Ollscoil na Gaillimhe
University of Galway

School of Mathematical and Statistical Sciences

9th ANNUAL IRISH SIAM STUDENT CHAPTER CONFERENCE

Friday 9th December 2022

9:00 – 18:00 h

Hardiman Research Building

University of Galway

Kindly supported by:

Valeo, SIAM, and the Stokes Cluster at the School of Mathematical and Statistical Sciences at University of Galway

siam Society for Industrial and Applied Mathematics

Valeo

Stokes Cluster for Applied Mathematics
University of Galway

Index

WELCOME

Welcome to the 9th edition of the annual Irish SIAM Student Chapter Conference taking place at University of Galway on Friday 9th December 2022. Each year since 2014, the different student chapters in Ireland have organised the conference, with the very first initiated here at the University of Galway. Last edition was hosted by the SIAM Student Chapter at University of Limerick in January 2022. This year's conference will be the ninth edition, and its fifth time being hosted in Galway, in addition to being the first time since the COVID-19 restrictions were fully lifted.

The purpose of this conference is to bring together students and researchers from all over Ireland and abroad who are working in applied mathematics and related fields, including pure mathematics, statistics, computer science, engineering, physics, and other related topics. Students and researchers attending this conference will have the chance to present their own research, hear from eminent keynote speakers, learn from their colleagues, and make connections. It is our pleasure to have more than 40 people registered, who will attend 9 talks in total: 2 from the keynote speakers, one from industry and one from academia; and 7 contributed talks. In addition, there will also be a poster session with 5 contributed posters and a mystery session ;)

We would like to thank our keynote speakers: Dr. Stephen Russel from the company Valeo; and Dr. Romina Gaburro from University of Limerick. We are also extremely grateful to Mary Kelly and Collette McLoughlin, the administration people at the School of Mathematical & Statistical Sciences at University of Galway, for all their help. We would like to thank our long-standing faculty advisor Niall Madden, who has been guiding and helping the chapter members since we started in 2014.

We sincerely appreciate the financial support from the Irish brand of Valeo, from SIAM, and from the Stokes Cluster for Applied Mathematics at the University of Galway.

We hope you enjoy your time in Galway and we look forward to seeing you again soon.

University of Galway SIAM Student Chapter

Victoria Sánchez Muñoz *(President)*
Koushik Paul *(Vice-president)*
Vikrant Pratap *(Secretary)*
Michael Flattery *(Treasurer)*
Niall Madden *(Faculty Advisor)*
Peter Phelan
Sairam Pamulaparthi Venkata
Badriah Safarji
Tatiana Lapina
Mark Ryder
Aisling McAree

