AE 625 - Particles Methods for Fluid Flow Simulation
SPH function and derivative approximation

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Consider the function sin(πx) in the region [-1, 1]. Sample this function at equal spaced intervals and perform an SPH approximation of the exact function.

The report is generated through the command ¨ sh a7-140010042.sh ¨

1 Plot the L2 error in the approximation with respect to the exact value as a function of the number of points used and the h́v́alue chosen. Use both a cubic spline kernel and the Gaussian Kernels. The L2 norm of a vector y is $|y|=(\sum iy_i)^{0.5}$. Perform the same for the derivative of the function and compare with the exact solution using the formula discussed..

Results:

Cubic spline kernel

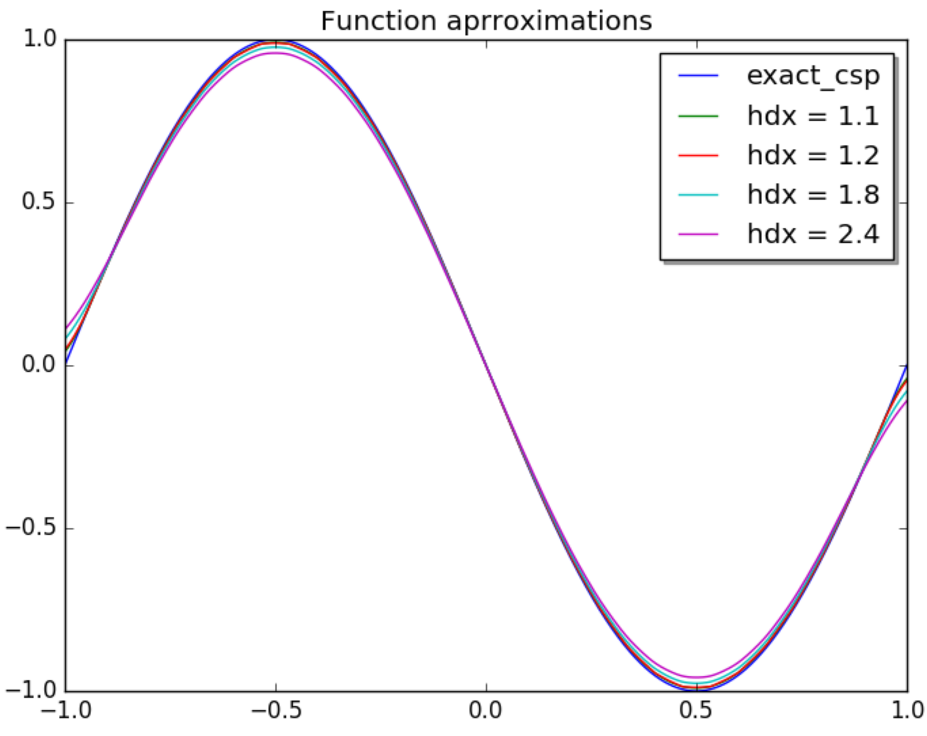

Figure 1: Cubic spline - function approx.

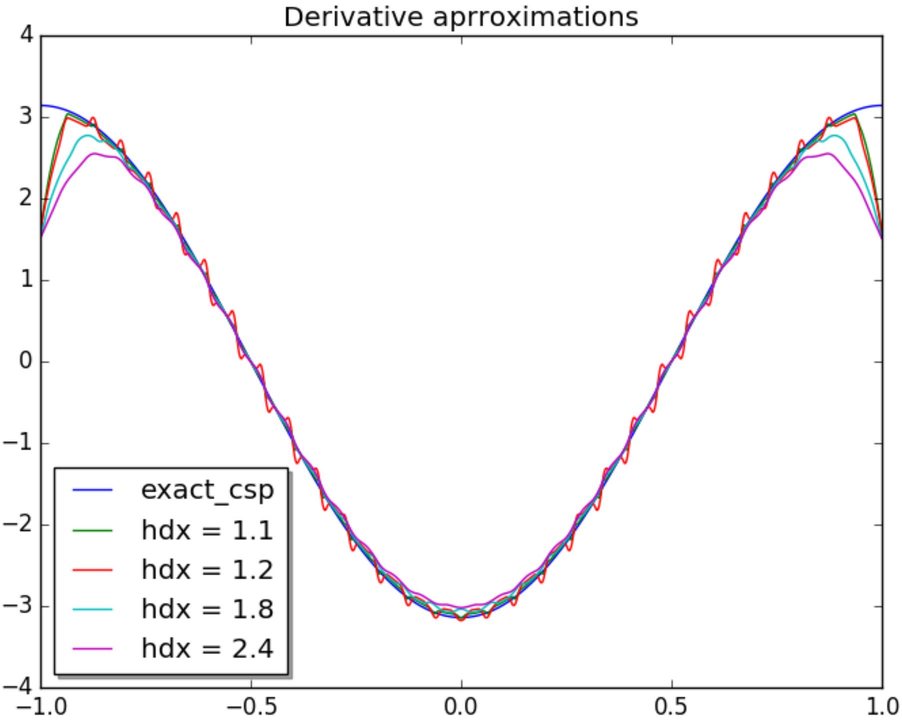

Figure 2: Cubic spline - derivative approx.

