An Arc Welding Task Planning Method Based on Improved Non-dominated Sorting Genetic Algorithm

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The 42nd Chinese Control Conference

Paper ID: 0206

◆Characteristics of Task Planning for Complex Component Dual Robot Collaborative Welding

- There are many kinds of welds in complex components, and their spatial distribution is very complex.
- Some welds have special welding process constraints, for example, collaborative synchronous arc welding and welding direction.

◆Problems of existing solutions

- First group the welds and then plan the welding sequence.
- Optimization of welding path for single robot welding.
- Single optimization objective.

◆Solution : A Heuristic Task Planning Algorithm is Proposed.

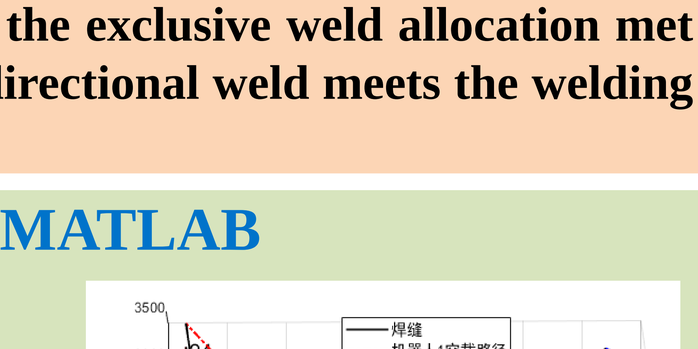
- The optimization model of dual-robot collaborative welding task planning is established.
- An improved non-dominated sorting genetic algorithm II (INSGA-II) is proposed to plan weld path.

◆Task Planning Modeling

- **Strategy**: the welding area be divided into exclusive and shared welding area.
- **Optimization Objectives**: the shortest no-load path and minimum working time.
- **Math model**: $\min F = [D, T]$

$$s.t.\begin{cases}\phi_1 : \alpha_i = \alpha_j, \beta_i = \beta_j, d_i = d_j = 1 \quad (i, j \in M) \\ \phi_2 : d_i = 1 \qquad\qquad (i \in L)\end{cases}$$

D denotes the total no-load path of the two robots.
T denotes the working time of the dual-robot cooperative welding system.
ϕ_1 represents synchronous welding constraints.
ϕ_2 represents welding direction constraints.

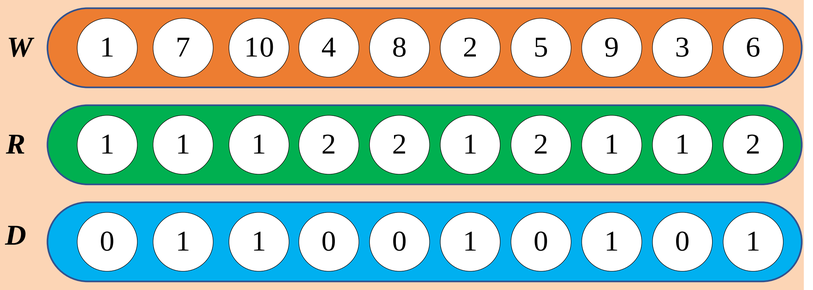


Schematic diagram of welding area division

◆Task Planning Method—INSGA-II

➢Improvement 1: three chromosomes coding strategy

The initial solution is constructed by using three chromosomes representing **weld number**, **robot number** and **welding direction** respectively.

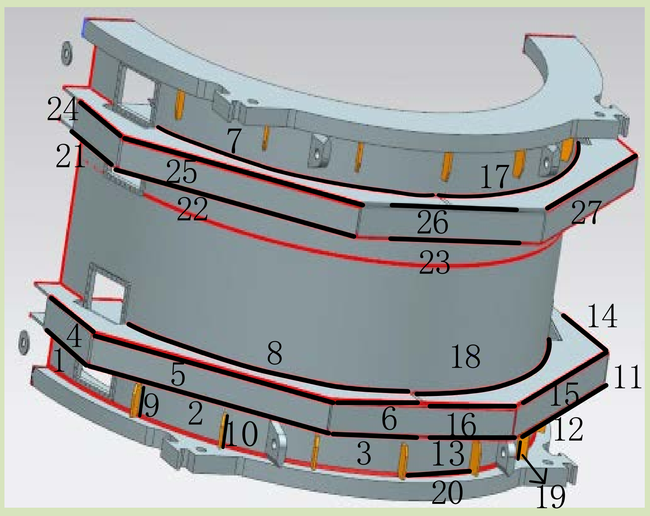


➢Improvement 2: adjustment operator

After each crossover or mutation, the **R chromosome** is used to detect whether the exclusive weld allocation met the exclusive welding constraints. **D chromosome** is used to detect whether the directional weld meets the welding direction constraint. Adjust the welds that do not meet the constraints.

◆Experiments

➢Experimental Object



➢Task Planning Result Based on MATLAB

Solution distribution

Welding path planning planned

◆Conclusion

- A **task planning model** is established with **synchronous welding** and **welding direction** as the constraints and dual optimization objectives of the shortest **no-load path** and minimum **working time**.
- Three chromosomes **coding strategy** and **adjustment operator** are introduced to improve NSGA-II.
- INSGA-II can plan **weld paths** meeting process constraints for two robots, and can get **better Pareto front** compared with NSGA-II, MOPSO and MOACO.

*This work is supported by the Sichuan Province Science and Technology Support Program (No.2020ZDZX0015).