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# Abstract

# Introduction

This project is implemented within the Systems Pharmacology Effect Control-Modelling (SPEC-M) Reserch Group from the Department of Anaesthesiology and reanimation of the Hospital Clinic of Barcelona. The Surgery Theatre number 4 of the Major Ambulatory Surgery department of the Hospital is the place where the field work has taken place, collecting data and familiarizing with the anaesthesia and surgical processes

## Objectives

The objectives mentioned below have been conceived around the expressed necessity of the anaesthesiology team to acknowledge the state of arousal of a patient rapidly and beforehand before the initiation of a surgical procedure. Even though anaesthesiologists have great knowledge in this matter, no predicted parameter is now a days used to quantitatively approach this event.

Therefore, the **principal aims of this project is to generate, train and validate a model in order to predict the level of Loss of Consciousness** (LoC) of a newly given patient undertaking Propophol and Remiphentanil mediated general anaesthesia.

Wide research will be undergone both in the anaesthesiology field and in the predictive modelling field in order to **acquire a model capable of being used in an operating room** **and therefore improving personalized anaesthetic management**

In order to achieve the two main goals of the project, several sub-goals are defined:

Firstly, it is crucial to **get deeply familiarized with the surgical environment and anaesthetic procedures**, which will be done through practical sessions in gynaecological surgical room 4.

Secondly, another sub-goal of this project is to **acquire knowledge on the intraoperatory collected variables and biological parameters**, in order to understand their significance and relevance in the LoC studied processes.

Finally, the last sub-goal of this project is to **properly use a control version software**, generating a commit every time an improvement has been made on the code until the final application is done, and correctly handling possible errors

## Methodology and Structure

Describe exactly what activities or procedures will take place during the award period. Specifically explain how the project will be completed.

Identify what you will do and what other individuals involved in the project will do.

What kinds of techniques will you use? Are they new or unique? In what ways? What types of data will be collected and analyses will be performed? Is your research quantitative? Qualitative? Exploratory? Historical? Another type of research? What procedures, materials, or concepts will drive your project?

Describe the extent of the involvement of the faculty mentor in the project.

The structure of the project is divided in different temporal sections (buscar algun gràfic rollo data rangling i tot això o ferlo jo...). Firstly, data is collected from the surgical procedures in the operating room number four of the Major ambulatory Surgery department on Tuesdays and Thursdays from September until November. The data used in the analysis is previously collected data from (insertar el estudi al que forma part) because of time restrictions. Currently collected data will be used in future studies conducted by other professionals.

Secondly, the data analysis, which consists of data preparation and model building, training and validation is performed using python language and Visual Studio Code user interphase. The packages used in the data analysis are a wide range, with special mention to scikit-learn. This package is a python packagespecifically designed for ML programming.

Finally

## Scope of the project

The scope of this pTable

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# Background

## Background

**¿En qué punto está la tecnología? ¿Cuál es el contexto del Proyecto?**

Estado del arte (estado de la tecnología)

Estado de la situación: ¿Cuál es la situación y el entorno donde se enmarca el proyecto? ¿Qué hay hecho? ¿Quién y para qué lo ha hecho?

A background of a project is just a simple and short statement of the project, meaning why we need to initiate it and what problems and needs will be addressed once it’s been implemented successfully. We do not say anything about objectives, resources to be allocated, methods to be used, and any other, more accurate information. The purpose of the background is to give an overview of the project for deciding on the need to do the project and for initiating the planning process. When you write a background for your project your primary focus should be placed on giving a general idea and explaining the key prerequisites. This will let your potential investors (sponsors) get the “initial impression” about the project.

### General Anaesthesia

General anaesthesia is a medically induced reversible loss of consciousness, with loss of both protective reflexes and the ability to acknowledge painful stimuli. Depending on the anaesthetics administered and their effects in the brain and muscles the effects of the anaesthesia are discerned in four different parts: unconsciousness or hypnosis, amnesia, analgesia, skeletal muscle relaxation, and akinesia. [1]

General anaesthesia as a reversible coma state of the patient is a widely accepted statement in the clinical environment. Although the patterns of EEG activity observed in comatose patients depend on the extent of the brain injury, they frequently resemble the high–amplitude, low-frequency activity seen in patients under general anaesthesia, therefore supporting this analogy [2]. This comparative rises an immediate question: How much anaesthetics are enough? The desired effects upon CNS does not remain isolated: when anaesthetic drugs are administered a wide range of other parameters such as HR, Contractility, SVM, MAP and respiratory functions are modulated. Once the desired therapeutic effect is achieved, further increasing concentrations of anaesthetics generally enhance these undesired effects of the drugs both within the surgical procedure and less drastically throughout the recuperation process. It is therefore accepted that the optimal concentrations of anaesthetics in a surgical procedure is the one that achieves the desired therapeutic effects and not more than that [3]. EEG supression?

