Matteo Russo

Date of birth: 08/01/1998 | **Nationality:** Italian, American | **Gender** Male | (+39) 3802346085 | mrusso@ethz.ch | russo.matteo0801@gmail.com | https://www.linkedin.com/in/matteo-russo-b5865414a/ | github.com/matteorusso | Skype: Matteo Russo | Via Papa Giovanni XXIII 62d, 90011, Bagheria, Italy

WORK EXPERIENCE

17/11/2020 – 17/11/2021 – Zürich, Switzerland
UNIVERSITY RESEARCH ASSISTANT – CHAIR OF SYSTEM DESIGN D-MTEC ETHZ

During my time at the Chair of System Design, I have worked and led two main projects, both involving oTree, a Django framework used to deploy large-scale behavioural game theory applications as well as experiments.

1. Agent-Based Modeling course: the aim was to make students simulate what they had learnt in the theoretical part of the course. I have thus built and deployed a multi-player application where randomly paired individuals play the famous Prisoner's Dilemma game against each other. I have also built and deployed a repeated game version of the Prisoner's Dilemma, where randomly paired individuals play against each other in each round. This way, I helped course instructors make students interact first-hand with what had learnt in class. For more information on the finished application, please visit https://abmotree.herokuapp.com/, for the source code, please visit https://github.com/sg-dev/abm-course-otree.

2. Tax-burden Prisoner's Dilemma research: at the same time, the research group was deeply interested in how taxation applied to the Prisoner's Dilemma game would affect the behaviour of players. In particular, I have developed a game where each player corresponds to a random node in a network and they play Tax-burden Prisoner's Dilemma against their whole neighbourhood repeatedly over rounds. In essence, we deployed an application where we are able to observe whether participants "follow the herd" within their neighbourhood or whether they act rationally depending on the tax-burden applied on the game they are playing during that round. For more information on the finished application, please visit https://pd-herding.herokuapp.com/demo, for the source code, please visit https://github.com/sg-dev/herding-game.

3. A certain future development of the above two project is a deep data analysis through computational statistics techniques based on multi-dimensional hypothesis testing as well as machine learning.

01/06/2019 – 31/08/2019
MACHINE LEARNING INTERN – NASA GODDARD SPACE FLIGHT CENTER

Greenbelt, MD, United States

01/02/2019 – 31/05/2019
DATA SCIENCE INTERN – KING STREET CAPITAL MANAGEMENT

New York, NY, United States

01/02/2018 – 31/01/2019
LAB TEACHER ASSISTANT – PRINCETON UNIVERSITY, COMPUTER SCIENCE DEPARTMENT

Princeton, NJ, United States

01/07/2018 – 31/08/2018
ADVERSARIAL MACHINE LEARNING RESEARCH ASSISTANT – IMPERIAL COLLEGE LONDON, DEPARTMENT OF COMPUTING

London, United Kingdom

01/06/2017 – 31/08/2017

APPLIED ALGORITHMS RESEARCH INTERN – MAX PLANCK INSTITUTE FOR DYNAMICS AND SELF-ORGANIZATION

Göttingen, Germany

01/06/2015 – 30/06/2015
APPLIED MATHEMATICS RESEARCH INTERN – VILLA SANTA TERESA, ISTITUTO RIZZOLI

Bagheria, Italy

EDUCATION AND TRAINING

15/09/2020 – CURRENT – Rämistrasse 101, Zürich, Switzerland
MASTER'S IN COMPUTER SCIENCE – ETH Zürich

01/08/2016 – CURRENT – Princeton (NJ), United States
BACHELOR OF SCIENCE IN ENGINEERING - COMPUTER SCIENCE (GPA: 3.60/4.00) – Princeton University

B.S.E. Computer Science
PACM Certificate Program in Applied and Computational Mathematics
CSML Certificate Program in Statistics and Machine Learning
CITP Certificate Program in Technology and Society, Information Technology Track

EQF level 7

01/09/2019 – 31/01/2020 – Zürich, Switzerland
EXCHANGE PROGRAM – ETH Zürich Department of Computer Science

Senior Year, Fall Semester
https://inf.ethz.ch/

EQF level 7

01/08/2014 – 31/05/2016 – Duino, Italy
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME – United World College of the Adriatic

