Developing the next generation of lung function measurement: A Study Group in Mathematical Modelling

Challenge Owners info pack

APRIL 17-20 2023

University of Sheffield
Co-organised by: BIOREME Network+, INSIGNEO
Institute, and the Knowledge Transfer Network
Funded by the EPSRC

Who are we?

BIOREME (Integrating data-driven BIOphysical models into REspiratory MEdicine) is an EPSRC-funded Network+ connecting researchers, industry and patient representatives at the interface of mathematical modelling and respiratory medicine. You can find out more about our activities at www.bioreme.net.

Based at the University of Sheffield, the INSIGNEO institute is Europe's largest research institute dedicated entirely to the development, validation, and use of in silico medicine technologies. Established in 2012, it has built a strong multidisciplinary network of over 260 academics and clinicians who bring together expertise in biomedical imaging, healthcare data, computational modelling, and digital healthcare technologies.

The Knowledge Transfer Network (KTN) was established by Innovate UK to connect innovators with partners and new opportunities. The Industrial Maths team within KTN harness the power of mathematics to meet business needs and help a wide range of industries express problems in an accessible way. They also facilitate new partnerships with an extensive network of mathematical scientists and institutions across the UK.

The BIOREME partner institutions:

An Introduction

What is a Study Group?

A Study Group is an intensive problem-solving workshop where participants form teams to work on specific research challenges or tasks. This study group "**Developing the next generation of lung function measurement**" will take a format similar to a hackathon whereby the participants choose which challenge they want to work on, brainstorm to propose potential solutions and then work together to progress these solutions as far as they can over the course of 3.5 days.

Challenge Owners will present their challenges and outline any accompanying datasets on the first afternoon of the event. There will be a Q&A to ensure participants get a clear idea of the challenges and what is being asked. Following this, Challenge Owners are welcome to remain present for the whole 3.5-day event and at minimum we ask they attend, either in person or virtually, the scheduled drop-in sessions to discuss progress and steer the group(s) working on their challenge. Participants are expected to attend in person for the full 3.5 days.

Who is it for?

The participants can be academic researchers (at least PhD candidate level or equivalent) from a range of backgrounds including statistical methods, biomechanics, biophysics, computational modelling, medical imaging and lung function/ breath content measurement. We expect most attendees to be Postgraduate Students or Early Career Post-Doctoral researchers. Participants are not required to have specific experience in the real-world challenges presented, they must have transferrable skills to tackle new challenges in their domain of expertise.

What can I expect to get out of it?

You can expect to benefit from:
- An opportunity to get some hands-on experience working on real-world industry challenges
- A taster of what industry collaboration could look like
- A taster of companies that value your skillset and their applications
- Networking opportunities with fellow participants
- Potential industry collaborations stemming from ideas generated at this study group
- Potential contributions to a scientific publication based on discussions at this event
- Opportunities to develop your communication skills, including conveying your expertise to an audience outside of your specialty.

What is expected of me?

You are expected to
- Commit **3.5 full days** of your time to work intensively on the challenges
- To be available **in person** for the full 3.5 days at The University of Sheffield
- To work collaboratively with your group members and be open to new perspectives and ways of thinking

How much does it cost?

There is no cost to attend the study group and the following will be included:
- Lunch and refreshments throughout the event
- A networking dinner on the evening of 17th April 2023

Accommodation. Accommodation is not included but we can recommend the following which are reasonably priced and within walking distance of the study group venue:
o Jonas Hotel or Halifax Hall
o The Rutland Hotel
o Wilson Carlile Centre

Location

Day 1 (17 April): Workroom 3, Diamond Building, the University of Sheffield
Day 2-4 (18 – 20 April) John Carr Design Suite, The Portobello Centre, The University of Sheffield, S14DT6

Transport

Car: Parking is limited in Sheffield city centre, nearby parking options include:
Q-park Rockingham Street
Fitzwilliam Street car park

Train: If arriving by train you can get the tram directly from the train station to nearby (a few minutes walk) the venue at West Street tram stop here

Registration Process

There are limited places at this study group, therefore we ask that you register in advance of the deadline. We ask that you provide a brief outline of your research interests to ensure you are suited to this event.

