Alessandro Tognan

MSc (Mechanical Engineering)

Current Position

Nov 2020 – present   **PhD Candidate.** *University of Udine, Udine, 33100, Italy.*
PhD Programme. Industrial and Information Engineering (XXXVI Cycle).
Scientific sector (SSD). ING-IND/14 – Progettazione Meccanica e Costruzione di Macchine.
Areas of Interest. Residual stress evaluation, fatigue life prediction, fatigue endurance limit estimation, Machine Learning.

Teaching Experience

Nov – Dec 2017   **Fundamentals of Computer Aided Design (CAD).**
Employer. F.A.T.A. S.c.a.r.l.
Details. 24-hour course held at Losco Frigoassistance (formerly, F.lli Losco S.n.c.), Porpetto, 33050, Udine, Italy. I delivered a series of lectures on CAD 2D drafting & 3D modelling.

Education

Feb – May 2023   **PhD Visiting Period.** *Delft Centre of System and Control (DCSC), Delft University of Technology (TU Delft), Delft, 2628, The Netherlands.*
Research activity. Development and implementation of a Bayesian Physics-guided Neural Network for predicting the fatigue behaviour of metallic alloys.

10-14 Oct 2022   **CISM-ECCOMAS Summer School on "Data-Driven Mechanics: Constitutive Model-Free Approach".** *International Centre for Mechanical Sciences, Udine, 33100, Italy.*

27 July 2022   **Italian Engineering professional title (Abilitazione alla professione di ingegnere).**
Area. Industrial engineering.
Sector. Mechanical Engineering.

Mar – June 2022   **Course on English for Academic Purposes.** *Language centre of the University of Udine, Udine, 33100, Italy.*

Nov 2021 – Jan 2022   **B2 English Course.** *Language centre of the University of Udine, Udine, 33100, Italy.*

13-14 Dec 2021   **Euromech Colloquium 618 on "Uncertainty Quantification in Computational Mechanics".** *Virtual event.*

Feb – May 2021   **B1 Advanced English Course.** *Language centre of the University of Udine, Udine, 33100, Italy.*

14-17 June 2021	**PhD Summer School AIAS on "Advances in Biomechanics".** *Società Scientifica Italiana di Progettazione Meccanica e Costruzione di Macchine (AIAS). Virtual event.*
12-16 Apr 2021	**CISM-UniUD Joint Advanced Webinar on "Optimization of Shape and Material Properties: Advanced Mathematical Methods and 3D Printing".** *International Centre for Mechanical Sciences (CISM), Udine, 33100, Italy. Virtual event.*
2017 – 2020	**MSc in Mechanical Engineering.** *University of Udine, Udine, 33100, Italy.* **Principal subjects.** Computational Mechanics, Calculus of Variations, Optimisation, System & Control Theory. **Thesis.** Identification and Control of a Rolling Process for Circularly Shaped Bars (Original title: "Identificazione e Controllo di un Processo di Laminazione per Barre a Sezione Circolare"). **Mark.** 110/110 *cum laude.*
2013 – 2017	**BSc in Mechanical Engineering.** *University of Udine, Udine, 33100, Italy.* **Principal subjects.** Traditional Calculus and Physics, Classic Mechanics, Continuum Mechanics, Material Science, Manufacturing Processes, Computer Aided Design. **Thesis.** Kinematic Analysis of a Sail Boat During the Regatta's Lineup Stage Using Matlab, and C-implementation of the Computational Algorithm, in the Context of the UniUD Sailing Lab Project (Original title: "Analisi cinematica dell'allineamento di regata in Matlab ed implementazione dell'algoritmo in C nell'ambito dell'UniUD Sailing Lab"). **Mark.** 108/110.

Languages

Italian	Mother tongue.
English	Spoken and listening: *independent user.* Written and reading: *independent user.*

Computer skills

Finite Elements	FEniCS, Gmsh, code aster, Paraview, Ansys.
Computer Aided Desing	Autodesk Inventor & Autocad, Solidworks, FreeCAD.
Programming Languages	Python, Matlab, C.
Markup Languages	LaTeX, Markdown, rST.
Control Version System	Git.
Operating Systems	Linux, Microsoft Windows.
Office Automation	Common word processors and spreadsheets.

Scientific Interests

Solid Mechanics	o Residual stress
	o Finite fatigue life of metallic alloys
	o Fatigue endurance limit of metallic alloys
	o Fracture Mechanics
Computational Mechanics	o Finite Element Method
	o Phase Field
Machine Learning	o Gaussian Process Regression
	o Maximum a Posteriori Estimation
	o Logistic Regression
	o Neural Networks
	o Physics Informed Neural Networks
	o Bayesian Neural Networks
	o Bayesian Physics-Guided Neural Networks

Personal Statement

Throughout my doctoral studies, I have been conducting research at the intersection of Solid Mechanics and Computer Science. In particular, I harnessed diverse Machine Learning to evaluate residual stress and assess fatigue performance. Such interdisciplinary research allowed me to garner an insightful understanding of the examined phenomena and gain relevant modelling expertise. A synopsis is given in the following.

I have considerable experience in utilising FEniCS and many low-level interface functions thereof. In this regard, I extensively worked with FEniCS to establish an optimised Gaussian Process Regression framework for the Finite Element back-calculation of residual stress involved in the Contour Method.

I have a background in Calculus of Variations regarding the weak formulations of Continuum Mechanics problems, Phase Field, and Fracture Mechanics. In this respect, I contributed to a project aimed at simulating the evolution of cracks in residually stressed brittle materials using the Phase Field method.

