IEEE 信息论学会广州分会季报

IEEE INFORMATION THEORY SOCIETY
GUANGZHOU CHAPTER NEWSLETTER

第十期, 2024 年 9 月 No. 10, Sept. 2024

主编序语

各位学者：

本期《分会季报》介绍了在参数空间约束下的极大-极小参数估计误差，为求解通信和机器学习中的问题提供了新方法；和基于重编码变换的代数几何码列表译码，为更高效的数字通信与存储提供新技术。7 月 7 – 12 日，2024 年 IEEE 国际信息论年会在希腊雅典盛大召开，华人学者成绩喜人；7 月 20 – 21 日，2024 年港-穗-台人工智能、通信与信息论联合研讨会在香港城市大学举办，两岸三地的信息论学者分享了最新研究进展、增强友谊，共筑信息论基础研究、探索交叉前沿。

陈立

From the Editor-in-Chief

Dear Chapter Members,

This issue introduces the characterization of minimax parameter estimation in restricted parameter space, offering a new method for solving some problems in communications and machine learning. This issue also introduces the re-encoding transform for algebraic list decoding of algebraic-geometric codes, providing a new technology for realizing more efficient data communications and storage. On Jul. 7 - 12, the 2024 IEEE International Symposium on Information Theory took place in Athens, Greece. Achievements of Chinese scholars are encouraging. On Jul. 20 - 21, the 2024 Hong Kong-Guangzhou-Taipei Joint Workshop on Artificial Intelligence, Communications and Information Theory took place at the City University of Hong Kong. Scholars across the straight shared their latest research work and strengthened their friendships. Together, they solidified the fundamental research of information theory and explored the cross-disciplinary frontiers.

Li Chen

来稿请包含中英文题目、联系人、联系方式、拟投稿栏目，正文可以是中文或英文，不超过800字。
The submission should include the title in both Chinese and English, author contacts, and the column that the article belongs to. Content of the article can be both in Chinese or English, and is limited to 800 words.

投稿邮箱/Submission email：
itguangzhou@163.com

目录 •Table of Contents •

最新结果 • RECENT RESULTS •

参数空间约束下极小-极大参数估计误差的二阶刻画
Second-Order Characterization of Minimax Parameter Estimation in Restricted Parameter Space

彭天任，童鑫熠，黄绍伦
清华大学深圳国际研究生院
Tianren Peng, Xinyi Tong, and Shao-Lun Huang
Tsinghua Shenzhen International Graduate School
ptr22@mails.tsinghua.edu.cn; txy18@mails.tsinghua.edu.cn; twn2gold@gmail.com

Estimating unknown parameters in restricted parameter space is an important problem with applications in communication, statistics, and machine learning. Mathematically, the estimation problem can be generally formulated as solving for $\hat{\theta}$ in

$$\inf_{\hat{\theta}:\mathcal{X}^n\mapsto\mathbb{R}} \max_{\theta\in[\alpha,\beta]} \mathbb{E}\left[\left(\hat{\theta}\left(\mathbf{X}\right)-\theta\right)^2\right], \tag{1}$$

where $\mathbf{X}$ is the random vector corresponding to n samples i.i.d. drawn from the parametrized distribution $P(x;\theta)$, $x\in\mathcal{X}$.

The formulation (1) includes several widely studied problems as its special cases. For example, when the model $P(x;\theta)$ is the Gaussian distribution $\mathcal{N}(\theta,\sigma^2)$, and $[\alpha,\beta]=[-D,D]$, the formulation (1) is reduced to the famous bounded normal mean estimation problem [1], which addresses the signal detection problem in AWGN channel with peak power constraint. When the model $P(x;\theta)$ is the Bernoulli distribution $\mathsf{Bern}(\theta)$, and $[\alpha,\beta]=[0,1]$, the formulation (1) is reduced to the worst-case distribution estimation problem considered in [2], [3]. Moreover, the problem (1) can also be viewed as designing robust estimators for transfer learning. To see that, consider the transfer learning setup, where the source and target models are $P(x;\theta_S)$ and $P(x;\theta_T)$, with the training samples i.i.d. drawn from $P(x;\theta_S)$ and $P(x;\theta_T)$, respectively. The goal is to learn the parameter θ_T from all the samples. In practice, the source task can often be learned well, and it is assumed that the source and target tasks are similar, so that the samples from the source task can be beneficial. Therefore, if we assume θ_S is perfectly learned from the source task, and formulate the similarity assumption as a bounded constraint $|\theta_T-\theta_S|\le D$, then a minimax problem for transfer learning can be formulated as [4]:

$$\inf_{\hat{\theta}:\mathcal{X}^n\mapsto\mathbb{R}} \max_{\theta\in[\theta_S-D,\theta_S+D]} \mathbb{E}\left[\left(\hat{\theta}\left(\mathbf{X}\right)-\theta_T\right)^2\right],$$

whose solution leads to robust transfer learning algorithms.

In this work, we investigate the minimax risk of (1), i.e.

$$r_n^*(\alpha,\beta)\triangleq \inf_{\hat{\theta}:\mathcal{X}^n\mapsto\mathbb{R}} \max_{\theta\in[\alpha,\beta]} \mathbb{E}\left[\left(\hat{\theta}\left(\mathbf{X}\right)-\theta\right)^2\right].$$

Assuming the efficient estimator $\hat{\theta}^*(\mathrm{x})$ based on $\mathrm{x} \sim P(x;\theta)$ exists, we demonstrate that the minimax risk $r_n^*(\alpha,\beta)$ is related to a minimax ordinary differential equation (ODE) of the bias function of the estimator $\hat{\theta}(\mathbf{X})$, based in the following lemma.

Lemma. The MSE of estimating θ based on $\hat{\theta}(\mathbf{x}) \triangleq \frac{1}{n}\sum_{i=1}^{n}\hat{\theta}^*(\mathrm{x}_i) + \psi(\mathbf{x})$ is given by

$$\mathbb{E}\left[\left(\hat{\theta}(\mathbf{X})-\theta\right)^2\right] = \frac{1}{nJ(\theta)} + b^2(\theta) + \frac{2b'(\theta)}{nJ(\theta)} + \mathrm{var}\left(\psi(\mathbf{X})\right),$$

where $b(\theta) \triangleq \mathbb{E}\left[\hat{\theta}(\mathbf{X})\right]-\theta$. Then the minimax risk $r_n^*(\alpha,\beta)$ is related to the value of

$$\tilde{r}^*(\alpha,\beta) \triangleq \inf_{b(\theta)} \max_{\theta\in[\alpha,\beta]} \frac{1}{nJ(\theta)} + b^2(\theta) + \frac{2b'(\theta)}{nJ(\theta)}. \tag{2}$$

With this observation, we show that for parametrized model $P(x;\theta)$ satisfying certain regular and singular conditions, the second-order convergence rate of $r_n^*(\alpha,\beta)$ is related to the local flatness of $J(\theta)$ around its global minimum. as described in **Theorem 1**

Definition 1. The degree d of $J(\theta)$ is defined as the minimal $k \geq 1$, such that the k-th order derivative $\frac{\mathrm{d}^k J(\theta^*)}{\mathrm{d}\theta^k} \neq 0$, when $\{\theta : J(\theta) = J^*\}$ is a single point, where $J^* \triangleq \min_{\theta\in[\alpha,\beta]} J(\theta)$, and $d = \infty$, when $\{\theta : J(\theta) = J^*\}$ is a subinterval of $[\alpha,\beta]$.

