Smoothing of Well Rates in Subsurface Hydrocarbon Reservoir Simulators

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Problem Formulation and Task

Replace the "rough" flow rate with a smoother function, which retains two properties of the original:

- It remains positive at very instance;
- The integral over the entire time range is preserved.

Different smoothing scenarios are expected to be seen.

First Scenario: Approximation by Splines and Newton-Raphson Method

Replace the data function by smoothing spline with restrictions

$$f(t)\ S_f \in C^2 :$$

$$\int_0^T f(t)dt = \int_0^T S_f\, dt$$

$$S_f > 0 \quad \text{for} \quad 0 \leq t \leq T$$

$OldArea = 1.316303598725274$
$NewArea = 1.316303598725274$, $Error \sim 10^{-17}$

First Scenario: Spline Approximation with Restrictions

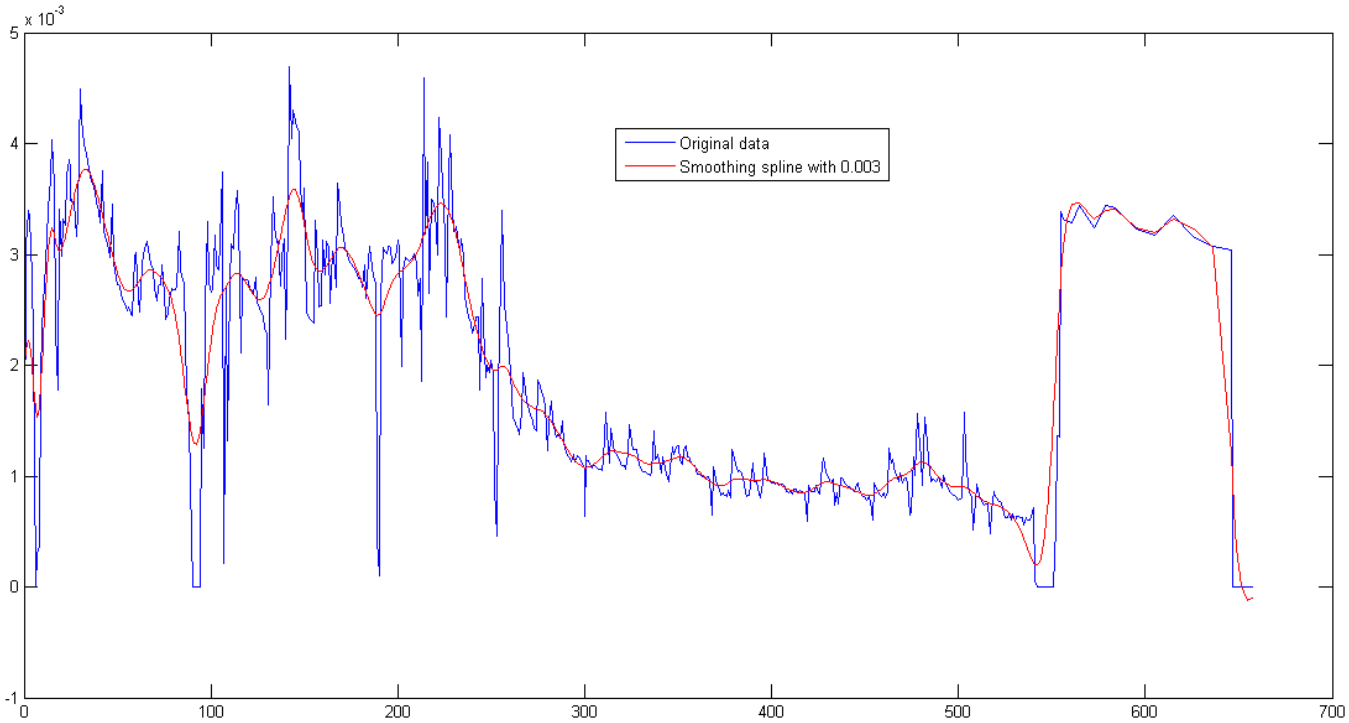

Figure: 1

First Scenario: Spline Approximation with Restrictions

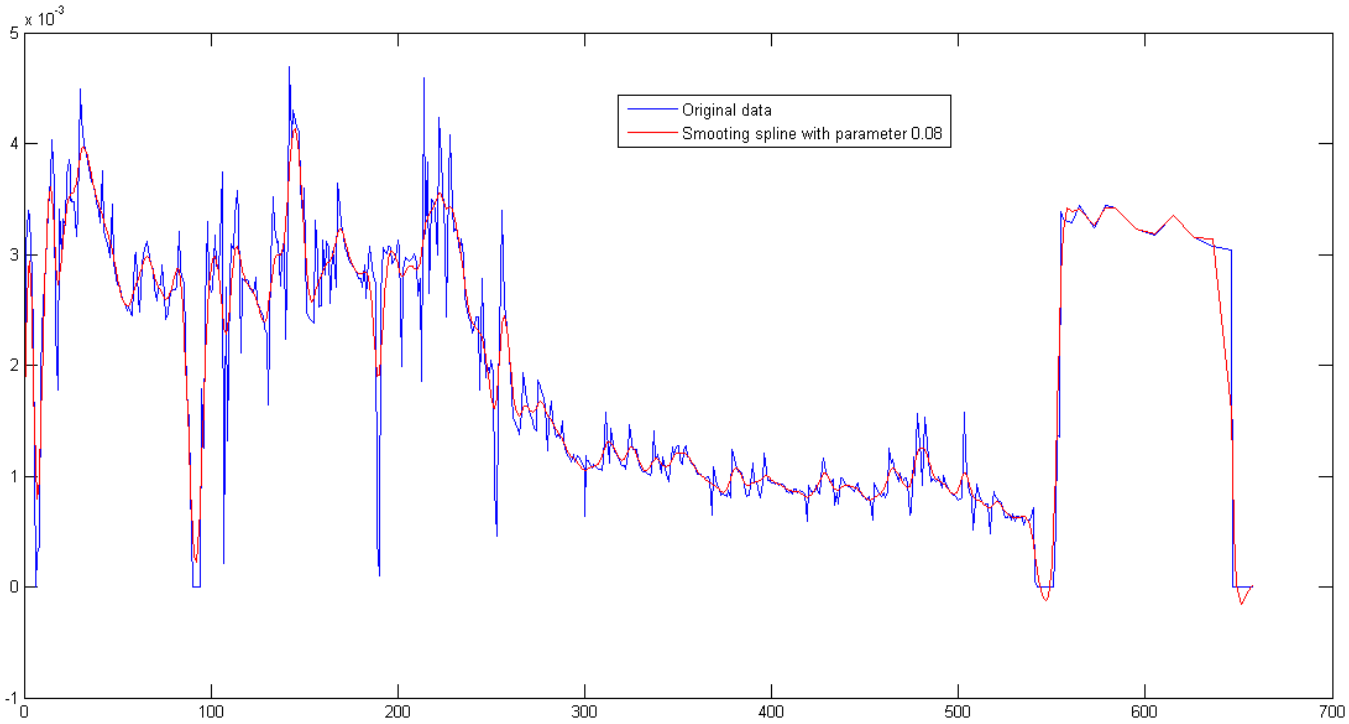

Figure: 2

First Scenario: Spline Approximation with Restrictions

