OSIPI-DCE Challenge: Guidelines

Anahita Fathi Kazerooni[1,2], Eve Shalom[3], Zaki Ahmed[4], Rianne van der Heijden[5], Seyed Ali Nabavizadeh[2], Hamidreza Saligheh Rad[6], Leland S. Hu[7], Laura C Bell[8], Harrison Kim[9], Steven Sourbron[10]

[1] *Center for Biomedical Image Computing and Analytics, Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, USA*

[2] *Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, USA*

[3] *School of Physics and Astronomy, University of Leeds, UK*

[4] *Mayo Clinic, Rochester, MN*

[5] *Department of Radiology & Nuclear Medicine, Erasmus MC University Medical Center, Rotterdam, The Netherlands*

[6] *Quantitative MR Imaging and Spectroscopy Group, Research Center for Molecular and Cellular Imaging, Tehran University of Medical Sciences, Tehran, Iran*

[8] *Neuroradiology Division, Department of Radiology, Mayo Clinic, Phoenix, AZ, USA*

[8] *Division of Neuroimaging Research, Barrow Neurological Institute, Phoenix, AZ, USA*

[9] *Department of Radiology, School of Medicine, The University of Alabama at Birmingham*

[10] *Department of Infection, Immunity and Cardiovascular Disease, University of Sheffield, UK*

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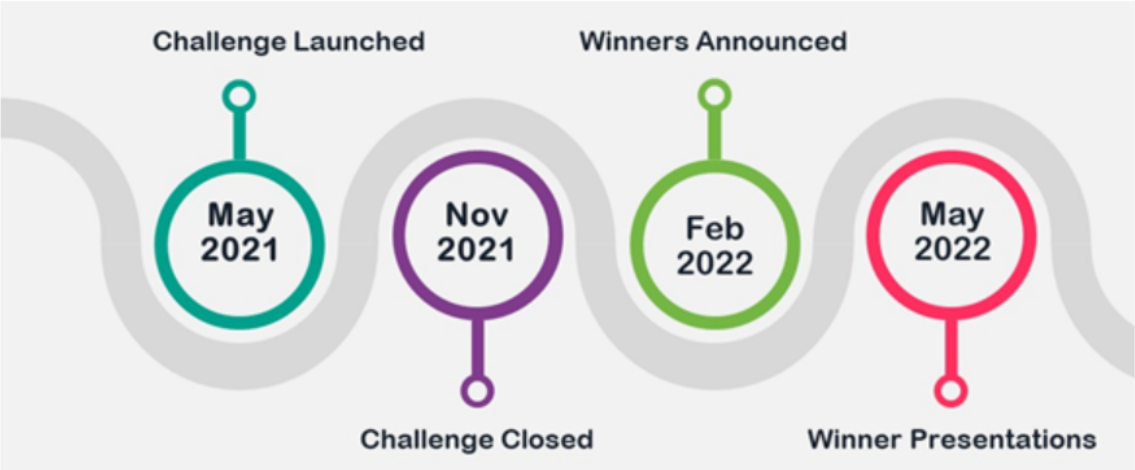
Important Dates

Dates	***Event***
15 May 2021	*Challenge launched*
30 November 2021 (Extended to December 24th)	*Submissions Closed*
4 February 2022	*Ranking of the teams; Winners announced*
May 2022 (TBA)	*Presentations*



Challenge Overview:

Research findings cannot be reproduced when researchers evaluate new methods on personal datasets and local code that is not shared with the public [1] . With a growing attention to the need for more reproducible research [2], community challenges with public datasets can play an important role in validating and benchmarking image quantification methods [3]. Dynamic contrast enhanced (DCE-) MRI has been widely used in brain tumor research and single center clinical studies [4, 5]. Several studies have suggested the key role of volume transfer constant (K^{trans}) as a potential marker for tumor differentiation and treatment response assessment in gliomas [5]. Yet, there is a lack of standardized acquisition and analysis methods, and therefore repeatability and reproducibility, in quantification of K^{trans} from DCE-MRI hampering its application in clinical practice, multi-institutional studies, or clinical trials.

The Open-Science Initiative for Perfusion Imaging (OSIPI), an initiative of ISMRM perfusion study group, is founded to promote reproducible research and open science in perfusion imaging and facilitate translation of software tools into clinical practice. In accordance with the aims of OSIPI, the DCE (OSIPI-DCE) challenge was designed for evaluating DCE-MRI methods that estimate the volume transfer constant (K^{trans}) in brain tumors. Through this challenge, the software packages and scripts will be evaluated and compared in a well-designed setting, with synthetic and real-world clinical data, with the ultimate goal of establishing a set of benchmarks for quantification of K^{trans} as a diagnostic or prognostic biomarker in glioma brain tumors.