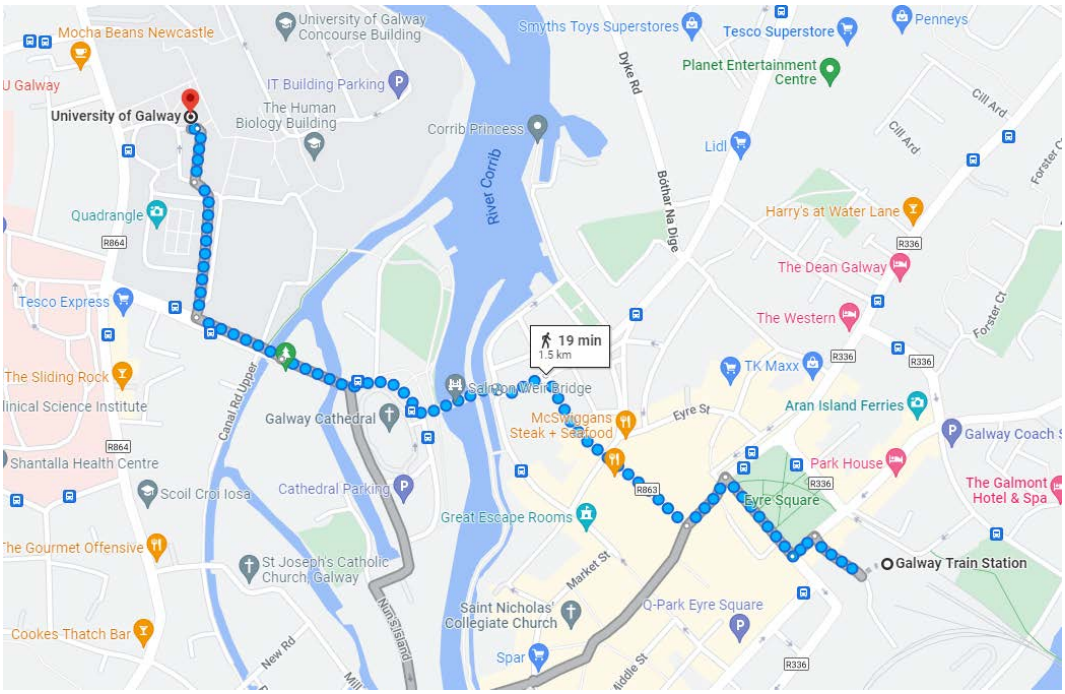
SCHEDULE

Time	Event
9:00-9:30	Registration
9:30-9:45	Introduction and Welcome
9:45-10:35	**Keynote Lecture** Stephen Russel (Valeo) *A vision based approach to driver assistance systems*
10:35-10:55	Robert Garvey (University of Limerick) *The Mathematical Theory of Plumes*
10:55-11:15	Pouyan Nejadi (University of Galway) *Movement Pattern Discovery with Applications In Elite Soccer*
11:15-11:40	Coffee break + poster session
11:40-12:00	Leah Keating (University of Limerick) *Modelling complex contagion on clustered networks with multi-type branching processes*
12:00-12:20	Khang Ee Pang (University College Dublin) *Geometric Diffuse Interface Method for Droplet Spreading*
12:20-13:00	MYSTERY SESSION ;)
13:00-14:20	Lunch (An Bhialann)
14:20 - 14:40	Sarah Murphy (University of Limerick) *Reaction dynamics of chemical decontamination*
14:40-15:30	**Keynote Lecture** Romina Gaburro (University of Limerick) *Inverse problems and imaging*
15:30 - 16:00	Coffee break + poster session + group photo
16:00 - 16:20	Caroline Pena (University of Limerick) *Finding polarised groups and tracking how information spreads using sentiment analysis and social structure on Twitter: The Irish Abortion Referendum*
16:20-16:40	Niall Donlon (University of Limerick) Stability and reconstruction of a special type of anisotropic conductivity in magneto-acoustic tomography with magnetic induction
16:40-16:50	Closing remarks and prize giving
16:50-18:00	Poster session / networking
18:30 - onwards	Conference Dinner at CAPRICE - Food served at 8pm

USEFUL INFORMATION

Getting there

The University is about a 20 minute walk from the train and bus stations, which are in the city centre. The campus bus stop is in front of the main gate of the university. We encourage walking (if weather permits) to promote good health and benefit the environment. Bus Éireann routes 402/404/405 and City Direct routes 410/411/412 connect Eyre Square to the University main gate. Please note that traffic/public transit delays are likely due to the Christmas market in Eyre Square.



NOTE: if traveling to Galway, please be advised to the latest weather forecast and warnings in https://www.met.ie/warnings/today *and allow extra time for possible disruptions.*

