

Magnetic Resonance Imaging (MRI)を用いた動物のイメージング (講義)
Introduction to magnetic resonance imaging (MRI) in animals (Lecture in Japanese)

山田 篤史 (創発的研究センター・先端医療研究開発部門)

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本講義では、Magnetic Resonance Imaging (MRI) の撮影原理を説明する。そして、MRI の操作方法や撮影シーケンスの種類、それによる撮影画像の違いを具体的に説明する。また、医用画像処理ソフトでの MRI 画像の取り扱いについて説明する。MRI 画像の応用例として、術前・術中 MRI 画像を用いた治療法の説明や、画像誘導手術などを紹介する。

This lecture will teach us about magnetic resonance imaging (MRI) and how it works. We'll also explore the specific operations involved in using an MRI scanner, various scan sequences, and image differences by their scan sequences. Image operations using medical image processing software are explained as working examples after scanning. Furthermore, medical applications using MRI images are introduced, including preoperative and intraoperative imaging and image-guided surgeries.

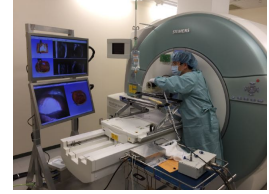
Introduction to Magnetic Resonance Imaging (MRI) in animals

Atsushi Yamada, PhD
Specially Appointed Associate Professor
Advanced Medical Research and Development Division
Medical Innovation Research Center

Sep 13/2023

Topics

- MRI in animal experiments
- Post-processing software
- Research for image-guided therapies



#1 Magnetic resonance imaging (MRI)

MRI scanners in SUMS



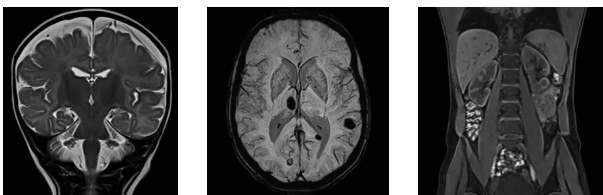
3 T MRI scanner (Verio dot, SIEMENS Healthineers)



4.7 T MRI scanner (BioSpec 47/40 USR, Bruker)

<https://www.bruker.com/ja/products-and-solutions/preclinical-imaging/mri/biospec/biospec-47-40.html>

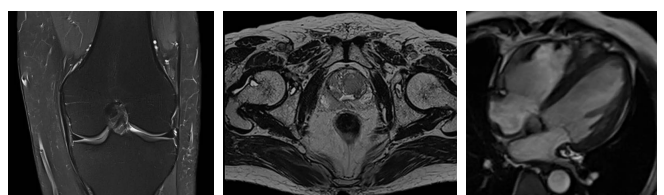
MRI images



Verio dot 3T, Siemens Healthineers

<https://www.siemens-healthineers.com/en-us/magnetic-resonance-imaging/3t-mri-scanner/magnetom-verio>

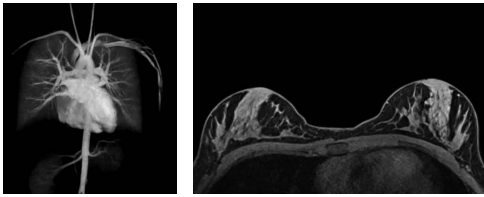
MRI images



Verio dot 3T, Siemens Healthineers

<https://www.siemens-healthineers.com/en-us/magnetic-resonance-imaging/3t-mri-scanner/magnetom-verio>

MRI images



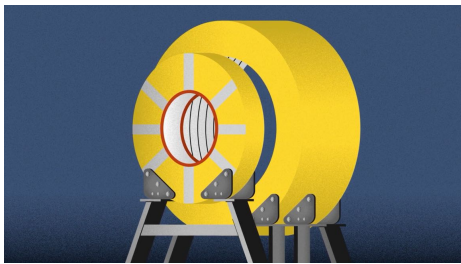
Verio dot 3T, Siemens Healthineers
<https://www.siemens-healthineers.com/en-us/magnetic-resonance-imaging/3t-mri-scanners/magnetom-verio>

Imaging mechanism



Dr. Paulien Moysaert, How does an MRI works? | MRI basics explained | Animation
<https://www.youtube.com/watch?v=FvOetML98U>

