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IEEE CSR Newsletter

June 2023

Inside This Issue

Welcome to the CSR Newsletter.

Preface

Welcome to the fourth edition of the IEEE Technical Committee on Communications Switching and Routing (CSR Newsletter). This is the fourth issue of the IEEE CSR Newsletter. The purpose of this newsletter is to provide specialized information to the members of the CSR and the communications community at large, the newsletter aims at inviting the authors of successful research projects and experts from the committee members and the larger communications community about CSR-related research activities to share their experience and knowledge by contributing in short news. This issue continues to bring to you the latest news of our technical committee by providing information about our meetings, events activities, and members' news. I would like to thank the colleagues who shared with us their latest news. In this volume, we have selected XX papers on Transfer Learning, Mutli-Access Networks and ML Estimation for Discrete-Time systems.

I hope you will enjoy this issue and I look forward to furthering good members' news to share.

Scott Fowler ***Sami Souihi***
CSR Secretary ***Newsletter editor***

TC-CSR

The objective of the Technical Committee on Communications Switching and Routing (TC CSR) is to advance the state of the art in theory and applications of information switching and networking by the following:

- To bring together professionals with interests in various aspects of Communications Switching and Routing such as theory and architecture (B-ISDN/ATM, optical switching), teletraffic theory, mobility and call control, signaling protocol, Intelligent Networks, and service features, switching software architecture, management, economics, and applications of switching and routing systems.
- To provide a forum for discussion and exchange of technical matters among members in the committee meetings, special interest group meetings, topical meetings, and workshops.
- To sponsor technical sessions at conferences and stimulate high-quality technical papers for conferences and IEEE publications.
- To organize special issues of IEEE publications.

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Committee Meetings

Current Meeting:

- Meeting before ICC 2023

  Location: Online Meeting

  7:00am–9:00am EST, Wednesday, May 3, 2023

Previous Meeting:

- Meeting before GC 2022

  Location: Online Meeting

  7:00am–9:00am EST, Tuesday, November 29, 2022

Next Meeting:

- Meeting TBD, at GC 2023

  Location TBD

Activities

CSR TC Meeting

Date: Wednesday May 3, 2023

Time: 7:00 AM – 9: 00 AM, Online: Zoom

The agenda for the meeting is:

(1) Welcome and Introduction
(2) Approval of the agenda
(3) Approval of the meeting minutes at GC 2023
(4) Report from the Chair
(5) TC Special Interest Groups (SIGs) and Newsletter
(6) IEEE ComSoc Student Competition
(7) TC activities at conferences and workshops
  - HPSR
  - Globecom/ICC
(8) Distinguished Service Award Committee
(9) Other business
(10) Adjourn

CSR TC Officers for 2022-2023

- Chair: Lotfi Mhamdi
- Vice Chair: Cheng Li
- Secretary: Scott Fowler
- HPSR Steering Committee Chair: Zuqing Zhu
- Award and Sponsorship Events Chair: Abdelhamid Mellouk
- ComSoc Student Competition Officer: Roberto Rojas-Cessa
- Standardization Committee Liaison Officer: Nirmala Shenoy
- SIG Officer: Thiago Abreu
- Newsletter Officer: Sami Souihi

Report from the Chair

- Two TC members were selected as symposium chairs for ICC 2024:
  - **Mohammed Atiquzzaman, University of Oklahoma, USA (MWN)**
  - **Roberto Rojas-Cessa, NJIT, USA (NGNI)**
- Nominations for GC'24 and ICC'25 are submitted, we should hear soon.

Members News

- **IEEE ComSoc Student Competition 2023**
  - **1st Place**: *will be announced* by Lotfi Mhamdi.
  - **2nd Place:** *will be announced* by Lotfi Mhamdi.

Report on HPSR

- HPSR 2023 (https://hpsr2023.ieee-hpsr.org/)
  - June 5-7, 2023, Albuquerque, NM, USA
  - General Chair: Eirini Eleni Tsiropoulou, University of New Mexico, USA.
  - General Co-chair: Abdelhamid Mellouk, Université Paris-Est Créteil, France.
- HPSR 2024 (in Europe)
  - Received one strong conference proposal, and SC will discuss about it in the next HPSR SC meeting.

