# A SIMULATION OF SOCIAL EVOLUTION

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## Abstract

We are to play with the combination of successive negative and positive feedbacks in the evolution of a variable through the time. This could, for example, simulate a social evolution with, respectively, stages of social stability and of social convulsion.

We will study the way of mathematically to simulate the succession of these stages with a decreasing stability, so that old social systems kept stable while more time then the modern ones, and the effect of reinforcing negative or positive feedbacks.

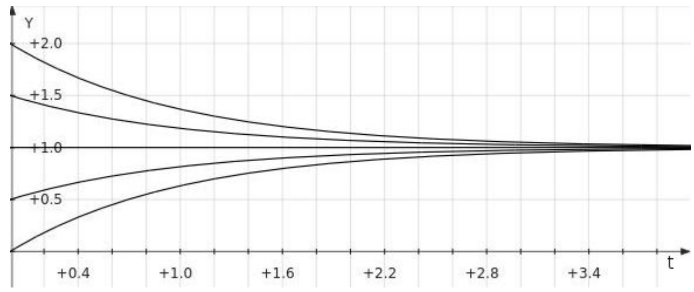
## Introduction

A clarification: we are not to make a modelization in order to predict a future evolution (Nemiche & Pla-Lopez 2002), but only an *a posteriori* "simulation" looking for differential equations (Puig Adam 1950) which reproduced the evolution along the history of humanity.

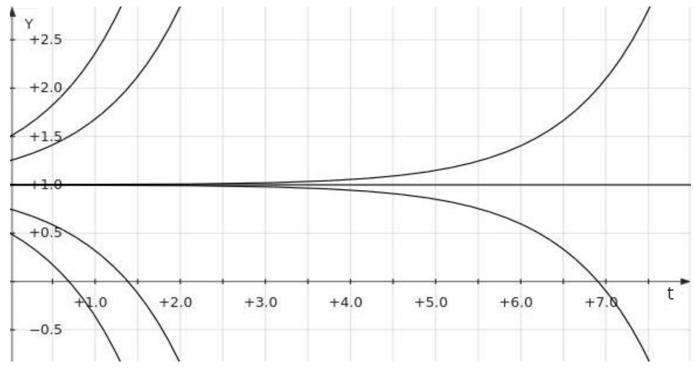
In this evolution there was periods in which a negative feedback (Wiener 1948) (Mindell 2002) predominated, so that the change are reversed by getting a social stability, but also "revolutionary" periods in which a positive feedback (Friis & Jensen, 1924) intensify the social changes.

And we want to simulate the succession of periods of stability and revolutionary periods.

Usually, the negative feedback generates the so named "equifinality" (Bertalanffy 1968), which consists in that from different initial conditions the curves evolve to tha same point, as the following figure shows with the differential equation y'=1-y .

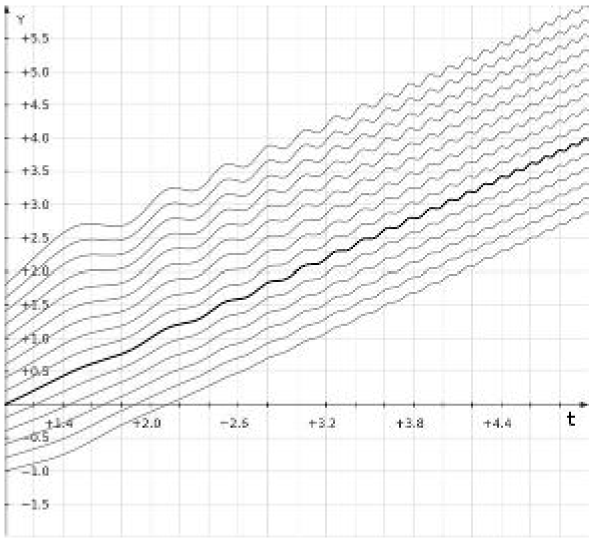


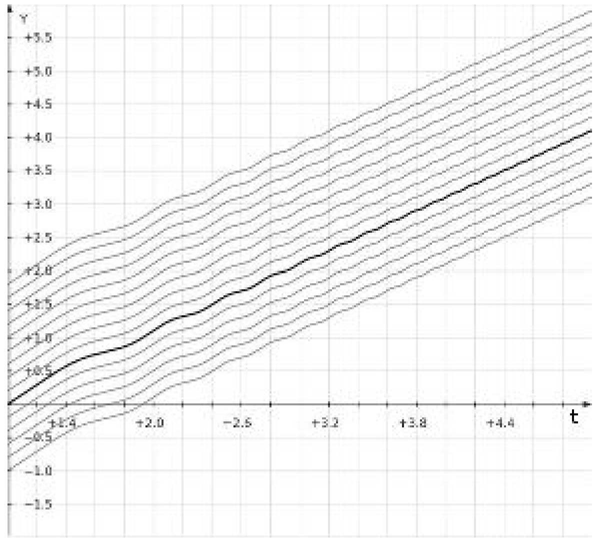

On the contrary, in the case of positive feedback, a slight variation of the initial condition can do that the curve would tend to plus o to minys infinite, as the following figure shows for the differential equation y'=y-1 from values next to y=1.



