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ANALYSIS OF FIXATIONAL EYE MICROMOVEMENTS THROUGH PUPIL TRACKING

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Summary

The human eye is constantly moving even when it is maintaining a stable fixation point. Stable images on the retina rapidly saturate the photoreceptors and fade. The visual system needs of constant stimulation is achieved by fixation micromovements consisting of microtremors, drifts and microsaccades. We present a technique for pupil segmentation and contour analysis which will provide valuable information about fixational eye movements.

Materials and methods

We use 2 high-speed video cameras (AOS Technologies AC) situated at a fixed distance about 34 cm. Each camera focuses on one of the subject's eyes and is connected to a different computer. The cameras are synchronized and record sequences of both eyes at the same time (fig.1b).

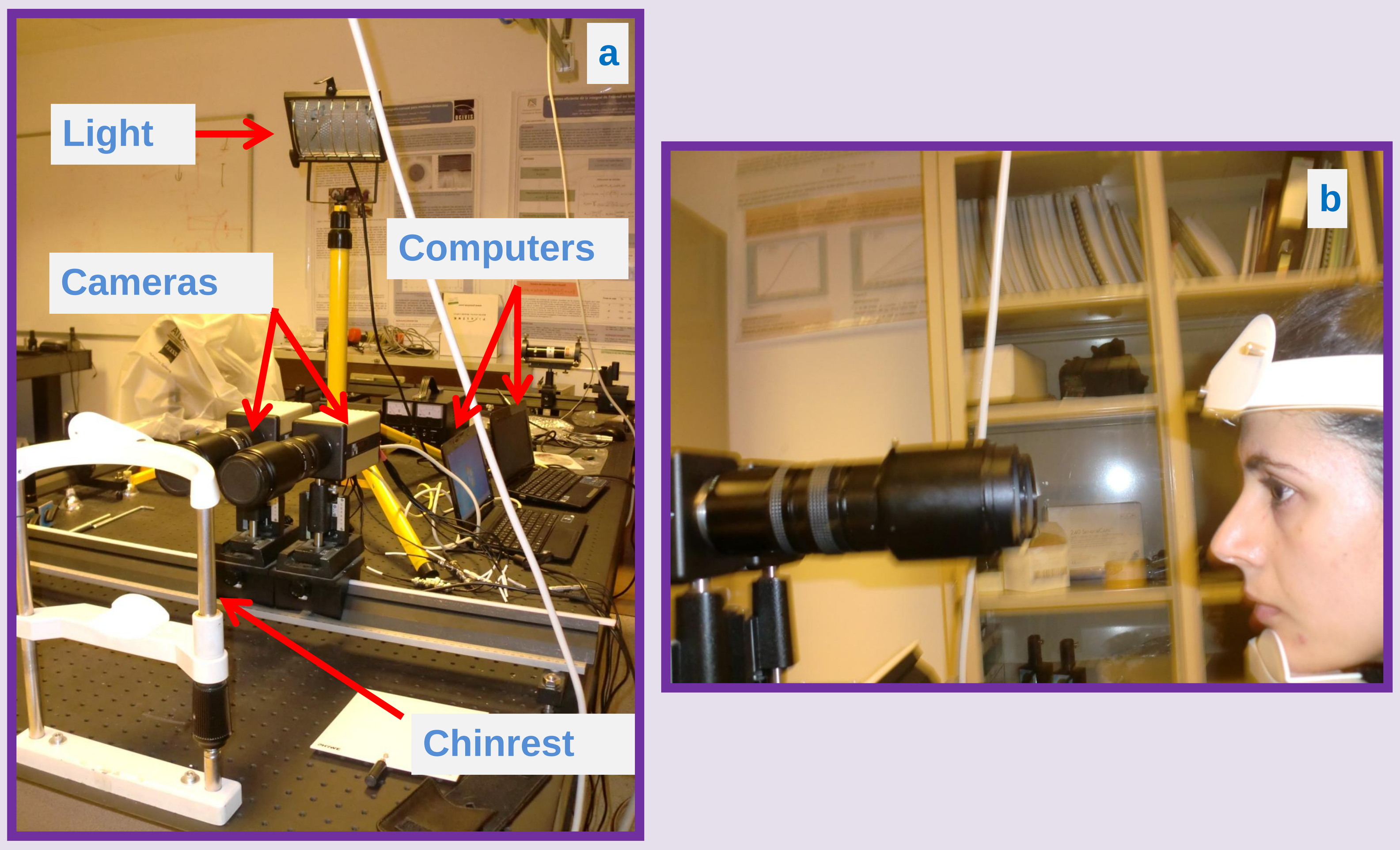

Fig.1. a) Picture of the general assembly. b) Position of the two cameras.

