FACULTY OF ENGINEERING AND ARCHITECTURE

FINITE ELEMENT MODELLING RESEARCH GROUP (FEMRG)

Laboratory Soete, Faculty of Engineering and Architecture, Ghent University

http://www.finiteelementresearch.ugent.be/

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Staff

Head of Research Group:

Prof. dr. ir. Magd Abdel Wahab

Current Researchers:

Yong Ling, Samir Khatir, Dang Bao Loi, Hoa Tran, Ho Viet Long, Chao Li, Nguyen Ngoc Lan, Minh Hoang Le, Thanh Sang To, Irfan Shirazi, Muhammad Imran, Can Wang, Hussein Zahran, Yifei Li, Kaifa Fan, Acar Kocabicak

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Investigate the effect of heterogeneity of material on fretting fatigue problem with numerical modeling

Keywords: fretting fatigue, heterogeneity, critical plane method, finite element model

Promoter: Prof. Magd Abdel Wahab

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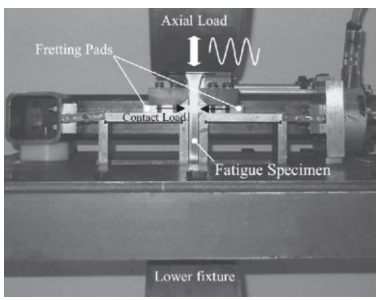
Student: Can Wang



Sketch of Fretting Fatigue Experiment Setup

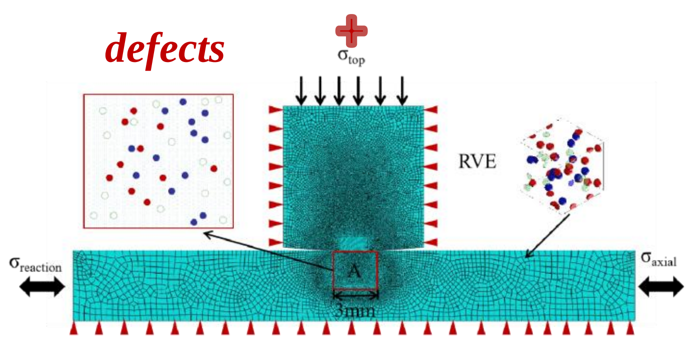
$$FP = \frac{\Delta\tau_{max}}{2} + k_1\sigma_n^{max}$$

$$FP = \tau_f^{'}\,(2N_i)^b$$

$$FS = \frac{\Delta\gamma_{max}}{2}\left(1 + k_2\frac{\sigma_n^{max}}{\sigma_y}\right) = \frac{\tau_f^{'}}{G}(2N_i)^{b^{'}} + \gamma_f^{'}\,(2N_i)^{c^{'}}$$

Critical Plane Method

N_i - Crack initiation lifetime



$N_{i\text{-numerical}}$

?

$N_{i\text{-experimental}}$

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Ali Merati et al, https//doi:10.1016/j.ijfatigue.2004.06.010

Can Wang et al, https://doi.org/10.1016/j.triboint.2022.107470

Finite element study of fretting wear of steel wires

Keywords: fretting fatigue, heterogeneity, critical plane method, finite element model

Promoter: Prof. Magd Abdel Wahab

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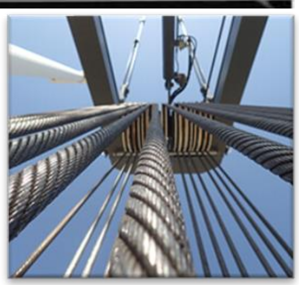
Student: Muhammad Imran

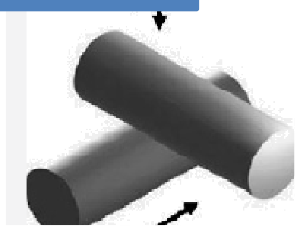
Objective

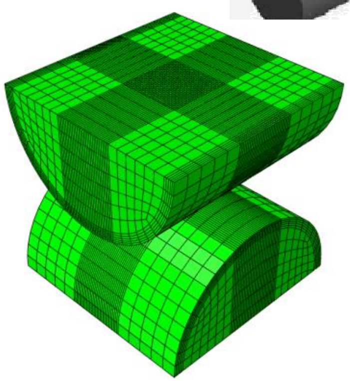


Applications

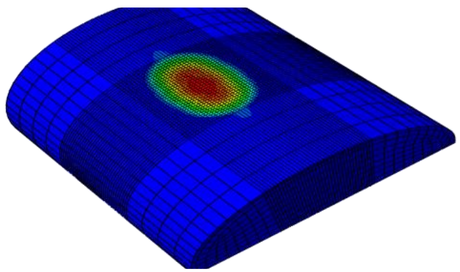
Fretting Wear of Steel Wires

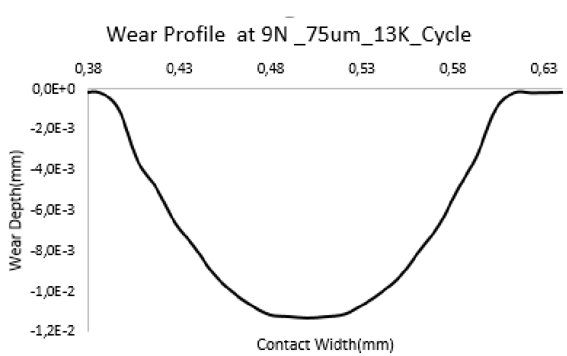
Methods





Tasks





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Damage assessment for bridges using artificial neural network