Theorem 1. Suppose that the model $P(x;\theta)$ is efficient and singular, then

$$r_n^*(\alpha,\beta) = \frac{1}{nJ^*} - \Theta\left(n^{-\frac{2d+2}{d+2}}\right),$$

where $J^* \triangleq \min_{\theta\in[\alpha,\beta]} J(\theta)$ and d are as defined in **Definition 1**.

To assist the comprehension of the theorem, we illustrate the minimax solution as follows:

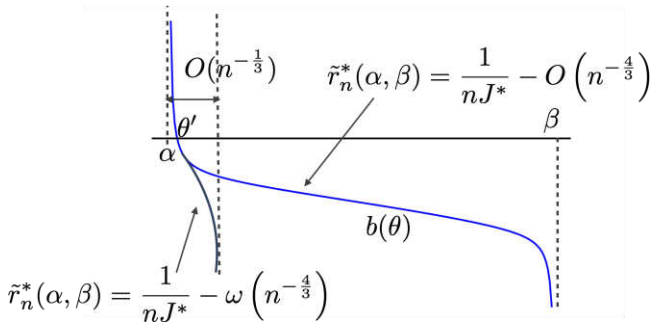


Fig. 1 the bias function $b(\theta)$ achieving $\tilde{r}^*(\alpha,\beta)$ where $d=1$ and $\theta^*=\alpha$.

As illustrated in **Fig. 1**, if the second-order term of $\tilde{r}^*(\alpha,\beta)$ is in the order of $\omega\left(n^{-\frac{4}{3}}\right)$, the derivative of $b(\theta)$ from the RHS of (2) will be too sharp, so that the function $b(\theta)$ will blow up in the interval

$\left[\alpha, \alpha + O\left(n^{-\frac{1}{3}}\right)\right]$, while the order of the second-order term in **Theorem 1** guarantees that the bias function can be well defined in the whole interval $[\alpha, \beta]$.

Experiments have also been done for some α and β, which are demonstrated in **Fig. 2**.

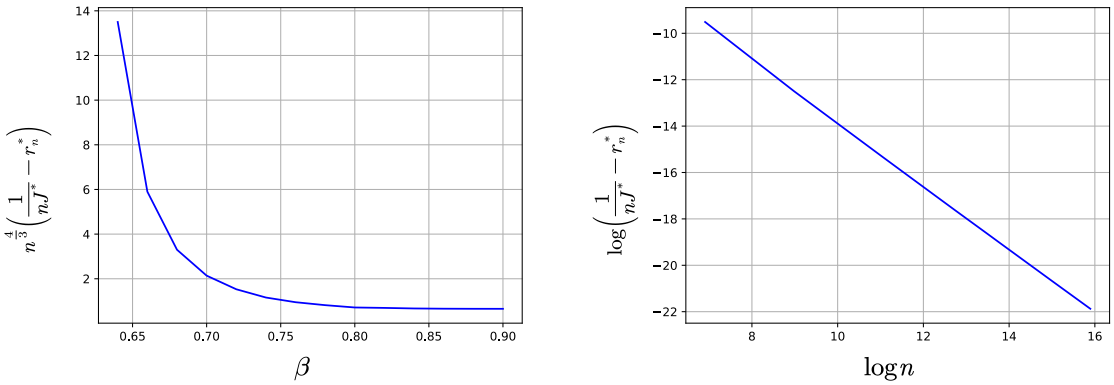


Fig. 2 (left) The coefficient of second-order term for $\alpha = 0.6$ and different values of β; (right) The log-plot of the second-order term of the risk with respect to n for $\alpha = 0.6$ and $\beta = 0.8$, where the slope is $-\frac{4}{3}$.

References:

[1] J. Berry, Minimax estimation of a bounded normal mean vector, *J. Multivar. Anal.*, vol. 35, no. 1, pp. 130-139, 1990.

[2] J. Hodges, E. Lehmann, Some problems in minimax point estimation, *AMS*, vol. 21, pp. 15-30, 1950.

[3] S. Kamath, A. Orlitsky, D. Pichapati, A. Suresh, On learning distributions from their samples, *Ann. Conf. Computational Learn. Theory*, 2015.

[4] P. Bickel, Minimax estimation of the mean of a normal distribution when the parameter space is restricted, *Ann. Stat.*, vol. 9, no. 6, pp. 1301-1309, 1981.

最新结果 • RECENT RESULTS •

基于重编码变换的代数几何码列表译码
The Re-encoding Transform in Algebraic List Decoding of Algebraic Geometric Codes

万韫琦，邢炯跃，黄羽亮，吴庭伊，白铂，张弓
华为技术有限公司 2012实验室 理论研究部
Yunqi Wan, Jiongyue Xing, Yuliang Huang, Tingyi Wu, Bo Bai and Gong Zhang
Theory Lab, 2012 Labs, Huawei Technology Co. Ltd.
wanyunqi@huawei.com

Algebraic geometric (AG) codes gained prominence when Tsfasman, Vladuts, and Zink [1] demonstrated that infinite families of such codes can surpass the Gilbert-Varshamov bound. A significant advancement towards practical applications occurred when Justesen et al. [2] developed an efficient decoding algorithm for a special class of curves. Since then, numerous curves have been proposed and investigated for constructing AG codes. These decoding algorithms can correct any AG code errors exceeding half its designed minimum distance, and ongoing improvements continue to enhance their implementation. However, the high decoding complexity still hinders the practical application of AG codes. In 2020, Huawei reignited interest in AG codes by proposing ten mathematical challenges for the information industry in the post-Shannon era, once again bringing the decoding problem of algebraic geometric codes into the spotlight and spurring further research.

In this paper [5], we propose an optimized decoding technique for AG codes called re-encoding transform (ReT). This technique, originally devised by Kötter and Vardy [3] to reduce the complexity of the Guruswami–Sudan decoding of Reed-Solomon codes, involves "replacing n with $n-k$ in the complexity estimate." By adding a codeword to the received word before decoding, at least k positions are forced to zero, simplifying the decoding process for the original word. However, due to the influence of the curve genus, the re-encoding polynomial for AG codes cannot be directly constructed, limiting the application of this technique to AG codes. Wan et al. [4] extended the ReT to a special class of AG codes, elliptical codes, achieving the same complexity reduction as [3] with only a slight loss of genus.

