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Advanced approaches for MR guided HIFU and MR guided Radiotherapy in the abdomen

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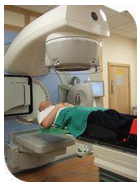
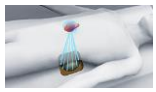
University Medical Center Utrecht

External beam therapies

External Beam Radiotherapy (EBRT)



High Intensity Focused Ultrasound (HIFU)



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MRI guidance of external beam therapies

- Target and OAR definition
  (HIFU and RT)
- Motion correction intra- and interprocedure
  (HIFU and RT)
- Temperature mapping during the procedure
  (HIFU)
- Evaluation of therapeutic efficacy
  (HIFU and RT)

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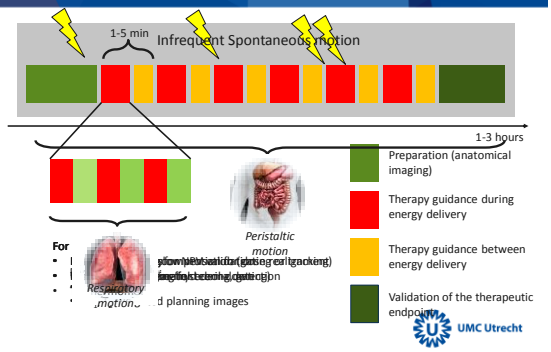
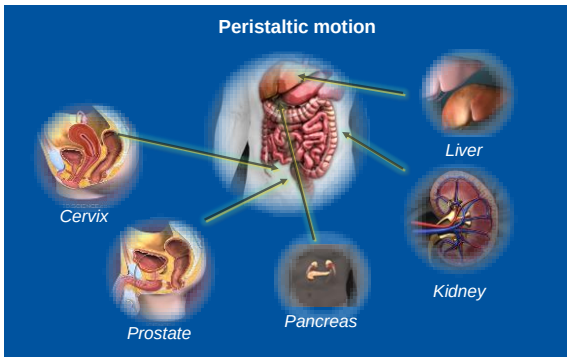
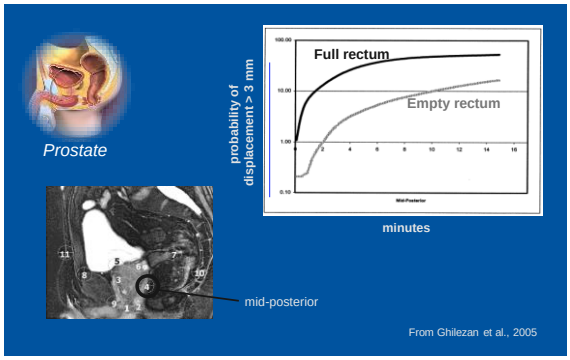
Thermal ablation on abdominal organs: Work-flow and motion



Physiological motion



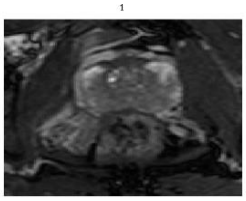
Physiological motion: Peristalsis



Physiological motion

Motion as seen by MRI 8 scans in 35 minutes

Prostate



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Physiological motion

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Peristaltic motion

Cervix

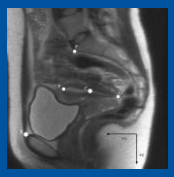


Table 2. Interscan tumor and organ motion in patients with cervical cancer

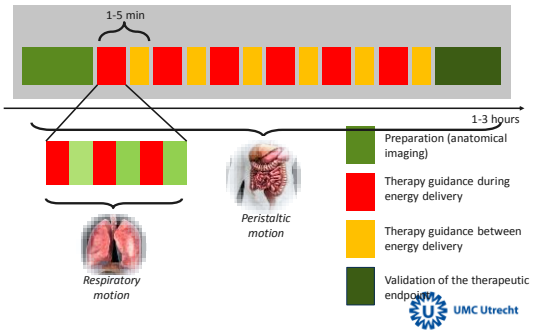
	Uterine fundus (F)		Uterine canal (C)		Cervical os (O)	
Overall	AP	CC	AP	CC	AP	CC
Grand-mean (mm)	−4.6	7.8	−4.8	5.7	2.4	1.5
Mean-range (mm)	14.5	24.4	13.1	15.7	11.2	11.3
95 PI (mm)						
Negative	−19.4	−21.8	−24.2	−11.0	−11.4	−11.9
Positive	10.7	37.6	15.2	21.9	16.6	15.2

