Chapter 43
Soft Methods for Automatic Drug Infusion in Medical Care Environment

Filipe Quinaz
University of Beira Interior, Portugal

Miguel Castelo-Branco
University of Beira Interior, Portugal

Paulo Fazendeiro
University of Beira Interior, Portugal & Portuguese Telecommunications Institute (IT), Portugal

Pedro Araújo
University of Beira Interior, Portugal & Portuguese Telecommunications Institute (IT), Portugal

ABSTRACT

The automatic drug infusion in medical care environment remains an elusive goal due to the inherent specificities of the biological systems under control and to subtle shortcomings of the current models. The central aim of this chapter is to present an overview of soft computing techniques and systems that can be used to ameliorate those problems. The applications of control systems in modern medicine are discussed along with several enabling methodologies. The advantages and limitations of automatic drug infusion systems are analyzed. In order to comprehend the evolution of these systems and identify recent advances and research trends, a survey on the hypertension control problem is provided. For illustration, a state-of-the-art automatic drug infusion controller of Sodium Nitroprusside for the mean arterial pressure is described in detail. The chapter ends with final remarks on future research directions towards a fully automated drug infusion system.

INTRODUCTION

With the constant evolution of computing technologies, the range of problems from the medical field that can be approached and effectively solved increases accordingly. The complexity inherent to Medicine and its related areas of knowledge raises algorithmic construction difficulties, creating challenging problems, cf. (Alexander, 2010; Eoyang, 2007). There is a large range of system solutions provided by computer technologies. These include management tools, patient iden-

DOI: 10.4018/978-1-4666-3990-4.ch043

tification, and communication methods, just to mention a few. While some of these systems are quite simple, in applications such as automatic drug infusion we often benefit from very complex and advanced computer solutions.

Drug administration is usually made manually by health care professionals, following a relatively broad protocol, cf. (Webster, 2010; Olasveengen et al. 2009). However, patients tend to react differently to the same treatment, having great intra and inter-patient variability, due to their personal characteristics (clinical background, weight, drug sensitivity…)

The adaptation of the protocol to each individual is often a very challenging task for health care professionals (Fazendeiro et al., 2007), where they need to analyze multiple sources of data in order to achieve the desired patient state. This situation is demanding and requires a great deal of attention and skill from the health care professionals in the treatment of their patients.

One of the major theoretical contributions that allowed automatic drug administration systems to be developed is control theory. Control theory (Koivo, 1981; Sheppard, 1980) is an interdisciplinary branch of engineering and mathematics, which studies the behavior of dynamical systems. In a very simple manner, when one or more output variables of a system need to follow a certain desired output value over time, a controller manipulates the inputs to obtain the desired effect.

Control systems are ubiquitous in the health care, e.g. (Lichtenstein 1984; Kami et al. 1996; Jacobsen et al. 1996; Spratt 1997; Ritchart et al. 1998), ranging from simple controllers implemented only by hardware, to more complex controllers implemented via hardware and/or software. Some day to day examples of control systems include a boiler regulator of water temperature, the pressure controller of the cuff in an automatic arterial pressure meter, the humidity controller in dehumidifiers and a pacemaker beat controller.

There are lots of important contributions of control theory to the health care system, as can be seen from the applications found in the literature, cf. (Carver& Scheier, 1982). While the examples given above may not be strictly medical related applications, they serve their purpose on illustrating some of the most basic characteristics of control systems. More complex controllers, related to automatic drug administration systems, provide an interesting application of these systems to medical problems.

Since the beginning of scientific studies of the human body, researchers began to create mathematical models of the various body function systems. Nowadays these mathematical models describe in a reasonably accurate form the way that our body operates (Montani & Vliet, 2009). The pharmacological response can be also mathematically modeled, making it possible to be simulated through computerized means. The explicit knowledge about the various functional systems that constitute the human body has enabled to address the challenge of automatic drug administration from various directions in the last decades.

In system modeling and control there are applications that require not only reliability and accuracy but also a high descriptive power in order to convey information about the behavior of the system and the actions being taken. Medical systems that offer a user interface and require operator's interaction while functioning are examples of such applications. Due to their safety-critical nature a mismatch between the designer's conceptual model and the user's mental model or otherwise insufficient system feedback to allow the user to understand the current state of the system can result in disastrous consequences (Palanque et al., 2007; Thimbleby, 2007).

Driven by these issues, the latter developments of automatic drug infusion techniques in the medical field are characterized by the employment of

Related Content