Imaging mechanism



Science Museum, How does an MRI machine work?
<https://www.youtube.com/watch?v=vFK8tUjYnLw>

#2 MRI scanner



MRI scanner types



Verio dot 3T, Siemens Healthineers
 Picture: 3T MRI room, Shiga University of Medical Science
Closed bore type
 3T

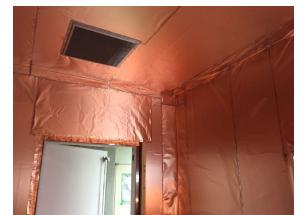
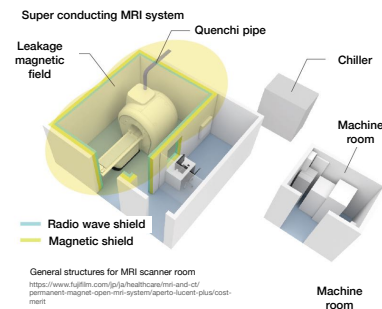


APERTO Lucent Plus, FUJIFILM Corp.
<https://www.fujifilm.com/jp/ja/healthcare/mri-and-ct/permanent-magnet-open-mri-system/aperto-lucent-plus/overview>
Horizontal open-bore type
 0.4T



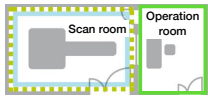
Signa SP12, GE HealthCare
 Picture: Interventional MRI room, Shiga University of Medical Science Hospital
Vertical open-bore type
 0.5T

Scanner room



Magnetic shield
 Picture: 3T MRI room (at the time of under construction) in Shiga University of Medical Science

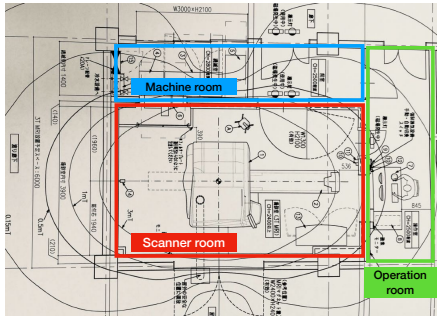
Magnetic field



- Radio wave shield
- Magnetic shield

5 gauss line (0.5mT): magnetic impact

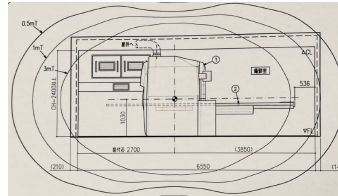
MRI keeps generating a magnetic field 365 days a year.



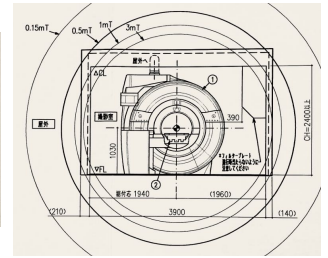
Room design: 3T MRI room in Shiga University of Medical Science

Magnetic field

5-gauss line (0.5mT)



Room design: 3T MRI room in Shiga University of Medical Science



Room design: 3T MRI room in Shiga University of Medical Science

Common dangerous accidents

Magnetic materials in scanner room



Playing with MRI before quenching 2019
<https://www.youtube.com/watch?v=FFCMyGN48s-26s>



Dangers of MRI
<https://www.youtube.com/watch?v=gVtE7zJK68s-34s>

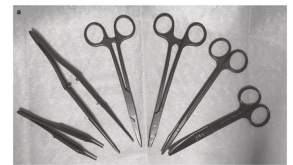
MR compatible and incompatible

Incompatible

ID cards, bank cards, pens, scissors, staplers, keys, injectors, belts, watches, smartphones, PCs, ECUs, motors, cables, SUS medical tools, energy devices, etc.

Compatible

Ultrasonic motors and MRI-compatible devices and equipment made of nonmagnetic aluminum, titanium, copper, brass, resin, etc.



