Geodesic Gaussian Process Model Fitting

(MATLAB Code documentation)

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This set of MATLAB programs accompanies the paper "Geodesic Gaussian Processes for the Reconstruction of a Free-Form Surface" by Enrique del Castillo, Bianca M. Colosimo and Sam D. Tajbakhsh. They fit a Geodesic Gaussian Process as explained in that paper to N points (x, y, z) (cloud point data), typically collected using a scanner or non-contact device, and provides the best estimate of the underlying "true" surface in the presence of measurement noise in each of the 3 coordinates for all of the small-dataset examples in the paper. This set of programs is recommended for up to N=1600 points. For larger datasets, a different set of programs are provided. Since the main program for big and small N require common functions, it is suggested to simply place all files in the same folder. The programs were developed with MATLAB 2011b.

To be able to properly run all the examples in the paper (up to $N \leq 1600$), it is required to have the MATLAB toolboxes:

- Optimization Toolbox
- Global Optimization Toolbox
- Statistics toolbox
- NURBS Toolbox

In addition, the following packages must be present in the current directory or path of your MATLAB software:

- Dimensionality Reduction library, by Laurens van der Maaten.

- MATLAB Mesh toolbox
- G. Peyer's Graph toolbox

The main program is a "driver" program, which calls all other programs and can be used to reproduce all the examples in the paper up to and including the case $N = 1600$. The driver function is called `driverProgramTest.m`. A typical call is:

```
[MSPx,MSPy,MSPz,MSPt,MSEx,MSEy,MSEz,MSEt,MSEonlyZ,MSPz_uv,phiV,sigma2V,tau2V,pV]=driverProgramTest
('sinusoidal','outputFile',true)
```

Here, the 3 inputs to the function are: 1) a NURBS filename as provided by the NURBS toolbox or the string 'sinusoidal' for reproducing the sinusoidal example in the paper; 2) an output filename (string outputFile), and a true/false flag where if true, ISOMAP is used in the parameterization, and when FALSE, ARAP is used.

The outputs of the program are as follows. MSP* (with *={x,y,z,t}) give the mean square prediction errors provided by the GGP model in each coordinate and in total in 3D. MSE* (with *={x,y,z,t}) give the simulated mean square errors in each coordinate. When MSP<MSE for any coordinate (or in total), the GGP predictions are reconstructing the true underlying surface more closely than what the actual, simulated surface is with respect to the true, noise-free surface. `MSEonlyz` is the mean square prediction error of a standard euclidean GP model that only fits the "heights" ($z(x, y)$), and `MSPzuv` is the mean square prediction error given by the GGP only in the z coordinate. `phiV, sigma2V, tau2V`, and `pV` are vectors with the estimated GP parameters for each coordinate model (by default, the powered exponential correlation parameter, p, is not estimated and is set to 1). All these output values are also saved in file outputFile.

In additions to these outputs, the program generates a good number of graphs, including graphs depicting the parameterization done, and the different predictions.

This version of the program (in contrast to the "big N" one) implements the iterative version of the GGP algorithm described in the supplementary materials (section B). If parameter `n_iter` is set to one in the driver program (this is the default), the non-iterative GGP fitting method is used.