# MRI based Virtual Histology:
# Meeting Tomorrow's Healthcare Challenges Today

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RÉPUBLIQUE FRANÇAISE

AMBASSADE DE FRANCE
AU ROYAUME-UNI

A French Embassy Sponsored Workshop
Partnered with UCL Grand Challenges


## 1. EXECUTIVE SUMMARY

A workshop aimed at improving diffusion MRI (dMRI) based non-invasive analysis of the human central nervous system was organised on the 26th-27th of May 2016 with the funding provided by the French Embassy. This workshop, titled *"MRI based Virtual Histology: Meeting Tomorrow's Healthcare Challenges Today"*, brought together scientists from a) the Microstructure Imaging Group (MIG), UCL, UK, b) Athéna, Inria Sophia Antipolis - Méditerranée, France, and c) VisAGeS U746 Research Unit, Rennes, France. The three research teams are well known for their contributions to dMRI and for their complementary approaches. While MIG advocates the microstructure paradigm and uses compartment based models, Athéna specialises in methods using functional basis representations. Finally VisAGeS has contributions in both techniques. Hence, the aims of this Anglo-French workshop were:

- to encourage new research collaborations and links between UCL, UK, Athéna, Inria, France, and VisAGeS, France in virtual histology and dissection from dMRI to advance the frontiers of noninvasive medical imaging.
- to seek joint research themes and directions that can combine the complementary model based histology approach of MIG, UCL, UK, & VisAGeS, France, and generic signal representation based connectivity analysis approach of Athéna, Inria, France.
- to explore funding possibilities for consolidating collaborations and for advancing to future concrete research projects.

The workshop was attended by 16 participants in total: 7 from UCL and 9 from France (Athéna: 5, VisAGeS: 4) and accounted for 3 Professors, 5 Lecturers and Research Scientists, 2 Research Associates and 6 PhD candidates. There were a total of 12 presentations: 3 overview presentations of the teams, and 9 scientific. The format followed was 20 minutes of talk and 10 minutes of discussion to strongly foster collaboration. The workshop also included dedicated discussion sessions to establish joint research themes and concrete funding opportunities.

By the end of the short but intense workshop all participants expressed their appreciation of the scientific content and exchange. Furthermore, a number of joint themes and funding opportunities were identified. And finally, a plan for applying for a collaborative funding proposal was drawn out.

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**Report prepared by** Dr Aurobrata Ghosh & Dr Gary Hui Zhang, Microstructure Imaging Group, UCL
**Sponsored by:** The French Embassy & UCL Grand Challenges

## 2. PROGRAM

**Day-1: Thursday 26th May**

| | | |
|---|---|---|
| 12:00 | Light lunch available for externals (Room: Roberts 1.03) | |
| 14:00 -- 14:15 | Welcome | |
| **INTRODUCTION** | | |
| 14:15 -- 14:45 | Neuroimaging in the VisAGeS Research Team | Christian Barillot<br>VisAGeS, Rennes |
| 14:45 -- 15:15 | Overview of research in the Athéna team: from microstructure modelling to mesoscopic anatomy representation | Demian Wassermann<br>Inria, (Sop.Ant.-Méd.) |
| 15:15 -- 15:45 | The UCL Microstructure Imaging Group | Daniel C. Alexander<br>UCL, London |
| 15:45 -- 16:00 | COFFEE BREAK | |
| **MICROSTRUCTURE IMAGING** | | |
| 16:00 -- 16:30 | Microscopic diffusion anisotropy imaging | Enrico Kaden<br>UCL, London |
| 16:30 -- 17:00 | Diffusion Multi-Compartment Models Processing | Olivier Commowick<br>VisAGeS, Rennes |
| 17:00 -- 17:30 | Exploring Diffusion Asymmetry and its Relationship with the Complex dMRI Signal: Theory and Feasibility | Marco Pizzolato<br>Inria, (Sop.Ant.-Méd.) |
| 17:30 -- 18:00 | DISCUSSION | |
| 19:00 | DINNER (vicinity of UCL) | |

