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Installation automation:
Weaving Structure Installation Optimization

_Automated labeling systems, Weaving Structure Installation, Installation sequence optimization

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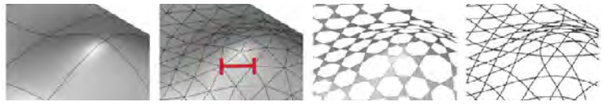
STRUCTURE INSTALLATION OPTIMIZATION

Basic Concepts of Weaving Structures:

A weaving structure is formed by connecting nodes fixed at different positions of the two mesh surfaces. The mesh structure is formed using different bending methods. The construction of the weaving structure able to adapt to the generation of a curved surface.



Abstract:

	Difficulties:	Current Solutions:	Optimization Directions:
Optimization (1)	Unstable Shape of Elastic Rods Difficulty in fixing the position of the rods, resulting in complex structures.	Regular Sequencing of Connections: From long edges to short edges. From the inside to the edge.	**Optimization of the installation sequences**
Optimization (2)	Irregular Positioning of Connecting Points Leading to difficulties in standardizing the structure.	Manual Marking: Time-consuming and costly.	**Development of an automatic rod marking system.**

Optimization (1): Optimization of the installation sequences

Research Methods:

(1) Simulate the Installation Process:
Run simulations to track how structures move and change during installation

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(2) Analysis of Sequence & Rod Performance
Compare changes in sequence and displacement to understand the basic rules of the process.

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(3) Generate Installation Guidelines:
Use these rules to create helpful installation sequences for workers.

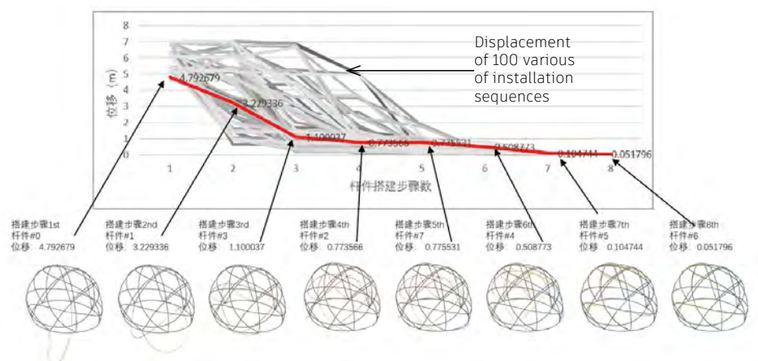


Figure: Simulation of the installation process for a specific braided structure according to certain sequencing steps.

Analysis Method for Installation Sequence & Rod Performance

1. Single Rod's Installation Convinience:

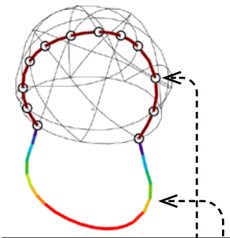
· Rod Positioning:
The complexity of balancing rods in space reflects the difficulty of forming shapes. A higher displacement value indicates more complexity and requires more manual labor for fixing.

· Rod Length:
Longer rods require more support, increasing construction difficulty.

· Rod Connection Points:
An increased number of nodes leads to more fixed workload and complex rod shapes, making the evaluation of construction stability a critical factor.

· Rod Types:
Divided into edge rods and internal rods; edge rods are prioritized in construction, but their differentiation is being standardized and optimized.

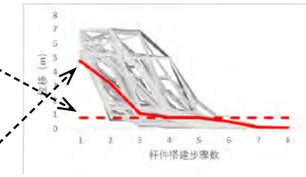
Rod #0 as example:



Rod Number: #0
Length: 6.845m
Number of Hinged Nodes: 12
Maximum Displacement: 5.153m

2. Installation Efficiency:
Evaluated through average displacement of structure, Δ_{avg}. Smaller displacement values indicate that rods are quickly approaching the intended shape.

3. Installation Stability:
Evaluated through maximum displacement of structure, Δ_{max}. Displacement can indicate rod position stability, requiring support.

