New Geometrical Filtration for Ultra-Precision and Micro/Nano Manufactured Products (EP/F032242/1)

Author: W. Zeng, X.Jiang, P.Scott, L. Blunt

centre for precision technologies

University of HUDDERSFIELD
Inspiring tomorrow's professionals

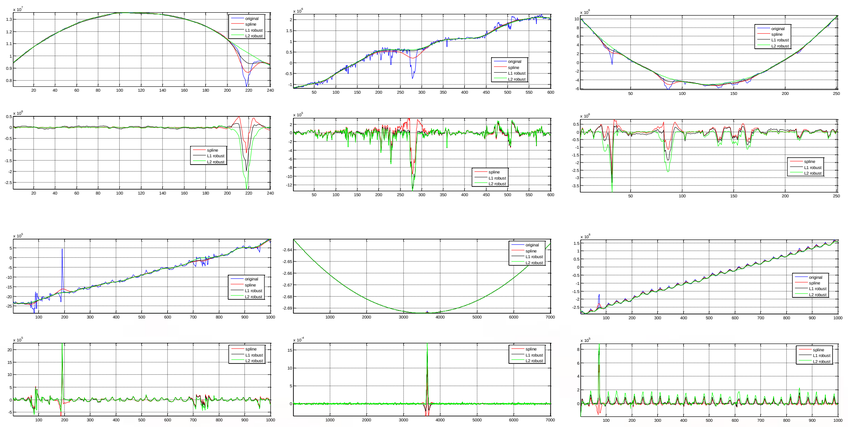
The aim of this project is to explore and develop fast and stable algorithms, standard reference algorithms, and measurement procedures for non-linear geometrical Gaussian and spline filtration. Focusing on:

- Exploration of suitable numeric models for robustness and stability of non-linear filters.
- Creation of fast algorithms for the efficient implementation of non-linear Gaussian and spline filters.
- Development of standard reference algorithms implementing the definitions according to the ISO 16610 series of standards.

$$\sum_{k=0}^{n-1}\rho\left(z_k - s(x_k)\right) + \lambda\int_{x_0}^{x_{n-1}}\{\frac{d^2s(x)}{dx^2}\}^2 dx \to \underset{s(x_k)}{Min}$$

Generalised Spline filter

L2	$\rho(x)=x^2/2$	$\psi(x)=x$	$w(x)=1$	linear
L1	$\rho(x)=\lvert x\rvert$	$\psi(x)=\mathrm{sgn}(x)$	$w(x)=\frac{1}{\lvert x\rvert}$	
Huber	$\rho(x)=\begin{cases}x^2/2, if\ \lvert x\rvert\le k\\ k(\lvert x\rvert-k/2), if\ \lvert x\rvert>k\end{cases}$	$\psi(x)=\begin{cases}x, if\ \lvert x\rvert\le k\\ k\,\mathrm{sgn}(x), if\ \lvert x\rvert>k\end{cases}$	$w(x)=\begin{cases}1, if\ \lvert x\rvert\le k\\ k/\lvert x\rvert, if\ \lvert x\rvert>k\end{cases}$	Nonlinear Robust
Cauchy	$\rho(x)=\frac{c^2}{2}\log\left(1+\left(x/c\right)^2\right)$	$\psi(x)=\frac{x}{1+(x/c)^2}$	$w(x)=\frac{1}{1+(x/c)^2}$	
Tukey	$\rho(x)=\begin{cases}\frac{c^2}{6}\left(1-\left[1-(x/c)^2\right]^3\right), if\ \lvert x\rvert\le c\\ \frac{c^2}{6}, if\ \lvert x\rvert>c\end{cases}$	$\psi(x)=\begin{cases}x\left[1-(x/c)^2\right]^2, if\ \lvert x\rvert\le c\\ 0, if\ \lvert x\rvert>c\end{cases}$	$w(x)=\begin{cases}\left[1-(x/c)^2\right]^2, if\ \lvert x\rvert\le c\\ 0, if\ \lvert x\rvert>c\end{cases}$	



$$\int_0^l \rho\left(z(\xi) - w(x) - \beta_1(x)\left(\xi - x\right) - \beta_2(x)(\xi - x)^2\right)s(\xi - x)d\xi$$
$$\to \underset{w(x),\beta_1(x),\beta_2(x)}{Min}$$

Generalised higher order gaussian regression filter for 2D Profile

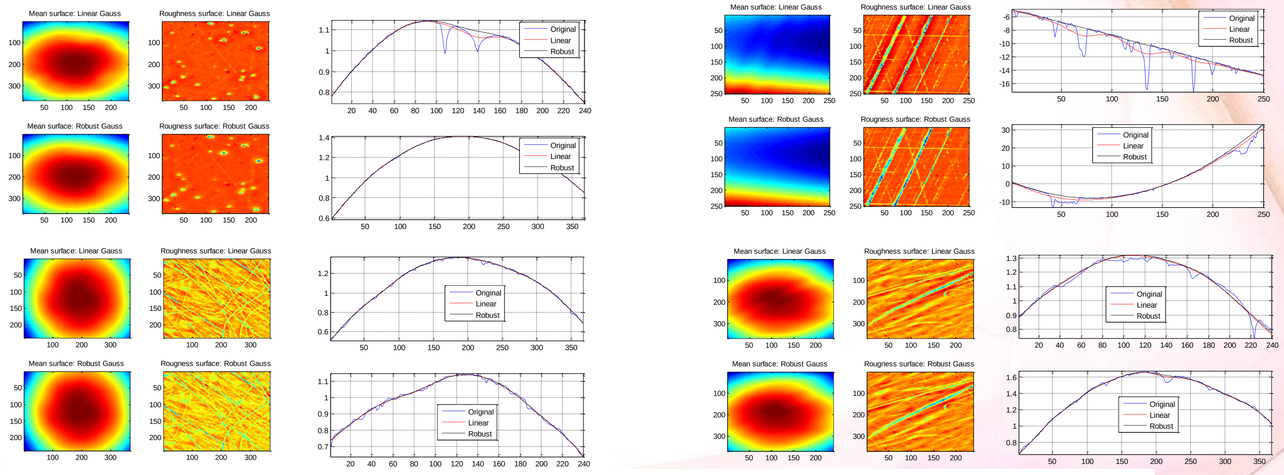
$$\int_0^{ly}\int_0^{lx}\rho\left\{\begin{matrix}z(\xi,\eta) - \beta_{10}(x,y)(\xi - x) - \beta_{01}(x,y)(\eta - y) - \beta_{20}(x,y)(\xi - x)^2\\ -\beta_{11}(x,y)(\xi - x)(\eta - y) - \beta_{02}(x,y)(\eta - y)^2 - w(x,y)\end{matrix}\right\}\cdot s(\xi - x,\eta - y)d\xi d\eta$$
$$\Rightarrow \underset{w(x,y),\beta_{10}(x,y),\beta_{01}(x,y),\beta_{20}(x,y),\beta_{11}(x,y),\beta_{02}(x,y)}{Min}$$

Generalised higher order gaussian regression filter for 3D surface

Fast algorithms:

1. Convolution to FFT;
2. Pre-calculation;
3. Separable in rows and cols

Significant speed improvement:
For a typical 60,000 pts data, 100 ms is needed compared with tradition algorithms need a few hours



Research Festival
23 March ~ 2 April 09

EPSRC Engineering and Physical Sciences Research Council

www.hud.ac.uk/researchfestival