Development of a Nonlinear K-Law Spectral Signature Index to Classify Basophilic Inclusion Bodies of the White Spot Syndrome Virus

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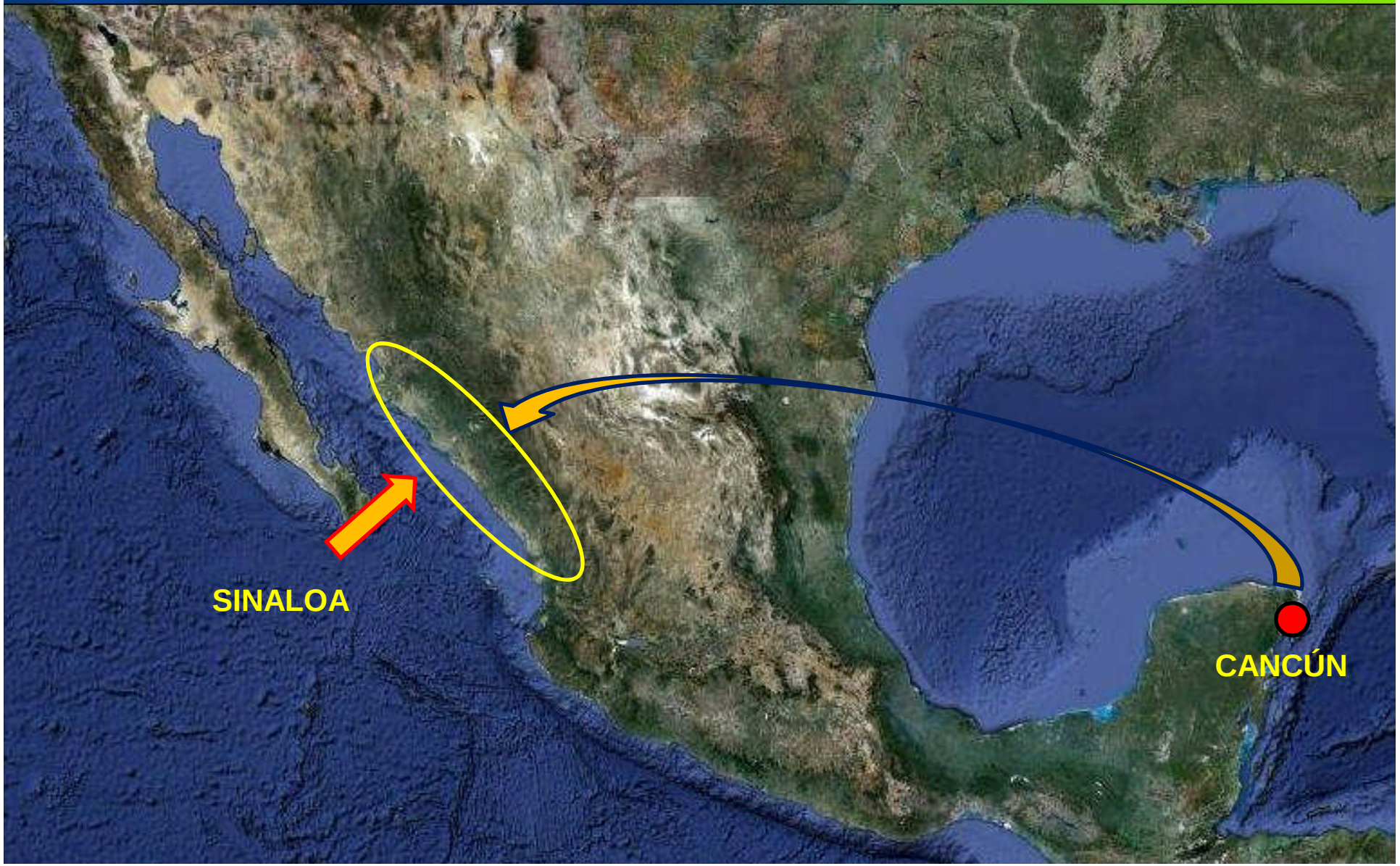
Shrimp Producers