Keywords: Structural Health Monitoring, Bridges, Artificial Neural Network

Promoter: Prof. Magd Abdel Wahab

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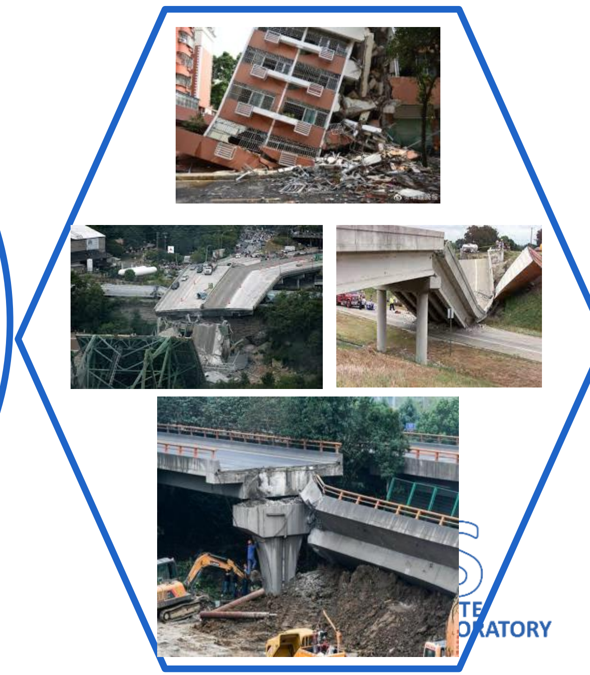
Student: Hoa Tran



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ANN prediction model for composite pipes against low velocity impact loads using finite element analysis

Keywords: FEM, Artificial Neural Network, Prediction model, Composite pipe

Promoter: Prof. Magd Abdel Wahab

Post-doc: Samir Khatir

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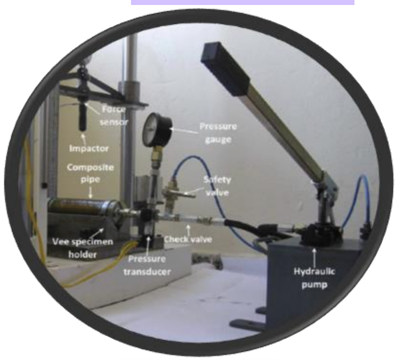
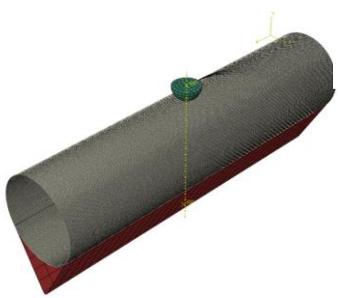
Objective 1



Low velocity impact test

Objective 2



Validation using FEM

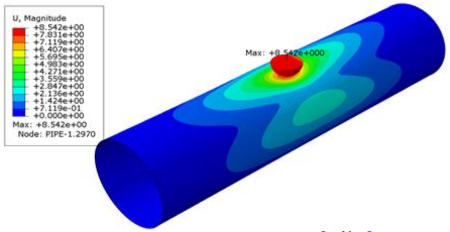
SIMULIA ABAQUS

Objective 3

Data collected from FEM

Objective 4

Fast prediction model



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Development of the simulation platform for WAAM processing

Keywords: Simulation, WAAM, FEM

Promoter: Prof. Magd Abdel Wahab

Post-doc: Yong Ling

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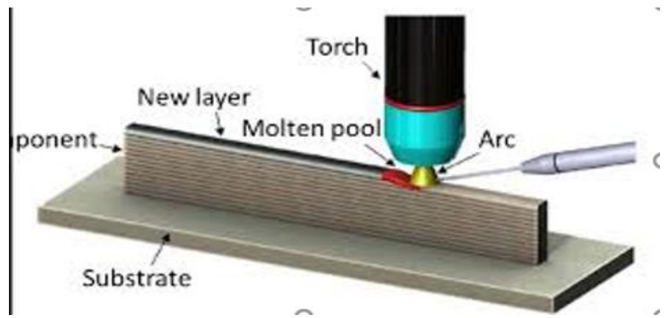
Objective:

- Build the platform is for WAAM parameters inputs.
- Connect Abaqus, Matlab, Python and Fortran subroutines



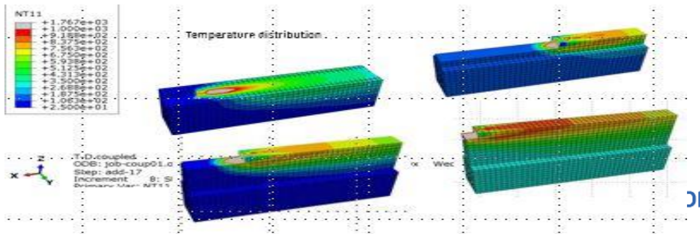
Method: T-M-M FEA by Abaqus, Matlab and subroutines.

