2021 GatherTown Poster Session on Motion Detection and Correction

September 1, 2021

Welcome

Welcome to this GatherTown poster session on Motion Detection and Correction. The room will be open throughout the day with three 1-hour sessions where presenters should be in the room. You can message presenters from the chat on the left of the screen.

- Session A. 08:00 UTC. Link for local time.
- Session B. 15:00 UTC. Link for local time
- Session C. 23:00 UTC. Link for local time

GatherTown Instructions

The link to the moco space is: https://gather.town/app/jkS45ZLfgi2Fscjw/moco and the password is '******'. Please use your real name for your avatar.

The GatherTown space is called 'moco'. You can participate through a web browser or the Gather app. The app can be downloaded for Mac or Windows from: https://www.gather.town/download. To access the moco space on the desktop app, open the moco link above in a browser, then from the Gather 'grapes' icon at the top left, select the 'Open in Gather desktop app' option at the bottom of the menu. If you use a browser on a Mac, please use Chrome, not Safari. Also, to share a screen from Chrome, you may need to allow Screen Recording from the Security and Privacy section of a Mac's System Preferences.

- Use the arrow or WASD keys to move your avatar.
- If blocked by other people, press **g** to "ghost" through them.
- At a poster, press **x** to view the poster.
- To highlight a part of a poster with a pointer, select the presenter button  on the right of a poster and then left click in the poster. A red circle will flash where you clicked.
- There is a screen share option from the button at the bottom of the page.

This programme booklet has been generated semi-automatically from the Google Form used to submit posters, with some minor editing applied for formatting. The LaTeX template for this booklet was supplied by Overleaf. Thanks to the Alan Turing Institute for funding the GatherTown subscription.

Contents

Abstracts

[008] Non-linear model to predict head motion during EPI using a magnetic field camera in a 7 T MRI scanner

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L. Bortolotti (a), R. Bowtell (a). (a) Sir Peter Mansfield Imaging Centre, University of Nottingham

A novel approach to motion tracking in a 7T scanner has been successfully tested with concurrent EPI data acquisition. A set of NMR field probes, placed in between the standard head transmit and receiver coils, was used to measure the extra-cranial field changes due to head movement every 150 ms during quiet periods of the EPI sequence. These measurements were used in conjunction with a non-linear regression method (NARX -Nonlinear autoregressive with external input) to predict head motion parameters. This represents a step forward in integrating a marker-less motion correction technique with standard imaging sequence.

Contact Information: `Laura.bortolotti@nottingham.ac.uk`

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[009] Prospective motion correction and reacquisition in a complete clinical protocol for pediatric brain MR imaging

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H Eichhorn (a,b), R Frost (c,d), A Kongsgaard (a), S Glimberg (e), P Wighton (c), MD Tisdall (f), AVD Kouwe (c,d), KS Madsen (g,h), M Ganz (a,i). (a) Neurobiology Research Unit, Rigshospitalet, Copenhagen, DK, (b) Niels Bohr Institute, University of Copenhagen, DK, (c) A. A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, (d) Department of Radiology, Harvard Medical School, Boston, MA, (e) TracInnovations, Ballerup, DK, (f) Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, (g) Danish Research Center for Magn. Reson., Hvidovre, DK, (h) Radiography, Dpt. of Technology, University College Copenhagen, DK, (i) Dpt. of Computer Science, University of Copenhagen, DK

With this work, we evaluated the performance of prospective motion correction (pMC) and selective reacquisition as an alternative to general anaesthesia for reducing motion artefacts in young children. For that, we used the markerless head motion tracking system Tracoline. We compared the proposed approach to the clinical standard - i.e. scans without motion correction - on a full pediatric brain MR

protocol for 22 healthy adult volunteers. Scans without intentional motion and with an intentional predefined head nodding motion pattern were acquired for both the clinical standard sequences and the motion-corrected versions. We analyzed and statistically compared observer quality scores, as well as Structural Similarity Index and Tenengrad. Our results confirmed that the use of pMC combined with reacquisition is feasible for a full clinical pediatric MR protocol, maintaining diagnostic image quality for motionless scans as well as reducing motion artefacts and improving diagnostic image quality for scans with motion.

