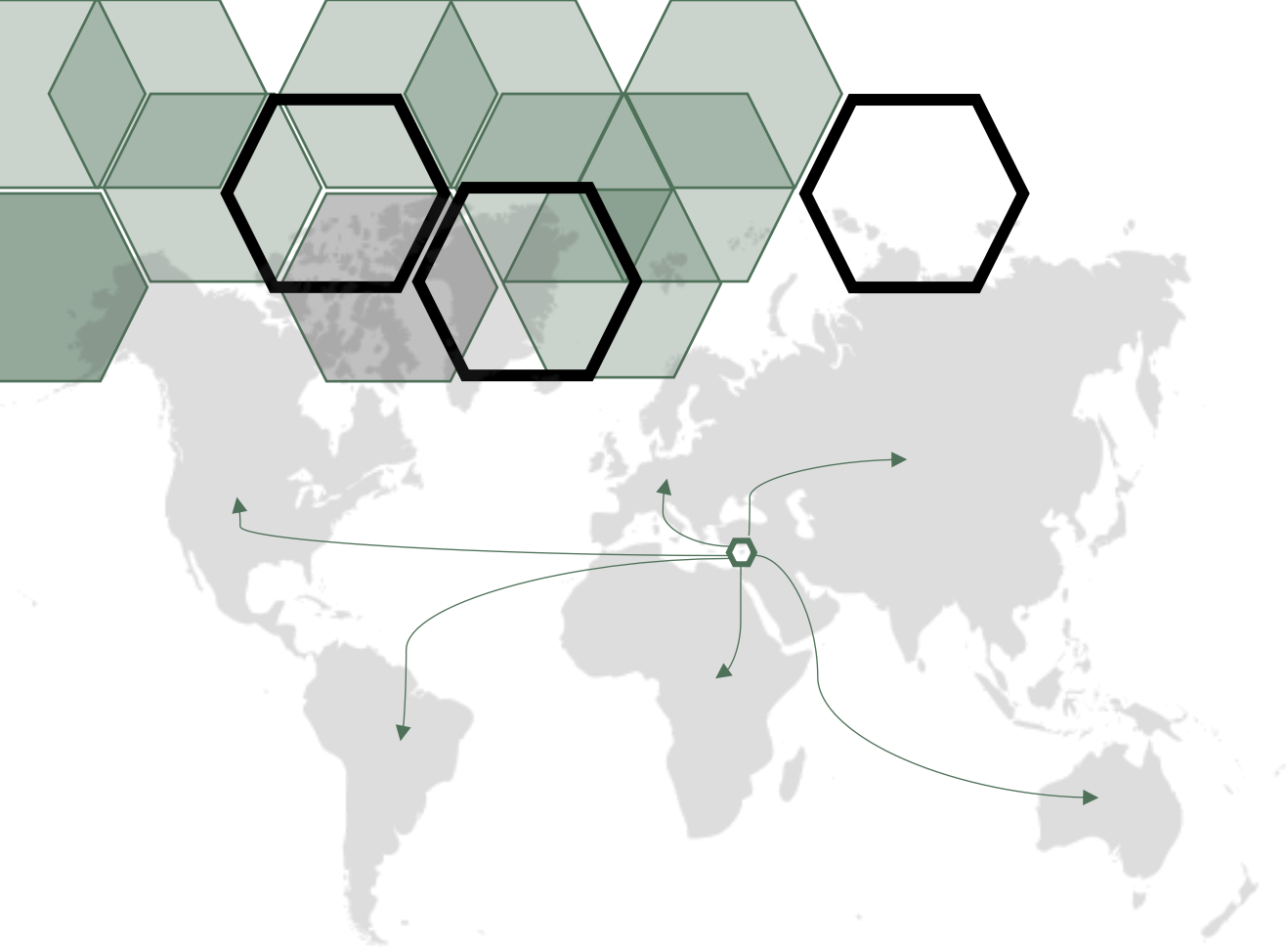


JULY 23th, 2021

INTEGRATED/0918/0008

SOUNDPET NEWSLETTER

ISSUE 2

Providing with news on MRI guided Focused Ultrasound technology in the field of oncology, in the framework of the SOUNDPET project!