Parking

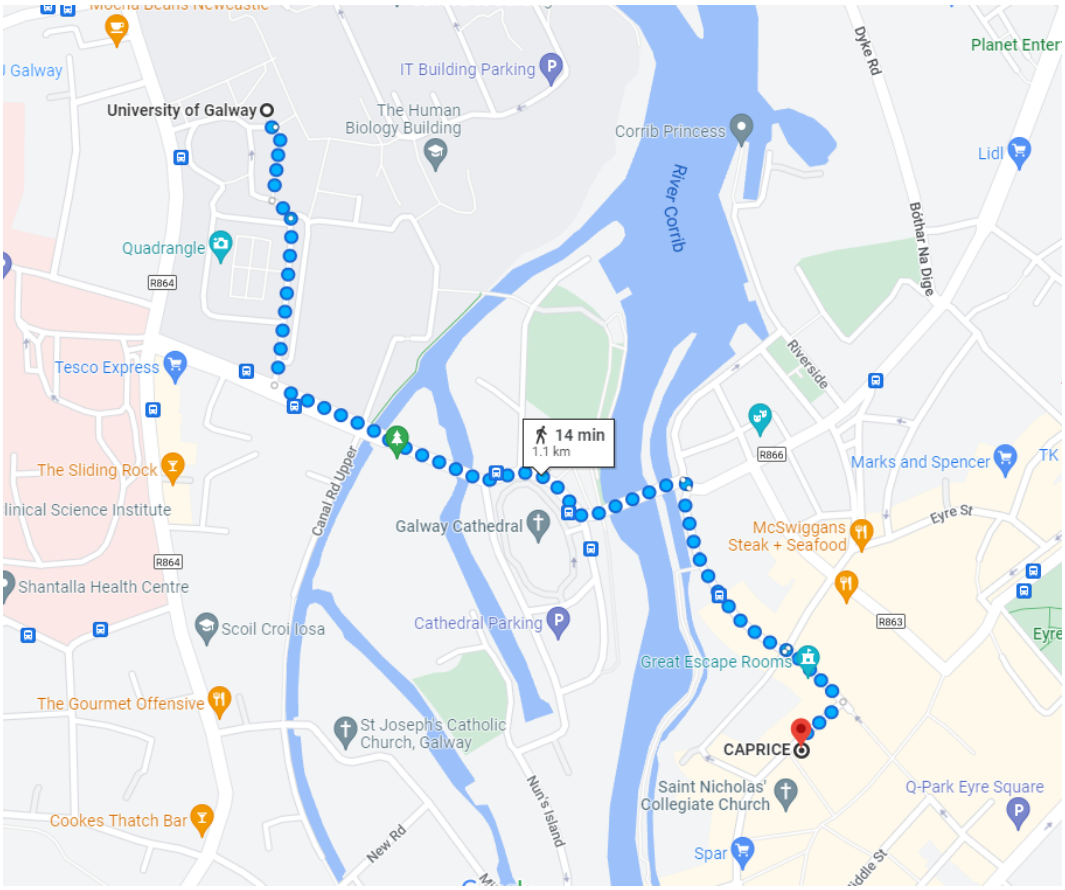
Participants traveling by car are encouraged to park in the city center due to the limited spaces on the campus. See the map below for a list of all the nearby parking spaces in the city. Note that there is also parking at the Mill St. Garda Station.

Coffee and lunch

During the coffee breaks, tea/coffee and pastries will be provided at the venue. Lunch will be provided for all participants at An Bhialann restaurant, which is downstairs (the basement) in the Hardiman Research Building.

Conference dinner

The conference dinner will take place at Caprice restaurant (1 Church Lane, Galway), with food being served at 8pm. The restaurant is about a 15-minute walk from the campus (see the map below). The dinner will be fully covered by the conference, thanks to our supporters, specially to the company Valeo. Before the dinner, everyone is welcome to join earlier for a walk around the city centre to see the Christmas market.



Wi-Fi

If you do not have eduroam setup already, you can connect to it with username: CollegeMedT and password: cr@zyFlag38.

Sustainability

We are committed to make the conference as sustainable as possible and due to that we are taking the next measures:

- Please, bring your own reusable cup, water bottle, notepad and writing materials.
- Feel free to return your badge to be reused.
- The booklet will not be printed and will only be available on the conference website and via a QR code.
- All participants are encouraged to use the public transport whenever possible. The venue is within walking distance from Galway City centre. Walking or cycling are probably the fastest option from the city centre.
- If participants need to stay overnight, we suggest the website https://www.bookdifferent.com/en/ which shows the greenest and most sustainable accommodation choices.

Code of conduct

The conference promotes a respectful, and inclusive environment for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion (or lack thereof), or technology choices. Any kind of discriminatory or inappropriate behaviour will not be tolerated. If you ever feel unsafe or in an inappropriate situation, or notice that someone else is, or if you have any other concerns, contact one of the organisers immediately. You might also send an email to siam.univofgalway@gmail.com.