This paper proposes the ReT based module basis reduction (BR) interpolation for a special class of AG codes which are constructed from the so-called C_{ab} curves

$$E(X,Y) = Y^a + \sum_{ai+bj<ab} c_{ij} X^i Y^j + cX^b$$

where $gcd(a,\ b) = 1$ and $c \neq 0$. This type of AG code possesses a regular algebraic structure, making it easy to implement in hardware. Two ReT methods are proposed to transform the received word and reduce the interpolation complexity. The first one is realized by the bivariate Lagrange polynomial over algebraic function field, while the second one is conducted based on the ReT of Reed-Solomon codes by transforming AG codes into the interleaved Reed-Solomon codes. Afterwards, the ReT based module BR interpolation of AG codes, including the basis construction and reduction, is proposed. Complexity analysis indicates that ReT provides a constant reduction, which is more pronounced for codes with high rates and can be significant for practical parameters. This method is particularly effective in soft-decision decoding, as it can eliminate positions with the highest computational cost.

Tables I and II show the numerical results of the BR interpolation and the ReT-BR interpolation

in decoding the (512, 409) Hermitian code, respectively. Note that the ReT is performed by method 1 and its complexity has been counted in the basis construction. The results demonstrate that ReT-BR interpolation is less complex than its non-ReT counterpart, with the complexity advantage increasing as the interpolation multiplicity m rises.

Table 1. The BR interpolation complexity in decoding the (512, 409) Hermitian code

m	2	4	6
Construction	$5.17 * 10^5$	$1.72 * 10^6$	$3.65 * 10^6$
Reduction	$4.23 * 10^6$	$9.60 * 10^7$	$7.41 * 10^8$
Interpolation	$4.75 * 10^6$	$9.78 * 10^7$	$7.44 * 10^8$

Table 2. The RET-BR interpolation complexity in decoding the (512, 409) Hermitian code

m	2	4	6
Construction	$8.72 * 10^5$	$9.82 * 10^5$	$1.18 * 10^6$
Reduction	$1.85 * 10^6$	$4.01 * 10^7$	$2.51 * 10^8$
Interpolation	$2.72 * 10^6$	$4.11 * 10^7$	$2.52 * 10^8$

References:

[1] M. Tsfasman, et al., Modular curves, Shimura curves, and Goppa codes, better than Varshamov–Gilbert bound, *Math. Nachrichtentech*, vol. 109, pp. 21-28, 1982.

[2] J. Justesen, et al. Construction and decoding of a class of algebraic geometry codes, *IEEE Trans. Inf. Theory*, 35.4, 811-821, 1989.

[3] R. Kotter and A. Vardy, A complexity reducing transformation in algebraic list decoding of Reed-Solomon codes, *in Proc. IEEE Inf. Theory Wkshp*, Paris, France, pp. 10-13, 2003.

[4] Y. Wan, L. Chen, and F. Zhang, Guruswami-Sudan decoding of elliptic codes through module basis reduction, *IEEE Trans. Inf. Theory*, vol. 67, no. 11, pp. 7197-7209, 2021.

[5] Y. Wan, J. Xing, Y. Huang, et al. The re-encoding transform in algebraic list decoding of algebraic geometric codes, *in Proc. IEEE Int. Symp. Inf. Theory*, pp. 19-24, 2023.

交流活动 • RESEARCH ACTIVITIES •

广州分会春茗活动
Spring Outing of IEEE IT Society Guangzhou Chapter

3 月 27 日，IEEE 信息论学会广州分会(以下称“广州分会”)一年一度的春茗活动在广州国际生物岛举行。中山大学电子与信息工程学院、广州分会主席陈立教授，广州科奥信息技术有限公司(以下称“广州科奥”)刘国兴董事长，华为技术有限公司 2012 无线技术实验室执行主任卢建民主任、广州高校合作部钟建伟主任，广州大学电子与通信工程学院陈庆春教授，华南理工大学电子与信息学院周智恒教授等专家学者出席活动。本次活动回顾了广州分会的成长和发展历程，介绍了最新的分会组织架构，汇报了 ITW 2024 和 ISIT2026 筹办情况，探讨 2024 年度工作计划以及分享最新学术工作等。

活动开始，陈立教授邀请了西安电子科技大学、中国电子学会信息论分会主任委员白宝明教授在线上做开场致辞。随后由清华大学深圳国际研究生院、广州分会副主席夏树涛教授和广东工业大学信息工程学院、广州分会副主席韩国军教授在线上做欢迎致辞。到场嘉宾卢建民主任对广州分会的工作表示赞赏与祝贺，指出 ISIT 2026 在广州的举办将是中国信息论学群发展的一个契机，并期待且支持中国信息论学群取得更大的成绩。刘国兴董事长也进一步表达自身对国内学术行业发展的憧憬，并会尽全力服务学术交流活动，让广州科奥成为独树一帜的学术服务企业走向世界。

在随后的活动中，陈立教授向与会者们介绍了广州分会成立的宗旨 — “促进交流、服务学群”，以及自 2019 年成立以来所开展过的学术交流活动。紧接着分享了 ISIT 2026 的筹备工作，以及各组委会专委的任务和时间截点。来自清华大学深圳国际研究生院的黄绍伦教授也在此分享了 ITW 2024 的筹办工作，并邀请各位赴深圳一同参与此次盛会。

最后，周智恒教授带来的学术报告《数据有限与算力有限问题的研究》，对数据的选择到算法的优化，再到模型的训练以及最新研究成果都做了详细的介绍。研究涵盖了图像处理、分析和模式识别等当前的热点与难题，具有丰富的学术价值和实用前景。




分享活动结束后，广州科奥代表吴焕联总监带领广州分会成员们在生物岛进行徒步活动。步履轻盈间，默契已心生。合作如金石，携手赴新程。再一次感谢广州科奥为广州分会活动提供的大力支持，通过多年的交流与合作，双方就未来共同承办 ISIT 2026 达成了共识。