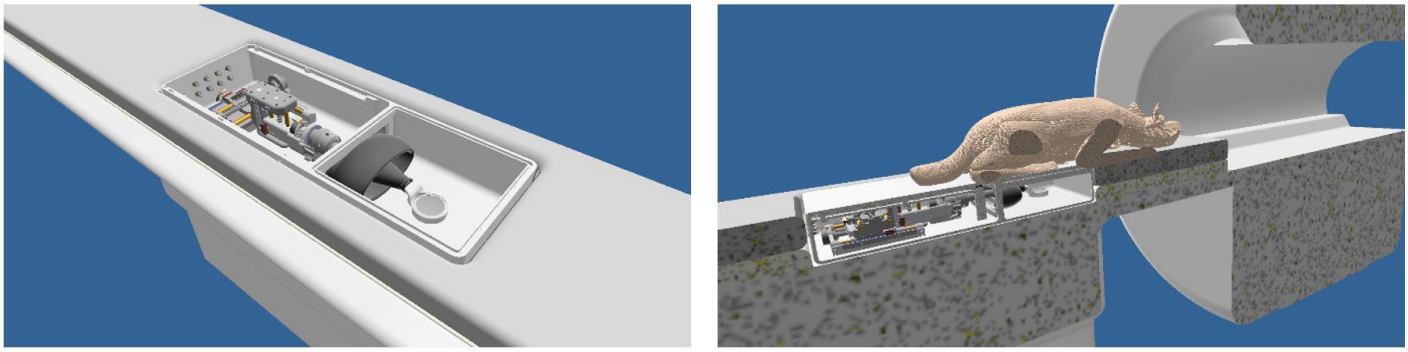
INDEX

co-funded by Ευρωπαϊκή Ένωση, Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης; Κυπριακή Δημοκρατία; Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

Four DOF robotic device (version 1)

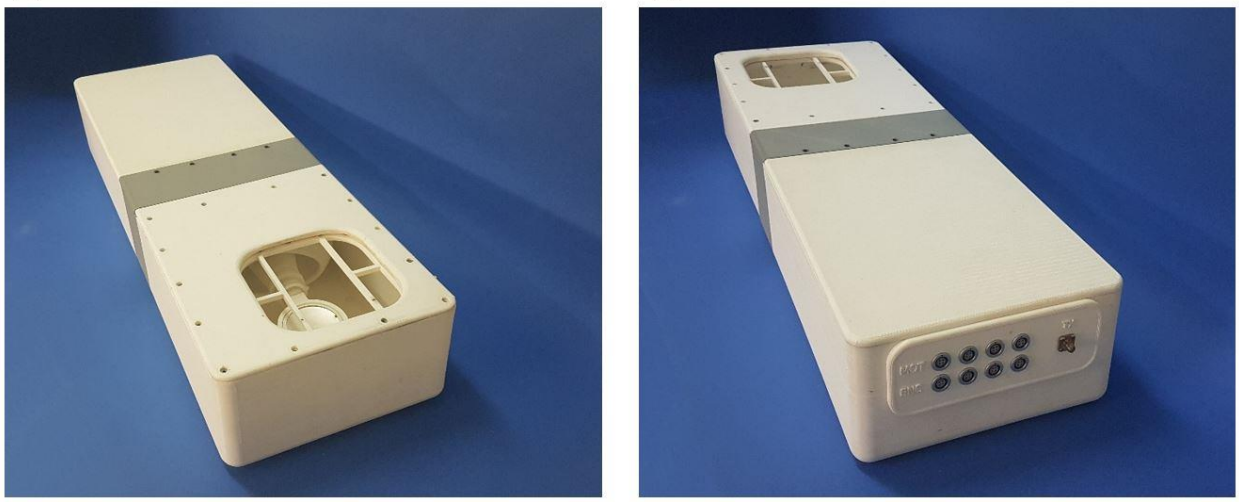
The robotic system allows navigation of the ultrasonic transducer in four stages. Specifically, the device enables linear movement 1) forward and backward (range of 55 mm), 2) left and right (range of 76 mm), and 3) up and down (range of 28 mm). An angular stage enables clockwise and counterclockwise rotation (range of 180°) of the transducer as well. The specific motion ranges were properly selected to allow access to the target organs. The linear stages are based on a jack screw principle, while the angular one uses a two-stage reduction unit which is composed of multiple gears. All four stages are actuated by small piezoelectric motors (USR30-S3, Shinsei Kogyo Corp., Tokyo, Japan) and monitored by optical encoders.