Tasks:

* develop the platform by using **.NET**.

* simulate WAAM process for the experiment part

* validate the thermo- mechanical modelling.



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Modeling multiaxial fatigue behavior of nuclear materials

Keywords: Fatigue, FEM, Nuclear materials

Promoter: Prof. Magd Abdel Wahab

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Student: Hussein Zahran

Method

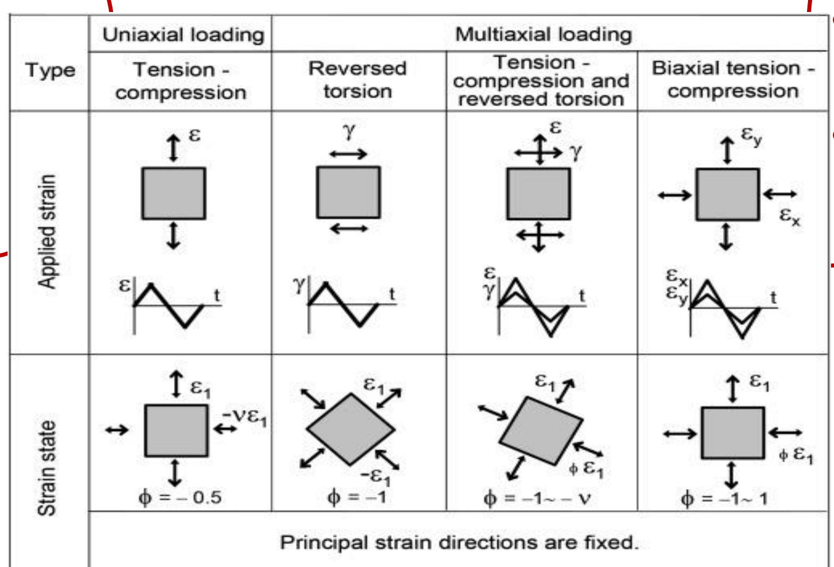
- Update an existing MATLAB code model to closer to application models

Objective

- Model the complex behavior of nuclear materials from multiaxial fatigue loading to plane stresses

Tasks

- Study nuclear materials fatigue behavior
- Study principle stress transformations
- Verify model with experimental results



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A surrogate-assisted stochastic optimization inversion algorithm for parameter identification of dams

Keywords: Concrete dams, Surrogate model, Stochastic optimization algorithm, Model update

Promoter: Prof. Magd Abdel Wahab

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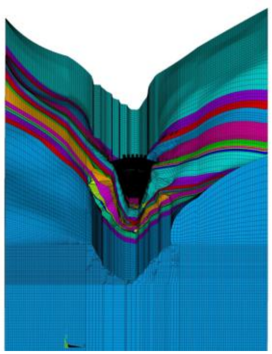
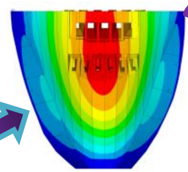
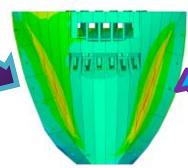
Student: Yifei. Li



High-precision FE models



Displacement field

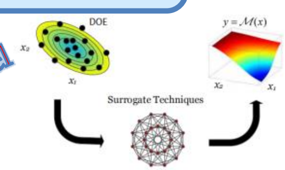


Stress field

Traditional method: call the model at least hundreds of times

sensitivity analysis
Parameter identification

Surrogate model



Extremely high computational cost

Cheap computational cost

Optimization algorithm

Model update

Surrogate modelling vs. machine learning [1]

Features	Supervised learning	Surrogate modelling
Computational model $\mathcal{M}$	✗	✔
Probabilistic model of the input $\boldsymbol{X} \sim f_{\boldsymbol{X}}$	✗	✔
Training data: $\mathcal{X} = \{(\boldsymbol{x}_i, y_i),\ i = 1, \dots, n\}$	✔ Training data set (big data)	✔ Experimental design (small data)
Prediction goal: for a new $\boldsymbol{x} \notin \mathcal{X}$, $y(\boldsymbol{x})$?	$\sum_{i=1}^{m} y_i K(\boldsymbol{x}_i, \boldsymbol{x}) + b$	$\sum_{\alpha \in \mathcal{A}} y_\alpha \Psi_\alpha(\boldsymbol{x})$
Validation (resp. cross-validation)	✔ Validation set	✔ Leave-one-out CV

$$Err_{LOO} = \frac{\sum_{i=1}^{N} \left(\mathcal{M}\left(\boldsymbol{x}^{(i)}\right) - \mathcal{M}^{meta \backslash i}\left(\boldsymbol{x}^{(i)}\right)\right)^2}{\sum_{i=1}^{N} \left(\mathcal{M}\left(\boldsymbol{x}^{(i)}\right) - \hat{\mu}_Y\right)^2}$$

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[1] Sudret, B. Surrogate models for forward and inverse uncertainty quantification, International Research Training Group "Modern Inverse Problems", RWTH Aachen University (Germany), January 11th, 2021.