Each sequence is recorded at 500fps with a resolution of 800x600px. Once captured, the sentence is processed frame by frame using our own software implemented in Matlab. First step for image processing consists of selecting a threshold value for hard clipping of the image thus obtaining the region of interest (pupil). Edge detection algorithms were applied to determine the pupil contour which is fitted to an ellipse (1).

$$Ax^2+Bxy+Cy^2+Dx+Ey+F=0 \qquad (1)$$

Thus, we get the coordinates of pupil centre (X0,Y0) (2) gives us the position of the pupil in the image. Furthermore, the position of the centre of the ellipse gives information about slow and sudden eye movements.

$$(X0,Y0)=-\left(\frac{D}{2A},\frac{E}{2C}\right) \qquad (2)$$

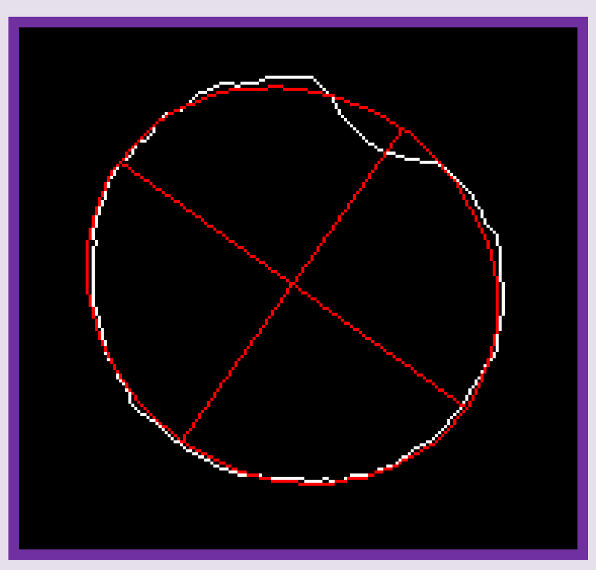

Fig.2 Pupil contour (white) and its fit to an ellipse (red).

Results

We have measured 12 eyes and processed the sequences of each one. In figure 3, we separately represent the coordinates X0 and Y0 for both eyes of a typical subject. Both X0 and Y0 move in parallel in the same direction. This indicates that the eyes of a same subject move similarly.

