

Applications of Machine Learning in medical research

QuanTII Summer Workshop

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About me

- No background in T-cells, immunology or immunotherapy
- Completed a PhD in statistical machine learning to predict eczema (skin disease)
- Expertise in Bayesian modelling and time-series forecasting
- Post-doctoral researcher in the Tanaka group, Department of Bioengineering, Imperial College London
- The group mostly focus on mathematical modelling, systems biology, etc.

Group website: <https://rtanaka.bg-research.cc.ic.ac.uk/>

Personal website: <https://ghurault.github.io/>

What is Machine Learning?

The field of study that gives computers the ability to learn without being explicitly programmed.

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Supervised Learning

Unsupervised Learning

Reinforcement Learning

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Supervised Learning

Learning from labelled data (prediction)

- Neural networks
- Tree-based algorithms: CART, boosting, bagging, etc.
- Support Vector Machines
- Regression models: generalised linear models, regularised regression, splines, generalised additive models, Gaussian Processes, etc.

Unsupervised Learning

Reinforcement Learning

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Supervised Learning

Unsupervised Learning

Learning from unlabelled data

- Clustering
- Dimensionality reduction

Reinforcement Learning

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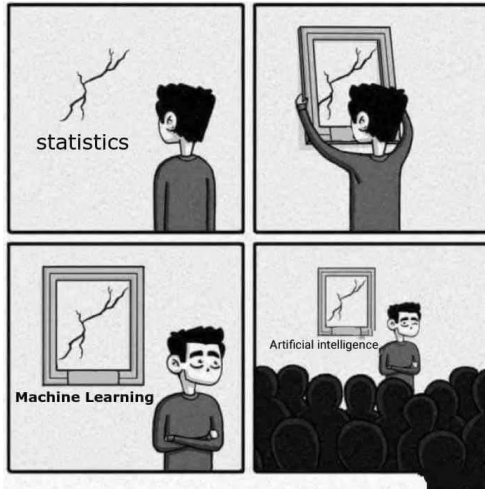
Supervised Learning

Unsupervised Learning

Reinforcement Learning

Learning how to make decisions

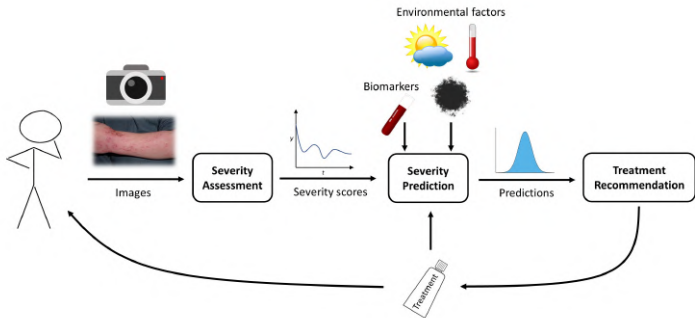
Machine Learning is mostly a buzzword



- Eczema cannot be cured but can be managed with treatments
- Treatment responses vary from patient to patients
- Designing personalised treatment strategies is of high clinical relevance

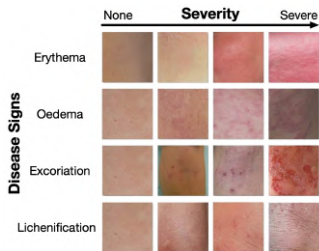
My work

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Assessing eczema from camera images¹

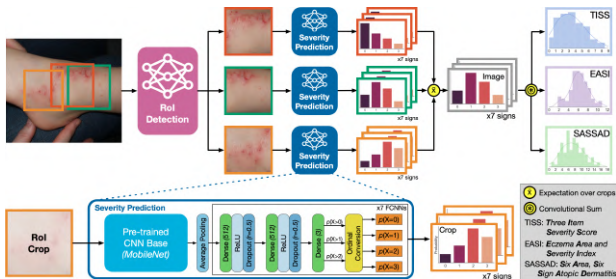
- Patients need to visit clinic to have their eczema assessed
- Assessments can be biased
- We developed a computer vision algorithm to automatically detect and assess eczema from camera images



¹K. Pan, G. Hurault, K. Arulkumaran, H. C. Williams, and R. J. Tanaka, “EczemaNet: Automating Detection and Severity Assessment of Atopic Dermatitis,” in Machine Learning in Medical Imaging, Springer, Cham, 2020, pp. 220–230.

