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Stochastics

In the winter term 2021/2022 I am teaching the course (module M27, taught in English)

Advanced Topics in Stochastic Analysis

(stochastic dynamics with mean-field-interactions, mean-field-games, propagation of chaos, stochastic control)

This lecture will introduce you to advanced topics of stochastic analysis, broadly centered around mean-field-games, dynamics with mean-field interactions and (optimally controlled) stochastic differential equations, and analysis on metric Wasserstein spaces of probability measures.
Aim is to provide mathematical foundations for own studies of current research articles.

The said topics in stochastic analysis have a wide range of applications, ranging from engineering [8,9], finance and economics [2,4], machine learning [7], social and natural sciences [9,11], and areas of mathematics like optimal transport [6,10].

Contents:
Some advanced topics in stochastic analysis. Topics will include, e.g., propagation of chaos, stochastic differential equations beyond strong solution theory as from the Module “Stochastic Analysis” (for instance mean-field interations, McKean-Vlasov equations, functional and weak solutions), stochastic optimal control and mean-field-games, analysis on Wasserstein space of probability measures.

Prerequisites: Stochastic (Itô) calculus as taught in the lecture "Stochastische Analysis", that is the BMS advanced course "Stochastic Processes II". (Covering martingale theory in continuous time, stochastic integration, stochastic differential equations, martingale representation and Girsanov theorem, cf. e.g. the last chapters of the probability-textbook by Achim Klenke (*), or reference no. [3].)

References: (*=online access in HU-net, see Primus catalogue)

1. Carmona, R. and F. Delarue, 2018: Probabilistic theory of mean field games with applications, vol.1+2, Springer Cham (*)
2. Sznitman, A.S.: Topics in propagation of chaos. In Ecole d'Eté de Probabilités de Saint-Flour XIX-1989, 1991, Springer Berlin, (*)
3. Le Gall, J.F.: Brownian motion, martingales & stochastic calculus, Springer Berlin, 2016 (*)
4. Lackner, Daniel: Mean field games and interacting particle systems. Columbia U., 2018
5. Huang, M., Malhamé, R.P. and Caines, P.E., 2006. Large population stochastic dynamic games: closed-loop McKean-Vlasov systems and the Nash certainty equivalence principle. *Communications in Information & Systems*, *6*(3), 221-252. (*)

(Complementary References:)

6. Villani, Cedric, Optimal Transport, old and new, Springer Berlin, 2008

7. Hu, K., Ren, Z., Siska, D. and Szpruch, L., 2019. Mean-field Langevin dynamics and energy landscape of neural networks. *arXiv preprint arXiv:1905.07769*.

8. Djehiche, B., Tcheukam, A. and Tembine, H., 2016. Mean-field-type games in engineering. *arXiv preprint arXiv:1605.03281*.

9. Huang, M., Caines, P.E. and Malhamé, R.P., 2003, December. Individual and mass behaviour in large population stochastic wireless power control problems: centralized and Nash equilibrium solutions. In *42nd IEEE International Conference on Decision and Control (IEEE Cat. No. 03CH37475)* (vol.1, 98-103). IEEE.

10. Karatzas, I., Schachermayer, W., et al., 2020: A trajectorial approach to gradient flow properties of Langevin-Smoluchowski diffusions. arxiv.org/pdf/2008.09220.pdf

11. Ha, S.Y., Lee, K. and Levy, D., 2009. Emergence of time-asymptotic flocking in a stochastic Cucker-Smale system. *Communications in Mathematical Sciences*, *7*(2), pp.453-469.

Lecture: *Monday, 09 – 11, RUD 25, room 3.006*
Classes: *tentative date, (I suggest to move it to Mon.13-15, RUD 25, room 3.011, instead)*
Friday, 11 – 13, RUD 25, room 3.006 , bi-weekly, starting **October 29nd**

First lecture: **October 25, 2021**

Office hour: by appointment

There will be an accompanying seminar and a course moodle-page with current information, check www.math.hu-berlin.de/~becherer