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Cross-modality frame alignment for surgical robot electrode insertion

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We use this protocol and it's working

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Disclaimer

The **protocols.io** team notes that research involving animals and humans must be conducted according to internationally-accepted standards and should always have prior approval from an Institutional Ethics Committee or Board.

Abstract

Scanners for animals often use different image orientations as in clinical scanners. Multi-modal imaging further introduces shifts between images since the animal cannot be placed in the exact same position in the field of view. This necessitates a cross-modality registration step. This protocol details step by step how to use stereotaxic frame features to align (or coregister) monkey head CT and MR images in a clinical **ROSA ONE Brain robot** (**website link**), in preparation for electrode insertion planning.

Protocol detailing scanning parameters for non-human primates using the 3D printed MR-compatible stereotaxic frame (**and critical steps to visualize ear bars for registration**) can be found here: **dx.doi.org/10.17504/protocols.io.q26g7p7rkgwz/v1**

The computer-aided design files and engineering drawings for the frame used in this protocol are publicly available, with the modular design allowing for low cost and manageable manufacturing.
You can find it here: https://github.com/SchaefferLab/Macaque-Stereotax

This protocol is supplementary to the manuscript:
Liang, L., Zimmermann Rollin, I., Alikaya, A., Ho, J.C., Santini, T., Bostan, A.C., Schwerdt, H.N., Stauffer, W.R., Ibrahim, T.S., Pirondini, E., Schaeffer, D.J., 2024. An open-source MRI compatible frame for multimodal presurgical mapping in macaque and capuchin monkeys. *BioRxiv* https://doi.org/10.1101/2024.02.17.580767

Materials

- Imaging of the same animal acquired in the 3D printed stereotaxic frame:

Note: images need to be in DICOM format, and must have a DICOMDIR, to be read correctly by the software

- CT:

* implant 3-5 titanium screws (ex. KLS Martin 25-975-04-09, level one neuro screw) on the skull of the animal on different planes before scan. These will be used by the robot to register the robot coordinate space to the animal's skull.

