CCP PET-MR Exchange Report

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1 Introduction

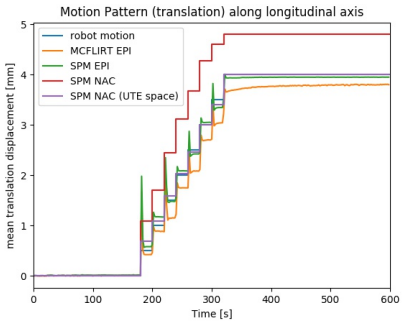
Due to comparatively long measurement times in PET/MR imaging, patient movements during the measurement are likely. These lead to artefacts which have a negative impact on the visual assessment and quantitative validity of the image data and, in the worst case, lead to misinterpretations. Simultaneous PET/MR systems allow the registration of movements and enable correcting the PET data.
In order to assess the effectiveness of the motion correction methods, it is necessary to carry out measurements on phantoms that are reproducible moved. For this purpose an experimental setup was developed for specific movements during my master thesis in Germany. Due to a cooperation between Leipzig (UKL) and London the data I measured during my master thesis could be used. An MR-compatible robotic system (Innomotion by INNOMEDIC GmbH) was used to generate rigid movements of a brain-like phantom acquired on a Siemens mMR. Different motion estimates were compared with the robot-induced motion.

2 Task

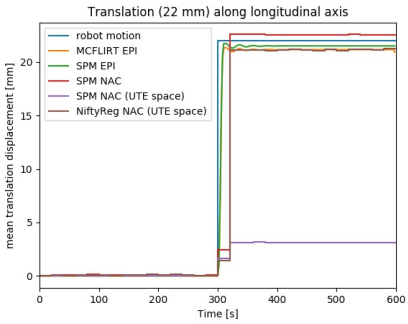
The open source program MCFLIRT (FSL package, [1]) was incorporated via a framework where FLIRT was used to estimate the motion from the EPI images. In addition, we used the open source SIRF framework [2] to reconstruct PET images without attenuation correction (NAC) and estimate motion using SPM12 [3], furthermore I used SPM12 to estimate the motion from the EPI data. It was necessary for a comparison to convert the NAC images into the EPI space. This is the only way to assume that the coordinate systems are at the same origin.
A code based on RTA (Reconstruction-Transform-Addition) was developed for the subsequent motion correction. Furthermore an implementation of MCIR (Motion-Corrected Image Reconstruction) was started.

3 Results

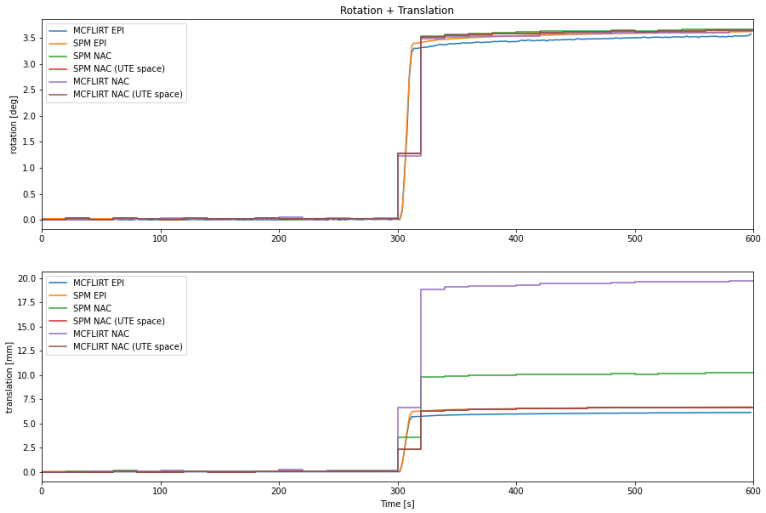
Various registration methods were tested based on the movement pattern (Figure 1a), a single large translation movement (Figure 1b) and a simultaneously occurring rotation and translation (Figure 1c). The given course of movement of the robotic system served as reference value. MCFLIRT (EPI-based) was compared with SIRF-SPM (NAC-based and EPI-based). In Figure 1 the different courses of motion are shown.



(a) motion steps



(b) large translation



(c) translation + rotation

Figure 1: Three different motion pattern and the detected motion tracks.

As you can see the motion registration hardly differs between MCFLIRT and SIRF-SPM (EPI-based). The deviation from the applied robotic movement (ground truth) never exceeds 0.5 mm. NAC in UTE space means that the NAC images have been resampled into the corresponding space. Figure 1a shows that the registration using the NAC images (SPM, UTE space) is almost identical to the ground truth. For large translation amplitudes (Figure 1b) all registration methods perform really good, only the NAC-based SPM registration in UTE space shows a large deviation (purple line). Finally a translation and rotation movement is shown in the Figure 1c. In this case the rotation is shown separately from the translation. It can be seen that, except for SPM NAC (green) and MCFLIRT NAC (pink), all registration methods showed only slight deviations from the ground thruth. The deviation is caused by a changed coordinate system in which the registration was made.
Some of the topics addressed are still in progress, independent of my internship.

4 Further Activities

On the first day I was asked to give a brief presentation regarding what I have done before. I attended several internal and PET/MR group meetings in the following weeks. A highlight was the participation in the 5^{th} Hackathon at the end of January. Within a few days, a small group worked intensively on various topics related to movement correction ("Add motion correction functionality to SIRF for synergistic PET/MR reconstruction").
As a conclusion a submission of my internship thesis to IEEE MIC 2020 is under consideration.

Acknowledgement

I would like to mention that the internship was an absolutely important experience for me. I was warmly welcomed, was introduced to the topic and the software and it was always possible to ask questions. It was possible for me to learn a lot and I want to thank you for that.

References

[1] Mark Jenkinson et al. "Improved optimization for the robust and accurate linear registration and motion correction of brain images". In: *Neuroimage* 17.2 (2002), pp. 825–841.

[2] Evgueni Ovtchinnikov et al. "SIRF: Synergistic image reconstruction framework". In: *Computer Physics Communications* 249 (2020), p. 107087.

[3] Karl J Friston et al. "Spatial registration and normalization of images". In: *Human brain mapping* 3.3 (1995), pp. 165–189.