**Day-2: Friday 27th May**

| | | |
|---|---|---|
| **PGSE AND BEYOND** (Coffee available) | | |
| 10:00 -- 10:30 | Exploring the brain using functional basis approaches: the three-dimensional diffusion propagator and beyond | Rutger Fick<br>Inria, (Sop.Ant.-Méd.) |
| 10:30 -- 11:00 | PGSE, OGSE and sensitivity to axon diameter in diffusion MRI | Ivana Drobnjak<br>UCL, London |
| 11:00 -- 11:30 | Predicting the Diffusion Signal: How General can we do? | Emmanuel Caruyer<br>VisAGeS, Rennes |
| 11:30 -- 11:45 | COFFEE BREAK | |
| **OTHER ADVANCES** | | |

| | | |
|---|---|---|
| 11:45 -- 12:15 | Logistic Random Effects Model for Groupwise Extrinsic Connectivity Parcellation | Guillermo Gallardo<br>Inria, (Sop.Ant.-Méd.) |
| 12:15 -- 12:45 | The realistic simulation of diffusion datasets and its applications | Mark Graham<br>UCL, London |
| 12:45 -- 13:15 | Image Quality Transfer | Ryutaro Tanno<br>UCL, London |
| 13:15 -- 14:00 | DISCUSSION (Light lunch will be provided) | |
| 14:00 | DEPARTURE | |

## 3. VENUE

**UCL "Bloomsbury Campus" (Gower Street, WC1E 6BT)**.
The workshop took place in Room 1.06, Roberts Building, first floor.

## 4. PARTICIPANT LIST

(alphabetical)

**Prof Daniel C. Alexander**
Professor of Imaging Sciences and Director of Research, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Prof Christian Barillot**
Research Director, VisAGeS U746 Research Unit, Rennes, France

**Dr Emmanuel Caruyer**
Research Scientist, VisAGeS U746 Research Unit, IRISA, Inria, Rennes, France

**Sudhanya Chatterjee**
PhD Candidate, VisAGeS U746 Research Unit, Rennes, France

**Dr Olivier Commowick**
Senior Research Scientist, VisAGeS U746 Research Unit, Rennes, France

**Prof Rachid Deriche**
Research Director, Athéna, Inria Sophia Antipolis - Méditerranée, France

**Dr Ivana Drobnjak**
Lecturer, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Rutger Fick**
PhD Candidate, Athéna, Inria Sophia Antipolis - Méditerranée, France

**Guillermo Gallardo-Diez**
PhD Candidate, Athéna, Inria Sophia Antipolis - Méditerranée, France

**Dr Aurobrata Ghosh**
Research Associate, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Mark Graham**
PhD Candidate, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Dr Enrico Kaden**
Research Associate, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Marco Pizzolato**
PhD Candidate, Athéna, Inria Sophia Antipolis - Méditerranée, France

**Ryutaro Tanno**
PhD Candidate, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

**Dr Demian Wassermann**
Associate Research Professor, Athéna, Inria Sophia Antipolis - Méditerranée, France

**Dr Gary Hui Zhang**
Senior Lecturer in Medical Image Computing, Centre for Medical Image Computing (CMIC) and Department of Computer Science, UCL

