Robot-based guiding of extrusion profiles – reduction of the material waste in the manufacturing process

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Agenda

Motivation

State of Art

Approach

Sequence optimization of the manufacturing process

Summary
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*Trends in industry*

- Weight reductions especially in the area of automobile and aviation industry
- Enlarged required-product-diversity, i.e. small series production.

A flexible production of individual product varieties and lighter construction of aluminum space-frame-structure is needed.

http://www.leichtbau.de/tr10
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State of Art

Sequence optimization of the manufacturing process

Summary
State of the art
The flying cut-off

Real manufacturing process

- Manufacturing through extruder
- Shaping by deflection tool
- Guidance through the room synchronously to the process by industrial robots
- Cut-off on the desired length by the flying cut-off unit

Flying cut-off installation
State of the art

*Material needed to create one profile*

The actual manufacturing installation only extrudes profiles one at a time.

In order to extrude a 3D curved profile (for instance Profile 2), two straight profiles have to be extruded (Profile 1 and 3).

- **Profile 1**: straight profile has to be produced to align the guiding tools and the deflection tool in front of the extruder output. (Material waste)
- **Profile 2**: 3D profile
- **Profile 3**: straight profile, for the same reasons as the profile 1 (Material waste)

**Material waste:** circa. 50%

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**Objective:**

Reduce the material waste thanks to a continuous production
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Summary
Approach

To produce several profiles in a batch a straight profile is needed in between each 3d curved profiles.

Approach:
Development of an optimization algorithm to determine the optimal chronological order of profiles to be produced and their orientation to each other.
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Sequence optimization of the manufacturing process

Summary
Sequence optimization of the manufacturing process

Modelling of the optimization algorithm

- Geometry input profiles
- Working Range of IR
- Optimization Method:
  - Mathematical description of the profiles
  - Produceability test function

Sequence of profiles

- Optimization
- Mathematical description of the profiles
- Produceability test function
Sequence optimization of the manufacturing process

Mathematical description of the profiles

Working of the algorithm:
- Joining of two profiles together
- Rotation of profile
- Test of the produceability

Input profile:
Line or circle with:
- Initial orientation
- Start point, end point
- Rotation center point

Mathematical description of the profiles:
- Interpolation of the profile:
  - Interpolation points with orientation
  - Orientation of the end point

Profiles can now be joined and rotated to re-create the production process

Produceability test
Interpolation point with orientation

Creation of the interpolation points
Sequence optimization of the manufacturing process

Optimization Method

Optimization algorithm:
- Backtracking algorithm for testing the combinations
- Return of the less expensive solution in terms of material waste
- Time optimization through storage of joined profiles that can be produced together

Backtraking algorithm

Profiles combinations are tested, The best solution is returned

Calculate the possible permutations

Test the permutation produceability

Rotate profile / insert straight profile

save the permutation and angles

Return the best solution

Simplified chart flow
Sequence optimization of the manufacturing process

Produceability test function

Test function:
- Working range of Industrial Robots is limited by the installation floor or discontinuous move
- The profile combination is tested step by step

The combination is tested based on the producing process

Working range of Industrial Robots is limited by the installation floor or discontinuous move:

- The profile combination is tested step by step.

Visualization within the routine:

- Real working range
- Floor
- Discontinuous move
- Working range of robot 1
- Working range of robot 2
Results

Test of the algorithm:

Material reduction up to 50%
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Objective:
Reduce the material waste by the means of a continuous production

Approach:
Development of an optimization algorithm to determine the optimal chronological order of profiles to be produced and their orientation to each other
- Development of functions to describe the profile with interpolation points and their orientation
- Development of functions to join the profile together, rotate the profile in the room and finally test the produceability of the combination
- Test of the combinations thanks to backtracking

Result:
The best solution is returned, in this solution there are few or no inserted straight profiles.
Material waste reduced (up to 50%)
Thank you for your attention

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