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Suitable segmentation method of a thermal signal representing sleep movement in the bed

T. Guettari, D. Istrate, N. Houmani, J. Boudy

University of Technologies Compiègne, Télécom SudParis

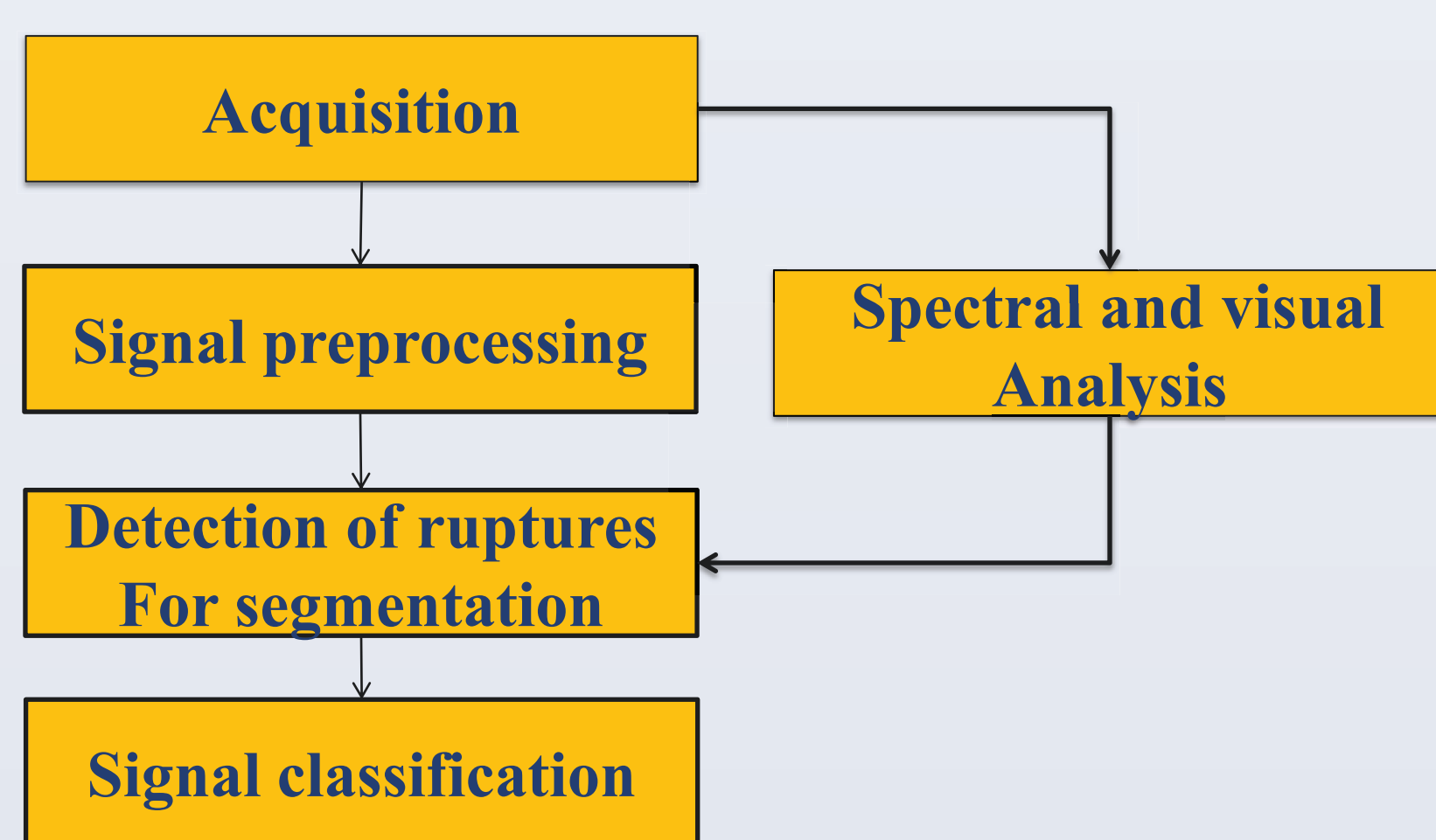
ABSTRACT

Sleep quality and quantity is an important factor in the prevention of frailty and serious diseases such as depression and diabetes. Therefore the devices that allow sleep monitoring are studied for well being. Body movement during sleep can be related to particular diseases such as sleep apnea and restless legs syndrome. In this paper we present a study on movements detection during sleep and the estimation of inactivity duration. Contactless thermal sensor (thermopile) is used to detect thermal variation caused by body movement in bed. A new