Table 3. Intrascan tumor and organ motion in patients with cervical cancer

	Uterine fundus (F)		Uterine canal (C)		Cervical os (O)	
Overall	AP	CC	AP	CC	AP	CC
Grand-mean (mm)	−1.1	−3.1	0.3	−1.8	−0.1	−0.5
Mean-range (mm)	12.0	18.8	11.3	12.8	10.6	11.2
95 PI (mm)						
Negative	−6.3	−9.1	−4.2	−5.3	−4.2	−4.1
Positive	4.2	6.6	4.7	3.9	4.4	3.8

From Chan et al. 2008
Int J Rad Oncol Biol Phys

Thermal ablation on abdominal organs: Work-flow and motion



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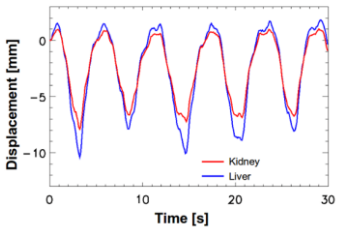
Physiological motion

Liver

Kidney



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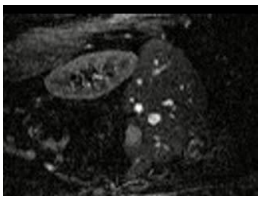
Physiological motion

Liver

Kidney



Fat suppressed SS-EPI, 10Hz

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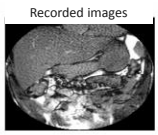
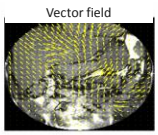
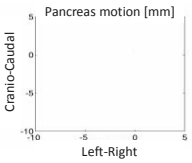
Physiological motion

Pancreas







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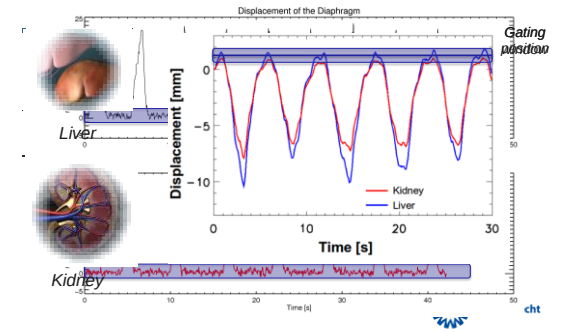
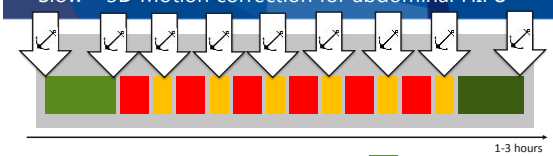
1) Roujol S, et al. *IEEE Trans on Med. Imag* 2012

Physiological motion



Physiological motion

« Slow » 3D Motion correction for abdominal HIFU



- 3D anchor images are periodically obtained and compared to a reference.

Preparation (anatomical imaging)

Therapy guidance during energy delivery

Therapy guidance between energy delivery

Validation of the therapeutic endpoint

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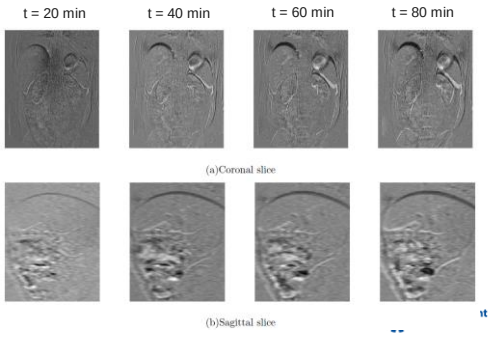
« Slow » 3D Motion correction for abdominal HIFU



« Slow » 3D Motion correction for abdominal HIFU

- A study on *10 healthy volunteers* – validation of the tracking method + proof that the targeted organs move due to slow physiological drifts beyond the acceptable therapeutic margins
- An *in vivo* experiment on a porcine liver – validation of the proposed method during a real HIFU therapy

