21st Berlin-Oxford Young Researcher's Meeting on Applied Stochastic Analysis

3^{rd} **July** – 5^{th} **July** 2025

Contents

1. Welcome

It is our great pleasure to welcome you to the 21st Berlin-Oxford Young Researchers Meeting on Applied Stochastic Analysis. We hope you enjoy a productive meeting!

Conference organisers
Peter Friz (TU and WIAS Berlin)
Terry Lyons (University of Oxford)
Helena Kremp (TU and WIAS Berlin)
Carlos Villanueva Mariz (FU Berlin)
Lingyi Yang (University of Oxford)
Alexandre Bloch (University of Oxford)

Presentations
All talks will be held in person. The talk length is 25 minutes and we will have 5 minutes for questions after each talk.

Conference dinner
On Thursday, July 3rd, we will have a conference dinner starting 18:30 at the event location "Alte Pumpe" (Lützowstraße 42, 10785 Berlin, location here).

Supporting Institutions

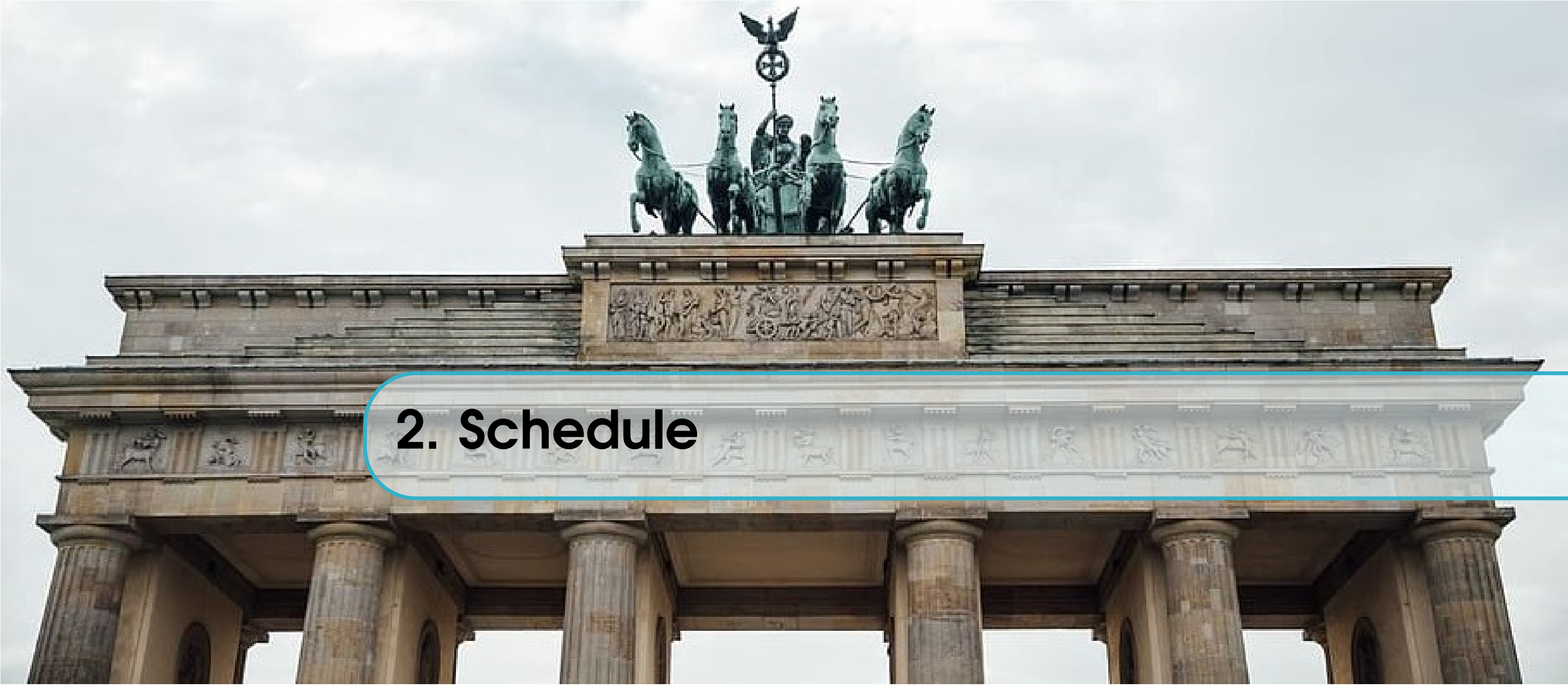
DataSig

WIAS

Stochastic Analysis in Interaction

TRR 388
ROUGH ANALYSIS, STOCHASTIC DYNAMICS & RELATED FIELDS

Gefördert durch
DFG Deutsche Forschungsgemeinschaft



2. Schedule

Thursday, 3rd July
Location: WIAS Berlin

09:00–09:30	**Welcome**		
09:30–10:00	Luca Pelizzari (WIAS and TU Berlin)	*Expected signatures for time-augmented processes*	8
10:00–10:30	Sheng Wang (University of Melbourne)	*Finite radius of log signature and Lyons-Sidorova conjecture*	8
10:30–11:00	**Coffee Break**		
11:00–11:30	Fride Straum (NTNU)	*Signatures on Separable Hilbert Spaces and Applications to 2D Paths*	8
11:30–12:00	Rosa Preiss (TU Berlin)	*Conjugation, loop and closure invariants of the iterated-integrals signature*	8
12:00–13:30	**Lunch Break**		
13:30–14:00	Francesco Triggiano (Scuola Normale Superiore, Pisa)	*Well-posedness of rough 2D Euler equation with bounded vorticity*	9