Funding For prospective participants who do not have their own funds to attend the event, you can apply to BIOREME's event support fund to cover any additional costs such as travel and accommodation. This will be an option on the registration form. You will be asked to:
- Detail your motivations for attending the study group
- State why you do not have access to other funding sources
- Estimate the cost to support the activity

The event support fund is limited, therefore we cannot guarantee your application will be successful.

Timeline

01/03/23: Confirmation of Challenges from Industry and Clinicians

24/03/23: Deadline for registration (including application to event support fund). Places are limited so we advise you register in advance of the deadline.

28/03/23: Final date to be informed whether your place has been confirmed (although we will aim to confirm within 1 week of your registration)

31/03/23: Informed of the outcome of applications to the event support fund

Challenge Summaries

Challenge 1: Remote monitoring to predict and prevent COPD exacerbations

Background: Global Access Diagnostics (GADx) have developed a remote patient monitoring platform 'Headstart' (https://www.globalaccessdx.com/respiratory-diseases) for measuring biomarkers in urine from lateral flow devices. Its purpose is to monitor COPD patients between clinical visits for biomarkers of that indicate increased risk of an exacerbation in the near future, enabling early intervention. The inflammatory responses preceding a COPD exacerbation are heterogeneous and complex, therefore the challenge is for Headstart to identify early or confirm the first signs of exacerbation with sufficient reliability and clarity for the patient to know when to seek medical attention or not. Early intervention on COPD exacerbations can avoid further damage to the patient's lungs, and so overall will result in reduced hospitalisations, Improved clinical and economic outcomes.

The problem: A machine learning algorithm has been developed to monitor urine biomarkers but requires further development, potentially including some mechanistic modelling. The problem is to make the algorithm more generalisable, so that a patient-specific `baseline' can be calculated and a multitude of elevated biomarker signals can be interpreted correctly.

Data available: Over 25,000 daily measurements are available for 5 biomarkers collected from 89 patients over a period of approximately 6 months.

Relevant expertise: Participants will require knowledge of techniques in Data Science and Machine Learning. Anybody with expertise in inflammatory markers and pathways would also be able to make valuable contributions to this challenge.

Challenge 2: Audio-phenotyping of patients using mobile-phone recordings

Background: Eupnoos are an audio-phenotyping company that use cloud-based software architecture to enable remote monitoring of lung function via a mobile app (https://www.eupnoos.com/). The data can then be sent to clinical practitioners to enable decision making across health care interfaces. Using this software, patients can upload audio recordings they have taken on their mobile phone of them undertaking a particular breathing manoeuvre for analysis. The goal is to democratise the availability of lung function diagnostic testing and thus address health inequalities and disparities by making use of the ubiquity of smartphone technology.

The problem: Eupnoos is using spectral analysis to identify features from the data that exhibit statistical associations with lung function. The challenge is to develop feature agnostic methods to measure and validate lung function using this spectral audio data.

Data available: Audio recordings of forced expirations taken via mobile phone coupled with ground truth gold standard spirometric data.

Relevant expertise: This challenge will be particularly relevant to those with expertise in data science/statistical modelling/machine learning and working with audio data as well as requiring insights regarding airway mechanics and lung function measurement.

Challenge 3: Accurate inference of airway mechanics from impulse oscillometry data

Background: Arete have developed a respiratory medical device, "The Respicorder" (http://www.aretemedtech.com/) that combines several measurements of lung function into one portable device. One of these measurements uses impulse oscillometry (IOS), whereby a small puff of air is quickly oscillated into and out of the mouth during normal breathing. The resulting pressure and flow rate changes can be used to the impedance of the airways, which in turn can provide proxy measurements for (patho)physiological changes in the small airways.

The problem: Disentangling the signal so that airway mechanics can be measured accurately (and device properties/environmental effects can be accounted for) remains an open challenge that has the potential to significantly improve the device and its translation to clinic.

Data available: Participants will have temporary access to IOS measurements collected by Arete for the purposes of this workshop

Relevant expertise: This challenge will likely require a combination of expertise in working with medical data, spectral analysis, as well as aspects of fluid/solid mechanics and airway physiology.