Improving keratoconus susceptibility screening on refractive surgery using wavelet computational model and learning machine techniques

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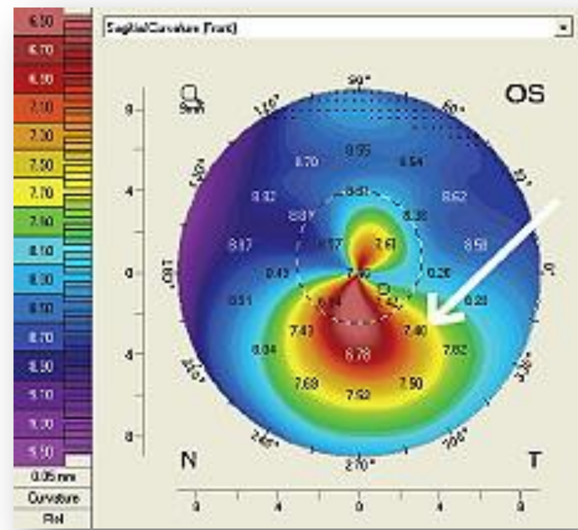
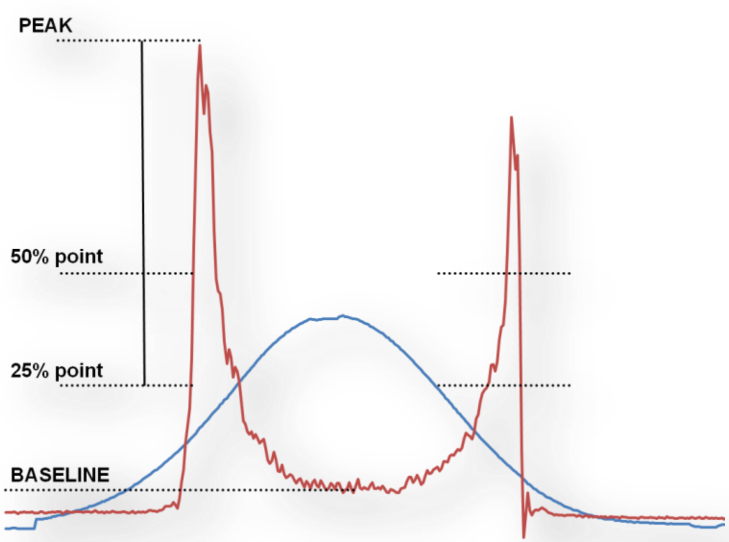
Purpose: To improve ***keratoconus susceptibility screening*** on refractive surgery, using corneal ***biomechanical data***, specifically the signs of applanation and pressure derived from Ocular Responser Analyser (ORA), based on ***wavelet*** computational model and ***learning machine techniques***.

Why enhance refractive surgery screening?

Ectasia as a rare but major ***complication following refractive surgery***. Its emergence led to the need for preoperative identification of mild and/or sub-clinical forms of ectasia. But ***even with rigorous an detailed screening methods***, some patients still develop post-LASIK ectasia of ***unknown etiology.***





Combination of tomographic and biomechanical corneal data provides more information to characterize the cornea beyond just corneal front surface topography and central corneal thickness.

How can we improve Refractive Surgery Screening?

USING LEARNING MACHINE AND SIGNAL PROCESSING...

- Learning machine is a area of computational science and a type of Artificial Intelligence (AI). The AI were designed to perform ***massive data analysis that would be relatively impossible for humans***. It can help answer ***clinically relevant questions***, such as ***what are the characteristics that should be considered to improve the screening process for ectasia risk among refractive candidates.***

- It was used different types of Learning machine techniques:

✓ Decision Tree

✓ Artificial Neural Network

✓ Radial Basis Function (RBF) Networks

How can we improve Refractive Surgery Screening?

USING LEARNING MACHINE AND SIGNAL PROCESSING...

- Signal processing is to ***extract the critical information*** of a signal. There are various techniques and signal processing, the most popular are based on Fourier and ***Wavelet***.

- It was used different types of Signal processing techniques:

✓ Haar

✓ Daubechies

✓ Coiflets

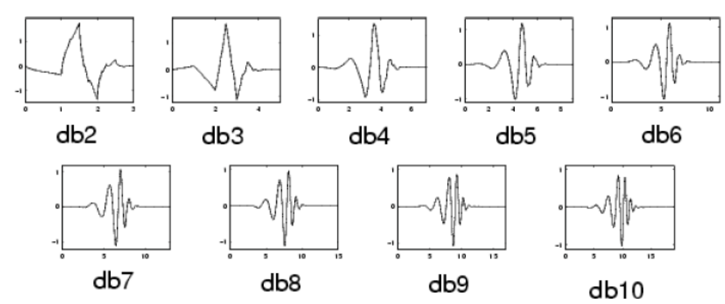


Figura 20. Família Wavelet Daubechies.