14:00–14:30	Julian Kern (FU Berlin)	*The Katzenberger method with an application to population genetics*	9
14:30–15:00	Thomas Wagenhofer (TU Berlin)	*Weak error rates for local stochastic volatility models*	9
15:00–15:30	**Coffee Break**		
15:30–16:00	Marco Rehmeier (TU Berlin)	*p-Brownian motion and the p-Laplacian*	9
16:00–16:30	Yueh-Sheng Hsu (TU Wien)	*Variance renormalisation of two dimensional gPAM with differentiated space white noise*	9
16:30–17:00	Aleksei Kroshnin (WIAS Berlin)	*Uniform approximation of occupation time functionals of diffusion processes*	10
18:30	**Conference dinner at Alte Pumpe (location here)**		

Friday, 4th July
Location: WIAS Berlin

09:00–09:30	Ioannis Gasteratos (TU Berlin)	*Kolmogorov equations for stochastic Volterra processes with singular kernels*	10
09:30–10:00	Filippo de Feo (TU Berlin)	*Stochastic optimal control in Hilbert spaces and applications to economic problems with delays and SPDEs*	10
10:00–10:30	Da Li (University of Oxford)	*Introduction to flow equation approach for singular Stochastic PDEs*	10
10:30–11:00	**Coffee Break**		
11:00–11:30	Shanshan Hu (TU Berlin)	*Generation of random dynamical systems for McKean–Vlasov SDEs*	10
11:30–12:00	Jannis Dause (TU Berlin)	*Duality in Stochastic Optimal Control Problems with Rough Paths*	11
12:00–13:30	**Lunch Break**		
13:30–14:00	Constantin Kogler (University of Oxford)	*Stationary Measures for Random Walks on Lie Groups*	11
14:00–14:30	Yuchen Sun (HU Berlin)	*Rough backward SDEs with discontinuous Young driver*	11
14:30–15:00	Jost Pieper (University of Durham)	*Rough SDEs and Robust Filtering for Jump-Diffusions*	11
15:00–15:30	**Coffee Break**		
15:30–16:00	Stefanos Theodorakopoulos (TU Berlin)	*Stability of backward propagation of chaos*	12
16:00–16:30	Huilin Zhang (HU Berlin)	*Rough stochastic filtering: robustness PDEs and approximation*	12

