

# Patients on Weaning Trials Classified with Neural Networks and Feature Selection

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## ABSTRACT

One of the challenges in intensive care is the process of weaning from mechanical ventilation. We studied the differences in respiratory pattern variability between patients capable of maintaining spontaneous breathing during weaning trials, and patients that fail to maintain spontaneous breathing. In this work, neural networks were applied to study these differences. 64 patients from mechanical ventilation are studied: Group S with 32 patients with Successful trials, and Group F with 32 patients that Failed to maintain spontaneous breathing and were reconnected. A performance of 64.56% of well classified patients was obtained using a neural network trained with the whole set of 35 features. After the application of a feature selection procedure (backward selection) 84.25% was obtained using only eight of the 35 features.

## INTRODUCTION

Neural networks are very sophisticated modelling techniques capable of modelling extremely complex functions (Bishop, 1995). A simple network has a feed-forward structure: signals flow from inputs, forwards through any hidden units, eventually reaching the output units. Such a structure has stable behaviour. Neural

networks are applicable in every situation in which a relationship between the predictor variables (independents, inputs) and predicted variables (dependents, outputs) exists, even when that relationship is very complex and not easy to articulate in the usual terms of “correlations” or “differences between groups.”

The weaning trial protocols are very important in patients under mechanical ventilation. A failed weaning trial is discomforting for the patient and may induce significant cardiopulmonary distress. When mechanical ventilation is discontinued, up to 25% of patients have respiratory distress severe enough to necessitate reinstatement of ventilatory support (Tobin, 2001).

The respiratory pattern describes the mechanical function of the pulmonary system, and can be characterized by the following time series: inspiratory time ( $T_I$ ), expiratory time ( $T_E$ ), breath duration ( $T_{Tot}$ ), tidal volume ( $V_T$ ), fractional inspiratory time ( $T_I/T_{Tot}$ ), mean inspiratory flow ( $V_T/T_I$ ), and frequency-tidal volume ratio ( $f/V_T$ ).

The variability of breathing pattern is nonrandom, and may be explained either by a central neural mechanism or by instability in the chemical feedback loops (Benchetrit, 2000). The study of variability in the respiratory pattern has been discussed in (Bruce, 1996; Caminal, Domingo, Giraldo, Vallverdú, Benito, Vázquez, & Kaplan, 2004; Khoo, 2000; Tobin, Mador, Guenter, Lodato, & Sackner, 1988).

The aim of the present work is the analysis with neural networks of the respiratory pattern variability in patients during weaning trials, in order to find differences between patients capable of maintaining spontaneous breathing and patients that fail to maintain spontaneous breathing.

As in many real situations, the suitable variables that describe the problem are partially unknown. When irrelevant variables are present, there may be many different models able to fit the data. But only some of them (those that do not use irrelevant variables) will lead to good generalization performance on unseen examples. However, in general it is not possible to control that irrelevant variables are not used during the training phase to learn the training set. This problem is shared by all modeling techniques, including neural networks. In this situation, feature selection techniques allow to search for a good subset of input features.

### ANALYZED DATA

Respiratory flow was measured in 64 patients on weaning trials from mechanical ventilation (WEANDB data base). These patients were recorded in the Departments of Intensive Care Medicine at Santa Creu i Sant Pau

Hospital and Getafe Hospital, according to a protocol approved by the local ethic committees. Using clinical criteria based on the T-tube test, the patients were classified into two groups: Group S (GS), 32 patients with Successful trials after 30 minutes; and Group F (GF), 32 patients that Failed to maintain spontaneous breathing and were reconnected after 30 minutes of weaning trials.

Respiratory flow was obtained using a pneumotachograph connected to an endotracheal tube. The signal was recorded at a sampling frequency of 250 Hz during 30 minutes.

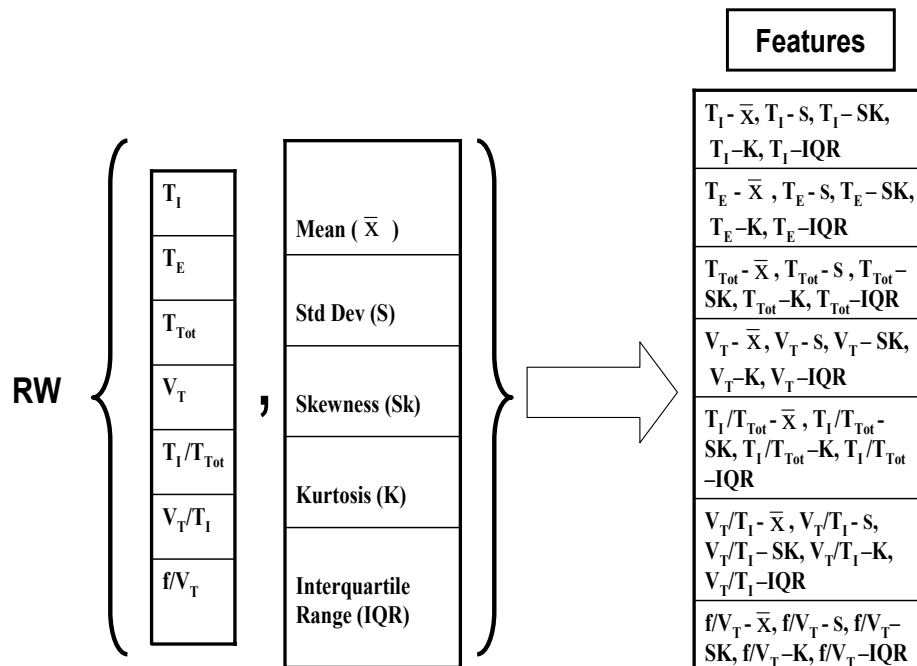
From each recorded signal the aforementioned time series were obtained: inspiratory time ( $T_I$ ), expiratory time ( $T_E$ ), breath duration ( $T_{Tot}$ ), tidal volume ( $V_T$ ), fractional inspiratory time ( $T_I/T_{Tot}$ ), mean inspiratory flow ( $V_T/T_I$ ), and frequency-tidal volume ratio ( $f/V_T$ ).

### METHODOLOGY

#### Data Preprocessing

Each one of the seven time series was processed by moving a Running Window (RW), with a width range from 3 to 100, consisting of several consecutive breath

Figure 1. Representation of 35 features for each patients obtained by Running Window (RW) with seven respiratory time series ( $T_I$ ,  $T_E$ ,  $T_{Tot}$ ,  $V_T$ ,  $T_I/T_{Tot}$ ,  $V_T/T_I$  and  $f/V_T$  and five statistics (mean, standard deviation, skewness, kurtosis and interquartile range) applied



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