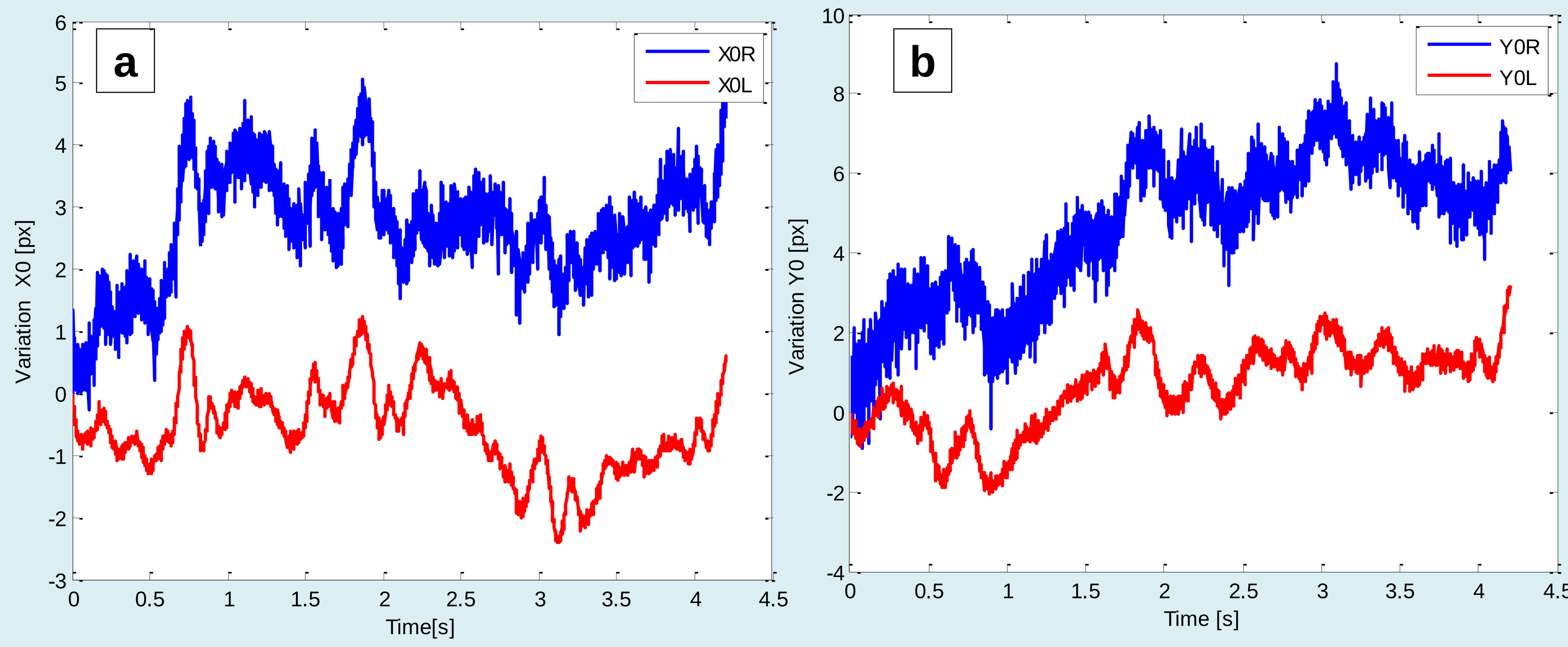

Fig.3. Variation of the X0 (a) and Y0 (b) coordinates of both eyes.

Another motion descriptor that we want to evaluate is the typical frequency of fixational eye movements. The Fourier transform (FT) allows us to obtain the frequency spectrum of the signal. Thus, we calculate the FT of coordinates X0, the direction in which these movements are more significant, of both eyes in figure 4. There, we can see a peak at frequencies around 80Hz, which are related with fixational eye movements, specifically with tremors. This kind of movements has a frequency range between 30-100 Hz with a maximum around 80-90Hz. Furthermore, maximum appearing between 0-0.5Hz. These values correspond to typical frequencies of cardiorespiratory rhythms which were studied in a previous work [1].