Saturday, 5th July
Location: WIAS Berlin

9:00–9:30	Jean-David Jacques (Potsdam Universität)	*Geometric post-Lie deformations and applications to Regularity Structures*	12
09:30–10:00	Richard Krieg (Universität Greifswald)	*Weighted iterated sums in deep learning*	12
10:00–11:30	Nero Ziyu Li (Imperial College London)	*The General Iterated Graph Systems*	12
10:30–11:00	**Coffee Break**		
11:00–11:30	Samuel Chun Hei Lam (University of Oxford)	*Learning ergodic time-series with recurrent neural networks*	12
11:30–12:00	Lingyi Yang (University of Oxford)	*Anomaly detection for streamed data*	13

3. Talks and Abstracts

3.1 Expected signatures for time-augmented processes

Luca Pelizzari, WIAS Berlin

Thursday
09:30-10:00

In this talk we address the problem of computing expected signatures for time-augmented rough processes. We demonstrate that the standard approach — using piecewise linear approximations of the noise — can lead to significant discretization errors when the underlying process is highly irregular. Our main contribution is an explicit representation of the signature in terms of time integrals and powers of the underlying noise, leading to accurate and practical formulas for the expected signature. We illustrate the advantages of this method numerically for fractional Brownian motion with small Hurst parameters and outline some applications in stochastic optimal control.

3.2 Finite radius of log signature and Lyons-Sidorova conjecture

Sheng Wang, University of Melbourne

Thursday
10:00-10:30

We showe that if the log-signature of a path has infinite ROC, its signature coefficients must satisfy (an infinite system of) rather rigid and explicit algebraic relations. These (higher-order) relations are much stronger than the first-order relation obtained by Lyons and Sidorova in 2006. We hope that these algebraic relations are rigid enough to force the path having very special geometry.

3.3 Signatures on Separable Hilbert Spaces and Applications to 2D Paths

Fride Straum, NTNU

Thursday
11:00-11:30

In this talk, we introduce paths in separable infinite-dimensional Hilbert spaces and study their signatures. We establish a dual pairing between words and signatures, prove the injectivity of the signature map, and present a universal approximation theorem. We then extend these ideas to 2D paths (images) using a lifting technique. Many of the desirable properties known for 1D paths carry over to the 2D setting, allowing us to prove injectivity of the double signature and a corresponding universal approximation result for images. If time permits, we will conclude by identifying subspace of the continuous dual space associated with continuous paths of finite p-variation.

3.4 Conjugation, loop and closure invariants of the iterated-integrals signature

Rosa Preiss, TU Berlin

Thursday
11:30-12:00

Given a feature set for the shape of a closed loop, it is natural to ask which features in that set do not change when the starting point of the path is moved. For example, in two dimensions, the area enclosed by the path does not depend on the starting point. In the present article, we characterize such loop invariants among all those features known as interated integrals of a given path. Furthermore, we relate these to conjugation invariants, which are a canonical object of study when treating (tree reduced) paths as a group with multiplication given by the concatenation. Finally, closure invariants are a third class in this context which is of particular relevance when studying piecewise linear trajectories, e.g. given by linear interpolation of time series. Joint with Jeremy Reizenstein, Joscha Diehl.

3.5 Well-posedness of rough 2D Euler equation with bounded vorticity

Francesco Triggiano, Scuola Normale Superiore, Pisa

Thursday 13:30-14:00

We consider the 2D Euler equation with bounded initial vorticity and perturbed by rough transport noise. We show that a unique solution exists, which coincides with the starting condition advected by the Lagrangian flow. Moreover, we prove that the solution map is continuous with respect to the initial vorticity, the advecting vector fields and the rough perturbation. As an immediate corollary, we obtain a Wong-Zakai result for fractional Brownian driving paths.

