PMR 5251

Assessment of Mechanical Behavior of Materials using Machine Learning Approach

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Schedule	Course program	Prof.
17/09	Relationship between microstructure, mechanical properties and mechanical behavior – Review and point out the most relevant parameters relate to the mechanical behavior of materials using the microstructural features approach	Izabel
24/09	Techniques to evaluating and quantify microstructure features - Present tools for experimental characterization of mechanical properties and microstructural features of materials	Izabel
01/10	Introduce Machine Learning main concepts	Larissa
08/10	Mechanical behavior - stress-strain constitutive equations, workhardening, effect of strain rate, temperature, state of stress, time dependent and independent deformation	Izabel
15/10	Neural Networks in structural analysis	Larissa
22/10	Multiscale analysis	Izabel
29/10	Regression in multiscale problems	Larissa
05/11	Damage and Failure analysis – microstructure heterogeneities stress intensifiers, nucleation and growth of cracks	Izabel
12/11	Classification applied to failure analysis	Larissa
19/11	Seminars	Izabel/Larissa
26/11	Seminars	Izabel/Larissa
03/12	Final Test	Izabel/Larissa

Course Activities:

1. Seminars

The seminar will be presented by 2 people. You have to find a partner. Sing up to 23/09 indicating the selected paper and your partner.
Theme - based on selected paper, must be related to both mechanical behavior and machine learning.
- The paper selected have to describe and criticize during the presentation. Scrutinize the main conclusions and its relevance in a machine learning approach.
- 15 min presentation – 30 minutes discussion
Evaluation criteria: Organization, Content and keep your presentation short and to the point (14 ± 2 min). (https://www.fluentu.com/blog/business-english/business-english-presentation-phrases/). It is not obligatory, but the presentation may be presented in English.
The evaluation will be made by professores and fellow students.

2. Final Test

The test will be divided in two parts:

2.1. Considering mechanical behavior
2.2. Machine learning approach

3. Homework

Different activities will be given in the classes. Deadlines to details and deliver activities will vary and they will be described during the classes.

4. Evaluation:

Marks: 30% Seminar, 30% homework, 40% Final test

5. Attendance and e-mail list (14 students and emails)

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OBJETIVES:
The main objectives of this course are as follows:
1. Review and point out the most relevant parameters relate to the mechanical behavior of materials using the microstructural features approach.
2. Present tools for experimental characterization of mechanical properties and microstructural features of materials. Additionally, discuss the Finite Element Methods as tool regarding the microscale level analysis.
3. Introduce Machine Learning main concepts and their application to design mechanical behavior of materials.

JUSTIFICATIVA:
Mechanical behavior of materials and its relationship with the mechanical properties and microstructural features is part important of the multiscale analysis. To conduct a deterministic development of design and performance of materials in different applications, ranging from structural to electronic can be improved using this relationship. Machine learning approach of the microstructural and damage features data is a new and an additional tool that allows a more precise evaluation mechanical behavior of materials, based on microscale level.

CONTEÚDO (EMENTA):
Different methodologies can be used to characterize microstructural features of the materials, which are straightly related to the mechanical behavior. Microscopy techniques and other techniques such as X-ray diffraction are used in the materials characterization and they are becoming more important and used in the mechanical sciences as well. In addition, the effects of stress-strain on the materials with the temperature and strain rate have also to be highlighted considering the mechanical behavior. The material's microstructure and mechanisms of failure characterization can be used as inputs in the machine learning approach to support the prediction as a tool for designing of materials for mechanical behavior.

The main objectives of this course are as follows:

1. Review and point out the most relevant parameters in the mechanical behavior of materials: stress-strain constitutive equations, workhardening, effect of strain rate, temperature, state of stress, time dependent and independent deformation and failure, effect of static and dynamic loads, effect of discontinuities (flaws, porosity and cracks) – fracture mechanics, wear and corrosion regarding the microstructural features.
2. Present tools for experimental characterization of mechanical properties and microstructural features of materials. Surface features characterization will also be also emphasized and its relevance on failure mechanisms evaluations. Additionally, Finite examples of Element Methods approach will be present considering the microscale, conducting a deterministic evaluation of mechanical behavior of materials.
3. Introduce Machine Learning main concepts. These concepts will put together with data of mechanical properties, damage models and microstructural features making it possible improve performance and design of materials, based on microstructural level.

BIBLIOGRAFIA:

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2. Marsland, S.- Machine Learning: An Algorithmic Perspective, Second Edition (Chapman & Hall/Crc Machine Learning & Pattern Recognition), 2014.
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3. MEYERS, M. A. e CHAWLA, K. K. - Mechanical Behavior of Materials, Cambridge University Press, 2009.
4. ABBASCHIAN, R., REED-HILL, R. E. - Physical Metallurgy Principles 4th Edition, Cengage Learning, 2009, 750p.
5. ANDRESON, T.L. Fracture Mechanics: Fundamentals and Applications, Third Edition, CRC Press, 2005, 640 p.
6. DIETER, G. E. - Mechanical Metallurgy, McGraw Hill Book Company , 1988.
7. HASLACH, H. W.; ARMSTRONG, R.W. Deformable Bodies and Their Material Behavior. USA: John Wiley & Sons. 2004, 531p.
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12. ·MITCHELL, T., Machine Learning, McGraw-Hill, 1997.
13. ·HASTIE, T; TIBSHIRANI, R.; FRIEDMAN, J. The Elements of Statistical Learning, 2nd edition, Springer-Verlag, 2009.

CRITÉRIOS DE AVALIAÇÃO:
Test in the end of course, seminars and homework assignments.

OBSERVAÇÕES:

This course proposal approach was based on the course PMR5001 - Comportamento Mecânico dos Materiais – in which the mechanical behavior and microstructure relationship were discussed. The Assessment of Mechanical Behavior of Materials using Machine Learning Approach course will emphasize the same aspects using different tools and complementary analysis to reach a modern view of design of materials. This course will be given in English.