Project Acronym: SOUNDPET

(INTEGRATED/0918/0008)

MRI-guided Focused ultraSOUND system for cancer in PETs
(dogs and cats)

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Date: 18/04/2022

SOUNDPET Animal therapies with focused ultrasound

Ευρωπαϊκή Ένωση
Ευρωπαϊκά Διαρθρωτικά και Επενδυτικά Ταμεία

Κυπριακή Δημοκρατία

Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

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Executive summary

This deliverable presents the conference papers that were presented at project-related scientific conferences during the second year of the SOUNDPET project. The deliverable includes all submitted abstracts and indicative power point presentations. Each conference presentation acknowledges the SOUNDPET project.

List of Oral & Poster Presentations

1. M. Giannakou, N. Evripidou, A. Antoniou, C. Damianou, “Robotic device for MRgFUS applications in veterinary medicine”. *2021 International Conference on Medical Imaging Science and Technology (MIST 2021),* Virtual Conference, 1-3 December 2021, **Oral Presentation**.

2. M. Giannakou, N. Evripidou, A. Antoniou, C. Damianou, “MRI compatible robotic device for FUS therapy of canine and feline mammary tumours”. *2021 VI International Scientific Conference – INDUSTRY 4.0*, Borovets, Bulgaria, 8-11 December 2021, **Oral Presentation** (in person attendance).

3. M. Giannakou, N. Evripidou, A. Antoniou, C Damianou, “Robotic device for veterinary applications of MRgFUS”. *2021 VI International Scientific Conference – INDUSTRY 4.0,* Borovets, Bulgaria, 8-11 December 2021, **Poster Presentation (i**n person attendance**)**.

4. M. Giannakou, N. Evripidou, A. Antoniou, C. Damianou, “Robotic device for preclinical and veterinary trials of magnetic resonance guided focused ultrasound”, *Annual Integrative Ultrasound Meeting 2022 (AIUM)*, San Diego, CA, USA, 12-16 March 2022, **Oral Presentation** (in person attendance).

5. C. Damianou, A. Filippou, M. Giannakou, N. Evripidou, “Agar/Wood-powder Phantom Mimicking Breast Tissue in Magnetic Resonance guided Focused Ultrasound Applications”, *Annual Integrative Ultrasound Meeting 2022 (AIUM)*, San Diego, CA, USA, 12-16 March 2022, **Oral Presentation** (in person attendance.).

6. A. Georgiou, N. Evripidou, A. Antoniou, I. Demetriades, C. Messios, C. Damianou, “Algorithm for path planning in MRgFUS therapy”, *21st Annual International Symposium for Therapeutic Ultrasound (ISTU 2022)*, Toronto, Canada, USA, 07-10 June 2022, **Poster Presentation (**in person attendance**)**.

7. A. Filippou, M. Giannakou, N. Evripidou, A. Antoniou, C. Damianou, “Agar/Wood-powder Breast Phantom for Focused Ultrasound Applications”, *21st Annual International Symposium for Therapeutic Ultrasound (ISTU 2022)*, Toronto, Canada, USA, 07-10 June 2022, **Poster Presentation (**in person attendance**)**.

8. M. Giannakou, N. Evripidou, A. Antoniou, C Damianou, “Robotic Device For Preclinical and Veterinary Trials Of Focused Ultrasound”, *21st Annual International Symposium for Therapeutic Ultrasound (ISTU 2022)*, Toronto, Canada, USA, 07-10 June 2022, **Poster Presentation** (in person attendance**)**.

Submitted Abstracts

MIST 2021, Virtual Conference, 1-3 December 2021, Oral Presentation.

Robotic device for MRgFUS applications in veterinary medicine

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Abstract. Magnetic Resonance guided Focused Ultrasound (MRgFUS) constitutes an emerging non-invasive therapeutic modality in modern oncology. Since application of this technology in veterinary medicine contributes to optimizing therapeutic protocols and more rapidly translating research into clinical practice, a robotic device intended for veterinary MRgFUS has been developed. The device comprises a positioning mechanism dedicated to navigating a single element spherically focused transducer operating between 1-3 MHz in four PC-controlled axes. All the motion stages are actuated by piezoelectric motors, whereas two optical encoder setups are arranged on each stage, thus providing precise position estimates. Sufficient accuracy and repeatability of motion were demonstrated through caliper-based and Magnetic Resonance Imaging (MRI) techniques, with an estimated mean positioning error smaller than 0.1 mm. Highly accurate motion was also confirmed through visual examination by performing multiple ablations on a plastic film. For MR compatibility assessment, quantitative evaluation was performed by calculating the signal-to-noise ratio during device activation in a 1.5 T scanner using an in-house phantom, as well as through a more comprehensive approach of quality assurance and a series of specialized tests. The system was proven safe for operation inside the scanner without significantly affecting the overall image quality. Due to its compact and simple design, it is easily transportable, ergonomic, and suitable for integration into the bore of up to 7T MRI scanners. Upon veterinary validation, the developed system could be easily translated into clinical medicine for treating abdominal cancer in humans with minimal design modification.

