Practical Scripting in MIM and Pinnacle³

Bingqi Guo, PhD
Cleveland Clinic Foundation
Scripting at Cleveland Clinic

No Conflict of Interest
Scripting at Cleveland Clinic

• Workflow
  - CT simulation → image fusion and contouring in MIM → treatment planning in Pinnacle

• We use MIM scripts for
  - Auto contouring, contour processing, and contour QA

• We use Pinnacle scripts for
  - Auto planning, plan report, and plan check
Scripting at Cleveland Clinic

• How to write scripts in MIM
  - MIM workflow
  - MIM assistant
  - MIM extension (Matlab and Java)

• How to write scripts in Pinnacle
  - Easy way: record and edit
  - Plug-in (C++ and Python)
A patient example
- A breast CT
  - A MIM assistant recognizes the treatment site and launches an auto contouring workflow
A patient example
- Auto segmentation for normal structures
  • A MIM workflow performs atlas-based segmentation for heart, lungs, and spinal cord, and save the contours

< 2 min
A patient example

- Auto segmentation for auto planning
  - A MIM workflow segments wires, identifies landmarks and creates targets for auto planning
A patient example

- Auto planning: create beams
  - A MIM extension using MATLAB sets beams to landmarks, optimizes beam angles, jaw positions and beam block

To cover 95% of PTVeval_breast while minimizing:

\[
f = 50 \times \% \text{ heart volume in the beam} + \% \text{ lung volume in the beam}
\]

Output of extension: a Pinnacle script for auto planning
A patient example

- Auto planning – hybrid IMRT
  - A **pinnacle script** creates a hybrid IMRT plan (3D + IMRT)

Localization, couch removal, CT to density table, wire density override and set dose grid

Add a 3D prescription including two static tangent beams; beam weight optimization

3D prescription: prescribe to max dose

Add a IMRT prescription with two step and shoot tangent beams

Optimize IMRT prescription to deliver uniform dose to breast and reduce dose to OARs
A patient example
- Auto contour vs manual Contour for this patient

<table>
<thead>
<tr>
<th></th>
<th>Dice</th>
<th>Mean Hausdorff Distance/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung_L</td>
<td>0.98</td>
<td>0.6</td>
</tr>
<tr>
<td>Lung_R</td>
<td>0.98</td>
<td>0.5</td>
</tr>
<tr>
<td>Heart</td>
<td>0.92</td>
<td>2.0</td>
</tr>
<tr>
<td>Spinal_Cord</td>
<td>0.90</td>
<td>0.5</td>
</tr>
<tr>
<td>CTV_Breast</td>
<td>0.80</td>
<td>6.5</td>
</tr>
<tr>
<td>PTVeval_Breast</td>
<td>0.84</td>
<td>5.5</td>
</tr>
</tbody>
</table>
A patient example
- Auto plan vs manual plan for this patient
A patient example

- Auto vs manual for 30 breast patients
  - 20 left breast (10 free breathing, 10 breath hold) and 10 right breast patients

Auto Contour vs Clinical Contour

<table>
<thead>
<tr>
<th></th>
<th>Heart</th>
<th>Lt Lung</th>
<th>Rt Lung</th>
<th>Cord</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dice Coefficient</td>
<td>0.94</td>
<td>0.97</td>
<td>0.98</td>
<td>0.91</td>
</tr>
<tr>
<td>Mean Hausdorff distance/mm</td>
<td>1.47</td>
<td>0.68</td>
<td>0.69</td>
<td>0.45</td>
</tr>
</tbody>
</table>
A patient example

- Plan export

  • A **pinnacle script** checks planning parameters

  **Pinnacle Plan Information**

  Patient: Demo, Breast  Patient ID: 20150711
  Plan: autoplan3  Trial: Trial_1
  Date of record: 07/11/2019 10:12

  CT image data set scan time is: 2017-06-12 08:17:30

  Remove couch top Y to Isocenter of "ISO" vertical distance to top of couch to be vertical at 28.6 cm

  SetUp Beam SSD information:
  ASU 38.16
  ISO-Vertical 29.1, with addition 0.5cm sag, at 28.6 cm

  The cross check on the beam consistency shows as below:
  LINAC machine name inconsistency is detected.
  Inconsistency between the beam name and the gantry or table angles is detected, use standard name convention.
  Inconsistency between the beam name and the filed ID is detected.
  Beam ISO inconsistency is detected.
  Reference point inconsistency is detected.
  Iso center shifts are detected. Please document the shifts in MOSAIQ.

  MIM Export status:
  Please export plan to MIM

  CT date and time
  Table-vertical
  SSDs of set up beams

  **Other checks**

  • 20 items checked via scripting

    - Correct beam names
    - All beams associated with the same Isocenter and treatment machine
    - Potential collision check
    - Couch inserted for SBRT plan, use small grid size
    - No 180° in VMAT plans
    - Field size and MLC limits

    ……
### Additional scripting examples

- Auto contouring
  - **MIM assistant rules and workflows** developed to auto segment OARs for six body sites

<table>
<thead>
<tr>
<th>Site</th>
<th>OARs</th>
<th>Number of patients March 2017-March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>Brain, Brainstem, Globe_L, Globe_R, Spinal cord</td>
<td>242</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>Brainstem, Cochlea_L, Cochlear_R, Mandible, Spinal_Cord, Trachea</td>
<td>180</td>
</tr>
<tr>
<td>Breast</td>
<td>Heart, Lung_L, Lung_R, Spinal_Cord</td>
<td>331</td>
</tr>
<tr>
<td>Thorax</td>
<td>Heart, Lung_L, Lung_R, Spinal_Cord</td>
<td>449</td>
</tr>
<tr>
<td>Male Pelvis</td>
<td>Bladder, Femur_L, Femur_R, Rectum</td>
<td>157</td>
</tr>
</tbody>
</table>
Additional scripting examples

- Contour QA
  - A MIM workflow (with extension using JAVA) checks all contours in the list for “simple” errors (missing contour, stray volume, hole, laterality mislabel, skipping slices etc.)
Additional MIM scripting examples

- Clearance check
  - A MIM extension using MATLAB inserts treatment table, contours immobilization devices, and checks for collision
Additional scripting examples

- Using **Pinnacle script** to detect a suboptimal plan
  
  • Why? MLC limitation

  The max leaf travel range for each bank in the same beam was restricted to 14.5 cm

  ![MLC A10](image)
Summary

- Automation using scripts improves safety, efficiency and quality

- At Cleveland Clinic
  - We use MIM scripts (workflows, assistant rules and extensions) for auto contouring, contour processing, and contour QA
  - We use Pinnacle scripts/plugins for auto planning, plan export, and chart check
Thank you

guob@ccf.org