perceived load on the operator. He claims that automation leads to under-utilization of the human’s skills and leads to errors. He also added that the automated process under supervision is no longer transparent to the human, hence leads to erroneous decisions under time pressure. Facts mentioned above inspire the idea of the adaptation of the interface. By these means researchers believe that computers can tailor their behavior according to the environment and the personal traits of the user. This adaptation can result in more efficient and effective interaction between human and computer, hence improve the quality of the operations (Wilson et al., 2000). What is proposed in this chapter is to exploit the meta-heuristic searching ability of the genetic algorithm in evolving the user interface based upon certain performance measures. What could be evolved include the position, size, shape, color of each element and even the way how they appear and change in the screen.

In this chapter, we propose a new approach to the adaptive interface design. We develop a generalized and easy-to-implement framework for the adaptation of the interfaces. The section “Literature Review on Conceptual Framework for Adaptation” presents a literature review of the adaptive interface domain. It is not our intent to give a complete taxonomy of the adaptive interfaces under this section; however, this discussion will help the readers to understand our approach easily. The section also justifies the conceptual details of the proposed algorithm. In the section “Proposed Method” we give abstract definitions of the adaptation method. This way readers may adapt the algorithm for their own domain of interest. The fourth section, “Air Traffic Control,” presents an application in the Air Traffic Control (ATC) task implementation. With this sample implementation, we aim to give more concrete basis for our approach. The fifth section, “Results,” provides some statistical analyses of the results and finally we will conclude with the sixth section.

**LITERATURE REVIEW ON CONCEPTUAL FRAMEWORK FOR ADAPTATION**

In the introduction, we have mentioned that adaptation of the interface is deemed to be the remedy for human errors in complex environments. The interface adaptation, on the other hand, is not a straightforward task. Difficulty lies in first assessing the user’s state of mind (goal-subgoal structure), state of psychology (situation awareness), and level of vigilance. All of these are non-deterministic and hard to model. Secondly, defining an appropriate adaptation behavior for the interface; and thirdly timeliness of the adaptation (Horvitz, 1999) are the other difficulties. Since the work undertaken in this area of research is not well defined, and hard to attack without an appropriate tool, we need to define a framework before we can start the discussion. There are three steps to be considered in adaptation of the interface. Many papers have been written on adaptation and adaptation methods, however Rothrock et al. (2002) have defined a simple and comprehensive framework for adaptation. In this study we will follow Rothrock’s methodology: identification of variables that call for adaptation, determination of necessary modifications to the interface and selection of decision inference mechanism.