(a) (b)



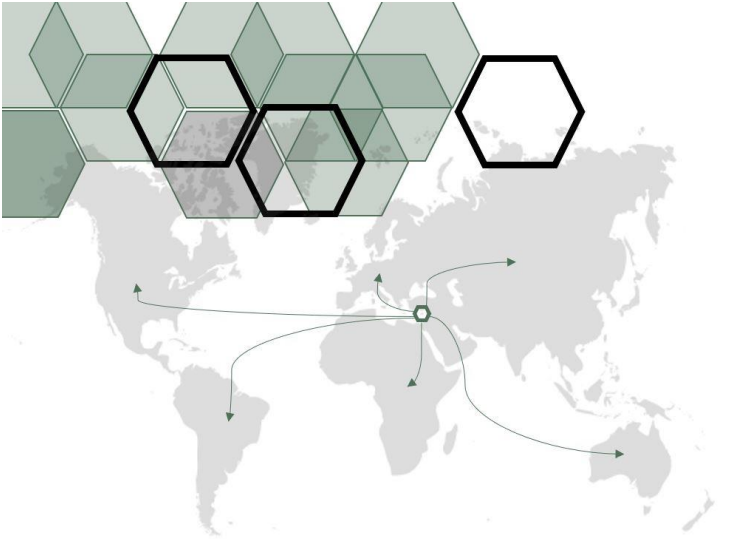
a) CAD drawing of the robotic device as placed in the MRI table, b) Cross section of the device with the dog placed in prone position.

(a) (b)



Photos of the manufactured positioning device (version 1), a) front view, b) rear view.

co-funded by
Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης
Κυπριακή Δημοκρατία
Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο



Four DOF robotic device (version 2)

The second version of the robotic system incorporates larger motors (USR60-S3, Shinsei Kogyo Corp., Tokyo, Japan). The positioning device can move the transducer 60 mm in the X axis (forward and reverse), 75 mm in the Y axis (left and right), 26 mm in the Z axis (up and down) and can angulate the transducer 90° (45° left and 45° right) about the Θ-axis.

