Artificial Intelligence Applications in Structural Engineering

Faculty: Faculty of Engineering

Course Name: Artificial Intelligence Applications in Structural Engineering

Training Course Overview

The goal of this Course is to introduce **programming paradigms** and **artificial intelligence concepts** not covered in traditional structural engineering courses. This **4-week course** (4 hours per day / 2 days per week) is designed for **students**, **engineers**, and **researchers**. Stimulating weekly sessions will introduce software development with **Python**, automation of **finite element models**, and **AI-assisted simulation** of structural design.

During the 4-week sessions, participants will be instructed by and interact extensively with the **BUE Faculty** that specialize in AI implementation in **Civil Engineering** applications. The target audience will be able to simulate structures (using SAP2000) and automate the generated models with Python. Additionally, participants will **learn salient machine learning techniques** (supervised and unsupervised) and **evolutionary algorithms** (optimization algorithms) that **align with modern AI developments worldwide**.

The training will provide participants with the fundamentals stated above, which will be reinforced with **hands-on examples** to boost confidence in utilizing ML in their applications beyond the training. The course presents a novice-level application for AI in structural engineering; therefore, we encourage students and engineers from **various disciplines** to attend this course.

Training Type: Practical Digital Implementation

Delivery Method: Instructor-led training, Hands-on practical sessions, Real-world case studies.

Contact Hours: **32 hours (Sundays and Thursdays from 4:00pm to 8:00pm)**

Minimum Number of Attendees: 5

Course fees: L.E. 3500

Venue: Faculty of Engineering (Computer Lab)

Type of Assessment: A final collaborative or individual project. Publication of work will be encouraged.

Type of Certificate: Certificate of attendance and accomplishing the Course requirements.

Instructors:

1. **Dr. Shady Salem** (Specialized in Theory of Structures)
2. **Dr. Ahmed A. Torky** (Specialized in AI implementation in Structural Engineering)

Target Audience:

1. Undergraduate students with basic knowledge of structural analysis.
2. Post-graduate students of engineering background.
3. Engineers and industrial practioners interested in applications of AI.

Course Objectives:

1. Basic understanding for finite element software.
2. Introduce programming with Python.
3. Learn how to link SAP2000/OpenSEES with Python.
4. Optimize parameters using structural analysis tools via Python.
5. Learn different AI methods such as supervised and unsupervised learning, regression analysis (Multilinear, Polynomial, Random Forest, and neural networks), and evolutionary algorithms (genetic algorithms and particle swarm).

Course Content:

The training program spans a duration of **four consecutive weeks**, with **two days** allocated per week and **four hours** designated per day. During each week, the **two days** are dedicated to exploring topics, outlined below for each respective week. Practical implementation will be carried out, providing hands-on experience, and reinforcing the theoretical and practical knowledge acquired during the four hours of each day.

Course Syllabus:

Week 1

- Introduction to Python:
    - Create an environment in Python.
    - Basics of coding in Python
    - Importing Libraries
    - Importing and manipulating datasets.

Week 2

- Basics of OpenSEES:
    - Creating models on OpenSEES.
    - Defining material properties.
    - Assigning sections and boundary conditions.
    - Assigning loads.
    - Pushover analysis.
- Integrating Python with SAP2000 and OpenSEES:
    - Controlling FEM inputs with Python.
    - Extracting outputs from FEM software.
    - Parametric investigations.
    - Generating parametric database using Python.

Week 3

- AI applications for engineered results:
    - Supervised VS unsupervised learning.
    - Regression analysis (Multilinear, Polynomial), Random Forest, Neural Networks.
    - Evolutionary algorithms (genetic algorithms and particle swarm).

Week 4

- Project on optimizing structural elements and parameters:
    - Establishing a complex design problem.
    - Setting up the optimization pipeline between code and FEM models.
    - Determine the optimum design by multiple AI techniques.