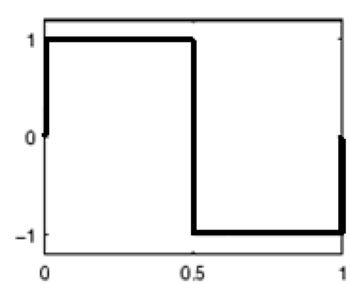


Figura 19. Wavelet Haar.

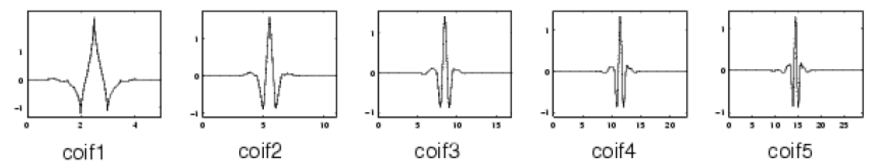
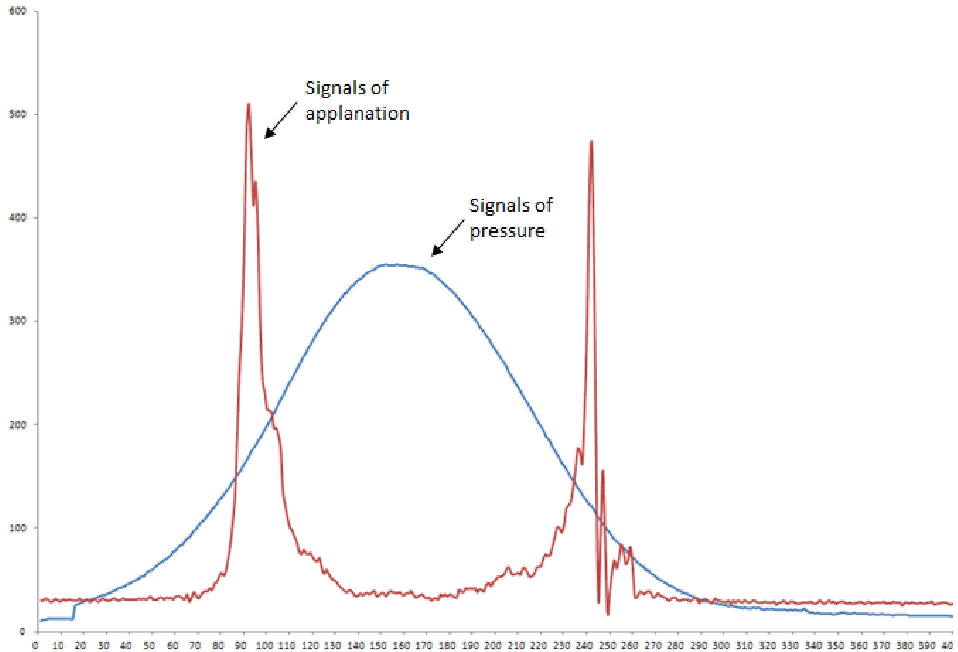


Figura 21. Família Wavelet Coiflets.

