# An Electrodermal Activity Psychophysiologic Model

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***Abstract:*** **To study the changes on the electrical characteristics of the skin several problems have to be solved. We present a model for the electrodermal activity (EDA) that provides the means to detect and quantify four event types: a discrete event; a pair of events overlapping in the increasing zone; a pair of events overlapping in a decreasing zone; and an isolated small event. The presented EDA model is derived following morphological evidences found in the collected database of EDA signals conducing to a low cost computational model. We provide the algorithmic steps to extract the EDA parameters.**

## Introduction

Electrodermal activity (EDA) is a psychophysiologic signal capable of being used for extraction of clinical and psychological relevant information. In this work we present the steps taken in the development of a new mathematical model for the electrodermal signal.

The electrodermal activity is related to the change in the electrical characteristics of the skin [1]. The sudomotor glands when activated via the sympathetic chain start to produce sweat that creates momentary and long-term alterations to the skin conductivity. The control of the sympathetic chain is performed both by the primary brain functions for temperature regulation (in the hypothalamus) and by higher order brain structures related to emotion and cognitive processing (mainly in the prefrontal lobes of the brain) [2].

The EDA signal is composed by a tonic and phasic activities. The slowly varying base signal is the tonic EDA part also called the skin conductance level (SCL). The faster changing part (phasic activity) is related to exterior stimuli or non specific activation, are the bumps that appear in the signal. In figure 1 (left) we present two minutes of EDA signal and in figure 1 (right) we show an example of an isolated phasic EDA event (SC) with the first (SC') and second derivative (SC''). The zeros of the first and second derivative are identified with t1, t2, t3 and t4.

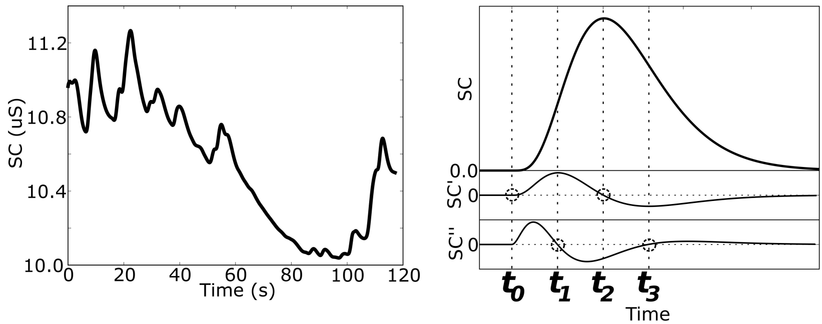


Figure 1 – EDA signal collected over two minutes (left). EDA event with first and second derivative (right).

## Electrodermal activity models

To detect the changes in the EDA response, several approaches have been taken, from qualitatively observations [3], and empiric measurements to the recently application of complex models based on parameters optimization. The evolution in the different models found the motivation in the recurrent problems of EDA modeling. The problems occur when the phasic events overlap and the parameters extraction of the signal is corrupted by the occurrence of a skin conductance response (SCR) in the time vicinity of a previous one. This type of overlap some times occurs in a pair of events with distinct orders of magnitude, where the stronger event entirely masks the smaller one.

The current models used in EDA research pass by an initial step of identification of event occurrences followed by the modeling of each of these events.

The first computational models used in EDA studies were based on the identification of peaks and valleys of the signal, using these values to retrieve the signal parameters without any consideration of the overlapping problems in EDA.

More recently a sigmoid-exponential model has been proposed [4]. The model uses a combined sigmoid-exponential version of two events plus the SCL to be able to work with overlapping events. The modeling procedure is performed via an optimization routine that is sensitive to the initial selected parameters proving to be hard to use since the parameters for pairs of overlapping events need to be very well selected to guarantee the convergence of the method.

Two other authors [5][6] have presented a bi-exponential model following distinct algorithmic steps. This model when compared to the real signal lacks some of the properties like the differentiability in the initial instant.

## Proposed model

The model being presented is motivated by the morphologic analysis of the EDA signal. We used a set of EDA signal collected in the context of 5 cognitive tasks from 26 subjects. Our proposal is a simple model that expressed the characteristics of the EDA signal. In equation 1 the base model is presented with a gain *a* and a decay constant *b*. More details in the model can be found in an internal report [7]. The model is computed by detecting consecutive zeros in the second derivative (see t1 and t3 in figure 1) and using equation 2 the parameters can easily be estimated. The model is computed apart from the tonic skin conductance level (SCL). In figure 2 we present the algorithmic steps for the complete extraction of several overlapping and non overlapping EDA events.

$$at^4 \mathrm{e}^{-bt} \tag{1}$$

$$b = \frac{4}{t_3 - t_1} \qquad a = b^3 \frac{f''_{t_1} - f''_{t_3}}{16\mathrm{e}^{-2} + 432\mathrm{e}^{-6}} \qquad t_0 = \frac{2t_1 - t_3}{2} \tag{2}$$

**Algorithm** *Processing steps*

1. filter the signal with low pass filter (2-5Hz)
2. detect second order derivative zeros ($t_1$ and $t_3$)
3. **for** each pair of zeros:
4. compute $a$, $b$ and $t_0$
5. compute SCL

Figure 2 – Algorithm for EDA parameters extraction

## Conclusion

The present model has the capability to overcome some of the EDA modeling problems with simple computational steps with low time requirements. In figure 2 we show a small interval of EDA signal where 4 events were detected. The isolated events are presented in the bottom of the figure. The usage of the model in the collected data demonstrated that the model fits well into the real data and correctly identifies and separates overlapping and smooth events.

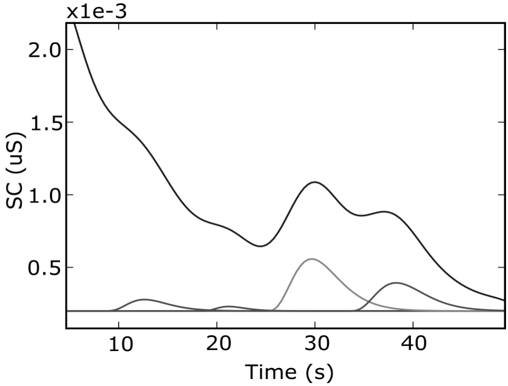


Figure 2 – EDA signal with the events extracted using the proposed model. The original signal is on top and the ditinct EDA events on the bottom.

## Acknowledgment

This work was partially sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC) and the Instituto de Telecomunicações (IT), Pólo de Lisboa.

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