# Project presentation

Programming Concepts in Scientific Programming EPFL, Master class

November 20, 2017

#### Rules

- 1. Project realized in groups of two students
- Delivery on c4science (Sources and report): Deadline Friday 15th December 2016, 14h
- 3. CMake build system
- 4. Inline documentation of your code (Doxygen)
- 5. Test suite
- Make a small report per group (4 pages) can be though as an extended README:
  - how to compile the program
  - typical program execution (the flow) and usage
  - List of features
  - List of tests
  - ► TODOs and perspectives
- 7. Make one oral presentation per student
  - ▶ the structure of the program
  - list of features
  - limitations and problems



#### Rules

#### What is important in the evaluation:

- ▶ The code
  - 1. must be compiling
  - 2. should be clean (coding convention)
  - 3. should have inline comments (and Doxygen)
  - 4. must have validating tests
  - 5. The git log entries/comments must be understandable
- ► The report should describe:
  - 1. the implementation in a consise way
  - 2. the validating tests
  - 3. the limitations and problems

### Project 1: Linear systems

- Implementation of direct and iterative methods for the solution of linear systems
- Mandatory: Direct methods: LU and Cholesky
- Mandatory: Iterative methods: Conjugate Gradient, Jacobi, Gauss-Seidel, Richardson
- ► Optional: Preconditioners, implementation of the Preconditioned Gradient and Preconditioned Conjugate Gradient methods

### Project 2: Eigenvalue problems

- ▶ Implementation of numerical methods for eigenvalue computation
- Mandatory: Power and Inverse power method
- Mandatory: Implementation of Power and Inverse power methods with shift
- ▶ Optional: Implementation of the QR method

# Project 3 and 4: Ordinary Differential Equations

▶ The first project focuses on scalar ODE, with generic non-linear function:

$$y'(t,x)=f(t,x)$$

▶ The second focuses on vectorial ODEs, only using a linear function:

$$y'(t,x) = f(t,x) = A * x + g(t)$$

#### Description:

- The implementation of explicit methods, such as Forward Euler and the multistep Adams Bashforth (up to 4 steps) is mandatory for both projects.
- The implementation of the implicit Backward Euler method is mandatory for the scalar ODE project.
- Optional: implementation of Runge-Kutta methods and/or Backward Differentiation Formulas (BDF schemes) and/or multistep Adams-Moulton.

### Project 5: Non-linear systems

- Implementation of numerical methods for the solution of nonlinear equations.
- Mandatory: consider a scalar nonlinear problem and implement the bisection, aitken, chord, newton and fixed point methods.
- Optional: extension to systems of nonlinear equations solved by the Newton and/or modified Newton method.

## Project 6: Data approximation

- This project deals with interpolation and data fitting.
- Mandatory: implement numerical methods such as polynomial approximation and piece-wise polynomial approximation for the solution of interpolation problems.
- Mandatory: For the data fitting, the least squares method has to be implemented.
- ► Mandatory: input data by reading file
- Optional: Fourier approximation of periodic data.

### Project 7: Numerical Integration

- Implementation of methods for the numerical computation of integrals in one or two dimensions.
- Mandatory: A simple geometrical domain can be considered (square, rectangle) and the first step consist in generating grids which can be structured.
- Optional: extension to more complex shaped domain.
- ► The numerical integration has to be carried out by the implementation of the following methods: Midpoint/Trapezoidal/Cavalieri-Simpson

# Project 8: Image/sound processing

- ▶ This project deals with the treatment of images or sound
- Mandatory: Computation of intensity histograms
- ▶ Mandatory: Implementation of the discrete Fourier transform (1D/2D)
- Mandatory: Contour extraction of an image or noise removal
- Optional: filtering image/sound

### Project 9: Monte Carlo

- ▶ This project deals with the statistical study of non-linear operators
- Mandatory: Computing numerically the expected value of a general function
- Mandatory: Visualization of statistical moments
- ▶ Mandatory: Verification of the central limit theorem