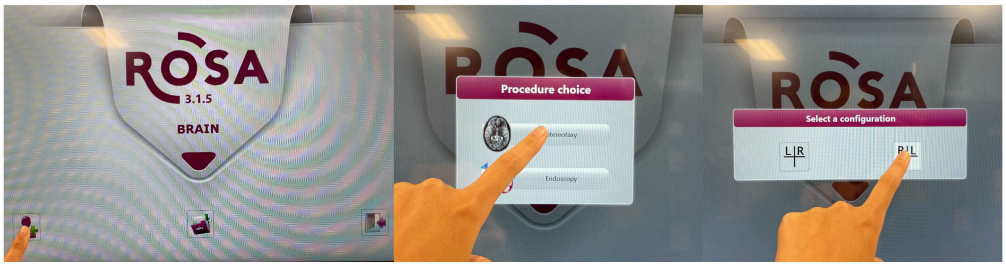
- MRI

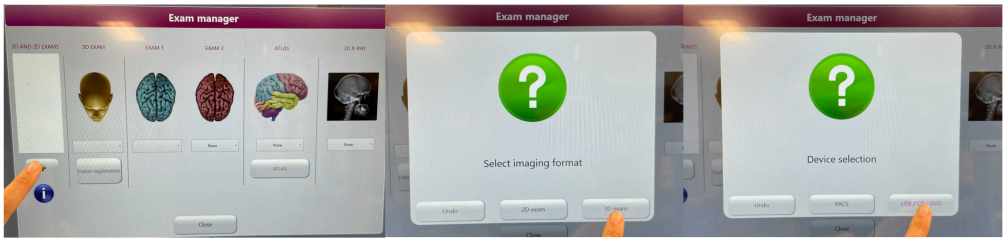
- ROSA ONE Brain software

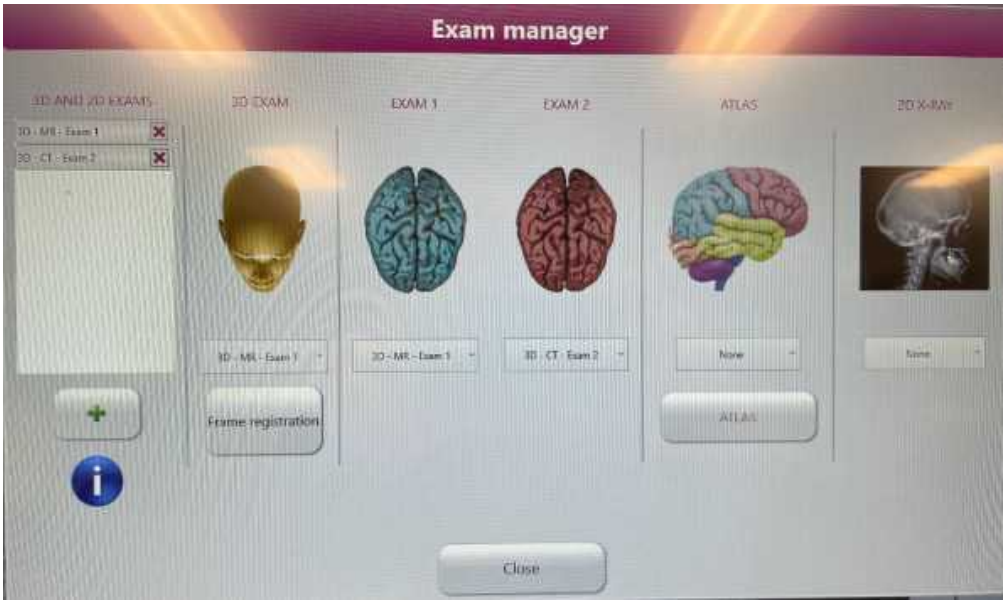
Troubleshooting

1 Open the ROSA ONE Brain software, either on a ROSA computer or the ROSA ONE robot.

2 Select add new subject, stereotaxy, import 3D images from USB.





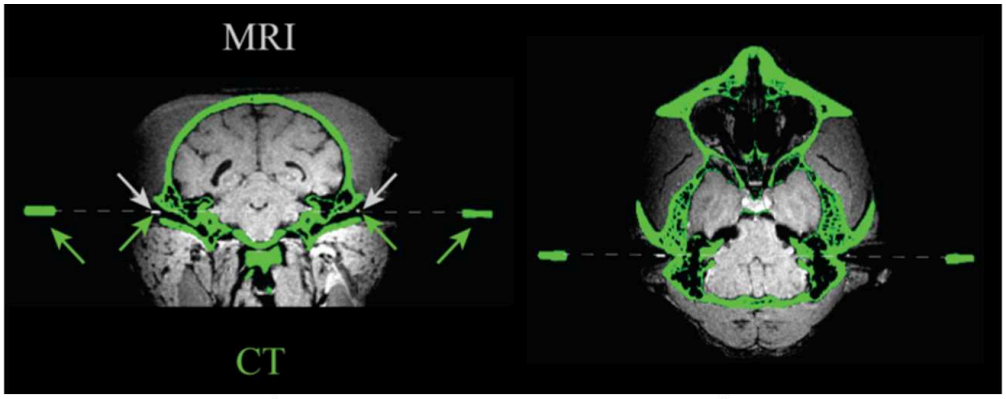


* There is a limit for image resolution in this software, so your images may be downsampled.

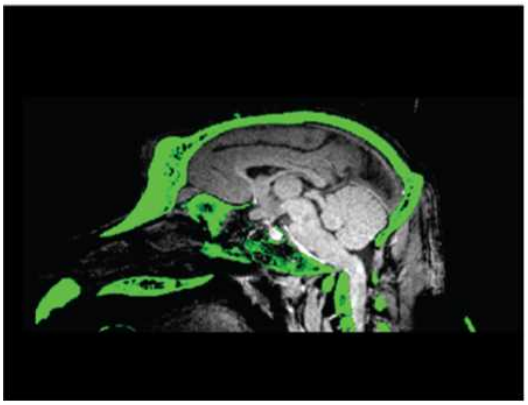
3 Once both MRI and CT are added, the program will prompt for an image registration, with options:
1) automatic: usually doesn't work for monkey images
2) semi-manual: we use this the most since the interface is nice (rotation & translation, editable step size)
3) manual: this also works

3.1 First, adjust the images so that the CT and MRI have the same orientation (matching axial, sagittal, coronal planes).

3.2 In both the CT and the MRI, the ear bar tips should be visible if filled with appropriate contrast agent during scan. Align the ear bar tips of the CT and MRI. This will give good alignment for the sagittal and longitudinal axis.