Yamada A, Tokuda J, Naka S, Murakami K, Tani T, Morikawa S (2020) Magnetic resonance and ultrasound image-guided navigation system using a needle manipulator. Med Phys 47(5):850-858. <https://doi.org/10.1002/imp.13958>

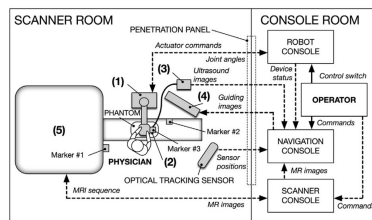
Mekata E, Yamada A, Shimagaki M, Kajiyama T, Tani T. (2021) Lightweight Carbon-Reinforced Resin Surgical Instruments. In: Takemoto S, Yasuhara H. (eds) Surgery and Operating Room Innovation. Springer, Singapore. https://doi.org/10.1007/978-981-15-8979-9_3

Penetration panels

Cable access between the scanner room and console room



Picture: 3T MRI room in Shiga University of Medical Science



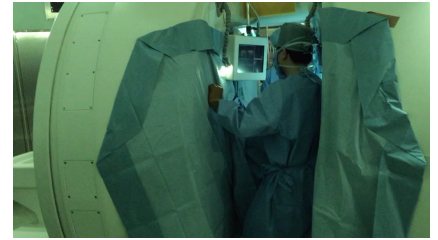
Yamada A, Tokuda J, Naka S, Murakami K, Tani T, Morikawa S (2020) Magnetic resonance and ultrasound image-guided navigation system using a needle manipulator. Med Phys 47(5):850-858. <https://doi.org/10.1002/imp.13958>

Points

- We can perform wide-categorized experiments by using MR-compatible instruments (energy devices) in the magnet room.
- We can use desktop-class systems in the magnet room by keeping them outside of the 5-gauss line inside of the room.
- We can use the ventilator or other desktop-class systems in the magnet room from the outside of the room because of using the penetration panels.

MRI + alpha: Interventional MRI Operation theater

Interventional MRI



Interventional MRI room, Shiga University of Medical Science Hospital

Scanner shutdown



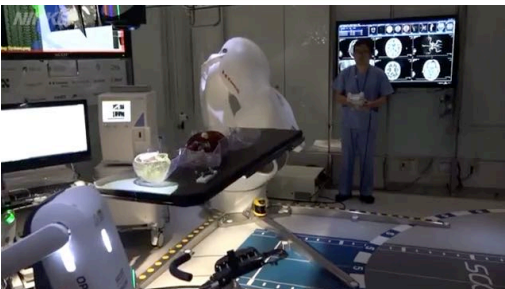
Interventional MRI room after quenching 2022, Shiga University of Medical Science Hospital

Operation theater: Operada Open



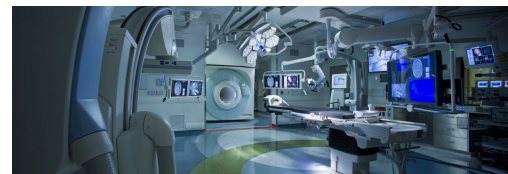
Operada Open, FUJIFILM Corp: an operation room with a horizontal open-bore MRI scanner
<https://www.fujifilm.com/jp/healthcare/surgery-support/digital-solution-for-surgery/operada-open>

Operation theater: SCOT



Nihon Keizai Shinbun Inc., Smart Cyber Operating Theater
<https://www.youtube.com/watch?v=8hUYYK4G2hw>

Operation theater: AMIGO Suite



Advanced Multimodality Image Guided Operating Suite (AMIGO Suite), Brigham and Women's Hospital, Boston
<https://www.brighamandwomens.org/research/amigo/advanced-multimodality-image-guided-operating-suite>

Operation theater: AMIGO Suite



Lengyel B, MD, Introducing the National Center for Image-Guided Therapy
<https://www.youtube.com/watch?v=DSAN8-8by2RQ>

Operation theater: Yamaguchi Univ Hospital



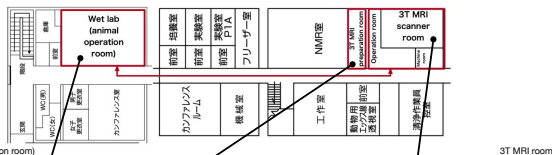
Yamaguchi univ, public relation office, Yamaguchi univ, public hospital
<https://www.youtube.com/watch?v=CCN8l8jgDTU>

#3 Scanning process for medium and large-sized animals

Animal scanning process in SUMS

1. A target animal is moved from RCALS (SUMS animal center)
2. Anesthesia is processed in the Wet lab animal operation room.
3. The animal is moved to the 3T MRI room using a plastic bed on a metal cart.
4. The animal with the plastic bed is placed in the scanner bed.
5. The anesthesia machine is set in the machine room to use the penetration panel.