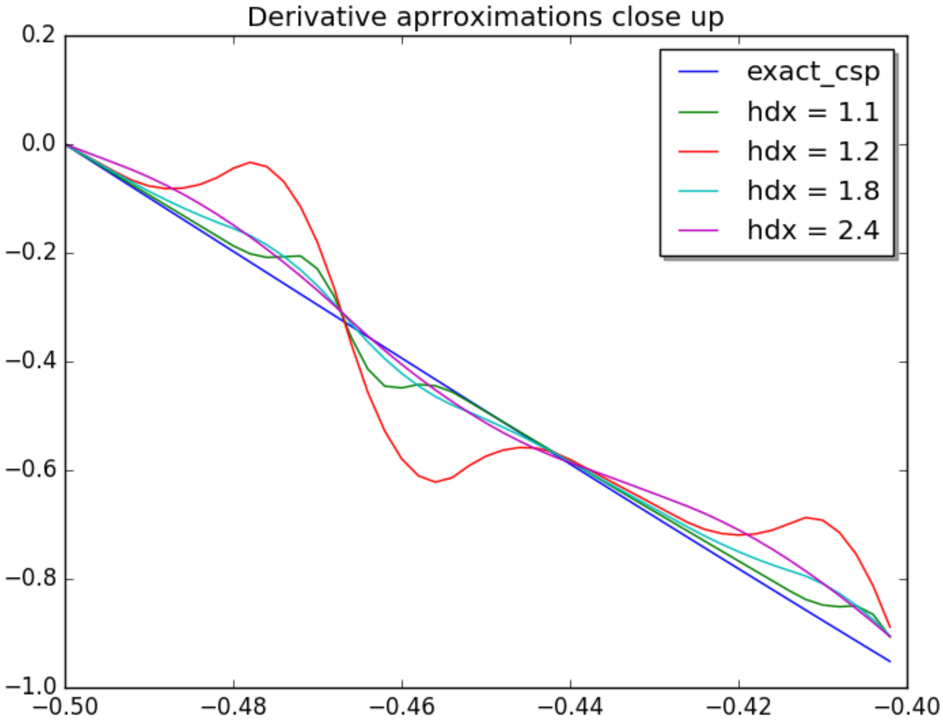

Figure 3: Cubic spline - derivative approx close up.

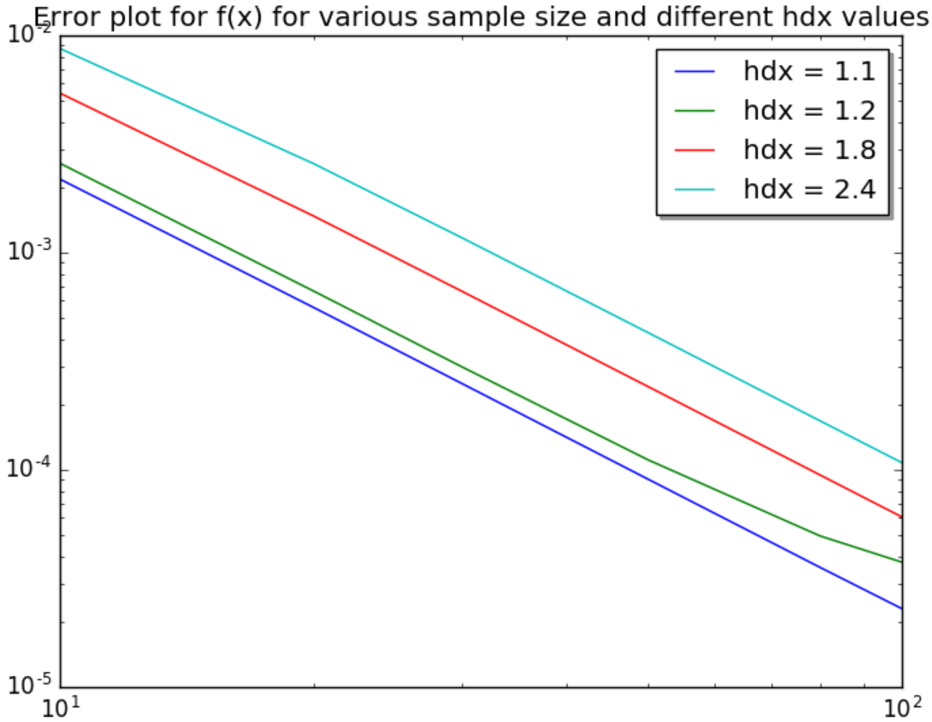

Figure 4: Cubic spline - function approx. error.