3.6 The Katzenberger method with an application to population genetics

Julian Kern, FU Berlin

Thursday 14:00-14:30

We will discuss a little known result on SDEs with a large drift towards a manifold from the 90s and show how it may be used to study sequences of Markov processes. One application of interest is the convergence of the multi-type logistic branching at large carrying capacity.

3.7 Weak error rates for local stochastic volatility models

Thomas Wagenhofer, TU Berlin

Thursday 14:30-15:00

Local stochastic volatility refers to a popular model class in applied mathematical finance that allows for "calibration-on-the-fly", typically via a particle method, derived from a formal McKean-Vlasov equation. Well-posedness of this limit is a well-known problem in the field with the general case still being largely open, despite recent progress in Markovian situations. Our approach is to start with a well-defined Euler approximation to the formal McKean-Vlasov equation, followed by a newly established "half-step"-scheme, allowing for good approximations of conditional expectations.
We show that this scheme converges with weak rate one regarding the step-size, plus error terms that account for the said approximation. Furthermore, the case of particle approximation is discussed in detail and the weak error rate, in dependence of all parameters used, is derived.

3.8 p-Brownian motion and the p-Laplacian

Marco Rehmeier, TU Berlin

Thursday 15:30-16:00

We construct a stochastic process which is related to the fundamental solution of the parabolic p-Laplace equation in the same way as Brownian motion is related to the heat kernel of the heat equation. More precisely, for the p-Laplace equation we identify an associated McKean—Vlasov SDE, and our constructed stochastic process consists of solutions to this SDE and, moreover, constitutes a nonlinear Markov process. We call this process p-Brownian, which for $p = 2$ coincides with standard Brownian motion.
Joint work with Viorel Barbu (A.I. Cuza University) and Michael Röckner (Bielefeld University).

3.9 Variance renormalisation of two dimensional gPAM with differentiated space white noise

Yueh-Sheng Hsu, TU Wien

Thursday 16:00-16:30

In this work, we consider the gPAM equation with a differentiated space white noise in two dimensions. A particularity of this equation is that the regularity of the noise just falls on the borderline of the “subcriticality” condition; moreover, even if one could have chosen a slightly more regular noise, the variance of certain non-linear functionals of the noise is expected to explode and the local solution theory would still fail. To tame down this variance blowup, a multiplicative renormalisation is required. This multiplicative renormalisation was first carried out by [Hairer ’24] in the case of KPZ equation, and a general prediction was there made for

a wider class of equations. The current work therefore has the objective to show gPAM falls into this picture. It is worth noting that, while a Da Prato-Debussche trick was used in the KPZ case, no such trick is available for gPAM. One thus has to work on the level of singular SPDE machineries such as regularity structure to obtain the desired result.
Based on joint work with Máté Gerencsér.

3.10 Uniform approximation of occupation time functionals of diffusion processes

Aleksei Kroshnin, WIAS Berlin

Thursday
16:30-17:00

We consider the uniform discrete approximation error of an occupation time functional $\int_0^1 f(X_t)dt$ of a d-dimensional Itô diffusion $(X_t)_t$. We obtain bounds on the expected error for Hölder functions as the number of discretization points grows. Notably, there are two regimes in the one-dimensional case, depending on the Hölder exponent, but only one in higher dimensions. Furthermore, on the example of a Brownian motion, we show that these bounds are sharp. Based on a joint work with Oleg Butkovsky and Antoine Grenier.

