EXPLORING CHINESE CALLIGRAPHY AND PAINTING WITH A DRAWING ROBOT

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Technology and Art

- Technology and art go hands in hands
- New horizon/medium to explore and develop new art forms
- Robot art powered by the great advances in computer/electronics/robotics technologies
- Robot art “inspired” by sound, light and more
- Artbot - Yearly event for art-producing robots since 2003
Examples of Robot Drawing

- AARON (by Harold Cohen)
  - Evolving, rule-based/AI program since 1974
  - From few rules/simple shapes to specific knowledge-based rules/complex figures
  - Works exhibited in various museums
- Humanoid Robot producing human portraits by S.Calinon
The ICSL Drawing Robot

- Focus on studying Chinese calligraphy/painting
- 5 DOF pen movement (x, y, z, z-rotation, pitching angle)
- Robot gripper pen holder
- DOFs independently commanded
- High repeatability and accuracy
- Drawing size: 0.8 m x 0.7m (A1 size)
- Camera system for visual feedback
Replicating Line Drawings

- Automated process with (x,y) DOF:
  Original → Skeletonized version → Replication
• Example: A work by Su Renshan “穉仁山”
Original

Replication
Acquisition of Human Hand Motion

- Writing Tablet and Pen system
  - Intuos©2 12” by 12”
  - Record pen tip motion (x, y, some z and pen orientation)
  - Capture hand drawing motions
- Robot retraces positions in recording order

... on Writing Tablet

... produced on paper
• Example of capturing human handwriting

• Enhanced setup to capture hand calligraphic motions
Iterative Corrective Drawing

- Errors in executed drawing due to misinterpretations
- Improvement by overlapping drawing with original to yield corrective actions for next execution
- Video camera (Sony EVI-D30/D31 Pan/Tilt/Zoom) captures executed drawing at angle
- Homography transformation needed to convert angled image to planar view for comparison
• Homography transformation
  – Determined by minimum 4 correspondence pairs
  – Overlapping error reduced by more correspondences via, e.g., SVD technique
  – Process highly sensitive to exact correspondence
  – Manual selection tedious and difficult
  – Genetic Algorithm (GA)-based selection yields high overlapping performance
  – Applicable to image mosaics
• Homography transformation results

Executed work captured

Original

Overlapping performance: Manual selection

Overlapping performance: GA-based
• Iterative Corrective Drawing
  - Comparison of executed drawing and original yields corrective actions to improve next drawing
  - Identification/correction of branch point errors:

Branch point pixels showing no error

Branch point pixels showing error

Identified branch point errors in 1st executed drawing

Next executed drawing
- Tuning of stroke thickness via varying z-depth:

Original image

First execution

Second execution
Full stroke Calligraphy

- Require more than x and y DOFs
- Brush stroke generation -- commands for x, y, z DOFs
- GA-based algorithm with Bézier curve representation and brush footprints
- Case study with tear drop brush footprint assuming size proportional to z-depth

Target stroke

GA-results

Gen=1
Gen=11
Gen=21
Gen=81
Gen=151
• Application to actual character

Chinese character “天” from Lan ting xu “蘭亭序” by Wang Xizhi “王羲之

Manual decomposition into 4 strokes
- GA-Based stroke generation

Animation result
- Overall results of GA-based stroke generation for “天”

Original

GA-generated with tear-shaped footprint
Experimental Acquisition of Brush Footprint

• Special setup with glass container and camera looking upwards
• Camera captures movement of brush footprint under command
• Video segmentation yields time-tagged footprints
• Enable preliminary correlation of footprint to input commands
• Union of footprints yields resultant line stroke

- Footprint size varying with z-depth

<table>
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<th>t=0</th>
<th>t=376</th>
<th>t=817</th>
<th>t=1254</th>
<th>t=1690</th>
<th>t=2129</th>
<th>t=2626 (ms)</th>
</tr>
</thead>
</table>

- z=-8  
- z=-6.8
- z=-5.8
- z=-4.8
- z=-3.8
- z=-2.8 (mm)
• Character “威” by Gan Shinkei (顔真卿) from the poem of General Hai (裴將軍詩)
• GA-based stroke generation using preliminary footprint correlation results
Automated Character Decomposition

- Skeletonization technique built upon Delaunay Triangulation

Original  Modified Delaunay Triangulation  Internal Edge Refinement  Resulting Skeletonization

- Preparation to decomposing “simple” painting

- Demonstration on writing of Bada Shanren
Other Possibilities

• Henri Matisse’s “Woman’s profile-left”

• Contour surface painting

Original
Simulated coordinates on semi-sphere
Picture drawn on half-sphere

Replicating Matisse
• Imitating Chuck Close

Photo of Chuck Close

Portrait of composer Philip Glass in 1977 by Chuck Close

Style of Chuck Close

Works from our machine
• Rendition by randomization
Conclusions

• Drawing platform to study Chinese calligraphy and painting
• Preliminary capabilities and demonstrations
• Future works: hardware upgrades, footprint modeling, full stroke execution, automated decomposition, skill acquisition/characterization/rendition, execution ordering, and more
• Cultural Engineering in CUHK
• Science and engineering methods to art
  - Artworks co-produced by human and robot
  - Preservation of artistic “skills”
  - Characterization and rendition of artistic style(s)
  - An “near” 齊白石 original in every home?
  - Characterization of the artistic process
  - How far can we go?