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Numerical Simulation of Fretting Fatigue Behaviours of Titanium Alloy Treated by Ultrasonic Surface Rolling Process

Keywords: fretting fatigue, ultrasonic surface rolling, compressive residual stress, finite element Method

Promoter: Prof. Magd Abdel Wahab

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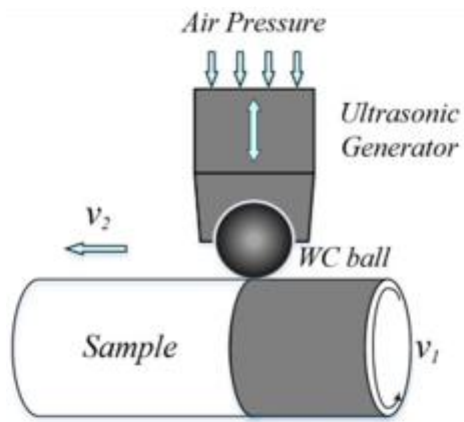
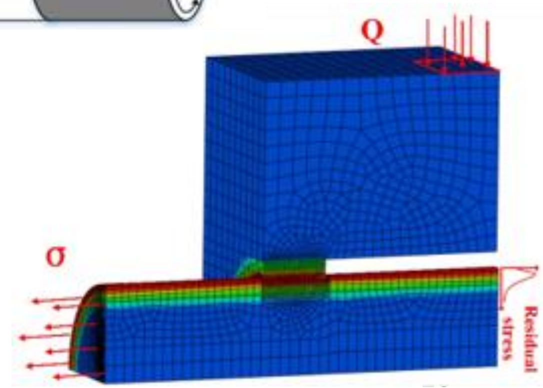
Student: Kaifa Fan



Objectives: USRP can introduce compressive residual stress (CRS), surface hardening, grain refinement to the surface of titanium alloy, which are beneficial to improve the fretting fatigue (FF) resistance.

Methods: Finite element methods are effective in predicting the FF life combined with critical plane model (CP) or continuum damage model (CDM).



Task: Investigate the effect of USRP on FF behaviors and predict the FF life under various working conditions.

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Vibration-based SHM in steel bridge using artificial intelligence

Keywords: Vibration, structural health monitoring (SHM), artificial intelligence

Promoter: Prof. Magd Abdel Wahab

Student: Ho Viet Long

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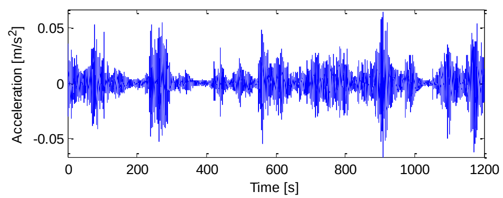
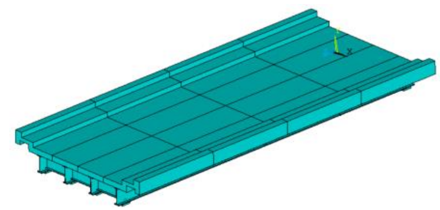
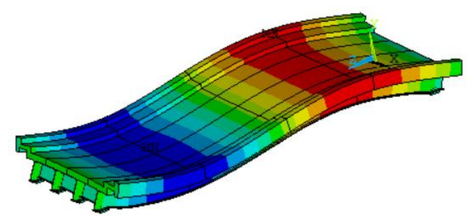
In-situ investigation of the observed bridge



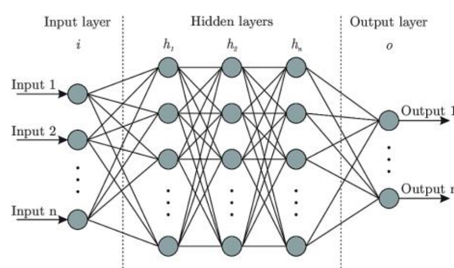
Vibration measurement under ambient load using accelerometers



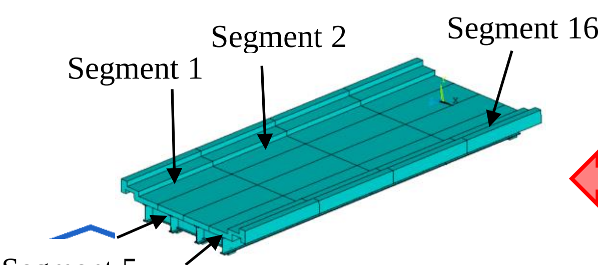
Building FE baseline model via model updating



Extracting modal properties (frequencies, mode shapes) from the baseline model



Optimizing ANN's structure for damage detection using a stochastic optimization process



Estimating damage based on the future modal properties

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Finite element study of fretting wear properties between Unsm-treated and as-printed alloy 718