adaptive segmentation method including symbolic representation (SAX) is introduced and implemented to compare identified sleep phases by our system to a reference hypnogram. The proposed sensor and his processing algorithm has been evaluated on 11 subjects. This evaluation shows good correlation between automatic segmentation and the hypnogram reference labels.

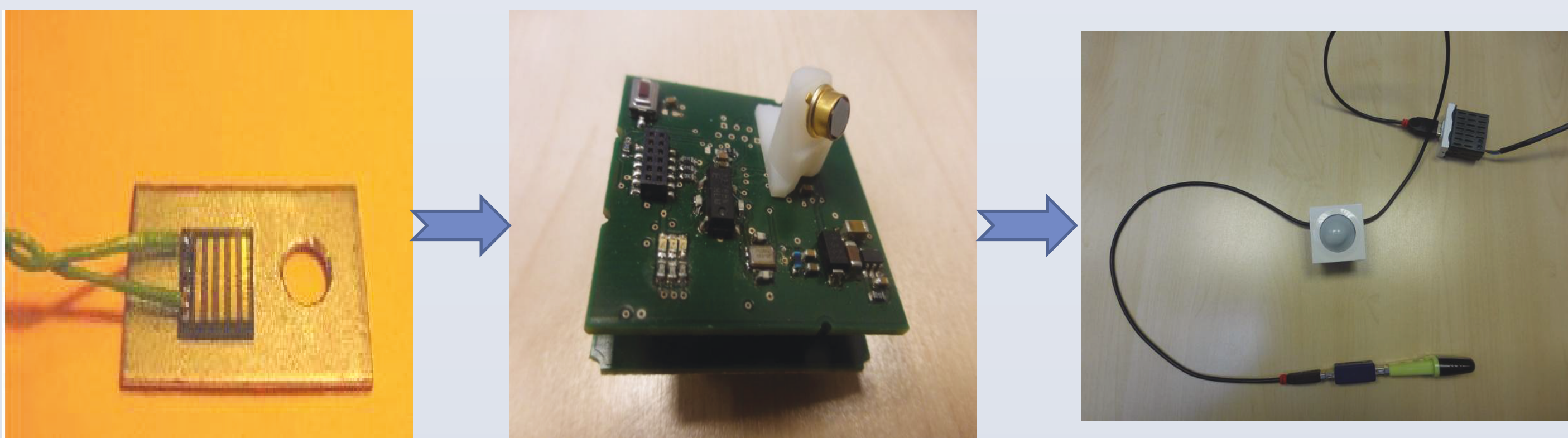
INTRODUCTION

Objectives of such project are multiple, for instance to easy analyze the sleep before using the polyspigraphy (PSG), to conduct experiment of a remote monitoring system at home on a specific category of patients (insufficient cardiac heart, asthma, apneic spells, diabetes, etc..) over several months or to build apartments, carried out smart sensors, alarm systems adapted to the healthcare telemonitoring requirements.