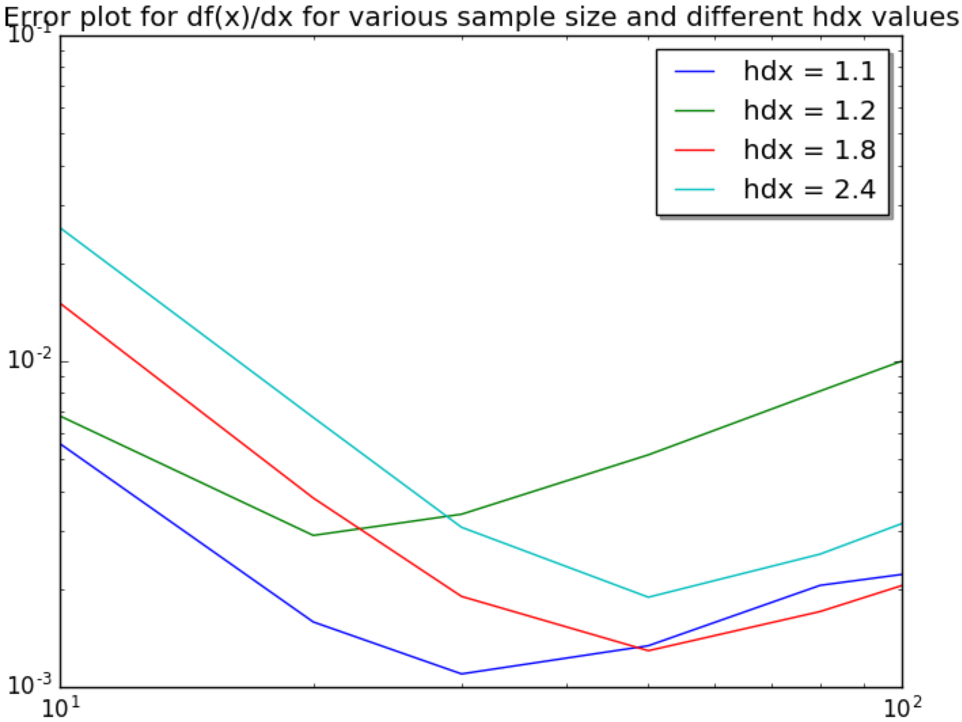

Figure 5: Cubic spline - derivative approx. error.

Gaussian kernel

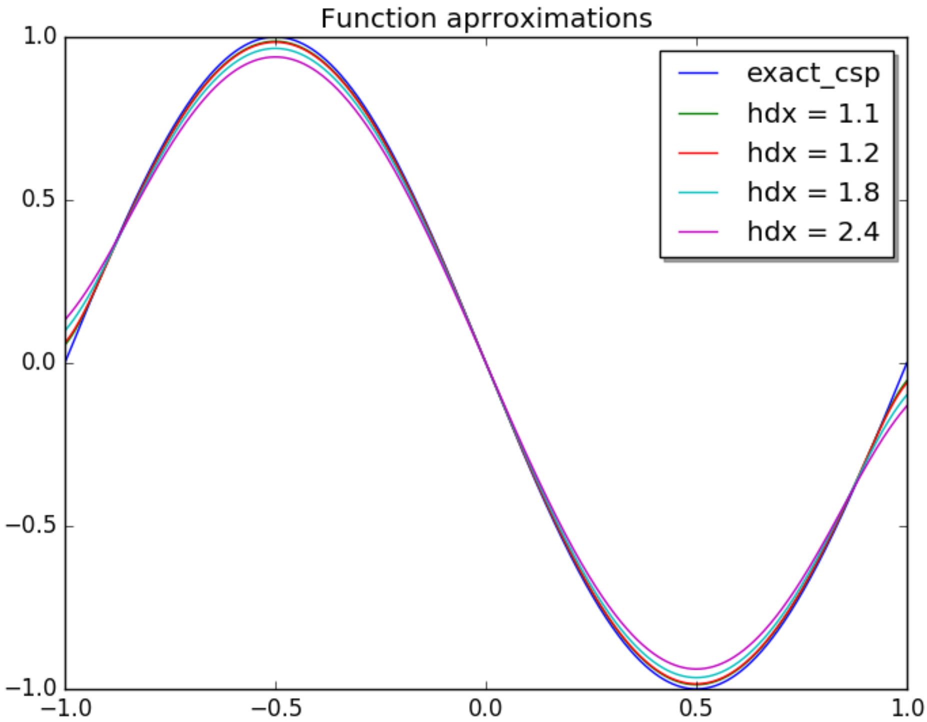

Figure 6: Gaussian - function approx.

