EPFL

CS-328	**Numerical methods for visual computing**

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Cursus	Sem.	Type
Communication systems	BA5	Opt.
Computer science	BA5	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Visual computing disciplines are characterized by their reliance on numerical algorithms to process large amounts of visual information such as geometry, images, and volume data. This course will familiarize students with a range of essential numerical tools to solve practical problems in this area

Content

This course provides a first introduction to the field of numerical analysis with a strong focus on visual computing applications. Using examples from computer graphics, geometry processing, computer vision, and computational photography, students will gain hands-on experience with a range of essential numerical algorithms.
The course will begin with a review of important considerations regarding floating point arithmetic and error propagation in numerical computations. Following this, students will study and experiment with several techniques that solve systems of linear and non-linear equations. Since many interesting problems cannot be solved exactly, numerical optimization techniques constitute the second major topic of this course. Students will learn how principal component analysis can be leveraged to compress or reduce the dimension of large datasets to make them easier to store and analyze. The course concludes with a review of numerical methods that make judicious use of randomness to solve problems that would otherwise be intractable.
Students will have the opportunity to gain practical experience with the discussed methods using programming assignments based on Scientific Python.

Keywords

Visual computing, numerical linear algebra, numerical analysis, optimization, scientific computing

Learning Prerequisites

Required courses
MATH-101 (Analysis I) and MATH-111 (Linear Algebra).

Recommended courses
The courses CS-211 (Introduction to visual computing) and MATH-106 (Analysis II) are recommended but not required.

Important concepts to start the course
Students are expected to have good familiarity with at least one programming language (e.g. C/C++, Java, Scala, Python, R, Ruby...). The course itself will rely on Python, but this is straightforward to learn while taking the course.

During the first weeks of the semester, there will be tutorial sessions on using Python and Scientific Python.

Learning Outcomes

By the end of the course, the student must be able to:

• Develop computer programs that use numerical linear algebra and analysis techniques to transform and visualize data.

• Reason about ways of structuring numerical computations efficiently.

• Analyze the numerical stability of programs built on top of floating point arithmetic.

• Recognize numerical problems in visual computing applications and cast them into a form that can be solved or optimized.

Teaching methods

Lectures, interactive demos, theory and programming exercises

Expected student activities

Students are expected to study the provided reading material and actively participate in class and in exercise sessions. They will be given both theoretical exercises and a set of hands-on programming assignments.

Assessment methods

1. Continuous assessment during the semester via project assignments (50%)
2. Final exam (50%)

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Slides and other resource will be provided in class.
The course textbook is
Numerical Algorithms: Methods for Computer Vision, Machine Learning, and Graphics by Justin Solomon (freely available at the following link: http://people.csail.mit.edu/jsolomon/share/book/numerical_book.pdf)
An optional reference is
Scientific Computing: An Introductory Survey (2nd edition) by Michael Heath

Ressources en bibliothèque

• Numerical Algorithms: Methods for Computer Vision, Machine Learning, and Graphics / Solomon

• Scientific Computing: An Introductory Survey / Heath

Websites

• https://rgl.epfl.ch/courses/NMVC16

Prerequisite for

Although it is not a strict prerequisite, this course is highly recommended for students who wish to pursue studies in the area of Visual Computing, in particular: CS-341 (Introduction to computer graphics), CS-440 (Advanced computer graphics), CS-442 (Computer vision), CS-413 (Computational Photography), CS-444 (Virtual Reality), and CS-445 (Digital 3D geometry processing)