交流活动 • RESEARCH ACTIVITIES •

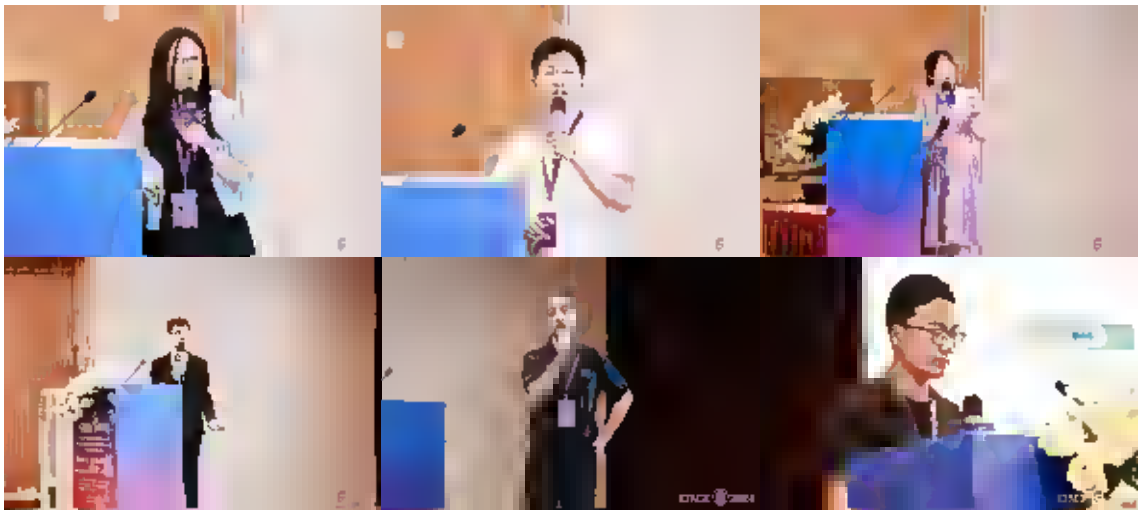
第六届通信、信息系统与计算机工程国际会议
The 6th International Conference on Communications, Information System and Computer Engineering

2024 年 5 月 11 日，由 IEEE 信息论学会广州分会(广州分会)、广东工业大学信息工程学院主办，福州大学、四川师范大学、西南民族大学协办，AEIC 学术交流中心承办的第六届通信、信息系统与计算机工程国际会议(CISCE 2024)在羊城广州顺利召开。本次会议采用了线上线下相结合的模式，成功跨越地域界限，线下吸引了近百位国内外知名专家及学者共聚一堂，线上参会及直播观看人数则超过了 2500 人次，专家学者们就通信、信息系统与计算机工程领域的最新研究成果进行了深入交流与探讨。

广州分会主席、中山大学陈立教授主持开幕式并作为大会主席致开幕词，热情地向与会者们介绍了学会的相关信息，并预祝本次大会取得圆满成功。同时，广州分会副主席、广东工业大学韩国军教授代表主办方向远道而来的各位嘉宾与学者致以了最诚挚和热烈的欢迎，寄望通过本次会议促进领域内的知识共享与创新合作。

大会进入主讲报告环节，亮点纷呈。来自希腊雅典国立卡波蒂斯坦大学的 P. Takis Mathiopoulos 教授，IEEE Fellow、美国内华达大学的 Shahram Latifi 教授，IET Fellow、西交利物浦大学的岳勇教授，中山大学的陈立教授，广东工业大学的韩国军教授，华南农业大学的吴伟斌教授，IEEE Fellow、香港科技大学的 Tin-Yau Kwok 教授等依次报告，就通信技术的未来趋势、信息系统安全、计算机工程的最新进展等核心议题，展开了高水准的演讲。现场互动频繁，提问环节更是激发了与会者对专业领域的深度思考。

此外，口头报告部分同样精彩纷呈，来自广东外语外贸大学、大连交通大学、吉首大学、江西理工大学等多所国内高校的学者分享了他们的最新研究成果。这些报告不仅展示了中国在通信与计算机科学领域的快速发展，还促进了参会者之间的思想碰撞，为未来潜在的跨校合作奠定了坚实的基础。



大会最后设立了评优环节，经严格评审，共 3 位杰出学者脱颖而出，分别荣获优秀论文奖、优秀青年学者报告奖和优秀海报奖各 1 名。这些奖项不仅是对获奖者学术贡献的高度认可，更是对全体参会者持续创新、勇攀科研高峰的激励。

第六届通信、信息系统与计算机工程国际会议(CISCE 2024)在广州的成功举办，不仅加深了国内外学者在通信、信息系统与计算机工程领域的相互了解，也为促进全球科研合作、推动技术创新提供了宝贵的平台。随着会议的圆满落幕，各方参与者均表示收获颇丰，期待广州分会在未来能够提供更多类似的交流机会，共同推动科技进步，为社会的发展贡献力量。

交流活动 • RESEARCH ACTIVITIES •

中山大学信息编码与智能传输实验室 2024 研讨会
2024 Seminar of Information Coding and Intelligent Transmission (ICIT) Lab at SYSU

中山大学信息编码与智能传输实验室的年度分享会于 5 月 12 日在中山大学东校园举办，由陈立教授主持，实验室的 2 名博士研究生和 6 名硕士研究生做工作汇报，10 余名大三本科生参会听取报告并做交流。此次汇报目的为开阔本科生对信息论与编码的见识，提升研究生们成果展示与演讲能力，是实验室全方位培养青年人才的重要举措。

研讨会分两个环节，第一环节为应届毕业生做毕业答辩预演，总结研究生阶段的科研工作以及成果。第一个工作《U-UV 码的低复杂度 SCL 译码》由陈文浩展示，其相关研究工作已发表于 TSP、TCOM 等国际期刊及国际会议；第二个工作《改进 PAC 码的编译码设计与分析》由蔡作鑫汇报，其工作曾被 ISIT 2023 大会接收并受邀至台湾做分组汇报；第三个工作《椭圆码的高效编译码算法》由赵建国汇报，其工作已多次被 ISIT 大会接收。

研讨会第二环节由研一学生何昕政开启，给本科生们讲解《Coded Chase 译码方法及其性能分析》；随后博三学生梁积卫进一步介绍 Chase 译码的工作《Reed-Solomon 码的部分并行化低复杂度 Chase 译码》；第五个报告为《OSD 的迭代基更新算法》，由研二李锡浩同学展示；第六个报告为《极化码的自适应置信传播译码算法》，由博二学生杨忠骏带来；最后一个工作《循环码的移加译码》由研一学生林敬禹带来，该工作已由 2020 级毕业生邢炯跃博士于今年发表于 *IEEE Transactions on Information Theory*。

此次研讨会给本科生们展示了实验室最主要的信道编译码工作及未来科研工作的聚焦点，让本科生们感受到了未来通信网络技术或许就在身边。

交流活动 • RESEARCH ACTIVITIES •

讲座：混合广义衰落信道下的双跳 AF 中继通信系统
Lecture on Dual-Hop AF Relaying Communication Systems over Mixed Generalized Fading Channels

On May 13 morning, Professor Takis Mathiopoulos gave a lecture on Dual-Hop AF Relaying Communication Systems over Mixed Generalized Fading Channels at the east campus of Sun Yat-sen University (SYSU), Guangzhou, China. This lecture was sponsored by IEEE Information Theory Guangzhou (ITGZ) Chapter and the School of Electronics and Information Technology (SEIT) of SYSU. Professor Takis Mathiopoulos is a professor of Telecommunications at the Department of Informatics and Telecommunications, National and Kapodistrian University of Athens (NKUA), Athens, Greece. In 1989, he joined the Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, Canada, as an Assistant Professor and where he was a faculty member until 2003, holding the rank of Professor from 2000 to 2003. From 2000 to 2014, he was the Director (2000 - 2004) and then the Director of Research of the Institute for Space Applications and Remote Sensing, National Observatory of Athens. He also held visiting faculty long term honorary academic appointments as Guest Professor at Southwest Jiao Tong University, Chengdu, China, and Guest (Global) Professor at Keio University, Tokyo, Japan.