Keywords: MRgFUS, robotic device, veterinary medicine

MRI compatible robotic device for FUS therapy of canine and feline mammary tumours

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Abstract: Veterinary medicine has expanded its applications beyond traditional approaches, increasingly incorporating the Focused Ultrasound (FUS) technology in veterinary oncology. A robotic device that comprises a positioning mechanism for navigating a single element spherically focused transducer in four PC-controlled axes has been developed for veterinary FUS applications. Motion is established using piezoelectric motors and monitored by dual optical encoder setups. Sufficient accuracy and repeatability of motion were demonstrated through benchtop and Magnetic Resonance Imaging (MRI) techniques, with an estimated mean positioning error smaller than 0.1 mm. The system was proven safe for operation inside conventional MRI scanners with minimal effect on the overall image quality. Efficient performance of the system was initially validated through extensive ex-vivo studies in tissue-mimicking phantoms and excised tissue. The prototype was then evaluated for its ability to precisely ablate naturally occurring mammary tumours in dogs and cats (n=3). Histological examination with hematoxylin and eosin staining demonstrated well-defined areas of coagulative necrosis in the exposed tumours. No adverse events compromising animal welfare were recorded. Overall, FUS ablation of pet mammary cancer under proper monitoring was proven safe and feasible. Application of this technology in veterinary medicine may help advance knowledge of the analogous human disease, optimize therapeutic protocols, and more rapidly translate research into clinical practice.

Keywords: FUS, MRI compatible robotic device, mammary tumours, dogs, cats

INDUSTRY 4.0, Borovets, Bulgaria, 8-11 December 2021, Oral Presentation

Robotic device for veterinary applications of MRgFUS

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Abstract: Given the current popularity of Magnetic Resonance guided Focused Ultrasound (MRgFUS) as a promising non-invasive therapeutic modality in modern oncology, a robotic system intended for MRgFUS applications in veterinary medicine has been developed. The positioning mechanism comprises four PC-controlled motion stages dedicated to navigating a single element spherically focused transducer with an operating frequency of 1-3 MHz. The motion in each axis is actuated by a piezoelectric motor and accurately monitored by two optical encoder setups. Experiments carried out in the benchtop setting using a caliper-based method demonstrated highly accurate motion with a mean positioning error smaller than 0.1 mm. Sufficient accuracy and repeatability of motion have also been verified through Magnetic Resonance Imaging (MRI) studies, as well as through visual assessment by performing multiple ablations on a plastic film. In addition, the system was proven MR compatible through a series of specialized quality assurance tests in a 1.5 T MRI scanner and capable of operating inside the scanner without significant effects on the image quality. Its compact design where all the mechanical parts are included in a single enclosure makes it portable and suitable for use in any conventional MRI scanner of up to 7 T field strength. Application of this technology in veterinary medicine will contribute towards optimizing therapeutic protocols and may also provide insights into the analogous human disease. Veterinary validation of the system may lead to its clinical adoption to be used in the treatment of abdominal cancer upon minimal design modification.

Keywords: robotic device, veterinary medicine, MRgFUS

AIUM 2022, San Diego, CA, USA, 12-16 March 2022, Oral Presentation

Agar/Wood-powder Phantom Mimicking Breast Tissue in Magnetic Resonance guided Focused Ultrasound Applications

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ABSTRACT

Objectives

Magnetic Resonance guided Focused Ultrasound (MRgFUS) has emerged in human medicine as an alternative non-invasive therapeutic solution for a wide range of oncological applications. High-quality Tissue Mimicking Materials (TMMs) serve as a valuable tool in the process of evaluating emerging MRgFUS applications. Herein, the main objective was to develop an agar-based phantom doped with wood-powder capable of mimicking breast tissue in MRgFUS applications. Accordingly, this work aimed at investigating the suitability of wood-powder as a cost-effective alternative to other added materials that have been widely suggested for controlling the ultrasonic properties of TMMs.

