Diffusions in Machine Learning: Foundations, generative models and non-convex optimisation (June – July 2024)

Academic Organisers: O. Deniz Akyildiz (Imperial College London), Gersende Fort (Université de Toulouse), Sotirios Sabanis (University of Edinburgh, The Alan Turing Institute, National Technical University of Athens) , Ying Zhang (Hong Kong University of Science and Technology (Guangzhou)).

Diffusion models have swiftly become indispensable tools in machine learning, serving as a cornerstone in generative models, sampling algorithms, and as continuous-time models in stochastic optimization methods. This cohesive mathematical framework elevates diffusion models to a unique position, fostering significant advancements across multiple domains of practical application.

Our Programme "**Diffusions in Machine Learning: Foundations, generative models and non-convex optimisation**" brought together a diverse group of experts and early-career researchers from various subfields within mathematical sciences, engineering, and computer science. This diversity facilitated a broad and dynamic programme, with a strong emphasis on fostering new collaborations both within individual disciplines and across different fields. Although the majority of participants were from the mathematical sciences, the inclusion of engineers, computer scientists, and social scientists enriched the programme, leading to a vibrant exchange of ideas and the initiation of interdisciplinary projects.

The inception of our programme was inspired by recent developments in diffusion-based stochastic optimizers for artificial neural networks, pioneered by organizers Sotirios Sabanis and Ying Zhang, along with their collaborators. These advancements, combined with the rapid progress in diffusion-based generative models, have significantly broadened the scope and applicability of machine learning and generative techniques in AI. This expansion has unlocked new potentials for this technology, making it more versatile and applicable across a wider range of fields than ever before.

We launched our program with a summer school specifically designed to meet the needs of our interdisciplinary audience, including early career researchers. The event, which was open to researchers beyond the invited participants through a ticketing system, experienced overwhelming demand, with tickets selling out quickly. This high level of interest underscores the significant demand and the critical importance of such initiatives within the academic community.

Key highlights of the programme included the hackathon week held at the University of Edinburgh supported by the Centre for Investing Innovation, where participants engaged in industry-inspired challenges provided by Amazon. Additionally, the "Open for Business" day featured a distinguished lineup of speakers, including Arnaud Doucet (Google DeepMind/Oxford University), Andrew Stuart (California Institute of Technology) and Eric Moulines (Ecole Polytechnique/French Academy of Sciences). The program culminated in an international conference in London, further enriching the experience for all involved. Insightful presentations by experts from renowned institutions worldwide, including Harvard, Yale, Oxford, Edinburgh, Université Paris 1, École Polytechnique, Hong Kong University of Science and Technology, and Google DeepMind, showcased a rich diversity of perspectives. These talks stimulated vibrant

discussions throughout the programme, offering fertile ground for the exchange of innovative ideas.

Looking ahead, the outcomes of this programme are poised to drive forward the frontier of research and innovation in machine learning. The new collaborations and ideas that emerged from our interdisciplinary approach are expected to catalyse further breakthroughs, pushing the boundaries of what is possible with diffusion models and their applications. By bridging gaps between distinct fields, our programme has not only advanced the state of the art but has also laid the groundwork for future interdisciplinary initiatives that will continue to expand the impact of these technologies.

We are confident that the relationships and collaborations formed during this programme will lead to lasting contributions in both academic research and practical applications, positioning diffusion models at the forefront of AI and machine learning for years to come.

On behalf of the organizers,

Prof Sotirios Sabanis,

University of Edinburgh & The Alan Turing Institute & National Technical University of Athens