FULLY AUTOMATIC EXTRACTION OF OTFT TRANSISTOR PARAMETERS USING IMPROVED GENETIC ALGORITHMS

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Abstract

This work describes a process that enables fully automated parameter extraction of model parameters. It has been applied to a well known model [1], whose first proposed parameter extraction procedure required human assistance.

The extraction method basically consists of a queen bee genetic algorithm. The difference in this method is that the mutations that originate the new generations, even though they are random, are bound to follow certain directives regarding sign and typical deviation.

Although it is obvious that all the parameters influence in some way all points of the curve, relationships may be established between certain zones on the Ids-Vds or Ids-Vgs curves and the value of certain specific individual form parameters [2]. In this way, specific points on the curves can be related to the individual adjustment errors of the parameters. Thus, on entering these errors into the controllers associated with the corresponding parameter, magnitude and sign of the new generation parameters distribution are obtained.

As a result, the new populations are generated in such a way that it is possible to know that the controlled parameters are going to approach their correct value although the total adjustment of the operation is worse, thus avoiding falling in local minima and drastically improving the convergence time. Then, when the error goes below a given (small) value, the output of the genetic algorithm is used as the initial point that allows us to launch a mathematical method. In this way an excellent precision and repeatability of the extraction process are achieved.

[1] M. Estrada, et al., "Accurate Modeling and Parameter Extraction Method for Organic TFTs", Solid-State Electronics, Vol. 49, pp. 1009-1016, 2005

[2] R. Picos, et al. "Optimized Parameter Extraction using Fuzzy Logic", Solid-State Electronics, Vol.51, pp. 683-690, 2007

Model:

Saturation Voltage Model:

$$V_{DSat} = \alpha_S \left(V_{GS} - V_T\right)$$

Mobility Model:

$$\mu_{FET} = \mu_0 \left(\frac{V_{GS} - V_T}{V_{aa}}\right)^{\gamma_a} = \mu_{FET0} \left(V_{GS} - V_T\right)^{\gamma_a}$$

Fitting Parameters

α_S: saturation voltage dependence
m: knee region sharpness
λ: channel length modulation
V_{aa}: mobility fitting factor
γ_a: mobility degradation
V_T: threshold voltage
V_K: subthreshold fitting parameter

Current Model:

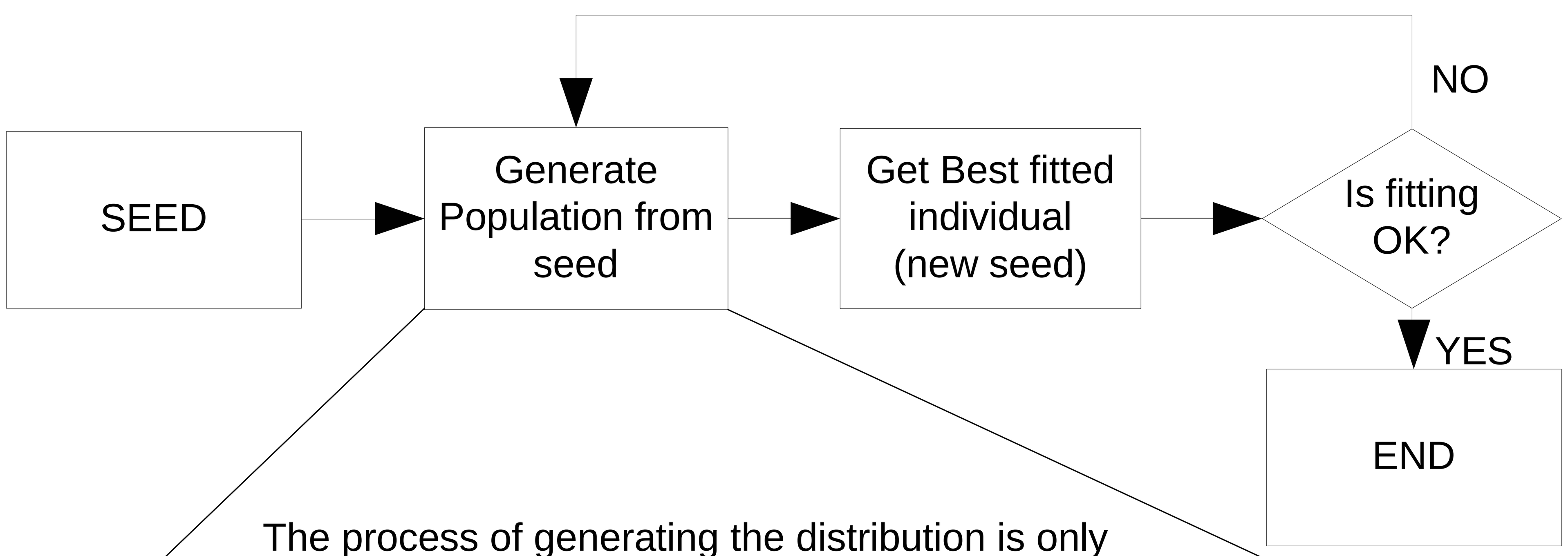
$$I_{DS} = \frac{W}{L} \cdot C_{diel} \frac{\mu_{FET}\left(V_{GS} - V_T\right)}{1 + R\frac{W}{L} \cdot C_{diel}\mu_{FET}\left(V_{GS} - V_T\right)} \cdot \frac{V_{DS}\left(1 + \lambda V_{DS}\right)}{\left(1 + \left(\frac{V_{DS}}{V_{DSat}}\right)^m\right)^{1/m}}$$

