Philips Integrated Motion Correction with Tracoline

Ulrich Lindberg, PhD [1]; Gérard Crelier, PhD[2]; Thomas Ulrich, PhD[2]; Malte Laustsen, MSc[3]; Stefan Glimberg, PhD[3]; Thomas Gaass, PhD[3]

[1] Department of Clinical Physiology, Nuclear Medicine and PET, Rigshospitalet, Copenhagen, Denmark
[2] GyroTools LLC, Zurich, Switzerland
[3] TracInnovations ApS, Ballerup, Denmark

Patient motion during MRI procedures poses a significant challenge, often compromising the diagnostic accuracy of acquired images. Factors such as discomfort, anxiety, medical conditions, and age frequently contribute to involuntary movement during examinations [1, 2, 3]. While sedation or anesthesia is commonly utilized, particularly in pediatric cases, to minimize motion, these methods come with inherent risks [4] and substantial cost implications [5]. Hence, implementing motion correction techniques remains pivotal in addressing motion artifacts without disrupting clinical workflow. Prioritizing motion correction not only ensures the integrity of diagnostic images but also optimizes patient care and resource utilization.

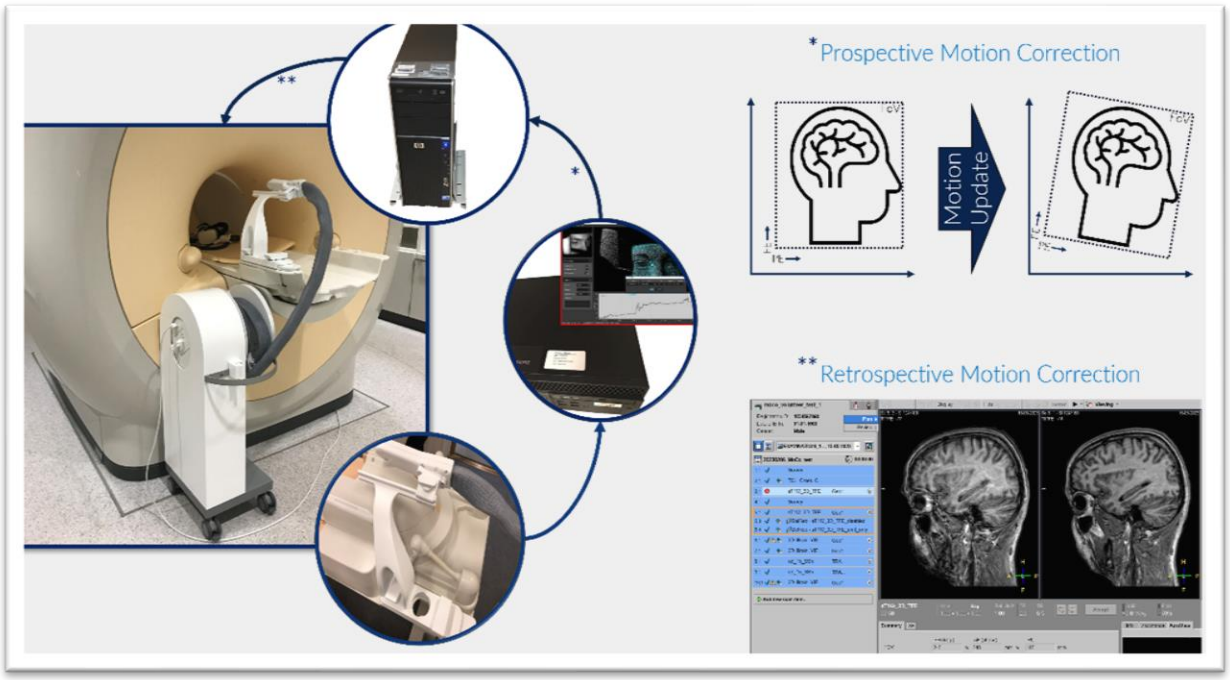

Fig. 1: Schematic illustration of the TracInnovations-Gyrotools implementation; The TCL3 Motion Tracking System continuously monitors and communicates the pose of the patient head to the MRI main PC; Real-time updates can be used to account for head pose changes prospectively or retrospectively inline.

