string_data 2020

Report of Contributions

https://indico.cern.ch/e/sd2020

Contribution ID: **1** Type: **not specified**

Welcome

Monday, 14 December 2020 15:40 (5 minutes)

Presenter: RUHLE, Fabian (CERN)

Contribution ID: **2** Type: **not specified**

Numerical Calabi-Yau Metrics from Holomorphic Networks

Monday, 14 December 2020 15:45 (30 minutes)

We propose and implement machine learning inspired methods for computing numerical Ricci-flat Kahler metrics, and compare them with previous work.

Presenter: Mr DOUGLAS, Michael (Simons Center / CMSA Harvard)

Contribution ID: **3** Type: **not specified**

Calabi-Yau Metrics from Machine Learning

Monday, 14 December 2020 16:15 (30 minutes)

The metric of the extra-dimensions in string theory contains crucial information about the low-energy dynamics of string theory systems. This talk reports on recent work (2012.04656) where we use machine learning to approximate Calabi-Yau and SU(3)-structure metrics, including for the first time complex structure moduli dependence. Our new methods furthermore improve existing numerical approximations in terms of accuracy and speed. In the case of SU(3) structure, our machine learning approach allows us to engineer metrics with certain torsion properties not accessible with previous numerical techniques. I comment on some applications, ranging from computations of crucial aspects of the effective field theory of string compactifications such as the canonical normalizations for Yukawa couplings, and the massive string spectrum which plays a crucial role in swampland conjectures, and mention applications to mirror symmetry and the SYZ conjecture.

Presenter: Dr KRIPPENDORF, Sven (LMU Munich)

Contribution ID: **4** Type: **not specified**

Reinforcement learning heterotic line bundle models

Monday, 14 December 2020 16:45 (30 minutes)

Heterotic compactifications on CY 3-folds dressed with line bundle sums provide a fruitful setting for the construction of standard model like models for particle physics. However, the computational resources provide a stumbling block in systematic explorations. In this talk, I will report on experiments where reinforcement learning is used to search for such models. The talk is based on 2003.04817.

Presenter: Dr LARFORS, Magdalena (Uppsala University)

Contribution ID: **5** Type: **not specified**

NN-QFT Correspondence

Monday, 14 December 2020 17:30 (30 minutes)

From a path integral perspective, the backbone of perturbative quantum field theory is a close-to-Gaussian distribution on function space that allows for the computation of correlators via expansion of the non-Gaussianities. Incidentally, many neural network (NN) architectures induce function space distributions with similar properties, allowing for direct import of techniques from QFT into the study of neural networks. In this talk, I will provide a new theoretical understanding of NNs in terms of Wilsonian effective field theory, complete with matches to experiment and renormalization. One insight gained is a duality between parameter space and function space treatments of NNs: as parameter complexity increases, Wilsonian RG flow and 1/N-corrections decrease the complexity of the function space distribution. This has the flavor of strong-weak dualities we are accustomed to in physics.

Presenter: Prof. HALVERSON, Jim (Northeastern University)

Contribution ID: **6** Type: **not specified**

Feature Learning in Infinite-Width Neural Networks

Monday, 14 December 2020 18:00 (30 minutes)

As its width tends to infinity, a deep neural network's behavior under gradient descent can become simplified and predictable (e.g. given by the Neural Tangent Kernel (NTK)), if it is parametrized appropriately (e.g. the NTK parametrization). However, we show that the standard and NTK parametrizations of a neural network do not admit infinite-width limits that can learn representations (i.e. features), which is crucial for pretraining and transfer learning such as with BERT. We propose simple modifications to the standard parametrization to allow for feature learning in the limit. Using the *Tensor Programs* technique, we derive explicit formulas for such limits. On Word2Vec and few-shot learning on Omniglot via MAML, two canonical tasks that rely crucially on feature learning, we compute these limits exactly. We find that they outperform both NTK baselines and finite-width networks, with the latter approaching the infinite-width feature learning performance as width increases. More generally, we classify a natural space of neural network parametrizations that generalizes standard, NTK, and Mean Field parametrizations. We show 1) any parametrization in this space either admits feature learning or has an infinite-width training dynamics given by kernel gradient descent, but not both; 2) any such infinite-width limit can be computed using the Tensor Programs technique.

