罗 可

kenleo_lucas#outlook#com github.com/Ken-Leo
华中科技大学 计算机系统结构 • 博士 1993-01-02 武汉

计算机系统结构专业博士，擅长磁存储及光存储系统建模与分析，热衷数据存储技术、信号处理与信息理论。

教育背景

至今 2023.03	**华中科技大学** • 武汉光电国家研究中心 光学工程 • 博士后合作导师：陈进才，张静宇
2022.12 2016.09	**华中科技大学** • 武汉光电国家研究中心 计算机系统结构 • 博士导师：陈进才
2016.06 2012.09	**中南民族大学** • 电子信息工程学院 电子信息工程 • 学士

科研项目

- 国家自然科学基金，面上项目，62272178, 超高密度三维热辅助磁记录写机制研究，2023/01 至 2026/12，在研，参与
  - 研究成果与创新点：三维磁记录介质模型，三维记录数据回读模型。
  - 主要贡献：申请书的撰写并获得资助，三维磁记录读通道建模，三维回读信号均衡检测。
  - 研究成果影响：实现双层磁数据记录保障三维磁记录数据读取可靠性以达到存储密度倍增，为超高密度磁存储提供理论基础和技术支持。
- 国家自然科学基金, 面上项目, 61672246, 超高密度二维磁记录读磁头阵列及其记录系统关键技术研究, 2017/01 至 2020/12，已结题，参与
  - 研究成果与创新点：二维磁记录介质模型，二维记录数据回读模型。
  - 主要贡献：开展二维磁记录介质建模、读写过程建模及回读信号处理，设计了二维 Voronoi 介质颗粒模型的生成方法，进行了不同介质及记录位尺寸参数下的写错误分析。
  - 研究成果影响：提出了平衡准确性和计算开销的二维回读响应区间的选取指标，搭建了二维磁记录写入、回读和数据恢复信道的系统结构，提出了基于神经网络的块均衡检测方法、限制连续磁化跃迁的约束控制编码方法等，有效提高了磁存储系统的可靠性，对大幅提升磁存储密度和容量具有重要的理论指导意义与应用价值。
- 国家自然科学基金，面上项目，61272068，比特图案介质的超高密度瓦记录关键技术研究，2013/01-2016/12，已结题，参与
  - 研究成果与创新点：比特图案磁记录介质模型，比特图案记录数据回读模型。
  - 主要贡献：比特图案磁记录读通道建模，记录位排列方式研究，回读信号仿真分析等。
  - 研究成果影响：提出了一种基于比特图案的磁记录介质模型，实现了基于该模型的磁记录读通道建模，为比特图案介质的瓦记录技术提供理论基础和技术支持。
- 企业横向，面向蓝光超多层 PRML 算法技术合作项目，2024/07 至 2025/02，在研，参与
  - 研究成果与创新点：基于独立引导层的多层蓝光光盘 PRML 信号处理算法与仿真模型。
  - 主要贡献：多层光盘 PRML 模型研究及信号质量评估方法研究。
  - 研究成果影响：300GB-500GB 多层蓝光光盘实现 RF 信号样本的检测，达到商用要求，为超大容量光盘的国产化提供技术支持。
- 企业横向，基于 BDXL 标准的 PRML 模型设计与实现合作项目，2022/08 至 2023/06，已结题，参与
  - 研究成果与创新点：蓝光光盘 BDXL 标准的 PRML 检测器设计。
  - 主要贡献：完成一套基于 BDXL 标准的蓝光存储 PRML 仿真模型的算法设计。
  - 研究成果影响：所设计的 PRML 通道方案在商用光盘中测试通过，检测效果达到国际同类先进水平。
- 企业横向，HDD 原型算法和先进磁记录技术合作项目，2022/03 至 2023/03，已结题，参与
  - 研究成果与创新点：磁记录系统微磁学仿真分析及建模，先进磁记录系统算法设计和仿真。

- 主要贡献：开展基于 PMR/TDMR 的 HDD 相关技术、算法和文献调研，进行 PMR、TDMR 优化算法选型研究，开展磁头、存储密度、可靠性、均衡、检测、编译码等方面关键技术的开发、设计和优化。
- 研究成果影响：基于 PMR+TDMR 磁记录技术，提供原型/商用可实现、性能在业界有竞争力的 HDD 算法以及浮点算法仿真代码开发，支撑原型系统开发和验证。

科研成果

[1] ZHU C, SUN C, LIU Y, CHEN J*, LUO K*. Enhancing Speech Emotion Recognition with Speech Dynamic Modeling and Multi-Modal Knowledge Distillation[C]//2025 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). 2025.