Methods

A breast mold was manufactured on a rapid prototyping machine to enable development of a phantom with the shape of real breast. A series of experiments were conducted to estimate the acoustic (attenuation coefficient, absorption coefficient, propagation speed, and impedance), thermal (conductivity, diffusivity, and specific heat capacity), and MR properties (T1 and T2 relaxation times) of the wood-powder doped material. The acoustic attenuation coefficient of the proposed material was measured utilizing a typical transmission through technique in the frequency range of 1–3 MHz, whereas the ultrasonic velocity was investigated utilizing a pulse-echo technique. The transient thermoelectric method was followed for estimating acoustic absorption.

Results

The optimized TMM containing 2 % w/v agar and 4 % w/v wood-powder demonstrated tissue like visibility in MRI. The estimated attenuation coefficient was close to 0.5 dB/cm.MHz and nearly proportional to frequency, whereas the acoustic absorption coefficient was about 0.35 dB/cm-MHz. It was also proven that the addition of wood-powder enhances acoustic absorption. The material possessed an acoustic impedance of 1.6 MRayl. The estimated propagation speed of 1487 m/s is close to that of soft tissue at room temperature. The thermal conductivity of the material was estimated at

0.5 W/m.K. Regarding MR properties, the longitudinal (T1) and transverse (T2) relaxation times were 844 and 66 ms, respectively. These values are within the range of values reported in the literature for soft tissue.

Conclusions

Overall, the TMM matched critical acoustic, thermal, and MR properties of human tissues adequately. Accordingly, the results propose that wood-powder could serve as a cost-effective modifier of critical properties of agar-based phantoms intended for MRgFUS applications. Additionally, experiments using MR thermometry demonstrated the usefulness of this phantom to evaluate ultrasonic thermal protocols.

AIUM 2022, San Diego, CA, USA, 12-16 March 2022, Oral Presentation

Robotic Device For Preclinical And Veterinary Trials Of Magnetic Resonance Guided Focused Ultrasound

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ABSTRACT

Objectives

Magnetic Resonance guided Focused Ultrasound (MRgFUS) has been demonstrated efficient in the treatment of numerous oncological diseases. Recently, the technology has been applied in veterinary oncology offering alternative therapeutic solutions to family pets, simultaneously influencing the advancement of human therapeutics. Accordingly, this study aimed at the development of an MRgFUS robotic system suitable for preclinical studies in tissue mimicking phantoms (TMPs), freshly excised tissue, and small animal models, as well as for veterinary applications in companion animals.

Methods

A prototype robotic system has been manufactured on a rapid prototyping machine to be used for preclinical and veterinary applications. The system employs a single element spherically focused transducer with an operating frequency in the range of 1-3 MHz. The system comprises a positioning mechanism dedicated to navigating the FUS transducer in four PC-controlled axes. Motion in all axes is established using piezoelectric actuators, whereas motion feedback is provided by optical encoders. Advantageously, all the mechanical parts were compactly contained into a single enclosure enabling the creation of a lightweight, simply transportable, and ergonomic device. The performance of the developed robotic system was evaluated in terms of MR compatibility, positioning accuracy, and temperature evolution during high intensity FUS exposures by both benchtop and MRI techniques. Specifically, the accuracy and repeatability of motion were evaluated quantitatively by caliper-based and MRI methods, as well as visually by performing multiple ablations on a plastic film. MR compatibility of the system was assessed through a series of specialized quality assurance tests in a 1.5 T MRI scanner. FUS exposures were conducted with varying sonication parameters to test the thermal heating effects of the FUS system. Finally, the *in vivo* efficacy of the developed therapeutic system and FUS protocol was evaluated utilizing a rabbit thigh model.

Results

Sufficient accuracy and repeatability of motion were demonstrated. The FUS transducer can be robotically moved in all four axes with a mean positioning error smaller than 0.1 mm. Notably, the spatial positioning errors estimated by MRI were defined by the size of the imaging pixels. Highly accurate motion was also confirmed by equally spaced lesions that were created on the plastic film following ablation in discrete patterns. In addition, the system was proven safe for operation in an MR environment exhibiting minimal effect on the quality of MR thermometry. Thermal lesions arranged in discrete and overlapping patterns were successfully inflicted in freshly excised tissue depending on the selected sonication parameters. Regarding *in vivo* validation, well-defined areas of coagulative necrosis were produced on rabbit tissue, without destructing healthy tissues. Remarkably, no adverse events compromising animal welfare were recorded.