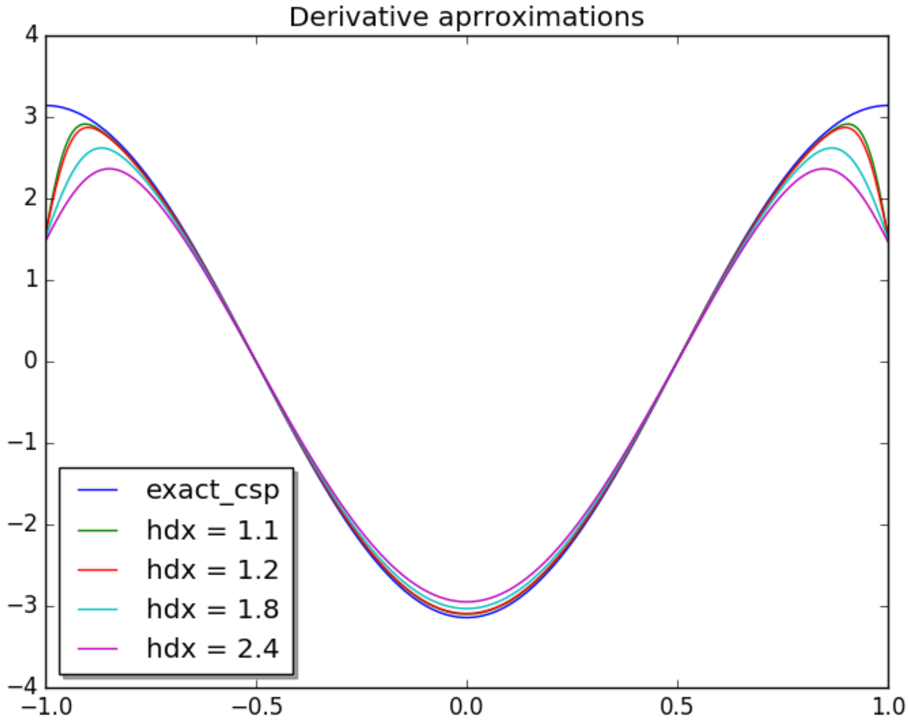

Figure 7: Gaussian - derivative approx.

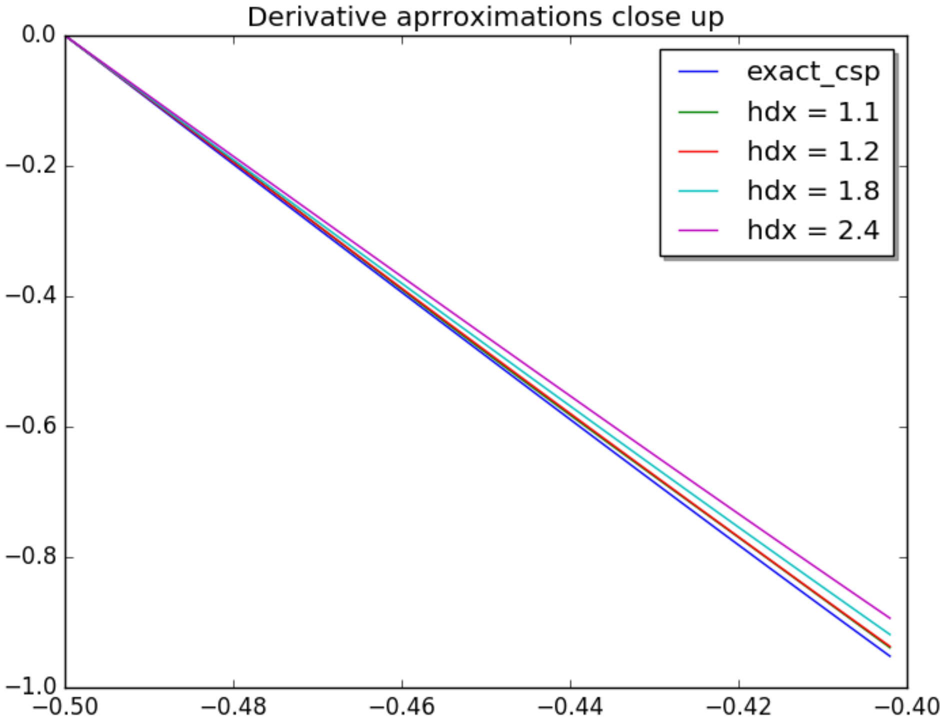

Figure 8: Gaussian - derivative approx closeup.