Professor Takis Mathiopoulos started his lecture from an introduction of NKUA's history. It was originally named the University of Athens and was the first university not only in the newly formed Greek state, but also in the Balkans and the Eastern Mediterranean region. In 1932, the University was renamed the National and Kapodistrian University of Athens, in honor of Ioannis Kapodistrias, a Greek statesman who served as the first Governor of Greece after its independence.

Here is the abstract of the lecture: The end-to-end performance of a dual-hop amplify-and-forward (AF) relaying communication system where the source-to-relay and the relay-to-destination channels are subject to different fading conditions. We consider the case of mixed generalized fading channels where the one hop's channel is subject to η-μ fading while the other one is subject to κ-μ fading. This mixed fading propagation channel is capable of accurately modeling various practical dual-hop transmissions. Examples of such environments are encountered in micro/macro cellular systems and/or hybrid satellite/terrestrial wireless communication systems, where typically only the one hop's channel has a line-of-sight component. For both CSI-assisted and fixed gain relaying and for integer-valued fading parameters, exact analytical expressions in the form of rapidly convergent infinite series for the

outage probability (OP) and average bit error probability (ABEP) of several modulation schemes are derived. Moreover, for CSI-assisted relaying and arbitrary-valued fading parameters, closed-form lower bounds (tight for high values of the signal-to-noise) for the OP and ABEP performance are obtained. The analysis is also substantiated by obtaining previously published equivalent performance expressions as special cases of our generalized fading models, namely those available for Nakagami-m and Rice fading channels.

After the lecture, Professor Li Chen, chair of the ITGZ Chapter presented a souvenir of SYSU to Professor Takis Mathiopoulos and went on a tour of the SYSU campus.

交流活动 • RESEARCH ACTIVITIES •

IEEE 信息论学会杰出讲座 - 选择性学习问题中的信息度量
IEEE ITSoc Distinguished Lecture - Information Measures in Selected Learning Problems

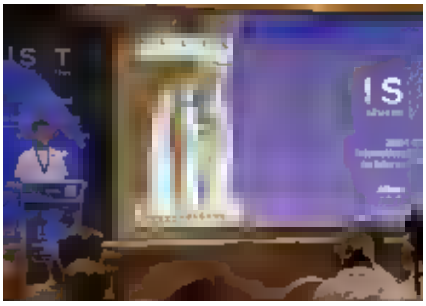
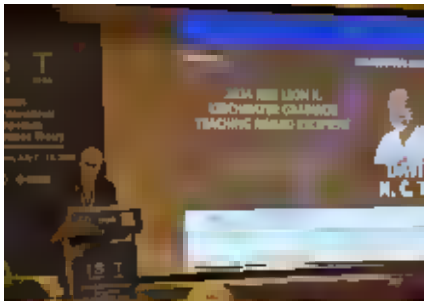
On June 07, 2024, Professor Chao Tian visited Guangzhou and gave an IEEE Information Theory Society (ITSoc) Distinguished Lecture on Information Measures in Selected Learning Problems. This visit took place as a part of his tour as a Distinguished Lecturer of ITSoc for 2023-2024. Chao is an Associate Professor in the Department of Electrical and Computer Engineering at Texas A&M University and was awarded the Society's Distinguished Lecturer. He had also been an Associate Editor for the IEEE Signal Processing Letters, IEEE Transactions on Communications and IEEE Transactions on Information Theory. He serves as a General Co-chair of 2024 IEEE Information Theory Workshop at Shenzhen, China. This lecturer was hosted by ITSoc Guangzhou Chapter.

The lecture was moderated by Professor Li Chen, Chair of the Guangzhou Chapter. Li gave an opening speech introducing Chao and welcoming all attendees. This lecture presented new results on three problems in selected learning: 1) the study of multi-armed bandits when there exists heterogeneity in the reward variances; 2) policy optimization for Markov decision process with multiple reward functions; and 3) the study of machine learning generalization error bounds. The results show that the information measures can also naturally capture the effects in learning theory and algorithms that are not directly related to information storage and communications. Chao pointed out that they may play pivotal roles in the study of machine learning algorithms in the future.

In summary, machine learning is a rapidly developing research area that holds great promise. However, there are still many technical challenges that we need to address before we can fully realize its potential. We shall collaborate to work, to exchange on any inspirations raising in mind, and to explore more possibilities.

交流活动 • RESEARCH ACTIVITIES •

2024 IEEE 雅典国际信息论年会
2024 IEEE International Symposium on Information Theory (ISIT) in Athens


2024 年 7 月 7 至 12 日，IEEE 国际信息论年会(ISIT 2024)在希腊雅典洲际酒店盛大召开。此次年会吸引了来自全球各地的信息论顶尖学者和行业专家近千人，共同探讨信息论领域的最新进展与未来趋势。此次会议选址希腊雅典，不仅为参会者提供了丰富的学术交流平台，还让他们有机会领略古希腊文明的魅力。

ISIT 2024 一如既往，设置有主旨报告、分组口头报告、工业论坛以及多项学会活动等。值得一提的是，本次大会还首次增设了 5 个领航研讨会(Pilot Workshops)：Coding Theory and Algorithms for DNA-based Data Storage, Information-Theoretic Methods for Trustworthy Machine Learning (IT-TML), Learn to Compress, NeurIT - Information Theory in Neuroscience and Neuroengineering, Quantum Information Knowledge (QuIK)，聚焦信息论和量子信息、DNA 存储、机器学习等新兴领域的交叉研究。本届 ISIT 程序册共收录了 632 篇论文，呈现了信息论领域最新的研究成果和应用进展，为参会者提供了宝贵的学习机会。其中，据 IEEE 信息论学会广州分会统计，华人作为第一作者的文章高达 218 篇，占据三分之一以上。