3.11 Kolmogorov equations for stochastic Volterra processes with singular kernels

Ioannis Gasteratos, TU Berlin

Friday
09:00-09:30

We are concerned with a class of fully nonlinear Stochastic Volterra Equations (SVEs) with convolution-type kernels K that are singular at the origin. Working with carefully chosen Hilbert spaces, we rigorously establish a link between the SVE solution and the Markovian mild solution of a transport-type Stochastic Partial Differential Equation (SPDE). Our Hilbert space framework allows access to well-developed tools from stochastic calculus in infinite dimensions. As a byproduct of our analysis, we obtain two Itô formulae for functionals of mild solutions and show that their laws solve an infinite-dimensional Fokker-Planck equation. Then, we introduce a notion of "singular" directional differentiation along K and prove that (conditional) expectations of SVE solutions can be expressed in terms of the unique solution to a backward Kolmogorov equation in infinite dimensions. Based on joint work with Alexandre Pannier (Université Paris Cité) and ongoing joint work with Peter K. Friz (TU Berlin and WIAS Berlin).

3.12 Stochastic optimal control in Hilbert spaces and applications to economic problems with delays and SPDEs

Filippo de Feo, TU Berlin

Friday
09:30-10:00

We consider optimal control problems of stochastic differential equations in Hilbert spaces using the dynamic programming approach. The main difficulty is that the associated Hamilton-Jacobi-Bellman equation is a partial differential equation on a Hilbert space with an unbounded operator. We discuss how to prove the $C^{1,1}$ regularity of the value function and how this regularity result can be used to solve the control problem by constructing optimal feedback controls. We discuss applications to problems governed by SPDEs and, motivated by economic models, to stochastic delay differential equations.
This talk is based on [F. de Feo, A. Święch, L. Wessels, "Stochastic optimal control in Hilbert spaces: $C^{1,1}$-regularity of the value function and optimal synthesis via viscosity solutions", Electron. J. Probab. 30 (2025), 1-39. https://doi.org/10.1214/25-EJP1294].

3.13 Introduction to flow equation approach for singular Stochastic PDEs

Da Li, University of Oxford

Friday
10:00-10:30

In this talk, we introduce Duch's flow equation framework, inspired by the Wilsonian renormalization group theory. The central idea is to study the so-called coarse-grained process, which captures the behavior of solutions to the original equation across different spatial scales. As an illustrative example, we describe this approach in the context of the ϕ_3^4 equation.

3.14 Generation of random dynamical systems for McKean–Vlasov SDEs

Shanshan Hu, TU Berlin

Friday
11:00-11:30

We establish the existence of a random dynamical system associated to a class of McKean–Vlasov equations. The proof relies on setting up a pathwise rough path-based solution theory for SDEs with time-dependent coefficients. Our results apply in particular to the so-called ensemble Kalman sampler (EKS), showing the existence of an associated RDS under some assumptions on the posterior.

3.15 Duality in Stochastic Optimal Control Problems with Rough Paths

Jannis Dause, TU Berlin

Friday
11:30-12:00

Classical stochastic optimal control is heavily based on the Markovianity of the underlying noise e.g. through the use of the dynamic programming principle and subsequently HJB-equations. Motivated by the increasing interest in optimal control of rough and non-Markovian systems (e.g. driven by fBm), we present a novel duality approach to tackle such problems. Inspired by the approach of Rogers [SICON, '07] in discrete time and the continuous-time, rough extension of Diehl-Friz-Gassiat [APPL MATH OPT, '17], we introduce a penalty term for the pathwise control problem based on a (functional) Taylor expansion and prove a approximative duality result by suitable tightness properties of solutions to controlled RDEs. We further discuss the viscosity theory needed to analyze the rough, pathwise problem.

3.16 Stationary Measures for Random Walks on Lie Groups

Constantin Kogler, University of Oxford

Friday
13:30-14:00

Markov processes have stationary solutions under weak assumptions. Analogously, random walks on Lie groups in various settings often have stationary measures. We will expose several settings where this is the case and discuss open problems.