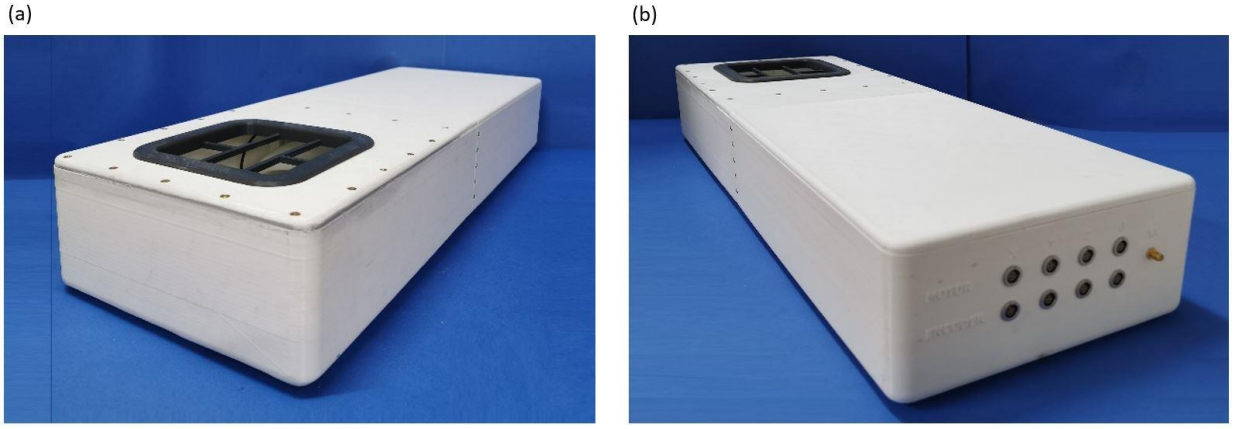
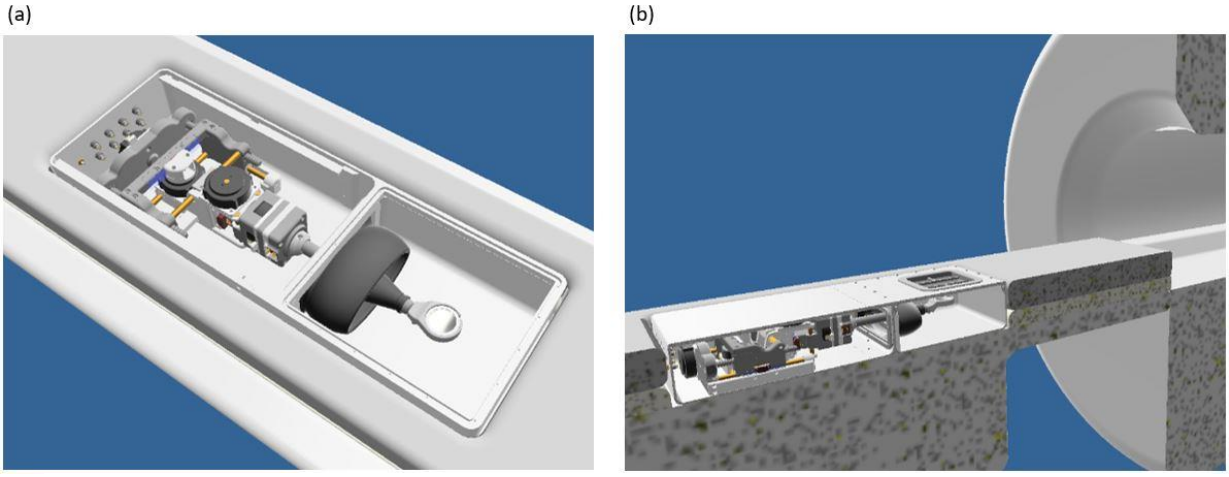


Photo of the robotic system (version 2) a) front view, b) rear view.

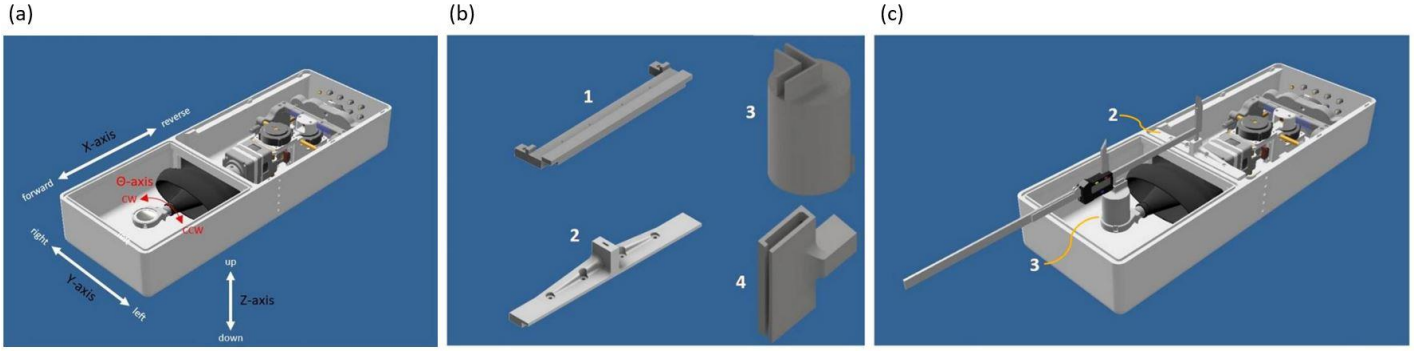


a) *Robotic system placed in the MRI with visible mechanism, b) Cross section of the MRI scanner with robot.*