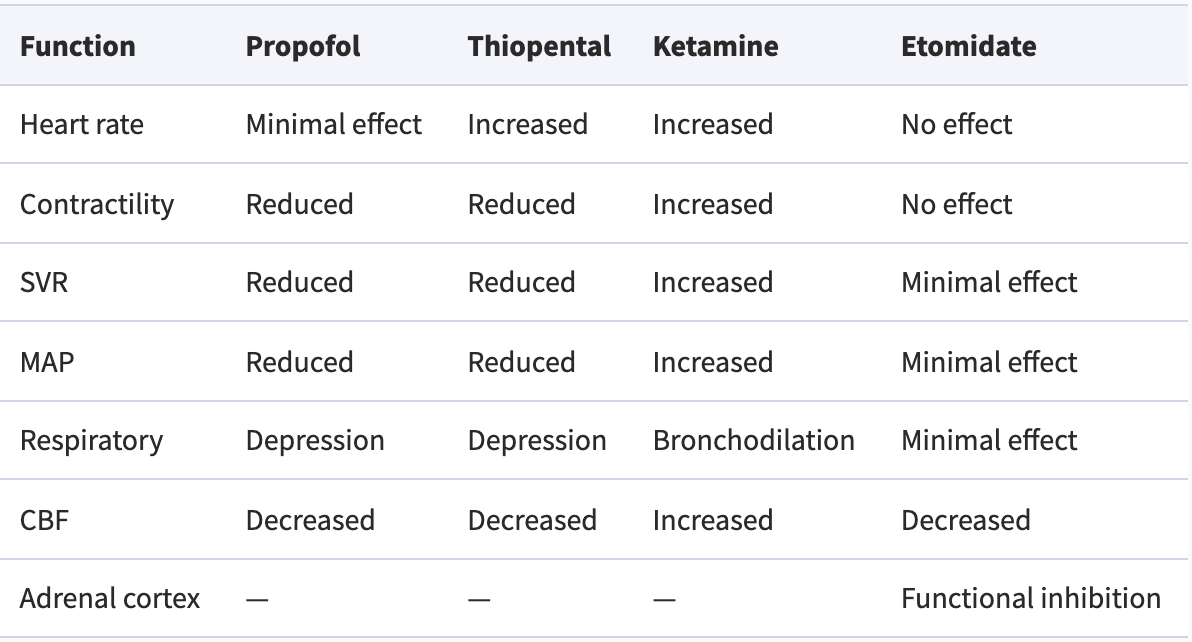


Table 1 Systemic effects of i.v. agents. SVR, systemic vascular resistance; MAP, mean arterial pressure; CBF, cerebral blood flow [3]

Several pharmacological models and techniques such as TCI (Target Controlled infusion) [4] have been implemented to achieve this goal and will be further discussed in the anaesthetics chapter.

The final desired effect when performing general anaesthesia is the event of LoC, which determines the point where the effect of the anaesthetics is strong enough to start with the surgical procedure

Indicacions i contraindicacions

LOC and EEG supression

#### Anaesthetics

Parlar del TCI i d’algun altre metode de donar el monim d’anestesia possible (mes aviat seria per controlar la quantitat d’anestesic donat, per controlarne lefecte es fan servir parametres com el BIS, EEG supression, HR etc.

#### States of anaesthesia

**Hipnosis and unconsciousness**

The state of hypnosis, which is analogous to unconsciousness, is induced by hypnotic agents such as propofol, the molecular pathways involved in this process have not yet been determined accurately, this is why it can be said that the way consciousness arises in the brain remains unknown. Yet, for nearly two centuries our ignorance has not hampered the use of general anaesthesia for routinely extinguishing consciousness during surgery. Unfortunately, once in every 1000–2000 operations a patient may temporarily regain consciousness or even remain conscious during surgery [5]. Such intraoperative awareness arises in part because our ability to evaluate levels of consciousness remains limited. Nevertheless, progress is being made in identifying general principles that underlie how anaesthetics bring about unconsciousness [] and how, occasionally, they may fail to do so.

**Analgesia**

**Amnesia**

**Akinesia**

### Anaesthesia monitoring

### Prediction modelling

Aquí caldria parlar de:

* Que és un model?
* i de predicció?
* Correlació vs causalitat (que es un model predictiu?)
* Perquè son útils?
* Quin tipus n’hi ha?

Generally, a system can be defined as a box, with a process happening inside of it, which takes some input arguments and delivers some output results. Depending on the processes inside the system and the type of inputs and outputs the system can be classified in several ways. If the given system is particularly a mathematical model, which is our case of study, it can be classified in several ways that will be in the next paragraphs.

