Predicting Maximum Deflection of N-Edged Thin-Shelled Hyperbolic-Paraboloid Umbrella Using Machine Learning Techniques
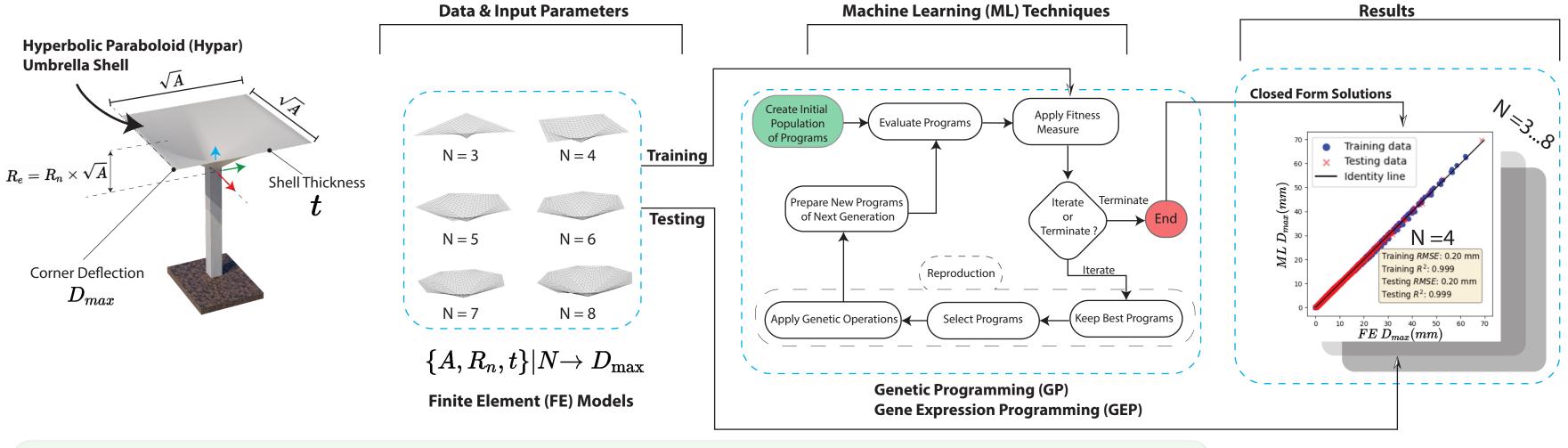
Hyperbolic Paraboloid (Hypar) Umbrella Shell

$\sqrt{A}$

$\sqrt{A}$

$R_e = R_n \times \sqrt{A}$

Shell Thickness t

Corner Deflection D_{max}

Data & Input Parameters

N = 3   N = 4

N = 5   N = 6

N = 7   N = 8

Training

Testing

$\{A, R_n, t\} | N \rightarrow D_{\max}$

Finite Element (FE) Models

Machine Learning (ML) Techniques

Create Initial Population of Programs

Evaluate Programs

Apply Fitness Measure

Prepare New Programs of Next Generation

Iterate or Terminate ?

Terminate

End

Reproduction

Iterate

Apply Genetic Operations

Select Programs

Keep Best Programs

Genetic Programming (GP)
Gene Expression Programming (GEP)

Results

Closed Form Solutions

N = 3...8

- Training data
- Testing data
- Identity line

$ML\ D_{max}(mm)$

$FE\ D_{max}(mm)$

N = 4

Training *RMSE*: 0.20 mm
Training R^2: 0.999
Testing *RMSE*: 0.20 mm
Testing R^2: 0.999

Summary:
- No closed-form solution exists for predicting the maximum deflection of hypar umbrella forms, crucial for conceptual design.
- Machine learning techniques successfully parameterized, with high accuracy, the maximum deflection of N-edged hypar umbrellas.