无锡太湖学院物联网工程学院面试汇报

汇报人：张辉耀

汇报时间：2022 年 4 月 24 号

教育背景

- 本科　大连工业大学
- 硕士　上海东华大学
  - 专业：数字化纺织工程
  - 研究内容：椭圆傅立叶和凸包算法在人体建模的应用
- 博士　日本京都工艺纤维大学
  - 专业：先端纤维学
  - 研究内容：遗传算法和神经网络在材料科学的应用

研究契机

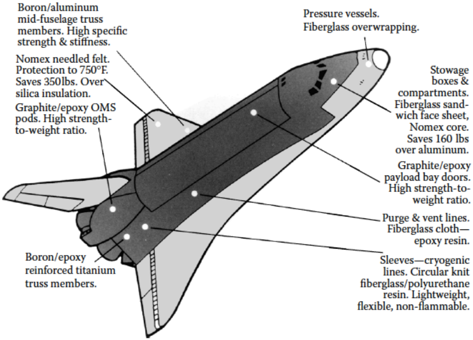

Figure 1: 层合材料的应用一 (Graphic courtesy of M.C. Gill Corporation, http://www.mcgillcorp.com.)

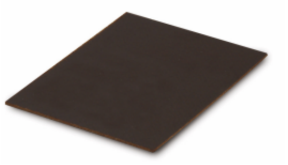

Figure 2: 层合材料的应用二 (https://www.thegillcorp.com)

什么是层合材料?

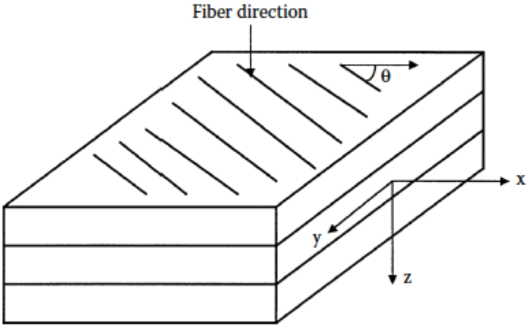

Figure 3: 层合材料结构图 (**来源**: Autar k. kaw 2006)

怎样设计?

- 目标：强度
- 约束条件：重量，成本等
- 变量：铺层角度，铺层数，材料等

- 1. **构造目标函数** $f(x)$.
- 2. **为满足约束条件，添加惩罚项** $\phi_1(x), \phi_2(x), \cdots, \phi_n(x)$
- 3. **重新构造目标函数** $f(x)+c_1\phi_1(x)+c_2\phi_2(x)+\cdots+c_n\phi_n(x)$

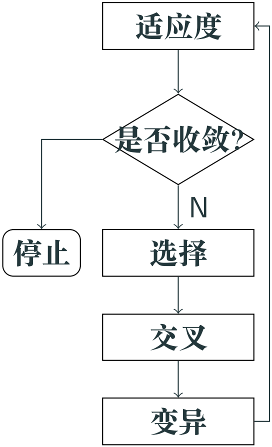

Figure 4: 遗传算法流程图

研究方法

- 1. **构造目标函数** $f(x)$.
- 2. **为满足约束条件，在群体中维护不同的子群**
- 3. **不改变目标函数** $f(x)$.

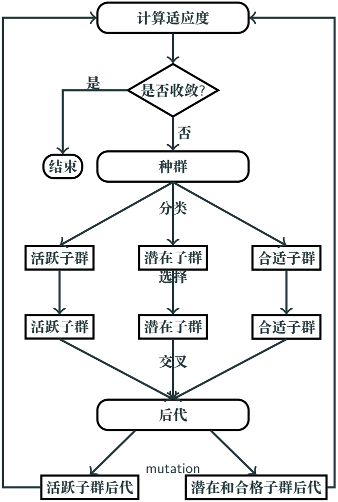

Figure 5: General flowchart of proposed GA model.

定义

- 活跃个体：如果一个个体的约束值远小于约束条件，那么我们称该个体为活跃个体，该个体所在的子群为活跃子群。
- 潜在个体：如果一个个体的约束值小于约束条件，那么我们称该个体为潜在个体，该个体所在的子群为潜在子群。
- 合适个体：如果一个个体的约束值满足约束条件，那么我们称该个体为合格个体，该个体所在的子群为合适子群。

研究方法

$$\mathrm{md} = [CT_1, \cdots, CT_{n-1}, CT_n] - [ICV_1, \cdots, ICV_{n-1}, ICV_n]$$

- md 表示变异向量
- CT_i 表示第 i 个约束条件，比如质量，强度等。
- ICV_i 表示当前个体的相应的约束值。

- length mutation $=$

$$\begin{cases} LMC * [0, \sum_{i=1}^{N} md_i] & \text{if } \sum_{i=1}^{N} md_i > 0 \\ LMC * [\sum_{i=1}^{N} md_i, 0] & \text{if } \sum_{i=1}^{N} md_i < 0 \end{cases}$$

LMC **表示长度变异系数。**

- $P(AM) =$

$$\begin{cases} 0.5, \text{ AM} = [0, AMC \sum_{i=1}^{N} (|CT_i - CV_i|)] \\ 0.5, \text{ AM} = [AMC \sum_{i=1}^{N} (-|CT_i - CV_i|), 0] \end{cases}$$

AMC **表示角度变异系数。**

Table 1: Comparison of experiment results of Choudhury and Mondal's and current study under in-plane loading $N_x = 1e6$ N. The results of present study is from previous experiment.

Cross Ply $[0_M/90_N]$	Choudhury and Mondal's study		Present study	
Material	Glass-Epoxy	Graphite-Epoxy	Glass-Epoxy	Graphite-Epoxy
M	68	17	76	19
N	72	18	49	2
no. of lamina(n)	140	35	125	21
SR	2.01	2.10	2.08	2.15
weight	9.10	1.84	8.12	1.10
cost	140	87.50	125	53

- Huiyao Zhang, Atsushi Yokoyama. 2021. A Technique for Constrained Optimization of Cross-ply Laminates Using a New Variant of Genetic Algorithm. International Journal of Advanced Computer Science and Applications, 12(6): 760-767.
- Huiyao Zhang, Atsushi Yokoyama. 2022. Optimum Design of Laminated Composites for Minimum Thickness by a Variant of Genetic Algorithm. Journal of Textile Engineering(accepted)

问题二：如何预测层合材料的强度?

$$\begin{bmatrix} N_x \\ N_y \\ N_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} \\ A_{12} & A_{22} & A_{26} \\ A_{16} & A_{26} & A_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_x^0 \\ \varepsilon_y^0 \\ \gamma_{xy}^0 \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{11} & B_{12} & B_{16} \\ B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{bmatrix} k_x \\ k_y \\ k_{xy} \end{bmatrix}$$

$$\begin{bmatrix} M_x \\ M_y \\ M_{xy} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{12} & B_{22} & B_{26} \\ B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_x^0 \\ \varepsilon_y^0 \\ \gamma_{xy}^0 \end{bmatrix} + \begin{bmatrix} D_{11} & D_{12} & D_{16} \\ D_{11} & D_{12} & D_{16} \\ D_{16} & D_{26} & D_{66} \end{bmatrix} \begin{bmatrix} k_x \\ k_y \\ k_{xy} \end{bmatrix}$$

$$A_{ij} = \sum_{k=1}^{n} (\overline{Q_{ij}})_k (h_k - h_{k-1}) i = 1,2,6, j = 1,2,6,$$

$$B_{ij} = \frac{1}{2} \sum_{k=1}^{n} (\overline{Q_{ij}})_k (h_k^2 - h_{k-1}^2) i = 1,2,6, j = 1,2,6,$$

$$D_{ij} = \frac{1}{3} \sum_{k=1}^{n} (\overline{Q_{ij}})_k (h_k^3 - h_{k-1}^3) i = 1,2,6, j = 1,2,6.$$

- Maximum stress failure

$$SF_{MS}^k = \min \text{ of } \begin{cases} SF_X^k = \begin{cases} \frac{X_t}{\sigma_{11}}, & \text{if } \sigma_{11} > 0 \\ \frac{X_c}{\sigma_{11}}, & \text{if } \sigma_{11} < 0 \end{cases} \\ SF_Y^k = \begin{cases} \frac{Y_t}{\sigma_{22}}, & \text{if } \sigma_{22} > 0 \\ \frac{Y_c}{\sigma_{22}}, & \text{if } \sigma_{22} < 0 \end{cases} \\ SF_S^k = \left\{ \frac{S}{|\tau_{12}|} \right. \end{cases}$$

- Tsai-wu failure theory

$$H_1\sigma_1 + H_2\sigma_2 + H_6\tau_{12} + H_{11}\sigma_1^2 + H_{22}\sigma_2^2 + H_{66}\tau_{12}^2 + 2H_{12}\sigma_1\sigma_2 < 1$$

如何设计网络的拓扑结构?

