Four Postdoc Positions in

Probability and Stochastic Processes

Stochastic Modeling of Interacting Systems

Fapesp 17/10555-0

The Instituto de Matemática e Estatística at Universidade de São Paulo is offering four post-doctoral positions in the field of probability and stochastic processes (stochastic modeling of interacting systems) starting February 15, 2020.

Research activities will concentrate on central and contemporary topics of Probability Theory, Stochastic Processes and related areas. Among them, the study of the properties of random walks in graphs and interlacings; particle systems, percolation theory and their variations such as epidemic models and rumors; biological models such as mutation-selection and population dynamics, random-media processes, scale limits, and aging of disordered system dynamics and random networks.

Colonization and catastrophes models.

We will investigate a model for population growth with disasters in which colonies grow for a random time until their collapse. At the time of collapse, a random number of individuals survive. These survivors try to establish new colonies in the neighborhood, in an independent fashion. We will analyze this process subject to distinct stochastic rules regarding to (i) colony growth; (ii) colony collapse time (catastrophe); (iii) reaction to catastrophe. We hope to obtain limit theorems (such as Law of Large Numbers, Central Limit Theorem, Large Deviations, Shape theorem) to make comparisons seeking better strategies for population survival.
Fábio Machado and Anatoli Yambartsev

Rumors spread and fake news models.

We are interested in a long-range percolation model in infinite, locally finite and connected graphs. The dynamics of these models can be understood as describing the spread of a rumor or virus as follows. For each vertex *v* of graph *G*, we assign a random radius of influence R(*v*). Next we think of a discrete-time chain reaction according to the following rules: (1) at time zero only the vertex *o*, the root of G, helps spreading the rumor by passing it to all vertices that are at a graph distance to *o* less than R(o). (2) at a generic moment *n*, all vertices that are less than R(*v*) from any vertex *v* that had contact with the rumor prior to instant *n* receive the rumor. The model known as *fireworks* (direct and reverse) on a tile fits into this framework and has received attention in recent articles. The aim of this project is to answer questions about the distribution of R(*v*) so that the survival probability of the rumor is positive, bounds for

spreading speed, shape and asymptotic density of the individuals receiving the rumor or even to study characteristics of G that facilitate or disrupt the rumor survival event.
Fábio Machado and Anatoli Yambartsev

Spin glass dynamics: Long time behavior of stochastic mean field models, such as the Metropolis dynamics for the REM in the hypercube at low temperature in ergodic time scales.

Long time behavior of random walks in noncompact dynamical random environments, such as independent birth-and-death processes. LLN, CLT, environment seen from the particle, large deviations, and other results would be of interest (we have a the CLT in the independent b-a-d case with jump rates given by a negative exponential of the environment, embedded chain independent of the environment, and a class of initial conditions for the environment).

System of interacting mechanical particles: we dispose particles of stationary, neutral, unit mass particles at marks of a renewal process on the positive reals; each of these, independently, are either sticky, with probability p, or non-sticky. A particle with unit positive electrical charge is initially placed at the origin, and a positive electric field is turned on, displacing the charged particle to the right, according to the laws of electrodynamics. The charged particle collides elastically with the non-sticky particles, and totally inelastically with the sticky ones; the latter kind of collision results in the particle along with its mass being incorporated to the charged particle. Non-sticky particles do not interact with each other. We are interested in the long-time behavior of the position of the charged particle.
Luiz Renato Fontes

Classical Markov Chains and Unitary Transformations

We describe dynamics of finite-state Markov Chain probability measures as unitary transformations on Hilbert spaces in three steps. We start with a arguably natural representation of probability distributions as vector in a unit-norm Euclidean sphere, with the stochastic dynamics being now represented as rotations in that sphere. Next, we see that a more mathematically interesting representation of probability distributions lead to unitary transformations on a complex-valued Hilbert space. This leads naturally to the final step, when powerful mathematical techniques from Lie algebra su(N) and Quantum Mechanics comes into play. The existence of strong connections relating classical Markov chains, quantum mechanics and quantum computing becomes evident. Several research directions naturally present themselves, relating Markov chains with several important quantum mechanics issues. To indicate a few of these issues, all recent topics of research in quantum mechanics, that appear particularly exciting at present: study Markov chains associated to Galois Quantum fields and other discrete phase-space quantum mechanics systems and the role of several, experimentally verified, *quantum weirdness* like *entanglement* and the quantum Zeno effect. Naturally, several of these ideas are not original and can be found scattered in the physics literature but, to our knowledge, they are still to be fully

developed, organized and presented with the focus on the theory of stochastic processes.
Eduardo Jordão Neves

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These positions are financed through the Fapesp grant 17/10555-0 - Stochastic modeling of interacting systems. For further information, please contact

Anatoli Yambartsev	yambar@ime.usp.br
Eduardo Jordão Neves	neves@ime.usp.br
Luiz Renato Fontes	lrenato@ime.usp.br
Fabio Machado	fmachado@ime.usp.br