Geographic Location

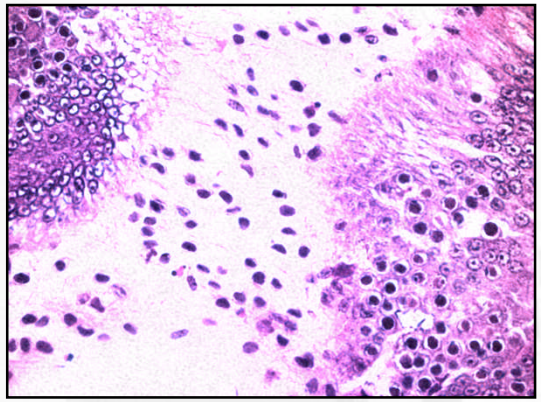


Shrimp Producers Location

Commercial Shrimp Ponds

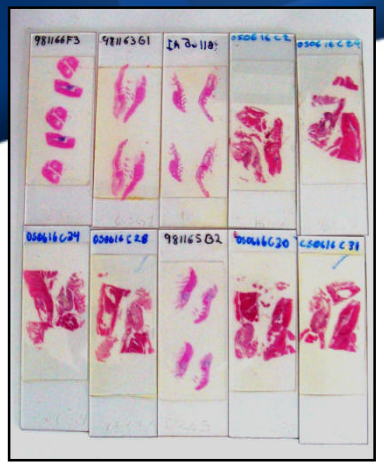
Shrimp Ponds

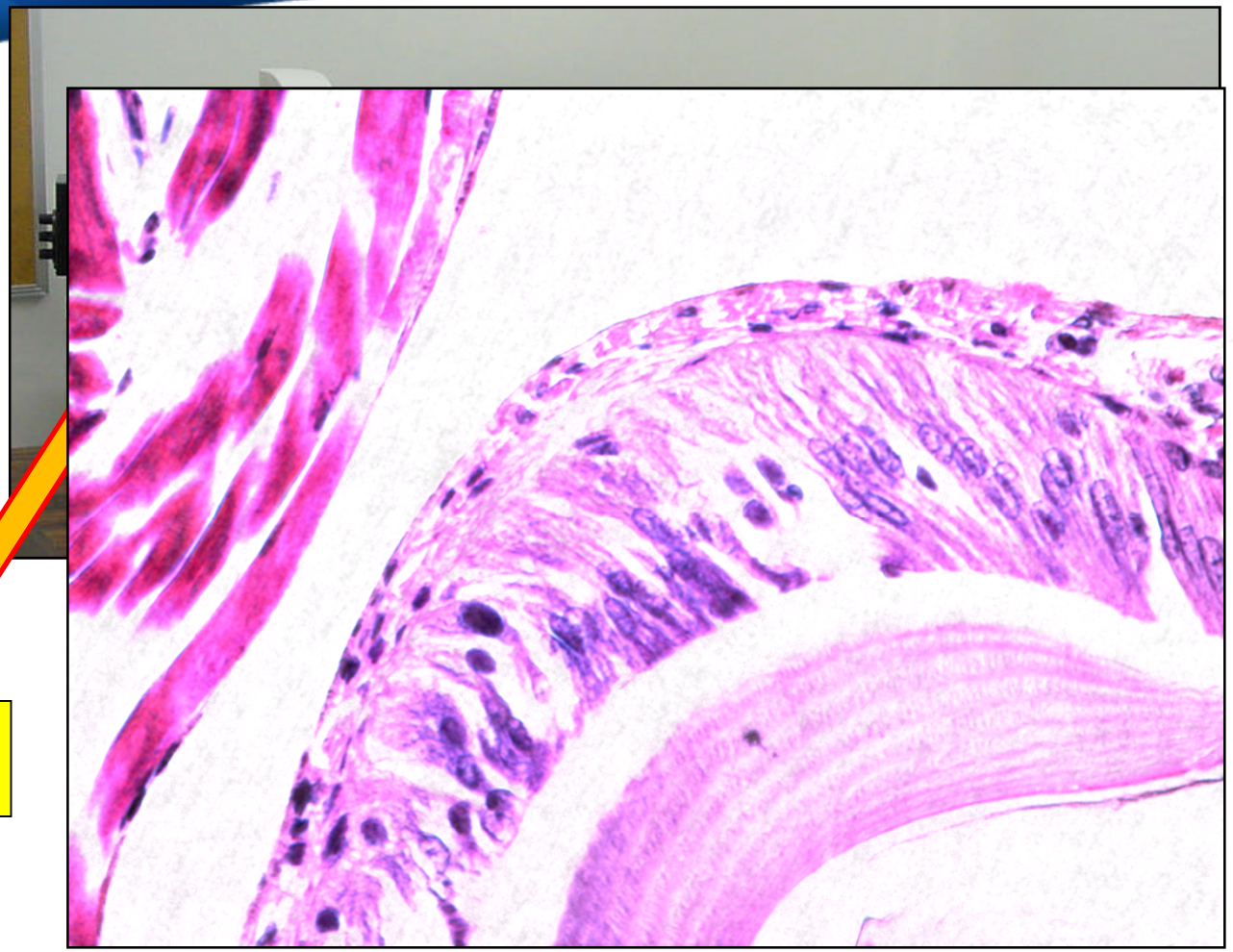
Histology



Laboratory for Shrimp Samples

Shrimp Samples Ready to be Analyzed





f (x,y) is obtained

Mathematical Foundation

$$\mathcal{F}[f(t)] = F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt$$

Non Linear K-Law Filter Mathematical Foundation

Fourier Based Filter General Form:

$$I(u,v) = \left|I(u,v)\right|^{k} \exp\left[-i\phi(u,v)\right]$$