Presenter: Mr YANG, Greg (Microsoft Research)

Contribution ID: **7** Type: **not specified**

The Topology of Data: from String Theory to Cosmology to Phases of Matter

Tuesday, 15 December 2020 15:45 (30 minutes)

We are faced with an explosion of data in many areas of physics, but very so often, it is not the size but the complexity of the data that makes extracting physics from big datasets challenging. As I will discuss in this talk, data has shape and the shape of data encodes the underlying physics. Persistent homology is a tool in computational topology developed for quantifying the shape of data. I will discuss three applications of topological data analysis: 1) identifying structure of the string landscape, 2) constraining primordial non-Gaussianity from CMB measurements and large scale structures data, and 3) detecting and classifying phases of matter. Persistent homology condenses these datasets into their most relevant (and interpretable) features, so that simple statistical pipelines are sufficient in these contexts. This suggests that TDA can be used in conjunction with machine learning algorithms and improves their architecture.

Based on:
https://arxiv.org/abs/2009.14231
https://arxiv.org/abs/2009.04819
https://arxiv.org/abs/1907.10072
https://arxiv.org/abs/1812.06960
https://arxiv.org/abs/1712.08159

Presenter: Prof. SHIU, Gary (University of Wisconsin-Madison)

Contribution ID: **8** Type: **not specified**

Towards the next level of string phenomenology using machine learning

Tuesday, 15 December 2020 16:15 (30 minutes)

String theory can be seen as the prime candidate for a consistent theory of gravity and particle physics. However, the task to explicitly construct a string model of particle physics that is in agreement with all experimental observations is very challenging due to the enormous size of the so-called string landscape of four-dimensional string models. In this talk, an overview of the heterotic orbifold landscape is given, where various techniques from machine learning are applied: i) an autoencoder neural network to identify structures in this landscape, ii) contrast patterns to construct new MSSM-like string models and iii) neural networks to predict the stringy origin of the MSSM. Moreover, by analyzing parts of the string landscape some novel ideas on flavor, CP and dark matter will be uncovered.

Presenter: Dr VAUDREVANGE, Patrick (TU Munich)

Contribution ID: **9** Type: **not specified**

Testing Swampland Conjectures with Machine Learning

Tuesday, 15 December 2020 16:45 (30 minutes)

We consider Type IIB string theory compactification on an isotropic torus with geometric and non geometric fluxes. Employing supervised machine learning, consisting of an artificial neural network coupled to a genetic algorithm, we determine more than sixty thousand flux configurations yielding a scalar potential with at least one critical point. Stable AdS vacua with large moduli masses and small vacuum energy as well as unstable dS vacua with small tachyonic mass and large energy are absent, in accordance to the Refined de Sitter Conjecture. Hierarchical fluxes favor perturbative solutions with small values of the vacuum energy and moduli masses, as well as scenarios with the lightest modulus mass much smaller than the AdS vacuum scale.

Presenter: Dr CABO BIZET, Nana Geraldine (Universidad de Guanajuato)

Contribution ID: **10** Type: **not specified**

(K)not machine learning

Tuesday, 15 December 2020 17:30 (30 minutes)

We present a simple phenomenological formula which approximates the hyperbolic volume of the knot complement based on an evaluation of the Jones polynomial at a complex phase. The error is 2.86% on the first 1.7 million knots. This approximate formula is obtained from reverse engineering a neural network which achieves a similar error after training on 10% of the data. In Chern-Simons language, the phase corresponds to a fractional level. We interpret this in terms of the analytic continuation of Chern-Simons theory.

Presenter: Prof. JEJJALA, Vishnu (University of the Witwatersrand)

Contribution ID: **11** Type: **not specified**

Can graph neural networks count substructures?

Tuesday, 15 December 2020 18:00 (30 minutes)

The ability to detect and count certain substructures in graphs is important for solving many tasks on graph-structured data, especially in the contexts of computational chemistry and biology as well as social network analysis. In this talk we study the expressive power of popular graph neural networks (GNNs) via their ability to count attributed graph substructures, extending recent works that examine their power in graph isomorphism testing and function approximation. No previous knowledge on graph neural networks is required.

Presenter: Prof. VILLAR, Soledad (Johns Hopkins University)

Contribution ID: **12** Type: **not specified**

Vacuum Selection in the Flux Landscape

Tuesday, 15 December 2020 18:30 (30 minutes)

The Ashok-Denef-Douglas method of counting flux vacua yields an enormous landscape of vacua, an overwhelming majority of which have a large number N of scalar fields. That same calculation suggests that the average density of vacua increases rapidly with N, leading to an increase in the bubble nucleation rates at large N, and therefore a decrease in the average lifetime of such vacua. I will discuss an investigation into how these effects influence cosmological vacuum selection in a standard bubble nucleation cosmology.