期间，2017 年香农奖得主谢雅正(David Tse)教授获颁 IEEE Leon K. Kirchmayer 研究生教学奖，如学会指出“for inspirational mentoring and contributions to graduate teaching in wireless communication, power systems, computational biology, and blockchains”，这是对谢雅正教授在信息论研究生教育方面所做杰出工作的充分肯定。

华人学者加拿大多伦多大学郁炜(Wei Yu)教授与学生 Justin Singh Kang 于 2021 年发表在 *Trans. Inf. Theory* 的文章《Minimum Feedback for Collision-Free Scheduling in Massive Random Access》获颁 IEEE 信息论学会(ITSoc)和通信学会(ComSoc)联合论文奖。

山东大学网络空间安全学院博士研究生李国栋的论文《MSR Codes with Linear Field Size and Smallest Sub-Packetization for Any Number of Helper Nodes》荣获 IEEE Jack Keil Wolf ISIT 学生论文奖。

随着信息技术的飞速发展，信息论作为数字信息技术的基础理论，重要性日益凸显。ISIT 2024 的成功举办促进了全球信息论学者的交流与合作，更推动了信息论研究的进步。值得期待的是，今年的 IEEE 信息论研讨会(ITW 2024)将于 11 月 24 至 28 日在中国深圳举办，将为我国学者提供一个便捷的国际学术交流平台。同样值得期待的是，ISIT 2026 将第一次来到中国内地，于 6 月 28 日至 7 月 3 日在中国广州举办，这将是中国信息论学群齐心协力、共同呈现的一届国际信息论学术盛会。

交流活动 • RESEARCH ACTIVITIES •

2024 港-穗-台人工智能、通信与信息论研讨会
2024 Hong Kong-Guangzhou-Taipei Joint Workshop on Artificial Intelligence, Communications and Information Theory (AICIT 2024)

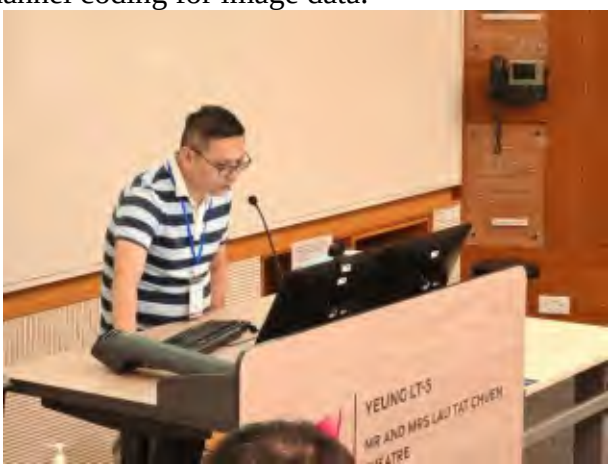
The 2024 Hong Kong-Guangzhou-Taipei Joint Workshop on Artificial Intelligence, Communications and Information Theory (AICIT 2024) took place at City University of Hong Kong (CityUHK) from July 20 to 21, co-organized by the Department of Computer Science at CityUHK and IEEE Information Theory Society Hong Kong, Guangzhou, and Taipei Chapters. The workshop aims to provide a fruitful platform for AI and IT Scholars across the strait to exchange ideas and build collaborations and friendships. The Steering Committee consists of Professor Raymond Wai Ho Yeung from the Chinese University of Hong Kong (CUHK) and Professor Xiaohua Jia from CityUHK. The workshop was generously sponsored by Huawei Technology Co., Ltd. and the Institute of Network Coding (INC) at CUHK. AICIT 2024 attracted over 70 participants, from both academia and industry.

This year, AICIT 2024 featured 12 talks and 14 student posters covering a range of topics, including information theory, coding theory, wireless communications, machine learning, generative AI, and etc. The General Co-chair of AICIT 2024 and IEEE Information Theory Society Hong Kong Chapter Chair, Professor Linqi Song, hosted the opening ceremony and welcomed all participants. General Co-chair of the workshop and Chair of the IEEE Information Theory Society Guangzhou Chapter, Professor Li Chen gave opening remarks and the background of this year's workshop. Professor Chia-Han Lee, on behalf of the IEEE Information Theory Society Taipei Chapter, expressed their best wishes for a successful workshop. Chair of the IEEE Hong Kong Section and Associate Provost of the CityUHK, Professor. Ray Chak-Chung Cheung, delivered an opening remark online, expressing the IEEE Hong Kong Section's great support for the workshop and best wishes for the workshop's success. Dr. Bo Bai from Huawei Technology Co., Ltd. warmly welcomed the participants and expressed their support to the academic-industrial collaborations.

On Day 1, the Shannon Awardee, Professor Raymond W. Yeung from CUHK delivered a keynote speech about proving information inequalities by Gaussian elimination. Proving information inequalities and identities under linear constraints on the information measures is an important problem

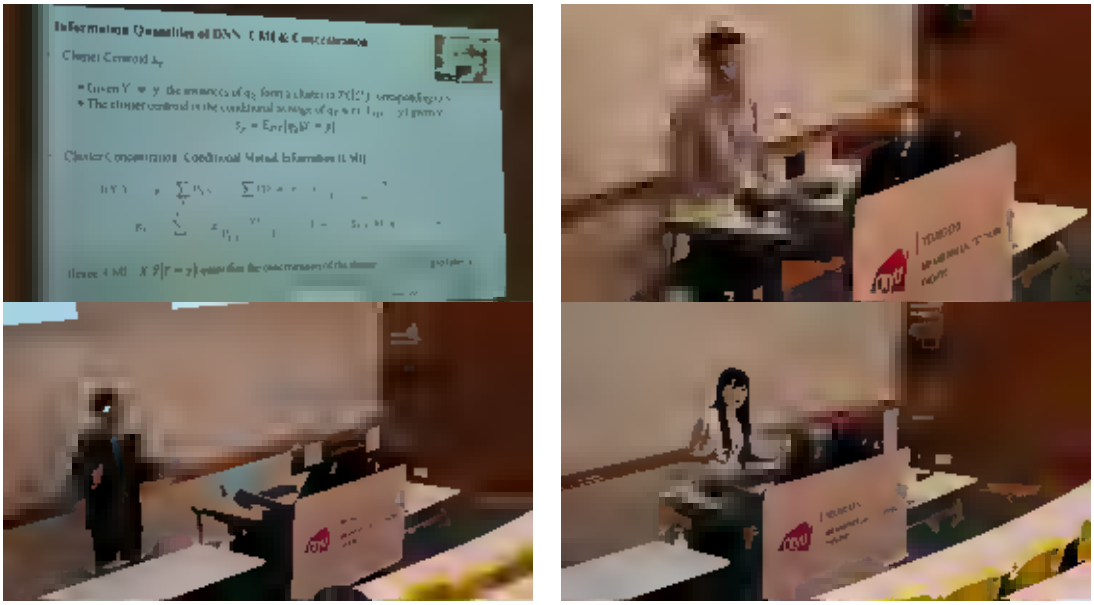
in information theory. For this purpose, ITIP and other variant algorithms have been developed and implemented, all of which are based on solving a linear program (LP). Professor Raymond W. Yeung presented their symbolic computation approach which can solve such LPs very efficiently. In some cases, only the Gaussian elimination is needed without having to solve an LP. In other cases, the original LP is reduced to a much smaller LP.