CAMPUS MAP


Campas Thuaidh, an Daingean North Campus, Dangan
Na Foirgnimh The Buildings
24 Eolaíochtaí Bithleighis Biomedical Sciences
25 Cúrsa Saoil Lifecourse
Páirceáil agus Taisteal Park and Ride
Na Foirgnimh The Buildings
1 Institiúid na hEolaíochta Cliniciúla Clinical Science Institute
2 Institiúid Lambe don Taighde Aistritheach Lambe Institute for Translational Research
3 Oileán Ealtanach Nuns Island
4 Ionad na hÉireann do Chearta an Duine Irish Centre for Human Rights
5 Oileán an Iarla Earls Island
6 Scoil Scannán & Meán Digiteach Huston Huston School of Film & Digital Media
7 Áras Mháirtín Uí Riain Ryan Institute (Martin Ryan Building)
8 An Chearnóg Quadrangle
9 Áras na Mac Léinn (Sciathán Bailey Allen) Áras na Mac Léinn (Bailey Allen Wing)
10 Bitheolaíocht Dhaonna Human Biology
11 Áras Uí Chathail (S.I.D.) Áras Uí Chathail (S.I.D.)
12 Áras Uí Argadáin The Hardiman Building
13 Áras Dán na Mílaoise Arts Millennium Building
14 Foirgneamh na nDán/na hEolaíochta Arts/Science Building
15 Áras Oirbsean Orbsen Building
16 Foirgneamh IT IT Building
17 Oifig Slándála Security Office
18 An tIonad Spóirt Sports Centre
19 An tIonad Taighde agus Nuálaíochta Research & Innovation Centre
20 Áras Mhaighe Seola Moyola Building (Áras Moyola)
21 Innealtóireacht Engineering
22 Áras Cairnes Cairnes Building
23 An tIonad Taighde don Chothú Sláinte Health Promotion Research Centre
26 Áras na Gaeilge Áras na Gaeilge
27 Ionad Drámaíochta, Amharclannaíochta agus Taibhléirithe Uí Dhonnchú O'Donoghue Centre - Drama Theatre & Performance
HARDIMAN RESEARCH BUILDING
Eochair Legend
Príomhbhealaí isteach d'fheithiclí Main vehicular entrances
Príomhbhealaí isteach do choisithe Main pedestrian entrances
Slí inrochtana trasna an champais (do dhaoine maolghluaiste) Accessible route across campus (for the mobility impaired)
Foirgnimh do sheisiúin eolais na chéad bhliana Buildings for first year undergraduate orientation
Forbairtí nua ar an gcampas New campus development sites
Ardaitheoirí Elevators
Caiféanna agus bialanna Cafés and restaurants
Beár an Choláiste Bar
Áiteanna Páirceála ar an gCampas Parking Locations on Campus
Spásanna Roinnte Comhaltaí Foirne & Mic Léinn Staff & Student Shared Spaces
Spásanna Foirne Staff Spaces
Spásanna Íoc & Taispeáin (Í & T) Pay & Display Spaces (P&D)
Spásanna Mac Léinn Student Spaces
Spásanna do Chuairteoirí Amháin Reserved Visitor Spaces
Cuasa do Dhaoine faoi Mhíchumas Disabled Access Bays
Baile na Coiribe Corrib Village
Ospidéal Choláiste na hOllscoile, Gaillimh University College Hospital, Galway
Bóthar Mhic Coisteala Costello Road
Bóthar na hOllscoile University Road
Coirnéal Wards Wards Corner
An Ardeaglais Cathedral
Droichead na gCúig Chéad Quincentenary Bridge
Chuig an Aerfort & Bóthar Bhaile Átha Cliath To Airport & Dublin Road
Áras Spóirt, an Daingean The Sports Pavilion
Páirc Ghnó an Daingin A Dangan Business Park A
Anailísíocht Sonraí Insight Insight Centre for Data Analytics
Bóthar Thomáis Uí Eidhin Thomas Hynes Road
An Naíolann The Crèche
An Séipéal Chapel
Bóthar na Drioglainne Distillery Rd
Bóthar an Chaisleáin Nua Íochtarach Lower Newcastle Road
Bóthar an Chaisleáin Nua Uachtarach Upper Newcastle Road

TALKS

KEYNOTE LECTURE

A vision based approach to driver assistance systems

Stephen Russel *(Valeo)*, stephen.russell@valeo.com

In most modern vehicles today, advanced driver assistance systems are implemented in order to improve road safety and driver comfort. As this technology becomes more sophisticated, increased levels of vehicle autonomy are becoming a reality. This is achieved by processing and manipulating data that is collected from sensors placed around the vehicle. Vision-based systems use cameras as their primary source of data. In this talk, we will look at the role that computer vision plays in the development of driver assistance systems, together with some of the mathematics involved that make it all possible.