3.17 Rough backward SDEs with discontinuous Young driver

Yuchen Sun, HU Berlin

Friday
14:00-14:30

We study backward differential equations driven hybridly by a Brownian martingale B and a deterministic discontinuous rough path W with finite q-variation for $q \in [1,2)$. Distinguishing between integration of jumps in a forward- respectively Marcus-sense, we refer to these equations as forward/Marcus-type rough backward stochastic differential equations **(RBSDEs)**. We establish global well-posedness by deriving apriori bounds for the global solution and employing a local fixed-point argument. Furthermore, we lift the RBSDE solution and the driving rough noise to the space of decorated paths endowed with a Skorokhod-type metric and prove the stability of solutions with respect to perturbations of the rough noise. Finally, we prove well-posedness for a new class of backward doubly stochastic differential equations (**BDSDEs**), jointly driven by a Brownian martingale B and an independent discontinuous stochastic process L of finite q-variation. We show, how our RBSDEs can be understood as conditional solutions to such BDSDEs, conditioned on the path information generated by L. This is a joint work with Dirk Becherer (HU Berlin).

3.18 Rough SDEs and Robust Filtering for Jump-Diffusions

Jost Pieper, University of Durham

Friday
14:30-15:00

Finding a robust representation of the conditional distribution of a signal given a noisy observation is a classical problem in stochastic filtering. Such representations are of interest as they justify the use of discrete observation data and ensure robustness of the signal approximation to slight model misspecification. When the signal and observation are correlated through their noise, Crisan, Diehl, Friz, and Oberhauser (2013) showed that such a robust representation typically cannot exist as a functional on the space of continuous paths, but must instead be formulated on the space of geometric rough paths. In this talk, I will discuss how to extend these results to stochastic filtering problems involving correlated multidimensional jump diffusions, using the theory of rough stochastic differential equations (RSDEs) with jumps. Specifically, I will discuss the consistency of (randomised) RSDEs with their purely stochastic counterparts, as well as exponential moment bounds provided by a version of the John–Nirenberg inequality for BMO processes with jumps, as first introduced by Lê in 2022. Building on these results, I will then address the existence of a robust representation of the conditional distribution in a filtering model with correlation in both the continuous and jump noise. This is a joint work with Andrew Allan and Josef Teichmann.

3.19 Stability of backward propagation of chaos

Stefanos Theodorakopoulos, TU Berlin

Friday
15:30-16:00

We are going to introduce and establish a notion of stability for the backward propagation of chaos, with respect to (initial) data sets. We consider the convergence scheme of the backward propagation of chaos as the image of the corresponding data set under which this scheme is established. Then, using an appropriate notion of convergence for data sets, we are able to show a variety of continuity properties for this functional point of view.

3.20 Rough stochastic filtering: robustness, PDEs and approximation

Huilin Zhang, HU Berlin

Friday
16:00-16:30

Motivated by the nonlinear stochastic filtering theory, we introduce a rough stochastic filtering theory in the general corellated case, which is based on the pioneering work of rough stochastic analysis by Friz-Hocquet-Le. We study three related filtering problems: robustness of the optimal filter (with respect to the observation); the uniqueness and existence of related rough Zakai and Kushner-Stratonovich equations; a numerical approximation to the rough optimal filter with convergence rate. In the end, we build the equivalence between the rough stochastic filtering and the original stochastic filtering. This talk is based on joint works with F. Bugini, P. Friz and K. Le.

3.21 Geometric post-Lie deformations and applications to Regularity Structures

Jean-David Jacques, Universität Potsdam

Saturday
9:00-9:30

In this talk, I will first give a short introduction to post-Lie algebras and briefly explain how it is used to build the structure group for quasi-linear SPDEs in the context of regularity structures, then I will present my lasts results concerning geometric deformations of post-Lie algebras and possible applications to the regularity structures theory.