Besides the keynote speech, on Day 1, Professor Cheuk Ting Li from CUHK gave a talk on one-shot coding using Poisson processes. He proposed a Poisson functional representation approach for proving finite blocklength coding theorems in multiuser settings. This technique uses a query-based mechanism for encoding / decoding and bounds error probability via the Poisson matching lemma. Dr. Qiaosheng Zhang from Shanghai Artificial Intelligence Laboratory introduced an information-theory-inspired method, called information-directed sampling (IDS). IDS balances information gain (exploration) and immediate reward (exploitation). Professor Shih-Chun Lin from National Taiwan University discussed the proposed optimal finite-length linear codes for broadcast packet erasure channels with feedback. He derived the exact optimal second-order achievability among all possible LNCs, closing the gap between the state-of-the-art LNC second-order inner and outer bounds. Professor Shenghui Song from The Hong Kong University of Science and Technology (HKUST) shared their results regarding the fundamental limits of several large-scale MIMO channels, including the non-Gaussian fading channels, the two-hop channels, and the two-hop wiretap channels. The last talk of Day 1 was delivered by Professor Chia-Han Lee from National Yang Ming Chiao Tung University. He presented their recent progress in utilizing generative models for the physical layer design of wireless communication systems. He discussed GANs, VAEs, and diffusion models, and demonstrated their applications in federated learning, semantic communication, and joint source-channel coding for image data.



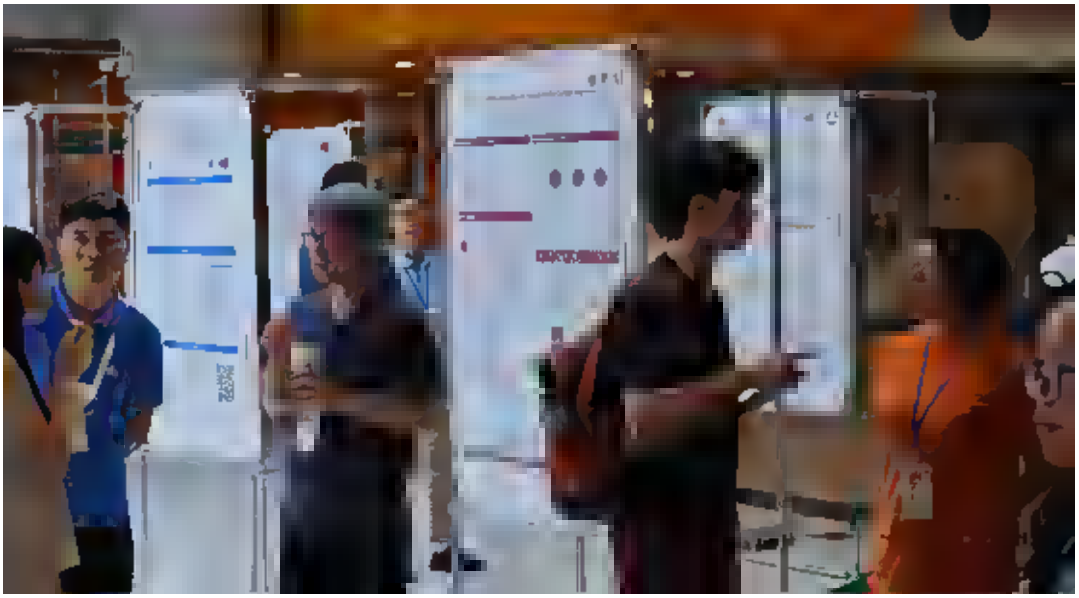
During the evening, the workshop organizing committee prepared a banquet for all participants. During the banquet, Chair of the Chinese Institute of Electronics (CIE) Information Theory Society, Professor Baoming Bai, gave a welcoming speech. He expressed the Society's encouragement and support for researchers from Guangzhou, Hong Kong, and Taipei to engage in academic exchanges.

Professor Li Chen and Professor Cheuk Ting Li chaired the Day 2 sessions. In the morning of Day 2, Professor En-Hui Yang from the University of Waterloo delivered an online keynote speech first. He discussed how to enable information theory to jump on the bandwagon of deep learning-based artificial intelligence. Several insights were provided in this talk: (1) conditional mutual information (CMI) can be used to measure the concentration of a classification deep neural network (DNN) in the output probability distribution space of the DNN, and (2) optimization techniques in rate distortion function and channel capacity can be modified to minimize (maximize, resp.) CMI along with minimizing the standard cross entropy function in DL, yielding CMI constrained deep learning (CMIC-DL), knowledge distillation (KD) resistant DL, and KD-amplifying DL.



Following the keynote speech from Professor En-Hui Yang, Professor Antoni B. Chan from CityUHK gave a talk about the next-generation explainable AI framework that promotes human-AI mutual understanding. He highlighted the need for cognitive science-based approaches to enhance transparency and trust in AI, especially in critical systems. Professor Yu-Chih Huang from National Yang Ming Chiao Tung University discussed the piecewise-stationary bandit problem from a minimalist perspective. This work introduced diminishing exploration, a mechanism that operates without knowing change points and improves the performance and regret scaling of existing algorithms. In the afternoon, Professor Wenrui Dai from Shanghai Jiao Tong University introduced their recent work on rate-distortion optimization for learned image compression. Key points include using reversible autoencoders for stable transforms, analytic models for precise rate control, and generative entropy modeling for accurate rate estimation. Dr. Xueyan Niu from Huawei Technology Co., Ltd. gave a talk on exploring the strengths and weaknesses of Transformers through the lens of information theory. Moreover, she also showed her recent work on extending the context window of LLMs through the lens of information theory. The final talk was given by Professor Qianqian Yang, who came from Zhejiang University. She showcased her work on semantics-oriented communications, using generative models to reduce transmitted information by over 99%. She also explored a system with evolving performance through caching and a method enhancing efficiency via probabilistic graphical models.

After all the talks, AICIT 2024 also included a student poster session. 14 posters were displayed at the University hall.



At the end of AICIT 2024, Professor Linqi Song and Professor Li Chen hosted the closing ceremony. They concluded the workshop and expressed their deepest gratitude to all the speakers, the organizing committees, sponsors, the participants and the volunteers. They also announced that the 2025 Joint Workshop will be hosted by Sun Yat-sen University (SYSU) in Guangzhou. Meanwhile, they shared their suggestions and best wishes for the future AICIT and other IEEE Information Theory Society conferences.