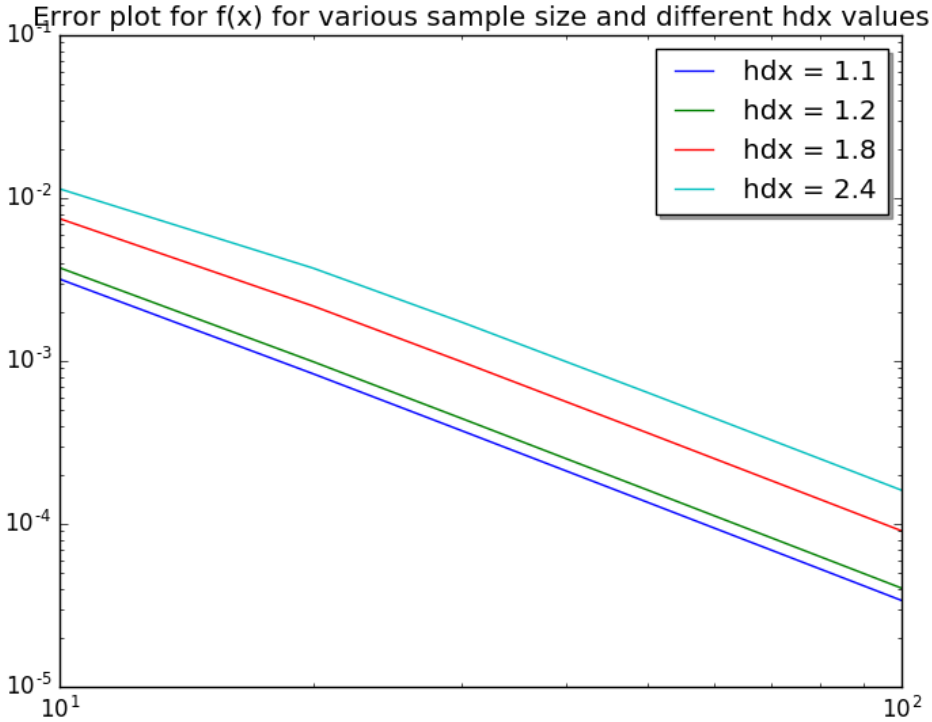

Figure 9: Gaussian - function approx. error.

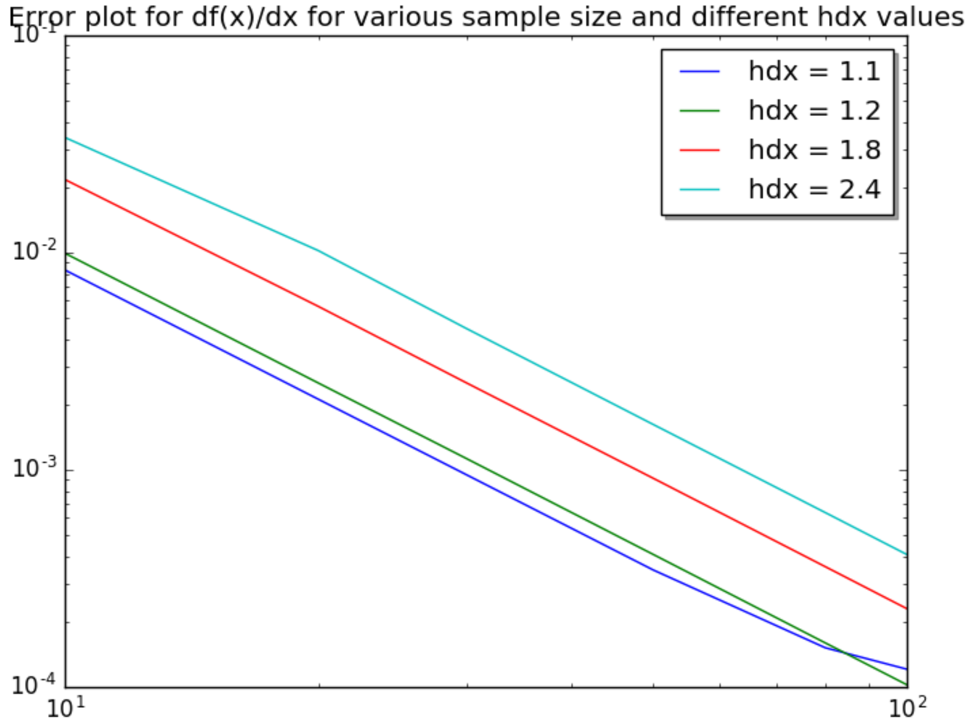

Figure 10: Gaussian - derivative approx. error.