Conclusions

In conclusion, a compact and ergonomic robotic device has been developed and validated through extensive preclinical studies. Benchtop and MRI experiments proved that the device maintains high standards of motion accuracy. Operation of the device in the MR scanner does not compromise the quality of MR imaging. *In vivo* FUS ablation in rabbits was proven safe and feasible when performed under proper monitoring. Future actions include validation of the device in pets. Veterinary practices will contribute to optimizing therapeutic protocols and may also provide insights into analogous human diseases. Accordingly, veterinary validation of the system may allow its clinical translation to be used in the treatment of abdominal cancer upon minor modifications.

Algorithm for path planning in MRgFUS therapy

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ABSTRACT

Objectives

This study concerns the development of a full coverage path planning algorithm for Magnetic Resonance guided focused Ultrasound (MRgFUS) therapy.

Methods

The algorithm implements five basic subprocesses starting from the segmentation stage that requires the indication of initial points by the user to the extraction of the transducer's path for full ablation of two-dimensional regions of interest (ROIs) following a Zig-Zag pathway. The developed algorithm was implemented in the software of an MRgFUS device. Its performance in path planning was evaluated on medical images, whereas the planned sonication paths were executed on acrylic films.

Results

Path planning on MR images was successfully implemented. The output motion vectors were successively sent to and executed by the driving system of the MRgFUS device using a 2.75 MHz single element transducer. The motion step between adjacent sonications was adjusted by the user resulting in the formation of both discrete and overlapping lesions on the films. Perfect match was observed between the segmented ROIs and experimental lesions formed on the acrylic films. In this regard, proper communication between software and hardware was also demonstrated.

Conclusions

Plastic films constitute cheap phantoms for quality assurance of FUS equipment. The software as integrated with the MRgFUS system provides accurate planning and execution of ablation for any segmented two-dimensional ROI. The development of a fully automated segmentation procedure would be a key improvement in enhancing the algorithm's reliability.

Agar/Wood-powder Breast Phantom for Focused Ultrasound Applications

Antria Filippou,[a] Marinos Giannakou,[b] Nikolas Evripidou,[a] Anastasia Antoniou, Christakis Damianou[a*]

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ABSTRACT

Objectives

The main objective was to develop an agar-based phantom doped with wood-powder capable of mimicking breast tissue in Magnetic Resonance guided Focused Ultrasound (MRgFUS) applications.

Methods

A tissue mimicking phantom (TMM) containing 2 % w/v agar and 4 % w/v wood powder was developed with the shape of real breast. A series of experiments were conducted to estimate the acoustic, thermal, and MR properties of the wood-powder doped material. The acoustic attenuation coefficient was measured utilizing a typical transmission through technique in the frequency range of 1–3 MHz, whereas the ultrasonic velocity was investigated utilizing a pulse-echo technique.

Results

The TMM demonstrated tissue like visibility in MRI. The estimated attenuation coefficient was close to 0.5 dB/cm.MHz and nearly proportional to frequency, whereas the acoustic absorption was about 0.35 dB/cm-MHz. It was also proven that the addition of wood-powder enhances acoustic absorption. The estimated propagation speed of 1487 m/s is close to that of soft tissue at room temperature. The thermal conductivity of the material was estimated at 0.5 W/m.K. Regarding MR properties, the T1 and T2 relaxation times were 844 and 66 ms, respectively. These values are within the range of values reported in the literature for soft tissue.

Conclusions

Overall, the TMM matched critical acoustic, thermal, and MR properties of human tissues adequately. Therefore, wood-powder could serve as a cost-effective modifier of critical properties of agar-based phantoms intended for MRgFUS applications. Furthermore, experiments using MR thermometry demonstrated the usefulness of this phantom to evaluate ultrasonic thermal protocols.

Robotic Device For Preclinical and Veterinary Trials Of Focused Ultrasound

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ABSTRACT

Objectives

This study aimed at the development of a Magnetic Resonance guided Focused Ultrasound (MRgFUS) robotic system for preclinical studies and veterinary trials in companion animals.

Methods

The performance of the developed robotic system was evaluated in terms of MR compatibility, positioning accuracy, and temperature evolution during high intensity FUS exposures by both benchtop and MRI techniques. The heating effects of the transducer were assessed by sonicating freshly excised tissue with varying sonication parameters. Finally, the *in vivo* efficacy of the developed system and therapeutic protocol was assessed utilizing a rabbit thigh model.

