A digital couch solution for treatment planning beams through the treatment couch

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CT images are used in proton treatment planning to model patient’s actual position during treatment.

Inaccurate CT representation of patient’s anatomy or treatment accessories could result in inaccurate treatment.

CT imaging artifacts, the couch shown in the CT images is not an accurate representation of the actual treatment couch.
Clinical Relevance
GE 65cm Large-bore CT Scanner
CT Imaging Artifacts

CT artifacts

- 0.42 g/cm³
- 1.38 g/cm³
- 0.38 g/cm³
- 0.26 g/cm³
520 HU (1.3 g/cm³)

-235 HU (0.8 g/cm³)

Measured physically at 0.95 cm uniform across

1.27 cm

1.40 cm
Goal

- Replace the couch in CT images slice by slice with a digital representation of the couch based on measurements.
- The attenuation of the couch will be measured using proton beams. An equivalent CT density will be given to the couch based on measurements.
Couch top (excluding overlay board)
Region of the digital couch

Always move vertically relative to the center of the image. Please note different Field-of-view (FOV) will change the size of the image. This CT was done at 65cm/512 field of view.
The digital template of the couch support

- Water-Equivalent-Thickness (WET) was measured experimentally from the change in the distal edge position of a proton beam.
- HU numbers were assigned to the geometry template obtained in previous CT scans.
Automatic Detection of Couch Top Position

- Check DICOM tag to make sure the images were scanned from this scanner
- Read DICOM tag to obtain an approximation of the couch vertical position.
- Use image processing technique to detect the couch feature (bottom line)
Digitally Replace the couch CT image

A square image increased the effective FOV of the reconstructed CT image.

Insert synthetic couch template

Automatic detection

Circular FOV

Fig. 1 Original CT

Fig. 2 Reconstructed CT

CT image reconstruction artifacts

− image format: DICOM FILE
− manufacturer: GE MEDICAL SYSTEMS LightSpeed RT16
− image type: AXIAL
− modality: CT Computed Tomography
− table pos: 7.7500 mm
− table height: 166.5000 mm
− scan time: 0.7180 sec
− image pos: -250.00 -250.00 7.75
− slice thickness: 2.50
− pixel dim: 0.98 0.98
− tube voltage: 120.00 kV
− tube current: 250.00 mA
− exposure: 16.00 mAs

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Example: FOV=65cm
Additional Benefit: 50cm FOV

Before

After
Overall Process

Desktop Conversion Software
Room PTCB.1138
Eclipse Viewing workstation (#3580)

Step 1: start DICOM Storage (login Eclipse)
Step 2: select 4DCT images or any CT series
Step 3: Send to “SimpleStorage PTCH (one)”
Wait until it finishes
Step 4: start “Digital Couch For Protons”
3 Options to choose (see descriptions next page)
Step 5: import them from Eclipse
(change folder to the converted folder)

Transfer to:
C:\Digital_couch_Incoming\CT

Converted to:
\protonbeam02\va_data$\Dicom\Digital_couch_Converted
Dicomread current CT slice from folder: ‘C:\Digital_couch_Incoming\CT’

Automatic or Manual?

yes
Line feature detection in the current slice. Replace the couch or just remove it.

no
User provides couch height (in pixel), using Tomovision. Replace the couch or just remove it.

Dicomwrite current CT slice into folder (keep DICOM tags): ‘\protonbeam02\va_data$\Dicom\Digital_couch_Converted’
Software Interface

Digital Couch Synthesizer

User Options

- Automatic mode
- Couch Replace

Process CT images
View Processed CT
Exit

Couch Height:
Option 2: Manual replacing CT couch from CT images scanned elsewhere

If the CT images were acquired from the main center or the automatic mode did not work, you can select a manual mode.

This function will replace the CT image below a specified height with the PTC digital couch, which will be used in actual patient treatment at the proton center.
Selection of Couch Height

- The couch height is defined as the top edge of the couch using a regular window/level (as you normally view soft tissue contrast).
- The height is measured in vertical pixels from the top window to the couch edge. The software used to measure this number is shown in the next page.
Examples (manual couch replacement)

Before

After
Option 3: Manual Remove CT images below a couch height (replaced with air)

- This is an option for the head & neck board, which has to be placed on top of the PTC couch top. The PTC couch top has to be removed from the CT image because it will not be present during treatment.
- In this case, the couch below the height will be replaced with “air”.
- Manual mode has to be specified.
Example Images After Couch Removal

CT Image before couch removal

CT Image after couch removal
Organization of Converted Images

- Special folders were created to assist the CT import into treatment planning system.
Summary

- We have developed a simple and practical solution to improve the CT number accuracy of the treatment couch for proton treatment planning.
- The software tool requires minimal human intervention and allows the flexibility to simulate patient on other compatible CT scanners.
- The solution also allowed the use of 50-cm FOV mode, which increased CT imaging resolution and the quality of the image.