The Mathematical Theory of Plumes

Robert Garvey *(University of Limerick), robert.garvey@ul.ie*

A plume is an isolated convective upwelling. Examples are the rise of smoke from an industrial chimney, the formation of cumulus clouds over oceans, 'black smokers' at mid-ocean rise vents, and explosive volcanic eruptions. In these examples, a source of buoyancy drives a convective flow in the fluid above.

We reconsider the theory of turbulent plume formation provided by Schmidt (1941a,b) and its integral formulation, particularly that of Morton *et al.* (1956). A particular issue in the theory is whether the plume is taken to have finite or infinite width, and whether the entrainment rate is prescribed or deduced. Fox (1970) showed that the entrainment rate for a (formally) infinitely wide plume can be deduced from the governing partial differential equations by the use of integral moment theory, but it is less clear if this is the case if the plume is taken to be of finite width. Here we choose an eddy viscosity model of a plume which differs from those previously used by allowing the eddy viscosity to vanish with the vertical velocity. We then show that for the ordinary differential equations describing a similarity solution of a plume rising in an unstratified medium, this model confirms Fox's result that the entrainment condition is a consequence of the model formulation, and we show that the entrainment coefficient which is thus determined is consistent with values obtained by experiment. We also show that the resulting velocity profiles differ from those found experimentally by their omission of the Gaussian tail, and we suggest that this discrepancy may be resolved in the model by the inclusion of the small molecular kinematic viscosity.

References

1 Fox, D. G. 1970 Forced plume in a stratified fluid. J. Geophys. Res. **75** (33), 6,818-6,835.

2 Morton, B. R., G. Taylor and J. S. Turner 1956 Turbulent gravitational convection from maintained and instantaneous sources. Proc. R. Soc. Lond. A**234** (1,196), 1-23.

3 Schmidt, W. 1941a Turbulente Ausbreitung eines Stromes erhitzter Luft. I. Teil. Z. angew. Math. Mech. **21** (5), 265-278.

4 Schmidt, W. 1941b Turbulente Ausbreitung eines Stromes erhitzter Luft. II. Teil. Z. angew. Math. Mech. **21** (6), 351-363.

Movement Pattern Discovery with Applications In Elite Soccer

Pouyan Nejadi *(University of Galway)*, p.nejadi1@nuigalway.ie

The objectives of sports analytics are varied and differ depending on the stakeholder where data in professional sport are typically used for training, tactics and transfers. In recent years, in stadium sensor technologies have allowed enormous amounts of motion tracking data to be collected on players as they compete. This is particularly true for group sports (e.g. football, basketball, American football), where all player movement data can be captured using motion capture sensors installed throughout the stadium. These vast amounts of data have little value in themselves. Rather, the challenge is to develop new methods of data analysis that are fit for purpose to use these data to increase understanding about the sport in question. To date, such motion tracking spatiotemporal position data are used to learn about the tactical strategies such as team formations, transitions and specific player's roles.
The main goal of our research is to use motion tracking data to generate player specific motion signatures in a way that can be used to inform training intensity and drill selection. A popular approach for pattern discovery in domains such herd movement and in understanding how people move in busy streets uses clustering techniques via extracted features based on a von Mises mixture distribution. In this presentation we will introduce a bivariate Generalised Linear Model (GLM) to model movement angles and distance from the origin (i.e. (θ,D)). In particular, our proposed bivariate model is an extension of the von Mises and Rayleigh joint probability distribution functions, where the XY coordinates can be translated to the form of (θ,D). This model allows us to identify the most common trajectories and movement patterns at the player level by clustering the model parameters. Identifying personalised movement patterns can benefit players in terms of quantifying the physiological demands and movement profiles conditional on playing position. Furthermore, sports scientists can use this information to customise drill selection, duration and intensity and to design an injured player's rehabilitation program.
Examples will be given using motion tracking data from an English Premier League team.