Upcoming Events

Conference	Location	Date
ICC 2023	Rome, Italy	May 28-Jun. 1, 2023
Globecom 2023	Kuala Lumpur, Malaysia	Dec. 2023
ICC 2024	Denver, USA	Jun. 2024
Globecom 2024	Cape Town, South Africa	Dec. 2024
ICC 2025	Montreal, Canada	May 2025

Announcements – continuation

Special Interest Groups (SIG)

- Looking for Special Interest Groups
- The topics of interest include:
  - Switching and Routing
  - Traffic Engineering
  - Network Signaling
  - Network Software, Hardware, and Middleware
  - Packet Network Applications
  - Network Processors
  - Network and Function Virtualizations
  - Data Center Networking and Cloud Computing
  - Mobile Networks
  - Energy Efficient and Green Networking
  - Information Networks
  - Intelligent System Analysis/Analytics
  - Optimal Systems
  - Optimization of Systems
- Please contact the SIG coordinator is Thiago Abreu, University of Paris-Est, Creteil, France, thiago.wanderley-matos-de-abreu@u-pec.fr

Announcements – continuation

Professor Ahmed E. Kamal

- It is with heavy hearts that we announce the passing of Dr. Ahmed Kamal, age 68, of Ames, Iowa on April 30th, 2023.

- A renowned and leading scholar and engineer. He dedicated 50 years of his life to being an engineer, teacher, researcher, and mentor to countless individuals.

Enhancing IoT Predictive Modeling with Monte Carlo Simulation and Brownian Motion

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I. Introduction

The field of data analysis has witnessed remarkable growth in recent years, largely driven by the Internet of Things (IoT) technology. IoT systems generate vast amounts of data from diverse sources, such as sensors, devices, and machines, offering invaluable insights across industries like healthcare, manufacturing, and construction. However, the sheer volume and complexity of data generated by IoT systems present significant challenges for data analysis and interpretation.

Machine learning (ML) has emerged as a popular approach in data analysis, enabling the analysis of large datasets and uncovering patterns and predictions beyond human capabilities. Another valuable technique in data analysis is Monte Carlo simulation, which generates probability distributions based on a large number of random samples. Monte Carlo simulation finds wide application in finance, physics, and engineering to simulate real-world scenarios and identify potential outcomes.

Geometric Brownian motion, a mathematical model describing the random movement of particles in a fluid, holds promise when combined with ML and Monte Carlo simulation in the field of IoT. This integration facilitates the creation of predictive models that can better understand and forecast complex systems, including traffic flow, weather patterns, and the behavior of intricate machinery.

The use of Monte Carlo simulation and Geometric Brownian motion (GBM) in conjunction with ML offers several benefits. Firstly, it enables the generation of large quantities of synthetic data that can be used to train and test ML models, particularly when real-world datasets are limited or expensive to acquire. Secondly, the generated data can be manipulated to explore different scenarios and evaluate the performance of ML models under various conditions. This aids in identifying potential weaknesses in models and improving their accuracy and robustness. Additionally, Monte Carlo simulation and GBM can be used to generate data with different levels of noise, allowing for the evaluation of models under varying levels of uncertainty.

Overall, the combination of Monte Carlo simulation and GBM with ML provides a powerful tool for predictive modeling and analysis in various fields, including IoT. By generating synthetic data sets that closely mimic real-world data, these techniques can enhance the accuracy and robustness of ML models, enabling more effective decision-making and problem-solving.

II. Problem definition

A significant research problem in this field pertains to optimizing the generation of synthetic datasets for the effective training and testing of ML models. This problem involves examining the trade-off between the synthetic dataset's size, the level of noise introduced through Monte Carlo simulation and GBM, and the resulting ML models' accuracy and robustness. Furthermore, it entails investigating how diverse data generation strategies impact the predictive performance of ML models when applied to complex systems like traffic flow or weather patterns using IoT data. By addressing this problem, we can achieve more efficient training and testing of ML models, leading to more accurate predictions of complex systems. Additionally, it enables the exploration of different scenarios and the evaluation of ML models' performance under various conditions.

III. System Model

The proposed system model aims to generate synthetic data sets that closely resemble real-world data and can be used to improve the training and prediction accuracy of machine learning models. This is achieved through the integration of Monte Carlo simulation and GBM, which can accurately model the behavior of complex systems in various fields, including IoT. At the heart of this system model is the use of GBM, which is a mathematical model commonly used to represent the random motion of particles in a fluid. When applied to data analysis and Monte Carlo simulation, GBM can effectively capture the evolution of a data point or dataset over time, taking into account both deterministic and stochastic factors. The GBM formula is a mathematical model that describes the random and continuous change of a variable S over time. The formula can be expressed as:

$$dS = \mu S dt + \sigma S dW, \qquad (1)$$

where, *dS* represents the change in the value of the variable *S* over a small time interval *dt*, and *S* is the value of the variable at the current time *t*. The average rate of return of the variable is represented by μ, and σ represents the volatility of the variable. The term *dW* is a random variable representing a Wiener process or GBM with mean 0 and variance *dt*. The formula represents the variable's deterministic or average growth ($\mu S dt$) and the stochastic or random component of its growth due to volatility ($\sigma S dW$).

The proposed system uses Monte Carlo simulation with GBM[1] to create synthetic datasets for ML model training and testing under various conditions. Monte Carlo simulation generates multiple simulations of a random process to draw outcomes from a known probability distribution, aiming to replicate the entire distribution of the variable of interest for a broad range of possible scenarios.

