BOSTON UNIVERSITY
Metropolitan College
Computer Science Department

**MET CS 599 BIOMETRICS (Special Topics), Spring 2025**

Lectures and labs in classroom
Class meets on Wednesdays, 6-8:45 PM EST
Room PHO 201, 8 Sant Mary's Street
First class on Wednesday, January 22, 2025
Office Hour between 5:15-6:00 PM Before Class

## Course Introduction

Automatic and reliable authentication, identification and verification of individuals using official documents (e.g., passports, driving licenses, others) or accessing secure facilities (e.g., military bases, bank vaults and similar) and proprietary information (e.g., corporate websites) has become an essential part of our modern networked society. Biometric recognition systems utilize the physiological or behavioral characteristics of an individual for his or her identification or characterization. Biometrics allows us to establish person's identity based on "who the person is", rather than by "what the person possess" (e.g., an ID card) or "what the person remembers" (e.g., a password). Covid-19 pandemic generated huge interest in the design, deployment, and evaluation of biometric systems for fulfilment of comprehensive security needs and protection of modern societies. The pandemic extended classical security domain with health-related concerns. Biometric sensing and analysis can make critical contribution to both classical and health-related security.

## Course Learning Objective:

At the end of this curse:

- Students will possess unique set of skills, knowledge and experience which will allow them to apply biometrics techniques in many security related jobs.
- Students will be able to use various biometric sensors and techniques to enhance existing or build new and efficient security applications.
- Students will be able to use biometric techniques for identification of individuals and or verification of presented credentials.
- Students will be able to use biometric techniques to determine person's state of mind and/or health.
- Students will be able to efficiently use fingerprints, voice, faces and facial expressions, hand geometry, iris, retina, gait, temperature of the skin, and other biometric modalities and integrate those with broader security systems.
- Students who finish this course will become advanced users of biometrics technology with full awareness of the benefits and limitations of various biometric instruments and techniques.

- Students will become fully aware of the privacy and human rights issues related to the use of biometric technology. Students will learn how to secure privacy and human rights while providing security services.

**Teaching Approach:**

- Lectures:
  - Lectures will describe biometric techniques, practically available devices and provide information on leading vendors.
  - Lectures will explain essential algorithms used in various biometric techniques. Discussed algorithms will be illustrated with working code.
  - Practical mechanisms for assessment of performance of various biometric techniques in the sense of accuracy and throughput will be explained and demonstrated.
  - During the lectures we will gradually introduce key mathematical and signal processing tools used in Biometrics. We will introduce or review key concepts in probability and statistics, signal processing with Fourier Series and Fourier Transform (FFT), wavelets, as well as OpenCV computer vision API.
  - Issues related to the privacy and human rights will also be addressed.
  - All lectures will be delivered in person by the instructor but they will also recorded as Zoom session and made available after the class.
- Labs:
  - All lectures will be followed by practical and mandatory on-line labs in which students will gain experience with different devices, measurements techniques and analysis of collected data. Issues related to the privacy and human rights will be addressed.
  - In most labs various biometric devices will be demonstrated by the instructor or course facilitators. Students will be provided with written and illustrated instructions on how to operate those devices themselves and how to collect the data generated by the devices. University will not be able to provide students with actual physical devices, though the devices will be available for the local students in the University lab.
  - All in class labs will be conducted as Zoom sessions with initial demonstration by the instructor or a course facilitator and group discussion of the processes and procedures. In the second portion of a typical lab students will perform numerical analysis of data and write lab reports.
  - Most labs will be based on samples and datasets provided by the instructor, large collections of fingerprints, images or irises, images of faces, and others.
  - In some labs, students will be asked to supplement supplied data sets with data collected by themselves, like the images of their own faces, faces of family members or friends and relatives.
  - Main portion of all labs will be an analysis of collected data in conjunction with the data provided by the instructor and the data generated by the student.
  - Typical outcome of the lab will be a report describing the process of measurement, data collection and data analysis with the results specifying the accuracy and the throughput of the measurements.

