Noise characterization in gene expression systems with positive feedback loop

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***Short Abstract* — Gene regulation is crucial for adaptation and signals processing. It's known that the process of gene expression involves the unavoidable interaction with the noise. Which is particularized by two sources: extrinsic and intrinsic. To know the impact of each source, we implemented a virtual plasmid with two identical copies of a gene positive self-regulated. Quantifying the noise components through statistical differences of the two series of time resolved through Gillespie algorithm. The model predicted that extrinsic noise correlate the systems, in an easier way if the frequency is low, and that the control parameters are related to the degradation rates.**

***Keywords* — gene expression, positive feedback loop, extrinsic noise, intrinsic noise, correlation, kinetic parameters.**

I. Purpose

The gene expression it is experimentally well known that presents variability, observing the level of expression of two genes identically contained in a single fluorescent plasmid, generating a heterogeneous expression of the color [1].

Gene expression, regardless of the regulatory mechanism, is subject to various noise sources: the processes don't occur at the same speed every time -intrinsic noise source-, also the expression is affected according to the conditions of the medium -extrinsic noise source- [2].

It is known that the main source of noise is the intrinsic component [3] so the extrinsic were ignored but what is the main effect of extrinsic noise on the dynamics of gene expression. How is the process of positive self-regulating control system?

To investigate this we used the stochastic model of two identical systems with positive feedback loop, by the protein expression. The implementation was through the Gillespie algorithm [4], which had to be modified to include an external perturbation source. The quantification of the individual noise components are made through statistical differences [1]. The kinetic parameters were modified to show the effect on the perceived noise level.

II. Results

Only were presented the mainly results:

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A. *Intensity and frequency of the extrinsic noise source*

The extrinsic noise tends to correlate the systems. This has been registered in other systems [1] It was observed that at lower frequencies of the noise source, the systems correlates easier than a higher frequencies. This behavior it's typical of a low-pass filter. Particularly a correlation low-pass filter.

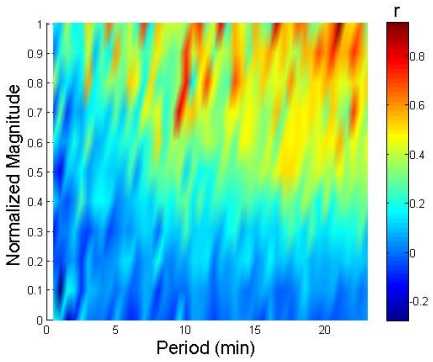

Figure 1: The dependence of the period and the magnitude of the external extrinsic noise source on the Pearson´s Correlation Coefficient (r)

B. *Kinetic parameters affects the perceived noise*

Mostly all the parameters affects the steady state value. When it's increase the perceived intrinsic noise decreases and vice versa, as observed in other systems [5]. Interestingly, the increase of the messenger's production rate increases the perceived intrinsic noise. The only parameters that make extrinsic noise vary, are messengers and protein degradation rates, especially the slowest. Interestingly these parameters are involved with the relaxation time determined by the eigenvalues in an inverse relation between the response time and the extrinsic noise attenuation.

III. Conclusion

The control parameters of the extrinsic noise are the degradation rates. The extrinsic noise correlates the systems with mayor facilities a lower frequency.

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