Results

Sufficient accuracy and repeatability of motion were demonstrated through benchtop and MRI techniques. The FUS transducer can be robotically moved in all four axes with a mean positioning error smaller than 0.1 mm. In addition, the system was proven safe for operation in an MR environment exhibiting minimal effect on the quality of MR thermometry. Discrete and overlapping thermal lesions were successfully inflicted in freshly excised tissue depending on the selected sonication parameters. Regarding *in vivo* validation, well-defined areas of coagulative necrosis were produced on rabbit tissue, without destructing healthy tissues. Remarkably, no adverse events compromising animal welfare were recorded.

Conclusions

In conclusion, a compact and ergonomic robotic device has been developed and validated through extensive preclinical studies. *In vivo* FUS ablation in rabbits was proven safe and feasible when performed under proper monitoring. Future actions include validation of the device in pets.

Acknowledgements

Each conference presentation acknowledged that the relevant study was funded by the Research and Innovation foundation (RIF) of Cyprus under the project SOUNDPET (INTEGRATED/0918/0008).

Indicative Power point Oral Presentation

VI INTERNATIONAL SCIENTIFIC CONFERENCE - WINTER SESSION

INDUSTRY 4.0

08 -11.12.2021, BOROVETS, HOTEL ELA

MRI compatible robotic device for FUS therapy of canine and feline mammary tumours

Marinos Giannakou, Nikolas Evripidou, Anastasia Antoniou, *Christakis Damianou**

Department of Electrical engineering, Computer engineering and Informatics

Cyprus University of Technology

**Corresponding author*

ROBOTIC DEVICE

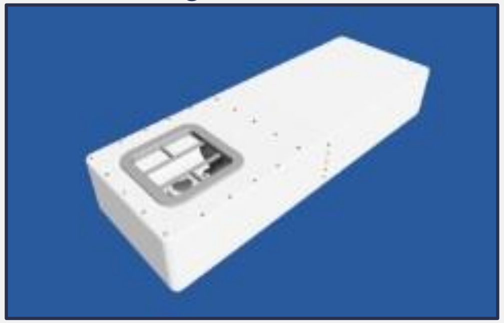
Intended Use :

Magnetic Resonance Guided Focused Ultrasound (MRgFUS) treatment of mammary cancer in pets (dogs and cats).

Main features :

- ❑ 3D printed (F270, Stratasys, USA)
- ❑ Four PC controlled motion stages
- ❑ Dimensions : 71 cm (L) x 25 cm (W) x 11.5 cm (H)
- ❑ MRI compatible
- ❑ Integrated into the MRI bed

CAD drawing of robotic device



Device integrated in MRI bed

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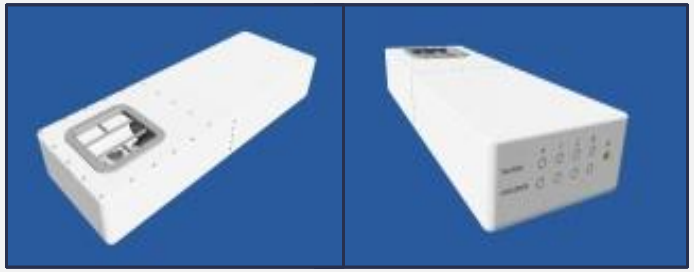
ROBOTIC DEVICE

CAD drawings of device



Principle of motion :

- ❑ Actuated by <u>piezoelectric motors</u> (USR 60-S3, Japan).
- ❑ Controlled with dual <u>optical encoders</u> (US Digital Corporation, USA).

CAD drawing of transducer

FUS system :

- ❑ Single element FUS transducer with frequency of <u>1-3 MHz</u>.
- ❑ Manufactured with <u>non-magnetic materials</u>.

MRI COMPATIBILITY

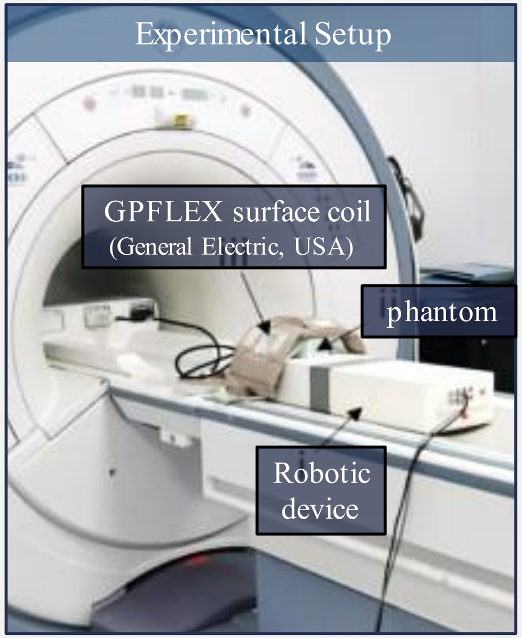
Signal to noise ratio (SNR) method:

- ❑ Device placed in 1.5 T MRI system (Signa, General Electric, USA).
- ❑ Phantom scanned at different activation states of system.
- ❑ Use of different sequences:

  Fast Spin Echo (FSE)

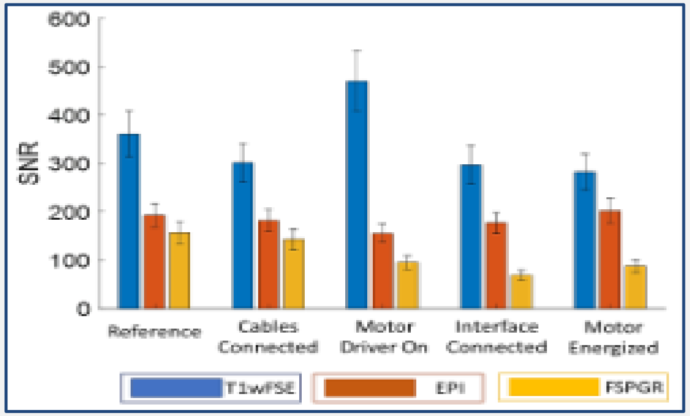
  Fast Spoiled Gradient (FSPGR)

  Echo Planar Imaging (EPI)



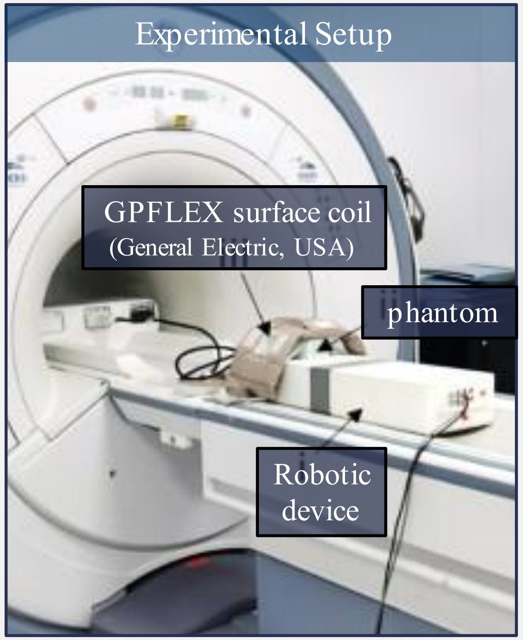
MRI COMPATIBILITY

Signal to noise ratio (SNR) method:



- ❑ Noticeable SNR reduction of FSPGR images.
- ❑ Image quality of FSE and EPI images is not affected significantly.

⇒ MR thermometry can be performed properly.



MOTION ACCURACY

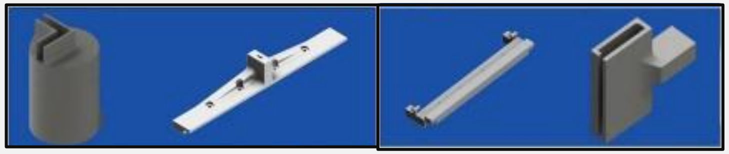
Caliper -based method:

- ❑ Digital calipers mounted on motion stages using special structures.
- ❑ Bidirectional motion steps commanded through software.
- ❑ Analogous incremental distance of caliper measured.

⇒ **Maximum positioning error ~ 0.1 mm.**

Experimental Setup

3D printed special structures



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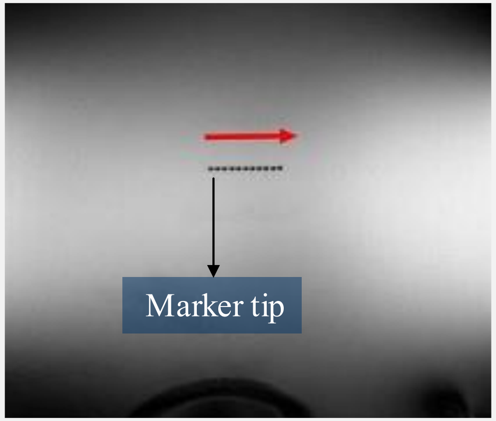
MOTION ACCURACY

Experimental Setup

MRI method:

- ❑ System placed in 1.5 T MRI scanner.
- ❑ FUS transducer replaced by plastic marker.
- ❑ Bidirectional motion steps performed.
- ❑ FSE images acquired to identify the marker tip location after each step.
- ❑ FSE images superimposed onto one image.