Presenter: Dr LONG, Cody (Harvard University)

Contribution ID: **13** Type: **not specified**

Towards Enumeration of Vacua

Wednesday, 16 December 2020 15:45 (30 minutes)

I will describe efforts to automate the construction of flux vacua of type IIB string theory, and to find associated anti-de Sitter and de Sitter solutions.

Presenter: Prof. MCALLISTER, Liam (Cornell)

Contribution ID: **14** Type: **not specified**

Machine learning for complete intersection Calabi-Yau manifolds

Wednesday, 16 December 2020 16:15 (30 minutes)

In this talk, I will explain how to compute both Hodge numbers for complete intersection Calabi-Yau (CICY) 3-folds using machine learning. I will first make a tour of various machine learning algorithms and explain how exploratory data analysis can help in improving results for most of them. Then, I will describe a neural network inspired from the Google's Inception model which reaches nearly perfect accuracy for h11 using much less data than other approaches. The same architecture also performs much better than any other algorithm for h21.

Presenter: Dr ERBIN, Harold (MIT & CEA-LIST)

Contribution ID: **15** Type: **not specified**

Machine-Learning Mathematical Structures

Wednesday, 16 December 2020 16:45 (30 minutes)

We report and summarize some of the recent experiments in supervised machine-learning of various structures from different fields of mathematics, ranging from geometry, to representation theory, to combinatorics, to number theory. We speculate on a hierarchy of inherent difficulty and where string theoretic problems tend to reside.

Presenter: Prof. HE, Yang-Hui (City, U of London; Merton College, U of Oxford; & Nankai U)

Contribution ID: **16** Type: **not specified**

Bayesian inference and quantum field theory

Wednesday, 16 December 2020 17:30 (30 minutes)

We will examine links between approaches to learning through Bayesian inference and properties of quantum field theories.

Presenter: Prof. BERMAN, David (Queen Mary University of London)

Contribution ID: **17** Type: **not specified**

Leveraging Permutation Group Symmetries for the design of Equivariant Neural Networks

Wednesday, 16 December 2020 18:00 (30 minutes)

Learning of irregular data, such as sets and graphs, is a prominent research direction that has received considerable attention in the last few years. The main challenge that arises is which architectures should be used for such data types. I will present a general framework for designing network architectures for irregular data types that adhere to permutation group symmetries. In the first part of the talk, we will see that these architectures can be implemented using a simple parameter-sharing scheme. We will then demonstrate the applicability of the framework by devising neural architectures for two widely used irregular data types: (i) Graphs and hyper-graphs and (ii) Sets of structured elements.

Presenter: MARON, Haggai (NVIDIA Research)

Session Classification: Physics meets ML seminar

Contribution ID: **18** Type: **not specified**

Learning to Unknot

Wednesday, 16 December 2020 18:30 (30 minutes)

We will apply the tools of Natural Language Processing (NLP) to problems in low-dimensional topology, some of which have direct applications to the smooth 4-dimensional Poincare conjecture. We will tackle the UNKNOT decision problem and discuss how reinforcement learning (RL) can find sequences of Markov moves and braid relations that simplify knots and can identify unknots by explicitly giving the sequence of unknotting actions. Based on recent work with James Halverson, Fabian Ruehle, and Piotr Sulkowski.

Presenter: GUKOV, Sergei (California Institute of Technology)

Session Classification: Physics meets ML seminar

Contribution ID: **19** Type: **not specified**

Quantitative and Interpretable Order Parameters for Phase Transitions from Persistent Homology

Monday, 14 December 2020 18:30 (5 minutes)

We apply modern methods in computational topology to the task of discovering and characterizing phase transitions. As illustrations, we apply our method to four two-dimensional lattice spin models: the Ising, square ice, XY, and fully-frustrated XY models. In particular, we use persistent homology, which computes the births and deaths of individual topological features as a coarse-graining scale or sublevel threshold is increased, to summarize multiscale and high-point correlations in a spin configuration. We employ vector representations of this information called persistence images to formulate and perform the statistical task of distinguishing phases. For the models we consider, a simple logistic regression on these images is sufficient to identify the phase transition. Interpretable order parameters are then read from the weights of the regression. This method suffices to identify magnetization, frustration, and vortex-antivortex structure as relevant features for phase transitions in our models. We also define "persistence" critical exponents and study how they are related to those critical exponents usually considered.

