Looking Forward: GIS-Based Population Forecasting in Australia

Accurately forecasting population change is critical for infrastructure planning, service delivery, and policy development. This project demonstrates how Space-Time Pattern Mining tools in ArcGIS Pro can be used to model and forecast future population trends across Australia using official statistics from the Australian Bureau of Statistics (ABS), accessed through the Digital Atlas of Australia.

The input dataset consists of Estimated Resident Population counts for 566 Local Government Areas (LGAs) spanning 2001–2023, with one population value per year for each LGA. While the original data structure stores years as columns, space-time analysis requires a "long" format with one record per location per time step. Using ArcGIS Pro's Transpose Fields tool, the dataset was transformed into a space-time-ready structure containing 12,581 records, each representing a single LGA-year observation. Additional preprocessing steps included converting year values into a proper datetime field, casting population values to a numeric type, and projecting the data into a projected coordinate system, a requirement for space-time cube creation.

The prepared dataset was used to create a space-time cube using the Create Space Time Cube from Defined Locations tool, where time functions as the vertical (Z) dimension. Visualization of the cube in a 3D scene reveals spatial and temporal population patterns across Australia, with denser populations appearing as higher-intensity values. A 2D visualization further highlights broad population trends, showing regions of growth and decline over time.

To forecast future population values, the Curve Fit Forecast tool was applied to the space-time cube. This method fits multiple curve types (e.g., linear, exponential, parabolic, Gompertz) to each LGA's historical population trajectory and selects the optimal model based on root mean square error (RMSE) during validation periods. This adaptive approach allows different regions to follow different growth dynamics, reflecting real-world variability—for example, exponential growth in rapidly developing coastal LGAs versus leveling growth in large metropolitan areas. The analysis forecasts population values five years into the future, producing a new space-time cube containing both historical and predicted values.

Forecast results can be interactively explored through popups that display observed versus predicted values, fitted curve types, and model diagnostics for each LGA. Residual analysis reveals where forecasts over- or under-predicted observed values, providing insight into model performance and uncertainty. Additional visualizations show the spatial distribution of curve types, highlighting areas experiencing rapid, exponential change versus those with steady or slowing growth.

To further evaluate forecasting approaches, alternative methods—including Exponential Smoothing and Forest-Based Forecasting—were tested. While exponential smoothing showed limited seasonality in the data, forest-based models captured complex temporal patterns. The Evaluate Forecasts by Location tool was then used to compare all methods and select the best-performing model for each LGA based on validation RMSE, resulting in a composite forecast cube that leverages the strengths of multiple techniques.

Finally, results were shared through ArcGIS Online, enabling interactive exploration via dashboards and AI-enabled instant apps. This workflow demonstrates how GIS-based space-time analysis can transform official statistics into actionable insights, revealing not only where populations are growing, but how and at what rate, supporting more informed, data-driven decision-making.