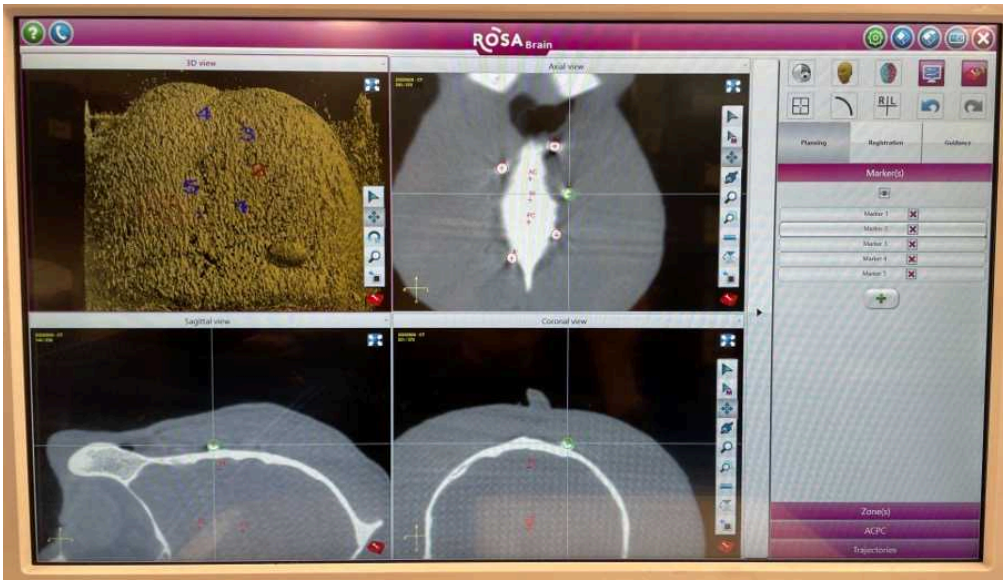


3.3 Finally, rotate the images on the frontal axis (sagittal plane) until the brain centers within the skull. This rotation should be minimal if the animal was positioned well inside the stereotaxic frame during imaging.

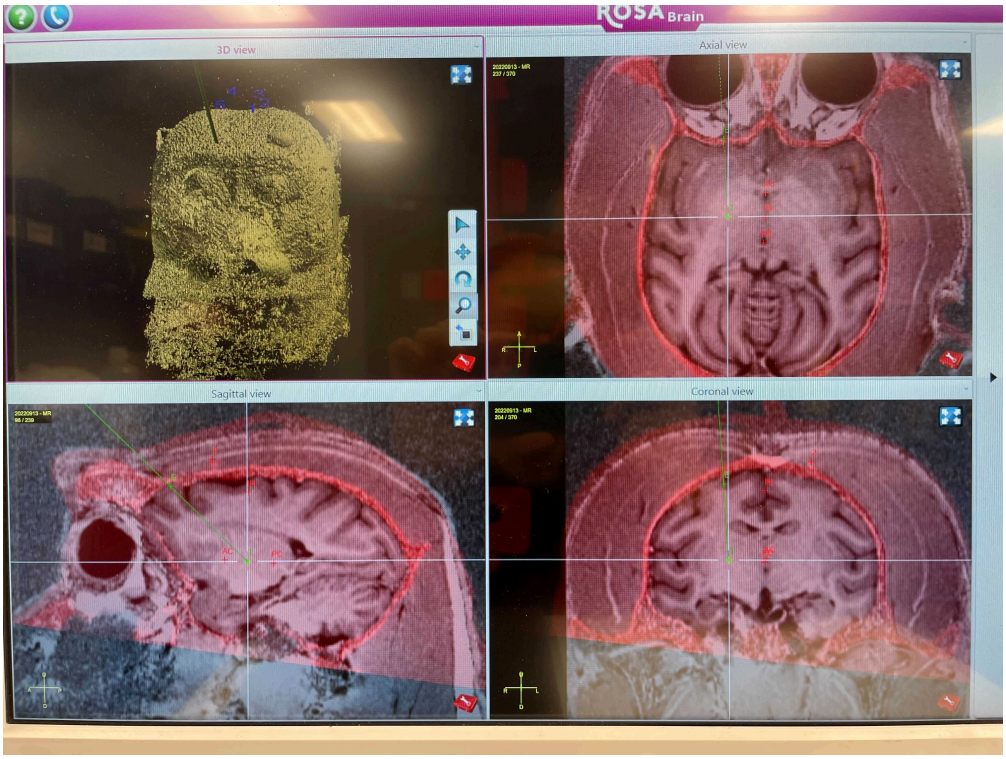


3.4 Scroll through the image to check the final registration on all planes. Check registration with an experienced neurosurgeon if you can.

4 After registration of the MRI and CT, we need to add markers on the CT that will guide robot to animal skull registration. Add a marker on top of each of the 5 titanium screws implanted on the animal's skull.



5 Now, you can plan implant trajectories based on the MRI images, and the robot will calculate the coordinates and distances to perform the implant. The robot uses the ACPC (anterior commissure and posterior commissure) points as reference.



Green line is example of planned trajectory for an internal capsule implant.

6 For arm area of the internal capsule, the common coordinates we use are:
Lateral: length of ACPC * ~0.83
Ant/Post: mid ACPC
Vertical: at level of ACPC line