Keywords: UNSM process, FEM, fretting wear

Promoter: Prof. Magd Abdel Wahab

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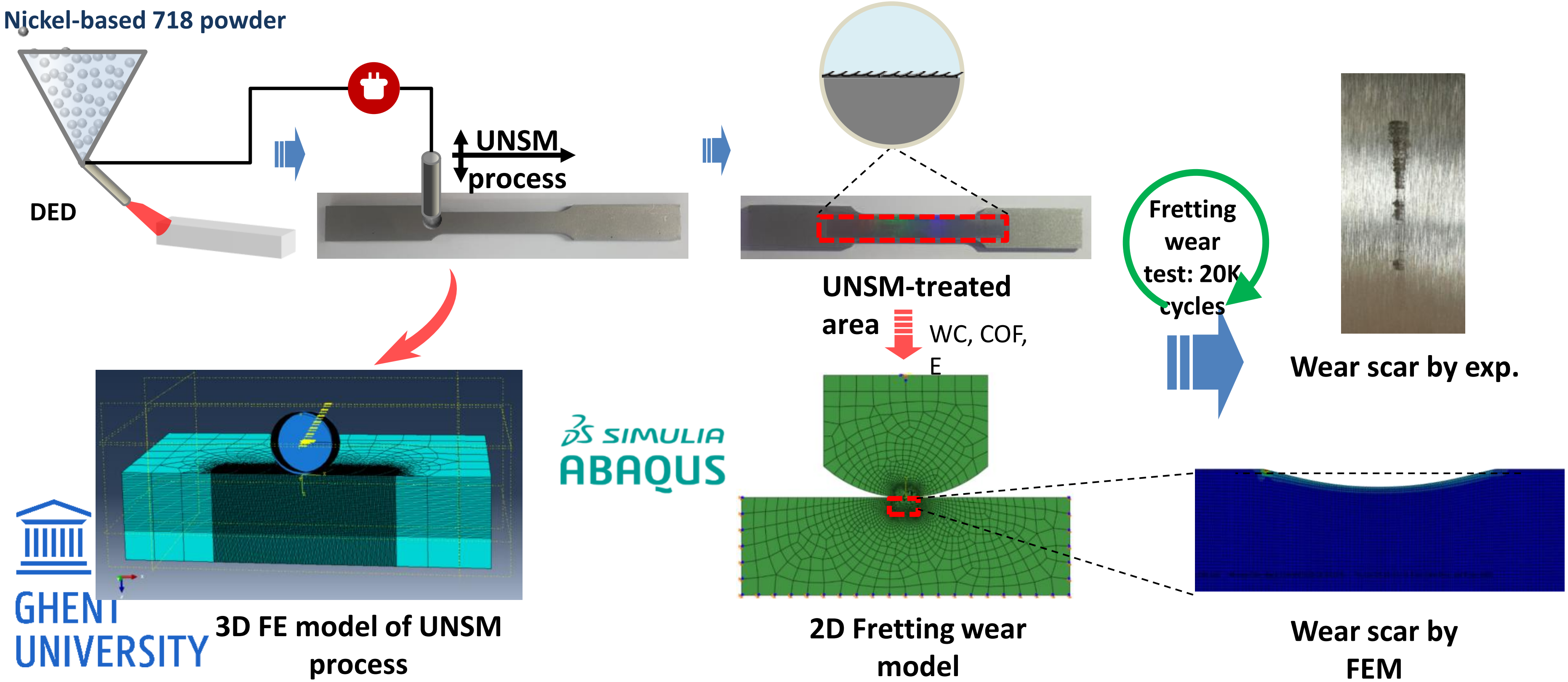
Student: Chao Li



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Predicting lateral displacement of retaining wall for underground structures

Keywords: Lateral displacement, optimization, underground structures

Promoter: Prof. Magd Abdel Wahab

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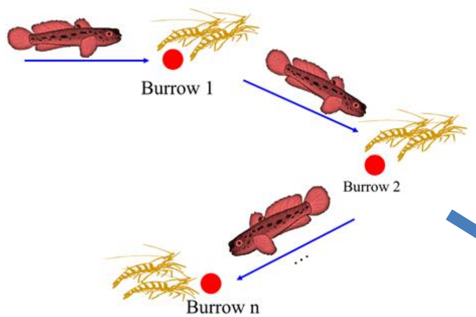
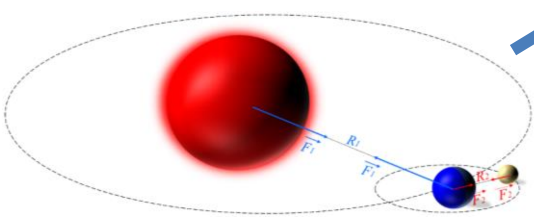
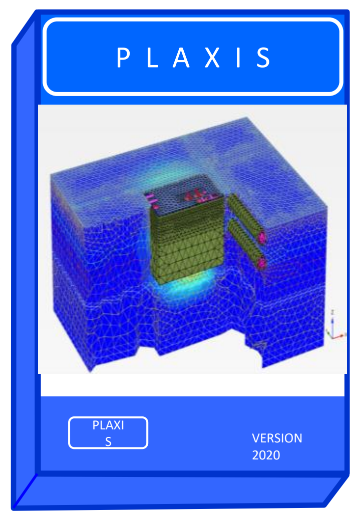
Student: Thanh Sang To