Contact Information: hannah.eichhorn@nru.dk,

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[010] Self-supervised motion-corrected reconstruction by a joint deep learning (3+1)D reconstruction and k-space registration network for respiratory motion compensation

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Thomas Küstner (a), Jiazhen Pan (b), Christopher Gilliam (c), Haikun Qi (d), Gastao Cruz (e), Kerstin Hammernik (b), Thierry Blu (f), Daniel Rueckert (b), René Botnar (e), Claudia Prieto (e), Sergios Gatidis (a). (a) Medical Image And Data Analysis (MIDAS.lab), Department of Diagnostic and Interventional Radiology, University Hospital Tübingen, Germany. (b) Lab for Artificial Intelligence in Medicine, Technical University of Munich, Munich, Germany. (c) RMIT University, Melbourne, Australia. (d) ShanghaiTech University, Shanghai, China. (e) School of Biomedical Engineering and Imaging Sciences, King's College London, St. Thomas' Hospital, London, UK. (f) Chinese University of Hong Kong, Hong Kong.

Respiratory motion can cause artifacts in magnetic resonance imaging of the body trunk if patients cannot hold their breath or triggered acquisitions are not practical. Retrospective correction strategies usually cope with motion by fast imaging sequences with integrated motion tracking under free breathing conditions. These acquisitions perform sub-Nyquist sampling and retrospectively bin the data into the respective motion states, yielding subsampled and motion-resolved k-space data. In this work, we propose a deep-learning based motion-corrected 4D (3D spatial + time) image reconstruction which combines a non-rigid registration network and a (3+1)D reconstruction network. Non-rigid motion is estimated directly in k-space based on an optical flow idea and incorporated into the reconstruction network. A self-supervised learning strategy is used on a cohort of 56 subjects. Implicit and explicit motion information sharing enables high quality images and deformation fields of a 14x-20x accelerated acquisition with a 25-fold faster reconstruction than conventional approaches.

Contact Information: www.midaslab.org

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[011] Progress in wireless motion tracking with shortwave RF

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C Schildknecht (a), D Brunner (a), T Schmid (1), K Prüssmann (a). (a)ETH Zurich and University of Zurich; C

For high quality and robust neuro MRI imaging, motion correction is gaining paramount importance. Nowadays, all tracking methods are based on electromagnetic mechanisms and reside in the kHz range, around the Larmor frequency or at several hundreds of THz for optical methods. Common for all current methods is that they operate in frequency bands that are not spare. Either because they are already used by MRI and have to compromise to get along with the scanning process. Or the utilized frequency band interacts heavily with the environment leading to strong design constraints and robustness issues. Therefore the optimal motion tracking modality should operate in an exclusive frequency band neither occupied by the scanner nor interacting with the setup.

In this work, we report recent progress on such a method based on short-wave RF operating in the 1-5 MHz frequency range in a quasi-stationary magnetic field mode. The exclusive frequency band enables high tracking performance where sub-micron or sub-millisecond performance is achievable. Most importantly, it is insensitive to tissue, enabling direct mounting of the marker to the upper jaw, solving a long-standing problem of rigid-body fidelity of the tracking modality, which has hampered robustness and reliability.

