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Education

Ph.D.	Electrical Engineering	2011	Institut National des Sciences Appliquées, Rennes, France
	Title: "*Analysis and Optimization of the Asian Mobile and Terrestrial Digital Television Systems*"		
	Mention: **très honorable** (*with highest honors*)		
Master	Electrical Engineering	2007	Xi'an Jiaotong University, Xi'an, China
Bachelor	Information Engineering	2004	Xi'an Jiaotong University, Xi'an, China

Experience

1/2017 – present	**Associate Professor, Ph.D. supervisor**	School of Computer & Information Technology, Beijing Jiaotong University, Beijing, China
1/2015 – 12/2016	**Lecturer**	School of Computer & Information Technology, Beijing Jiaotong University, Beijing, China
4/2011 – 1/2015	**Postdoctoral Researcher**	Institute of Electronics & Telecommunications of Rennes (IETR), France

Research

- **IoT Device Identification Based on Radio Frequency Fingerprint**, *National Science Foundation of China (NSFC),* **PI** *01/2020-12/2023*

  Project Objective: Researching the radio frequency fingerprint (RFF) for new identification mechanism of IoT device

  - **Robust radio frequency fingerprint (RFF) extraction**

    Existing researches on RFF mainly focus on extracting unique features resulted by certain device imperfections (e.g. carrier frequency offset, I/Q imbalances, nonlinearity, frequency response, etc.), and visualizing them through some processing (e.g. Fourier, wavelet, Hilbert-Huang transforms and correlations). Recent advances adopt the machine learning techniques to identify the visualized features. However, most researches considered only one feature. Hence, they are not resilient to the channel uncertainty, and the capacity of identification is limited. This work will propose new machine learning models that integrate multiple signal features in order to achieve higher identification accuracy and robustness.

  - **Bidirectional device identification based on RFF for IoT scenarios**

    Existing researches on Radio Frequency Fingerprint (RFF) mainly focus on unilateral device identification in one communication direction. However, in practice, it is difficult for IoT devices to identify the base station due to their hardware insufficiencies. This work investigates the bidirectional device identification method for the IoT application scenarios. The inherent reciprocity of the communication pair's RFFs is studied and exploited to offload the learning process, which is supposed to be proceeded by the IoT device, to the base station. The autoencoder-based RFF reciprocal conversion network is devised to predict the downlink RFF based on the data samples acquired in the uplink, so that the training process of the downlink identification network can be accomplished by the base station and the computational complexity of IoT devices is reduced. Evaluations with real-world data show that, the IoT devices can achieve a high accuracy to identify the base station using the identification network trained by the base station.

  - **RFF impersonation and countermeasures**

    RFF may be impersonated by adversaries to circumvent the authentication method. Anti-spoofing techniques (e.g. liveness detection) has been investigated for the similar authentication mechanisms such as facial or fingerprint recognitions. However, the detection of RFF impersonation attacks is highly insufficient in the existing research. This work will study the possibility that malicious users impersonate the legitimate users' RFF by adversarial learning. To overcome the problem that each device, including the legitimate users and malicious users, has unique hardware imperfections in both transmission and reception circuits and the response caused by these imperfections can hardly be calibrated by the device itself, this work proposes to introduce a cooperative attacker that serves as a 'spectator' or 'critic' to help the malicious users to impersonate their RFFs. A Generative Adversarial Network

(GAN) based cooperative RFF spoofing method is proposed, which can generate high fidelity RFFs that look alike to the targeted legitimate users. Countermeasures will be proposed to effectively detect the RFF spoofing or, alternatively, increase the sophistication of RFF that can incapacitate the RFF impersonation attacks.