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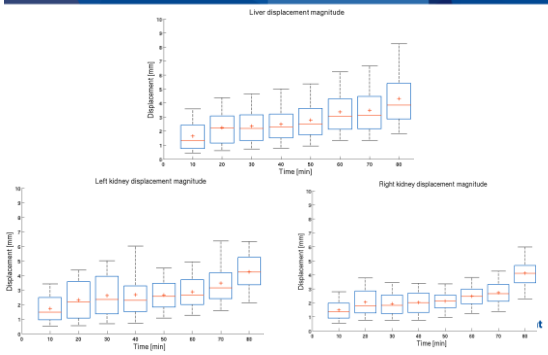
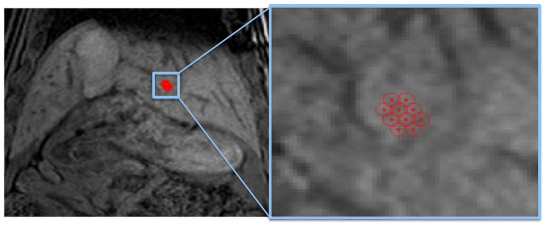
« Slow » 3D Motion correction for abdominal HIFU



« Slow » 3D Motion correction for abdominal HIFU



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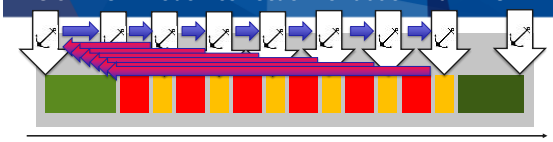
« Slow » 3D Motion correction for abdominal HIFU



1-3 hours

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delivery

y guidance between
delivery

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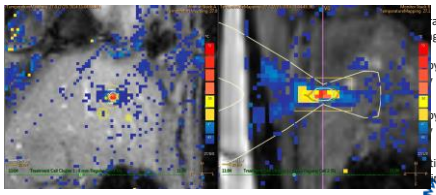

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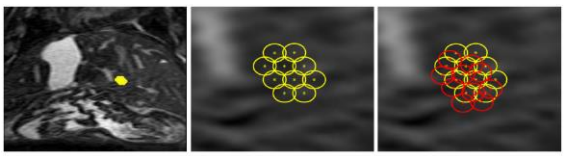
« Slow » 3D Motion correction for abdominal HIFU

Propagate the initial treatment plan down the flow of the motion



(a) (b) (c)

In vivo porcine experiment on the liver for validation

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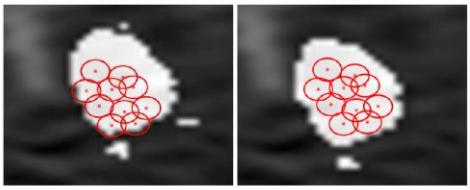
« Slow » 3D Motion correction for abdominal HIFU

Project and accumulate the currently delivered thermal dose on the initial treatment plan "upstream" the flow of the motion



(a) In vivo porcine experiment on the liver for validation (b)

•"A framework for the correction of slow physiological drifts during MR-guided HIFU therapies: Proof of concept" Zachiu et al. *Medical Physics, in press.*

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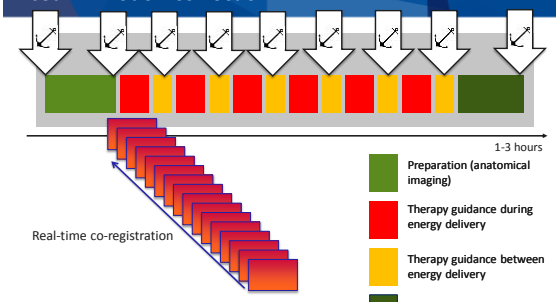
Fast 2D motion correction



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Fast 2D motion correction

Fast 2D motion correction

Concluding remarks

- MRI allows detailed intra- and inter procedure motion tracking of the ordr of 1 mm
- A framework has been developed for 3D correction of (slow) peristaltic motion and 2D correction for respiratory motion

- Funding was provided by the project OnTrack (STW, the Netherlands, in collaboration with Philips Healthcare)

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