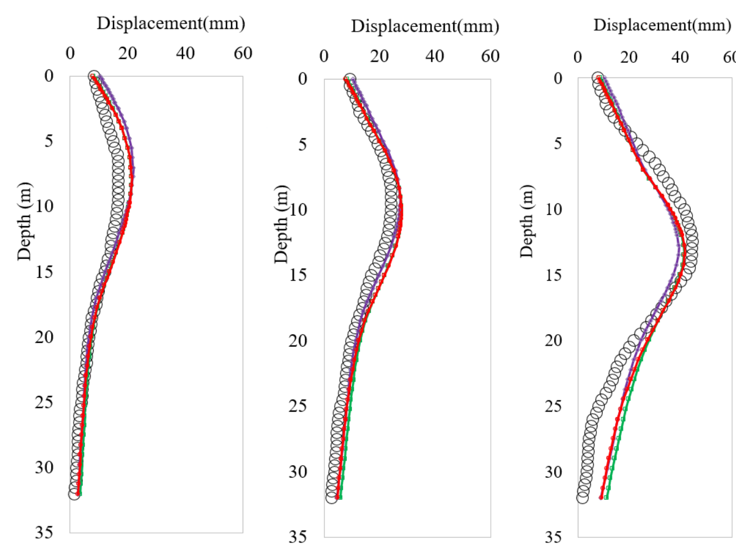
Nature-Inspired Algorithm



Physics-inspired Algorithm



Nonlinear Analyses



Predicting Lateral displacement Retaining Wall

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Applications of novel bio-inspired metaheuristic algorithms on damage assessment of Chuong Duong truss bridge

Keywords: Structural Health Monitoring, optimization, damage assessment

Promoter: Prof. Magd Abdel Wahab

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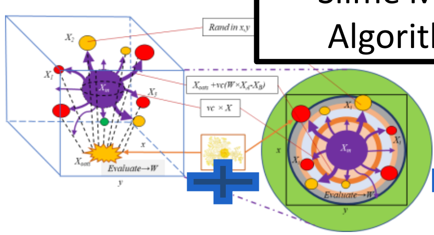
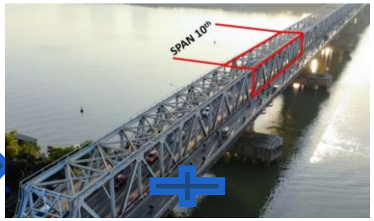
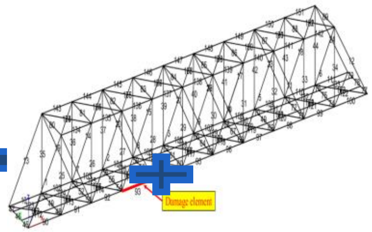
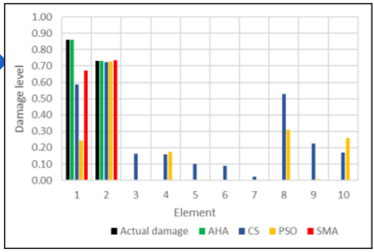
Student: Nguyen Ngoc Lan

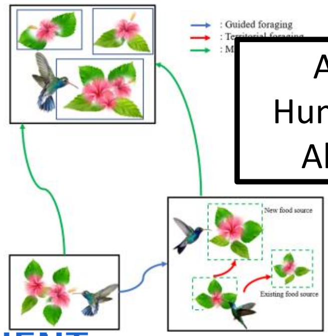
Slime Mold Algorithm



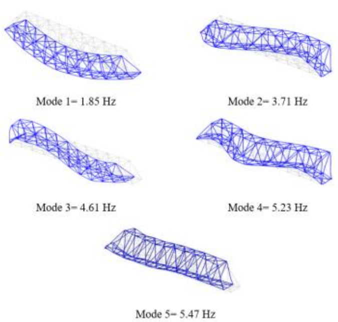


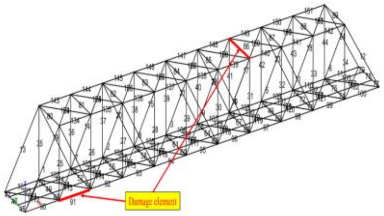






Artificial Hummingbird Algorithm





Application of novel Bio-inspired metaheuristic algorithms

Vibration Measurement + Model updating of Chuong Duong truss bridge

Single and multiple damage scenarios to validate damage detection method

Optimal damage detection capability of proposed methods are proven versus traditional optimization algorithms

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Damage Assessment in Laminated Composite Plates using Model Strain Energy and YUKI-ANN algorithm

Keywords: Artificial Neural Network, Modal Strain Energy, YUKI algorithm, Damage in laminated composite plates

Promoter: Prof. Magd Abdel Wahab

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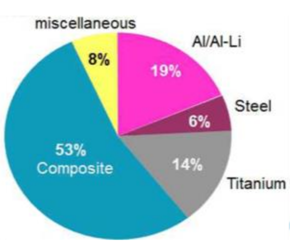
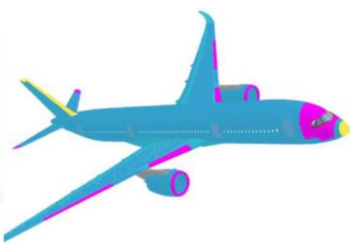
Student: Irfan Shirazi