12-13th grade
Final grade: 43/45
Courses and grades:
Extended Essay: Mathematics EE (A/A)
High Level Courses: Mathematics HL (7/7), Physics HL (7/7), Italian A HL (6/7)
Standard Level Courses: English B SL (7/7), History SL (7/7), Biology SL (6/7)
https://www.uwcad.it/

EQF level 4

01/09/2011 – 30/06/2014 – Bagheria, Italy
LICEO CLASSICO ITALIANO – Liceo Classico Francesco Scaduto

9-10-11th grade
http://lnx.classicoscaduto.it/w3/

EQF level 4

LANGUAGE SKILLS

Mother tongue(s): ITALIAN | ENGLISH

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken production	Spoken interaction	
FRENCH	B2	B2	B1	B1	B1
SPANISH	B1	B1	A2	A2	A2

Levels: A1 and A2: Basic user; B1 and B2: Independent user; C1 and C2: Proficient user

NETWORKS AND MEMBERSHIPS

Memberships

Princeton L'Avant Scene (French Theater)
Princeton Laboratorio Teatrale (Italian Theater)
Princeton Tower Club
Princeton Data Science Club
UWC Alumni Network
Davis UWC Scholars
Interact Club

PROJECTS

Projects

Applied Data Science, ETH Zürich (Feb 2021-July 2021)
Collaborative Filtering for Netflix Movie Recommendations: Reinforced Graph Neural Network (RGNN) to construct a bipartite graph built from the user-item rating matrix to gather information between neighboring nodes. This information is then used to generate user and item embeddings which are fed directly into the feed-forward network. The resulting prediction from the feed-forward network and the reinforcements are then used in a final linear layer to obtain the movie ratings.

Software Engineering, Princeton University (Sep 2018-Jan 2019)
Dynamic News Delivery: Online Machine Learning News Hub, suggesting articles using a User-Driven Collaborative Filtering based on online DBSCAN clustering and Fake News Detection through Generative Models

Machine Learning, Princeton University (Feb 2019-Jun 2019)
Melanoma Interpretable AI: Combination of Activation Maps, LIME and SHAP values for interpretability in Melanoma classification in the ISIC challenge

Entrepreneurship, Princeton University & ETH Zurich (Feb 2019-Dec 2019)
Dugongo: MVP, Business and Strategy plans for a novel B2B online and dynamic waste management service.

HONOURS AND AWARDS

Honours and awards

High-Honors (Magna cum Laude) in Princeton Computer Science (2020)

Gamma Kappa Alpha, The National Italian Honor Society of Princeton University (2020)
Normale di Pisa, Sapienza University Rome, Bocconi and Imperial College London PhD Competition Winner (2020)
ETH Exchange Program Award Winner (2019)
Streicker International Fellows Fund Award Winner (2018)
UROP Research Program Award Winner (2018)
International Internship Program Award Winner (2017)
UWC successful candidate (2014)
AFS/Intercultura successful candidate (2014)

COURSES

Courses

ETH Zürich
Advanced Algorithms, Optimization for Data Science, Probabilistic Artificial Intelligence (in Fall 2021), Natural Language Processing (in Fall 2021), Big Data (in Fall 2021), High-Dimensional Statistics, Reliable and Interpretable AI, Computational Intelligence Lab, Information Security Lab, Algorithmic Game Theory, Randomized Algorithms and Probabilistic Methods, Network Modeling, Entrepreneurship.

Princeton University
Honors Analysis, Advanced Physics, Linear Algebra, Multivariable Calculus, Algorithms and Data Structures, Programming Systems, Foundations and Advanced Machine Learning, Advanced Programming Techniques, Contemporary Logic Design, Theory of Algorithms, Economics and Computation, Probability and Stochastic Systems, Information Technology and Public Policy, Mathematical Econometrics, Microeconomics, High-Tech Entrepreneurship, Computational Complexity, Venture Capital.

RESEARCH EXPERIENCE

22/02/2021 – 09/08/2021
Low-degree polynomials for Gaussian Graphical Models Computation-Information Gap

Supervisor: Prof. David Steurer and Jingqiu Ding

Information-computation gap is the gap between number of samples to make a distinguishing problem information-theoretically possible and number of samples to make a distinguishing problem computationally viable. We study information-computation gaps for the Gaussian Graphical Model (GGM) distinguishing problem employing techniques entailing low degree polynomials and, in particular, multi-sample low degree likelihood ratios (LDLR) and statistical query complexity.

