Disease-Atlas:
Navigating Disease Trajectories with Deep Learning

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Background: Chronic Disease Management

- Patients with long-term conditions have complex medical needs
- Requires long-term monitoring and complicated treatment regimens
- Strong correlation between multimorbidity and age
- Effective decision support tools required!

Beyond Simple Prognostic Questions

- What is the expected rate of lung function deterioration?
- Is the patient likely to develop any infections or comorbidities?
- What is the expected survival time of the patient?
- How do expected outcomes change over time?
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Beyond Simple Prognostic Questions

How long will the patient survive?  
Not enough!

Clinical biomarkers

What will happen to the patient in the future?

Model the Entire Health Trajectory  
Predict patterns of decline

Patterns of interactions with healthcare system
Predicting biomarkers.
Predicting complications.
Predicting infections.
Predicting survival.
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Disease-Atlas

Additional Characteristics

- **Personalised** based on a patient’s unique characteristics and history
- Predictions over multiple horizons
- Quantifies uncertainty of forecasts

![Diagram showing disease progression and biomarker predictions](image-url)
Multitask Learning

\[ L(W) = -\alpha_c \sum_{i,t,w,c} \log f_c \left( Y_{t+\tau}^{(c)} | W \right) - \alpha_b \sum_{i,t,w,d} \log f_b \left( P_{t+\tau}^{(d)} | W \right) - \alpha_T \sum_{i,t,m} \log f_T \left( T_t^{(m)} | W \right) \]

Standard (Multivariate) Training

Multitask Learning
Case Study: Cystic Fibrosis

- Annual review data for 10,000+ patients over the period from 2008 to 2015
- Each patient is associated with 87 variables!
Dynamic Prediction Results

Jointly Predicting...

- **Mortality** as the event-of-interest

- **Lung Function Scores** – FEV1, Predicted FEV1

- **9 Comorbidities** – Liver Disease, Asthma, Arthropathy, Bone fracture, Raised Liver Enzymes, Osteopenia, Osteoporosis

- **11 Infections** – Burkholderia Cepacia, Pseudomonas Aeruginosa, Haemophilus Influenza, Aspergillus, NTM, Ecoli, Klebsiella Pneumoniae, Gram-Negative, Xanthomonas, Staphylococcus Aureus, ALCA

![Results for Mortality Predictions (AUPRC)](chart.png)

- **Survival AUPRC**
- **Prediction Horizon (τ)**
- **Results for Mortality Predictions (AUPRC)**

- Disease-Atlas
- LSTM
- Landmarking
- JM
Dynamic Prediction Results

- FEV1 Results (MSE)
- Ave. Comorbidity Results (AUPRC)
- Ave. Infection Results (AUPRC)
Web Demo: Use Cases for Clinicians
Thank you

See you at the poster session!