Rooms for animal scanning in SUMS

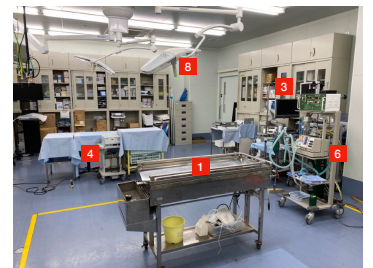


Wet lab (animal operation room)



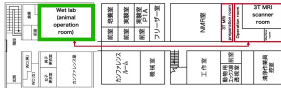
Equipments (some of items)

1. OR beds for animals
2. Resin bed for MRI
3. Cardiovascular ultrasound system (Acuson S2000, Siemens Healthcare)
4. Surgical energy devices (Acrosurg microwave scissors, electric scalpels, RF devices)
5. Endoscope systems
6. Ventilator for animals (Compose X, Metran Co., Ltd.)
7. Bed side monitor (BSM-3000, Nihon Kohden Co., Ltd.)
8. Operating lights



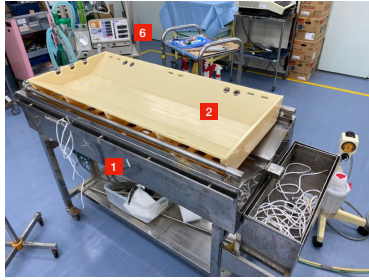
Wet lab (Animal operation room)

Wet lab (animal operation room)



Equipments (some of items)

1. OR beds for animals
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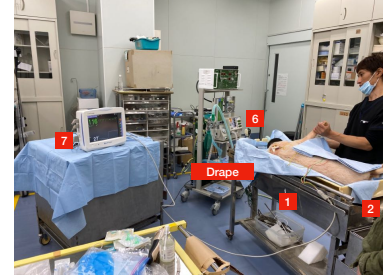
Wet lab (Animal operation room)

Wet lab (animal operation room)



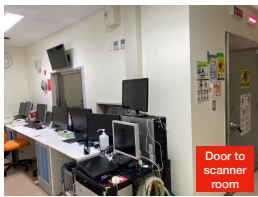
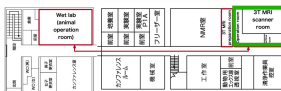
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8. Operating lights



Wet lab (Animal operation room)

3T MRI room

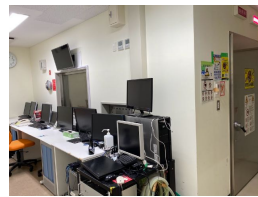


3T MRI operation room



3T MRI scanner room

3T MRI room

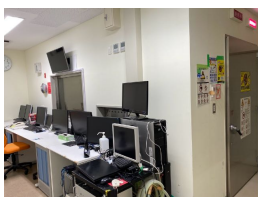


3T MRI operation room

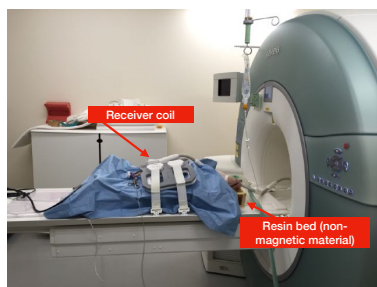


OR bed moved in front of the 3T MRI room

3T MRI room



3T MRI operation room

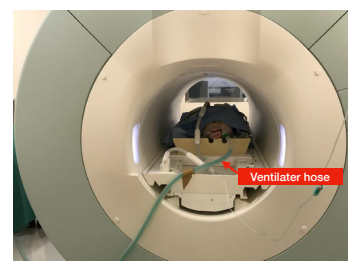


Mini pig with the resin bed on the scanner table

3T MRI room

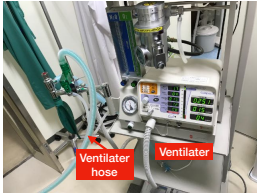
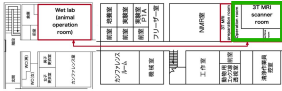


3T MRI scanner room

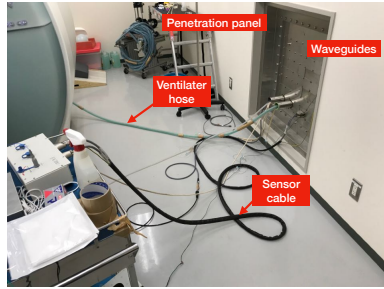


3T MRI scanner room

3T MRI room



Ventilator in the operation room



3T MRI scanner room

#4 Post-processing software

Post-processing software

3D Slicer (<https://www.slicer.org/>)

A free, open source software for visualization, processing, segmentation, registration, and analysis of medical, biomedical, and other 3D images and meshes; and planning and navigation of image-guided procedures.