- **Reliable transmission techniques in massive MIMO systems for 5G**, *National Science Foundation of China (NSFC),* **PI** *01/2016 – 12/2018*

Project Objective: Researching key physical layer techniques for reliable and scalable massive MIMO system

- **Physical layer security technique to prevent pilot contamination attack**

  The pilot contamination phenomenon is seen as the bottleneck of the performance of massive MIMO, but also contains serious information security breach. We research different methods to detect the pilot contamination attack from active eavesdroppers. A simple detection method based on the transmission of random symbols from mobile terminals is proposed. As the number of receive antennas goes large, the distribution of the phase differences of received random symbols converges to a set of finite regions. Once contaminated by the active attackers, the phase difference distribution is disturbed, which is exploited to detect the existence of active attacker. In a further study, we research to use random matrix theory to characterize the distribution of the eigenvalues of the random symbols which also converges to a series of sectors. The boundary of the sectors can be determined by a theoretical way. This property is employed to detect the active attackers.

- **Massive uplink connections in massive MIMO system**

  The random access of massive concurrent Internet-of-Thing devices becomes a major challenge for the future mobile communication network. We seek the possibility of exploiting the great spatial degrees of freedom brought by the massive MIMO technique. The small-scale fading channels of concurrent users sharing the same band is converted to a scalar form after the simple Maximal Ratio Combining (MRC). The overlapped users' symbols are then recovered using the iterative interference canceller as long as the received powers of different users exhibit significant difference. The random access of multiple concurrent users is turned into a power allocation problem. It is proved that the proposed random access scheme can support around 300% system overload ratio.

- **Communication enhancement using AI techniques,** *internal project,* **PI** *11/2019 – present*

Project Objective: Integrating the recent advances in AI to solve the fundamental problems in communications

- **Non-linearity mitigation in visible light communications**

  Light emitting diodes (LED) are the main source of non-linearity in visible light communication (VLC). The non-linearity and memory effects of indoor VLC channels is characterized by the Wiener-Hammerstein model. A Long Short-Term Memory Network (LSTM) based pre-distortion is proposed to compensate the non-linearity of the power amplifier. The proposed pre-distortion module migrates the complexity spent for the signal equalization to the transmitter side, and reduces the complexity at the receiver side, which is important for the VLC application. Furthermore, a neural network based pre-distortion with end-to-end training is proposed to integrate the direct current (DC) point selection and the signal normalization in the training process, making it more flexible to different application scenarios. Simulation results show that the proposed pre-distortion scheme outperforms the traditional Volterra series based equalization method.

- **Power efficiency optimization for MISO-NOMA uplink transmissions**

  The power control is critical for the efficiency of uplink MISO-NOMA transmissions. The optimal power control in the sense of minimum total transmission power is prohibitively complicated especially when the number of users is large. Alternatively, the power control problem is realized by a user clustering followed by an iterative power control over clusters. In the first step, an improved K-means algorithm is proposed for user clustering. Both channel gain and channel similarity among users are considered in the clustering to reduce the intra- and inter-cluster interference. The optimal cluster number and cluster centers are dynamically obtained by the semi-orthogonal user selection (SUS). With the clustering results, the optimal power control within each cluster using the closed-form expression. The power control among different clusters is realized by an efficient iterative algorithm. Simulation results show that the proposed scheme achieves a near-optimal performance in terms of total power consumption and energy efficiency at a reasonable cost. Currently, we are moving to using the deep reinforcement learning to solve the uplink power control problem

- **5G End-to-End performance optimization for hybrid service scenarios**, *Nokia Bell Labs project*, **technical leader** *04/2017 – 03/2018*

Project Objective: Proposing radio resource management strategy for future mobile communication networks

- **Hybrid Transmission Time Intervals for TCP Slow Start in Mobile Edge Computing System**

  5G NR allows to schedule the users with variable transmission time intervals (TTIs) and can allocate the radio resources with more flexibility. In this work, a novel scheduling scheme with hybrid TTI is proposed to improve the performance of Transmission Control Protocol (TCP) transmission in Mobile Edge Computing (MEC) systems. The enhanced mobile broadband (eMBB) traffic can be scheduled with shorter TTI at TCP slow start stage and utilize the available resource after the low latency communication (LLC) users being scheduled. It can speed up the slow start procedure at the initial transmission phase thanks to faster feedback of acknowledgement enabled by the short TTI. After a given time, while the throughput probably approaching saturation, eMBB traffic switches to its own band with long TTI to reduce the transmission overhead. With the proposed scheme, the radio resources can be allocated with finer granularity and higher flexibility. The proposed scheme is evaluated by Nokia's system level simulator and its effectiveness is proved.

- **RFID localization algorithm and its application**, *Zhongjing Fudian Company project*, **PI** 03/2018 – 03/2019

  Project Objective: Investigating the item localization algorithm and its application in the automated logistics systems

  - **Deep learning based RFID localization algorithm**

    The commercial RFID reader can obtain the RSSI and phase information of the surrounding RFID tags in the interrogation process. The information can be exploited to localize the position of the RFID tags in the 1-D, 2-D or 3-D space. This research began by investigating the relative position of the tags in 1-dimension. A convolutional neural network (CNN) based localization algorithm was proposed to accurately determine the relative position of the moving RFID tags in a line. This makes the automated dispatch possible for the modern logistics systems. The method is validated by the real RFID signal samples captured in the working environment.

- **Machine-to-machine communications via cellular networks**, *Orange Labs project*, **researcher** *06/2014 – 01/2015*

  Project Objective: Proposing energy-efficient solutions to deliver M2M communications over the GSM system

  - **Evaluation of physical layer performance of the GSM/GPRS/EDGE systems**

    The MATLAB based simulation chain contains main features of GSM with different Modulation Coding Schemes (MCS) and channel models. The implemented receiver algorithms include the optimal maximum-likelihood sequence estimation (MLSE) detector, the sub-optimal reduced-state sequence estimation (RSSE) and decision-feedback detectors, as well as the linear detectors.

- **High-speed data transmission in low-cost optical fiber systems,** *IETR internal project,* **researcher** *06/2013 – 01/2015*

  Project Objective: Proposing high-efficiency, low-complex transmission schemes for the Polymer Optical Fiber (POF) systems

  - **Proposal of a high performance PN-ZP-DMT transmission scheme**

    The proposed PN-ZP-DMT scheme is based on the DMT technique and combines the advantages of PN- and ZP-based guard intervals. It employs the pseudo-noise (PN) sequences to obtain accurate channel estimation, and reduces the transmission power through the use of zero padding (ZP) guard intervals. The proposed scheme achieves a transmission data rate of 1.5 Gbps over a 50-meter experimental POF system, which represents the highest transmission rate reported in the literature.

- **STBC design for distributed MIMO systems,** *French ANR & European CELTIC projects,* **researcher** *04/2011 – 12/2013*

  Project Objective: Proposing effective MIMO encoding and decoding algorithms for future broadcasting system

  - **Proposal of a new form of the 3D MIMO code**

    I proposed to permute the positions of information symbols so that the orthogonality is 'concentrated' in the first 4 information symbols. The resulting new 3D MIMO codeword is therefore fast-decodable. It is among the least complex STBCs with the same code rate and diversity. The new code is robust to the 'near-far problem' in distributed MIMO.

  - **Proposal of a short version 3D MIMO code**

    The new code has the coding rate of 2 (full-rate, 4 information symbols within 2 channel uses). It requires much less complexity than 3D MIMO code with negligible performance loss. It achieves best trade-off between performance and complexity with different channel coding configurations.

- **Proposal of a new fast-decodable DjABBA code**

  The new code is full-rate, full-diversity for 4×2 MIMO transmission. It requires lowest ML decoding complexity among the fast decodable STBCs. The proposed codeword possesses highest coding gain and has best BER performance among STBCs.

- **Proposal of an ML decoders for original and new 3D MIMO codes**

  The simplified decoder is realized by a four-level tree-search followed by four parallel decisions, yielding a complexity order of 4:5. It provides the ML performance and requires less processing time than the classical sphere decoder with Schnorr-Euchner enumeration.

o **Channel estimation for PN-OFDM based systems,** *French "Mobile TV World" project,* **researcher** *10/2007 – 03/2011*

Project Objective: Proposing high performance channel estimation techniques for the PN-OFDM based systems

- **Proposal of several PN-correlation-based channel estimation techniques**

  I proposed the time domain channel estimation techniques exploiting the unique correlation properties of m-sequences. I also proposed several improved estimators which reduce estimation error floor caused by the imperfect correlation results of PN sequences. The proposed PN-based channel estimation methods achieve good performance in typical channel conditions with low implementation complexity.

- **Proposal of an iterative data-aided channel estimation technique with low complexity**

  I proposed an iterative data-aided channel estimation technique which is used in combination with PN-based estimation to handle the harsh channel conditions (such as the cases of SFN). In contrast to the classical 'Turbo channel estimation', data symbols are directly rebuilt based on the soft information output from the demapper to reduce complexity. The rebuilt 'soft' data symbols serve as training sequence for a second channel estimation. The data-aided channel estimation results are refined using moving average or Wiener filtering techniques. The PN-based and data-aided channel estimation results are combined according to their estimation accuracies and the resulting new channel estimation will be used to decode the information in the next iteration. The overall system performance is significantly improved with only a few iterations.

Skills

Telecom	massive MIMO, OFDM, space-time coding, iterative process, channel estimation, random access, physical layer security, optical fiber communications, GSM, LTE, DVB-T/T2/NGH, DTMB
AI	hands on experience on typical machine learning models, e. g. CNN, auto-encoder, GAN
Tools	MATLAB, Python, C, C++, JAVA
Language	English (fluent), French (fluent), Chinese (mother tongue)

Teaching

Courses	"Assembly Language & Computer Interface" 64 hours undergraduate course in BJTU, since 2017 fall "Design and Analysis of Algorithms" 24 hours postgraduate course in BJTU, since 2019 fall
Qualification	Teaching qualification in French universities ("**La qualification aux fonctions de maître de conférences**", section 61, in the field of computer science, automatics & signal processing)

Advising

Master	Junxia Zhang (2018-2021), Xiaoyi Han (2018-2021), Jiaxin Ren (2018-2021), Cihang Cheng (2019-2022), Tianzhuang Zhang (2019-2022), Xin Wang (2020-2023), Y. Xu (2021-2024) Xiaoyi Wang (2015-2017, now at **China Railway Fifth Survey and Design Institute Group**), Qing Wang (2015-2018, co-advised with Prof. Zhangdui Zhong, now at **Huawei**), Li Xu (2016-2019, now at **People's Bank of China**), Nian Liu (2017-2020, now at **China Merchants Bank**), Yawen Zheng (2017-2020, now at **Minsheng Bank**), Lanlan Wei (2017-2019, now at **Chinese Academy of Sciences**), Mingshan Zhang (2017-2020, co-advised with Prof. Zhangdui Zhong, now at **Intel**)
Ph.D.	Rida El Chall (in assistance to Prof. Maryline Hélard and Prof. Fabienne Nouvel, INSA-Rennes)

Award

2021 **China Railway Society Science and Technology Progress Award**, Second Prize (4/20)

2020 **Excellent Bachelor thesis prize of Beijing Jiaotong University** (for Mr. Lei Zhang's thesis)

2019 **Excellent Bachelor thesis prize of Beijing Municipal** (for Mr. Cihang Cheng's thesis)

2019 **Huawei Prize** (two recipients each year in BJTU)

2018 **Watchdata Prize**

2017 **Excellent Master thesis prize** of School of Computer & Information Technology of Beijing Jiaotong University (for Miss Xiaoyi Wang's thesis)

Publication (A full list of publication can be found in *https://xjtumliu.github.io/web/pub*)

Journal Articles:

- L. Peng, J. Zhang, **M. Liu** & A. Hu, "Deep Learning Based RF Fingerprint Identification Using Differential Constellation Trace Figure," *IEEE Transactions on Vehicular Technology*, vol. 69, no. 1, pp. 1091–1095, 2020.
- L. Xu, J.Q. Chen, **M. Liu (*)** & X.Y. Wang, "Active Eavesdropping Detection Based on Large-Dimensional Random Matrix Theory for Massive MIMO-Enabled IoT," *Electronics*, 2019, 8(2), 146.
- L. Peng, G. Li, J. Zhang, R. Woods, **M. Liu** & A. Hu, "An investigation of using loop-back mechanism for channel reciprocity enhancement in secret key generation, " *IEEE Transactions on Mobile Computing*, vol. 18, no. 3, pp.507-519, 2019.
- L. Peng, **M. Liu**, M. Hélard & S. Haese, "PN-PAM scheme for short range optical transmission over SI-POF--an alternative to Discrete Multi-Tone (DMT) scheme," *Journal of the European Optical Society*, 13:21, 2017.
- R. El Chall, F. Nouvel, M. Hélard & **M. Liu**, "Performance and complexity evaluation of iterative receiver for coded MIMO-OFDM systems," *Mobile Information Systems*, 2016.
- **M. Liu**, J.-F. Hélard, M. Hélard & M. Crussière, "Towards the next generation TV broadcasting-improved performance using distributed MIMO," *Wireless Personal Communications*, 84(4):2635-2649, 2015.
- R. El Chall, F. Nouvel, M. Hélard & **M. Liu**, "Iterative receivers combining MIMO detection with turbo decoding: performance-complexity trade-offs," *EURASIP Journal on Wireless Communications and Networking*, 2015.
- L. Peng, M. Hélard, S. Haese, **M. Liu** & J.-F. Hélard, "Hybrid PN-ZP-DMT scheme for spectrum-efficient optical communications and its application to SI-POF," *IEEE Journal of Lightwave Technology*, 32(18): 3149–3160, 2014.
- **M. Liu**, M. Crussière, M. Hélard & J.-F. Hélard, "Achieving low-complexity maximum-likelihood detection for the 3D MIMO code," *EURASIP Journal on Wireless Communications and Networking*, 20, pp.1-16, 2014.
- **M. Liu**, M. Hélard, M. Crussière & J.-F. Hélard, "Distributed MIMO coding scheme with low decoding complexity for future mobile TV broadcasting," *IET Electronics Letters*, 48(17):1079–1081, 2012.
- **M. Liu**, M. Crussière & J.-F. Hélard, "A novel data-aided channel estimation with reduced complexity for TDS-OFDM systems," *IEEE Transactions on Broadcasting*, 58(2):247–260, 2012.

Conference Papers:

- **M. Liu**, X. Han, N. Liu & L. Peng, "Bidirectional IoT Device Identification Based on Radio Frequency Fingerprint Reciprocity," in *Proc. IEEE International Conference on Communications (ICC)*, Montreal, Canada, 2021.
- Q. Wang, **M. Liu**, N. Liu & Z.D. Zhong, "On augmenting UL connections in massive MIMO system using composite channel estimation, " in *Proc. IEEE Global Communications Conference (GLOBECOM)*, 2018.
- Q. Wang, Z.Y. Zhao, D.S. Miao, Y.T. Zhang, J.Y. Sun, **M. Liu** & Z.D. Zhong, "Non-orthogonal coded access for contention-based transmission in 5G," in *Proc. 2017 IEEE 86th Vehicular Technology Conference (VTC2017-Fall)*, Toronto, Canada, 2017.
- X.Y. Wang, **M. Liu**, D. Wang & C.J. Zhong, "Pilot contamination attack detection using random symbols for massive MIMO systems," in *Proc.2017 IEEE 85th Vehicular Technology Conference (VTC2017-Spring)*, Sydney, Australia, 2017.

Patent

- **M. Liu**, X. Han, L. Wei, *et al.* "A radio frequency fingerprinting method based on differential constellation trace figure with multiple differential intervals," Chinese Invention Patent, Dec. 19, 2019. **Granted**.
- **M. Liu**, N. Liu, Q. Wang, "Non-orthogonal multiple access based on massive MIMO," Chinese Invention Patent, May 21, 2018, **Granted**.
- **M. Liu**, X. Wang, D. Wang, "Active eavesdropping detection for massive MIMO systems based on random symbols," Chinese Invention Patent, Nov. 7, 2016. **Granted**.
- **M. Liu**, N. Liu, W. Xue, *et al.* "A RFID localization method based on deep learning," Chinese Invention Patent application, Jul. 3, 2019.
- **M. Liu**, C. Cheng, T. Zhang, *et al.* "A tool monitor system based on RFID," Chinese Invention Patent application, Nov. 7, 2019.