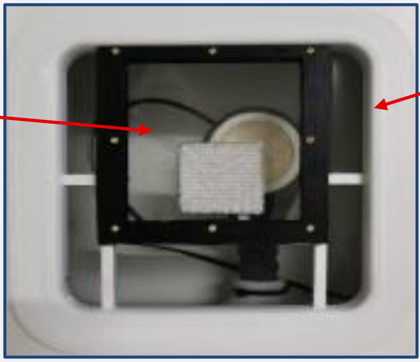
- ❖ **Excellent repeatability evidenced by equally spaced spots.**
- ❖ Minimum error defined by the size of imaging pixels .

MOTION ACCURACY

Visual method :

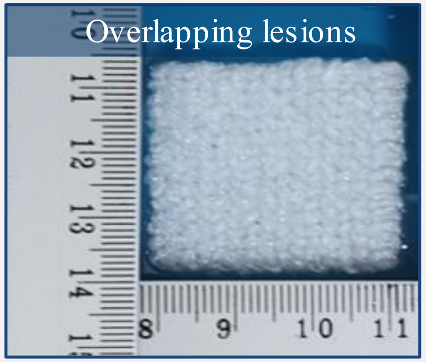
- ❑ Multiple ablations on plastic film.
- ❑ Grid operation with varying parameters.

Plastic film



Acoustic opening

- ❑ Discrete and overlapping lesions formed.
- ❑ High accuracy of motion and alignment demonstrated.

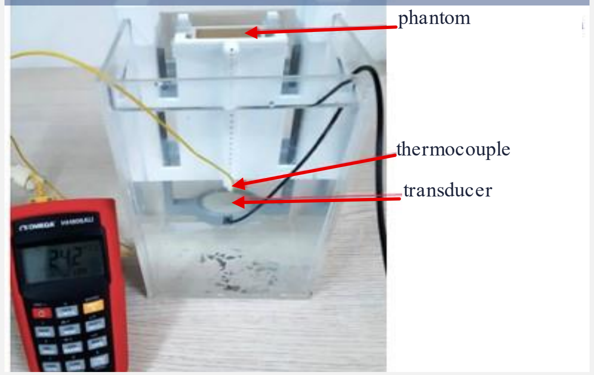


HEATING EFFECTS OF TRANSDUCER

High power sonication :

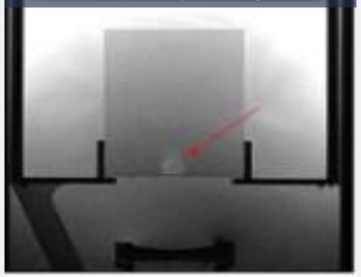
- **In Tissue mimicking phantom**
- Temperature change (ΔT) measured using thermocouple (5SC-TT-K-30-36, Omega Engineering, Connecticut, USA).

Experimental Setup

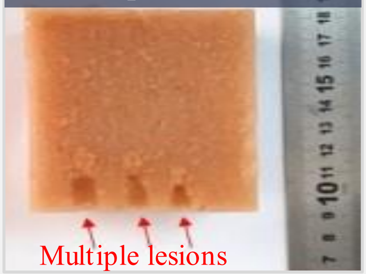


- ΔT of 63°C achieved by applying acoustic energy of 44 W for 30 s.

Post-sonication Proton Density image



Cross-sectioned phantom



HEATING EFFECTS OF TRANSDUCER

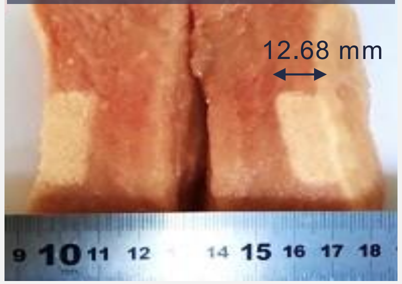
High power sonication

- In **Freshly Excisedtissue**
- Transducer moved in grid patterns.
- Different sonication protocols used.