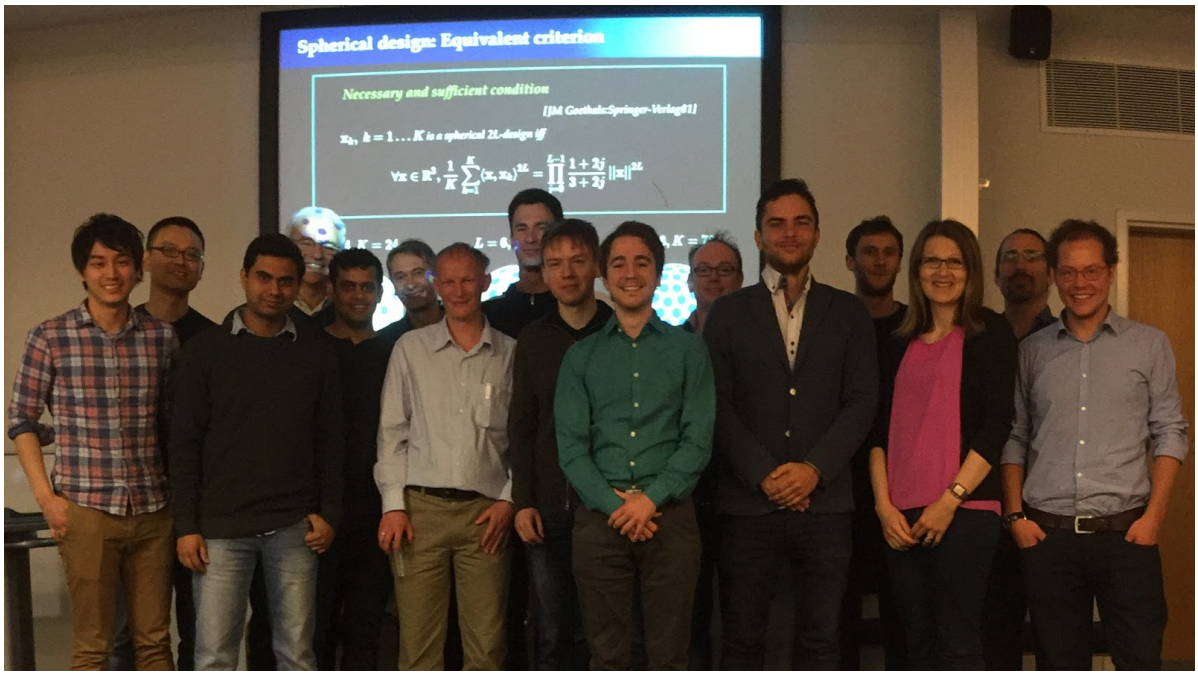


**Figure 1.** All participants of the workshop photographed in the conference room.

## 5. OUTCOME

There were several beneficial outcomes from the workshop. First, everyone appreciated the scientific content. A number of novel dMRI techniques that had been recently developed by the teams were presented in great detail with opportunity for elaborate questions. This led to enthusiastic exchanges. Next, the informal and flexible environment was conducive towards fruitful dialogues between the participants and the teams. This provided the junior researchers a platform to present their work and to interact with experts in the domain.

The participants also identified common research themes which could potentially lead to long term collaborations. Some pertinent ideas are as follows:

1. *Next Generation Multimodal Brain Connectivity Mapping:* Mapping the human connectome non-invasively is stipulated as the next major challenge. However, it is becoming evident that pure dMRI based tractography leads to humongous false-positives and false-negatives in the connectivity maps. Hence, during this workshop, the need for a next-generation multimodal brain connectivity mapping endeavour was recognised. It is clear that dMRI tractography needs to be constrained and augmented by other measures and modalities such as microstructure information, functional information (M/EEG, fMRI), histology or polarised light imaging data etc. Given the extensive experience of the three teams, this problem was identified as a prospective joint research theme.
2. *Managing Data from Multi-Centre Studies:* Managing and harmonising data from large scale studies conducted in multiple data acquisition centres with different parameters and hardware is a common problem worldwide and requires a definitive solution. This was identified as another common research theme.

During the discussion sessions funding opportunities were also investigated from which emerged the interest to target Horizon 2020 grants for Future and Emerging Technologies and for support for Innovative Training Networks. The idea of forming a larger European consortium for building the next generation brain connectivity mapping tools was also discussed extensively. It was agreed to begin with the current three core teams and then to expand progressively to a maximum of six to eight partners in the future. A plan for the senior participants, from the three teams, to meet next at an upcoming conference in end June 2016, and to apply for a grant was also chalked out.

## 6. FINANCE

The funds provided were spent for the travel and stay of the French participants. Two participants from Rennes had to travel the day before the start of the workshop due to flight constraints, hence they were covered for two nights' stay each. The funds were also spent for lunch and light refreshments for all participants during the workshop and a dinner on day-1 at the Koba restaurant was also organised. The final costing details are being calculated and will be reported in a follow-up email.

## 7. FINAL REMARKS

The three teams realised that the complementarity of their expertise and the diversity of their individual research interests in dMRI naturally led to common themes for future research collaborations. It was also noted that a large scale European collaboration could be initiated, which motivated fruitful discussions on fundings. The senior participants planned to meet in end June 2016 to carry this forward.

Finally, the authors of this report, on behalf of all the participants express their gratitude to the French Embassy for generously funding this workshop.