

Exercises for 3D Image Analysis

Summer term 2015

Exercise 6 (Issue Date: 07.07.2015, Due Date: 21.07.2015)

Transform the World

The goal of the exercise is to do a spherical harmonic transformation of the world (and back).

1) Write a program "**compute_basis.cc**" which computes the basis functions of the spherical harmonics on a grid of 360x180 pixel (corresponding to 360 degree by 180 degree). Use the complex exponential function of the standard library. Use the gnu scientific library (gsl) to compute the normalized associated Legendre polynomials. The gsl only provides the associated Legendre polynomials for positive m . So use the fact that the normalized $P(\ell, -m) = (-1)^m * P(\ell, m)$

The basis functions shall be computed up to the band 6, which is

$Y(0,0)$,

$Y(1, -1)$, $Y(1,0)$, $Y(1,1)$

$Y(2,-2)$, $Y(2,-1)$, $Y(2,0)$, $Y(2,1)$, $Y(2,2)$

...

Store the resulting functions in a blitz Array with 49 x 180 x 360 complex elements (the first index is the linearized index of the spherical harmonics basis functions, with index = $\ell * (\ell+1) + m$). Save the functions as two arrays "basis_real" and "basis_imag" to an HDF5 file, and display them with **vivi** or **Fiji** (you will need the HDF5 plugin from our homepage: http://lmb.informatik.uni-freiburg.de/lmbsoft/imagej_plugins/hdf5.en.html)

2) Check the orthogonality of your basis functions and output the results in a 49x49 table. Round the results to 1/1000 to get rid of accumulated numeric errors. Hint: Don't forget the integration measure ds , when computing the integral.

3) Write a program "**transform_world.cc**", which does the following tasks:

- read the provided "world_elevation.h5" into a double blitz Array.
- compute the spherical harmonic coefficients up to band 30
- reconstruct the world with 1 band, 2 bands, 3 bands, etc and stack up the resulting images (only the real part) into a 3D blitz Array and save it as HDF5
- (Extra Points) speed up the computation of the coefficients and the reconstruction and do the reconstruction up to band 100.