Contact Information: `schildknecht@biomed.ee.ethz.ch`

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[012] Data-driven motion-corrected brain MRI incorporating pose dependent B0 fields

Yannick Brackenier(a), Lucilio Cordero-Grande(a,b,c), Raphael Tomi-Tricot(a,b,e), B
Tom Wilkinson(a,b), Jan Sedlacik(a,b), Pip Bridgen(a,b), Sharon Giles(a,b), Shaihan Malik(a,b), Enrico De Vita(a,b) and Joseph V Hajnal(a,b) (a)Biomedical Engineering Department and (b)Centre for the Developing Brain, School of Biomedical Engineering and Imaging Sciences, King's College London, London, United Kingdom (c)Biomedical Image Technologies, (d)ETSI Telecomunicación, Universidad Politécnica de Madrid and CIBER-BNN, Madrid, Spain (e)MR Research Collaborations, Siemens Healthcare Limited, Frimley, United Kingdom

A fully data-driven retrospective motion correction reconstruction for volumetric brain MRI at 7T that includes modelling of pose-dependent changes in polarising magnetic (B0) fields in the head has been developed. Building on the DISORDER framework, the use of a physics-based B0 model constrains the number of unknowns to be found, enabling motion correction based solely on data-consistency without requiring any additional probe- or navigator-data. The proposed reconstruction was validated on an in-vivo spoiled gradient echo acquisition in which the subject deliberately moved. Substantial removal of motion artefacts was achieved.

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[013] Motion Correction of 3D GRASE Arterial Spin Labelling with ESPIRiT

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(a) J Highton (b) D Thomas (c) E De Vita (d) J Schott. (a) School of Biomedical Engineering and Imaging Sciences, King's College London, London, UK (b) Dementia Research Centre, UCL Queen Square Institute of Neurology, University College London, London, UK (c) Neuroradiological Academic Unit, Department of Brain Repair and Rehabilitation, UCL Institute of Neurology (d) Wellcome Centre for Human Neuroimaging, UCL Queen Square Institute of Neurology, University College London, UK

Arterial Spin Labelling (ASL) is a non-invasive MRI method to measure cerebral blood flow (CBF). However, ASL is particularly sensitive to motion artefacts, which can cause a significant amount of patient data to be unusable. Here, a novel retrospective method (summarised below) for correcting motion in multi-shot 3D GRASE ASL is presented and tested, using in vivo data: 1) The raw k-space data from all four shot acquisitions from all control image repeats are used to calculate coil sensitivity maps, via ESPIRiT. 2) These are used to reconstruct full images from each of the individual shots, via SENSE. 3) These are then registered and combined before quantifying CBF maps. The test requisition was repeated with the subject remaining still, deliberately nodding over a 1.6 degree range, and 3.3 degree range. The motion correction improved the quality of the CBF maps affected by severe motion (according to voxel correlation analysis with the no-motion data), but not the moderately motion affected data.

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[014] Navigator Parameter Optimisation for MS-PACE Prospective Motion Correction

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S Winata (a), D H Hoinkiss (b), G A Keith (a), D A Porter (a), M Günther (b). (a) Imaging Centre of Excellence, University of Glasgow, UK; (b) Fraunhofer Institute for Digital Medicine MEVIS, Bremen, Germany

Multislice PACE (MS-PACE) is a prospective motion correction technique adapted from Prospective Acquisition CorrEction (PACE). In-plane and through-plane motion parameters are estimated by registering a small number of equidistantly spaced 2D-EPI navigator slices to a reference volume. It was validated with functional MRI and RARE (Rapid Acquisition with Relaxation Enhancement) imaging and compared favourably with PROPELLER (Periodically Rotated Overlapping ParallEL Lines with Enhanced Reconstruction). In this study, we investigate the effects of varying the quantity of navigator slices on the technique's performance in detecting subject motion.