K = 1:

$$I(u,v) = \left|I(u,v)\right|^{k=1} \exp\left[-i\phi(u,v)\right] = \Im\left(I(x,y)\right)$$

K = 0:

$$I(u,v) = \exp\left[-i\phi(u,v)\right] \rightarrow Phase\ only\ \ filter$$

0 < K < 1

$$I(u,v)_{k-Law} = \left|I(u,v)\right|^{0<k<1} \exp\left[-i\phi(u,v)\right]$$

Spectral Signature (SSF)

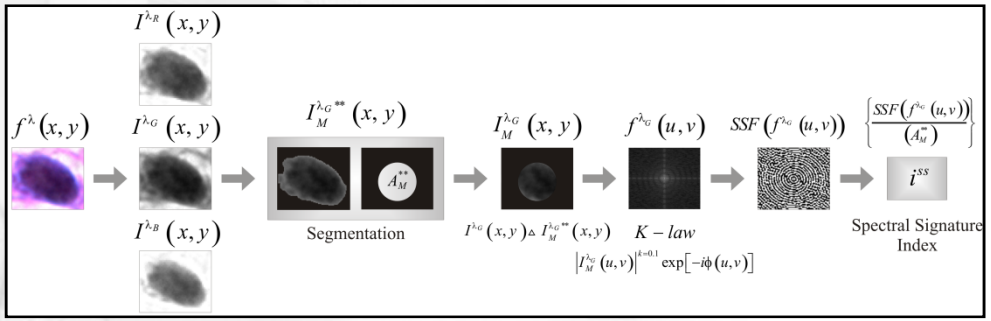
Spectral Signature

$$SSF\left(f_w^{\lambda_G}(u,v)_k \right) = \begin{cases} 1, & if\ \mathrm{Re}\left(f_w^{\lambda_G}(u,v)_k \right) > 0 \\ 0, & otherwise \end{cases}$$