Resulting from a successful collaboration between TracInnovations, GyroTools and the Glostrup Hospital, a cutting-edge motion correction solution has been developed*. This system leverages the continuous stream of motion information from TracInnovations' FDA-cleared Markerless Motion Tracking System, the TCL3 [6, 7], and integrates seamlessly with the Philips MRI scanner software for both retrospective (RMC) or prospective motion correction (PMC).

*Motion correction available for research purposes only

Patient Comfort

A common solution for head motion tracking involves attaching trackable passive markers [8] or active markers [9] to the patient's face. However, these markers often cause irritations, particularly in pediatric patients. Discomfort of any sort is one of the major reasons why patients cannot restrain from moving during an MRI procedure.

The TCL3 solution utilizes a markerless technology. It relies on invisible near-infrared light to continuously collect high-resolution images of the patient's face.

Thousands of Virtual Markers

The TCL3 Markerless Motion Tracking System utilizes 3D point clouds of the patient's face for exceptionally precise and reliable head pose tracking. Each 3D cloud comprises thousands of individual points, each functioning as a marker in its own right. The device calculates a new pose update every 30ms.

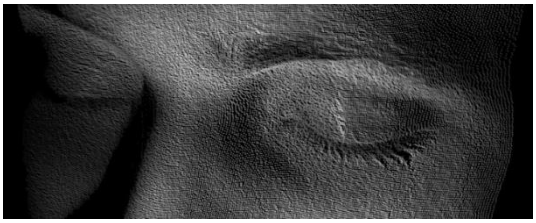

Fig. 2: 3D point cloud of a patient face consisting of thousands of single points

Anywhere and Anything

MRI procedures are inherently complex, requiring the design of any additional device to be carefully optimized for versatility and ease-of-use.
The TCL3 Motion Tracking System was specifically tailored to seamlessly integrate into the clinical workflow of a Radiographer without imposing restrictions on the use of most other accessories.

Motion Correction

The complexity of human motion (cf. motion plots in Fig. 3) necessitates a multifaceted approach to motion correction.

The developed solution offers a choice between the real-time correction of PMC and the versatility of a retrospective approach, depending on the application and the specific situation.

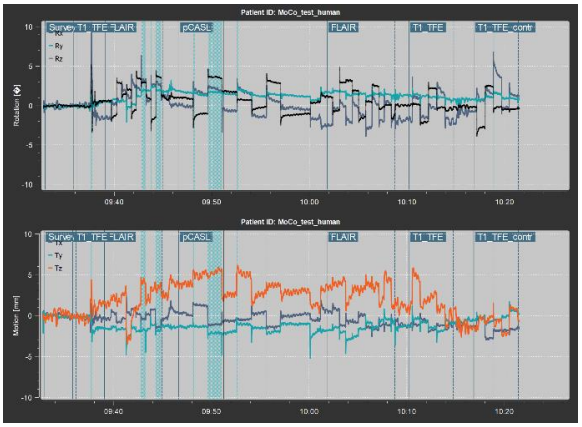

Fig. 3: Plots of simulated rotational and translational motion in three degrees of freedom each, occurring during one complete scan session.

Fully integrated functionality

The seamless integration of essential functionalities lies at the core of our motion correction system. Building upon the original Philips scan control software, we have enhanced it to encompass every critical aspect of motion correction. This includes precise time synchronization with the motion tracker, efficient transmission and storage of motion data, real-time pulse sequence modification for PMC, and integrated RMC in the image reconstruction process.

The rigorous testing of the system's performance and its clinical viability was spearheaded by the dedicated efforts of the staff at Glostrup Hospital. Their findings and invaluable feedback have significantly contributed to the ongoing refinement and enhancement of TracInnovations' solution. We are delighted to announce that the GyroTools' implementation of TracInnovations' motion correction technology has yielded remarkable results in various applications, including TFE, TSE, and dynamic image acquisition.