ImageJ (<https://imagej.nih.gov/ij/index.html>)

Image processing and analysis in Java.

Orthanc (<https://www.orthanc-server.com/>)

Open-source, light-weight DICOM server

DCMTK (<https://www.dcmk.org/en/>)

A collection of libraries and applications implementing large parts of the DICOM standard.

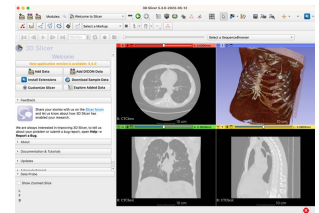
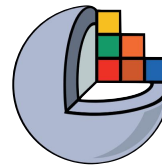
OsiriX (<https://www.osirix-viewer.com/>)

The world famous medical images viewer

3D Slicer

3D Slicer (<https://www.slicer.org/>)

A free, open source software for visualization, processing, segmentation, registration, and analysis of medical, biomedical, and other 3D images and meshes; and planning and navigation image-guided procedures.



Free open-source software

3D Slicer, OpenIGTLink, CMake, ITK, VTK, Linux etc.

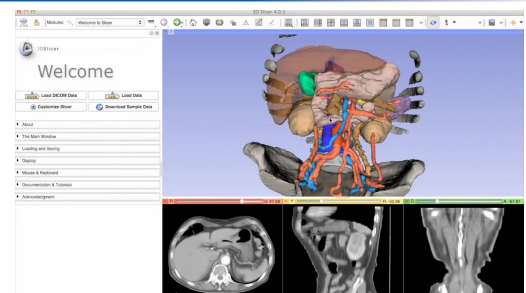


Asset value of 3D Slicer (based on development cost):

- Over one million 3D Slicer's source code lines: 2 or 3 billion yen (20~30億円!)
- VTK and ITK: over 3 billion yen
- Total: over 6 billion yen (60億円!)***

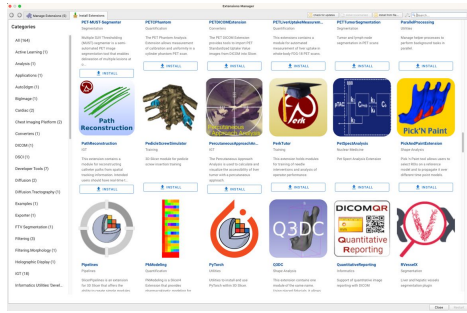
*AZE Special, 波多伸彦, 先端医用画像処理-オープンソースソフトウェアから展開する産学連携体制への期待. https://www.innvision.co.jp/suite_ws/aze/supplement/0906/frontline/index.html

About 3D Slicer



Langyei B, MD, Introducing the National Center for Image-Guided Therapy
<https://www.youtube.com/watch?v=05A9Wt8y9nQ>

Module development



Community



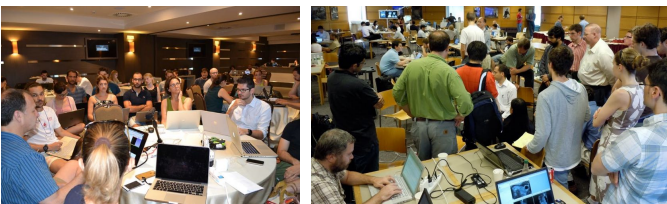
Welcome to the web page for the 39th Project Week!



This event will take place June 12-16, 2023 in Montreal, Canada.

- Project Week 39 will be a hybrid event with a strong in-person component
 - The venue for in-person events is Ecole de Technologie Supérieure, Montreal, Canada.
- If you have any questions, you can contact the organizers.