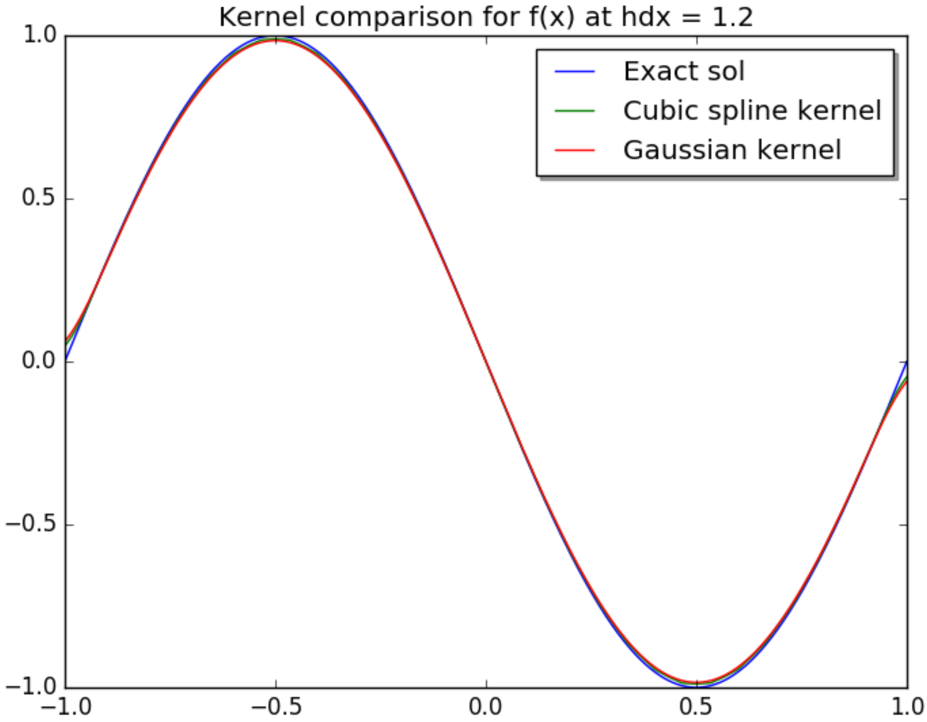

Figure 11: Kernel comparison - function approx.

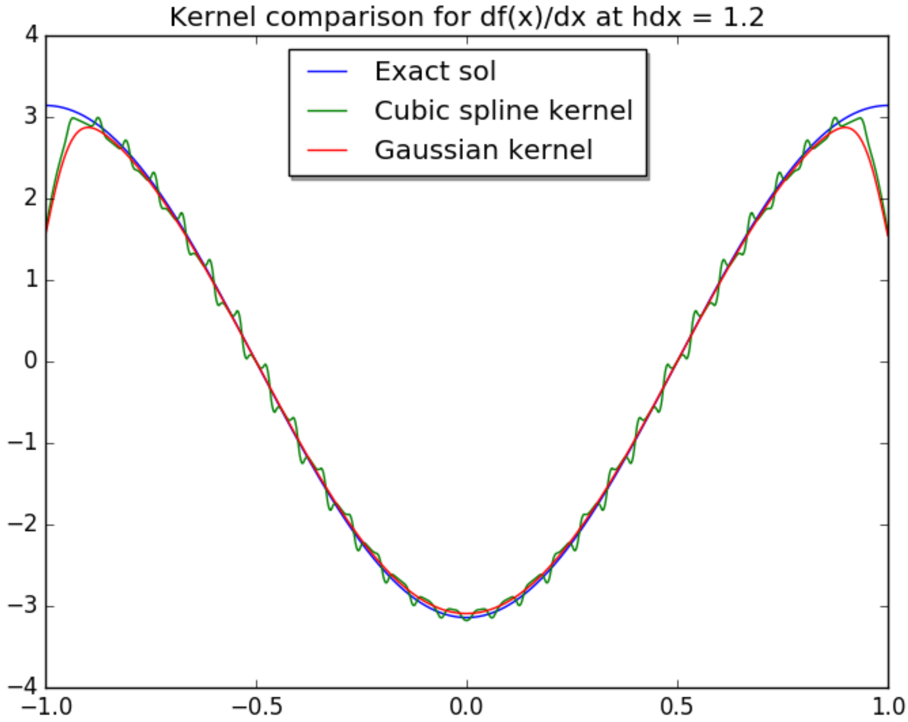

Figure 12: Kernel comparison - derivative approx.