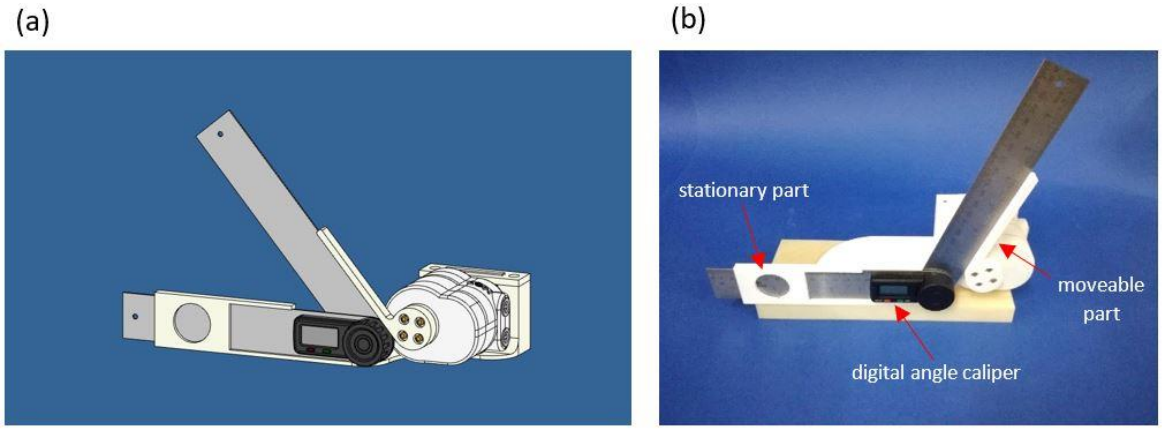
co-funded by

Motion accuracy of the robotic device

The motion accuracy of the robotic device (version 2) was assessed with three simple methods in both benchtop and MRI environments. In the first method, a digital calliper was mounted on the motion stage under evaluation with the assistance of specially designed 3D-printed parts, having its one edge fixed on a stationary part and the other on a movable part. In that way, a specific step movement of the stage resulted in an analogous increment in the calliper. The second evaluation procedure related to accuracy assessment in the MRI setting. The robotic device was sited on the MRI couch, and a plastic marker was mounted on the top of the FUS transducer so that it was visualized in MR images. The third method involved performing multiple ablations in a transparent plastic film by robotic movement of the transducer.



a) Computer-aided design (CAD) drawing of the 4 DOF robotic system (version 2) without the cover showing the motion axes, b) Stationary (1,2,4) and moveable (3) 3D-printed structures that were used for the X and Y axes distance measurements, c) CAD drawing of the setup that was used for the X axis motion accuracy estimation.

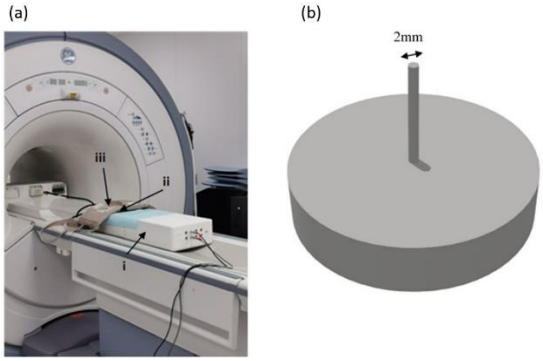


Experimental setup for estimating the angular motion accuracy using the digital angle calliper; a) CAD drawing and b) photo.

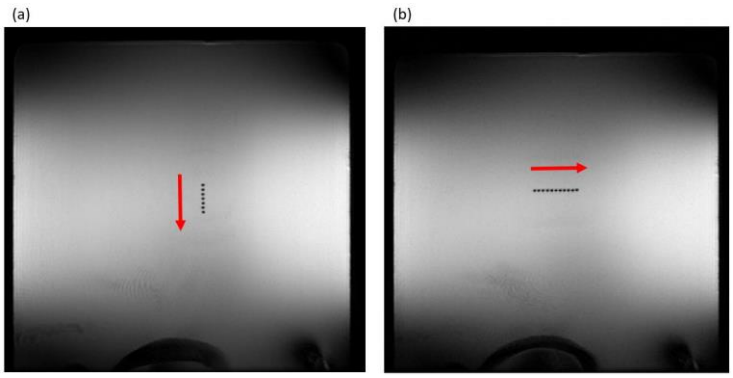
co-funded by
Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης
Κυπριακή Δημοκρατία
Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

Motion accuracy of the robotic device (cont.)