The analysis methods submitted by the competing teams will be evaluated and compared for quantification of K^{trans} from DCE-MRI in terms of accuracy, repeatability, and reproducibility. Accuracy will be scored based on synthetic data specifically designed for

this challenge; repeatability will be rated based on test-retest DCE-MRI scans of patients with brain tumors; reproducibility will be assessed based on an independent analysis by a neutral team. The submissions will be ranked according to a global score reflecting that an ideal method should be accurate AND repeatable AND reproducible (**Figure 1**).

OSIPI-DCE challenge is an ISMRM challenge (http://challenge.ismrm.org/), launched at 2021 ISMRM Annual Meeting in May 2021, and the winners will be announced at ISMRM Perfusion Study Group Workshop in February 2022. The top three teams will be offered presentations at the Perfusion Study Group Session at 2022 ISMRM Annual Meeting in London, UK.

This document serves as a detailed guideline for the challenge participants.

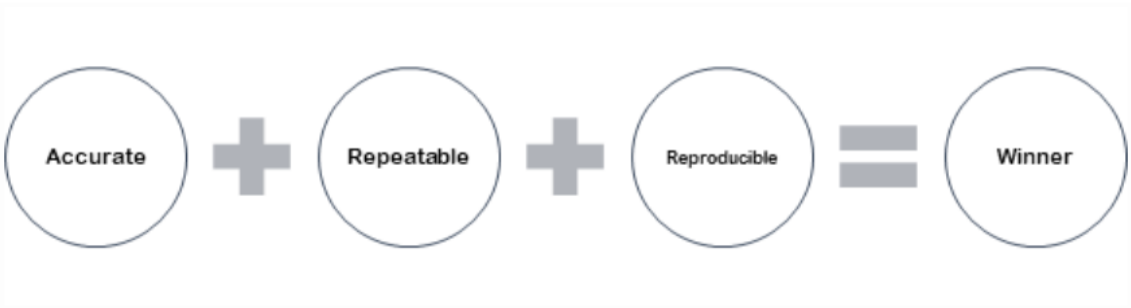


Figure 1. The criteria for a winning team

Benefits of Participating in the Challenge:

- All participants will be listed as co-authors on the challenge publications.
- The winners will be announced in ISMRM Perfusion Study Group Workshop in February 2022 and on ISMRM Challenges Website.
- The top three teams will present their methods at the ISMRM 2022 annual meeting.

How to register?

To register for this challenge for free, you need to visit https://challenge.ismrm.org/forums/topic/osipi-dce-challenge/ :

- Click on "Create a New Account".
- Fill in the required information.
- Review the Policies and if you agree with the terms, click on "Confirmed".
- You will receive submission guidelines and a link to the data, which is uploaded in the OSF repository.

Challenge Data

Two sets of data are provided in our challenge repository [6] (https://osf.io/u7a6f/):

Clinical Data:

A set of repeat DCE-MRI and T1-mapping scans from 8 patients with brain tumors, selected from RIDER Neuro MRI database [7, 8] and renamed, acquired on a 1.5T scanner at two scan dates, typically a few days apart is provided. The details of sequences are as follow:

- **For T1 mapping** variable flip angle (VFA) 3D FLASH images in axial plane have been obtained using flip angles of 5, 10, 15, 20, 25 and 30 degrees, TR of 4.43 ms, TE of 2.1 ms, 2 signal averages.
- **DCE-MR images** acquired using a 3D FLASH technique in axial plane have been obtained during the intravenous injection of 0.1mmol/kg of Magnevist at 3

mL/second, started 24 seconds after the scan had begun. The dynamic images were obtained with a flip angle of 25 degrees, TR of 3.8 ms, TE of 1.8 ms using a 1 x1 x 5mm voxel size. The 16-slice volume was obtained every 4.8 sec (temporal resolution).

Accompanying data:

- **Contrast-enhanced 3D FLASH:** The patients underwent whole brain 3D FLASH imaging in the sagittal plane after the administration of Magnevist. For this sequence, TR was 8.6 ms, TE 4.1 ms, 20 degree flip angle, 1 signal average, matrix 256 x 256; 1mm isotropic voxel size.
- **Contrast-enhanced 3D FLAIR:** The patients have 3D FLAIR sequences in the sagittal plane after the administration of Magnevist. For this sequence, the TR was 6000 ms, TE 353 ms, and TI 2200ms; 180-degree flip angle, 1 signal average, matrix 256 x 216; 1 mm isotropic voxel size.

Synthetic Data:

Two synthetic patient DCE-MRI datasets were derived from RIDER subjects in order to produce ground truth data that mimic actual data. The aim was to produce a Digital Reference Object (DRO) that can be analyzed with the same processing pipeline as the clinical data. For this reason, the synthetic DCE-MRI data were integrated into an original DICOM study including also the anatomical reference data from the same RIDER subjects.