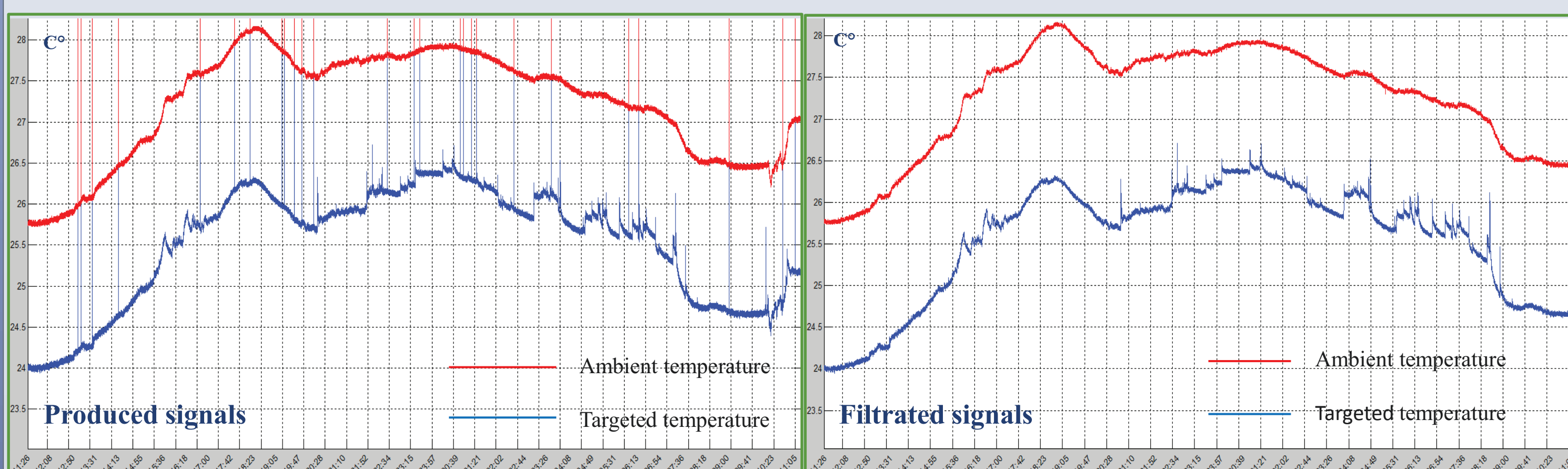
METHODOLOGY



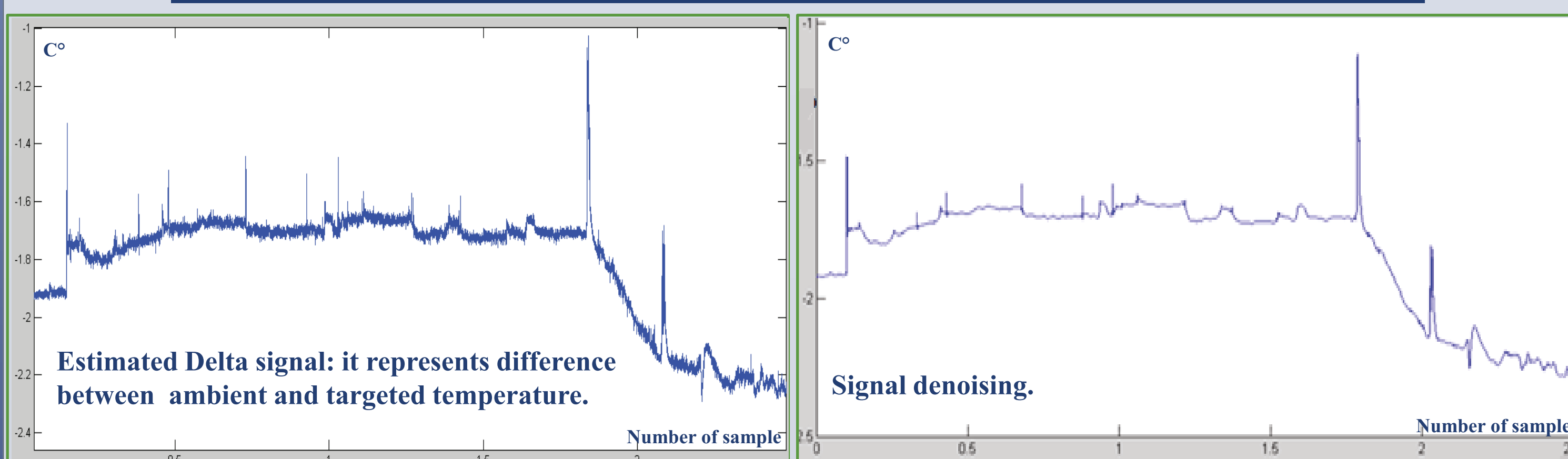