MRI was also used to examine the accuracy of motion in the *X* and *Y* axes. The MR images acquired after execution of each 3 mm motion step in the *X* axis reverse and *Y* axis right directions were superimposed onto the images.



(a) The robotic device (i) as placed on the magnetic resonance imaging table, showing the location of the plastic marker (ii) and *the flex surface coil (iii), and (b) CAD drawing of the plastic marker used for accuracy measurements.*



Minimum intensity projection from a combination of fast spin echo coronal images that shows a (a) reverse step movement of 3 mm in the X direction and (b) right step movement of 3 mm in the Y direction.

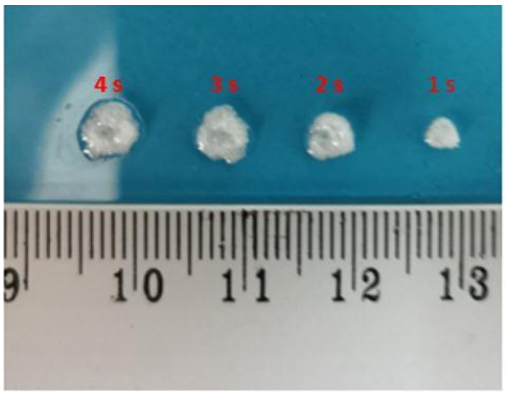
Linear axis	Commanded step (mm)	Range of actual displacement (mm)	Mean error ± SD forward (mm)	Mean error ± SD reverse (mm)
X	3	2.73–3.83	0.277 ± 0.007	0.342 ± 0.172
	5	4.92–5.47	0.339 ± 0.184	0.352 ± 0.179
	Commanded step (mm)	**Range of actual displacement (mm)**	**Mean error ± SD right (mm)**	**Mean error ± SD left (mm)**
Y	3	2.73–3.83	0.330 ± 0.166	0.278 ± 0.007
	5	4.37–5.47	0.171 ± 0.191	0.286 ± 0.239

The range of distance measurements as estimated by MRI at commanded spatial steps of 3 and 5 mm in X and Y axes bidirectional movements, and the corresponding mean motion error and standard deviation.

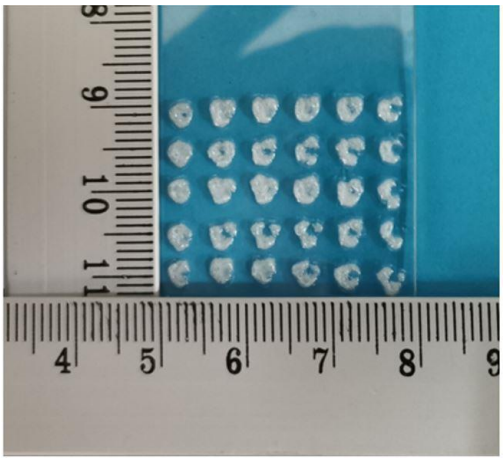
co-funded by
Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης
Κυπριακή Δημοκρατία
Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

Motion accuracy of the robotic device (cont.)

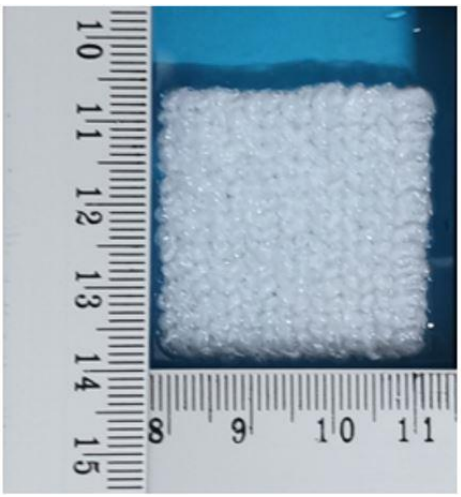
The motion accuracy was visually observed by sonicating plastic films. The effect of lesion formation on the plastic film was originally examined by varying the sonication time while keeping constant the acoustic power. The appropriate selection of sonication time and grid step allowed formation of discrete and overlapping lesions and visual evaluation of the accuracy of motion and alignment.



Effect of varying sonication time on lesion formation on the plastic film, using low power and a spatial step of 10 mm (transducer specifications: 1.1 MHz frequency, 50 mm diameter and 70 mm focal length).