The signals of the Ocular Responser Analyser

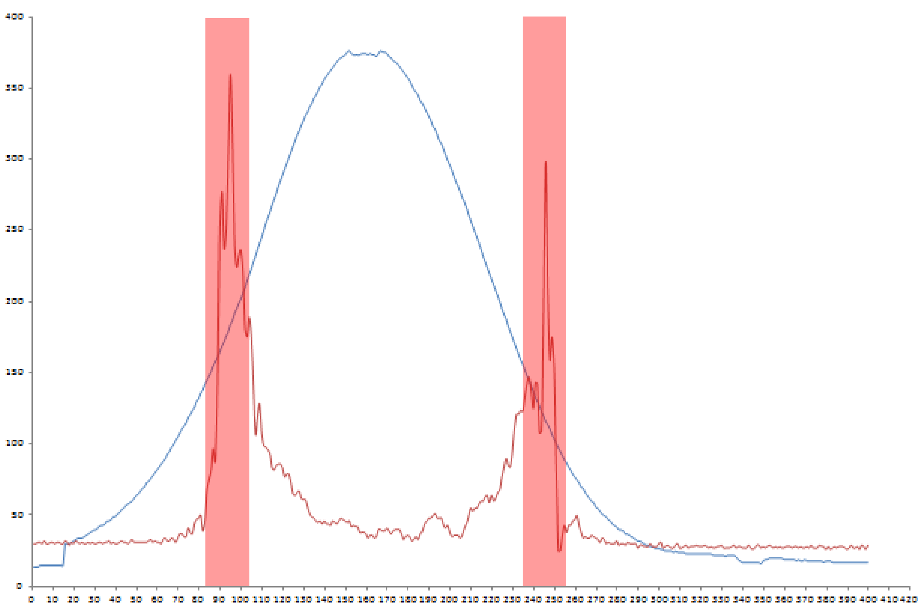
<u>Ocular Response Analyser</u>

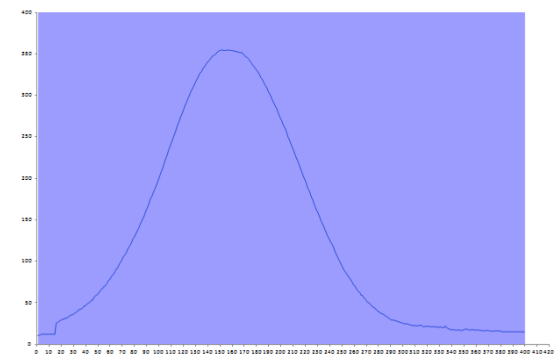
- ✓ Analize ***corneal biomechanical properties*** in vivo and the intraocular pressure.
- ✓ ***Keratoconus diagnosis.***
- ✓ *It follows two signals: applanation and pressure.*

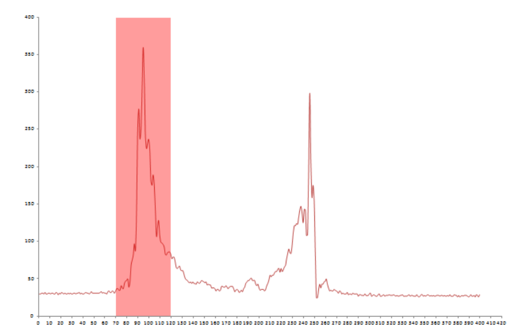


Applying signal processing techniques on signals resulting from ORA

- The signal processing techniques were applied to two signals returned by the ORA. The signs of applanation and pressure.
- Reviewing each signal individually and together.
- Specific parts of the signal were also analyzed.





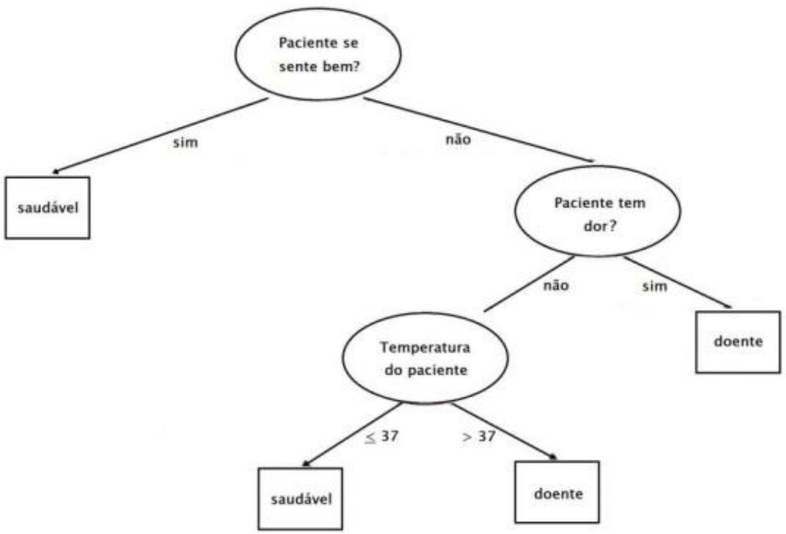


Applying learning machine techniques on signals resulting from ORA

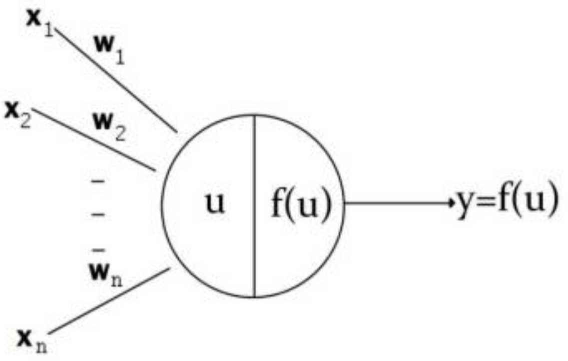
Pressure signals were processed by flattening and machine learning techniques.