Grafic de systema

As a matter of fact, any type of modelling is intrinsically a representation, numerical or not, of the world surrounding us. Or more concretely of the system we wish to study. When models are developed, some input variables or characteristics are used, and some others are excluded; it is therefore straightforward that a models can be good enough to be useful or not but will never pretend to explain a real process in its whole complexity. Otherwise, they will try to simplify the studied system in a way the results have significance.

As stated before, mathematical models can be classified in several ways;

* deterministic vs stochastic (probabilistic): Where the model’s output is the same always for a given set of input values, or otherwise it has an intrinsic randomness which makes the output values vary even for the same set of input values. In this last case we usually see that state variables of the system are not described by unique values, but for probabilistic equations.
* **Static vs. dynamic:**
* **Discrete vs. continuous:**
* **Linear vs. nonlinear:**
* Etc.

When talking about predictive modelling, the adjective predictive stands for its finality to obtain information about what is going to happen in the future based on information of the past.

For instance, sophisticated predictive models are used to predict health events in patients and to screen high risk individuals, such as for predicting cardiovascular disease, breast cancer or anaesthetic complications and events. Predictive modelling does not inherently belong to any of the classifications stated above but takes different forms depending on its characteristics and those of the algorithms inside it.

Correlation vs causation?

Therefore, a model is predictive if it uses information from the past, e.g., past examples, in order to achieve a future prediction or output result. Even though the term Machine Learning model is frequently used, what we are handling is a predictive model, which inside it we are using a ML algorithm. Also, methods and algorithms used inside the model can be of several types and origins: basic statistics, time-dependant causal equations, AI algorithms such as ML and DL, and a long etcetera.

But what is exactly ML and what has in common with AI? AI is a set of algorithms and techniques which pretend to mimic or assemble human like mental processes to accomplish tasks which usually require of human intelligence. ML is a subset of the AI paradigm, which is characterised by being capable of learning without being explicitly programmed. Finally, DL is a subset of ML characterised by a brain-like net of artificial neural networks (NN) which the DL algorithm uses to learn, also without being explicitly programmed. [8]

Diagram

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Figure 1Visualization of algorithms vs. artificial intelligence vs. machine learning vs. deep learning (Author: Johannes Vrana, Vrana GmbH, Licenses: CC BY-ND 4.0) [8]

Estatistics vs ML vs DL (?)

IA? Que és? Tipus?

Aqui ja parlar dels diferents models de ML

## Situation

### State of the art

### Sources

# Solution implementation

## Concept engineering

Ingeniería de concepción (funcional) de la solución. Esquemas de principio, balances y predimensionados

### Different solutions

Aqui hauriem de tractar les diferents solucions possibles al problema (estadistica, ML, DL...)

### Proposed Solution

Justificar la solucio triada sobre les altres

## Detail engineering

En la ingenieria de detalle pondriamos todos los planes, especificaciones, condiciones que se empezaron a describir en la ingenieria de concepcion

### Data processing

### Exploratory analysis

### Model training

### Model Validation

# Technical

## Specifications and technical characteristics

## DAFO

Debilidades y fortalezas. Resistencias. Puntos criticos

Mantenibilidad, fiabilidad, disponibilidad y calidad

Seguridad

Suministros y repuestos

Asistencia tecnica

# Economic viability

Estudio de costes y presupuestos

Planificación económica

Estudios de costes

Estudios de financiación

Análisis de rentabilidad: Payback, VAN, TRI

Análisis de sensibilidad

# Chronogram and execution

Definición de tareas, tiempos y asignación de

responsabilidades. Establecimiento de fases e

hitos. Análisis de caminos: camino critico

Diagramas de PERT, GANT

Cronograma. Penalizaciones

EDT, Análisis de precedencias, CPM/PERT y

GANTT

# Results

# Discussion and Future Prospects

Referencies:

[1] <https://www.ncbi.nlm.nih.gov/books/NBK557596/>

[2] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3162622/#R10>

[3] <https://academic.oup.com/bjaed/article/14/3/100/340780>

[4] <https://pubmed.ncbi.nlm.nih.gov/15886597/>

[5] <https://pubmed.ncbi.nlm.nih.gov/15333419/>

[7] <https://injepijournal.biomedcentral.com/articles/10.1186/s40621-019-0208-9>

# [8] **The NDE 4.0: Key Challenges, Use Cases, and Adaption**

Validació prospectiva d’un model de supervivència, que preten donar una probabilitat de que el pacient romangui conscient en funció de la dosi de propofol (Hipnotic) administrada.

Loss of consciousness refers to a **state in which an individual lacks normal awareness of self and the surrounding environment.** The patient is not responsive and will not react to any activity or stimulation. Syncope is the medical term for temporary loss of consciousness.