2 Finally, pick one of the kernels and add a small amount of noise to the positions of the particles (by adding a small random displacement, uniformly distributed), and see how this affects the accuracy.

Results:

Approximation without noise for hdx = 1.1 .

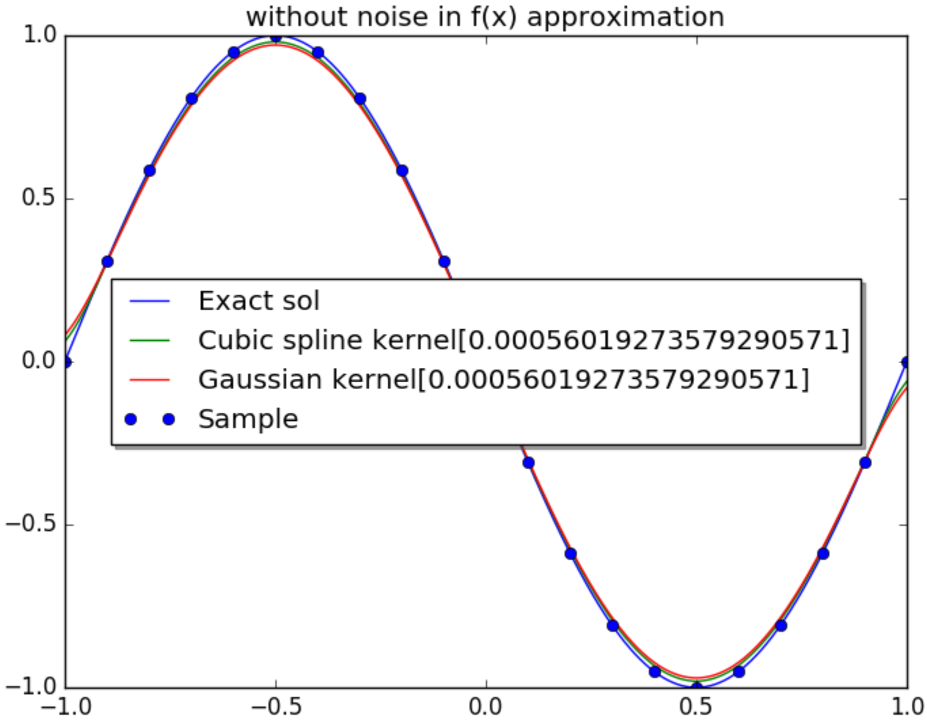

Figure 13: function approx without noise

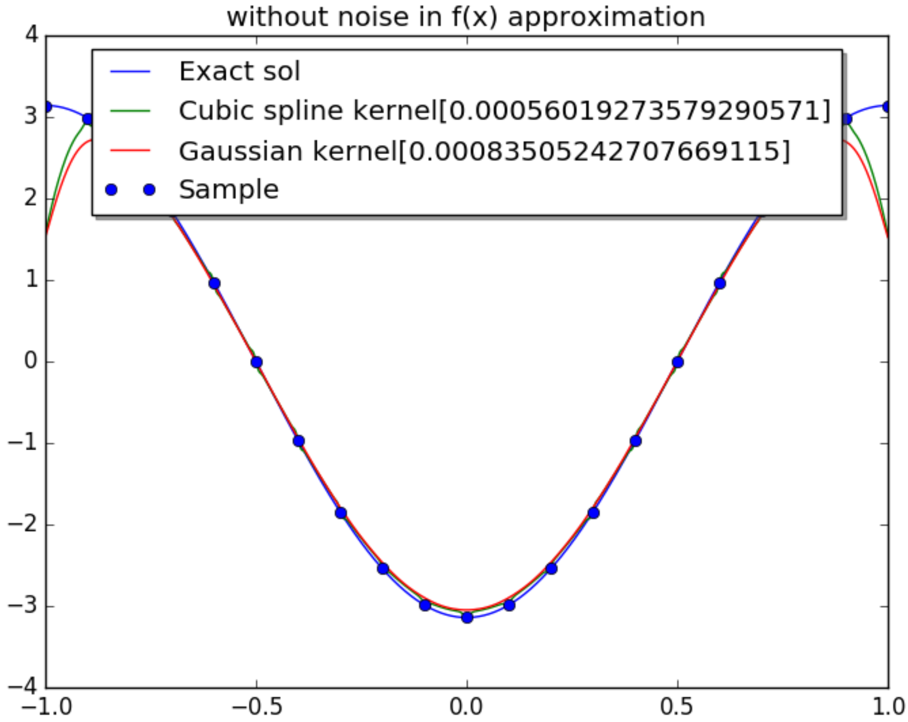

Figure 14: derivative approx without noise

Approximation with noise for hdx = 1.1 .

