



Dr. Nicholas Fewster-Young

Professor

Mathematical Sciences

Adelaide University

When the Past Shapes the Present: Fractional Memory, Time Scale Dynamics and the Geometry of Time

Abstract. Many systems depend on their history, not only their current state. Their evolution may unfold continuously, through discrete steps, or through a combination of both. Time-scale calculus connects the differential and difference equations used to describe these settings, while fractional calculus introduces dependence on the past through nonlocal memory. Bringing these theories together raises a geometric question: how does the underlying time domain shape the accumulation of memory and the evaluation of solutions? This talk explores that question through graininess-dependent fractional shift operators, which interpolate between a point and its forward or backward jump. These shifts make changes of domain explicit and provide a foundation for fractional calculus on time scales. We examine the resulting domains, the role of closure, and the projections connecting shifted points to their original time scale. Examples on isolated points, continuous time, discrete lattices, hybrid domains, and the Cantor set illustrate how the geometry changes, including why successive forward and backward shifts can alter the geometry rather than simply reverse a displacement or one another. Building on this structure, we introduce Δ -fractional sums and integrals on time scales and explain their connection to both classical continuous and discrete fractional calculus. This shows the bridge back classical calculus and how the framework provides a deeper connected understanding, and followed by definitions and results of existence and uniqueness of dynamical systems. To illustrate the theory, we will apply the framework and jump into some wellknown dynamics – logistic dynamics of Beverton–Holt type. Through the use of an associated integral formulation, sufficient conditions for existence and uniqueness of solutions is established, showing how the structure of time and the accumulation of memory enter the analysis of fractional dynamic equations. This illustrates how discrete and continuous histories enter the memory operator, and how these time scales extend the geometric setting.

Biographical Sketch. Dr Nicholas Fewster-Young is a Professor of Mathematics and holds the title of Program Director in Data Science at Adelaide University. His research sits at the interface of fractional calculus, time scales analysis and modelling dynamical systems. His work is concerned with mathematical models that capture memory, nonlocal behaviour, and hybrid forms of time, bridging continuous and discrete approaches to applied analysis. His broader research interests include stochastic modelling, dynamic equations, sufficient conditions, and inequalities for the existence of solutions, and the development of mathematical frameworks for complex systems. He has extensive experience in education, curriculum leadership, program development, and interests in educational research, particularly in data science education, student engagement, and the role of emerging technologies in learning and assessment.