Presenter: Dr COLE, Alex (University of Amsterdam)

Session Classification: Short talks

Contribution ID: **20** Type: **not specified**

Algorithmically solving the Tadpole Problem

Monday, 14 December 2020 18:35 (5 minutes)

I demonstrate how to use differential evolutionary algorithms to find flux compactifications of M-theory on K3xK3. The assumption that large numbers of moduli can be stabilized with fluxes within the tadpole bound is one of the corner stones of the String Landscape. However, showing moduli stabilization for manifolds with many moduli explicitly is highly challenging. On K3xK3 moduli stabilization is well understood and can be formulated exclusively in terms of integer matrices and their eigenvalues and -vectors. In particular, there is no knowledge of complicated period integrals or the corresponding Picard-Fuchs equations required. This makes this example predestined for a computer aided search. Using differential evolution we show that there are no smooth compactifications on K3xK3 with arbitrarily small flux M2-charge, in tension with the tadpole bound.

Presenter: Dr LUST, Severin (Harvard University)

Session Classification: Short talks

Contribution ID: **21** Type: **not specified**

Baryons as Solitons in the Meson Spectrum: A ML Perspective

Monday, 14 December 2020 18:40 (5 minutes)

Inspired by Witten's idea that in the large N limit of QCD Baryons correspond to soliton states of mesons, we construct a model of hadronic masses using both Bayesian and non-Bayesian techniques in machine learning. From knowledge of the meson spectrum only, neural networks and Gaussian processes predict the masses of baryons with 90.3% and 96.6% accuracy, respectively. We also predict the masses of pentaquarks and other exotic hadrons and demonstrate that machine learning is an effective tool for testing composition hypotheses. Our results surpass the benchmark constituent quark model both in terms of accuracy of predictions and hypothesis testing across all sectors of hadrons. We anticipate that our methods could yield a mass formula for hadrons from quark composition and other quantum numbers.

Presenter: Dr MAYORGA PENA, Damian (WITS University)

Session Classification: Short talks

Contribution ID: **22** Type: **not specified**

Vector-like spectra in F-theory 1

Monday, 14 December 2020 18:45 (5 minutes)

I will elaborate on how data science helps uncover the structure of vector-like spectra in F-theory.

Presenter: Dr BIES, Martin (University of Pennsylvania)

Session Classification: Short talks

Contribution ID: **23** Type: **not specified**

Vector-like spectra in F-theory 2

Monday, 14 December 2020 18:50 (5 minutes)

I will talk about further challenges for realistic vector-like spectra in F-theory MSSM-constructions and how to overcome them in the future.

Presenter: Ms LIU, Muyang (University of Pennsylvania)

Session Classification: Short talks

Contribution ID: **24** Type: **not specified**

Output dimension effects in untrained Neural Networks

Monday, 14 December 2020 18:55 (5 minutes)

Untrained asymptotically wide Neural Networks are Gaussian Processes, with a direct correspondence to Euclidean free field theory; deviations of the NN away from GP can be effectively described using Wilsonian EFT. Further, output dimension d shows up as the number of independent species in the free / interacting field corresponding to GP / non-GP NN outputs. Experimentally, we verify Ward identity for n-point correlation functions of Gauss-net architecture in both GP and NGP limit in appropriate regime of validity of EFT description. Resulting SO(d) symmetry has interesting consequences on perturbative corrections to GP correlation functions, in terms of couplings corresponding to interaction terms of EFT action.

Presenter: Ms MAITI, Anindita (Northeastern University)

Session Classification: Short talks

Contribution ID: **25** Type: **not specified**

Fixed Points in Neural Network Non-Gaussian Processes

Monday, 14 December 2020 19:00 (5 minutes)

We apply a recent correspondence between neural networks and quantum field theory to study RG fixed points of single-layer neural networks with exponential activation. Many architectures with a biased linear output layer exhibit a universal fixed point at large cutoff, and for some architectures, another fixed point at low cutoff. These fixed points are demonstrated at second-order in the leading non-Gaussian coefficients of the distribution, which are defined using the techniques of Wilsonian effective field theory.

Presenter: Mr STONER, Keegan (Northeastern University)

Session Classification: Short talks