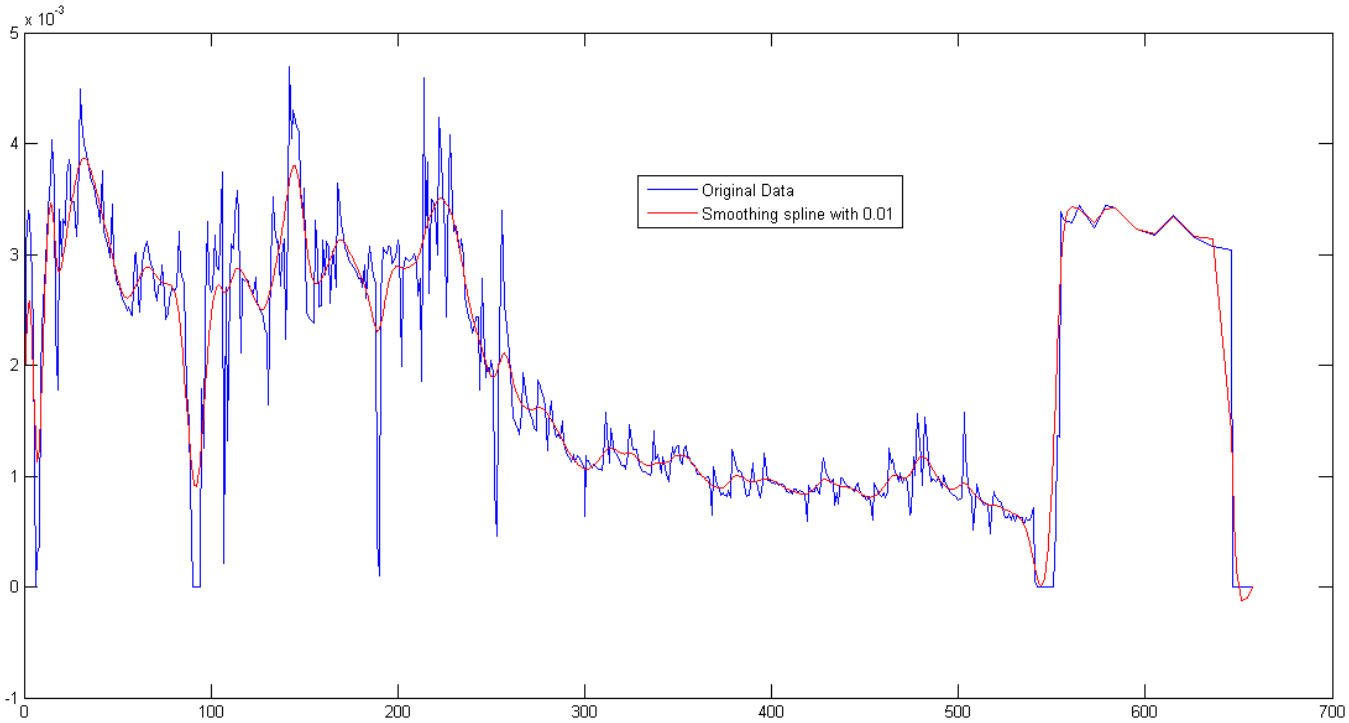

Figure: 3

Second Scenario: Explicit Relationship to the Average Value

$$f_x = \frac{f_{i-1}(h_{i-1} + h_i) + f_i(h_i + h_{i+1}) + f_{i+1}(h_{i+1} + h_{i+2})}{h_{i-1} + 2(h_i + h_{i+1}) + h_{i+2}}$$

where $h_i = t_i - t_{i-1}$, $i = 1, N$ procedure for $i = 1, ..., N$ by step 4.
It is possible to cut the largest deviations by reiterating.
We repeat this

$OldArea = 1.316303598725 27E + 00$
$NewArea = 1.316303598725 27E + 00$, , $Error \sim 10^{-17}$

