**Global Learning Initiatives Program Course Syllabus**

Please complete the following form in English. The information will be updated to the Global Learning Initiatives Program website for students’ reference. If you will be offering more than one course, please fill out one form per course offered. Examples in grey.

**Course Information**

|  |  |
| --- | --- |
| Course Name  \*provide the **English** course name of the course. | Introduction to compressed sensing |
| Lecturer(s)  \*provide the lecturers’ **English** name. If there are more than one lecturer, please indicate all lecturers in the column. | Prof. Stefano Rini |
| Course Description  \*briefly describe the contents covered in the courses. | This course will discuss the theoretical, numerical, and practical foundations of sparse representations and compressive sensing. Sparsity has become a very important concept in recent years in applied mathematics. The key idea is that many types of functions and signals arising naturally in applications can be described by only a small number of significant degrees of freedom. Compressive sensing is an ingenious means to exploit sparsity. Compressive sensing is not only one of the hottest topics in mathematics in recent years, but it also has the potential to revolutionize the technology of data acquisition and processing in a broad sense. We will investigate the many fascinating connections between these topics and other areas such as harmonic analysis, random matrix theory, optimization, statistics, information theory and signal processing. Furthermore, we will discuss matrix completion as well as applications of compressive sensing in image processing, radar, and analog-to-digital conversion. |
| Course Objectives  \*list out knowledge or skills students should acquire upon completion of course. | The goal of this course is to provide an overview of the recent advances in compressed sensing and sparse signal processing. We start with a discussion of classical techniques to solve undetermined linear systems, and then introduce the l0 norm minimization problem as the central problem of compressed sensing. We then discuss the theoretical underpinnings of sparse signal representations and uniqueness of recovery in detail. We study the popular sparse signal recovery algorithms and their performances guarantees. We will also cover signal processing interpretations of sparse signal recovery in terms of MAP and NMSE estimation. |
| Suggested Proficiencies  (if any)  \*list preferred knowledge or skills students should have before taking the course. | A strong foundation in linear algebra and python programming language |
| Reading List  (if any)  \*list out the textbooks, references, or other reading materials. | 1. M. Elad, “Sparse and Redundant Representations”, Springer, 2010.  2. H. Rauhut, “Compressive Sensing and Structured Random Matrices,” Radon Series Comp. Appl. Math., 2011. 3. M. A. Davenport, M. F. Duarte, Y. C. Eldar, G. Kutyniok, “Introduction to Compressed Sensing,” available here.  4. S. Foucart and H. Rauhut, “A mathematical introduction to compressive sensing,” Birkhauser Pre |
| Grading Criteria  \*how would the students be assessed during the course. | Project, quizzes and exams will all account for one third of the grade. |

**Course Schedule**

Please complete the following table with the dates and expected course topics. If there are more than one lecturers instructing the course, please also indicate the lecturer for each class.

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| --- | --- | --- | --- |
| Class | Date (YYYY/MM/DD) | Course Topic | Lecturer |
| 1 | 2023/02/15 | Introduction and math review | Prof. Stefano Rini |
| 2 | 2023/02/22 | Introduction and math review cont. | Prof. Stefano Rini |
| 3 | 2023/03/01 | Uniqueness and uncertainty principles | Prof. Stefano Rini |
| 4 | 2023/03/18 | Uniqueness and uncertainty principles cont. | Prof. Stefano Rini |
| 5 | 2023/03/15 | Recovery algorithms - greedy and convex | Prof. Stefano Rini |
| 6 | 2023/03/22 | Recovery algorithms - greedy and convex cont. | Prof. Stefano Rini |
| 7 | 2023/03/29 | The theory of compressed sensing | Prof. Stefano Rini |
| 8 | 2023/04/12 | The theory of compressed sensing cont. | Prof. Stefano Rini |
| 9 | 2023/04/19 | Stable recovery | Prof. Stefano Rini |
| 10 | 2023/04/26 | Approximate recovery algorithms | Prof. Stefano Rini |
| 11 | 2023/04/03 | Bayesian recovery algorithms | Prof. Stefano Rini |
| 12 | 2023/04/10 | Extensions and applications | Prof. Stefano Rini |