Machine Learning Algorithms for Predicting the Force of Infection of Japanese Encephalitis

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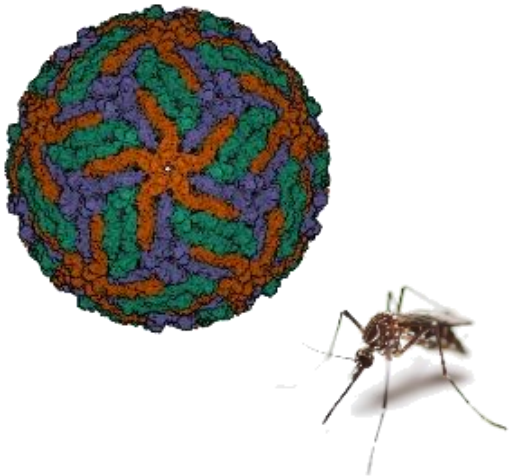
Background- Japanese Encephalitis

- JE is a vaccine preventable mosquito-borne flavivirus.
- JE primarily affects children. Most adults in endemic countries have natural immunity after childhood infection, but individuals of any age may be affected.
- Most JEV infections are mild (fever and headache), but approximately 1 in 250 infections results in severe clinical illness.
- Approximately 67,900 JE cases typically occur annually, of which only about 10% are reported to the World Health Organization.



Background- Force of Infection and disease burden

- Force of Infection (FOI) is the rate at which susceptible individuals in a population acquire infection.
- The FOI is a key parameter used in estimation of disease burden in susceptible countries.
- Current FOI estimates assume homogeneity across the entire country- limits assessment of disease burden on a finer scale.
- Due to lack of data- burden estimates are based on broad assumptions.
- Hence- there is a need to estimate the FOI on smaller geographical scales

Methodology

We use tree based machine learning models to estimate the FOI for pixel-level (10s x 10s) data points.

A. Data:
   - Demographic variables (population density, age groups)
   - Geographical data (elevation, Pigs and rice distribution)
   - Bioclimatic data

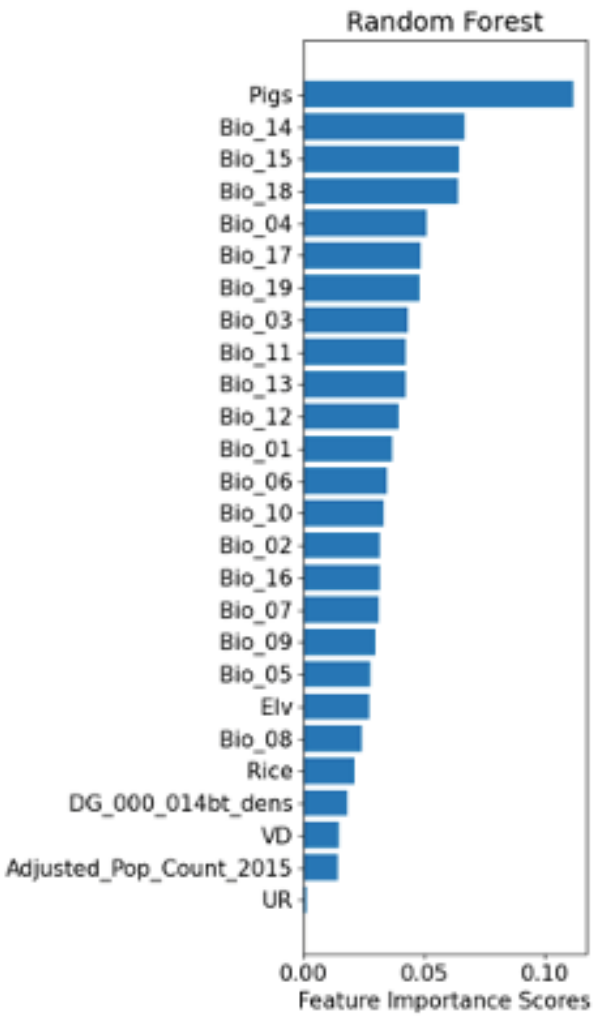
B. Models used:
   - Principal Component Regression (PCR)
   - Random Forest (RF)
   - Gradient Boosting (GB)
   - XGBoost (XGB)