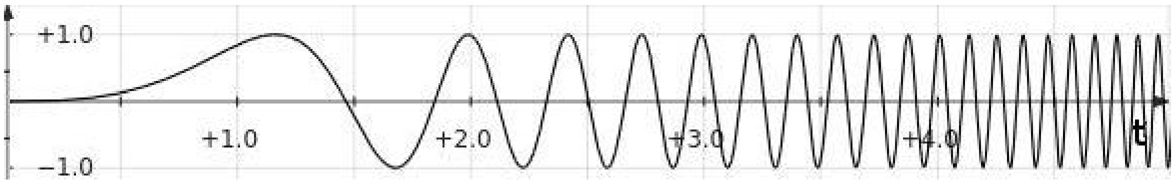
### Compensation of negative amb positive feedbacks

Then, in the figure of the left the case of $y' = 1 + y \cdot \sin(t^3)/2$ is showed, comparing it with the figure of the right for the equation $y' = 1 + \sin(t^3)/2$ in the same interval and from the same initial conditions.



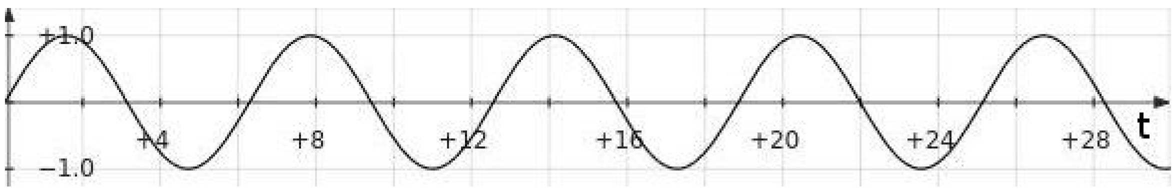




In this case, we see that the solutions of the differential equation $y' = 1 + y \cdot \sin(t^3)/2$ are similar to the solutions of the equation $y' = 1 + \sin(t^3)/2$ , only with greater oscillations. The reason of theses oscillations is precisely the feedback of **y** over **y'**. But, so that $\sin(t^3)$ changes quickly of sign, as is showed in the following figure, the positive and negative feedbacks are succeeded and compensated without to arrive to predominate.

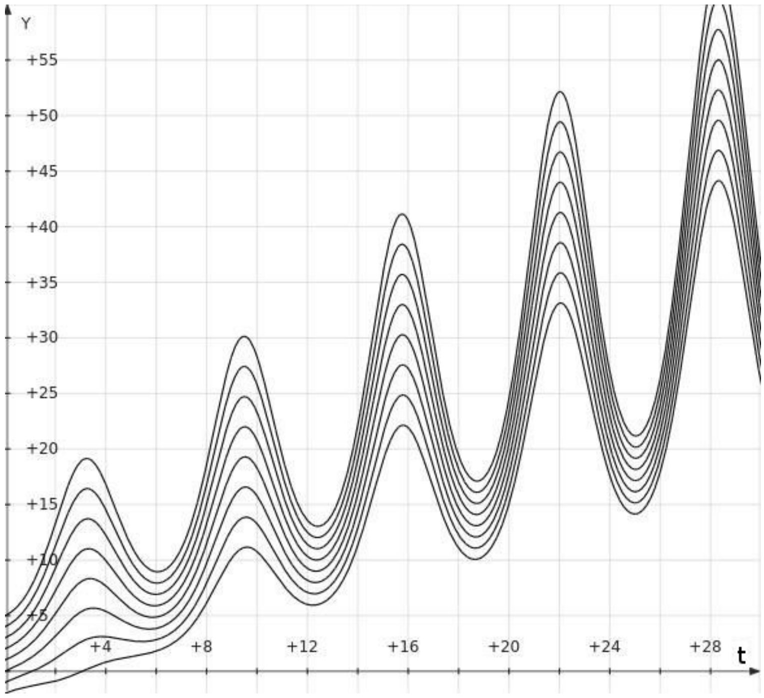



### Succession of stability and social convulsion

Now, we are going to see what happen with a slower variation of the feedback, by substituting $\sin(t^3)$ by $\sin(t)$, which oscillate in a periodic way:



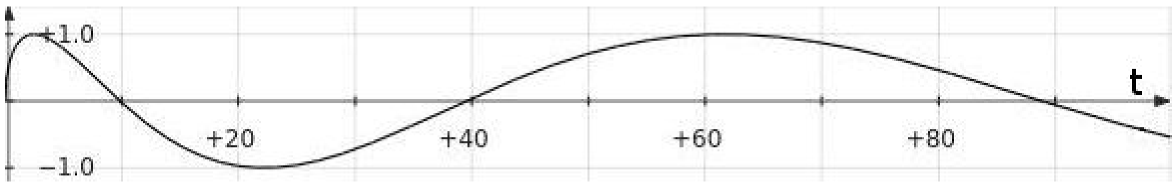

So, in the following figure we represent the integration of $y' = 1 + y \cdot \sin(t)/2$ with different initial conditions:



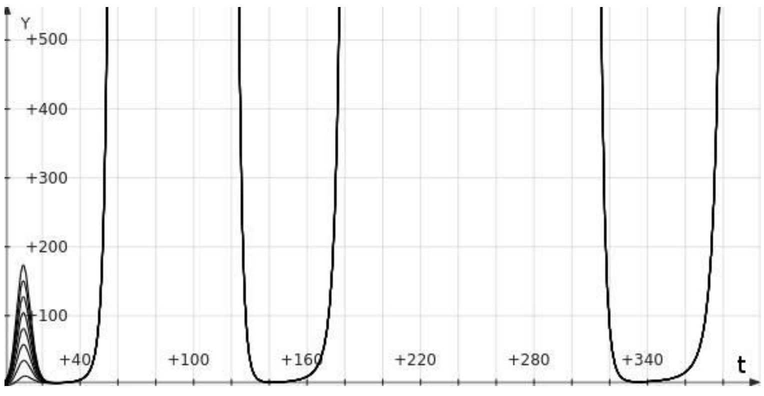

We observe that the different curves converge between them with negative feedback, and diverge with positive feedback. But the convergence do not approximate them enough to visualize an equifinality with different initial conditions. Apparently, befote this equifinalty were manifested as expression of an stable equilibrium, the positive feedback separated them. And globally, oscillations around an eventual straight line of slope y'=1 appear newly.

If we interpreted these curves as a simulation of a social evolution, these would show a stete of social convulsion practically permanent, which would frustrate each intent of social stabilization.

In order to slow down the oscillations, by giving time so that the stabilization by negative feedback can be manifested, we can substitute sin(t) by $\sin(\sqrt{t})$ which carry to slower oscillations:

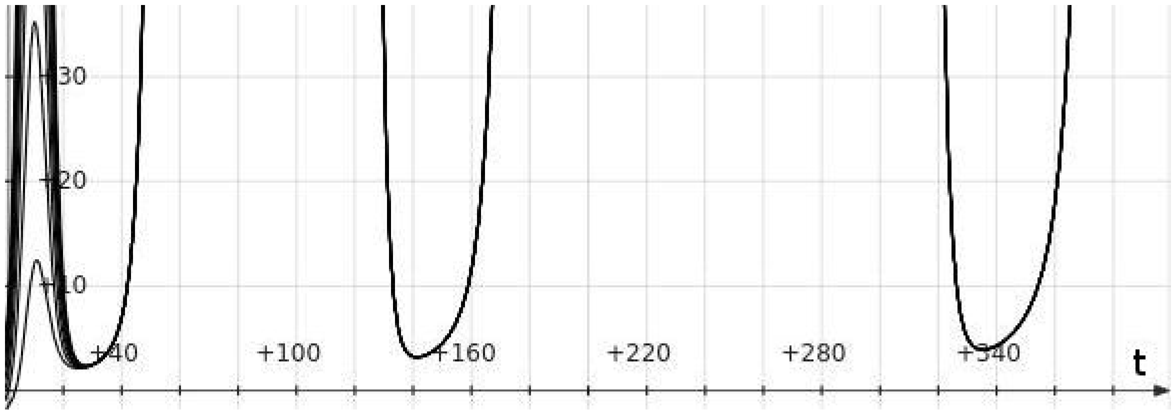



Then we represent the integration of $y' = 1 + y \cdot \sin(\sqrt{t})/2$ with different initial conditions:



In this case, the curves converge after the first negative feedback, and this convergence keeps through the successive positive feedbacks.

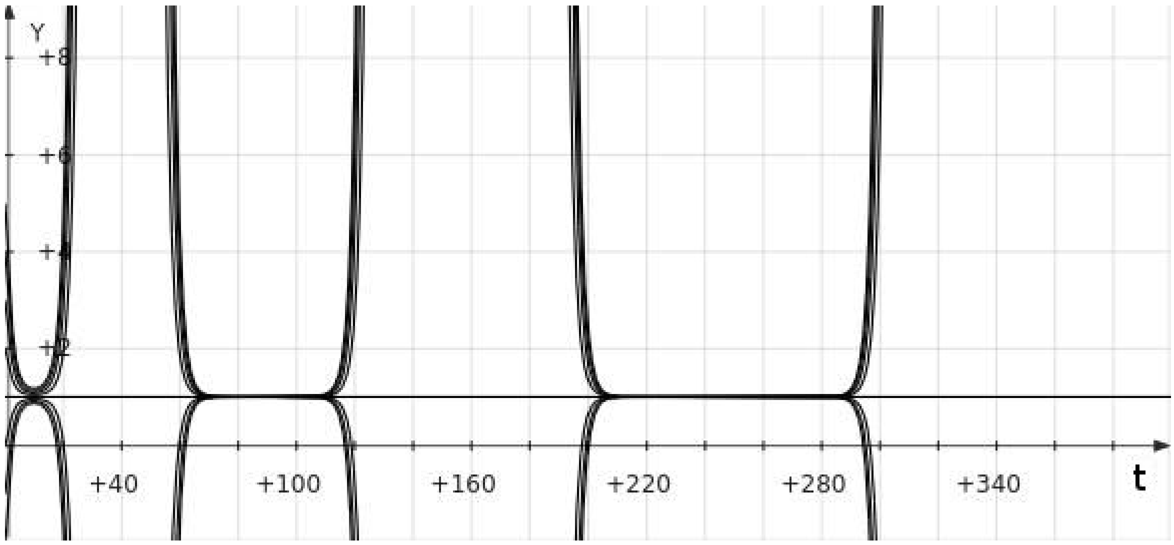
But, although a global evolution around a straight line of slope y'=1 already does not appear, in the whole of the simulates social evolution seems predominate the positive feedback, with stages increasingly more durable of social convulsion. This is perceived more clearly if we increase the vertical resolution of the figure:




So we see clearly the transitory character of the alleged equilibrium from the negative feedback, which moreover increases slightly in the successive oscillations.

We will test now the differential equation $y'=(1-y)\cdot\sin(\sqrt{t})/2$ which produce oscillations which are generated by the sinusoidal function between the solutions of the differential equations which we initially analyzed in order to stude the two ways of feedback: y'=y-1, which generated a positive feedback, and y'=1-y , which generated a negative feedback with equifinality toward y=1.

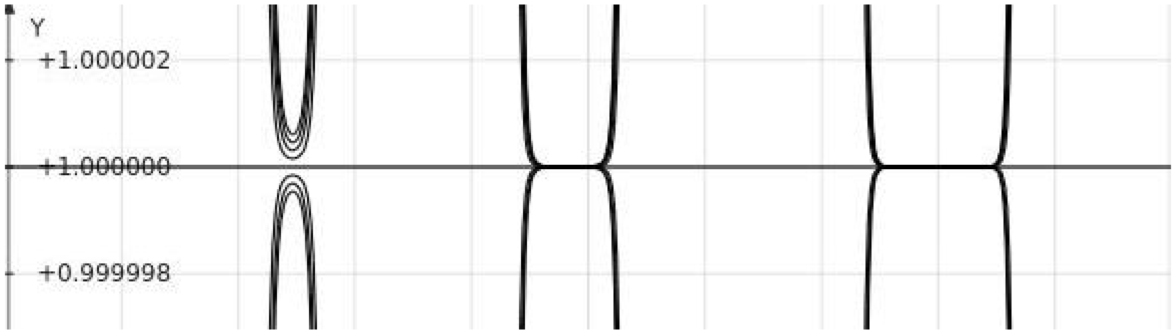
So we get, from the different initial conditions, the following figure:



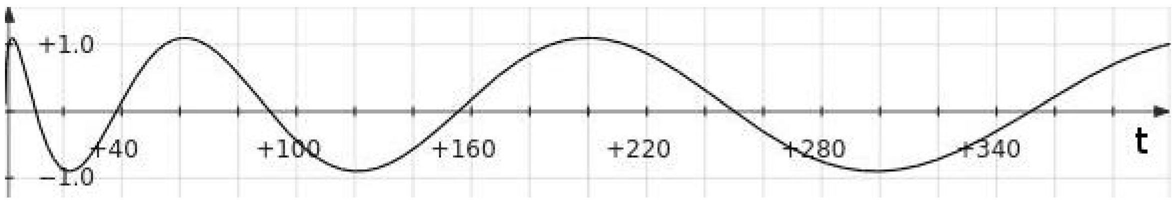

Here, we can perceive a convergence with negative feedback toward en equifinality y=1 which keeps through the successive oscillations, after the positive feedback had did to slightly diverge the different curves.

Moreover, in the simulation of the social evolution, now as the temporal intervals of social stability as the temporal intervals of social convulsion would increase in successive stages.

By the way, the straight line y=1 is generated from the initial conditions x=1 and y=1, which produces y’=0 in a permanent way. Of course, from y≠1 the function **y** approximates to 1 without get it, although in each stage of negative feedback approximates more, alcanzarla, as can be perceived in the following figure.

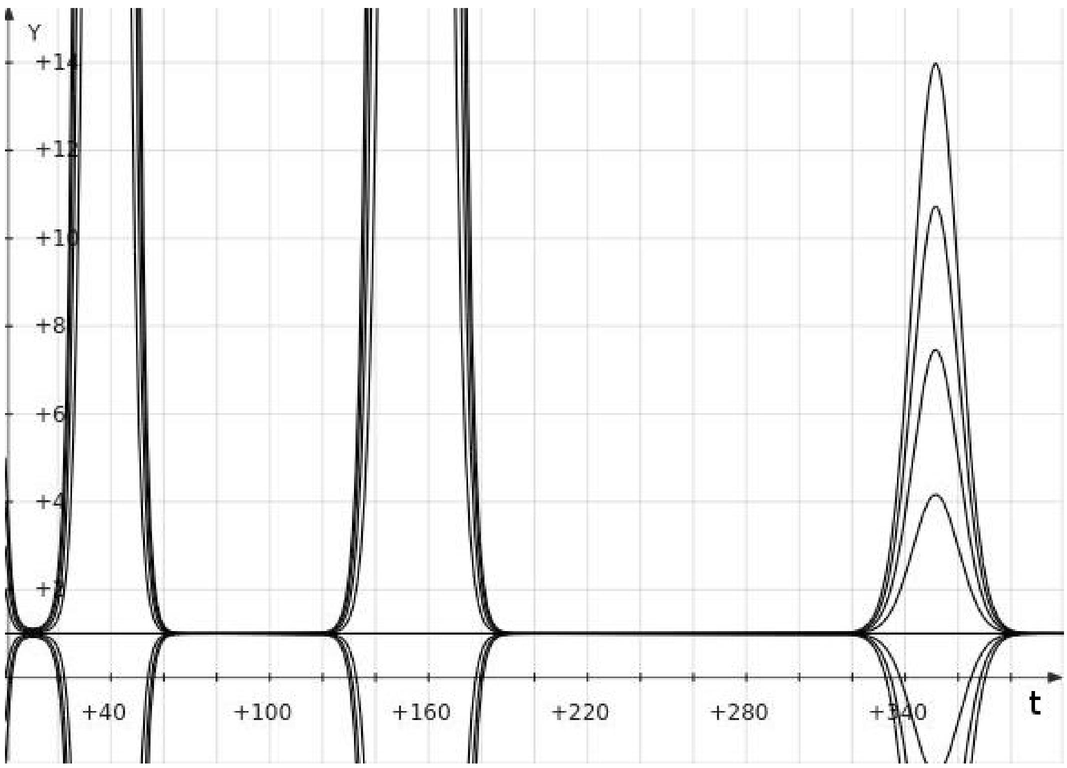



We can also increase the duration of the negative feedback if we substitute $\sin(\sqrt{t})$ by $\sin(\sqrt{t})+0'1$ , which keeps with positive value for more time, which the following figure shows:




where the curve oscillate betwwen -0’9 and 1’1.

In spite of the slight variation, the effect is considerable, as it is showed by integrating $y'=(1-y)\cdot(\sin(\sqrt{t})+0'1)/2$ from the different initial conditions, getting:

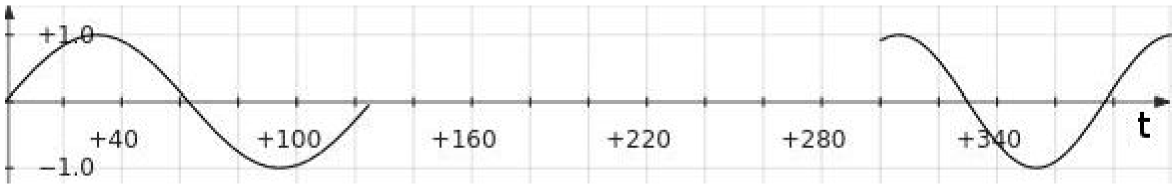



It is perceived now that, in the simulation of the social evolution, the stages of social stability would be increasingly durable, while, on the contrary of the previous case, the stages of social convulsion would be increasingly short and of minor intensity.

