MAD (modeling, analysis and design) about variabilities: when fractional calculus meets big data and machine learning

YangQuan Chen
Director, Mechatronics, Embedded Systems and Automation Lab
Professor, Department of Mechanical Engineering, University of California
5200 Lake Road, Merced, CA 95343, USA
Contact: yqchen@ieee.org

MAD stands for modeling, analysis and design. I first argue that “variability” is a defining feature of big data in its 10 “V” characteristics (Volume/Velocity/Variety/Variability/Veracity/Validity/ Vulnerability/ Volatility/ Visualization/Value). Then I suggest that to quantitatively model, analyze the variabilities, fractional calculus is required when the big data is from a complex dynamic system. I advocate the use of “fractional order data analytics” (FODA) based on fractional order signal processing (FOSP) techniques. Design for desirable level of variability is then possible based on the modeling and analysis. Examples in crop water stress drone remote sensing, networked control systems are briefly introduced as motivating real world applications. I will go a step further by suggesting a connection between fractional calculus and machine learning in two settings: deterministic case where fractional order gradient can play a positive role, while in stochastic setting, optimal randomness links to fractional order stochasticity.