Research Summary: A practical formula of solutions for a family of linear non-autonomous fractional nabla difference equations

Ioannis Dassios University College Dublin

Fractional nabla difference equations have recently proven to be valuable tools in the modelling of many phenomena in various fields of science and engineering. Indeed, we can find numerous applications in viscoelasticity, electrochemistry, physics, control, porous media, electromagnetism. The dynamics of complex systems are better described within this new powerful tool.

These types of operators are very useful tools for time scale analysis with applications in macroeconomic problems, electrical power systems and energy storage models. A backward operator of n-th order when applied to a sequence at time k, takes back the sequence n steps, i.e. k-n. While the fractional nabla operator when applied to a sequence at time k it takes it back as many steps as we want, i.e. to a constant number independent from k which we can control. This idea makes this fractional operator a tool for time scale analysis and storage.

This article focus on the development of novel analytical and computational tools to understand, efficiently design, and optimize ever-changing modern systems that model evolution problems in engineering, such as storage models, communication systems, and energy power systems.

Research objectives

The research results in this article are significant because the new tools we propose will change the way of modelling with systems of difference equations. The higher order (and expensive in computing) difference equations are replaced by the more elegant fractional difference operators. With these new tools a modeller will be able to have more control on how back in time he/she wants to go (backward operator) in order to absorb information and use it for future predictions. In addition he/she can use time in the future (forward operator) to set goals. This better control of the discrete variable will help researchers, and engineers who work on time scale analysis, and storage problems.

To sum up, the aim of this article is to create new and advanced theoretical methods in mathematics for efficient mathematical modelling. This will have significant impact on solving problems that require fast computer codes for simulating large scale problems, which include big data. Problems like these are commonplace in engineering and physics for describing phenomena like energy storage, control of time, and obtaining the conditions under which robustness of the model can reassured.

Summary of Results

In this article, we focus on a family of problem of linear non-autonomous fractional nabla difference equations. Firstly, we define the equations and describe how this family of problems covers other linear fractional difference equations that appear in the literature. Then, by using matrix theory we provide a new practical formula of solutions for these type of equations. Finally, numerical examples are given to justify our theory.