[2] LIU Y, LUO K*, CHEN J. Multi-modal Image Reflection Removal with Prior Knowledge of Reflection Structure Inconsistency[C]//The 10th IEEE International Conference on Data Science and Systems (DSS 2024). 2024.

[3] **LUO K**, LIAO Y, ZHANG K, JIAN Y, WANG S, CHEN J*, LU P. On the impact of interlayer misalignment for dual-layer data detection in three dimensional magnetic recording[J/OL]. Journal of Magnetism and Magnetic Materials, 2024, 610: 172522. https://www.sciencedirect.com/science/article/pii/S0304885324008138. DOI: https://doi.org/10.1016/j.jmmm.2024.172522.

[4] **LUO K**, ZHANG K, WU Y, LIAO Y, GAO H, LI W, JIAN Y, LIU Z, ZHAO Y, CHEN J*, LU P, WANG S. The Compatible Partial Response Maximum Likelihood Detection Schemes for Blu-Ray Discs[C]//The 21st International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology. Thailand, 2024: 1-5.

[5] LIAO Y, ZHANG K, JIAN Y, WANG S, CHEN J, LU P, LUO K*. Decision-Feedback Single-Layer Read Reconstruction and Separation for Three-dimensional Magnetic Recording[C]//2024 IEEE International Magnetics Conference (INTERMAG): AD-03. Rio de Janeiro, Brazil, 2024: 1-2.

[6] **LUO K**, WU Y, LIAO Y, WANG S, JIAN Y, CHEN J*, LU P. Quaternary Neural Network Equalization for Three-Dimentional Magnetic Recording[C]//2024 IEEE International Magnetics Conference (INTERMAG): AD-11. Rio de Janeiro, Brazil, 2024: 1-2.

[7] **LUO K**, JIAN Y, LIAO Y, ZHANG K, CHEN J*, LU P. A Graded Precompensation Scheme by Pattern Classification on Nonlinear Transition Shift for Perpendicular Magnetic Recording[J]. IEEE Transactions on Magnetics, 2023: 1-1. DOI: 10.1109/TMAG.2023.3288371.

[8] JIAN Y, **LUO K**, LI W, LOMAKIN V, CHEN J*, LU P. Pattern Constraints Limiting Nonlinear Transition Shift in High Density Magnetic Recording[J]. Journal of Magnetism and Magnetic Materials, 2023, 588: 171370. DOI: https://doi.org/10.1016/j.jmmm.2023.171370.

[9] CHEN W, CHEN J*, GAN Z, MA Y, **LUO K**, HUANG Z, HE Y, LU P. A Simple and Effective Semi-Circle Resonator System for Bit-Patterned HAMR[J]. Physics Letters A, 2021, 391: 127129. DOI: https://doi.org/10.1016/j.physleta.2020.127129.

[10] **LUO K**, WANG S, XIE G, CHEN W, CHEN J*, LU P, CHENG W. Read Channel Modeling and Neural Network Block Predictor for Two-Dimensional Magnetic Recording[J]. IEEE Transactions on Magnetics, 2020, 56(1): 1-5. DOI: 10.1109/TMAG.2019.2950704.

[11] CHEN W, CHEN J*, GAN Z, **LUO K**, HUANG Z, LU P. High-Field Enhancement of Plasmonics Antenna Using Ring Resonator for HAMR[J]. IEEE Transactions on Magnetics, 2020, 56(7): 1-5. DOI: 10.1109/TMAG.2020.2990525.

[12] **LUO K**, WANG S, CHAN K S, CHEN W, CHEN J*, LU P, CHENG W. A Study on Block-Based Neural Network Equalization in TDMR System With LDPC Coding[J]. IEEE Transactions on Magnetics, 2019, 55(11): 1-5. DOI: 10.1109/TMAG.2019.2931760.

[13] WANG S, CHEN J*, **LUO K**, XIE G, LU P, CHENG W. Joint Four-Reader Array Equalization and Detection for a Single Track in TDMR[J]. IEEE Transactions on Magnetics, 2019, 55(12): 1-6. DOI: 10.1109/TMAG.2019.2936181.