- Discrete and Overlapping lesions created.
  - Example of Overlapping lesions
  - *Grid:* 3 x 3 with 10 mm step
  - *Sonication:* 55 W for 30 s

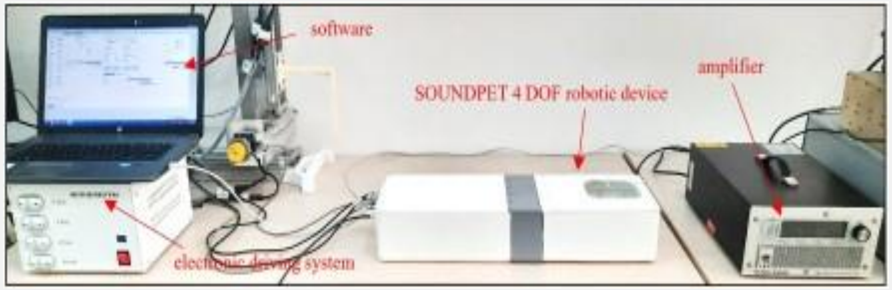
Photo of formed lesion

Vertically Dissected tissue



IN VIVO EVALUATION

- ❑ **Safety assessment in rabbits**
- ❑ Multiple ablations by robotic motion in grid patterns.



❖ All experiments approved by authorities of the Veterinary Services, Ministry of Agriculture (CY/EXP/PR .L01/2020).

- ❑ Lesions formed.

Sonication: 75 W for 5 s

Discrete lesions	Overlapping Lesions
1 x 3 grid, 10 mm step	5 x 5 grid, 5 mm step

- ❑ In vivo safety validated.

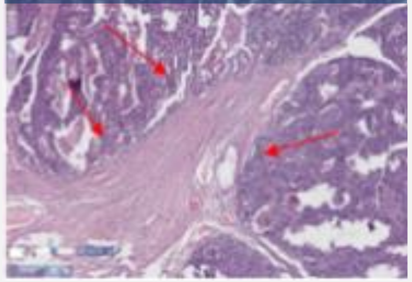
IN VIVO EVALUATION

Evaluation in pets: dogs and cats

- ❑ Pets with superficial mammary tumours treated.
  - ❑ Tumour ablation using high power sonication .
- ❑ Tumour dissected by surgery.
- ❑ Analyzed by hematoxylin and eosin staining for assessing effects of FUS therapy.

Dog placed on device

Histological Slide



Conclusions :

- ❑ MRgFUS robotic system developed.
  - ❑ Treatment of pet mammary cancer.
  - ❑ Compact, Portable & Ergonomic.
- ❑ Safely integrated with conventional MR scanners.
- ❑ Highly accurate motion demonstrated.
- ❑ In vivo Safety & Efficiency demonstrated by initial animal/pet studies.
- ❖ Size modification for future clinical use in abdominal cancer.

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ACKNOWLEDGEMENTS

Indicative Power point Poster Presentation

ROBOTIC DEVICE FOR VETERINARY APPLICATIONS OF MRGFUS

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OBJECTIVES

A robotic device was developed that can be used for veterinary applications.

METHODS

A single element spherically focused transducer of 5 cm diameter, focusing at 10 cm and operating at 1.1 MHz was used. The positioning device incorporates only MRI compatible materials. The propagation of ultrasound is a bottom to top approach. The robotic system includes 3 linear axes and 1 angular axis.

Figure 1: Schematic of the robotic system embedded in the MRI Bed.

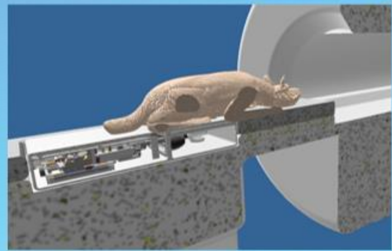

Figure 2: Schematic of a dog placed in prone position on the robotic system (cross section)

Figure 3: Electronic system that controls the robotic device.

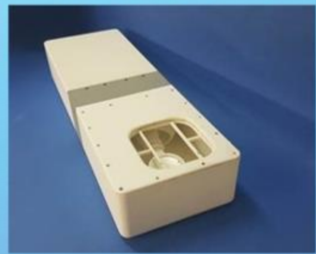

Figure 4: Photo of the developed robotic robotic device (front view).

Figure 5: Photo of the developed robotic device (rear view).

RESULTS

The system was tested successfully in agar/silica/evaporated milk phantom for various tasks such as MR compatibility, motion accuracy and functionality.

CONCLUSIONS

This positioning device has the potential to be marketed as a cost effective solution for performing experiments in small animals. With minimum changes the positioning device can be converted into a device for performing interventions with focused ultrasound in humans.

ACKNOWLEDGE

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