A-CUBE Way of Manufacturing

A-CUBE Research Team

Industrial and Manufacturing Engineering
School of Engineering and Technology
Asian Institute of Technology
Adaptive Layered Manufacturing

A-CUBE

Abrasive Waterjet Technology

Automotive Technology
How are your customers today?
Develop an intelligent manufacturing System to respond rapidly to customer needs

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Revolution of Product Design Concepts

Manufacturer-oriented mass production → Customer-oriented mass production → Customer-oriented mass customization → Customer-oriented Personalization

Translation process
Product Flexibility ← Customer Needs

Customer Order 1

Design → Manufacturing → Assembly

Customer Order n

Personalized Product 1

Personalized Product n

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Design by Customer

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DBC: Multi CIDP
Customers can flexibly involve in any stages
- Select
- Combine
- Modify
- Design
Product Attribute Analysis

1. Identify some important product’s attributes

2. Analyze the flexibility level of each attribute
   - Can it increase satisfaction?
   - Possible and easy to make?
   - Any engineering constraints?

3. Classify attributes based on their flexibility
   - Group 1: Fixed, no modification is allowed
   - Group 2: Customize, provide variety
   - Group 3: Flexible, customer can modify or design

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Crowdscreening Process

Diagram:
- Crowd
- Multi CIDP Interface
  - Ready-made Products (MTS)
  - Product Configurator
  - Design Tool (MTO)
- Group 1
  - ATO
- Group 2
  - MTO
- Screening
- FSCs & FSPs Buffer Database
  - FSCs
  - FSPs
- Main Database
  - LFSPs
  - LFSPs
  - FSCs
  - FSPs

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Design by Customer
Abrasive Waterjet Machining

- CAD system
- Geometrical data
- CAM system
- G code
- AWJ machine
- Workpiece

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Rapid prototyping (RP) is a process that manufactures products without molds and dies. 3D CAD model is translated into stacks of 2D contours which are used to generate machine commands to fabricate a prototype layer by layer.
Rapid Prototyping Process

Input
- STL file
- Pre-processing
- Slicing
- Build
- Post-processing

Reverse Engineering (RE)
- CAD file
- CT scan
- MRI
- Ultrasound

Build

Post-processing

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Interface between RE-RP

Interfacing modes between RE and RP

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Input Transformation

Scanning/Slicing

Topological Hierarchy
Contour Tracing

0G-Code AWT
SVM RP
D-LOM RP
Printing m/c

Picture
Sketch Information from Drawing Customer
CT Scan
Object
CAD Model

Products

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Obtaining Cloud Point in RE Process

Layered Manufacturing process

- Predict the complexity of Object’s Surface
- Recommend where on Object should be scanned
SLS-based selective data acquisition

Scanned positions analysis

Recommended scanning positions

Controlled environment

Structured light system

Contour points

Prototype

RP process

Data acquisition

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Orthographic Reconstruction Algorithm for Adaptive Layered Manufacturing

Layer-Based Geometrical Reconstruction (LB-GR)

Engineering drawing

Program Implementation

Layer by layer fabrication

A stack of contours

RP part
AUTOMATIC PROTOTYPE CREATION FROM A PAPER-BASED OVERTRACED FREEHAND SKETCH

A paper-based overtraced freehand sketch

Direct interface between a paper-based overtraced freehand sketch and rapid prototyping

A single line drawing

Module 1: Single line drawing identification

A single line drawing

Module 2: Contours generation

A stack of contours

Module 1: Single line drawing identification

Module 2: Contours generation

RP process

A Prototype

A stack of contours
Module 1: Single Line Drawing Identification

A paper-based overtraced freehand sketch

A single line drawing identification

A thick line sketch

A dual line sketch

A set of segments

A set of fitted segments
Module 2: Contours Generation

A single line drawing

Contours generation

A stack of contours

3D reconstruction

Check for the presence of a completely invisible face

Identify visible faces and their vertices

Visible faces

Visible vertices

A list of vertices’ 3D coordinates

Visible vertices

Identify hidden faces and their vertices

Hidden vertices

A stack of contours

Contours generation

Project all faces on XY plane and YZ plane

Recommend scanning positions

Scanning positions for each layer

Construct contour

Contour for each layer
Towards a Design by Customer in Multi-Color Nesting Problem

Input
Design by customer

Output
Wall decoration (example product)

Production Process

Photograph → Automatic preprocess → Identify contour → Classify color → Arrange layout → Cut the contour

single pixel wide closed contour image

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Types of contours in an object image

- Nested contours (Isolated contours)
- Nested contours (A group of contours containing inside one another)
- Interconnected contours
- Combination contours

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Contour extraction
- Similarity concept
  Thresholding, region growing)
- Discontinuity concept
  (Edge detection)

Contouring operation
- Contour tracing approach
- Line scanning approach
- Active contour approach

Types of contours in an object image

- Nested contours
  (Isolated contours)
- Nested contours
  (A group of contours containing inside one another)
- Interconnected contours
- Combination contours

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“Contours appearing on an image can be separated into independent groups, and that each group contains one single contour or a cluster of interconnected contours. Consequently, the sum of all groups found equals to the original.”
Contour Tracing Algorithm

File Loading ➔ Contour Tracing ➔ Result of Process

- Original Image
- Found Contour(s)
- Remaining Contour(s)
- Result of Contour Tracing

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Design a Two Axes Servo Table for Abrasive Waterjet Machining
## Waterjet-Based RP

<table>
<thead>
<tr>
<th>Nozzle diameter (mm)</th>
<th>Conic angle (deg)</th>
<th>Cylindrical tube length (mm)</th>
<th>Pressure (bar)</th>
<th>Beam profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>13</td>
<td>2</td>
<td>78.5</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>13</td>
<td>10</td>
<td>91.5</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>24</td>
<td>2</td>
<td>83.25</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>24</td>
<td>10</td>
<td>88</td>
<td></td>
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</table>

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<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (mm)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>PVC</td>
<td>0.1</td>
<td>Cannot be cut</td>
</tr>
<tr>
<td>Celluloid</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Natural rubber</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Natural rubber</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Natural rubber</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>
Waterjet-Based RP process
Waterjet-Based RP Machine

- Cutting unit
- Cutting platform
- Storage
- Pick&Place unit
- Stacking platform

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Selective Vacuum Manufacturing (SVM)

SVM principle concept:

- Sand casting + Powder sintering
- Vacuum tech. + Sintering tech.

SVM process:

- Support material layers
- Vacuum head
- Filler head
- Heater
- Roller
- Platform
- (1) Layering
- (2) Cavity creating
- (3) Filling
- (4) Sintering

SVM Parts

SVM Machine

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Selective Vacuum Manufacturing Process

- PLA Pellets
- Support material
- Roller
- Vacuum head
- Filler head
- Heater
- Layering Support Material
- Sucking To create Cavity
- Filling Part Material
- Sintering Solidification

SVM Machine | Pattern

PLA Powder

Scaffolds

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Development of Dual Platform LOM

Internal contour cutting

Remove Excess Material

External contour cutting

A prototype of D-LOM Machine

Sample part

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Development of Flat Screen Printing Machine with Automatic Alignment System

Automatic Alignment System

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Product Samples

Universal base

Pen holder

CS fixture base

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Product Samples

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Thank You!

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