Contact Information: `s.winata.1@research.gla.ac.uk`

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[015] Online motion-corrected reconstruction for breast MRI in supine position

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Karyna Isaieva (a), Pierre-André Vuissoz (a), Marc Fauvel (b), Claire Dessale (b), Jacques Felblinger (a,b) and Freddy Odille (a,b). (a) Université de Lorraine, INSERM U1254, IADI, Nancy, F-54000, France, (b) CIC-IT, INSERM U1433, CHRU de Nancy, Nancy, F-54000, France

Breast MRI is an important diagnostic tool, especially for women of high risk. The current clinical protocol implies prone patient position and a dedicated coil. Supine MRI has several advantages; however, motion artifacts make the breast images almost uninterpretable in this case. In this work we show our first results on application of a model-based motion correction algorithm which utilizes respiratory belt measurement. We use a standard cardiac coil. Flexible breast supports that were wore by some participants, aided to limit gravitational deformation of the breast. We demonstrate that image quality is noticeably higher for the motion-corrected images from both visual and quantitative sharpness evaluations, that makes them comparable with the images acquired in prone position.

Contact Information: `karyna.isaieva@univ-lorraine.fr`

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[016] Comparing retrospectively corrected motion with two tracking techniques

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Elisa Marchetto (a), Kevin Murphy (b), Daniel Gallichan (a). (a) CUBRIC, School of Engineering, Cardiff, United Kingdom, (b) CUBRIC, School of Physics, Cardiff, United Kingdom.

We investigated the artifacts arising from different types of head motion in brain MRI and how well they can be compensated using two retrospective correction motion-tracking techniques: 3D-FatNavs and a TCL markerless device (TracInnovations). We applied these techniques on MPRAGE images acquired using a Siemens Prisma scanner on 9 healthy participants, which moved their head to generate continuous motion, small/large stepwise motion, and pitch-wise motion. Results showed noticeable differences in FatNav and TCL motion estimates in stepwise motion, likely due to non-rigid movement of neck-fat for large nodding motion that can degrade FatNav motion estimation. Both methods showed good improvements in small-stepwise motion experiments compared to un-corrected images. Despite the higher sampling rate (30 Hz vs 0.4 Hz), TCL does not seem to improve the image quality noticeably in our continuous motion scenario. TCL motion parameters show higher noise than FatNavs, which might compromise the image correction: a smoothing function could be applied to reduce the noise quantity without losing motion information.

Contact Information: `marchettoe1@cardiff.ac.uk`
www.cardiff.ac.uk/people/research-students/view/1725950-marchetto-elisa

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[017] Assessing the Generalizability of Deep Learning-Assisted Joint Image and Motion Estimation

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Brian Nghiem (a,b), Zhe (Tim) Wu (a), Melissa Haskell (c), Lars Kasper (a), Kâmil Uludağ (a,b). (a) BRAIN-To Lab, University Health Network, (b) Department of Medical Biophysics, University of Toronto, (c) Electrical Engineering and Computer Science, University of Michigan.

Convolutional neural networks (CNNs) have been successfully adapted for retrospective motion correction (RMC). However, the robustness of deep learning (DL)-assisted RMC against varying imaging conditions has yet to be thoroughly investigated. In this poster, we investigate the impact of MRI contrast and motion severity on the performance of a DL-assisted joint image and motion estimation algorithm (Haskell et al MRM 2019). Of particular interest was assessing the ability of the algorithm's artifact-identifying CNN to generalize for test cases outside of its training distribution. To this end, two different CNNs were separately trained on T1w and T2w data containing simulated in-plane motion. The joint estimation algorithm was then tested with images containing MR contrast and motion content within and outside the training distribution. The results demonstrated that the CNN performed worse for out-of-distribution test cases. As such, MRI contrast and motion content seen during CNN training can limit the generalizability of RMC performance.

