Image and Video Analysis Using Machine Learning Algorithms

We welcome applications from all qualified candidates who would be interested in the areas of image and video analysis using machine learning algorithms.

Topic 1: Counting Small and Clustered Objects Using Deep Neural Network

Object counting has received growing attention due to its practical usages, such as counting goods/crowd/bacteria colony/blood cells. Counting small and clustered objects is a challenging computer vision task. Many researchers have attempted to apply machine learning algorithms to tackle this task. However, feature engineering using deep learning algorithms is yet to be explored comprehensively. This project aims to investigate how deep neural network techniques can be used to address the issues of counting small and clustered objects.

Topic 2: Human Fall Detection Using Deep Neural Network

Demographic trends make one-to-one personal care increasingly unsustainable. Care funders are looking for cost effective solutions to the care crisis. Presently there are bed sensors, chair occupancy and absence sensors, emergency and mobile alarms, bracelets, but these rely on the client activating them or remembering to wear/activate them. This may not be possible with sudden falls, unconsciousness or immobility. The project aims to investigate how deep neural network techniques can be used to detect human falls from video, conducting risky human activity recognition, and rapidly identify vulnerable clients in danger, due to a collapse/fall. This project lies in the area of human activity recognition but focuses on fall detection under domestic settings.

Topic 3: Applying Deep Learning for Classification of Single Particle Light Scattering Patterns

This is a collaborative project with the Department of Physics, Astronomy and Mathematics at UH.

Cloud feedback is a large source of uncertainty in climate models [1]. Predicting the radiative properties of cirrus clouds is problematic, since cirrus is composed of various ice crystal shapes, which also vary substantially in terms of complexity. This variation depends on environmental variables such as temperature and relative humidity [2]. Reducing this uncertainty requires detailed in situ characterization of cloud particles. Cloud probes based on imaging techniques, such as the Cloud Particle Imager (CPI) provide extremely valuable data for particles larger than ~25 µm, but below this, diffraction, optical aberrations, and constrained depth of field make detailed assessment of particle shape problematic [3]. Alternatively, indirect methods use observations of single scattering properties. Single particle scattering patterns are obtained by the family of the Small Ice Detector (SID) instruments pioneered by [3]. Obtaining particle information from the scattering patterns requires solving the inverse scattering problem. This is often facilitated by previous knowledge of how scattering properties of small particles depend on the particle size parameter, morphology, relative refractive index and orientation. In order for such databases to be created, either computational models which can determine the intensity of light scattered by a known particle into a given angular range, or experimental data are required.
Machine learning methods (support vector regression models [5,6], random forest classifier [6], a pilot study using deep learning [7]) have been applied for characterization of pristine hexagonal prisms [5-7] as well as rough and rounded particles [7] from their 2D scattering patterns. Here, we propose to use Deep Learning methods to classify 2D scattering patterns of single atmospheric particles, in particular ice particles. During the project, a database of 2D scattering patterns from particles with different shape, size, surface properties and orientations will be generated using a novel physical optics light scattering model [8]. Data from this data base will be applied for training machine learning models, which then will be used to evaluate test data. This project aims to propose and implement new algorithms that can classify scattering patterns reliably and fast.

[1] IPCC. Climate Change The physical science basis. Clim Chang 2014 Synth Rep 2013;2014:151.

doi:10.1017/CBO9781107415324.
[2] Baran AJ. From the single-scattering properties of ice crystals to climate prediction: a way forward. Atmos Res 2012;112:45–69. doi:10.1016/j.atmosres. 2012.04.010
[3] Kaye PH, Hirst E, Greenaway RS, Ulanowski Z, Hesse E, Demott PJ, et al. Classifying atmospheric ice crystals by spatial light scattering. Opt Lett 2008;33:1545–7. doi:10.1364/OL.33.001545
[4] Mishchenko MI, Travis LD, Lacis AA. Scattering, absorption, and emission of light by small particles. Cambridge university press; 2004
[5] Priori, D., de Sousa, G., Roisenberg, M., Stopford, C., Hesse, E., Davey, N. & Sun, Y. (2016) Using Machine Learning Techniques to Recover Prismatic Cirrus Ice Crystal Size from 2-Dimensional Light Scattering Patterns. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 9887: 372-379
[6] Salawu, E. O., Hesse, E., Stopford, C., Davey, N. & Sun, Y. (2017) Applying machine learning methods for characterization of hexagonal prisms from their 2D scattering patterns – an investigation using modelled scattering data. J. Quant. Spect. Rad. Trans. 201:115-127.
[7] Mathen, E.R. Analysis and Modelling of TTL ice crystals based on in-situ light scattering patterns. PhD thesis. University of Hertfordshire, 2023.
[8] Ballington H, Hesse E. A Light Scattering Model for Large Particles with Surface Roughness. Submitted to J. Quant. Spect. Rad. Trans..

Required academic entry qualifications

The prospective candidates should have a Master's degree at merit plus an upper second-class (2:1) honours degree or above in Computer Science or in a relevant subject. In particular, they should demonstrate strong programming skills in one or more major computer languages. For example, Python, C++. Previous knowledge and experience on machine learning will be beneficial to this studentship application. For Topic 3, an interest in physics/optics will be helpful.

Contact

Please contact **Dr. Na Helian (n.helian@herts.ac.uk) or Dr. Yi Sun (y.2.sun@herts.ac.uk)** directly if you have any specific questions on the proposed research areas.