Creation of synthetic data used two steps: first an inverse model was applied to the DCE-MRI and VFA data set to obtain realistic parameter maps (R_{10}, K^{trans}, v_p, k_{ep}) and a realistic arterial concentration (AIF); subsequently these parameter maps were altered to

produce an unknown ground truth, and a forward model was applied to produce synthetic DCE-MRI and VFA signal intensity curves. The details of the inverse model are embargoed until the challenge closes.

For the forward model, the modified Tofts model was applied with the AIF and parameter maps (K^{trans}, v_p, k_{ep}). The resulting tissue concentration time curves were converted into longitudinal and transverse relaxation rates, $R_1(t)$ and $R_2^*(t)$, assuming a linear relationship between concentration and each relaxation rate. Precontrast R_{20}^* was assumed to be constant. Subsequently, these relaxation rates were converted into DCE-MRI signal time curves assuming the signal evolution can be modelled as a spoiled-gradient echo sequence in steady state. Finally, Rician noise with a fixed standard deviation was added to the signal-time data. The VFA data were recreated using the same signal model and R_{10} maps.

Synthetic signal time data were exported into DICOM file format and the original DICOM DCE-MRI data were replaced by the synthetic data. The patient identifiers were overwritten to avoid confusion with the original RIDER data from which the DRO was derived.

How to download the data?

In our OSF repository (https://osf.io/u7a6f/) [6], navigate to the field called “Files”, where Synthetic and Clinical datasets are uploaded. Click on the OSF Storage as indicated in the picture below and then click on the button “Download as zip” to download the whole data.

Name	Size
OSIPI_TF6.2	
OSF Storage (United States)	
Challenge_Guideline	
OSIPI-DCE_challenge_guidelines.pdf	3.5 MB
Clinical_Data	
Clinical_P1.zip	187.4 MB
Clinical_P2.zip	170.6 MB
Clinical_P3.zip	187.0 MB
Clinical_P4.zip	195.7 MB
Clinical_P5.zip	171.4 MB
Clinical_P6.zip	203.1 MB
Clinical_P7.zip	202.3 MB
Clinical_P8.zip	197.2 MB
Synthetic_Data	
Synthetic_P1.zip	200.6 MB
Synthetic_P2.zip	202.0 MB

In the “Clinical_Data” folder, each of the .ZIP files include a main directory with the ID of the patient, e.g., Clinical_P{ID}, and two subdirectories, named “Visit1” and “Visit2”, representing the test-retest scan sessions for the patient.

The “Synthetic_Data” folder contains two directories for the two synthetic data (Synthetic_P1 and Synthetic_P2), each including two subdirectories, “Visit1” and “Visit2”, for the test-retest scans of the synthetic data.

How to submit the results?

Submissions should include the results of quantification along with a report about the analysis approach:

- Matrices of voxel-wise K^{trans} maps (in the original space) for all slices in the synthetic and clinical DCE-MRI (2 visits per patient) in NifTI format.
- Standard Operating Procedures (SOPs) with sufficient detail to allow a neutral team to reproduce the results without interaction with the submitters. The SOPs should explain how to access and install the software used, and provide a step-by-step guide needed for an independent individual to reproduce those steps. It is essential that the DRO data and patient are analyzed with the same analysis approach as the independent team will not analyze the DRO data any differently from the patient data.

There is no requirement to release the source code or base the submissions on open-source code. However, for commercial or in-house software that is not freely available, a trial license should be granted or an executable file be provided for the neutral team so the results can be reproduced independently. The license can be temporary allowing sufficient time for re-analysis. Instructions on how to obtain the license should be included in the SOPs and should not require interactions between submitters and neutral teams.

To submit:

Please create a single .ZIP file including the results AND the SOP, labeled as "OSIPI_DCE_challenge_{Name of the Team}.ZIP":

- For the results, we will accept files in NifTI format (.nii or .nii.gz) for the K^{trans} maps for each of the two visits of the DROs and patient scans, labeled with the corresponding DRO or patient name, and the associated visit (e.g., for the patient with ID "Clinical_P1", we will expect to receive "Clinical_P1_Visit1.nii" for K^{trans} in Visit1 and "Clinical_P1_Visit2.nii" for K^{trans} in Visit2).
- When you are ready to submit your results, submit your .ZIP file including your K^{trans} maps in NifTI format and the accompanying document (SOP) here: https://ismrm.sharefile.com/r-rb1013490f2df44b6a180f88eab861427
- Enter your email address, first and last names, and your institution in the form.
- Upload the .ZIP file in the designated area.
- Please contact osipichallenge@gmail.com if you have any problems.