Moreover, the repertoire of compatible applications and imaging sequences is constantly expanded, reflecting a commitment to ongoing innovation and excellence.

Showcases

Ensuring accurate correction across a range of motion magnitudes is imperative for any motion correction method, encompassing both substantial and subtle movements, as well as still scenarios. In the following section, we present a range of motion correction cases illustrating diverse intra-sequence pose variations, from notable to minor adjustments.

Large Motion

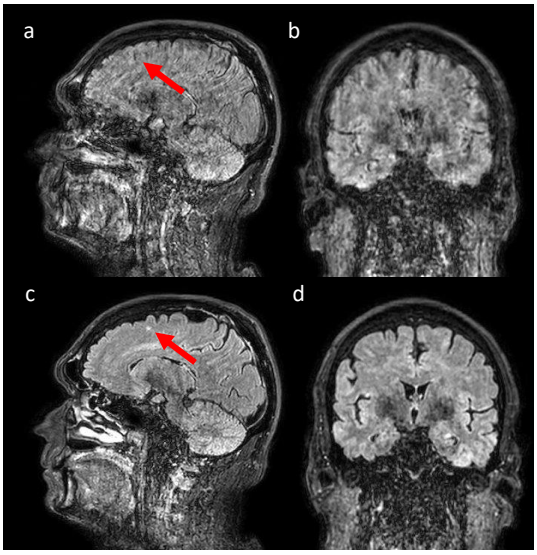

Fig. 4: T1-weighted 3D IR-TFE scan of subject with large pose changes during scan. (a/b) Scan without PMC. (c/d) Scan with PMC enabled. The reduction of motion artifacts reveals a white matter lesion previously obscured.

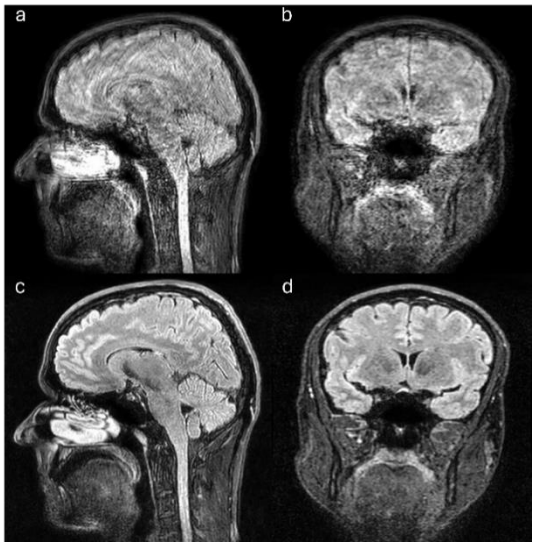

Fig. 5: 3D T2 FLAIR TSE scan of subject with large pose changes during scan. (a/b) Non-corrected reconstruction. (c/d) RMC reconstruction recovering details, contrast, and SNR.

Medium Motion

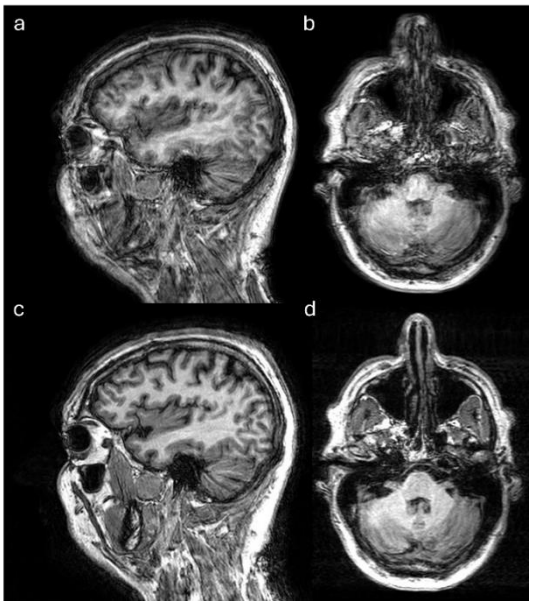

Fig. 6: T1-weighted 3D IR-TFE scan of subject with medium sized pose changes during scan. (a/b) Non-corrected standard reconstruction. (c/d) RMC reconstruction shows substantial improvement in image quality, most tangible in the realignment of the nasal septum.

