




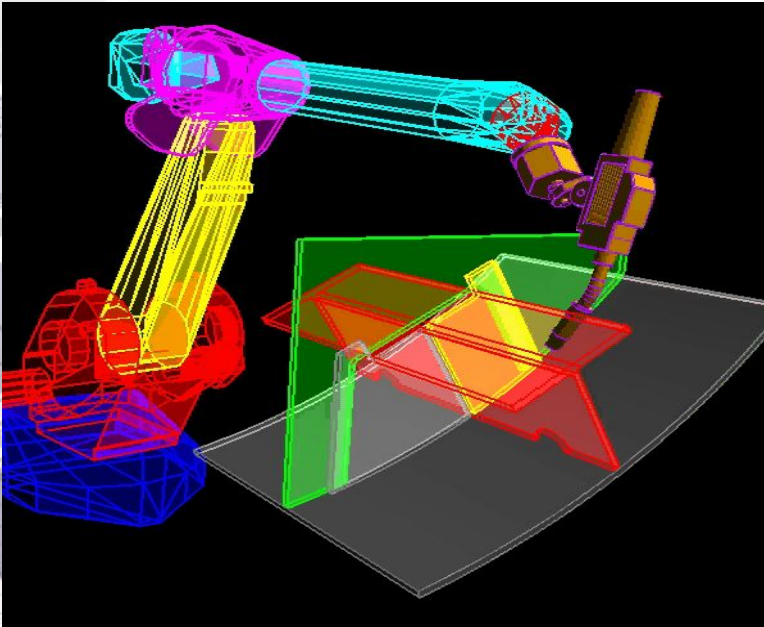
AutoGen



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What is AutoGen

Process Centered Automatic Generation of Robotic Welding commands using Geometric Part Models and Manufacturing Intent



Weld Planning



1st Welding Demo 12/03

CAD Model to OLP Weld Commands

- **Import CAD models for Work Cell and Parts**
 - Create internal data structures
- **Apply geometric reasoning to identify and classify welds**
- **Plan robot motion**
 - Free space
 - Weld
- **Output results**
 - Graphically
 - Robot commands



How AutoGen Works

- **Combines Design and Manufacturing Information to Determine**
 - Part Geometries and Relationships
 - Weld joint types and sizes
 - Presentation of Parts in Manufacturing Space
- **Classifies Welds by Joint Design and Welding Position**
- **Designs Collision Free Manipulation Strategy**
- **Designs Order of Weld Accomplishment**
- **Designs Collision-Free Robot Motions**
- **Computes Commands for the Robot Controller**

AutoGen Process Flow

Load CAD Files
(Workcell, robots,
work pieces)

Find Joints to Weld
(Analyze CAD geometry)

Classify Joints
Orientation: vertical,
horizontal, overhead
Type: butt, edge,
corner, etc

Construct Welds
(6D tag points
in joints)

**Plan Collision-free
Weld Paths for
Robot**

**Plan Collision-free
Open Space
Paths for Robot**

**Combine Task
And
Open Space
Plans**

**Preview
Robot Motion in
Visualizer**

**Specify
Weld Procedures**
(Database lookup,
operator input)

Create OLP File



Current work for GD Electric Boat

- **Functional requirements driven by EB**
- **Priority items identified**
 - **GUI development**
 - **Weld procedure/process information integration**
 - **Weld preparation geometry**
 - **Data definition**
 - **Robot motion planning**

GUI Development

- **Develop operator GUI with inputs through menus and widgets**
 - Currently based on developer's testing interface
 - Level consistent with operator's view of process
- **Functionality to include:**
 - Select, load, move, remove workcells, parts, tables, etc.
 - Select/deselect edges
 - Specify order & direction for weld path and concatenation
 - Run/re-run weld analysis and preview robot motion
 - Operator friendly diagnostics

Weld Procedure/Process Information Integration

- **Interface to existing weld procedure database**
 - Empirical data from experienced welders
- **Apply joint preparation data**
 - Combine joint preparation and part model data
 - Generate weld paths for beveled edges
 - New geometric representation required
- **Identify and apply multipass weld data**
 - Number and orientation
- **Identify and apply other procedure information that affects weld planning**
- **Produce IFS file consistent with existing PAWS input**

Robot Motion Planning

- **Improve collision free torch positioning capabilities**
 - Plan collision free deep penetration/multipass weld paths using supplied offsets
 - Develop true 8 DOF inverse kinematic solver
 - Incorporate torch windup
- **Plan all collision free space motion**
- **Improve robot base placement to extend continuous weld regions**
 - Incorporate manual 9th DOF
- **Explore the command of robot motion in joint space**
- **Establish robot start/stop home positions**

Path Forward

- **Developing interface specification for GUI development**
- **Investigating EB weld procedure database information and how to incorporate it**
- **Developing geometric representation for beveled edge preparations**
- **Improving automated path planning for weld and free space motion**
- **Begin testing at EB with first pass of new functionality**