Modelling complex contagion on clustered networks with mul5-type branching processes

Leah Keating *(University of Limerick)*, leah.keating@ul.ie

Understanding cascading processes on complex network topologies is paramount for understanding how diseases, information, fake news and other media spread. Complex contagion is one such cascading process which is characterised by repeated exposures making adoption more likely. Complex contagion dynamics have been observed in the adoption of health behaviour online [1], among other contexts. Clustering; i.e., the extent to which *"a friend of my friend is a friend of mine"* in a network, drives the complex contagion. In this talk, we extend the multi-type branching process method for modelling complex contagion on clustered networks developed in Keating et al., 2022 [2], which relied on homogenous network properties, to a more general class of clustered networks and, using a model of socially-inspired complex contagion, we obtain results, not just for the average behaviour of the cascades but, for full distributions of the cascade properties.

References

1 D. Centola, The spread of behavior in an online social network experiment, Science, 329 (2010), pp. 1194–1197.

2 L. A. Keating, J. P. Gleeson, and D. J. P. O'Sullivan, Multitype branching process method for modeling complex contagion on clustered networks, Physical Review E, 105 (2022), p. 034306.

Geometric Diffuse Interface Method for Droplet Spreading

Khang Ee Pang *(University College Dublin)*, khang-ee.pang@ucdconnect.ie

We introduce a mathematical model with a mesh-free numerical method to describe contact-line motion in lubrication theory. We show how the model resolves the singularity at the contact line, and generates smooth profiles for an evolving, spreading droplet. The model describes well the physics of droplet spreading – including Tanner's Law for the evolution of the contact line. The model can be configured to describe complete wetting or partial wetting, and we explore both cases numerically.

Reaction dynamics of chemical decontamination

Sarah Murphy *(University of Limerick)*, sarah.murphy@ul.ie

When a hazardous chemical soaks into a porous material such as a concrete floor, it can be difficult to remove. One approach is chemical decontamination, where a cleanser is added to react with and neutralize the contaminating agent. The goal of this talk is to investigate the reaction dynamics and the factors that affect the efficacy of the decontamination procedure. We consider a one-dimensional porous medium initially saturated with an oil-based agent. An aqueous cleanser is applied at the surface, so the two chemicals are immiscible and a boundary forms between them. A neutralising reaction takes place at this boundary in which cleanser and agent are consumed and reaction products are created. This is a Stefan problem, and the boundary between the cleanser and agent moves as the reaction proceeds. Reaction products formed at the interface may dissolve in one or both liquids. This may temporarily prevent cleanser and/or agent from reaching the reaction site, so diffusion of the chemical species plays a key role. The scenario described above was considered previously by [1] in the limit where the depth of the porous medium is large compared to the length scale over which concentrations vary inside the medium. Here, we present an alternative approach in which the ratio between these length scales can be varied. We will investigate how removal times and reaction dynamics vary with changes in this ratio and other dimensionless parameters in the model. We will also briefly discuss and present some results for the early-time behaviour of the system, highlighting the emergence of a boundary layer associated with diffusion in the oil phase similar to that discussed in [2] where the thickness of the boundary layer is directly proportional to the square root of the time variable.

Keywords: decontamination, Stefan problem.

References

1 M. Dalwadi, D. O'Kiely, S. Thomson, T. Khaleque, and C. Hall. Mathematical modelling of chemical agent removal by reaction with an immiscible cleanser. SIAM Journal on Applied Mathematics, 77(6):1937-1961, Nov. 2017

2 M. Assunção, M. Vynnycky, S. L. Mitchell. On small-time similarity-solution behaviour in the solidification shrinkage of binary alloys. Eur. J. Appl. Maths, 32:199-225, 2021.