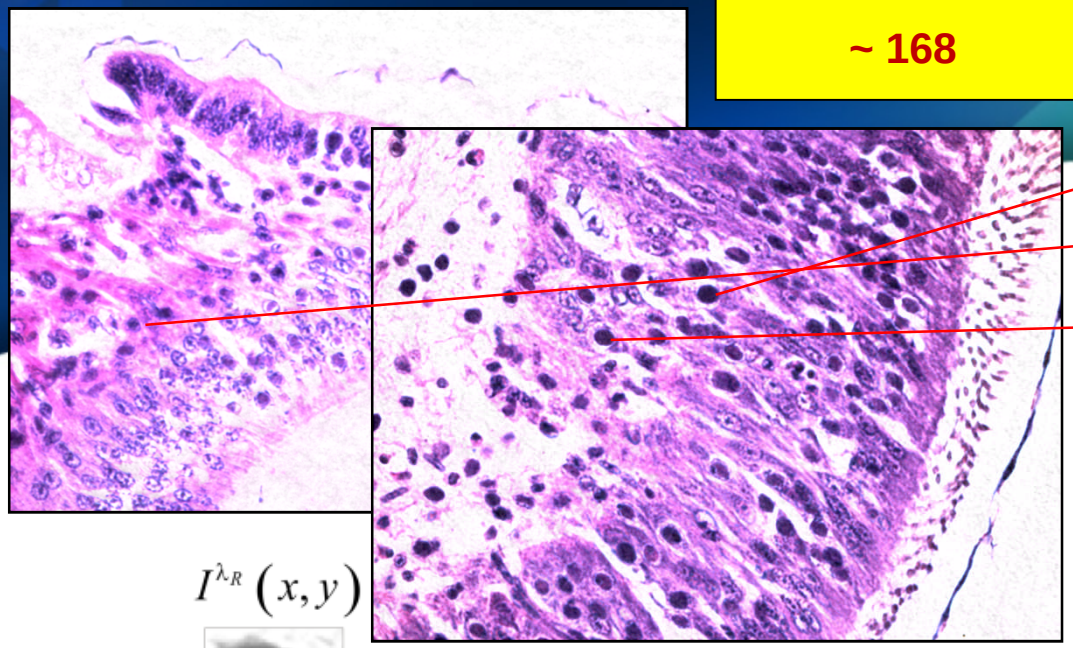
Spectral Signature Index

$$i_k^{ss} = \left\{ \frac{SSF\left(f_w^{\lambda_G}(u,v)_k \right)}{\left(A_M^{**} \right)_w} \middle| (u,v) \in \square \right\}$$

Spectral Signature Algorithm



K-Law Spectral Signature Index Algorithm



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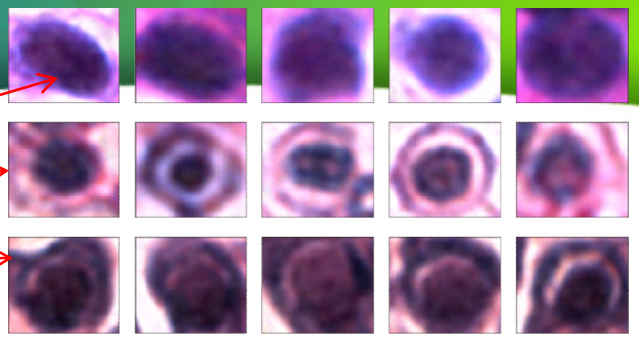
Cowdry Type A Inclusion Bodies



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$f^{\lambda}(x,y)$ $I^{\lambda_R}(x,y)$ $I^{\lambda_G}(x,y)$ $I^{\lambda_B}(x,y)$ $I_M^{\lambda_G **}(x,y)$ $I_M^{\lambda_G}(x,y)$ $f^{\lambda_G}(u,v)$ $SSF\left(f^{\lambda_G}(u,v)\right)$ $\left\{\frac{SSF\left(f^{\lambda_G}(u,v)\right)}{\left(A_M^{**}\right)}\right\}$