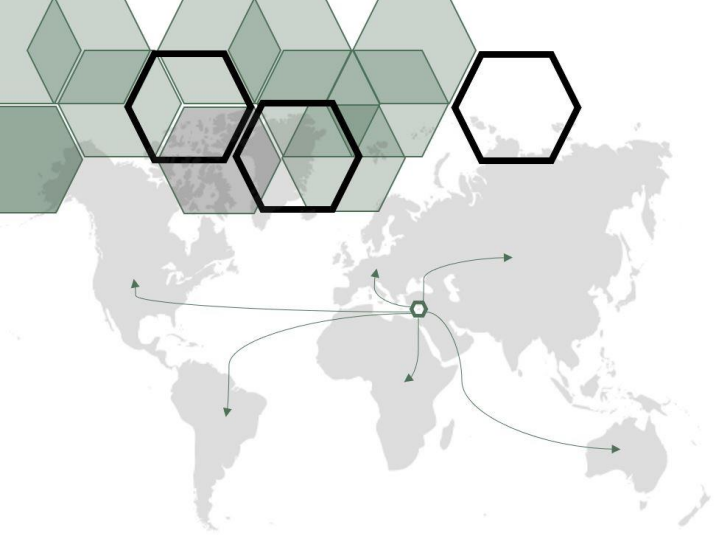


Discrete lesions as formed on the plastic film for sonications in a 6 x 5 grid pattern, with acoustical power of 10 W for 1 s and a step distance of 5 mm.



Overlapping lesions as formed on the plastic film for sonications in a 15 x 15 grid pattern, with acoustical power of 10 W for 3 s and a step distance of 2 mm.

co-funded by Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης
Κυπριακή Δημοκρατία
Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

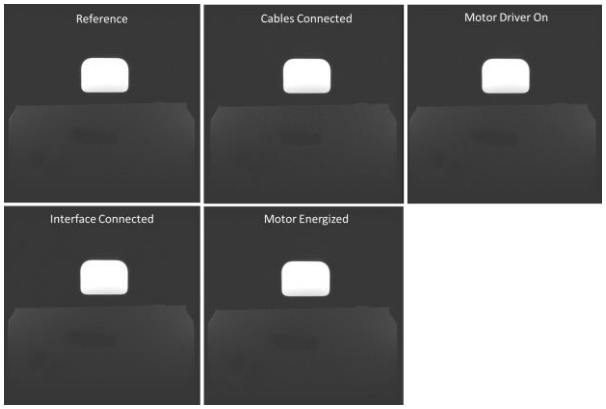


MR compatibility of the robotic device (version 2)

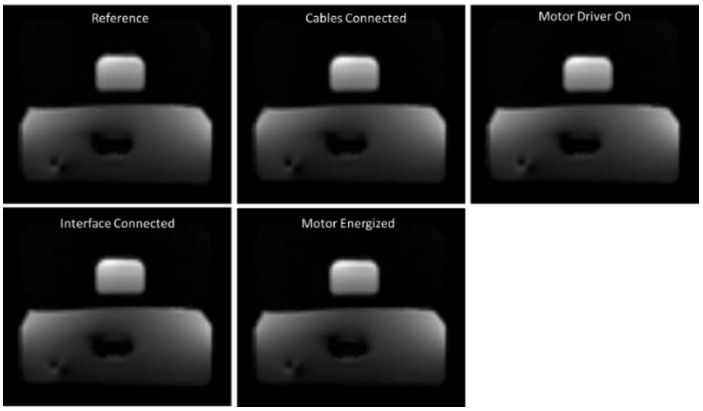
The MR compatibility of robotic device (version 2) that controls large piezoelectric motors was also examined. A phantom was scanned using fast spin echo (FSE), fast spoiled gradient-recalled echo (FSPGR) and echo planar imaging (EPI) sequence under the following activation states:

I. Reference image
II. Cables plugged, amplifier OFF, transducer OFF
III. Electronic system motor driver switched ON
IV. Interface connected
V. Motor energized