Extended Current Model (subthreshold):

Replace V_{GS}-V_T by the expression:

$$V_{GS} - V_T \rightarrow V_{GSX} = \frac{1}{2}\left(V_{GS} - V_T + \sqrt{\left(V_{GS} - V_T\right)^2 + 4V_K^2}\right)$$

Method

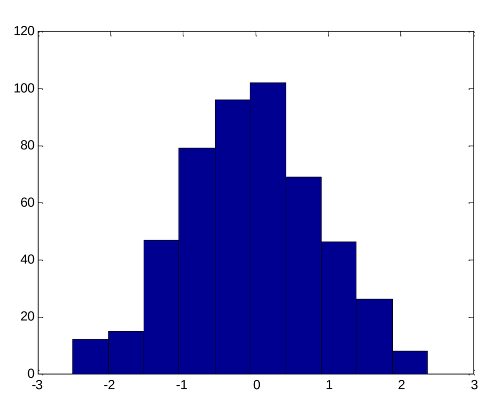


The process of generating the distribution is only pseudo-random, and knowledge about the model is embedded into it.

Classical

Parameter Variation distribution:

For instance: Vth distribution

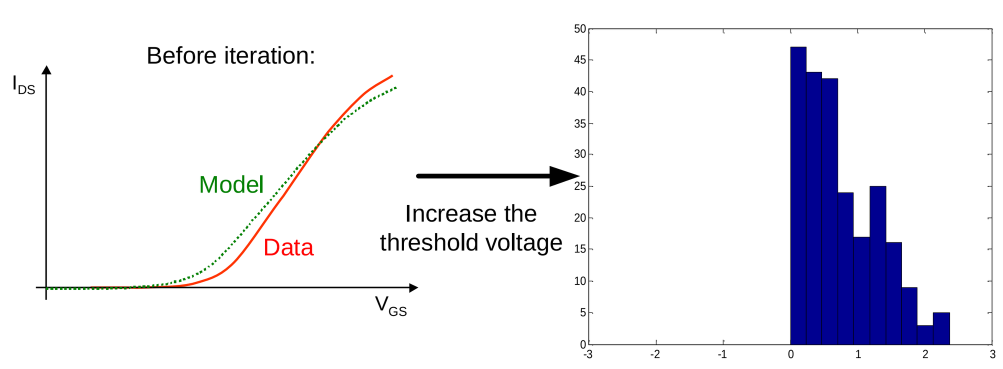


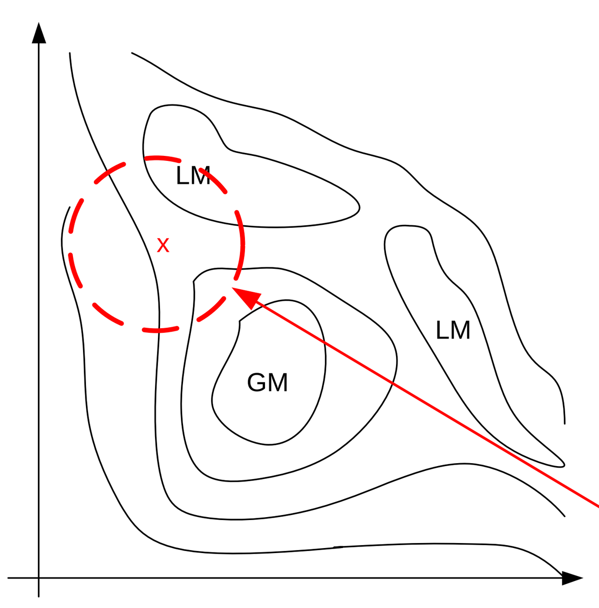
Proposed

Parameter Variation distribution:

1- Analysis of best curves vs experimental
2 - Determination of Parameter Variation Distribution

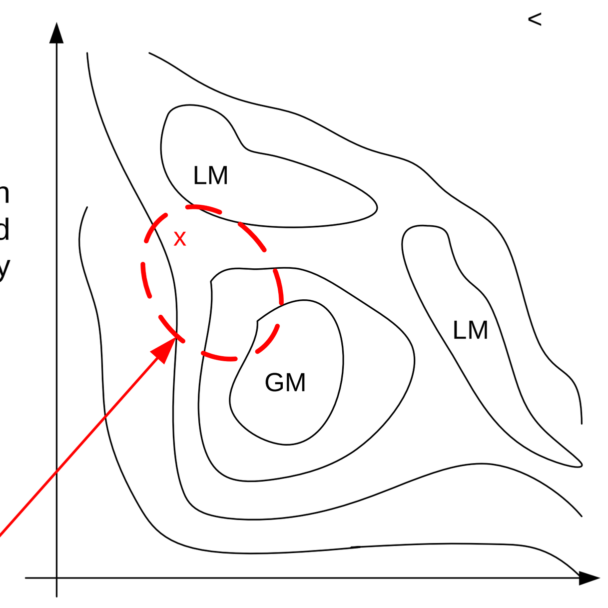
For instance: Vth distribution





Error level curves between experimental and best fitted data, varying two arbitrary parameters.

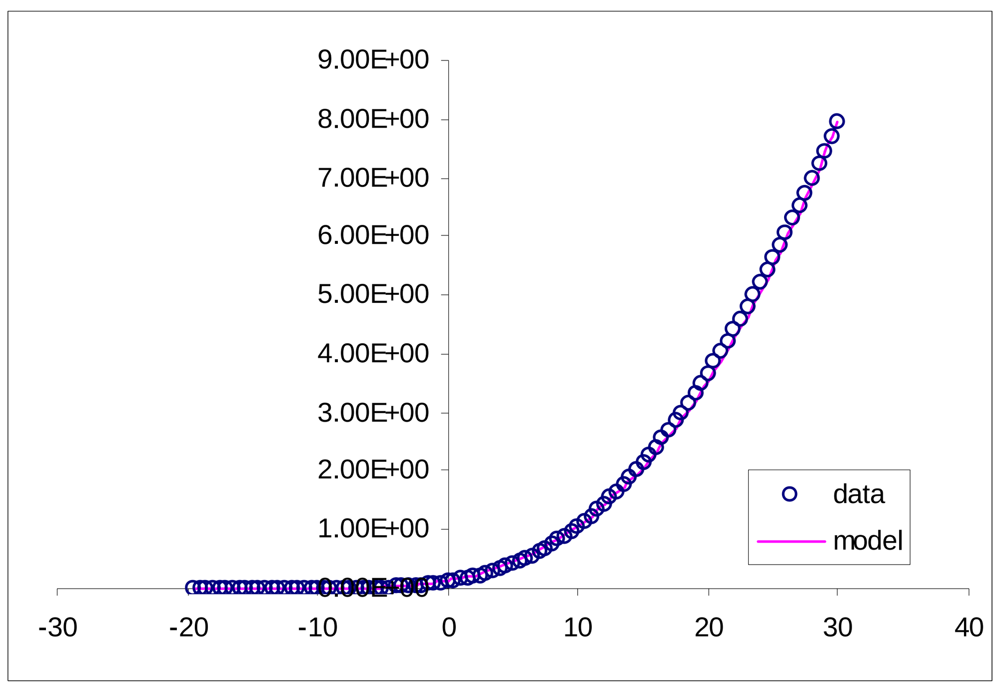
LM: Local minimum
GM: Global Minimum (goal)