The responses of both signals and parts for detecting mild cases of ectasia were observed.

Applying machine learning before and after wavelet processing of signals.



Fonte: REZENDE,2005.



Fonte: REZENDE,2005.

Methods

Were used the signals of applanation and pressure of 201 eyes examinations. 65 exams classified as keratoconus grades I and II by Krumeich classification and 136 normal cases.

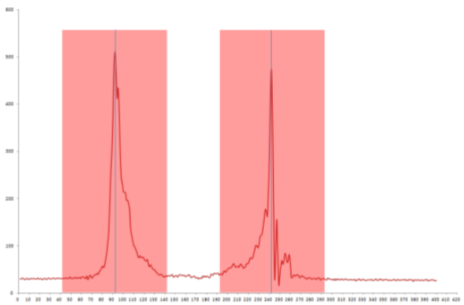
The results were divided into two groups:

(1) without the use of signal processing and

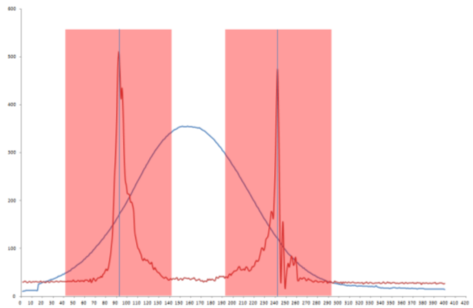
(2) using signal processing.

Results

Without the use of signal processing the best results were:



Graph 1: Only Applanation Signal



Graph 2: Applanation + Pressure Signals Combined

Graph 1 Results

accuracy: 92.52% +/- 6.03% (mikro: 92.54%)

	true KK	true NORMAL	class precision
pred. KK	55	5	91.67%
pred. NORMAL	10	131	92.91%
class recall	84.62% (Sensitivity)	96.32% (Specificity)	

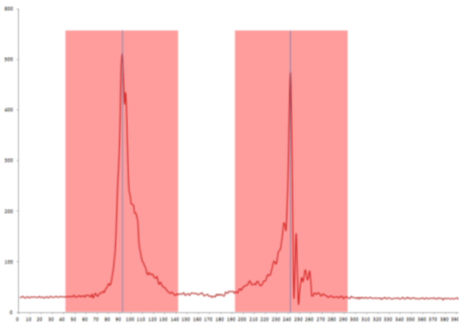
Graph 2 Results

accuracy: 88.57% +/- 4.45% (mikro: 88.56%)

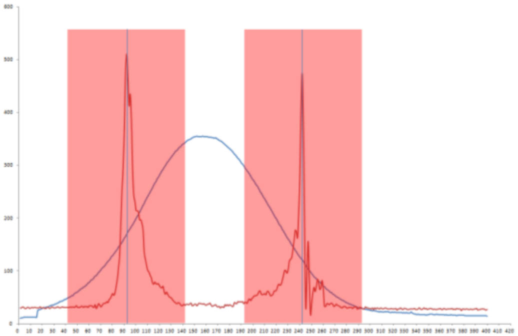
	true KK	true NORMAL	class precision
pred. KK	60	18	76.92%
pred. NORMAL	5	118	95.93%
class recall	92.31% (Sensitivity)	86.76% (Specificity)	

Results

Using signal processing the best results were:



Graph 1: Only Applanation Signal



Graph 2: Applanation + Pressure Signals Combined

Graph 1 Results

accuracy: 88.07% +/- 5.97% (mikro: 88.06%)

	true KK	true NORMAL	class precision
pred. KK	61	20	75.31%
pred. NORMAL	4	116	96.67%
class recall	93.85% (Sensitivity)	85.29% (Specificity)	

Graph 2 Results

accuracy: 93.00% +/- 4.58% (mikro: 93.03%)

	true KK	true NORMAL	class precision
pred. KK	57	6	90.48%
pred. NORMAL	8	130	94.20%
class recall	87.69% (Sensitivity)	95.59% (Specificity)	

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CONCLUSION

- The **combination of different ophthalmology devices** using **Artificial Intelligence** enabled the **improvement in refractive surgery screening regarding to keratoconus diagnosis**.

- The results demonstrate that the **wavelet computational model and the learning machine techniques** have the **potential to improve keratoconus susceptibility screening**, providing more **reliable and accurate indication and results of refractive surgery**.

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