THE THERMAL SENSOR



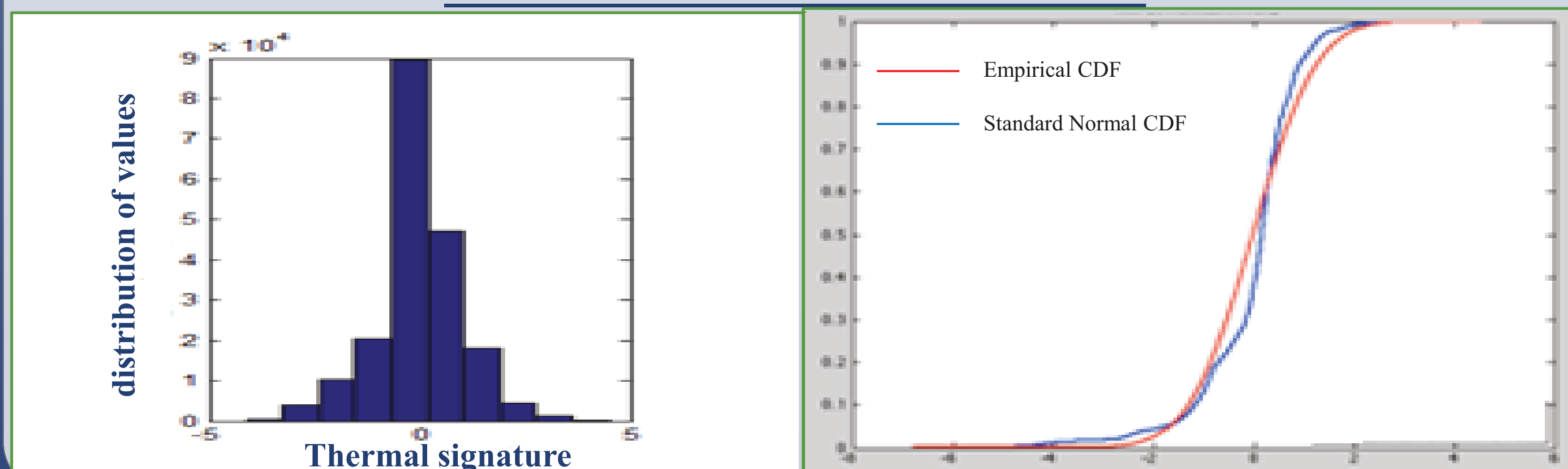
SIGNAL PREPROCESSING : MEDIAN FILTER