KEYNOTE LECTURE

Inverse problems and imaging

Romina Gaburro *(University of Limerick)*, romina.gaburro@ul.ie

In this talk we introduce the concept of inverse problem, the mathematical technique behind imaging and material characterisation. We explain the idea of inversion from data/measurements to physical parameter (describing a physical property of a medium) and the mathematical challenges behind imaging. These challenges are mostly due to the intrinsic ill-posed and non-linear nature of inverse problems. Thus, inversion from data/measurements to physical parameter, requires regularisation so that it can produce reliable images of the material in question.

Finding polarised groups and tracking how information spreads using sentiment analysis and social structure on Twitter: The Irish Abortion Referendum

Caroline Pena *(University of Limerick)*, caroline.pena@ul.ie

Twitter is a popular venue for the expression of opinion and dissemination of information. As a result, Twitter is an invaluable resource for insights into the relationships and mechanisms that govern social interactions, such as identifying the sides of the debate and, importantly, how information spreads between these groups in our current polarised climate.
Previous research examined the 2015 Irish Marriage Referendum and successfully used Twitter data to identify those who were pro and anti-same-sex marriage equality with a high degree of accuracy. We improve on this work by 1) Showing that we can obtain better classification accuracy of yes- and no- supporters on two independent datasets (Irish Marriage and Abortion referendums) while using substantially less data. 2) We extend the previous analysis by tracking not only how yes- and no-supporters interact but how the information they share spreads across the network, within and between yes- and no-aligned groups.
To achieve this, we collect over 688,000 Tweets from the Irish Abortion Referendum of 2018 to build a conversation network from users' mentions with sentiment-based homophily. From this network, community detection methods allow us to isolate yes- or no-aligned supporters with high accuracy (97.6%). We supplement this by tracking how information spreads via over 31,000 RT Tweet cascades, which are reconstructed from a user mention's network in combination with their follower's network. This provides a valuable methodology for extracting and studying information spread on large networks by isolating ideologically polarised groups and exploring how information diffuses within and between these groups.

Stability and reconstruction of a special type of anisotropic conductivity in magneto-acoustic tomography with magnetic induction

Niall Donlon *(University of Limerick)*, niall.donlon@ul.ie

We study the issues of stability and reconstruction of the anisotropic conductivity σ of a biological medium $\Omega \subset \mathbf{R}^3$ by the hybrid inverse problem of Magneto-Acoustic Tomography with Magnetic Induction (MAT-MI). More specifically, we consider a class of anisotropic conductivities given by the symmetric and uniformly positive definite matrix-valued functions $A(x, \gamma(x))$, $x \in \Omega$, where the one-parameter family $t \mapsto A(x, t)$, $t \in [\lambda^{-1}, \lambda]$, is assumed to be *a-priori* known. Under suitable conditions that include $A(\cdot, \gamma(\cdot)) \in C^{1,\beta}(\Omega)$, with $0 < \beta \leq 1$, we obtain a Lipschitz type stability estimate of the scalar function γ in the $L^2(\Omega)$ norm in terms of an internal functional that can be physically measured in the MAT-MI experiment. We demonstrate the effectiveness of our theoretical framework in several numerical experiments, where γ is reconstructed in terms of the internal functional. Our result extends previous results in MAT-MI where the conductivity σ was either isotropic or of the simpler anisotropic form γD, with D an *a-priori* known matrix-valued function in Ω. In particular, the more general type of anisotropic conductivity considered here allows for the anisotropic structure to depend non-linearly on the unknown scalar parameter γ to be reconstructed. This is joint work with Romina Gaburro, Shari Moskow and Isaac Woods.

POSTERS

Classical and Quantum computing Technology for Error correction

Abdul Fatah *(Atlantic Technological University, Galway)*, abdul.fatah@research.atu.ie