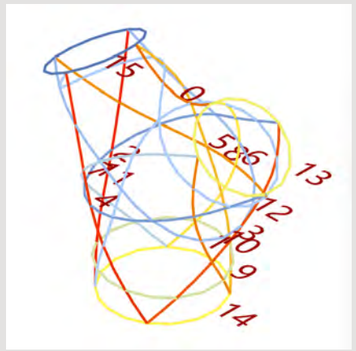


4. Starting Displacement
Structural displacement at first steps of rod installation.

Results:

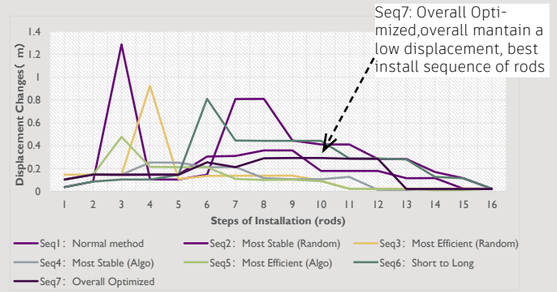
1. Result for Case 1, Triple-Connected Pipeline:

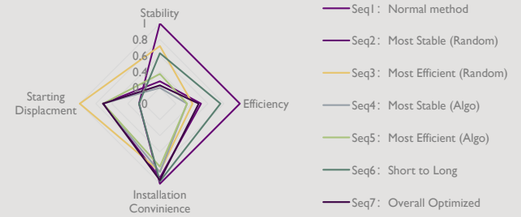
Install first



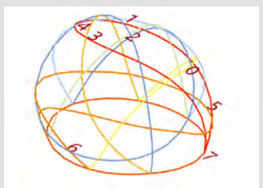
Install later

Overall Optimized Installation Sequence:
2, 4, 3, 0, 1, 8, 5, 6, 14, 13, 9, 7, 12, 10, 11, 15.

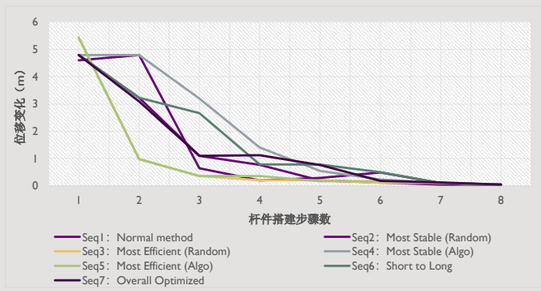


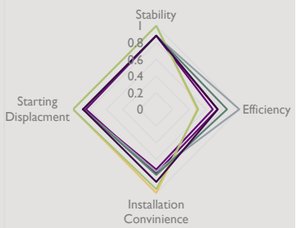


2. Result for Case 2, Half sphere:

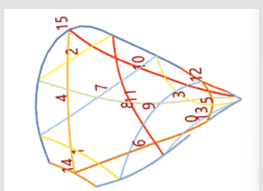


Overall Optimized Installation Sequence:
4, 7, 5, 3, 0, 2, 1, 6

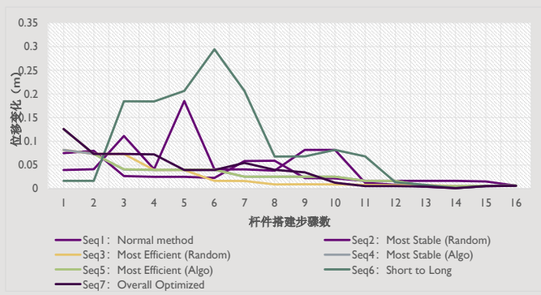


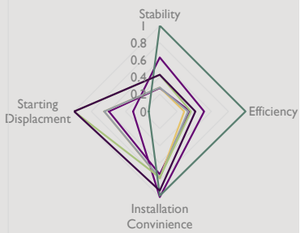


3. Result for Case 3,



Overall Optimized Installation Sequence:
10, 8, 12, 6, 5, 14, 4, 1, 2, 3, 11, 0, 7, 9, 13, 15,





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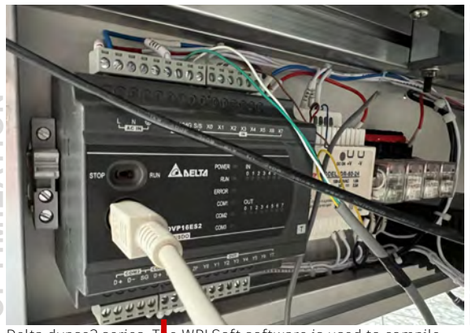
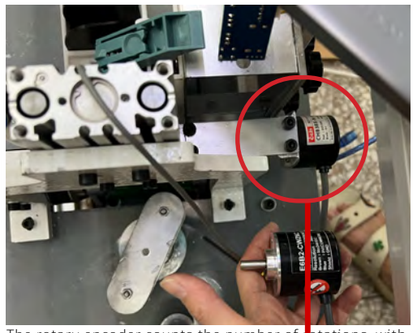
Optimization (2): Development of an automatic rod labelling system

Below are the parts and details of automatic rod labelling machine, which is the essential part of the automatic rod labelling system, built by arduino, Delta dvpes2 series microcomputer, rotary encoder, stepper motor and Ink Cartridges.

