Semenzato Corinna, corinna.semenzato@studenti.unipd.it Date: 18/07/2022

Boldrini Gloria, gloria.boldrini@studenti.unipd.it

**Smart Multidrug Delivery for Anesthesia**

**Introduction and Model**

Anesthesia is a medical treatment that prevents patients from feeling pain during procedures like surgery, certain screening and diagnostic tests. General anesthesia affects the whole body, making patients unconscious and unable to move. In particular, the clinical procedure consists of inducing 3 conditions: hypnosis, analgesia and neuromuscular blockade. The first condition is ensured by the injection of Propofol, the second by the Remifentanil and the last by the Atracurium. The obtained outputs are respectively: Bispectral Index (BIS), Richmond Agitation-Sedation Score (RASS) and NeuroMuscolar Blockde (NBM).

BIS processes the EEG signals in order to obtain a value, which is an integer number, that reflects the level of consciousness of the patient and during the surgery the target value is 50 (general anesthesia). RASS is a 10-point scale of integer numbers that goes from -5 (unarousable) to +4 (combative) and describes the agitation or sedation of the patient; during the surgery the goal is to maintain RASS among -4 (deep sedation). Finally, NBM defines the lack of movement, and the aims is to maintain an adequate level of paralysis during the surgery; the value range goes from 0 up to 100% where 0 means total paralysis and 100 means total muscular activity, the goal is 15.

Because we are two-persons group we consider only two inputs: Propofol (drug 1) and the Remifentanil (drug 2) and we want to maintain the level of BIS = 50 10 in less than 60 s and the level of RASS = -4 1 in less than 60 s and keep to these levels in steady state via a closed-loop delivery. In particular the inputs of the system are the dose of Propofol and Remifentanil injected, while the outputs are respectively the BIS and RASS signals as reported in the following schema[[1]](#footnote-1).



Figure : Schema of the control system.

The Simulink Non-Linear model is reported below. First, it’s possible to notice that after the input block there is a saturation block both for the Propofol and the Remifentanil, this is used in order define an upper and a lower limit for the injection that are for drug 1 [0, 5] and for drug 2 [0, 2,5].

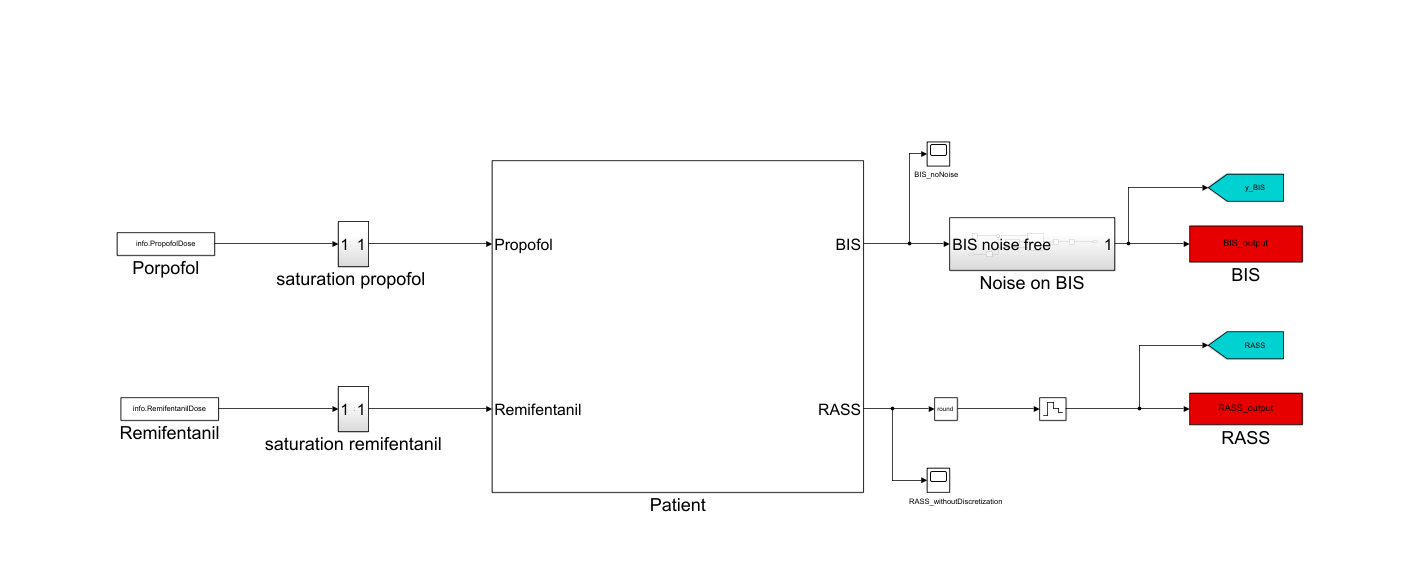


Figure : Non-Linear Simulink model.