Composite plates are now widely used in aerospace, naval and military applications

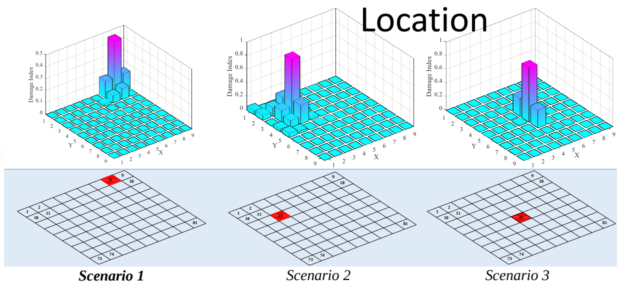
Structural health monitoring of these structures is crucial to detect presence and location of damage and compute damage severity

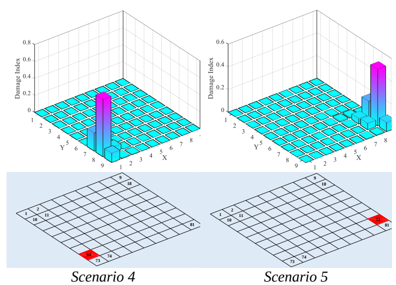




Source: Bachmann et al. Science China Technological Sciences. 60, 2017

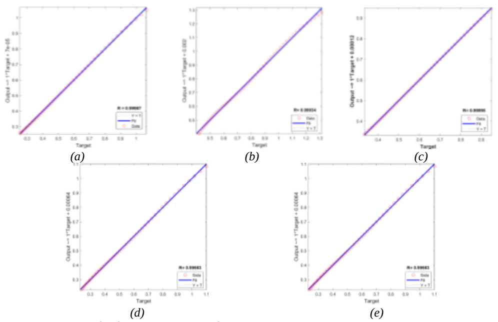
Damage Location





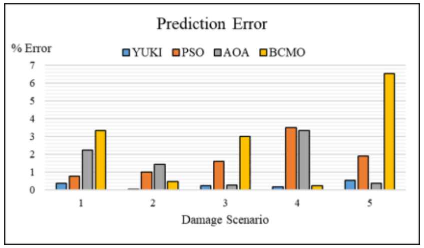
Identification of damage location for different damage scenarios using FEM-MSEcr.

Damage Quantification



Regression fits for YUKI algorithm for (a) Scenario 1, (b) Scenario 2, (c) Scenario 3, (d) Scenario 4 and (e) Scenario 5

Damage indices for different optimization techniques compared with YUKI algorithm



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An efficient approach for simulation of wave interaction with porous structure using combined VARANS-VOF equations and GBDT method

Keywords: VARANS-VOF, gradient boosting decision trees, machine learning

Promoter: Prof. Magd Abdel Wahab

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Student: Dang Bao Loi

Introduction

To analyze interaction between sea wave and porous coastal structures

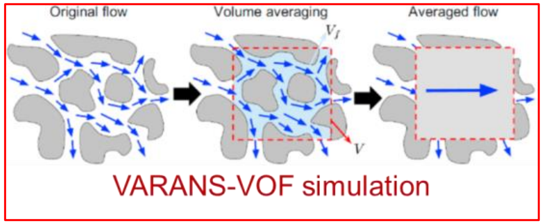
⇨ *different approaches*

Objectives

Determine appropriate empirical coefficients of VARANS-VOF equation to establish effective numerical model:

- Time-efficient
- High accuracy

Methodology



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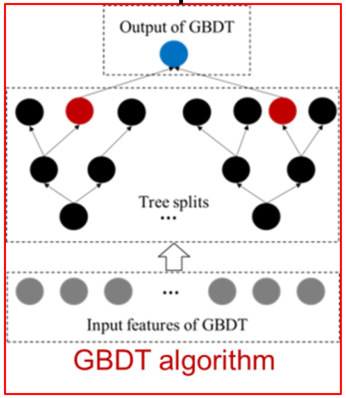
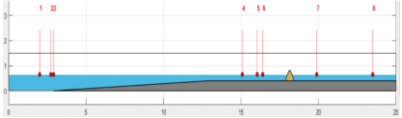
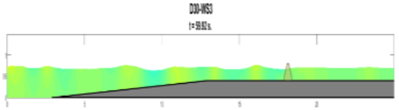


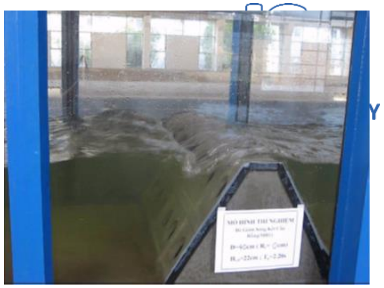


In this study, VARANS-VOF equations is used for CFD simulations



Tasks

- Conduct and validate numerical model
- Generate dataset
- Develop prediction model
- Compare numerical and experimental results



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Fatigue and fracture investigation of flow forming process

Keywords: Flow forming, fatigue, fracture

Promoter: Prof. Magd Abdel Wahab

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Student: Acar Kocabicak

Objectives

- The effect of the flow forming process on the fatigue life will be investigated.
- Obtaining accurate results via FEM techniques to validate the process.
- The difference between starting material and flow formed tubes properties will be compared

Methods

- FORGE NxT FEM software will be used in order to examine flow forming process
- Material properties such as tensile strength, micro-structure analysis will be applied before and after flow forming process.
- Torsional fatigue test system (Sincotec – power swing) will be carried out for the preform and flow formed tubes.