Previously the information-theoretic lower bound has been derived only for the estimation problem of a small set of precision matrices. In this work, we study an associated easier hypothesis testing problem. We prove that below the same information threshold, multivariate Gaussian distributions parameterized by well-conditioned precision matrices has bounded LDLR for arbitrarily large polynomial degree. As complement result, we show for the same distinguishing problem, the LDLR diverges for nearly constant degree. This coincides the fact that efficient distinguishers exist in this case. Combining these two results, we conclude that in this hypothesis testing problem, the low degree model predicts no information-computation gap for any well-conditioned matrix.

For ill-conditioned precision matrices, we obtain similarly divergent LDLR for diagonal dominant matrices, which can be ill-conditioned. This implies either that the hypothesis testing problem we are considering is not hard enough for capturing the information-computation gap or that diagonal dominant matrices are not suitable matrices for predicting the separation in low degree model.

[ETH Zürich Master's Practical Work]

10/09/2020 – CURRENT
Truthful Combinatorial Auctions: can we obtain constant approximation for subadditive bidders?

Supervisor: Prof. Stefano Leonardi

Exploring techniques and algorithms to understand whether a truthful constant approximation is possible for the problem of Combinatorial Auctions for bidders with subadditive valuation functions.

[Research collaboration with Sapienza University Rome]

11/08/2020

Credible, Truthful, Optimal and Bounded-Round Mechanisms through Commitment Schemes

Princeton University, Department of Computer Science (Jun 2020 - Sep 2020)
Supervisor: Prof. Matthew S. Weinberg and Matheus V.X. Ferreira

In a seminal paper by Akbarpour and Li, they show that there is no mechanism which satisfies the properties of truthfulness, credibility and bounded-roundness. However, when bids are encrypted through commitment schemes, Ferreira and Weinberg show that there exists a 2-round truthful, credible and optimal mechanism which fines the bidders (and potentially fictitious ones submitted by the auctioneer) in addition to the payment scheme. In our work, we prove that, in 1-round mechanisms, commitment schemes are of no use and, hence, Akbarpour and Li's result still holds. For what regards k-round mechanisms, with k > 1, we are in the process of proving (or disproving) whether the mechanism proposed by Ferreira and Weinberg is the only one with those characteristics.

[Princeton Computer Science Senior Summer Research]

Exploiting Mean-Based Bidders in Symmetric Settings

Princeton University, Department of Computer Science (Feb 2020 - May 2020)
Supervisor: Prof. Mark Braverman

With the advent of the Internet and of powerful search engines such as Google, private businesses, who want their ads to be the first to be displayed, would also like to comprehend how to bid effectively whilst automatizing the process. Notably, during the past two decades, the paradigm of Machine Learning has blindly and ubiquitously spread throughout a vast variety of application-specific domains: one of those is indeed automatic bidding in Sponsored-Search Auctions. In recent years, the problem of repeatedly selling an item to a single-buyer has been considered. Hereby, a strategic seller prices an item dynamically so to extract the whole utility from a buyer that plays most historically-rewarding actions. In this paper, we extend this framework by substituting the contrasting seller and buyer with two bidders who have to bid for a single item repeatedly while: we denote it by the term Welfare Redistribution Auction (WRA for short). At each time step, the mean-based bidder as well as the strategic one draw independently valuations f and v respectively from two distributions F and D which have both support over the set of possible actions B = {b_1, ..., b_K}. They, therefore, bid for the item. The winner gets the item and pays the adversary some amount. We formulate the conjecture of whether there exists an algorithm for which the strategic bidder may extract the whole surplus from the mean-based bidder up to a sublinear factor in number of rounds. We, thus, test, in a variety of WRA settings, whether Reinforcement Learning agents such as Deep Q-Learning agents perform well against mean-based ones. The empirical evidence demonstrates how even very blazoned algorithms are not potential candidates for the conjecture strategy to exist, thus, opening future lines of research.