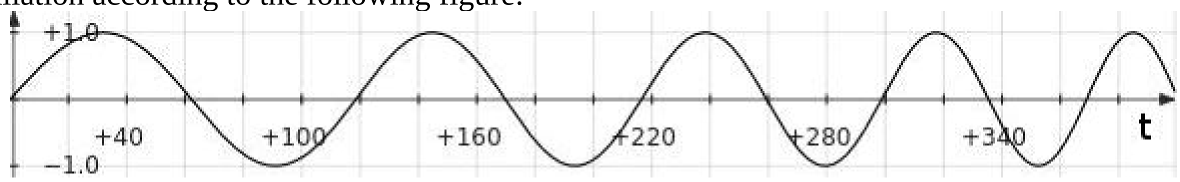
**Simulating a decreasing stability**

Now then, this cannot correspond to the social evolution of the humanity (Engels 1884), where the old social systems kept stable while more time then the modern ones. To intend to simulate this evolution we will have to find that the oscillations do not slow down but accelerated through the time.

After a set of trials, in which I have tested that taking a quick acceleration of the oscillation the game between the two types of feedback was not showed, I have find a sinusoidal which behaves as sin(t/20) around t=50, and as sin(t/15) around t=350, so that it is indicated in the following figure.t

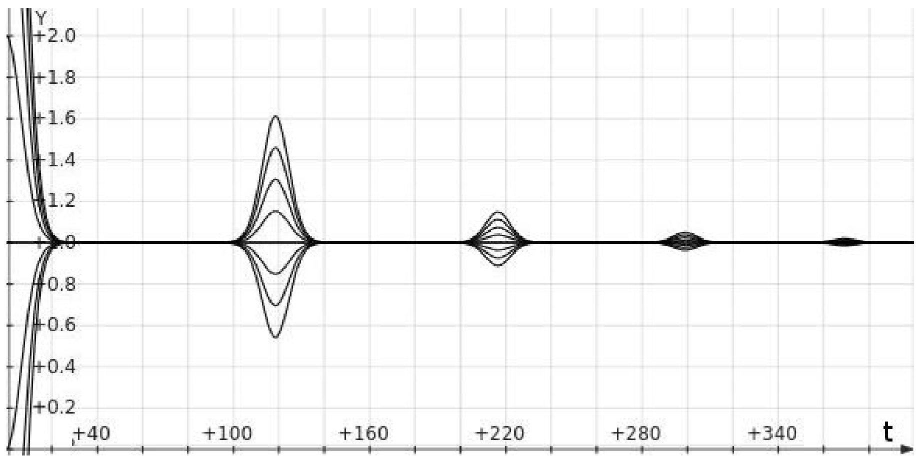



For that purpose, I have realized a lineal interpolation between 20 for t=50 and 15 for t=150, resulting $\frac{1250-t}{60}$ , and thus the sinusoidal $\sin\left(\frac{60 \cdot t}{1250-t}\right)$ , which accelerates slowly the oscillation according to the following figure:




We will use for now directly this sinusoidal, without increasing nor decreasing for now the duration of the negative or positive feedback.

So, we will represent in the following figure the integration of the differential equation $y' = (1-y) \cdot \sin\left(\frac{60 \cdot t}{1250-t}\right)/2$ from the different initial conditions.