Tasks

- Fatigue life of the flow formed tube will be investigated
- The obtained FEM results will be compared with experimental studies in order to validate the model.
- Material properties such as tensile test, micro structure will be applied to starting material (preform) and flow formed samples.

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DAMAGE IDENTIFICATION IN LARGE-SCALE STRUCTURES USING NEW METAHEURISTIC OPTIMIZATION ALGORITHMS

Keywords: Optimization algorithms, damage detection, model updating

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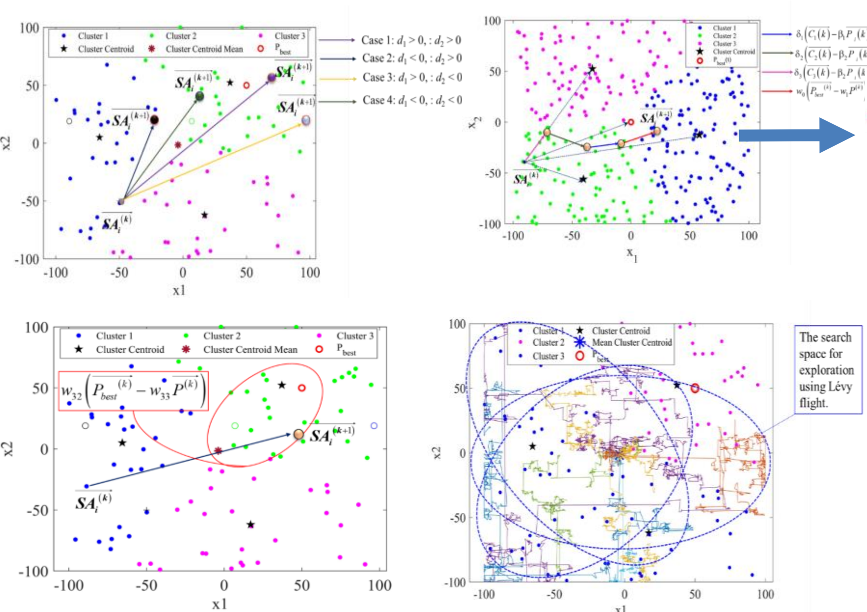
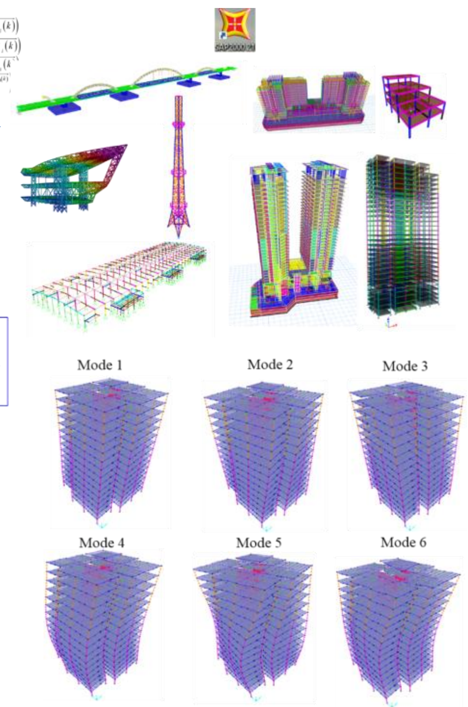
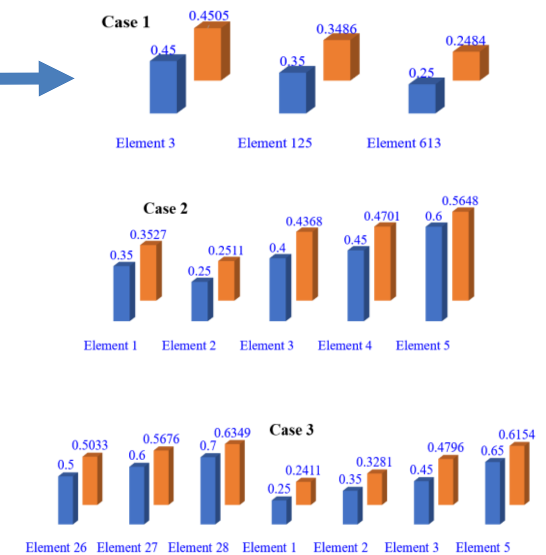


K-means clustering optimizer



Finite element model updating



Damage identification

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