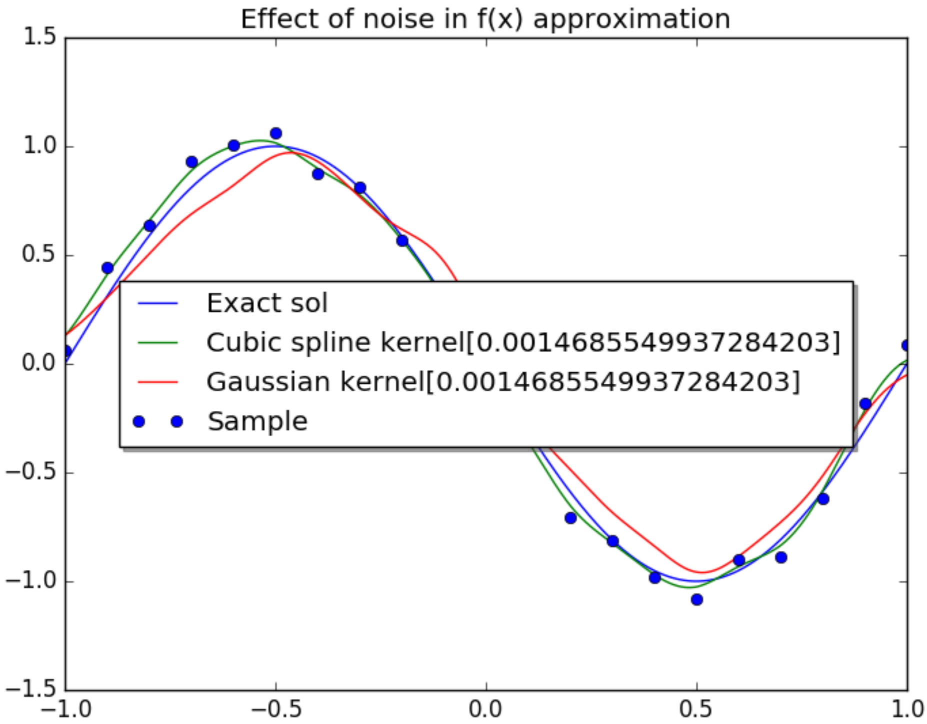

Figure 15: function approx with noise

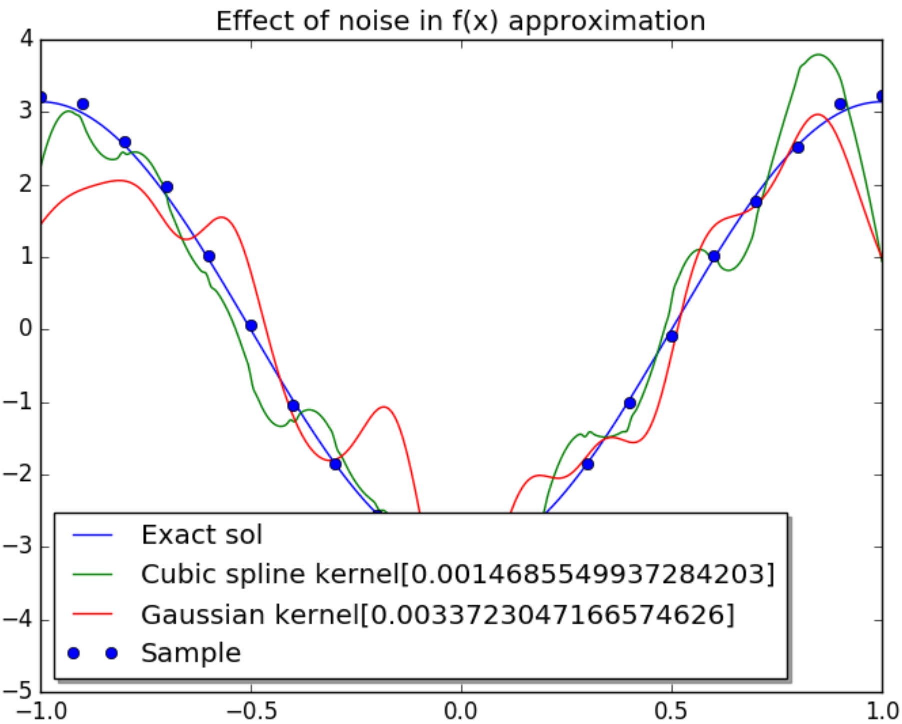

Figure 16: derivative approx with noise