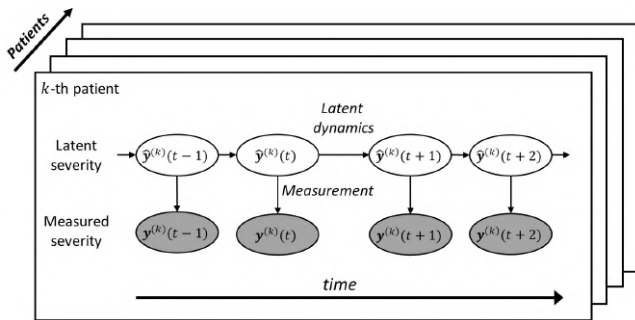
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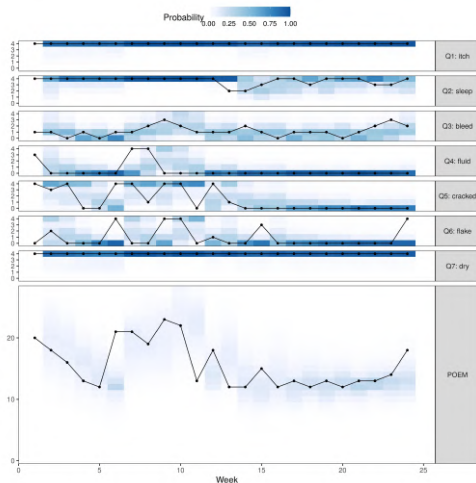
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Predict eczema severity²



²G. Hurault et al., "EczemaPred: A computational framework for personalised prediction of eczema severity dynamics," Clin. Transl. Allergy, vol. 12, no. 3, p. e12140, Mar. 2022.

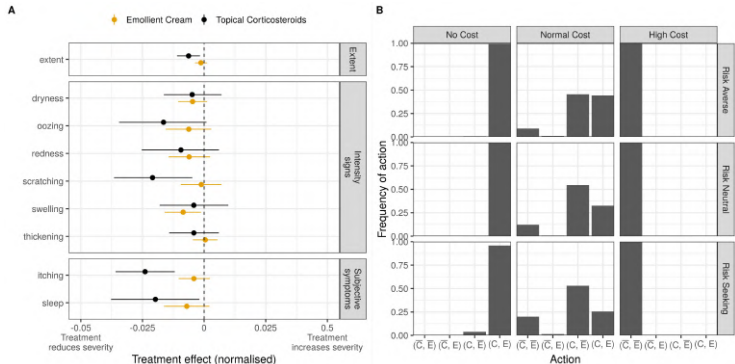
Predict eczema severity²



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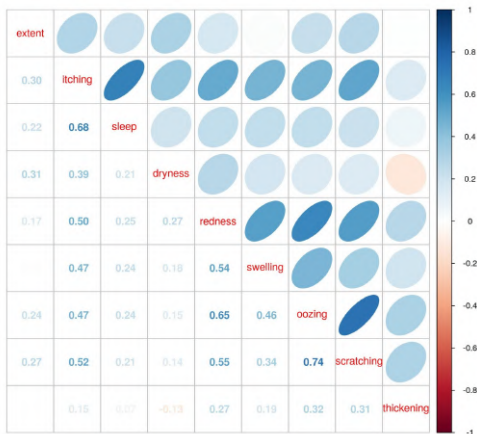
Making personalised treatment recommendations

- Turning predictions into actions
- Decision-making under uncertainty (Bayesian decision theory)



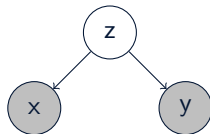
Finding a lower dimensional representation of eczema severity data

The data shows strong correlations



Finding a lower dimensional representation of eczema severity data

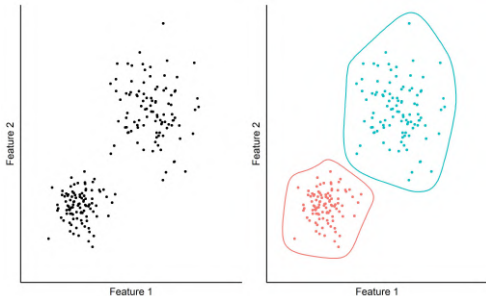
Mechanisms that could explain these correlations



Finding a lower dimensional representation of eczema severity data

A principled dimensionality reduction could

- Help us understand the data better (interpretability)
- Separate patients into different subgroups (clustering)
- Provide computational benefits



Questions?