3.22 Weighted iterated sums in deep learning

Richard Krieg, Universität Greifswald

Saturday
09:30-10:00

The iterated sums signature has been shown to perform well for feature extraction on time series data. In our method FRUITS, these iterated sums had no learnable parameters and a time-dependent, randomly parameterized weighting was crucial for its success. Recently, we extrapolated this formulation to an attention-like deep learning framework. The resulting model, called Elissabeth, has linear time complexity and can handle interactions between more than two time steps at one position in a single layer, contrary to a standard Transformer. On artificial data, we show that our model is more interpretable due to its input-dependent cosine weighting. Switching to another semiring gives our model even more flexibility to adjust for problem-specific data challenges.

3.23 The General Iterated Graph Systems

Nero Ziyu Li, Imperial College London

Saturday
10:00-10:30

We aim to introduce fractal geometry to graph theory. Hence, we propose the concept of General Iterated Graph Systems (GIGS), which is a universal model capable of generating fractal-like graphs including Sierpinski graph. Overall, we analysed the combinatorial (degree distribution, average distance), fractal (dimensions, classifications) and physical (random walk and Bernoulli percolation) properties of GIGS. Unexpectedly, even within this natural and simple model, there is still much we don't yet understand.

3.24 Learning ergodic time-series with recurrent neural networks

Samuel Chun Hei Lam , University of Oxford

Saturday
11:00-11:30

Recurrent neural networks (RNNs) are commonly used to learn time-series. To avoid costly computations of the gradient of the parameters, RNNs are either trained with real-time recurrent learning (RTRL), or truncated version of back-propagation-through-time (TBPTT). We aim to disseminate the technique to establish convergence of both algorithms, which based on the observation that the distribution of the hidden layers is ergodic if the input time series is ergodic. With this in mind, appropriate Poisson equations could be set up to analyse the limiting (stationary) distributions of the hidden layer, which is crucial to the studying the convergence of the algorithms. We will mostly analyse the training of finite-width RNN using RTRL, and if time allows, to discuss the asymptotic analysis of training an infinite width RNN using TBPTT, which gives rise to a limiting, infinite-dimensional ODE.

3.25 Anomaly detection for streamed data

Lingyi Yang, University of Oxford

Saturday
11:30-12:00

Anomaly detection on streamed data is crucial across a range of sectors like finance and communication. We present a novel pipeline designed for scoring anomalous streams based on clean corpus anomaly detection. The conformance scores of new samples are derived from a combination of path signatures with the Mahalanobis distance. Our pipeline is versatile and preserves desirable invariances, namely to linear transformations of the data and appending metadata. In the past past few years, generative AI has been widely integrated into our lives. At our fingertips, we can generate essays, art, music, and much more. With new technologies, come new challenges. These tools can be maliciously used for misinformation, and therefore detection tools need to keep up with the evolution of generative AI. We frame the problem of detecting fake/generated data as an anomaly detection problem. We showcase the effectiveness of using our pipeline on the voice authentication problem.

4. Participants

Peter Bank
Helena Kremp
Jannis Dause
Nicolas Perkowski
Jost Pieper
Nikolas Tapia
Sheng Wang
Shanshan Hu
Dirk Becherer
César Zarco Romero
Stefanie Hesse
Peter Friz
Ioannis Gasteratos
Da Li
Fride Straum
Martin Geller
Rosa Preiß
Jean-David Jacques
Terry Lyons
Carlos Villanueva Mariz
Yuchen Sun
Justus Werner
Huilin Zhang
Richard Krieg
Luca Pelizzari
Lingyi Yang
Thomas Wagenhofer
Matteo Ravot Licheri
Javier Castro
Nero Ziyu Li
Xueru Liu
Aleksei Kroshnin
Marco Rehmeier
Stefanos Theodorakopoulos
Ioannis Gasteratos
Samuel Chun Hei Lam
Yueh-Sheng Hsu
Alexandre Bloch
Constantin Kogler
Julian Kern
Thamsanqa Moyo
Francesco Triggiano
Dave Jacobi
Rahama Sani Abdullahi
Felix Medwed