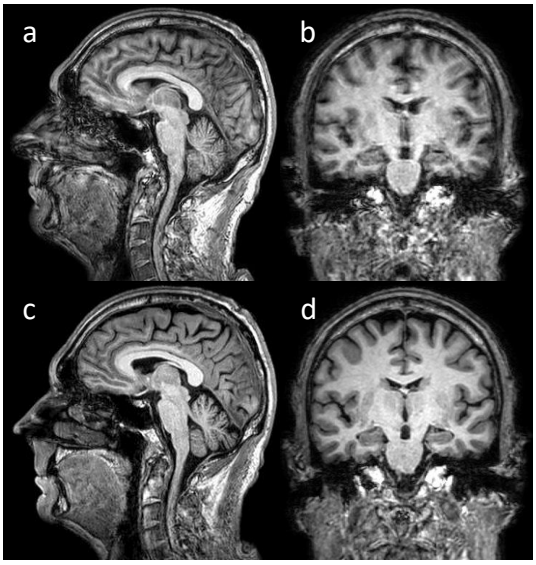

Fig. 7: T1-weighted 3D IR-TFE scan of subject with medium pose changes during scan. (a/b) Scan without PMC. (c/d) Scan with PMC enabled.

Still Case

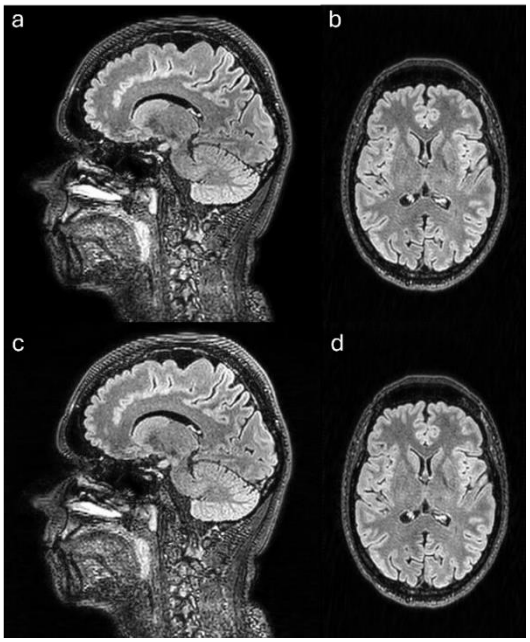

Fig. 8: T2 FLAIR TSE of a mostly still subject. The non-corrected reconstruction (a/b) and the motion corrected reconstruction (c/d) show no significant difference.

The road ahead

TracInnovations' TCL3 motion tracking and correction system has demonstrated exceptional and reliable performance across a diverse range of cases involving various sequences. However, the extensive variety of imaging techniques and methods leaves room for additional optimization and customization for specific applications.

Addressing non-rigid facial motion remains a significant challenge in optical tracking. Fortunately, the rich information embedded in the point clouds forming the basis of TCL3 motion tracking enables the identification and exclusion of non-rigidly moving facial areas.

Reflecting TracInnovations' commitment to continuous improvement, their ongoing in-house research and development currently targets the optimization of motion classification and exclusion of non-rigid face motion.

Conclusion

TracInnovations' TCL3 Motion Tracking and correction system offers a versatile and effective solution for addressing unwanted motion during MRI scans. The system's markerless technology prioritizes patient comfort, especially in pediatric cases, while seamlessly integrating into clinical workflows. Demonstrating reliability across diverse scenarios, from significant to minor motion cases, the TCL3 system showcases its adaptability and clinical viability.

References

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