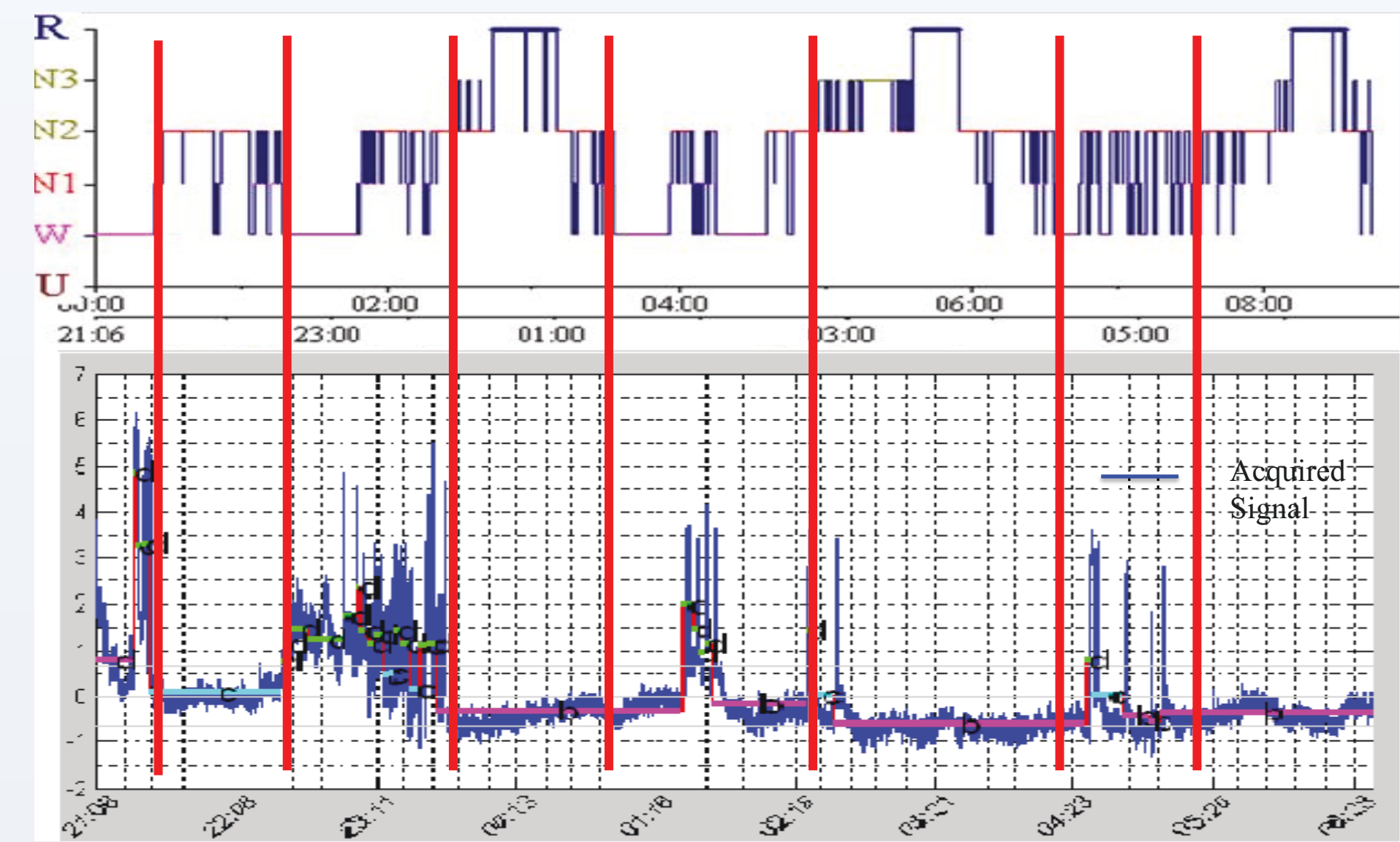
SIGNAL PREPROCESSING : DENOISING USING WAVELET



