VANDERBILT UNIVERSITY INSTITUTE OF IMAGING SCIENCE
HUMAN IMAGING CORE

FRAMEWISE INTEGRATED REAL-TIME MRI MONITORING (FIRMM)

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Introduction

This document describes Framewise Integrated Real-time MRI monitoring (FIRMM) feature that has been integrated with the VUIIS HIC 3T MRI scanner. FIRMM provides users real time data on subject head motion, real time assessment of acquired data quality and information on required scan times for reaching data quality thresholds.

FIRMM is an open source tool developed by NOUS Imaging based in St Louis, MO, USA. (https://firmm.io/) . FIRMM software is available for download at NITRC. (https://www.nitrc.org/projects/firmm). FIRMM is available for investigational (non-commercial use) only. Further information on FIRMM and other documents are available in the above websites.

FIRMM is currently being used by multiple clinical and research MRI sites nationwide on GE and SIEMENS platforms. The VUIIS implementation is the first working implementation on PHILIPS MRI scanners. FIRMM on PHILIPS works in tandem with Direct Reconstructor Interface (DRIN) real time data extraction package developed by Philips (Maarten Versleuis and Joseph S. Gillen, Kennedy Krieger Institute, Johns Hopkins University). Our current implementation is available on 3TA. 3TB implementation is planned for the near future.
Components

FIRMM needs the following **hardware** components to operate:

1. An external Linux computer with required specifications ([https://firmm.io/](https://firmm.io/))
2. An Ethernet connection for communicating between the Linux computer and the MRI scanner behind the firewall.

FIRMM needs the following **software** components to operate:

1. A DRIN (or alternative) python package for real-time DICOM data dumping to the external Linux computer.
2. Open source FIRMM software.

The current hardware sits beside the fMRI control computers in the 3TA suite. The computer has an Ubuntu 18.10 Linux Operating system.

Operation

FIRMM usage requires the following steps:

1. Turn ON the Auxiliary Linux computer located on the fMRI console cart.

2. Log in to the `firmmproc` profile using the technologist provided password.

3. Start the MRI scanner scan application and load the scan study.

4. Open a terminal window on the Linux machine. Launch DRIN by typing:

   ```
   Python DRIN/drinDICOM3Dumper.py -s <scanner_ip_address> -o /home/firmmproc/FIRMM/incoming_DICOM/
   ```

   at the terminal prompt. For 3TA the scanner IP is **10.115.30.251** For example, for 3Ta the command is:

   ![Terminal Window](image)

   **TIP**: This command can be easily retrieved by pressing the UP arrow in the terminal a few times as it is usually stored in terminal history.
This launches the DRIN tool shown below

![DRIN tool screenshot]

The DRIN output format does not contain the slice thickness. So, the user has to manually enter the slice thickness so that it is stored correctly in the output image files. By default, the slice thickness will be stored as 10 mm.

5. Check the ‘Add Timestamp’ box. This ensures data from different scans are downloaded in different timestamped folders.

6. Connect to the scanner, select File -> Connect. The system is now ready to receive DICOMS in real time from the scanner. Incoming DICOM images are stored in /FIRMM/incoming_DICOM/Time Stamped Folder for FIRMM to read.

![Connect to scanner screenshot]

![Python command prompt screenshot]
Note: This Folder is created only after the scan is started. It takes a few seconds for DICOMS transfer to commence.

7. Open a second terminal window, type **FIRMM** to launch FIRMM

![FIRMM Interface](image)

8. Start the MRI scan that needs monitoring on the scan console.

9. Incoming DICOMS on DRIN should appear in a newly created folder in **/FIRMM/incoming_DICOM/TimeStamped Folder**

![Folder with DICOMs](image)

10. Press ‘Start’ in FIRMM to start the process. Once you press start, a list of potential folders will appear, as shown below.
The folders should be listed in chronological order, with the most recently modified folder at the top of the list. If you do not see the folder you are expecting, you can hit the "Refresh" button. This will tell FIRMM to search again for folders, so any additional folders (created after "Start" was pressed) will now show up in the list.

11. Select the appropriate folder and press the "Run" button to start processing. FIRMM will start monitoring the scan.
**IMPORTANT NOTES:**

- **The current implementation requires that the scan being monitored have ‘EPI’ or ‘BOLD’ in the scan name. Future versions will correct this issue.**

- **If ‘time stamp’ is not selected, DICOMS from one scan will be overwritten by the next.**

- **The reconstruction mode in the examcard has to be set to ‘realtime’ or ‘on the fly’.**

- **Initial few (up to ~10) DICOM frames in dynamic scans are very often dropped due to system latencies.**

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**Help and Contacts**

Please contact Saikat Sengupta ([saikat.sengupta@vumc.org](mailto:saikat.sengupta@vumc.org)) for help, suggestions and reporting bugs. Further information and detailed help are available at [https://www.nitrc.org/projects/firmm/](https://www.nitrc.org/projects/firmm/)

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**Acknowledgements**

We are extremely grateful to the following individuals for their help and expertise:

- Jon Koller, Todd Deckard, Damien Fair and the entire FIRMM team (FIRMM)
- Maarten Versluis (Philips Healthcare)
- Joe S. Gillen (KKI, Johns Hopkins University)
- Bruce Martin, Chris Thompson, Sumeeth Jonathan, April Cribbs, Vicky Morgan and Seth Smith (VUIIS).