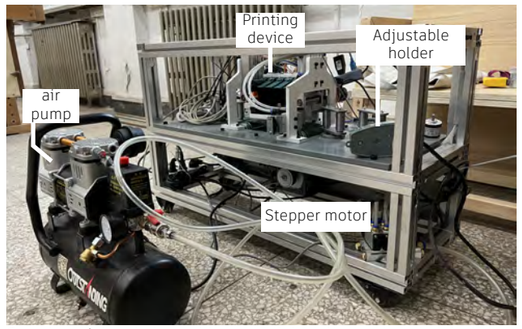


Delta dvpse2 series. The WPLSoft software is used to compile the program, which is then input into the single-chip microcomputer.

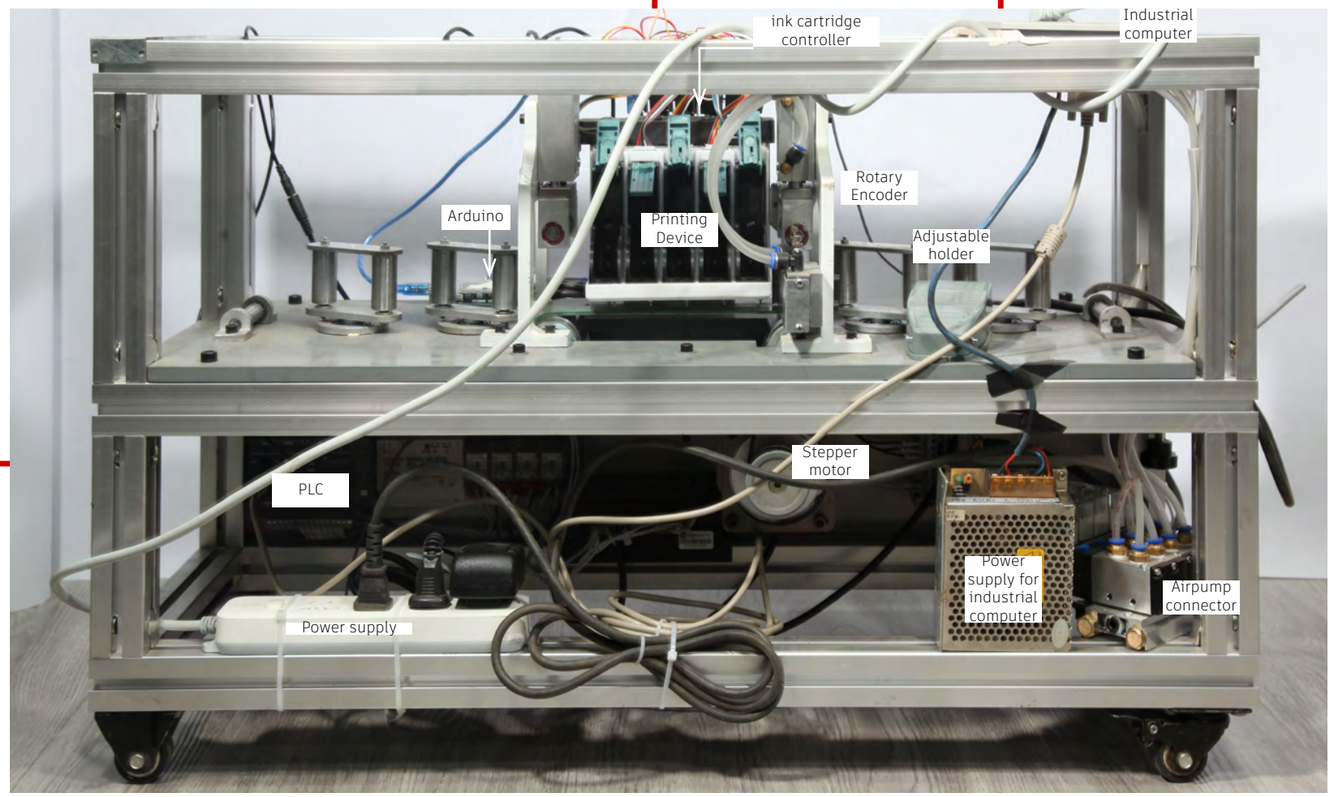
The printing device consists of 5 ink cartridges, 5 ink cartridge controller, and a protective case made by 3d printing.



The rotary encoder counts the number of rotations, with a rod radius of 8mm, control by an Arduino.