Second Scenario: Moving average sketch

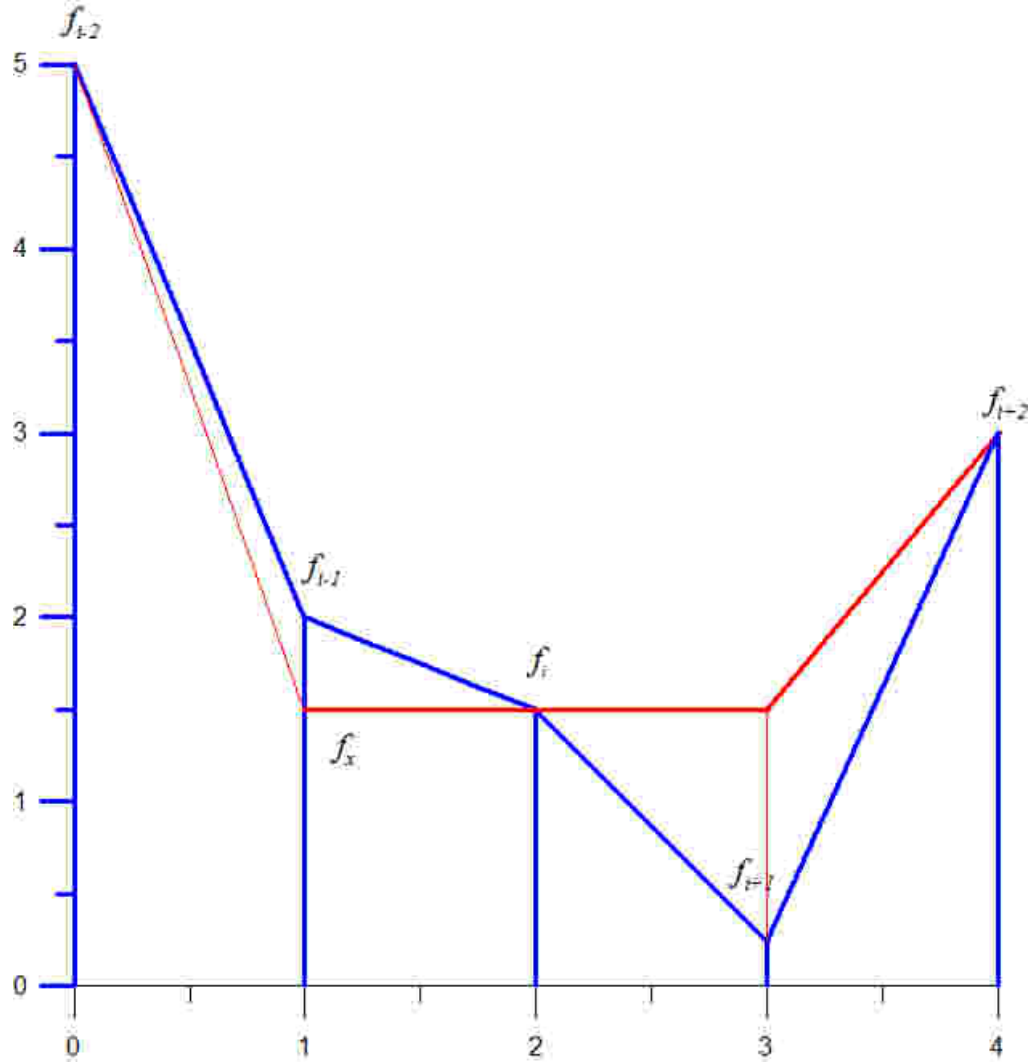

Figure: 4 Graph sketch of the averaging.

Second Scenario: Moving average sketch

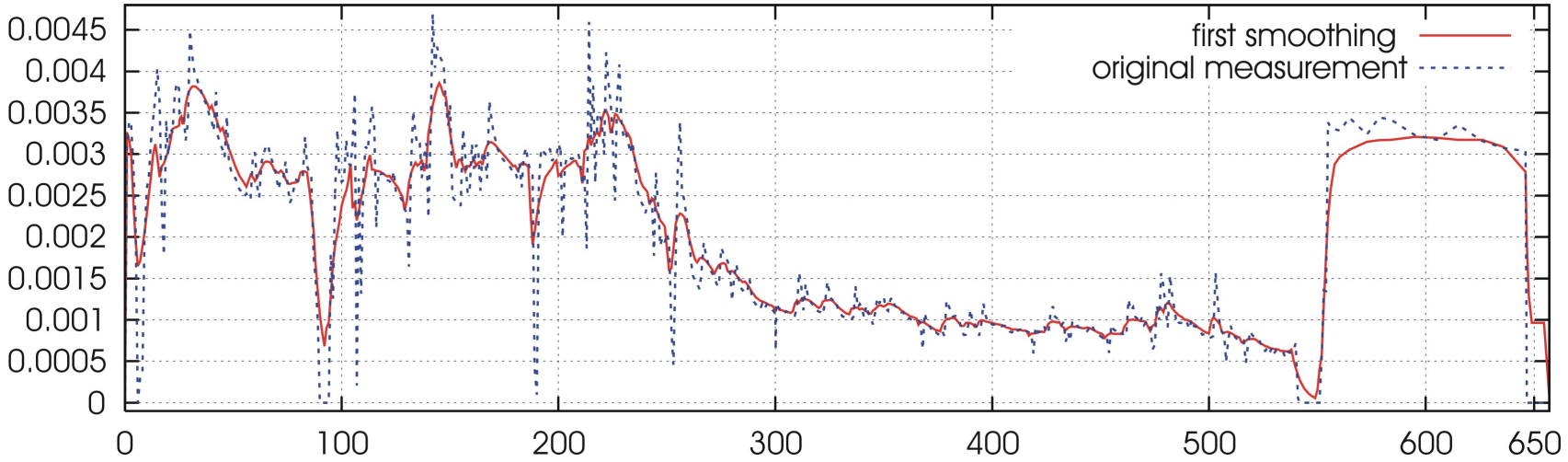

Figure: 5

Piece-wise linear replacement or Spline Approximation with Restrictions

Which scenario to choose? We'll see on Monday.

Thanks

Thank you for your attention!