I have become proficient in fatigue modelling and prediction using Machine Learning techniques while prioritising physics-informed/guided approaches over mere data-driven methods. With particular regard to metallic alloys, I implemented a Physics-informed Neural Network for the prediction of the finite fatigue life and a Bayesian Physics-guided Neural Network for the estimation of the fatigue endurance limit. In both cases, I effectively constrained their training stage by semi-empirical laws of Fracture Mechanics with the aim of attaining superior, robust, physically consistent predictions.

Below is an overview of my publications, where I conveyed the proposed methods and related findings. Following, I summarise my contribution at both international and national conferences, where I actively disseminated my work.

Publications

[1] Alessandro Tognan, Andrea Patanè, Luca Laurenti and Enrico Salvati. "A Bayesian defect-based physics-guided neural network model for probabilistic fatigue endurance limit evaluation". In: *Computer Methods in Applied Mechanics and Engineering* 418 (Jan. 2024), p. 116521. DOI: 10.1016/j.cma.2023.116521.

[2] Emanuele Avoledo, Alessandro Tognan and Enrico Salvati. "Quantification of uncertainty in a defect-based Physics-Informed Neural Network for fatigue evaluation and insights on influencing factors". In: *Engineering Fracture Mechanics* (Sept. 2023), p. 109595. DOI: 10.1016/j.engfracmech.2023.109595.

[3] Alessandro Tognan and Enrico Salvati. "Probabilistic defect-based modelling of fatigue strength for incomplete datasets assisted by literature data". In: *International Journal of Fatigue* (Apr. 2023), p. 107665. DOI: 10.1016/j.ijfatigue.2023.107665.

[4] Enrico Salvati, Alessandro Tognan, Luca Laurenti, Marco Pelegatti and Francesco De Bona. "A defect-based physics-informed machine learning framework for fatigue finite life prediction in additive manufacturing". In: *Materials & Design* 222 (Oct. 2022), p. 111089. DOI: 10.1016/j.matdes.2022.111089.

[5] Alessandro Tognan, Luca Laurenti and Enrico Salvati. "Contour Method with Uncertainty Quantification: A Robust and Optimised Framework via Gaussian Process Regression". In: *Experimental Mechanics* (Apr. 2022). DOI: 10.1007/s11340-022-00842-w.

[6] Alessandro Tognan, Lise Sandnes, Giovanni Totis, Marco Sortino, Filippo Berto, Øystein Grong and Enrico Salvati. "Evaluation and Origin of Residual Stress in Hybrid Metal and Extrusion Bonding and Comparison with Friction Stir Welding". In: *International Journal of Mechanical Sciences* 218 (Mar. 2022), p. 107089. DOI: 10.1016/j.ijmecsci.2022.107089.

[7] Enrico Salvati, Francesco Menegatti, Manish Kumar, Marco Pelegatti and Alessandro Tognan. "On the significance of diffuse crack width self-evolution in the phase-field model for residually stressed brittle materials". In: *Material Design & Processing Communications* (July 2021). DOI: 10.1002/mdp2.261.

Talks at Conferences

6-9 Sept 2023	**52nd AIAS National Conference.** *University of Genova, Genova, Italy.* **Organiser.** Società Scientifica Italiana di Progettazione Meccanica e Costruzione di Macchine (AIAS). **Presented work.** Defect-based Bayesian Physics-informed Neural Networks for estimating the fatigue endurance limit (Original title: "Physics-Informed Neural Networks Bayesiane per l'Inferenza Statistica della Fatica a Vita Infinita a Partire dall'Analisi dei Difetti").
22-24 Feb 2023	**27th International Conference of Fracture and Structural Integrity.** *La Sapienza – University of Rome, Rome, Italy.* **Organiser.** Italian Group of Fracture (IGF). **Presented work.** Machine Learning Identification of El Haddad Curves via Logistic Regression and Maximum a Posteriori Estimation.

7-10 Sept 2022 **51th AIAS National Conference.** *University of Padua, Padua, Italy.*
Organiser. Società Scientifica Italiana di Progettazione Meccanica e Costruzione di Macchine (AIAS).
Presented work. Recent Advancements of the Contour Method: Uncertainty Quantification via Gaussian Process Regression (Original title: "Sviluppi Recenti del Contour Method: Quantificazione dell'Incertezza Mediante Gaussian Process Regression").

13-16 June 2022 **SEM 2022 – Annual Conference & Exposition on Experimental and Applied Mechanics.** *Pittsburgh (PA), USA.*
Organiser. Society for Experimental Mechanics (SEM).
Presented work. Contour Method with Uncertainty Quantification: A Robust and Optimised Framework via Gaussian Process Regression".

7-9 Sept 2021 **BSSM 2021 – 15th International Conference on Advances in Experimental Mechanics.** *Virtual event.*
Organiser. The British Society for Strain Measurement (BSSM).
Presented work. Contour Method Residual Stress Uncertainty Evaluation and Sensitivity Analysis: A Friction Stir Welded Plate Case-Study.

Awards

15 June 2022 **Oustanding Presentation.** *SEM 2022.*
Awarded presentation. Contour Method with Uncertainty Quantification: A Robust And Optimised Framework via Gaussian Process Regression.

Co-supervised Theses

Nov 2020 – Mar 2021 **MSc Thesis. "Numerical Analysis of the Thermo-mechanical Behaviour in a Dissimilar Weld".** *University of Udine, Udine, 33100, Italy.*

Aug 2022 – Mar 2023 **MSc Thesis. "Sensitivity and uncertainty analysis of a PINN model for the evaluation of fatigue life of additively manufactured metallic materials".** *University of Udine, Udine, 33100, Italy.*

Journal Roles

Peer Reviewer
○ Experimental Mechanics
○ Materials Today Communications
○ Forces in Mechanics