## Prerequisites

- Basic aptitude for mathematics, probability, and statistics.
- Knowledge of Python at the level of MET CS 521 Information Structures with Python

## Learning Materials

Selected scientific and trade papers in the field will be distributed before every class. Recent and most relevant books in the field will be referenced but will not be required.

## Evaluation and Grading

Lecture material (papers) should be reviewed before the next class. The reading assignments should be done before the lecture, and then carefully studied afterwards. All assignments must be legible, well formatted, submitted on time and complete. 10% penalty per day will be applied for every late assignment, without any exceptions.

Homework assignments are issued once a week and are due in 7 days. Every lab involved collection of data and processing the data into reports which will be graded similarly to homework assignments.
Every student will implement a final project, an individual effort to understand and describe a biometric technology, device or use case. All final project materials will be shared with the entire class. Selected students will present their final projects to the entire class.

Grades will be based on:

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| Class Participation | 5% |
| Homework | 60% |
| Labs | 15% |
| Final Project: | 20% |

## Academic Honesty

The course is governed by the Academic Conduct Committee policies regarding plagiarism (any attempt to represent the work of another person as one's own). This includes copying (even with modifications) of a program or segment of code. You can discuss general ideas with other people, but the work you submit must be your own. Collaboration is not permitted.

## Instructor Information

**Dr. Zoran B. Djordjevic**
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## Schedule of Lectures and Labs

| Class | Date | Lectures | Labs |
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| 1 | 01/22/25 | Overview of Biometrics: definitions, biometric modalities, access control, areas of use, forensics. General biometric systems architecture. Privacy and human rights. | Introduction to NumPy and Pandas. Examples of signal processing with FFT, examples of OpenCV image manipulation |
| 2 | 01/29/25 | Overview of Matlab | Matlab |
| 3 | 02/05/25 | Speech capture and speech recognition fundamentals. Formants and spectrograms. | Speech capture Lab. Speech to text (transcription). |
| 4 | 02/12/25 | Speaker Recognition, Cloud APIs for Speaker Recognition. Limitations and benefits of the technology. Use in banking and voice activated applications. | Speaker Recognition Lab<br>Cloud Speaker Recognition API |
| 5 | 02/19/25 | Estimating error from data, definition of False acceptance rate (FAR), False rejection rate (FAR), Receiver Operating Characteristic (ROC) curve, other measures | Quality and performance lab. Discussion of high scalability for Government systems, voting, food stamps distribution, and such. |
| 6 | 02/26/25 | Face Recognition, Eigenfaces approach.<br>3D Face ID, AWS service Recognition.<br>Examples in banking and transportation security | Face recognition lab. |
| 7 | 03/05/25 | Face expressions and emotion recognition. Emotion recognition using speech. | Emotion recognition lab. Use in security setups. |
| | 03/12/25 | **No class. Spring recess** | |
| 8 | 03/19/25 | Iris Recognition. Basic Wavelet concepts. Practical implementations of wavelets | Iris recognition lab. Illustrations in Airport and Government |
| 9 | 03/26/25 | Fingerprint Recognition, feature extraction, minutea, other fingerprint techniques. | Fingerprint recognition lab and gummy bear spoofing lab |
| 10 | 04/02/25 | Other biometric modalities: DNA, retina, thermograms, keystroke, etc. | Thermogram and keystroke lab. Illustrations in health monitoring |
| 11 | 04/09/25 | Image Segmentation, Pattern Recognition and Classification | OpenCV lab for image processing |
| 12 | 04/16/25 | Remote Identification. Remote measurement of vital signs. Gait and gesture recognition. | Gait and gesture recognition lab. Security of outdoor facilities |
| 13 | 04/23/25 | Simultaneous use of multiple biometric modalities, performance, and system error. Gain or loss of precision and/or accuracy with multiple modalities. | Multiple modalities lab. Performance and error analysis. |

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| 14 | 04/30/25 | Integration of biometric sensors in large scale security systems, Privacy issues | System integration lab. Scalability issues in large government applications |
| **15** | **05/04/25** | **Final project presentations** | |