Segmentation

$I^{\lambda_G}(x,y) \triangle I_M^{\lambda_G **}(x,y)$

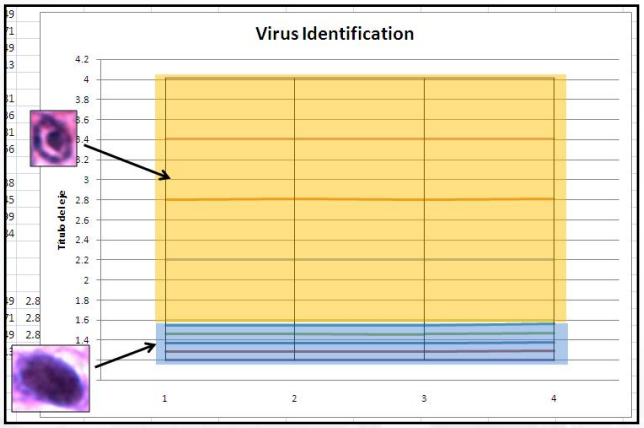
$K-law$

$\left|I_M^{\lambda_G}(u,v)\right|^{k=0.1} \exp\left[-i\phi(u,v)\right]$

i^{SS}

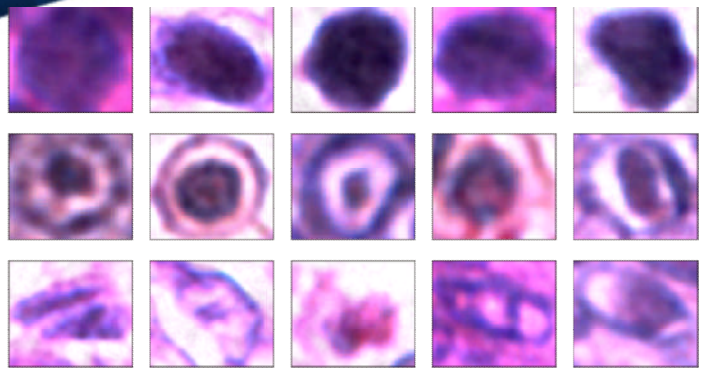
Spectral Signature Index

Results


Virus Identification
Título del eje
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1
2
3
4

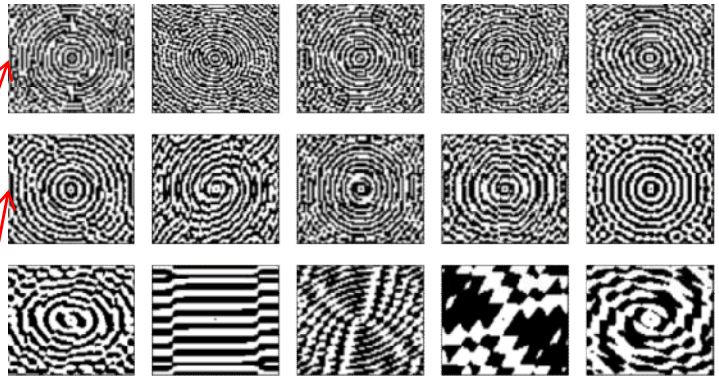
Classification Results

Cowdry Type A Inclusion Bodies Bank



100 Representative CAs

Spectral Signature

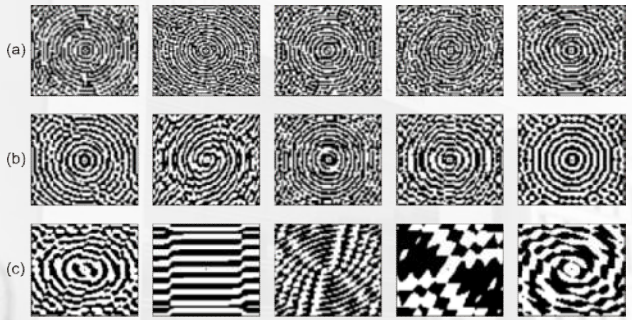


WSSV Group	Signature Index Statistical Behavior			
	$\bar{x}_{i^{ss}}$	$\sigma_{i^{ss}}$	$1SE$	$2SE$
I	1.3748	0.4817	0.0852	0.1703
II	2.6069	1.8533	0.4953	0.9906
III[a]	159.4229	352.5394	94.2201	188.4402
IV[b]	1.7498	1.2362	0.1823	0.3645

a. Non-infected tissue group particles;

b. Groups I and II analyzed together

Conclusion



Conclusion

A new algorithm based on the analysis of frequencies found in the green channel and processed by K-Law Fourier filter was developed with an efficient performance (< 0.5s by CAs).

Results show that inclusion bodies are well defined in a numerical fringe;

$$\left(1.3853 \leq i^{ss} \leq 2.1143\right)$$

This algorithm is easy to be implemented inside an automatic system to find if is present the WSSV .

The SSI can be extrapolated to work on a new kind of histology tissues.

Thank you !!!