Towards an assistive drug delivery system for general anesthesia

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1 Introduction

General anesthesia plays an important role in surgery and intensive care unit (ICU) and requires critical assessment of induced quantities of drugs into the patient [1]. It is characterized by unconsciousness through the action of anesthetics, but also by loss of the ability to perceive pain through the action of analgesics. Analgesia is a key feature of general anesthesia, but there is no available sensor to measure pain relief during general anesthesia. Therefore, in clinical practice, the anesthesiologist has to provide specific care during surgery for neuromuscular blockade, hypnosis and analgesia.

2 Modeling

Pharmacokinetic/pharmacodynamic (PK-PD) modeling brought a significant contribution to anesthesia. PK-PD models are a set of mathematical equations used to predict the drug effect in time. PK models describe what the body does to the drug while PD modeling describe what the drug does to the body. Compartmental modeling approach is widely used in the specialized fields of pharmacokinetics and pharmacology. Compartmental analysis is based on mathematical models represented by a set of differential equations that are widely used to characterize the uptake, distribution and elimination of a drug into the body. From patient-individualized control point of view, PD models are the most challenging part of the patient model and pose most challenges for control (i.e. highly nonlinear characteristic).

3 Control

When inducing and maintaining anesthesia, anesthesiologists select initial doses based on a variety of considerations, they observe the results, and then make adjustments based on several factors, at irregularly varying intervals. In control engineering terminology, this constitutes a closed loop control system, due to the feedback present in the observations and interventions of the anesthesiologist. The purpose of computer-controlled closed-loop systems is to formalize the process of observation and intervention as to provide better and more accurate control. A short summary of the control techniques used in anesthesia are presented in figure 1. The proposed closed loop control scheme consists of: the syringe pump, as the actuator; the patient, as the system to be controlled; the monitoring device, which can be consid-

![Figure 1: Control methods applied in anesthesia.](image)

![Figure 2: Left: Current state of use in anesthesia. Right: State of the art.](image)

4 Conclusion

General anesthesia is difficult to interpret due to the fact that the physiological signals and responses are time-variant. Standard dosing guidelines often result in an inappropriate under - or over-sedation leading to increased morbidity and mortality.

References