[Princeton Computer Science Senior Independent Work]

Robust OOD Detection in Secure Open-World Learning

Princeton University, Department of Computer Science (Feb 2019 - May 2019)
Supervisor: Prof. Prateek Mittal

In recent years, the paradigm of Deep Learning has revolutionised prediction techniques in extremely diverse fields of knowledge, ranging from autonomous driving to medical diagnosis. Oftentimes, Deep Learning models are tested against a pre-defined distribution of samples with a fixed set of labels. This does not account for the fact that, in real world settings, samples are collected from an open-world environment, where input data is partially if not fully out-of-distribution (OOD). We, thus, propose and test two methods for robust OOD detection:
- Deep Learning algorithm based on Gradient Magnitude and Hessian Spectral Norm analyses distinguishing in-distribution from out-of-distribution samples at test time through ResNet architecture.
- Implemented the model in TensorFlow and tested it against 15 datasets.
- Observed how Loss Hessian Spectral Norms reveals strong geometric distinguishing properties in benign and adversarial settings.

[Princeton Computer Science Junior Independent Work]

Tweet Stream Anomaly Detection for GPM Data

NASA GSFC, Earth Sciences (Jun 2019 - Aug 2019)
Supervisors: Arif Albayrak, Dr. William Teng, Long Pham

The various social media data streams are, potentially, important new sources of real-time and historical global information for science applications (e.g., augmenting the validation programs of NASA earth science missions). There is an ongoing effort using Twitter at the Goddard Earth Sciences Data and Information Services Center (GES DISC) that is extracting relevant tweets, processing and analyzing them, and comparing them with data from NASA's Global Precipitation Measurement mission. The validation of satellite precipitation estimates is challenging, because many regions lack data or access to data, especially outside of the U.S. and in remote and developing areas. An innovative solution I have developed includes the following:
- Implement end-to-end Twitter and Satellite data collection procedure.
- Investigate and implement GAN techniques to create an homogeneous map in regions that lack tweets.
- Develop probabilistic anomaly detectors to compare robustly satellite data with Twitter stream data.

[NASA GSFC Internship]

Poisoning Attacks with Generative Adversarial Nets

Imperial College London, Department of Computing (Jul 2018 - May 2019)
Supervisor: Prof. Emil Lupu and Dr. Luis Muñoz-Gonzàlez

Working on the generally known Adversarial Machine Learning, this area concerns itself with both attack techniques against machine learning algorithms, whether it is to evade them at test time or poison them during training and with techniques that enable to improve the robustness of the algorithms to such attacks.
- Introduced a novel adversarial GAN structure, that through generator G is capable of generating and injecting poisoning points that resemble the ones of the real distribution by "fooling" discriminator D, while diminishing significantly classifier C's accuracy and generating poisoning points which hardly detectable by an adversarial samples detection system.
- Implemented the model in TensorFlow and PyTorch, testing it against the SpamBase, MNIST and CIFAR-10 datasets.
- Observed that for a certain configuration, the attack against the DNN classifier C reveals itself to be very satisfactory both in terms of effectiveness and in terms of detectability.

[UROP Research Program]

2D Compass Rose Depth First Search for Minimum Paths Construction: A Graph Theory approach to Pixel

Max Planck Institute for Dynamics and Self-Organization (Jun 2017 - Jul 2017)
Supervisor: Dr. Azam Gholami

-Carried out experiments to breed and isolate Chlamydamonas Reinharditii through first-hand made chemical compounds, dividing the work in an efficacious and precise manner, to make the process optimized. Moreover, we used different types of centrifuges to demembranate the axoneme to observe and record its pure motion.
- Designed, developed and coded, in both MATLAB and Java, a software capable of tracking the Axoneme on the plane. The purpose of this project was obtaining curvature plots at each point for each frame of the recorded videos and eventually, apply resistive force theory to obtain the friction coefficients in parallel and perpendicular directions that best fit to the experimental trajectories of the swimming isolated axonemes (isolated flagella without membrane).
- In particular, after the process of biochemical isolation and demembranation of the alga, I have recorded videos with an electronic microscope and hence gathered data on the motion of their flagellar structure. Therefore, I first needed to interpolate the distribution of points for each image in a unique, general method so that the contour of the the resolved axoneme could be extracted. This revealed itself to be the most difficult part of the whole software development insofar as I had to face a topological problem in R^2, possibly extendable to R^n.
- Discovered a general condition for which this problem can be solved for both continuous and discrete sets (namely, the set of pixels on the screen). From that condition, I designed, built and implemented a new algorithm which I named Compass Rose Depth First Search (CRDFS) that allows finding a sorted path of pixels to be interpolated through a Uniform B-Spline. Showed a proof of correctness and exactness of the above mentioned algorithm as well as a deep analysis of the algorithm computational complexity.