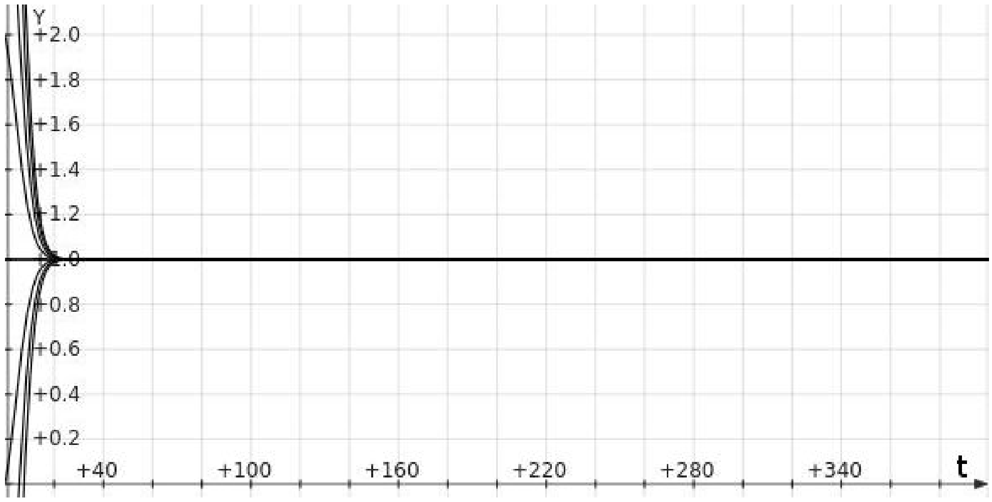



So we find, by interpreting it as a simulation of the social evolution, a predominance of the stages in which the negative feedback does to converge the different curves toward a equifinality corresponding to a social stability with y=1, while the curves clearly diverge in the stages of social convulsion which is generated by the positive feedback. We also observe that the duration of the stages of social stability decrease little by little, but that at the same time the effects of the social convulsions become less intense, perhaps by the introduction of democratic proceeding to approach them?

**Reinforcing the feedbacks**

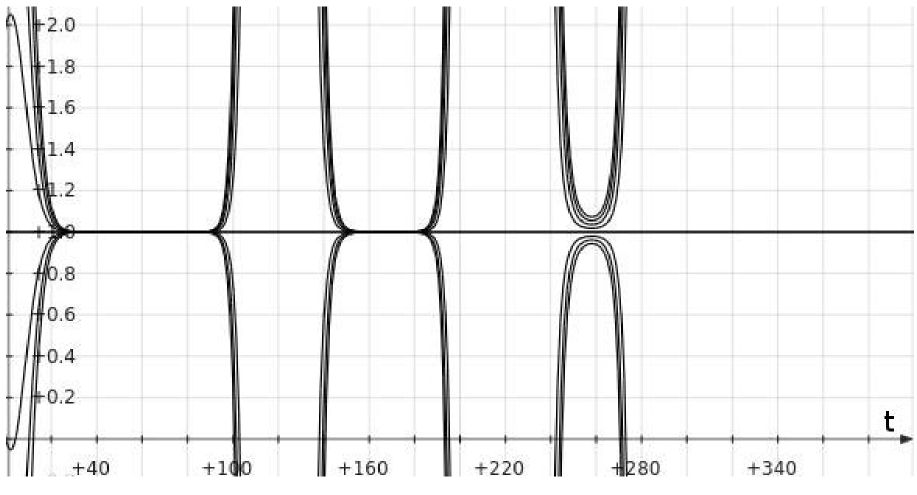
We will test now to reinforce each type of feedback, finding that the evolution in very sensitive to this reinforcement. So, by reinforcing the negative feedback with

$y'=(1-y)\cdot(\sin(\frac{60\cdot t}{1250-t})+0'1)/2$ we get

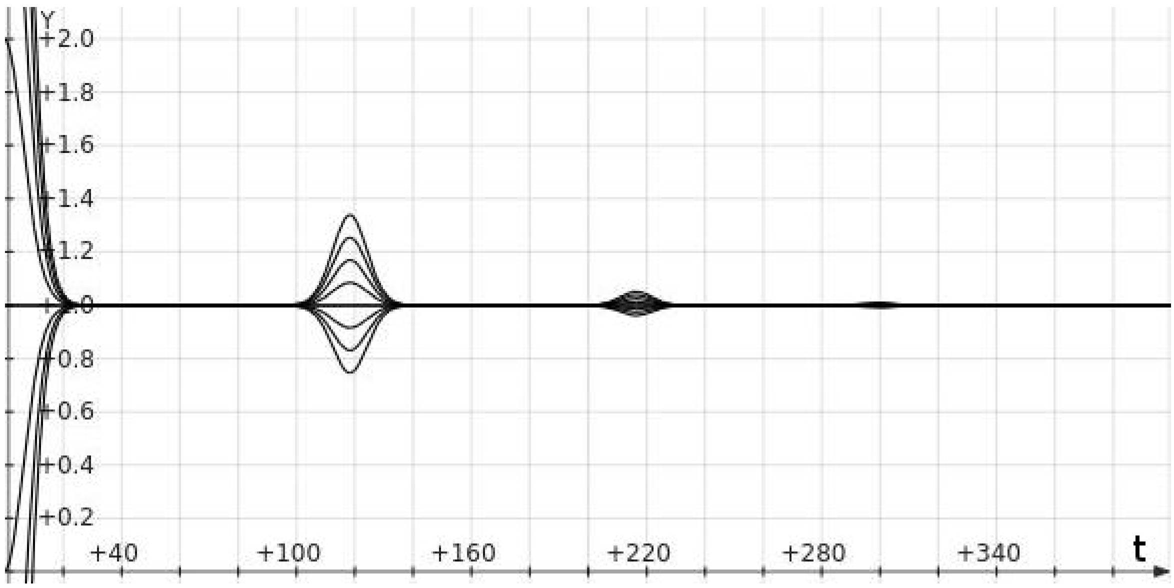



with the result of totally annulating the social convulsions (and perhaps also the social progress).

