

EE/ME 599/699

**Process Monitoring and Machine Learning**

Semester/Term: Spring 2020

Credit Hours: 3

Meeting Days/Time/Location: TR, 11:00 a.m. - 12:15 p.m., Barker Hall 306

**Instructor Information**

Instructor: Peng Wang

Office Building & Room Number: RMB 414H

Email: Edward.Wang@uky.edu

Office Phone: (859) 562-2415

Office Hours: Tuesday 2:00 p.m. - 4:00 p.m.

**Course Description**

The course covers:

- **Background of Manufacturing Process Monitoring:** sensing and modeling of processes such as machining, injection molding, rolling, and chemical-mechanical polishing; condition monitoring, fault detection, diagnosis, and prognosis of machines or machine parts
- **Supervised Machine Learning Techniques:** Multiple/polynomial Regression, Support Vector Machine/Regression (SVM/SVR)
- **Unsupervised Machine Learning Techniques:** Principal Component Analysis (PCA), t-SNE, K-Means Clustering
- **Bayesian Inference Techniques:** Kalman Filtering (KF), Particle Filtering (PF)
- **Deep Learning:** Neural Network, Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)

**Skill Requirements**

1. Linear Algebra, matrix operation, derivative
2. Signal representation and time domain analysis
3. Programing background

**Student Learning Outcomes**

After completing this course, the student will be able to:

1. Master the fundamental idea of machine learning-based data analytics for manufacturing process monitoring and other applications
2. Describe the state-of-the-art of the machine learning techniques
3. Understand and code commonly adopted machine learning techniques and models in Python or Matlab
4. Provide a solution and analysis for a specific application through developing a data analytics model from scratch or leverage existing software modules
5. Prepare written reports and presentations describing model establishment, data analysis, and findings on topics of process monitoring

**Activities and Assignments**

**Course Assignments**

- 3 small projects and 1 big project
- Final presentation, based on the outcome and findings of the big project.

**Submission of Assignments**

- Small projects should be done individually. For each project, a written report (including problem statement, data analysis and modeling approach, details of data processing and modeling, results, and discussions) together with the original codes should be submitted via Canvas. All submissions must be in PDF file.
- Group works are encouraged for the big project. Each group must have no more than 2 participants. Project topics will be differentiated for the undergraduate and graduate students. The report for the big project must be submitted no later than 11:59 p.m. on May 1<sup>st</sup>, Friday. The presentations of the final project are held at the final week, 04/28 and 04/30.
- Unexcused Late Submissions: not accepted and will be treated the same as no submissions.
- Excused Late Submissions: accepted and will not be penalized. See page 3 for discussion of Excused Absences.
- Any similarity between project reports and codes from different students will raise a flag to trigger the instructor to investigate and interview students involved. Unexplainable similarity will lead to investigation of possible cheating. The instructor also reserves the right to interview all students to assure the projects are solved and reports are written by the students themselves regardless if any similarities have been found. If any cheating is determined, all students involved will fail the class. See pages 4-5 for discussion on Academic Integrity and Cheating.

**Course Grading**

The Final grade will be based on:

- 3 small projects: 60% (20% each)
- Big project and final presentation: 40%

Letter grade assignment: A (90-100 points), B (80-89), C (65-79), and E (0-64).

**Tentative Course Schedule**

| Unit | Dates            | Topics  |
|------|------------------|---|
| 1    | 1-16, 21, 23     | Background of process monitoring, modeling, and programming in Python                           |
| 2    | 1-28             | Multiple Regression (case study, injection molding process modeling)                            |
| 3    | 1-30, 2-3, 6     | Support Vector Regression (SVR), Kernel-SVR (injection molding process modeling)                |
| 4    | 2-11             | Principal Component Analysis  |
| 5    | 2-13, 18, 20     | Feature Extraction, Bayesian Inference, and Kalman Filtering (case study, tool wear prediction) |
| 6    | 2-25, 27, 3-3    | Particle Filtering and variants (case study, tool wear prediction)                              |
| 7    | 3-6, 10          | K-Means Clustering (case study, machine fault type classification)                              |
| 8    | 3-12, 23, 26     | Neural Networks (case study, machine fault type classification), t-SNE                          |
| 9    | 3-31, 4-2, 6, 9  | Convolutional Neural Networks (case study, machine fault type classification)                   |
| 10   | 4-14, 16, 21, 23 | Recurrent Neural Networks (case study, tool wear prediction)                                    |