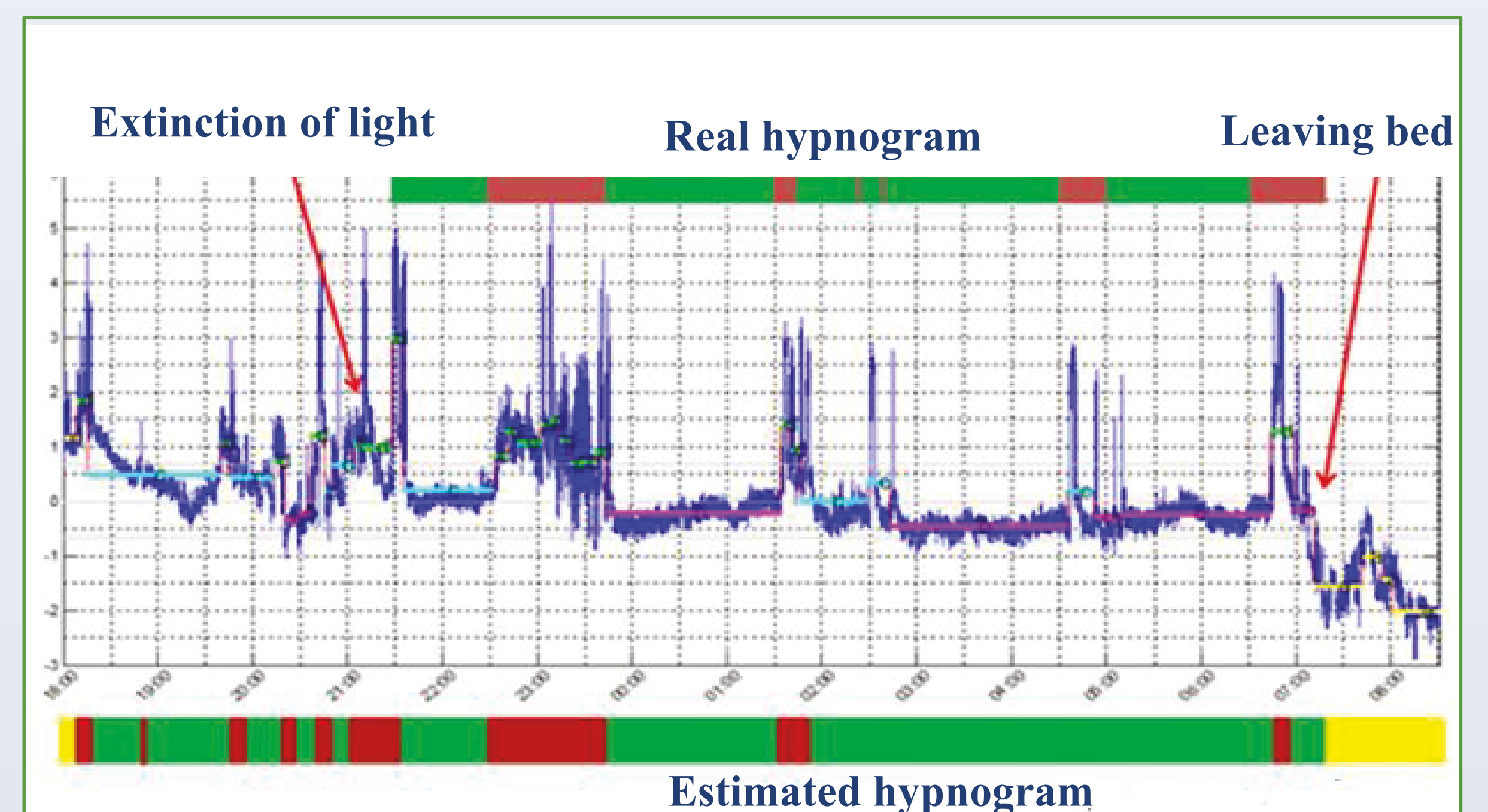
KOLMOGOROV-SMIRNOV TEST



ANNOTATION



SIGNAL CLASSIFICATION : SAX SEGMENTATION METHOD

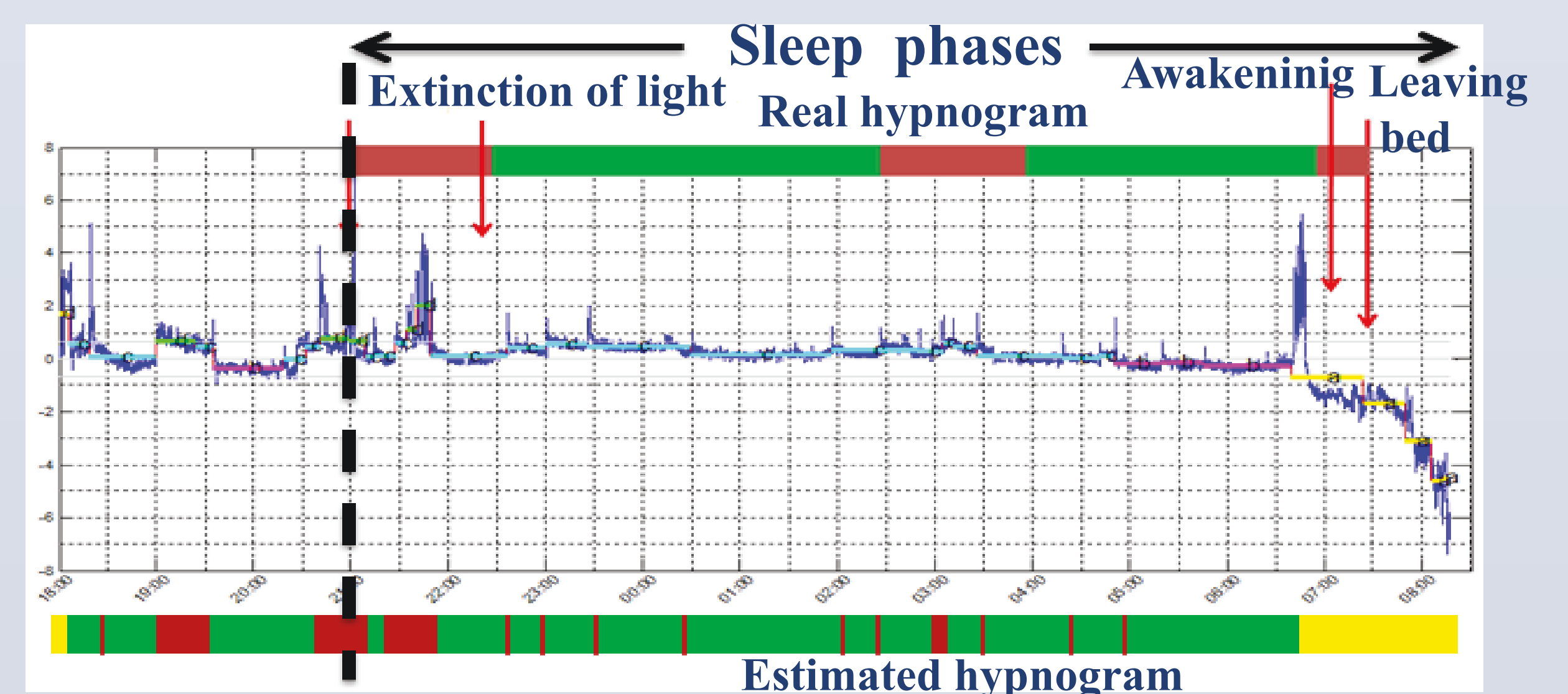


RESULTS

97% of short segments that have a duration less than thirteen minutes are matched with week, very light and light sleep phase.
90% of long segments that have a duration more than thirteen minutes are matched with deep and REM sleep phase.

Therefore, the duration of segments represents a significant parameter to identify sleep phase using thermal signal produced by our infrared sensor

AWEAK PERIOD DETECTED



CONCLUSIONS AND PERSPECTIVES

This work addressed the sleep analysis problem of people in hospital using an IR thermopile sensor without contact.

This preliminary work validates the feasibility of exploiting the thermal signature for monitoring sleep. Its contribution consists in extracting information not only on the presence of the person but also on his actimetry (actigraphy). Based on this information we were able to distinguish and make difference between a quiet and fitful sleep. Thanks to the comparison with the result of polysomnography, we validate these findings throughout experiments carried out at the Hospital of Limoges.

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