On the contrary, if we reinforce the positive feedback with $y'=(1-y)\cdot(\sin(\frac{60\cdot t}{1250-t})-0'1)/2$ we get the following figure, with short decreasing stages of social stability and demeaning social convulsions, perhaps by the use of weapons of massive destruction?

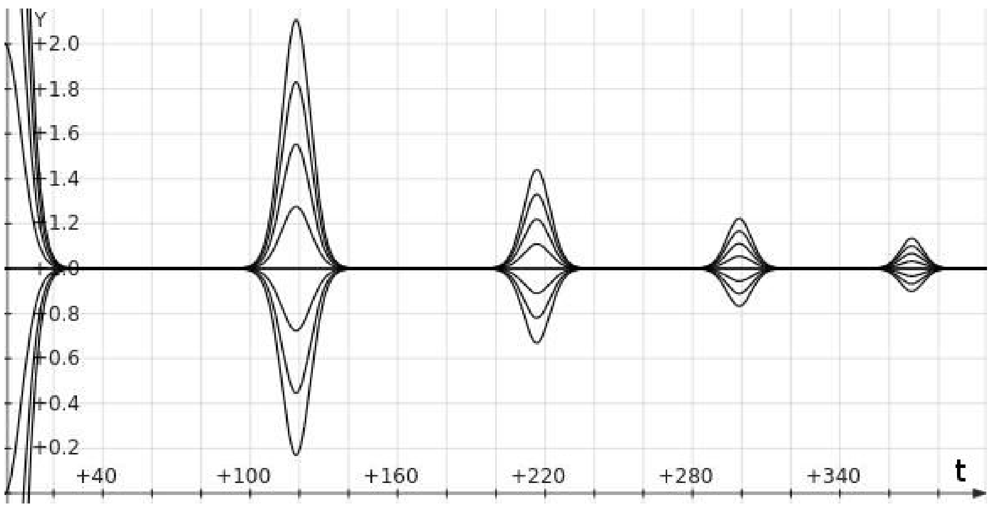



We will test now with softer reinforcements of the feedback. So, increasing slightly the negative feedback with $y'=(1-y)\cdot(\sin(\frac{60\cdot t}{1250-t})+0'01)/2$ we get




where the main effect seems to be the progressive decreasing of the intensity of the social convulsions..

On the contrary, by reinforcing softly the positive feedbach with $y'=(1-y)\cdot(\sin(\frac{60\cdot t}{1250-t})-0'01)/2$ we get the following figure, which shows, on the contrary, a notorious, although also decreasing, intensification of the social convulsions.




**Conclusion**

Differential equations can be used to graphically and pedagogically simulate the social evolution.

I leave to you to take the morals of these simulations. But a clear conclusion is that, in the framework of the interaction between negative and positive feedback, little actions can produce big effects: a little increasing of negative feedback can carry to a big decreasing of social convulsions, and a little increasing of positive feedback can carry to a strong increasing of social convulsions.

And this can be a reason to avoid as the resignation as the imprudence. This can indicate a clear relevance of these equations to social evolution.

## Bibliography

Bertalanffy, Ludwig von 1968), “General System Theory, Foundations, Development, Applications”, Georfe Braziller, New York

Engels, Friedrich (1884), “Der Ursprung der Familie, dos Privateigenthums und des Staats”, Verlag der Schweizerischen Volksbuchhandlung, Hottingen-Zürich

Friis, H.T., and Jensen, A.G. (1924). "High Frequency Amplifiers", Bell System Technical Journal 3 (April 1924):181-205.

Mindell, David A. (2002), “Between Human and Machine : Feedback, Control, and Computing before Cybernetics”, Johns Hopkins University Press, Baltimore

Nemiche,M. & Pla-Lopez,R. (2002), "A Learning Model for the Dual Evolution of Human Social Behaviors", Kybernetes: The International Journal of Systems and Cybernetics, Volume 32 Number 5/6 2003, pp.679-691, Emerald

Puig Adam, P. (1950), “Ecuaciones Diferenciales”, Biblioteca Matemática, Madrid

Wiener, Norbert (1948), “Cybernetics or control and communication in the animal and the machine”, Massachusett Institute of Technology, Cambridge