**Summer School in Numerical Mathematics: Numerical Analysis, Image Processing and Surface Computing**

Numerical Analysis is the study of algorithms for solving the problems of continuous science. By "algorithm" we mean a sequence of calculations, typically performed on a computer. This is a broad and exciting subject. This course will introduce (or review, depending on your background) some basic areas of numerical analysis. We will then explore, computationally, several application areas which intersect

with cutting-edge Oxford Mathematics research.

**Intro to Numerical Analysis**

Course description: this first week of the course covers background material in Numerical Analysis. It will consist of lectures and computer demonstrations.

Prerequisites: calculus, basic linear algebra, basic knowledge about differential equations. It will be helpful to have either Matlab or GNU Octave installed on your computer.

Contents: finite differences and interpolation; quadrature; interpolation in barycentric form; numerical solution of differential equations (ODEs and PDEs); software considerations.

Examining: the first week of material will be assessed by a midterm examination.

**Image Processing**

Course description:

Image processing uses mathematics to manipulate digital images (e.g., from a camera or a medical scanning device).

The aim of this course is to give an introduction to diffusion PDEs as a means for image processing. Diffusion processes are used to remove noise while preserving or enhancing features such as edges which play an important role in the human perception of an image. The course will be a combination of lectures and practical computing work.

Prerequisites: Multivariable calculus, basic linear algebra, basic knowledge about differential equations.

Contents: The 1D & 2D heat equation, frequency response (low-pass filter), fundamental solution with Fourier Transform, numerical solution with finite difference schemes, MATLAB implementation, unsharp-mask filter. Aniosotropic and non-linear diffusion for edge preservation, transport equation and the Osher and Rudin shock filter for edge enhancement.

**Surface Computing**

Course description:

This course introduces numerical solutions of Partial Differential Equations (PDEs) on surfaces using the Closest Point Method.

Surface PDEs arise from many applications in physics, biology, and engineering. Among various numerical techniques for solving surface PDEs, the Closest Point Method is easy to implement and it works for a wide range of PDEs on surfaces with complex geometries. This course will cover basic theories, numerics and MATLAB implementations related to the method.

Prerequisites: Multivariable calculus, basic linear algebra, basic knowledge about differential equations.

Contents: Applications of surface PDEs, surface differential operators and examples, introduction to the Closest Point Method, matrix formulation of spatial discretizations, diffusion equation on a unit circle, reaction-diffusion on a unit sphere, MATLAB implementations and demos.

**Student Presentations**

In the second week, students will break out into groups and chose a short project based on the material covered in the image processing and surface computing lectures. Each group will present their results to the class.

Prerequisites: Each group will use either Matlab or the open source alternative GNU Octave to complete their project. It will be helpful to have either Matlab or Octave installed on your computer before the start of the second week.