**Excused Absences (Senate Rules 5.2.4.2)**

Senate Rules 5.2.4.2 defines the following as acceptable reasons for excused absences: (a) significant illness, (b) death of a family member, (c) trips for members of student organizations sponsored by an educational unit, trips for University classes, and trips for participation in intercollegiate athletic events, (d) major religious holidays, (e) interviews for graduate/professional school or full-time employment post-graduation, and (f) other circumstances found to fit “reasonable cause for nonattendance” by the instructor of record. Students should notify the professor of absences prior to class when possible.

If a course syllabus requires specific interactions (e.g., with the instructor or other students), in situations where a student’s total EXCUSED absences exceed 1/5 (or 20%) of the required interactions for the course, the student shall have the right to request and receive a “W,” or the Instructor of Record may award an “I” for the course if the student declines a “W.” (Senate Rules 5.2.4.2.1)

**Verification of Absences (Senate Rules 5.2.4.2.1 - 6)**

Students may be asked to verify their absences in order for them to be considered excused. Senate Rule 5.2.4.2 states that faculty have the right to request appropriate verification when students claim an excused absence due to: significant illness; death in the household, trips for classes, trips sponsored by an educational unit and trips for participation related to intercollegiate athletic events; and interviews for full-time job opportunities after graduation and interviews for graduate and professional school. (Appropriate notification of absences due to University-related trips is required prior to the absence when feasible and in no case more than one week after the absence.)

**Religious Observances (Senate Rules 5.2.4.2.4)**

Students anticipating an absence for a major religious holiday are responsible for notifying the instructor in writing of anticipated absences due to their observance of such holidays. Please check the course syllabus for the notification requirement. If no requirement is specified, two weeks prior to the absence is reasonable and should not be given any later. Information regarding major religious holidays may be obtained through [the Ombud’s website](#) or calling 859-257-3737.

**Make-Up Work (Senate Rule 5.2.4.2)**

Students missing any graded work due to an excused absence are responsible: for informing the Instructor of Record about their excused absence within one week following the period of the excused absence (except where prior notification is required); and for making up the missed work. The instructor must give the student an opportunity to make up the work and/or the exams missed due to the excused absence, and shall do so, if feasible, during the semester in which the absence occurred. The instructor shall provide the student with an opportunity to make up the graded work and may not simply calculate the student's grade on the basis of the other course requirements, unless the student agrees in writing.

**Accommodations Due to Disability**

If you have a documented disability that requires academic accommodations, please see me as soon as possible during scheduled office hours. In order to receive accommodations in this course, you must provide me with a Letter of Accommodation from the Disability Resource Center (DRC). The DRC coordinates campus disability services available to students with disabilities. Visit the [DRC website](#), [email the DRC](#), contact them by phone at (859) 257-2754, or visit their office on the corner of Rose Street and Huguelet Drive in the Multidisciplinary Science Building, Suite 407.

**Non-Discrimination Statement and Title IX Information**

UK is committed to providing a safe learning, living, and working environment for all members of the University community. The University maintains a comprehensive program which protects all members from discrimination, harassment, and sexual misconduct. For complete information about UK’s prohibition on discrimination and harassment on aspects such as race, color, ethnic origin, national origin, creed, religion, political belief, sex, and sexual orientation, please see [the electronic version of UK’s Administrative Regulation 6:1 \(“Policy on Discrimination and Harassment”\)](#) . In accordance with Title IX of the Education Amendments of 1972, the

University prohibits discrimination and harassment on the basis of sex in academics, employment, and all of its programs and activities. Sexual misconduct is a form of sexual harassment in which one act is severe enough to create a hostile environment based on sex and is prohibited between members of the University community and shall not be tolerated. For more details, please see [the electronic version of Administrative Regulations 6:2 \(“Policy and Procedures for Addressing and Resolving Allegations of Sexual Assault, Stalking, Dating Violence, Domestic Violence, and Sexual Exploitation”\)](#). Complaints regarding violations of University policies on discrimination, harassment, and sexual misconduct are handled by the Office of Institutional Equity and Equal Opportunity (IEEO), which is located in 13 Main Building and can be reached by phone at (859) 257-8927. You can also visit [the IEEO’s website](#).