[14] XIE G, **LUO K**, WANG S, LU P, CHENG W, CHEN J*. Rounded Corner Effect on Write Performance for Shingled Magnetic Recording System[C]//2018 Asia-Pacific Magnetic Recording Conference (APMRC): S01-A01. USST, China, 2018: 1-2. DOI: 10.1109/APMRC.2018.8601116.

[15] **LUO K**, WANG S, XIE G, CHEN J*, LU P, CHENG W. Read Channel Modeling and Neural Network Block Predictor for TDMR[C]//2018 Asia-Pacific Magnetic Recording Conference (APMRC): S05-A01. USST, China, 2018: 1-2. DOI: 10.1109/APMRC.2018.8601082.

[16] WANG S, CHEN J*, **LUO K**, LU P, CHENG W. Four-Reader Array Detection for Two-Dimensional Magnetic Recording[C]//2018 Asia-Pacific Magnetic Recording Conference (APMRC): S08-B01. USST, China, 2018: 1-2. DOI: 10.1109/APMRC.2018.8601111.

[17] CHEN J*, XIE G, **LUO K**, CHENG W, LU P, WANG Y. Study of Erase Band and Write Performance in Shingled Mag-netic Recording with Exchanged Coupled Composite Media[C]//2018 IEEE International Magnetics Conference (INTERMAG): BQ-05. Singapore, 2018: 1-1. DOI: 10.1109/INTMAG.2018.8508564.

[18] CHEN J*, XIE G, **LUO K**, WANG S, LU P, WANG Y. Study of Erase Band and Write Performance for Shingled Magnetic Recording With FePt-Based Exchanged Coupled Composite Media[J]. IEEE Transactions on Magnetics, 2018, 54(11): 1-6. DOI: 10.1109/TMAG.2018.2829848.

[19] **LUO K**, WANG S, CHAN K S, CHEN W, CHEN J*, LU P, CHENG W. A Study on Block-Based Neural Network Equalization in TDMR System with LDPC Coding[C]//The 30th Magnetic Recording Conference (TMRC 2019): P1-7. Minneapolis, UM, USA, 2019: 1-2.

[20] WANG S, CHEN J*, **LUO K**, XIE G, LU P, CHENG W. Performance Evaluation of Four-Reader Array Detection for Two-Dimensional Magnetic Recording[J]. Science of Advanced Materials, 2019, 11(6): 835-841.

[21] **罗可**, 张克政, 蹇雨根, 李桅, 廖彦哲, 吴宇飞, 高宏宇, 陈进才, 卢萍. 一种磁盘数据写入过程非线性跃迁偏移的分类补偿方法: [P]. CN 117059134 A. 2023.

[22] 陈进才, **罗可**, 卢萍, 甘棕松, 王少兵, 陈玮, 刘鑫, 鲍锦星. 二维信道均衡模型训练方法及二维信道均衡方法: [P]. CN 110211611 B. 2019.

Ke Luo

luoke_kenleo@hust.edu.cn github.com/Ken-Leo
Ph.D. in Computer System Architecture Huazhong University of Science and Technology (HUST)
1993 Jan. Wuhan

Highly-motivated Ph.D. in Computer Science(Computer Architecture) with good foundations of math and statistics. Proficient in storage channel modeling, analysis, and signal processing and enthusiastic about data storage technologies and deep learning inspired information theory. Skilled in Matlab/Octave, Python, and C/C++ programming. Passionate about computer science, hiking, and photography.

Education

Till now	Wuhan National Laboratory for Optoelectronics, **Huazhong University of Science and Technology**
March 2023	Postdoc. in Optical Engineering , Mentor: Prof. Jincai Chen, Prof. Jingyu Zhang
December 2022	Wuhan National Laboratory for Optoelectronics, **Huazhong University of Science and Technology**
September 2016	Ph.D. in Computer Architecture , Supervisor: Prof. Jincai Chen
June 2016	College of Electronics and Information, **South-Central Minzu University**
September 2012	Bechelor in Electronics and Information Engineering