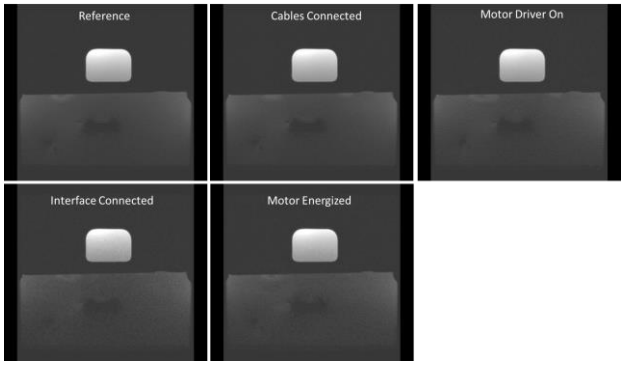
Visual assessment of the acquired images did not show a significant effect after transition between the different activation states.



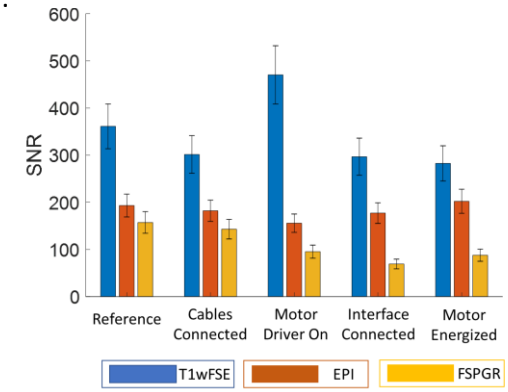
Axial image acquisition using FSE sequence.



Axial image acquisition using EPI sequence.



Axial image acquisition using FSPGR sequence.

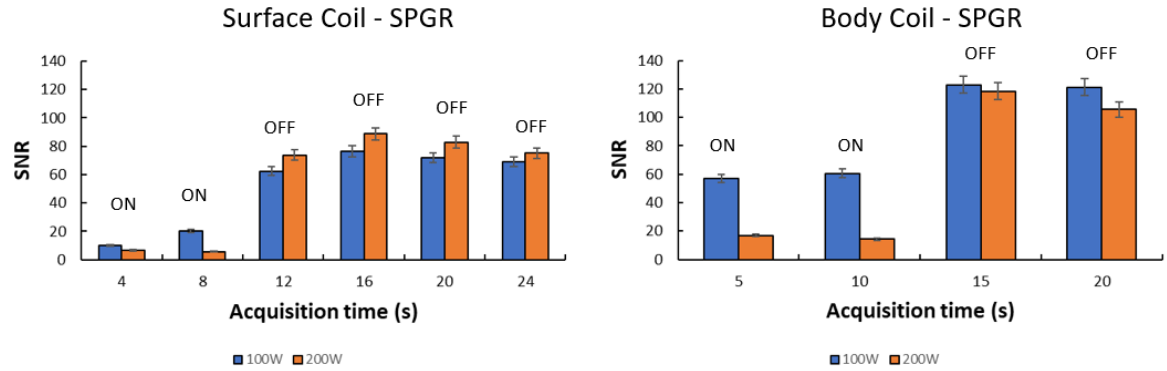


Bar chart of measured SNR (with error bars) for the various robot activation states for both electronic systems used and different pulse sequences; fast spin echo (FSE), echo planar imaging (EPI) and fast spoiled gradient-recalled echo (FSPGR).

co-funded by

MR compatibility of the robotic device (version 2)

The MR compatibility of the robotic device (version 2) was tested using two different coils, the GP FLEX coil, and the body coil. A combination of MR compatible positioners were used to increase the distance between the coils and the transducer. SNR measurements for both coils with the power of the US transducer ON and then OFF. The image acquisition was dynamic, i.e., images were acquired in succession at a specific temporal resolution while the power of the US transducer was set from ON state to OFF state.



(Left) Bar chart of SNR (with error bars) for the different acquisition times using the surface coil and a SPGR sequence, (Right) Bar chart of SNR (with error bars) for the different acquisition times using the body coil and a SPGR sequence. Both power settings (100W and 200W) are displayed.

CONNECT WITH US

https://www.facebook.com/soundpet

cy.linkedin.com/in/medsonic-ltd-cyprus-288286153

www.soundpet.eu

JULY 2021

co-funded by Ευρωπαϊκή Ένωση, Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης, Κυπριακή Δημοκρατία, Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο