# Postdoc Position in Importance Sampling and MCMC Methods

## Universidad Carlos III de Madrid, Spain

### General Description

There is an open postdoc position in the area of importance sampling and MCMC methods in the Signal Processing Group of the Universidad Carlos III de Madrid, Spain. The position is in relation to the ERC Starting Grant "Information Theory for Low-Latency Wireless Communications (LOLITA)." The duration of the position is up to 5 years, and the annual gross salary is approximately 29,500€.

### About the ERC Starting Grant

The majority of wireless connections in the fifth generation (5G) of wireless systems will most likely be originated by autonomous machines and devices rather than by the human-operated mobile terminals for which traditional broadband services are intended. It is thus expected that enhanced mobile-broadband services will be complemented by new services centered on machine-type communications (MTC). An important emerging area among MTC systems is that of low-latency communications, which targets systems that require reliable real-time communication with stringent requirements on latency and reliability.

The design of low-latency wireless communication systems is a great challenge, since it requires a fundamentally different design approach than the one used in current high-rate systems. Indeed, current systems exchange packets of several thousand bits. For such packet lengths, there are error-correcting codes that can correct transmission errors with high probability at rates close to the capacity. Consequently, the design of current systems is supported by the extensive information-theoretical knowledge we have about wireless communications. In contrast, low-latency systems exchange packets of only several hundred bits, so the rate of the error-correcting code must be significantly below the capacity to achieve the desired reliability. Consequently, for such systems, capacity is not a relevant performance measure, and design guidelines that are based on its behavior will be misleading.

Currently, we are lacking the theoretical understanding of low-latency wireless communication systems that would be crucial to design them optimally. This project addresses this problem by establishing the theoretical framework required to describe the fundamental tradeoffs in low-latency wireless communications.

### About the Position

The postdoc will be working on topics related with the Starting Grant. Of particular interest is a characterization of the maximal coding rate $R^*(\mathrm{P}, n, \epsilon)$ at power P, packet length $n$, and packet error probability $\epsilon$ for multi-antenna systems. While there exist accurate bounds on $R^*(\mathrm{P}, n, \epsilon)$, these bounds cannot be evaluated in closed-form. Instead, they are currently evaluated using Monte Carlo integration. Unfortunately, standard Monte Carlo estimators are inefficient and hence computationally expensive, which prohibits a numerical analysis of $R^*(\mathrm{P}, n, \epsilon)$. The aim of this project is to develop computationally-efficient algorithms based on importance sampling or MCMC methods that numerically approximate $R^*(\mathrm{P}, n, \epsilon)$. We expect that this will give rise to novel Monte Carlo methods that will also be relevant for other applications.

While the Starting Grant is mainly in the area of information theory, the consortium will actively collaborate with researchers working on Monte Carlo methods.

The following literature is relevant for the project:

[1]  G. Durisi, T. Koch, and P. Popovski, "Towards massive, ultrareliable, and low-latency wireless communication with short packets," Proceedings of the IEEE, Vol. 104, No. 9, September 2016.

There is the possibility to teach courses at UC3M if desired, but teaching is not mandatory. There is also the possibility to (co-)supervise Ph.D. students.

**Duration and Salary**

The postdoc will sign a fixed-term contract for one year with the possibility of renewal for up to 5 years.

The annual gross salary is approximately 29,500€, paid 14 times a year (12 monthly salary payments and two extra payments). This is about the salary of an Assistant Professor in Spain.

**Requirements**

Candidates who wish to apply should satisfy the following criteria:

- Ph.D. degree in Electrical Engineering, Computer Science, or related areas.
- Demonstrated research experience in importance sampling and/or MCMC methods.
- Research experience in wireless communications and/or information theory beneficial.

**About the Host Institution**

The Universidad Carlos III de Madrid was founded in 1989 and is one of the top universities in Spain. Our campus is located in Leganés, which is about 10km south of the center of Madrid. The postdoc will be part of the Signal Processing Group, which is an interdisciplinary group that conducts research in the areas of signal processing, machine learning, Bayesian and Monte Carlo methods, and information and coding theory. Currently, 2 professors in the group are working on Monte Carlo methods.

**Application Process**

Interested candidates should send their application to Prof. Tobias Koch (koch@tsc.uc3m.es). The application must include:

- Curriculum vitae.
- List of publications.
- Copy of one representative publication.
- Name and contact information (including email address) of one academic reference.

Shortlisted candidates will be invited to give an oral presentation of their work.

The position will remain open until filled.

**Contact**

For further information, please contact Prof. Tobias Koch (koch@tsc.uc3m.es).