Research Projects

- National Natural Science Foundation of China, General Program, No. 62272178, Study of Write Mechanism of Ultra-high Density Three-Dimensional Heat-Assisted Magnetic Recording, 2023/01 to 2026/12, ongoing, participant
  - Research Achievements and Innovations: 3D magnetic recording medium model, 3D data readback model.
  - Main Contributions: Writing the proposal and obtaining funding, 3D magnetic recording read channel modeling, 3D readback signal equalization and detection.
  - Research Impact: Achieved dual-layer magnetic data recording to ensure the reliability of 3D magnetic data reading, doubling the storage density, providing theoretical foundation and technical support for ultra-high-density 3D magnetic storage.
- National Natural Science Foundation of China, General Program, No. 61672246, Key Technologies of Read Heads Array and The Recording System for Two-Dimensional Magnetic Recording at Ultra-high Densities, 2017/01 to 2020/12, completed, participant
  - Research Achievements and Innovations: 2D magnetic recording medium model, 2D data readback model.
  - Main Contributions: Conducted modeling of 2D magnetic recording media, read/write processes, and readback signal processing. Designed a method for generating a 2D Voronoi medium particle model and analyzed write errors under different medium and recording bit size parameters.
  - Research Impact: This study proposes selection criteria for two-dimensional readback response intervals that balance accuracy and computational overhead. It establishes a systematic framework for two-dimensional magnetic recording, including writing, readback, and data recovery channels. Additionally, it introduces a neural network-based block equalization detection method and a constraint control encoding method that limits consecutive magnetization transitions. These advancements effectively enhance the reliability of magnetic storage systems and provide important theoretical guidance and practical value for significantly increasing magnetic storage density and capacity.

- National Natural Science Foundation of China, General Program, No. 61272068, Key Technologies of Ultra-high Density Shingled Magnetic Recording on Bit Patterned Media, 2013/01 to 2016/12, completed, participant
  - Research Achievements and Innovations: Bit-patterned magnetic recording medium model, bit-patterned data readback model.
  - Main Contributions: Modeling of bit-patterned magnetic recording read channels, study of recording bit arrangement, and readback signal simulation analysis.
  - Research Impact: This study proposes a bit-patterned magnetic recording (BPMR) medium model and develops a corresponding magnetic recording read channel model. It provides a theoretical foundation and technical support for shingled recording technology in bit-patterned media.
- Corporate Collaboration, PRML Algorithms and Techniques for Multi-layer Blu-ray Discs Cooperation Project, 2024/07 to 2025/02, ongoing, participant
  - Research Achievements and Innovations: Multi-layer blue-ray disc PRML signal processing algorithm and simulation model based on an independent guiding layer.
  - Main Contributions: Research on multi-layer disc PRML models and signal quality assessment methods.
  - Research Impact: Achieved RF signal sample detection for 300GB-500GB multi-layer blue-ray discs, meeting commercial requirements, providing technical support for the domestic production of ultra-large capacity optical discs.
- Corporate Collaboration, PRML Model Design and Implementation Based on BDXL Standard, 2022/08 to 2023/06, completed, participant
  - Research Achievements and Innovations: PRML detector design for blue-ray discs based on the BDXL standard.
  - Main Contributions: Completed algorithm design for a PRML simulation model of blue-ray storage based on the BDXL standard.
  - Research Impact: The designed PRML channel solution was tested in commercial optical discs, achieving detection results at the international advanced level.
- Corporate Collaboration, HDD Prototype Algorithms and Advanced Magnetic Recording Technology Cooperation Project, 2022/03 to 2023/03, completed, participant
  - Research Achievements and Innovations: Micromagnetic simulation analysis and modeling of magnetic recording systems, advanced magnetic recording system algorithm design and simulation.
  - Main Contributions: Conducted research on HDD-related technologies, algorithms, and literature based on PMR/TDMR, optimized algorithms for PMR and TDMR, and developed, designed, and optimized key technologies related to magnetic heads, storage density, reliability, equalization, detection, and encoding/decoding.
  - Research Impact: Based on PMR+TDMR magnetic recording technology, this study provides prototype/commercially viable HDD algorithms with industry-competitive performance, along with floating-point algorithm simulation code development, supporting prototype system development and validation.

Publications and Patents

[1] Chuanbo Zhu, Chao Sun, Yifan Liu, Jincai Chen*, and **Ke Luo***, "Enhancing speech emotion recognition with speech dynamic modeling and multi-modal knowledge distillation," in *2025 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 2025.