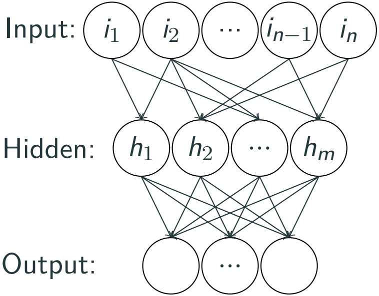

Figure 6: Neural Network Model

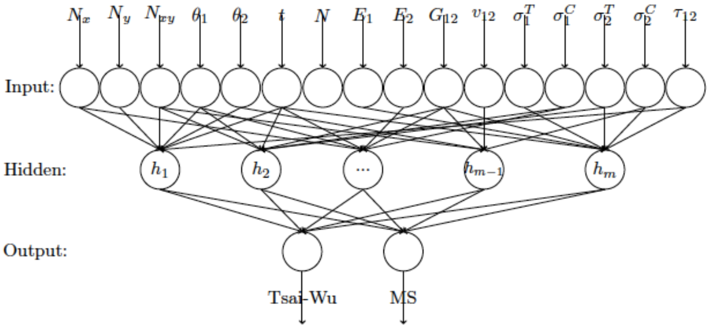

Figure 7: General neural network for prediction the strength of an angle ply laminate.

研究方法

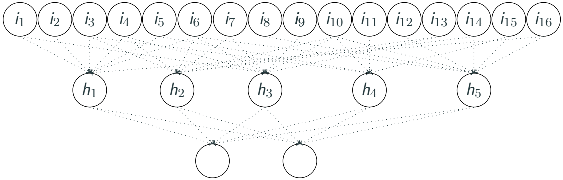

Figure 8: Example of proposed architecture.

Table 2: The binary representation of Figure 8.

Nodes	i_1	i_2	i_3	i_4	i_5	i_6	i_7	i_8	i_9	i_{10}	i_{11}	i_{12}	i_{13}	i_{14}	i_{15}	i_{16}	f	f
h_1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
h_2	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	0	1	1
h_3	1	0	0	1	0	1	1	0	1	1	0	0	1	0	0	0	0	0
h_4	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1
h_5	0	0	0	0	0	1	0	1	0	1	0	1	0	1	1	1	0	1

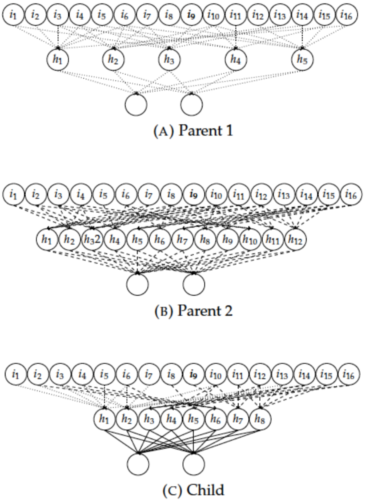

Figure 9: Examples of three ANNs, with (a) and (b) as parent ANNs, and (c) as the child of (a) and (b).

Table 3: Part of train dataset

Input				Output	
Load	Laminate Structure	Material Property	Failure Property	MS	Tsai-Wu
-70,-10,-40,	90,-90,4,1.27,	38.6,8.27,0.26,4.14,	1062.0,610.0,31,118,72,	0.0102,	0.0086
-10,10,0,	-86,86,80,1.27,	181.0,10.3,0.28,7.17,	1500.0,1500.0,40,246,68,	0.4026,	2.5120
-70,-50,80,	-38,38,4,1.27,	116.6,7.67,0.27,4.173,	2062.0,1701.0,70,240,105,	0.0080,	0.0325
-70,80,-40,	90,-90,48,1.27,	38.6,8.27,0.26,4.14,	1062.0,610.0,31,118,72,	0.0218,	0.1028
-20,-30,0,	-86,86,60,1.27,	181.0,10.3,0.28,7.17,	1500.0,1500.0,40,246,68,	0.6481,	0.9512
0,-40,0,	74,-74,168,1.27,	181.0,10.3,0.28,7.17,	1500.0,1500.0,40,246,68,	1.3110,	3.9619

Table 4: Comparsion of Fully-connected Neural Network and GA-based Neural Network

Model	Training Error	Validation Error
Fully-connected ANN	0.051	0.050
GA-based ANN	0.054	0.055

- Huiyao Zhang, Atsushi Yokoyama. 2021. Predicting Strength Ratio of Laminated Composite Material with Evolutionary Artificial Neural Network. International Journal of Advanced Computer Science and Applications, 12(6): 11-18.

谢谢