[Princeton IIP Internship]

A geometrical approach to optimize a cancer radio therapeutic treatment

UWC EE Applied Mathematics Research (Jun 2015 - Aug 2015)
Supervisor: Dr. Sergio Montalbano and Dr. Antonino Daidone

The main scope of this research experience was the mathematical optimization of the oncologic radiotherapy treatments through the particle linear accelerator, in order to maximize the irradiation to the cancer while reducing the damage of the healthy organs. I developed models and algorithms in order to generalize and solve a medical problem starting for abstract mathematics. Oncologic radiotherapy treats neoplastic pathologies through irradiating beams emitted by a particle linear accelerator. The patient treatment must be designed in order to maximize the irradiation, which hits the cancer, while avoiding the adjacent healthy organs damage. After having gathered data on multiple cases of prostate cancer over a period of 3 years and identified the involved variables, I have formulated a linear mathematical model in a continuous field, which allows describing the problem in its entirety. The model consists of two main parts:

- A target function to be maximized, which permits to express the link between the therapy effect (total radiation) and the considered variables (radiations emitted from different positions).
- A system of linear constraints (inequalities) which are conditions to be satisfied in order to make the system work correctly. This allows geometrically delimiting the set of feasible solutions, among which searching for the optimal one.

Afterwards, I have analyzed the 2 and k-dimensional case, using linear algebra and convex geometry theorems to find algebraically the solutions for the different problem configurations. This model gives us the possibility to transform a geometrical continuous problem in an algebraic combinatorics problem, for which I elaborated two linear programming and convex optimization searching algorithms, finding the problem optimal solutions.

[UWC Adriatic Summer Research Experience]

Application of a binary tree to the spending review problem of a public administration

UWC IA Applied Mathematics research (Sep 2015 - Mar 2016)
Supervisor: Prof. Roman Rudzinski

- Faced a typical Spending Review problem in a Public Administration setting.
- Defined the mathematical model, formulated theorems on convergence and complexity bounds for the problem's generalization.
- Elaborated an Integer Programming knapsack-like algorithm to find the problem's optimal solution.

[UWC Adriatic Mathematics Research Experience]

Brownian motion stochastic models investigation and experimental verification through videotracking

UWC IA Physics Research (Sep 2015 - Mar 2016)
Supervisor: Prof. Mark Sylvester

- Verified empirically the main theoretical stochastic models describing the properties of Brownian motion: random walk and Einstein-Smoluchowski's equation.
- Analyzed the random walk model, developing numerical simulations with the aim of catching the phenomenon main mathematical-physical features, until the determination of the individual particles spatial trajectories, putting under evidence their fractal nature.
- Developed a methodology for video footage analysis, in order to quantify and correct the combined effect of the main error factors involved in the experimental observation of particle moving, with particular reference to the one-dimensional drift, usually convective, which, overlapping with the pure Brownian motion, significantly alters the ideal behavior.

[UWC Adriatic Physics Research Experience]

TEACHING EXPERIENCE

Teaching experience

Lab Teacher Assistant, Princeton University Computer Science Department (Feb 2018 - Jan 2019)
Teaching Assistant for the following courses:
- COS 226 - Algorithms and Data Structures
- COS 217 - Introduction to Programming Systems
- COS 126 - General Computer Science

CERTIFICATIONS

Certifications

GRE General Test (Apr 2019)
Verbal Reasoning (159/170)
Quantitative Reasoning (163/170)
Analytical Writing (4/6)
SAT Reasoning Test (Oct 2015)
Mathematics (780/800)
Critical Reading (640/800)
Writing (670/800)
Advanced Placement (Jul 2014)
AP Calculus BC Subject Test (5/5)
SAT Physics (710/800) (Jun 2014)
SAT Latin (760/800) (Dec 2013)
SAT Math Level 2 (760/800) (Jun 2013)

EXTRA-CURRICULAR ACTIVITIES

Extra-curricular Activities

Theater/Drama
Sports
Community Service