The outputs of this system are reported in the graphs below.

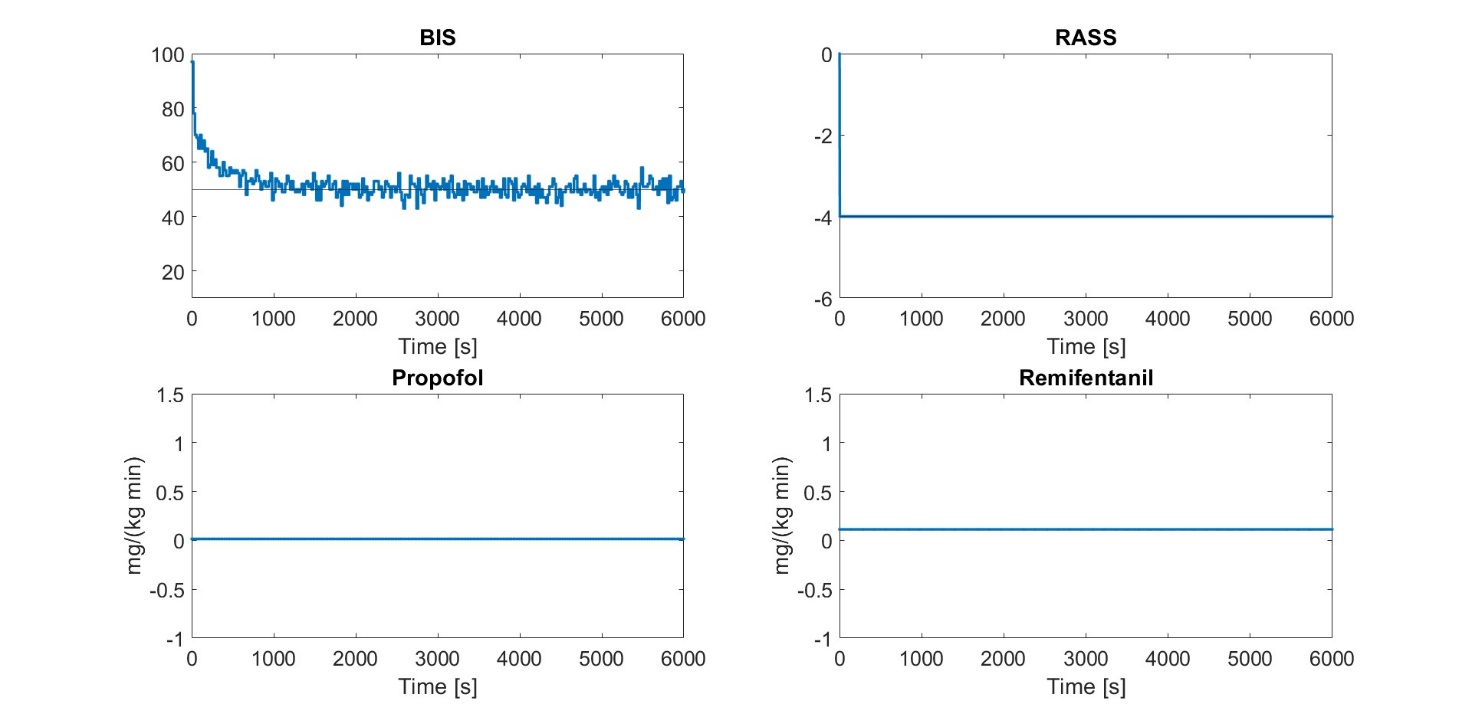


Figure : Inputs and outputs of the non-linear system.

**Task 1: Model Linearization Average Patient and Validation**

The first step in order to obtain a linear model is to trim the non-linear model of the average patient around an operating point, this is necessary in order to maintain the output in a steady state.

The trimming procedure was done with Simulink by using its App called ‘Model Linearizer’, that produce as output the operating point of the system.

1. Final Project Anesthesia, prof. Del Favero [↑](#footnote-ref-1)