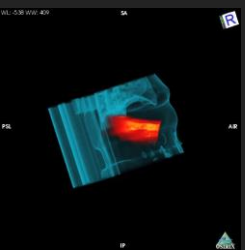


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ULTRASOUND AS A QUANTITATIVE IMAGE GUIDED MODALITY IN RADIOTHERAPY



VL: 0.38 WVL: 400

SA R

FR AP

DF

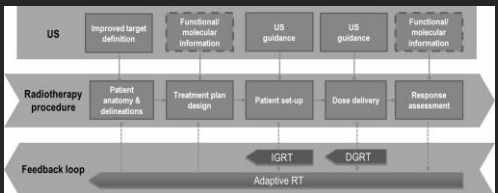
Davide Fontanarosa, PhD

July 31 2017 Denver

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US GUIDANCE RT WORKFLOW



US Improved target definition Functional/molecular information US guidance US guidance Functional/molecular information

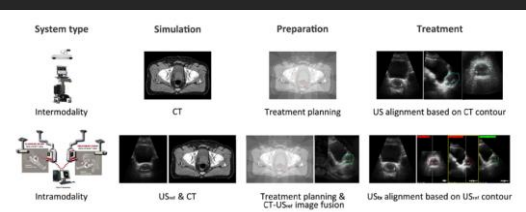
Radiotherapy procedure Patient anatomy & delineations Treatment plan design Patient set-up Dose delivery Response assessment

Feedback loop IGRT DGRT Adaptive RT

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US GUIDANCE RT WORKFLOW



System type	Simulation	Preparation	Treatment
Intermodality	CT	Treatment planning	US alignment based on CT contour
Intramodality	US & CT	Treatment planning & CT-US image fusion	US alignment based on US contour

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CLINICAL APPLICATIONS



- PROSTATE
- BREAST
- OTHER SITES:
 1. LIVER
 2. GALLBLADDER
 3. PANCREAS
 4. BLADDER
 5. H&N
 6. ...

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QUANTITATIVE



- LOCALIZATION
- VOLUME MEASUREMENT
- MOTION TRACKING

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LOCALIZATION



CT 3D-US

Berrang et al (2009)

MOTION TRACKING

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WHAT PREVENTS QUANTITATIVE USE OF US?

- OPERATOR DEPENDENCE
- PROBE PRESSURE EFFECT
- IMAGE QUALITY
- ABERRATIONS
- US SPECIFIC WORKFLOWS
- ...
- NOT BEING AWARE OF WHAT WE ARE DOING..

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OPERATOR DEPENDENCE

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It is THE major (perceived) reason why US guidance is not as widespread as it deserves.

LOW PROFILE US PROBES

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SOS ABERRATION

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SOS ABERRATION CORRECTION

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$c = (1.12\rho + 0.391)m/s \pm 0.0203$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
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SOS ABERRATION CORRECTION

Water

Sunflower oil

17% saline solution

Original US CF scan Corrected US

Original US CF scan Corrected US

Original US CF scan Corrected US

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IMAGE QUALITY

TSD 1 MI'S

In general it is difficult to have consistent image quality

- 1) Select your probe well
- 2) Decide what (possibly mixed) flavor of dimensions you want to use...

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AUTOMATION

Automate US imaging operations:

- Contouring
- Probe positioning
- Image interpretation
- Use of information
- ...

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AUTOMATED US-BASED OR CROSS-MODALITY CONTOURING

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Ermacorà et al 2015

US SPECIFIC DEFORMABLE REGISTRATION

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Simulation stage Treatment stage

US_{sim} (Deformable) registration US_{tx}

CT_{sim} Apply deformation field CT_{pseudo} Comparison CT_{tx}

Deformation field

US SPECIFIC DEFORMABLE REGISTRATION

Simulation US Treatment US Deformed US

Note: Spatially corresponding slices of the US volume

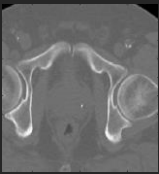
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US SPECIFIC DEFORMABLE REGISTRATION


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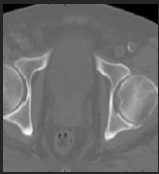
Simulation CT



Pseudo-CT



Treatment CT




Note: Spatially corresponding axial slices of the CT volume

AUTOMATIC TRANSPERINEAL ULTRASOUND PROBE POSITIONING

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A




Acquire CT scan and in case necessary resample to 1.5x1.5 mm

B




Identify and segment target (green), organ at risk (orange) and blocking structures (red)

C




Determine which parts of organs are required (blue in the FOV) and which are optional (yellow)

D




Convert a 3D FOV model of the need ultrasound insert probe

E




Determine a probe position and orientation so the required structures are fully in the FOV

F




Make sure that the required structures (blue) are not (partially) blocked by, for example, bones (red)

G




Find a probe position and orientation where most of the optional structures are in the FOV as well

H



Use a gel-filled probe cover to ensure sufficient coupling between the probe and scanning surface

I

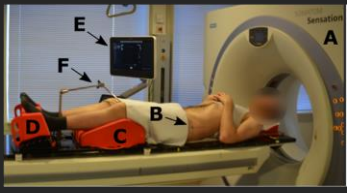


Reproduce the calculated probe position using a mechanical or robotic arm

OUR SETUP

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(A) CT scanner

(B) Skin markers on the patient's body for isocenter laser alignment;

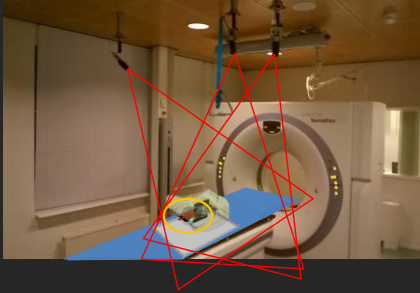
(C) Kneefix™ 2;

(D) Feetfix™ 2;

(E) EpiQ7 US system monitor;

(F) Mechanical arm with rotary knob for US probe fixation.

OUR SETUP



ACKNOWLEDGMENTS



- Prof. Frank Verhaegen*
- Saskia Camps*
- Dr. Skadi van der Meer*
- Dr. Pedro Sanches*
- Dr. Matilde Costa*
- Dr. Esther Bloemen-van Gorp*

•Questions?