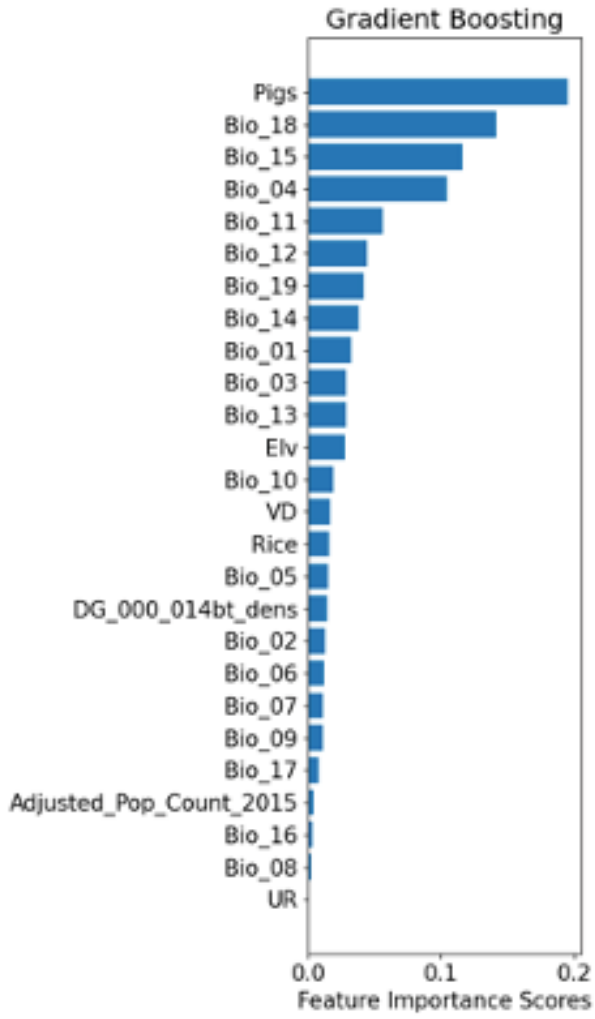
Results- MSE

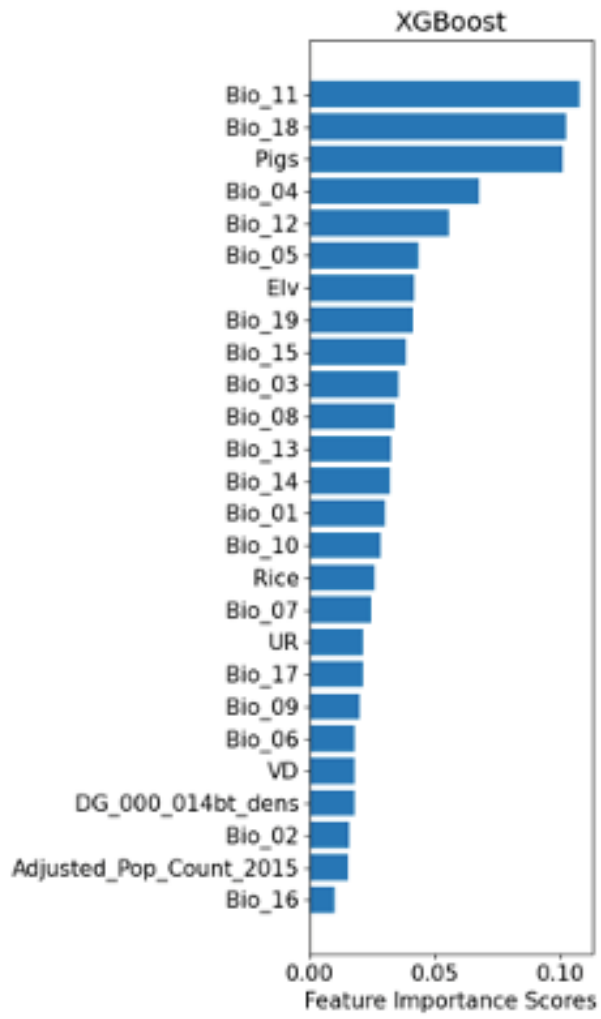
We compared the test Mean Squared Error (MSE) for the four modelling methods:

PCR	0.00496
Random Forest	0.00197
Gradient Boosting	0.00183
XGBoost	0.00172

Results- Feature Importance







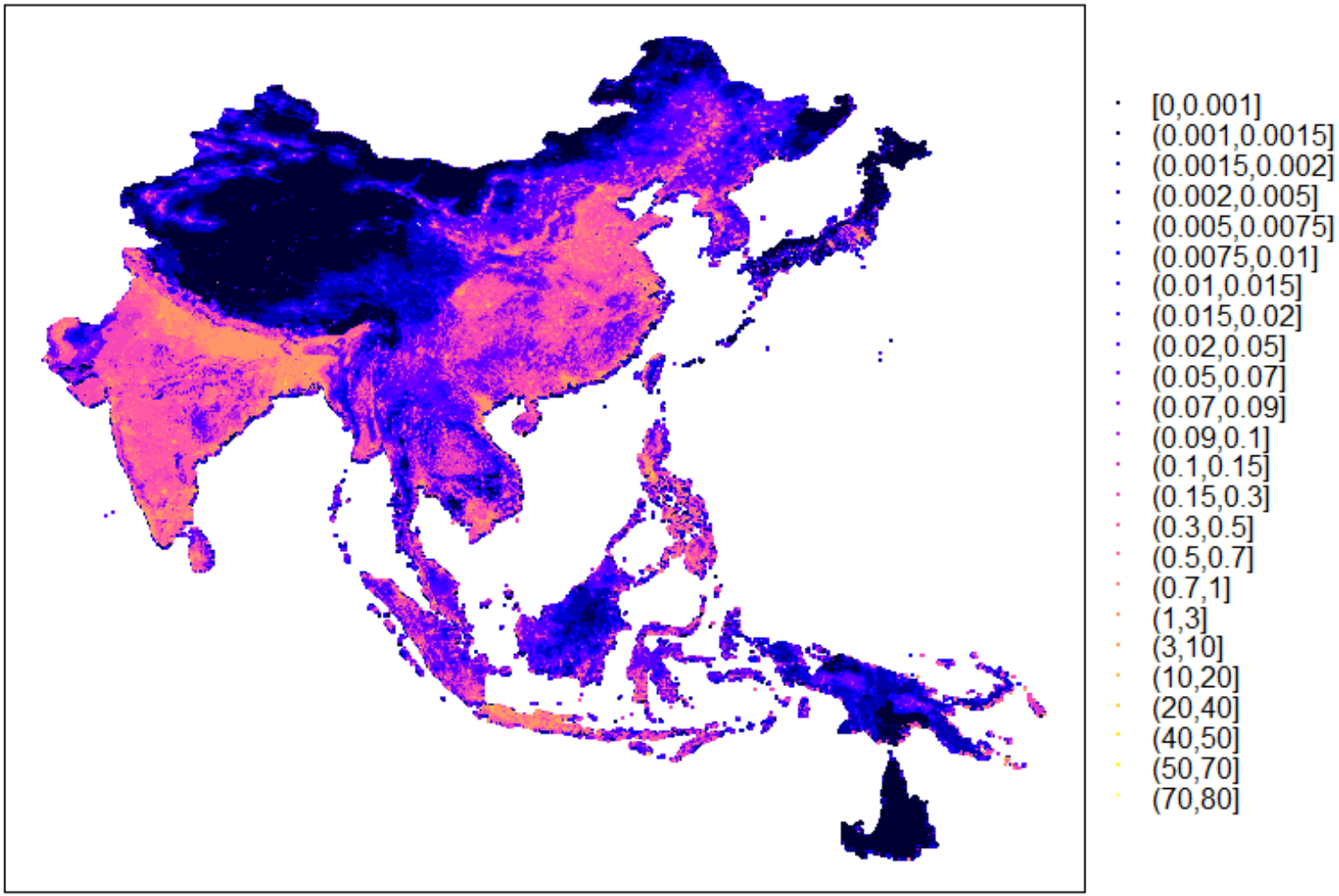
Results

- We also used Individual Conditional Expectation (ICE) plots.

- Our results suggested that the top 10 features are relatively consistent across methods. These features included various bioclimatic variables and the pig distribution.

- Features with low importance scores across all three methods, such as adjusted population count and the urban-rural divide (UR), might indicate that they do not contribute much to the prediction of FOI.

Output- Generating number of JE cases



Conclusion

- The finer scale estimates of the FOI allowed for the precise calculation of disease burden, even for countries without surveillance systems in place for JE.
- More accurate burden estimates lead to more effective understanding of vaccination impact in countries with significant JE burden.
- The study offers insight on using tree based algorithms for understanding public health problems involving heavily correlated predictors.