[2] Yifan Liu, **Ke Luo***, and Jincai Chen, "Multi-modal image reflection removal with prior knowledge of reflection structure inconsistency," in *The 10th IEEE International Conference on Data Science and Systems (DSS 2024)*, 2024.

[3] **Ke Luo**, Yanzhe Liao, Kezheng Zhang, Yugen Jian, Shaobing Wang, Jincai Chen*, and Ping Lu, "On the impact of interlayer misalignment for dual-layer data detection in three dimensional magnetic recording," *Journal of Magnetism and Magnetic Materials*, vol. 610, p. 172 522, 2024.

[4] **Ke Luo**, Kezheng Zhang, Yufei Wu, Yanzhe Liao, Hongyu Gao, Wei Li, Yugen Jian, Ziqian Liu, Yuqian Zhao, Jincai Chen*, Ping Lu, and Shaobing Wang, "The compatible partial response maximum likelihood detection schemes for blu-ray discs," in *2024 21st International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*, 2024, pp. 1–5. DOI: 10.1109/ECTI-CON60892.2024.10594973.

[5] Yanzhe Liao, Kezheng Zhang, Yugen Jian, Shaobing Wang, Jincai Chen, Ping Lu, and **Ke Luo***, "Decision-Feedback Single-Layer Read Reconstruction and Separation for Three-dimensional Magnetic Recording," in *2024 IEEE International Magnetics Conference (INTERMAG)*, Rio de Janeiro, Brazil, May 2024, pp. 1–2.

[6] **Ke Luo**, Yufei Wu, Yanzhe Liao, Shaobing Wang, Yugen Jian, Jincai Chen*, and Ping Lu, "Quaternary Neural Network Equalization for Three-Dimensional Magnetic Recording," in *2024 IEEE International Magnetics Conference (INTERMAG)*, Rio de Janeiro, Brazil, May 2024, pp. 1–2.

[7] **Ke Luo**, Yugen Jian, Yanzhe Liao, Kezheng Zhang, Jincai Chen*, and Ping Lu, "A Graded Precompensation Scheme by Pattern Classification on Nonlinear Transition Shift for Perpendicular Magnetic Recording," *IEEE Transactions on Magnetics*, vol. 59, no. 8, pp. 1–6, 2023. DOI: 10.1109/TMAG.2023.3288371.

[8] Yugen Jian, **Ke Luo**, Wei Li, Vitaliy Lomakin, Jincai Chen*, and Ping Lu, "Pattern Constraints Limiting Nonlinear Transition Shift in High Density Magnetic Recording," *Journal of Magnetism and Magnetic Materials*, vol. 588, p. 171 370, 2023. DOI: https://doi.org/10.1016/j.jmmm.2023.171370.

[9] Wei Chen, Jincai Chen*, Zongsong Gan, Yaxiong Ma, **Ke Luo**, Zhenxing Huang, Yang He, and Ping Lu, "A Simple and Effective Semi-Circle Resonator System for Bit-Patterned HAMR," *Physics Letters A*, vol. 391, p. 127 129, 2021. DOI: https://doi.org/10.1016/j.physleta.2020.127129.

[10] **Ke Luo**, Shaobing Wang, Guoqiang Xie, Wei Chen, Jincai Chen*, Ping Lu, and Weiming Cheng, "Read Channel Modeling and Neural Network Block Predictor for Two-Dimensional Magnetic Recording," *IEEE Transactions on Magnetics*, vol. 56, no. 1, pp. 1–5, 2020. DOI: 10.1109/TMAG.2019.2950704.

[11] Wei Chen, Jincai Chen*, Zongsong Gan, **Ke Luo**, Zhenxing Huang, and Ping Lu, "High-Field Enhancement of Plasmonics Antenna Using Ring Resonator for HAMR," *IEEE Transactions on Magnetics*, vol. 56, no. 7, pp. 1–5, 2020. DOI: 10.1109/TMAG.2020.2990525.

[12] **Ke Luo**, Shaobing Wang, Kheong Sann Chan, Wei Chen, Jincai Chen*, Ping Lu, and Weiming Cheng, "A Study on Block-Based Neural Network Equalization in TDMR System With LDPC Coding," *IEEE Transactions on Magnetics*, vol. 55, no. 11, pp. 1–5, 2019. DOI: 10.1109/TMAG.2019.2931760.