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[018] Head Motion Tracking using an EEG-system and Retrospective Correction of T1W MRI

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Malte Laustsen(1,2,3,4), Mads Andersen(5,6), Rong Xue(3,7,8), Kristoffer H. Madsen(2,9), and Lars G. Hanson(1,2) 1) Section for Magnetic Resonance, DTU Health Tech, Technical University of Denmark, Kgs. Lyngby, Denmark, 2) Danish Research Centre for Magnetic Resonance, Centre for Functional and Diagnostic Imaging and Research, Copenhagen University Hospital Hvidovre, Hvidovre, Denmark, 3) Sino-Danish Center, University of Chinese Academy of Sciences, Beijing, China, 4) TracInnovations, Ballerup, Denmark, 5) Philips Healthcare, Copenhagen, Denmark, 6) Lund University Bioimaging Center, Lund University, Lund, Sweden, 7) State Key Laboratory of Brain and Cognitive Science, Beijing MRI Center for Brain Research, Institute of Biophysics, Chinese Academy of Sciences, Beijing, 100101, China, 8) Beijing Institute for Brain Disorders, Beijing, 100053, China, 9) DTU Compute, Technical University of Denmark, Kgs. Lyngby, Denmark

Tracking and retrospective correction of high-resolution structural 3D-GRE images is accomplished with a slightly modified EEG cap and sampling system. Carbon wire loops added to the EEG cap allow for motion tracking using gradient-induced signals from native sequence elements, without the need for sequence modification, or electrode-skin contact, while requiring only a short calibration scan, and mounting of the cap. The motion estimates closely resemble estimates from interleaved

navigators (mean absolute difference: [0.13,0.33,0.12]mm, [0.28,0.15,0.22]deg). Retrospective correction using carbon wire loops yield similar improvements to Average Edge Strength (12%) for images with instructed movement, and does not degrade images without motion.

Contact Information: mallau@dtu.dk

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[019] Prospective Motion Correction in Kidney MRI Using Free Induction Decay Navigators

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C Ariyurek (a), TE Wallace (a), T Kober (b,c,d), SK Warfield (a), S Kurugol (a), O Afacan (a). (a) Computational Radiology Laboratory, Boston Children's Hospital, Harvard Medical School, Boston, MA, (b) Advanced Clinical Imaging Technology, Siemens Healthcare, Lausanne, Switzerland, (c) Department of Radiology, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland, (d) LTS5, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

Abdomen MRI scans may require breath-holding to achieve sufficient image quality which might be challenging for patients. Free breathing imaging with radial acquisition is relatively robust to motion. However, image quality is often degraded when imaging nervous and sick patients who are deep breathing. Here, we propose to use free induction decay navigators (FIDnavs) to apply motion correction (MoCo) prospectively during acquisition in kidney MRI by using a linear motion model to translate FIDnav signal into kidney displacement due to respiration. FIDnavs were inserted into a golden angle ordered radial stack-of-stars sequence after each excitation. A calibration scan was acquired on each volunteer to find the linear motion model parameter for converting FIDnavs to kidney displacement. In the real-time MoCo scan, kidney motion was corrected using the motion model based on FIDnav measurements. Using FIDnavs to correct motion, decreases blurriness in kidneys and would result in more accurate quantitative analysis.

Contact Information: cemre.ariyurek@childrens.harvard.edu

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[020] FatNav Based Prospective Motion Correction of Single Slice Phase Contrast MRI

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C Xiaopeng Zong(1,2) Julia Maitland(1), Jordan Jimenez(1), Weili Lin(1,2), William Powers(3) (1). Biomedical Research Imaging Center, (2). Department of Radiology, (3). Department of Neurology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

High resolution single-slice 2D phase contrast (PC) MRI is a useful technique for characterizing penetrating arteries (PA) in centrum semiovale which plays an important role in small vessel disease. We explore the potential benefits of FatNav-based prospective motion correction (MC) in improving PA visualization with PC-MRI at 7 T. FatNav and PC MRI data were acquired in a interleaved manner. Slice coordinates were updated every FatNav image TR (4.6 s) based on registration of FatNav images. We found MC increased the number of visualized PAs and reduced image intensity fluctuations over repetitions and the changes correlated with the degree of motion during the scan with no MC. However, replacing k-space data with potential motion (translation > 0.1 mm or rotation $> 0.1°$) by reacquired data did not further improve PA visibility or reduce the image intensity fluctuations.

Contact Information: zongxp@gmail.com
