Advance Optical Guidance

Part III. Clinical Aspects of Stereovision (3D Vision) Guidance

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I. Why Stereovision Guidance (SG)?

✅ most efficient 3D imaging (taking as snapshot)
✅ most accurate in monitoring patient’s motion even during beam-on time
✅ no ionization, no body contact
✅ Intuitive for users
✅ and easy to use
II. Issues in clinical application

1. How to correlate SG with plan images?
Verify the accuracy of the SG with 3D (left) & 2D (right) displays

Stereotactic Localizer

Surface Image

Isocenter

CT Slice
A Stack of CT-based External Contours

A CT-plan skin contour

Easily converted to a stereovision with optic surface format images

Liu and Li at Henry Ford Hospital
2. How to register stereovision in a Linac Coordinate (LC)

- Setup Cal. phantom with marks and lines aligned with LC
- Capture and transform the phantom surface image lines to the axes of LC, keep the transformation matrix for future captured images.
- Verify phantom with portal or CBCT images

Liu and Li, Med Phys. 2006, 4379-83
<table>
<thead>
<tr>
<th><strong>Patient:</strong></th>
<th>test</th>
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<tr>
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<td>C:\3DCamera...</td>
</tr>
<tr>
<td><strong>Patient Folder:</strong></td>
<td>C:...\test\05Sep</td>
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</tbody>
</table>

Marker Position: 138.86, 65.41, 116.11
Marker Movement: 0.06

![Graph showing data](image)

Please wait...
3. Special features of 3D camera?

✓ Speed of Imaging (< 1 sec)
✓ Spatial Resolution at the Focus Distance (0.2 to 4 mm)
✓ FOV and Depth of View
✓ Projector Power or Light Intensity Range
✓ Stability of Camera System
Rainbow Camera (Geng, Opt. Eng, 1996): Resolution: 0.5 – 1 mm at 1.8 m focus distance, >40x40 FOV and >40 cm DOV, less light and skin tone effect, projector power at 20% to 250%
AlignRT (VisionRT Ltd, London, United Kingdom)
Resolution ~ speckle size, room-light < projector light intensity, commercially available

AlignRt with Two VisionRT cameras increase the view of patient’s body
3D Laser scanners, e.g. LAP, GmbH

Laser Application L.C., Lueneburg, Germany

- Resolution and accuracy (~0.5 mm) are good
- Major issues is the speed of laser scanners that cannot capture instant surface image for moving part of body
4. How to capture reliable stereovision?

A method and results for monitoring an abdomen

Li, Chapter 7 in “IGRT Clinical Aspects” Ed. Mount & Roske, in press
A New Gating/Motion Monitoring

Marker Position: 167.93, 46.18, 20.77
Marker Movement: 0.07

Overexposure Edge Artifacts

Shift (mm):

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
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<tbody>
<tr>
<td>-0.03</td>
<td>0.05</td>
<td>-0.04</td>
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Rotation (Order Z--Y--X)

<table>
<thead>
<tr>
<th>Z</th>
<th>Y</th>
<th>X</th>
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<tbody>
<tr>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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Or Rotation (Order Z--X--Y)

<table>
<thead>
<tr>
<th>Z</th>
<th>X</th>
<th>Y</th>
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<tbody>
<tr>
<td>0.01</td>
<td>0.01</td>
<td>-0.01</td>
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Average Error (RMS): 0.203
5. Eye-Safety & Feasibility

Skin tones and eye-safe tests have been performed with volunteers prior to clinical application with the first Rainbow camera @ JHU

A physician
White (25%PP)

A dosimetrist
Tan (100%PP)

A Therapist
Dark (200%)
III. Results of Early Clinical Trials
Setup P-point Displacements (Estimated by Mean +/- 2SD)

\[ X_p = 1.1 \pm 6.8 \text{ mm} \]
\[ Y_p = -1.7 \pm 8.0 \text{ mm} \]
\[ Z_p = -1.0 \pm 7.1 \text{ mm} \]

Li, et al, Submitted for publication
Visualization of treatment volume by the skin outline of the beam edges and useful for an automatic beam-setup and adjustment.
Shape Changes
Overlap of 2\textsuperscript{nd} week surface image on the reference image shown significant shape changes due to the arm position.
A SRT under SG detects 2 mm setup errors

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<tbody>
<tr>
<td>X</td>
<td>-0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>2.02</td>
<td></td>
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</tr>
<tr>
<td>Z</td>
<td>0.84</td>
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<tbody>
<tr>
<td>Z</td>
<td>-0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>-0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>0.09</td>
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Average Error(RMS): 0.915
Manual adjusted based on SG <0.6 mm errors

Shift(mm):

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>z</th>
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<tbody>
<tr>
<td>-0.45</td>
<td>0.35</td>
<td>0.56</td>
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Rotation(Order Z-Y-X):

<table>
<thead>
<tr>
<th>z</th>
<th>y</th>
<th>x</th>
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<tbody>
<tr>
<td>-0.08</td>
<td>-0.16</td>
<td>0.23</td>
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Average Error(RMS): 0.044
Useful for patients wearing flexible masks

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<th>Y</th>
<th>Z</th>
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<tbody>
<tr>
<td></td>
<td>-1.23</td>
<td>-0.67</td>
<td>-0.44</td>
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Rotation (Order Z-Y-X)

<table>
<thead>
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<th>Z</th>
<th>Y</th>
<th>X</th>
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<tbody>
<tr>
<td>45.20</td>
<td>0.71</td>
<td>-0.32</td>
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Average Error (RMS): 0.909
Target Position Uncertainty During Irradiation

Every Table-Beam Setup

Shift (mm), Rotation (degree), and RMS (mm)
Initial Isocenter Setup error, $\sigma_y = 0.40 +/- (1.05 + 1.26)$ mm with CI > 90%
Final Isocenter Position Error $\sigma_y = 0.02 +/- (0.35+0.65)$ mm with CI >90%

Data of 61 pts out 86 pts at JHU, Accepted for publication by TCRT Journal
IV. CONCLUSION

• OG, particular SG, provides an easy and accurate patient positioning and monitoring.

• Early clinical trials and technical developments have demonstrated its usefulness for stereotactic radiotherapy of brain and IMRT of H&N, breast, and other superficial lesions.

• OG combined with CBCT is an ideal approach in IGRT