NA-MIC Project Weeks



NA-MIC Project Weeks



2014 Project Week: Percutaneous Approach Analysis

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- Permanent link
- Page information
- Cite this page

Key Investigators

- Atsushi Yamada (Shiga University of Medical Science, Japan, ayamada@shiga-u.ac.jp)
- Junichi Takada (SMU)
- Kazuo Moriyasu (SMU, Shiga University of Medical Science, Japan)

Project Description

Objective

- The goal of the web program is to display pathlines to a target frame, avoiding anatomical structures including arteries and other organs and to use these pathlines for planning.
- The goal of this project is to implement the function to link up generatively, smoothly pathlines (short distance, small offset) and to only from calculated pathline candidates.

Approach, Plan

- Implement function to display maximum and minimum weight paths
- Implement function to display maximum and minimum offset paths
- The logic

Progress

- Created this page (1/6)
- Fixed GitHub repository: "Percutaneous Path Designer"
- Implemented planning part (1/6)
- Implemented weight path calculation part (1/6)
- Planning completed
- Set a target point, obstacle, radius of insertion operation
- Offset the path candidates with calculation as we use
- Search one path from the path candidates by using the offset method
- Find a nearby insertion point obtained by extending the tip of the selected nearby path candidate

NA-MIC Project Weeks



2014 Project Week: EndoscopeConsole

Jump to: Navigation, search

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Key Investigators

- Atsushi Yamada (Shiga University of Medical Science, Japan, ayamada@shiga-u.ac.jp)
- Junichi Takada (SMU)
- Laurent Chénay (SMU)

Project Description

Objective

- Reimplemented OpenCV module as shared module
- Develop the base module for our MRI compatible endoscope project

Approach, Plan

- Create a shared OpenCV module and installer
- Use CMake to refresh the captured video image
- Display the video image in 3D view pane of Slicer UI

Progress

- Created this page (1/6)
- Fixed GitHub repository: "EndoscopeConsole Module"
- Implemented OpenCV module and installer by using SlicerBuild (1/6)
- Checked Slicer video system configuration including alignment and endoscope with Junichi and Andrieu (1/6)
- Prepared an image overlay by copying the video frame into the background of 3D viewer in Slicer (1/6)

3D Slicer

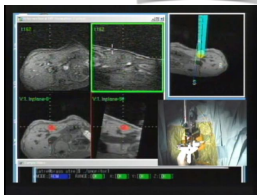
<https://www.slicer.org>

#5 Research examples

#5-1 Interventional MRI

Microwave Ablation with Robot System

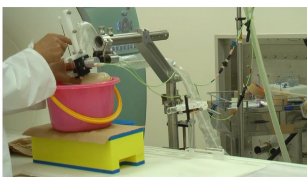
- One surgeon was replaced with a motorized MR-compatible manipulator at the assistant position
- The manipulator guided a needle path
- Applied to 23 clinical cases for MR-guided microwave ablation of liver tumor



#5-2 MR and ultrasound image-guided navigation system using a needle manipulator

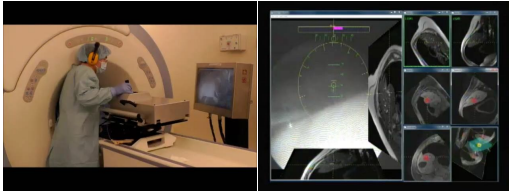
Targeting Procedure

- Decide the needle path to the target by cooperative physician-device interaction
- **Insert the needle while observing MR/US fusion images**



#5-3 Real-time MRI navigation system

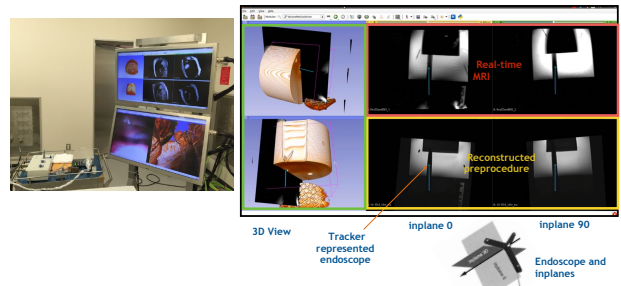
Previous System



Problems

- Fiberscope (low resolution)
- 1.5T closed bore MRI scanner (55cm Inner Diameter)
- Low refresh rate of real-time MRI (1.5 sec/slice)

Real-time MR Navi User Interface



Animal Study

Pig (female, BW 32kg)

4 Surgeons + 1 Engineering Researcher