Scoring the Submissions

The received submissions will be ranked by the organizing team according to the OSIPI-DCE score defined in **Table 1**. Masks of enhancing tumor (ET) and normal appearing white matter (NAWM) will be overlaid on the submitted K^{trans} maps teams, and the N pixels within the map will be used in calculating the scoring metrics. The general score for each submission is based on 3 metrics:

- Accuracy: how close are the submitted K^{trans} values based on the synthetic data to the hidden ground truth K^{trans}?
- Repeatability: how similar are the submitted K^{trans} values between test and retest scans, averaged over 8 clinical subjects?
- Reproducibility: how similar are the submitted K^{trans} values to those produced by the neutral team using the submitted SOPs?

Table 1. *Scoring metrics for evaluating the competing teams and their definitions*

Global OSIPI-DCE scoring metric	
$Score_{OSIPI-DCE} = 100 \times Score_{accuracy} \times Score_{repeatability} \times Score_{reproducibility}$	
Component scoring metrics	
$Score_{accuracy} = 1 - \frac{\sum_{i=1}^{N} stdev\left(K_i^{trans}, K_{i,\ exact}^{trans}\right)}{\sum_{i=1}^{4+N} mean\left(K_i^{trans}, K_{i,\ exact}^{trans}\right)}$	***Accuracy Score:*** A measure for the accuracy of K^{trans} values submitted by the competing teams (K_i^{trans}) in comparison to the exact value ($K_{i,exact}^{trans}$) in the synthetic data for *N* pixels in the predefined masks.
$Score_{repeatability} = 1 - \frac{\sum_{i=1}^{N} stdev\left(K_{i,\ visit1}^{trans}, K_{i,\ visit2}^{trans}\right)}{\sum_{i=1}^{N} mean\left(K_{i,\ visit1}^{trans}, K_{i,\ visit2}^{trans}\right)}$	***Repeatability Score:*** A measure for the repeatability of K^{trans} values submitted by the competing teams. The metric compares submitted K^{trans} values for the two patient visits ($K_{i,visit1}^{trans}$ and $K_{i,visit2}^{trans}$) in *N* pixels for all the 8 patients.
$Score_{reproducibility} = 1 - \frac{\sum_{i=1}^{N} stdev\left(K_i^{trans}, K_{i,\ neutral}^{trans}\right)}{\sum_{i=1}^{N} mean\left(K_i^{trans}, K_{i,\ neutral}^{trans}\right)}$	***Reproducibility Score:*** A measure that quantifies to what extent the submitted K^{trans} values are independently reproducible. The metric compares the submitted K^{trans} values (K_i^{trans}), calculated in *N* pixels for the 2 visits of each of the 10 cases (i.e., 2 synthetic and 8 patient data), against the same values reproduced independently by a neutral team ($K_{i,neutral}^{trans}$) based on the SOPs provided.

About Us

OSIPI task force (TF) 6.2 is a group of medical physicists, radiologists, and biomedical engineers, gathered to address the current issues of benchmarking perfusion quantification methods by organizing community challenges, where the methods proposed by researchers will be tested and evaluated in a systematic and controlled approach. This is the first challenge of TF6.2 contrast-based perfusion MRI challenge series. For more information about TF6.2 on OSIPI, please visit the webpage: https://www.osipi.org/task-force-6-2/.

More Information

News, dates, updates, tutorials, etc. can be found through the challenge task force at OSIPI website (link), OSIPI Google Group (link), and the challenge pages on LinkedIn and Twitter.

Contact:

The interested competing groups can contact osipichallenge@gmail.com for any queries and reporting any issues. You may also contact the challenge lead, Anahita Fathi Kazerooni (anahitaf@upenn.edu), or the co-lead, Harrison Kim (hyunkikim@uabmc.edu), for any queries.

Policies:

Data Usage Policy:

Upon registration in this challenge, the teams agree to use the synthetic data only for the purposes of this challenge and not to publish or share the data, or their results on the topic of this challenge with a third party until the embargo on the synthetic data is lifted, which would be at the time the challenge paper is published. After publication of the challenge paper, the embargo will be lifted, and the noise-free synthetic data will be released for public use, as well as the code used to generate them. The teams may use the synthetic data and their results on the topic of this challenge with proper citation of (1) the challenge paper, which will be provided at the time of the release, and (2) the challenge repository [6]. Citations will be to our OSF repository AND the challenge publication (we will notify all the challenge participants of the citation list).

The teams can download the original clinical data from TCIA collection: RIDER Neuro MRI [6, 7] (link) for their work and follow the citation & publication policies for this database.

Publication Policy:

For authorship on the publications, at OSIPI, the ICMJE criteria (International Committee of Medical Journal Editors) will be followed. The competing teams will be listed as co-authors on the publications of this challenge and their results will be published in supplemental material of the journal article.

References

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