Faculty members are obligated to forward any report made by a student related to IEEO matters to the Office of Institutional Equity and Equal Opportunity. Students can *confidentially* report alleged incidences through the Violence Intervention and Prevention Center, Counseling Center, or University Health Services.

### **Academic Integrity– Prohibition on Plagiarism (Senate Rules 6.3.1)**

Per University policy, students shall not plagiarize, cheat, or falsify or misuse academic records. Students are expected to adhere to University policy on cheating and plagiarism in all courses. The minimum penalty for a first offense is a zero on the assignment on which the offense occurred. If the offense is considered severe or the student has other academic offenses on their record, more serious penalties, up to suspension from the University may be imposed.

Plagiarism and cheating are serious breaches of academic conduct. Each student is advised to become familiar with the various forms of academic dishonesty as explained in the [Code of Student Rights and Responsibilities](#). Complete information can be found on the [Academic Ombud](#) page. A plea of ignorance is not acceptable as a defense against the charge of academic dishonesty. It is important that you review this information as all ideas borrowed from others need to be properly credited.

*Senate Rule 6.3.1* (see current [Senate Rules](#)) states that all academic work, written or otherwise, submitted by students to their instructors or other academic supervisors, is expected to be the result of their own thought, research, or self-expression. In cases where students feel unsure about a question of plagiarism involving their work, they are obliged to consult their instructors on the matter before submission.

When students submit work purporting to be their own, but which in any way borrows ideas, organization, wording, or content from another source without appropriate acknowledgment of the fact, the students are guilty of plagiarism.

Plagiarism includes reproducing someone else's work (including, but not limited to a published article, a book, a website, computer code, or a paper from a friend) without clear attribution. Plagiarism also includes the practice of employing or allowing another person to alter or revise the work which a student submits as his/her own, whoever that other person may be, except under specific circumstances (e.g. Writing Center review or peer review) allowed by the Instructor of Record or that person's designee. Plagiarism may also include double submission, self-plagiarism, or unauthorized resubmission of one's own work, as defined by the instructor.

Students may discuss assignments among themselves or with an instructor or tutor, except where prohibited by the Instructor of Record (e.g. individual take-home exams). However, the actual work must be done by the student, and the student alone, unless collaboration is allowed by the Instructor of Record (e.g. group projects).

When a student's assignment involves research in outside sources or information, the student must carefully acknowledge exactly what, where and how he/she has employed them. If the words of someone else are used, the student must put quotation marks around the passage in question and add an appropriate indication of its origin. Making simple changes while leaving the organization, content, and phraseology intact is plagiaristic. However, nothing in these Rules shall apply to those ideas, which are so generally and freely circulated as to be a part of the public domain.

Please note: Any assignment you turn in may be submitted to an electronic database to check for plagiarism.

#### **Academic Integrity – Prohibition on Cheating (Senate Rules 6.3.2)**

Cheating is defined by its general usage. It includes, but is not limited to, the wrongfully giving, taking, or presenting any information or material by a student with the intent of aiding himself/herself or another on any academic work which is considered in any way in the determination of the final grade. The fact that a student could not have benefited from an action is not by itself proof that the action does not constitute cheating. Any question of definition shall be referred to the University Appeals Board.

#### **Academic Integrity – Prohibition on Falsification/Misuse of Academic Records (SR 6.3.3)**

Maintaining the integrity, accuracy, and appropriate privacy of student academic records is an essential administrative function of the University and a basic protection of all students. Accordingly, the actual or attempted falsification, theft, misrepresentation or other alteration or misuse of any official academic record of the University, specifically including knowingly having unauthorized access to such records or the unauthorized disclosure of information contained in such records, is a serious academic offense. As used in this context, "academic record" includes all paper and electronic versions of the partial or complete permanent academic record, all official and unofficial academic transcripts, application documents and admission credentials, and all academic record transaction documents. The minimum sanction for falsification, including the omission of information, or attempted falsification or other misuse of academic records as described in this section is suspension for one semester.