[13] **Ke Luo**, Shaobing Wang, Kheong Sann Chan, Wei Chen, Jincai Chen*, Ping Lu, and Weiming Cheng, "A Study on Block-Based Neural Network Equalization in TDMR System with LDPC Coding," in *The 30th Magnetic Recording Conference (TMRC 2019)*, Minneapolis, UM, USA, Jul. 2019, pp. 1–2.

[14] Shaobing Wang, Jincai Chen*, **Ke Luo**, Guoqiang Xie, Ping Lu, and Weiming Cheng, "Performance Evaluation of Four-Reader Array Detection for Two-Dimensional Magnetic Recording," *Science of Advanced Materials*, vol. 11, no. 6, pp. 835–841, Jun. 2019.

[15] Shaobing Wang, Jincai Chen*, **Ke Luo**, Guoqiang Xie, Ping Lu, and Weiming Cheng, "Joint Four-Reader Array Equalization and Detection for a Single Track in TDMR," *IEEE Transactions on Magnetics*, vol. 55, no. 12, pp. 1–6, 2019. DOI: 10.1109/TMAG.2019.2936181.

[16] Guoqiang Xie, **Ke Luo**, Shaobing Wang, Ping Lu, Weiming Cheng, and Jincai Chen*, "Rounded Corner Effect on Write Performance for Shingled Magnetic Recording System," in *2018 Asia-Pacific Magnetic Recording Conference (APMRC)*, USST, China, Nov. 2018, pp. 1–2. DOI: 10.1109/APMRC.2018.8601116.

[17] **Ke Luo**, Shaobing Wang, Guoqiang Xie, Jincai Chen*, Ping Lu, and Weiming Cheng, "Read Channel Modeling and Neural Network Block Predictor for TDMR," in *2018 Asia-Pacific Magnetic Recording Conference (APMRC)*, USST, China, Nov. 2018, pp. 1–2. DOI: 10.1109/APMRC.2018.8601082.

[18] Shaobing Wang, Jincai Chen*, **Ke Luo**, Ping Lu, and Weiming Cheng, "Four-Reader Array Detection for Two-Dimensional Magnetic Recording," in *2018 Asia-Pacific Magnetic Recording Conference (APMRC)*, USST, China, Nov. 2018, pp. 1–2. DOI: 10.1109/APMRC.2018.8601111.

[19] Jincai Chen, Guoqiang Xie, **Ke Luo**, Weiming Cheng, Ping Lu, and Yao Wang*, "Study of Erase Band and Write Performance in Shingled Mag-netic Recording with Exchanged Coupled Composite Media," in *2018 IEEE International Magnetics Conference (INTERMAG)*, Singapore, Apr. 2018, pp. 1–1. DOI: 10.1109/INTMAG.2018.8508564.

[20] Jincai Chen, Guoqiang Xie, **Ke Luo**, Shaobing Wang, Ping Lu, and Yao Wang*, "Study of Erase Band and Write Performance for Shingled Magnetic Recording With FePt-Based Exchanged Coupled Composite Media," *IEEE Transactions on Magnetics*, vol. 54, no. 11, pp. 1–6, 2018. DOI: 10.1109/TMAG.2018.2829848.

[21] **Ke Luo**, Yufei Wu, Jincai Chen, Ping Lu, Kezheng Zhang, Yanzhe Liao, and Yuegn Jian, *A method for detecting readback signal sample sequences in optical disc data reading process*, National Invention Patent of China, to be authorized, 2025.

[22] **Ke Luo**, Kezheng Zhang, Yugen Jian, Wei Li, Yanzhe Liao, Yufei Wu, Hongyu Gao, Jincai Chen, and Ping Lu, *A Classification Compensation Method for Non-Linear Transition Shift in the Process of Disk Data Writing*, National Invention Patent of China, CN 117059134 A, Nov. 2023.

[23] Jincai Chen, **Ke Luo**, Ping Lu, Zongsong Gan, Shaobing Wang, Wei Chen, Xing Liu, and Jinxing Bao, *Two-Dimensional Channel Equalization Model Training Method and Two-Dimensional Channel Equalization Methods*, National Invention Patent of China, CN 110211611 B, 2019.