Adaptive Business Intelligence: Three Case Studies

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Summary. This chapter contains a general discussion on the prediction and optimization issues present in dynamic environments, and explains the ideas behind Adaptive Business Intelligence. The chapter also presents three diverse case studies. The first deals with pollution control, the second one with ship navigation, and the third one with car distribution. All these problems are set in dynamic environments; all three problems require some level of prediction (prediction of weather for pollution optimization, prediction of paths for unidentified ships at sea, and prediction of prices for cars sold at different auction sites). All these problems also require optimization for recommending the best course of action.

8.1 Introduction

Every problem has an objective. Usually, this is a general statement describing what we are looking for. The objective defines the goal (or set of goals) for a particular problem. These goals are translated into evaluation functions, which provide mappings from the solution space to a set of numbers. Thus, evaluation functions assign numeric values for each solution for each specified goal.

Evaluation functions (for single-objective problems) or a set of evaluation functions (for multi-objective problems) are key components of any heuristic method (whether genetic algorithms, tabu search, simulated annealing, ant system, or even simple hill-climbers), as they define the connection between the method and the problem. By assigning a numeric quality measure to

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3 The objective may consist of several goals, thus making the problem multi-objective. Note, some confusing terminology: a problem, where the objective consists of a few goals, is called a multi-objective problem.
each solution, evaluation functions allow comparison between the quality of various candidate solutions. Note that evaluation functions may return just the rank of a candidate solution among a set of solutions, a precise number (when the evaluation function is defined as a closed formula), or they may include various components (as penalty expressions for cases when a candidate solution violates some problem-specific constraints).

Many real world problems are set in uncertain (possibly changing) environments. There is a general agreement [2] that such uncertainties can be categorized into four classes: (1) noise, (2) robustness, (3) approximation, and (4) time-varying environments. Consequently, evaluation functions should be modified accordingly to deal with each particular case. However, it seems that the above classification misses the most important (and probably most frequent) real world scenario: namely, where the evaluation functions are based on predictions of the future values of some variables. Using case studies, we illustrate three such scenarios, expose the similarities between them, and we suggest a system architecture (called Adaptive Business Intelligence) to deal with such problems.

This chapter is organized as follows: The next section provides a brief overview of four categories of uncertainties and introduces a new category, where the evaluation functions are based on predictions of some variables. The next three sections present three case studies: optimisation of pollution in Poland, path planning (ship navigation), and car distribution. We then discuss the common characteristics of these case studies, and propose an Adaptive Business Intelligence architecture to deal with such problems. The last section concludes this chapter.

8.2 Uncertain Environments

As mentioned in the Introduction, uncertain (and possibly changing) environments are usually categorized into four classes: (1) noise, (2) robustness, (3) approximation, and (4) time-varying environments. Before we present and discuss the fifth category, and argue that this fifth category is the most common in real world situations, let’s first discuss the main features of these four categories.

**Noise.** Sometimes evaluation functions are subject to noise. This happens when evaluation functions return sensory measurements or results of randomised simulations. In other words, the evaluation procedure for the same solution (i.e., the solution defined as a vector of some design variables) may return different values. The common approach in such scenarios is to approximate a noisy evaluation function eval by an averaged sum of several evaluations:

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eval(x) = \frac{1}{n} \sum_{i=1}^{n} (f(x) + z_i),
\]  

(8.1)