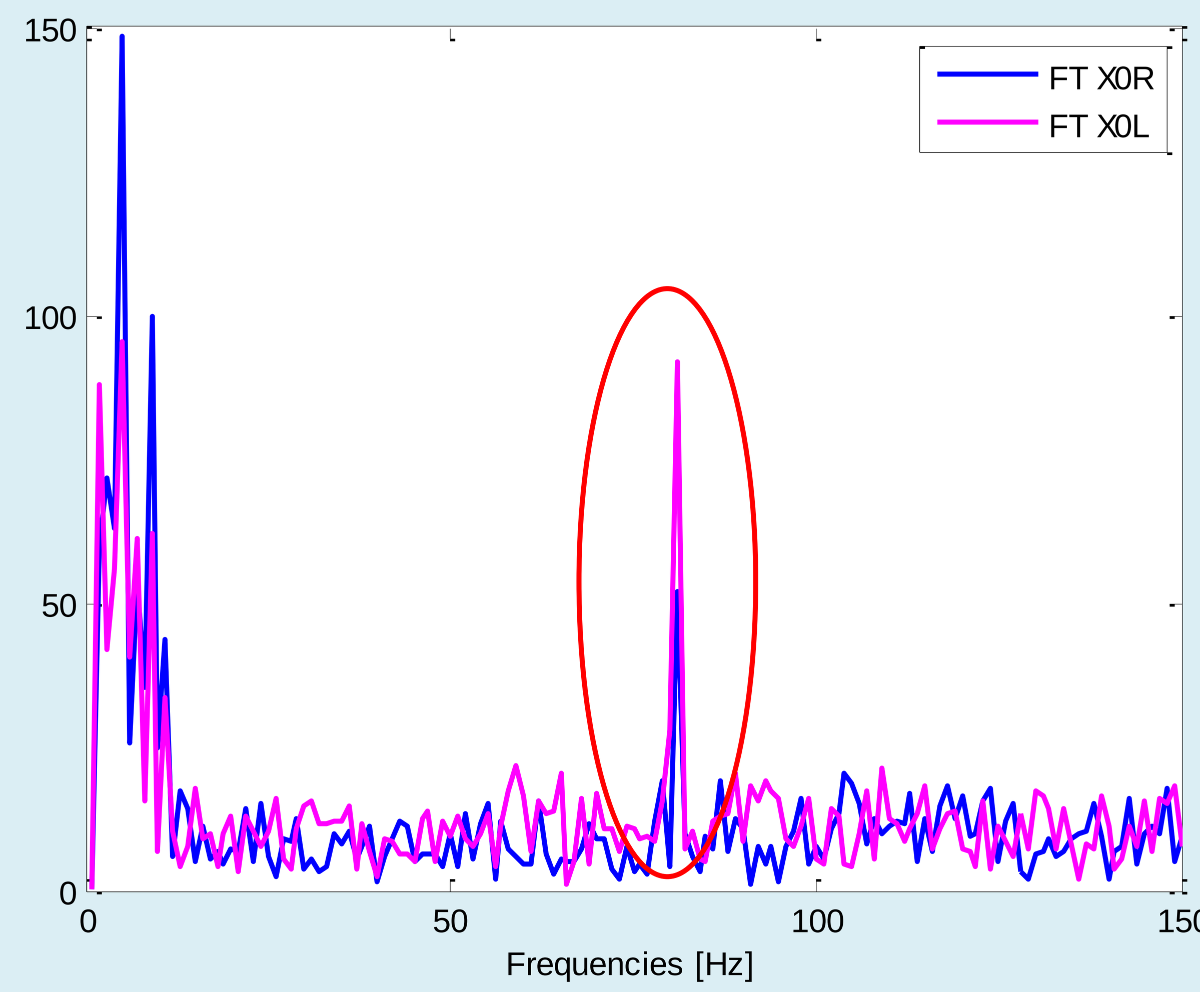

Fig.4. Fourier Transform of oordinates X0 of both eyes.

Conclusions

Our method allowed us to observe and compare the movement of both eyes. We could also detect typical frequencies of fixational eye movements.

References

[1] A.B. Roig, *"Influencia de los ritmos cardiorrespiratorios sobre la dinámica ocular y pupilar"*, Research Work, Master of Advanced Optometry and Vision Sciences, 2009. http://rua.ua.es/dspace/handle/10045/17157

Acknoledgments

Thanks to Spanish Ministerio de Ciencia e Innovación through BIA2011-22704, the Generalitat Valenciana through the project PROMETEO/2011/021 and theUniversity of Alicante through the project GRE10-09. A.B. Roig thanks Fundación Cajamurcia the grant"Beca de investigación Cajamurcia 2010