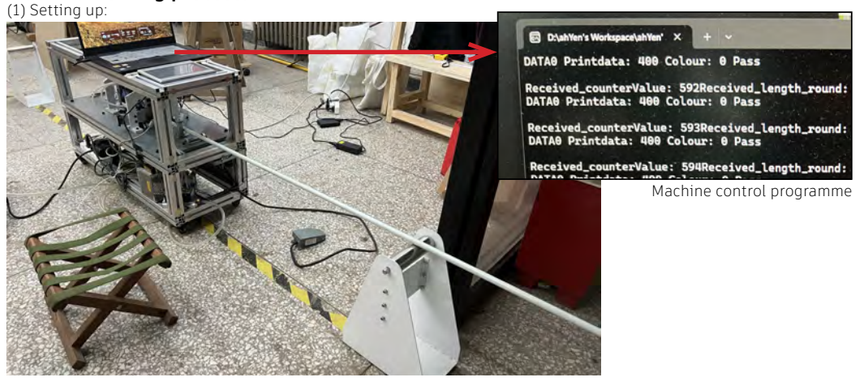


Overview of the whole machine, containing airpump, printing device, stepper motor and adjustable holder.



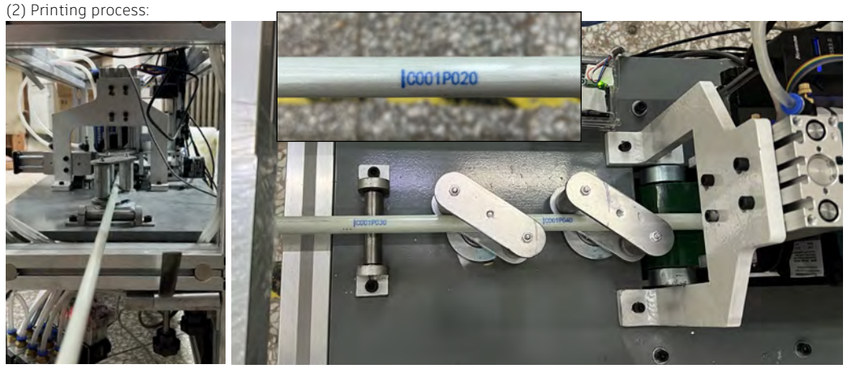
Machine working process:

(1) Setting up:



Machine control programme

(2) Printing process:



Overview of automatic rod marking system

The automatic rod marking system was developed to eliminate manual rod measuring and labeling. It prints specific content at designated positions on elongated rods. **Challenges included the need for multi-color printing, irregular spacing, and millimeter-level precision, with fixtures adapting to various rod cross-sections.**

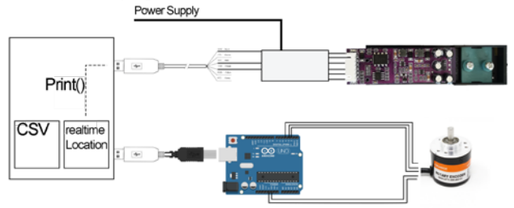
Development Process

The hardware design was split into two parts: the printing device and the rod transportation device. I prototyped the rod transportation device and had it produced by a manufacturer. The printing device was fully developed by me, modified from handheld inkjet printer components.

Technologies Involved

Key technologies used included mechanical design, serial communication, and electronic component assembly and control. This ensured accurate and efficient rod labeling.

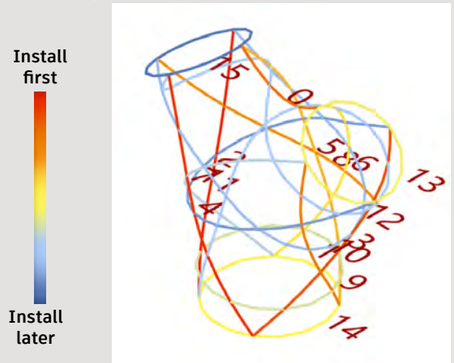
Machine control program structure:



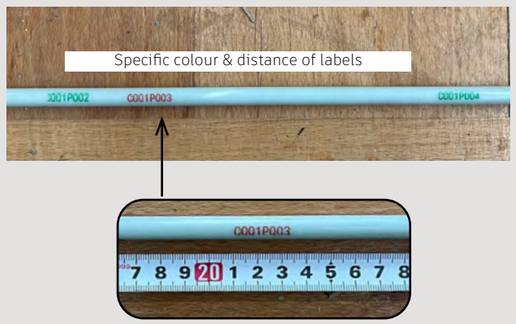
Conclusion

In summary, we propose digital methods to help and improve the construction of weaving structures. Our approach focuses on human-centered design and data analysis to establish construction principles. By optimizing the assembly sequence and using an automated rod marking system, we aim to solve construction challenges, improve efficiency and quality, and advance the technology of weaving structures.

· Accomplishment (1):
Clear and logical installation sequece



· Accomplishment (2):
Transition from manual rod marking to automated labeling machine



No longer mark the rod manually but with the machine developed

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