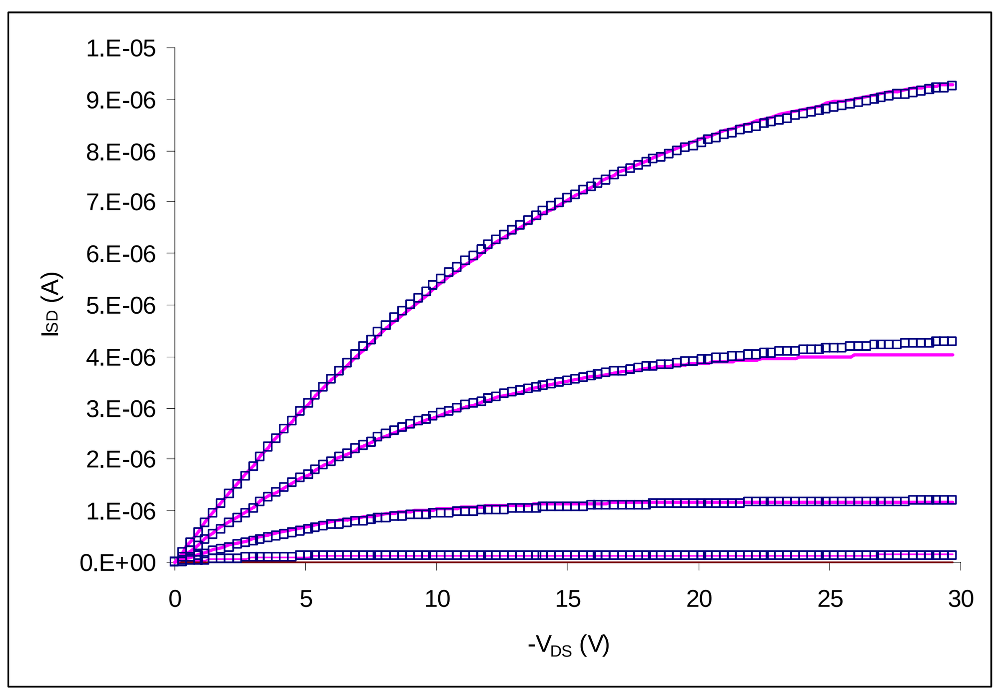


Population distribution

Results

Organic TFT, Pentacene, W=170µm, L=130µm, ε_r=3.9, µo=4·10^{-5} m·s^{-2} (provided by Infineon)





In order to test the method, we run 1000 times the parameter extraction process with the same experimental data. The process provided an excellent repeatability, with a dispersion in the extracted parameters much better than in the case of undirected GA. Agreement with the direct method is fairly good, and no intervention by a human operator was required to set the starting point.

Parameter	Undirected GA Mean Value	Undirected GA σ (%)	Directed GA Mean Value	Directed GA σ (%)	Direct Method [1]
V_T(V)	-11.49	3.4	-11.41	0.6	-11.38
γ_a	1.24	2.4	1.26	1.1	1.26
V_{aa}(V)	48.82	0.7	48.08	0.2	48.2
α_S($V^{1/2}$)	0.409	0.9	0.412	0.3	0.413
λ (V^{-1})	0.99u	10.1	0.98u	2.5	0.96u
m	2.22	1.7	2.18	1.7	2.19
Time (s)	44.08	44.6	24.8	21.7	-