To align the simulated values of GBM with actual data, we utilize axis rotation, which involves rotating the coordinate system to a new orientation. GBM is a widely-used approach in Monte Carlo simulations to generate synthetic data sets for machine learning model training and testing in various fields. Axis rotation applied to these synthetic data sets can generate new data sets with different behaviors and patterns, enabling simulation of diverse scenarios and testing of machine learning models under varying conditions. The equations defining the transformation in two dimensions, which rotates the xy axes counterclockwise through an angle θ into the $x'y'$ axes, are:

$$x' = x\ cos(\theta) - y\ sin(\theta) \tag{2}$$

$$y' = x\ sin(\theta) + y\ cos(\theta), \tag{3}$$

where x and y represent the original coordinates in the xy plane, and x' and y' represent the coordinates in the rotated plane.

IV. Result

The Figure 1 shows the influence of temperature on cement hydration during the curing of concrete. Initially, without insulation (time 1 to 2800), the concrete experiences uncontrolled drying conditions, resulting in fluctuating temperatures. After 2800, with insulation, controlled drying conditions are established, maintaining a stable temperature. During the early stages, the temperature rises as cement hydration generates heat. However, as hydration progresses, the temperature gradually decreases. This decrease is attributed to the consumption of reactants and the completion of hydration reactions.

In Figure 1 around 5980, each line represents a separate scenario among 10 simulations, visually depicting their performance and fluctuations over time. The starting point for each scenario is marked at 5985 on the x-axis, indicating the initial value at the beginning of each simulation. Based on the data and analysis, we can infer that the temperature in the next 15-minute interval of 5325 measurements is expected to range around 40.5°C, with a minimum of 37.1°C.

Running a Monte Carlo simulation with GBM provides valuable insights into the behavior and potential outcomes of the modeled process. By simulating multiple paths, we observe the distribution of future values, aiding risk assessment and decision-making. The simulation results offer insights into the probability distribution of future values, estimate the expected value, quantify volatility and uncertainty, and assess risk and potential downside. In the context of ML, these simulation results can be utilized to generate synthetic training data, assess risk, aid decision-making, provide valuable features, and quantify uncertainty. Overall, the Monte Carlo simulation with GBM provides crucial information on behavior, risk, and potential outcomes of the modeled process, supporting decision-making, risk management, and understanding of uncertainties. Integrating the simulation results enhances the robustness and accuracy of predictions in ML tasks

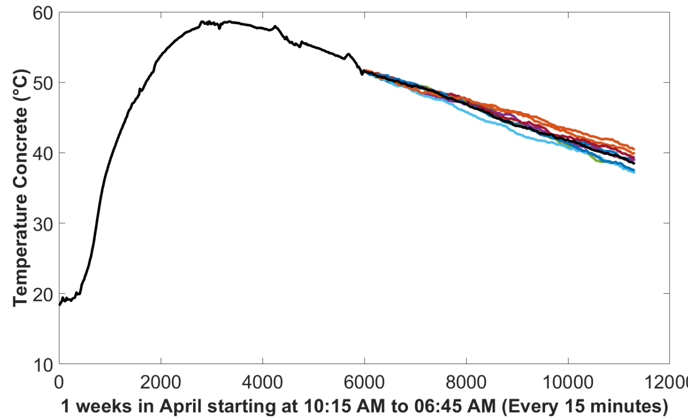

Figure 1: *Monte Carlo simulation results.*

[1]Note the different types of drift are indeed used to distinguish various Brownian motions. A standard Brownian motion has no drift, meaning it has an expected value of zero. A Brownian motion with constant drift has a non-zero constant value added, resulting in a linear drift over time. On the other hand, a GBM incorporates a drift proportional to the process's value, resulting in exponential growth or decay.

V. Conclusion

In this paper introduces a novel approach that integrates the GBM formula with axis rotation to create synthetic data sets for machine learning in the context of IoT applications. The effectiveness of this method is demonstrated through the training and testing of a machine learning model using the generated data sets, and a comparison is made against a model trained on real-world data. The results of our experiments highlight the success of the proposed method in generating synthetic data sets that closely resemble the statistical properties of real-world data. The machine learning model trained on these synthetic data sets achieves high accuracy, comparable to the model trained on actual data.

By leveraging the proposed method, researchers and practitioners in the field of IoT can overcome challenges related to limited or inaccessible real-world data by generating synthetic data sets that capture the essential characteristics of the target domain. This approach opens up possibilities for more extensive experimentation, robust model development, and performance evaluation in machine learning applications.

Overall, this research contributes to the advancement of machine learning in the IoT domain, providing a valuable tool for data generation and enabling accurate model training and testing using synthetic data sets closely aligned with real-world data distributions.

Acknowledgement

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