ICMS Modelling Camp 2026 - Challenge descriptions

Photo-stitching workflow for seabird cliff surveys

Facilitator: Jessica Enright, University of Glasgow
Challenge holder: HiDef Aerial Surveying Ltd

Dynamic transition modelling in tennis to replace IID assumptions for sports prediction

Facilitator: Abdul-Lateef Haji-Ali, Heriot-Watt University
Challenge holder: Sports and Wellbeing Analytics

To spot or predict adverse pressure for A&E services and how to predict this pressure

Facilitator: Lisa McFetridge, Queen's University Belfast
Challenge holder: Public Health Scotland

Quantifying shape variation in 3D human body data

Facilitator: Alberto Paganini, University of Leicester
Challenge holder: Body Aspect

Photo-stitching workflow for seabird cliff surveys

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Accurate monitoring of cliff-nesting seabirds is fundamental to understanding the health of marine ecosystems and informing conservation policy in UK waters. Population trends in breeding colonies are used as indicators of wider environmental change, including shifts in prey availability and oceanographic conditions. Traditional manual counts conducted from a moving boat are valuable but inevitably limited by observer experience, sea state and the difficulty of estimating numbers across complex cliff faces.

HiDef Aerial Surveying Ltd have supplemented this manual count with the collection of thousands of high-resolution overlapping photographs; this represents a major step forward, offering a permanent and reviewable record and the potential for automated detection and counting. However, without reliable stitching into coherent composites, these images remain fragmented and cannot fully support efficient, large-scale analysis. Designing a methodology that enables robust stitching under real survey conditions is therefore scientifically important.

In practice, stitching more than a few images at once has proven challenging. As the boat is moving, the camera's distance, angle, and perspective constantly change, introducing parallax and distortion. Standard stitching software assume a fixed camera position, so it performs poorly under these conditions. Other difficulties include predominantly vertical overlap, complex three-dimensional cliff structures, very large datasets, and high computational demands - all of which can lead to misalignment and outputs unsuitable for reliable automated analysis.

This project asks you to design a methodology for stitching these survey images, but while producing a full workflow is desirable, a key outcome is understanding the limitations of the data and/or improvements to the original image collection methodology to enable more reliable stitching in future.

Dynamic transition modelling in tennis to replace IID assumptions for sports prediction

Facilitator: Abdul-Lateef Haji-Ali, Heriot-Watt University
Challenge holder: Sports and Wellbeing Analytics

Standard tennis prediction models assume that each point is an independent and identically distributed (IID) Bernoulli event with a fixed probability of winning a point [1]. Using this assumption, match-winning chances can be derived using absorbing Markov chains. However, this approach fails to capture momentum shifts, pressure effects, fatigue, and tactical adaptation, all of which influence point-level outcomes but are ignored in IID formulations.

In contrast, live prediction markets adjust probabilities dynamically, indicating point-win probabilities are treated as state-dependent and time-varying rather than fixed [2]. This suggests the need for more flexible models where transition probabilities evolve based on recent point history, scoreline context, or even as a stochastic process using time-inhomogeneous Markov chains or Stochastic Differential Equations (SDEs).

The aim of this project is to develop a dynamic, non-IID probability model for tennis point transitions and evaluate whether it better matches observed in-play prediction compared to traditional static models. The outcome may help identify conditions where markets overreact or underreact to momentum, offering insight into prediction efficiency.

[1] Klaassen, F. J., & Magnus, J. R. (2001). Are points in tennis independent and identically distributed? Evidence from a dynamic binary panel data model. Journal of the American Statistical Association, 96(454), 500-509.

[2] Kovalchik, S., & Reid, M. (2019). A calibration method with dynamic updates for within-match forecasting of wins in tennis. International Journal of Forecasting, 35(2), 756-766.

To spot or predict adverse pressure for A&E services and how to predict this pressure

Facilitator: Lisa McFetridge, Queen's University Belfast
Challenge holder: Public Health Scotland

Public Health Scotland

Public Health Scotland is Scotland's lead national agency for improving and protecting the health and wellbeing of all of Scotland's people. One of Public Health Scotland's goals is the use of intelligence and data to support the system and improve the experience we will have with the system.

The health and social care system faces many challenges. To support these challenges, Public Health Scotland are building models to simulate parts of the system and ultimately create a Whole System model. Currently, the acute hospital focused model estimates the number of beds required in hospitals to manage demand, which includes looking at the flows of patients in and out of the system. This enables stakeholders such as health boards and the Scottish government to adapt to the expected future outcomes.

For our challenge we are looking for people to support us in 'widening' our modelling specifically for A&E. The challenge has four steps, you can do steps 2 and 3 in either order:

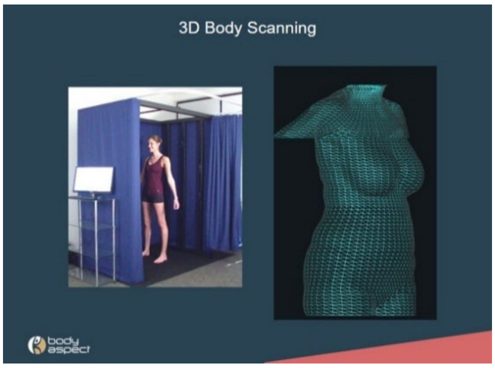
1. Using our open data and a specifically created dataset, identify hours or days where demand for A&E services stands out and label these as adverse pressure.
2. Use your labelled datasets to understand what drives these adverse events: is it related to some time related factor, demand from ambulance arrivals or admissions to hospital?
3. Using the open data, think beyond the core data to look at other factors that might impact on pressures, such as events, weather or geographical issues.
4. Bring everything together to propose how your findings can help PHS to further develop modelling and make an impact on the system.

We have built a national A&E model and we are continuing to develop it to support the system. All the ideas that you generate will be useful for us to understand the system. We are open to any new solutions that might expand our knowledge of this part of the system, please try to surprise us.

Quantifying shape variation in 3D human body data

Facilitator: Alberto Paganini, University of Leicester
Challenge holder: Body Aspect

Body Aspect is an innovator in the field of 3D body imaging. Through its technological developments the company has led the industry into new territories including sizing surveys for the apparel industry, 3D image assessment, and body measurement services for the NHS. For example, Body Aspect collaborates with several NHS organisations to support the assessment of patients seeking NHS-funded elective breast surgery.



Body Aspect 3D body models are constructed from images collected with 14 infrared sensor cameras (see figure). Body Aspect has developed proprietary technology to convert these images into accurate full-360-degree body models.

To further refine and evolve its products, Body Aspect is interested in mathematically robust techniques to quantify local and global shape variations (e.g., breast development anomalies or non-typical body shapes), including situations where only partial data may be available. Methods that enable meaningful comparison of body shape and support the extraction of clinically relevant measurements from 3D scan data are of particular interest.

Body Aspect is also exploring new synergies with virtual reality technology, which requires shifting from static representations of bodies to morphable virtual models capable of representing realistic variation in human body shape.

This project aims to update Body Aspect with a review of the latest advancements in 3D full body modelling. This will guide their future product roadmap. Students working on this project can expect to make use of standard data analysis techniques (e.g., singular value decomposition/principal component analysis) and scientific programming (e.g. Python).

The graphics paper “SMPL: a skinned multi-person linear model” by Loper et Al, (2015, DOI: 10.1145/2816795.2818013) provides an important starting point.