We aim to develop computational techniques for hybrid systems of classical and quantum computers. We are working to make Noisy Intermediate-scale Quantum (NISQ) computers more fault tolerant by mitigating the errors present in quantum computation. The work revolves around the central theme of quantum circuits, making them useful with quantum algorithms, i.e. understanding the quantum mechanism, analysing existing and developing new algorithms. We envision developing new quantum computing algorithms using standard classical computational tools such as Jupyter, Python, GitHub, and Qiskit. Work on this project will be primarily through Jupyter notebooks and the Python programming language. IBM's open source python library Qiskit can be used to code for the quantum computers. The benefit of quantum algorithms is their inherent efficiency compared to classical algorithms. We envision developing new quantum computing algorithms using standard classical computational tools such as Jupyter, Python, GitHub, and Qiskit. Work on this project will be primarily through Jupyter notebooks and the Python programming language. IBM's open source python library Qiskit can be used to code for the quantum computers.The benefit of quantum algorithms is their inherent efficiency compared to classical algorithms. They can potentially make classically intractable problems tractable. Several quantum algorithms already exist but We are specifically targeting quantum algorithms based on dihedral symmetries. Theoretical analysis is one of the important aspect of any quantum algorithm verification. Quantum computing advancement tend to replace classical computers, communication and cyber-security in their current form but it's too early to claim. Quantum computers will open new horizons of technological world but classical ones will always be an essential part of technology to feed quantum computers and other usual tasks.

Programmable wrinkling for functionally-graded auxetic circular membranes

Sairam Pamulaparthi Venkata *(University of Galway)*, s.pamulaparthivenkata1@nuigalway.ie

Materials with negative Poisson's ratio belong to the so-called auxetic material class: they display exotic properties such as contraction/expansion in all directions under uni-axial compression/tension. They are found in a wide range of applications in robotic, structural, aerospace, and biomedical engineering. In this work, we investigate how spatial variations of Young's modulus and Poisson's ratio across a circular membrane under radial tension, affect the formation of wrinkling patterns in the membrane. We show that, in principle, inhomogeneities can be tailored to specify the locations of wrinkling in auxetic circular membranes.

Instability analysis of laminated magnetorheological elastomers (MREs)

Chen Xie *(University of Galway)*, c.xie1@nuigalway.ie

Magnetorheological elastomers (MREs) are composite materials involving an elastomeric matrix and magnetizable inclusions. The unique microstructures in materials make it possible to switch the mechanical properties of MREs by triggering local buckling or instability phenomena artificially. This work mainly focuses on the instability phenomenon of the MRE laminates. In this study, we have developed simulation models of MRE laminates with soft magnetic material inclusions and performed post-buckling analysis using Comsol. At the same time, we have established an efficient analytical model to determine the critical characteristics of the onset of magneto-mechanical instabilities in MRE laminates. Based on these models, we have obtained the relationships between critical stretch (critical wavelength) and magnetic field level. Further, we have studied the effect of volume fraction on the onset of magneto-mechanical instabilities.

Linear and nonlinear modelling for Metamaterials

Tiziana Comito *(University College Dublin)*, tiziana.comito@ucdconnect.ie

Advance in technology and infrastructure created an increasing demands for specific features that traditional materials can not satisfy. Metamaterials are artificially engineered design structures that interacts uniquely with waves. Their properties depend on the geometrical construction rather than chemical composition. Interests of this work is to propose a set of discrete, dispersive, one dimensional systems, constructed as extremely simplified toy models able to mimic the fundamental characteristics of a Metamaterial. Studying their behaviour in the linear and nonlinear limit allow to explain the state of vibration of the physical counterpart. Some industrial-related applications worth mentioning: absorption of mechanical vibrations, manipulation of acoustic waves, prevention from earthquakes damages, and coastal erosion.

A Mathematical Model for Holographic Recording in Photopolymer Media with Zeolite Nanoparticles

Jack Lyons *(TU Dublin)*, c10381149@mytudublin.ie

Researchers from the Industrial and Engineering Optics group and the School of Mathematical Sciences at TU Dublin have done extensive work on a mathematical model to describe holographic recording in a photopolymer materials, more recent studies have shown that the addition of zeolite nanodopants can improve the dynamic range and reduce photopolymerization-induced volume shrinkage. In this research project, a new mathematical model is presented capable of explaining these observations. A coupled system of reaction-diffusion equations will be presented that can describe the mass spatial-temporal profile of monomer, short polymer chains (oligomer), long polymer chains and inert nanoparticles over the duration of holographic recording. These new equation will take into account how both the mass transport properties of the mobile monomer and oligomer and rate of photochemical reactions are impacted by the presence of zeolite nanodopants. The new model is validated via a comparison of its predictions against experimental observations.

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