

EVINN: Extreme value-informed neural networks model for modeling extreme events

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Outline

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2. Background
3. Methodology
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Introduction

The following topics will be covered in this talk:

- Extreme value theory (EVT)
- Theory guided machine learning (TGML)
- EVINN

Motivation

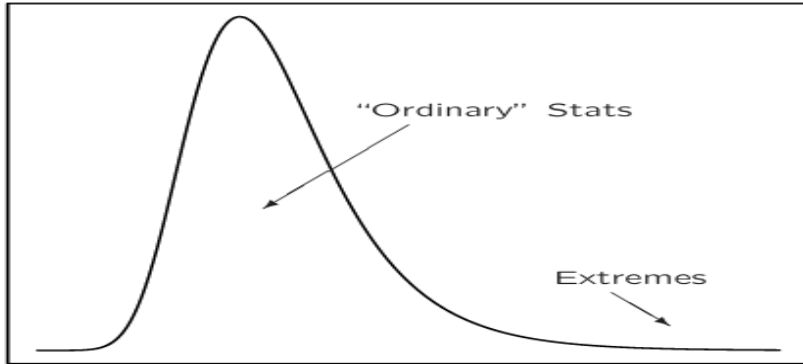
- Conventional machine learning models are data-driven
- There is a new approach to machine learning that embeds known theory into the machine learning model (it is called theory guided machine learning)
- This work proposes the extreme value guided machine learning model - extreme value-informed neural networks (EVINN)

Background

Definitions

- EVT entails the use of statistical and probability methods for the modeling and analysis of extreme events (maximum or minimum values).
- An extreme event is a rare event whose occurrence causes debilitating impact (e.g. flash flood, drought, earthquake, heat wave, market crash). Such events are characterized by low probability of occurrence but high impact

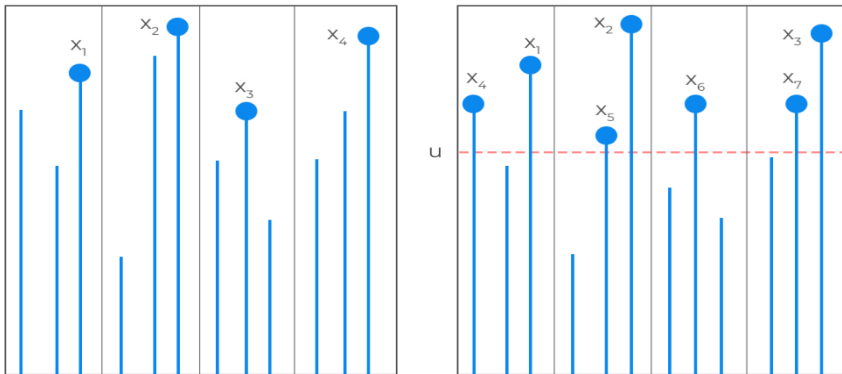
EVT - Ordinary vs Extreme Statistics



In the main, EVT uses two frameworks, namely:

1. Block maxima: effective for analyzing periodic extrema
2. Peak-over-Threshold (POT): considers data points that exceed a prescribed threshold (these points are called exceedance points)

Block Maxima vs POT



Credit: <https://analystprep.com/study-notes/frm/part-2/operational-and-integrated-risk-management/parametric-approaches-ii-extreme-value/>

- Incorporates domain knowledge (scientific knowledge) into ML
- The domain knowledge constrains the ML model to realistic outputs; thereby improving the accuracy of the model
- The model's total loss is then given as:

$$L_{tot} = L_{data} + \lambda L_{theory} \quad (1)$$

Some of the examples of theory guided ML models include:

- Physics informed neural networks (PINN)
- Physics informed neural ODE (PINODE)
- Biology informed neural networks
- **Extreme value-informed neural networks (EVINN)**

Methodology

- Programming language: Python
- Baseline model: MLP
- EVT framework: block maxima
- Performance metric: root mean square error (RMSE)
- Dataset: South Africa daily rainfall from September 2010 to January 2026

Results

Model	RMSE
Baseline (MLP)	6.00
EVINN	5.63

Summary

In this talk, the following were covered:

- Extreme value theory (EVT)
- Theory guided machine learning (TGML)
- EVINN implementation on daily rainfall dataset
- EVINN outperformed the MLP baseline model

Thank You

Questions?