交流活动 • RESEARCH ACTIVITIES •

未来网络前沿-第九届信息论与编码中大论坛顺利举办
Frontiers of Future Networks – The 9th Workshop on Information Theory and Coding Held at SYSU

世纪中大，山高水长。2024 年 7 月 26 至 28 日，为献礼中山大学百年华诞，计算机学科系列论坛之一“未来网络前沿-第九届信息论与编码中大论坛”在中山大学广州校区南校园顺利举办。本次论坛由中山大学计算机学院主办，中国电子学会信息论分会、西安电子科技大学广州研究院、华为技术有限公司和 IEEE 信息论学会广州分会联合协办。一百六十余位专家学者齐聚羊城，欢聚一堂，聚焦学术前沿和产业应用，共享学术盛宴。

中山大学计算机学院党委书记马啸教授致欢迎辞，他对与会专家学者的到来表示热烈欢迎，并介绍了学校学院发展情况。他指出，此次论坛不仅为学校师生带来最前沿的学术成果及动向，也促进了学术交流和合作，他祝愿各位专家学者能在百年中大的校园留下一段精彩难忘的记忆。

白宝明教授、朱夏博士分别代表中国电子学会信息论分会、华为技术有限公司致欢迎辞，预祝未来网络前沿—第九届信息论与编码中大论坛圆满成功，希望大家在本次论坛中有所收获、满载而归。刘少腾博士和李亮博士代表产业界分别介绍了网络领域和高速接口领域在编译码方向的关注及需求，来自高校和企业的 19 位专家学者依次做了精彩的学术报告，分享了

最新研究成果。围绕信道编码、联合信源信道编码、多用户编码、新场景编码、量子纠错码等前沿专题，参会学者与报告专家就报告内容、研究方法和现场展示的海报等进行了热烈交流与探讨，纷纷表示报告精彩，收获丰富，受益匪浅。

论坛最后，马啸教授进行总结发言表示，信息论与编码中大论坛旨在为国内外学者提供一个交流最新研究成果、探讨学术前沿热点话题、寻求产学研合作的平台，促进中国在信息论与编码领域的发展。希望通过大家的智慧碰撞，推动学术研究和产学研用蒸蒸日上。

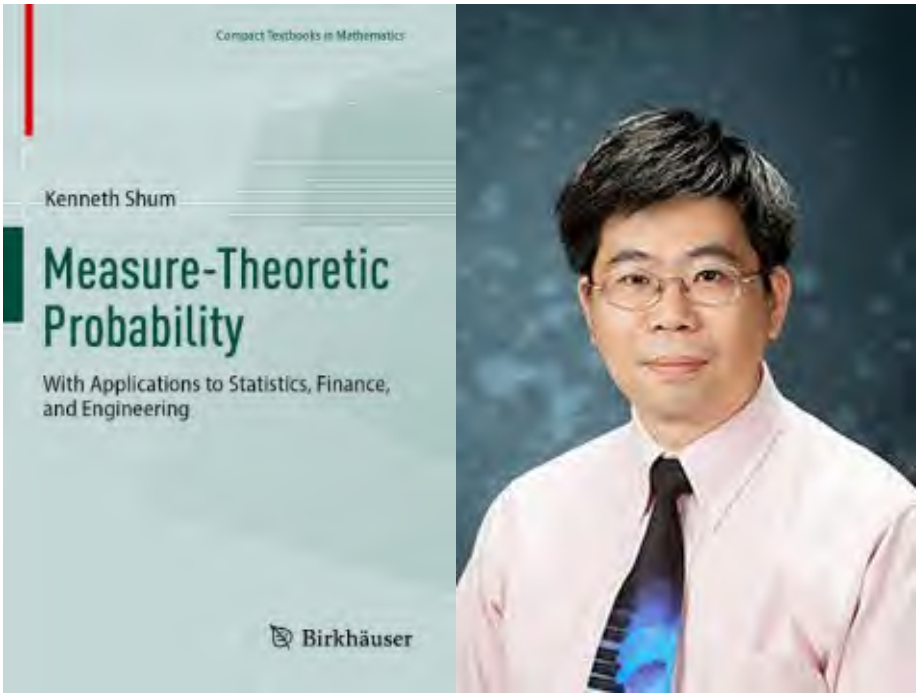
特别感谢华为技术有限公司对本次论坛的赞助和大力支持，为本次论坛的顺利举办提供了有力保障。

喜讯 • GOOD NEWS •

新书出版
New Book

2024 年 3 月，香港中文大学(深圳)沈颖祺教授著作的《Measure-theoretic Probability: with Applications to Statistics, Finance, and Engineering》由 Birkhauser 出版社出版。测度论概率是现代概率论的标准数学模型，也是研究生概率论课程的典型内容。然而，随着机器学习和金融数学的兴起，有必要让学生较早接触高等概率论。

测度空间、Lebesgue 积分等数学分析概念的引入，使我们能够严格证明大数定理、中心极限定理等基本结果。近年来，统计学习理论快速发展，与统计相关的信息论也变得日益复杂。比如，研究 Kullback-Leibler 散度、f-散度等概念时，我们需要涉及标准 Borel 空间、Radon-Nikodym 定理等测度论知识，而不能局限于简单的离散分布。除了基础概率论外，本书还介绍了 Wasserstein 距离、耦合、最小二乘估计、蒙特卡罗积分等应用，可作为统计学习和通信专业研究生的参考读物。



机会信息 • OPPORTUNITIES •

求贤若渴，康乐拥抱
Open Positions on Associate Professor / Assistant Professor / Postdoc Positions at School of Electronics and Information Technology, SYSU

陈立，中山大学
Li Chen, Sun Yat-sen University
chenli55@mail.sysu.edu.cn
www.chencode.cn

The Information Coding and Intelligent Transmission (ICIT) Laboratory of the School of Electronics and Information Technology, Sun Yat-sen University is recruiting *Associate Professor*, *Assistant Professors and Postdoctoral* and sincerely invites young talents to join. The lab is directed by Professor Li Chen, who is the chair of IEEE Information Theory Society (ITSoc) Conference Committee and Guangzhou Chapter, a member of the ITSoc Board of Governors.

ICIT offers a vibrant research environment, state-of-the-art facilities, and opportunities for professional growth. If you are driven, enthusiastic, and ready to contribute to ground-breaking research in digital communications and storage, we want to hear from you. ICIT also offers rich platforms and opportunities for young talents to be engaged with the international research communities and industry. It is where you can realize your vision.

Recruit Field Information Theory and Coding, Data Communications and Storage, Artificial Intelligence and Machine Learning.

Recruit Positions

Associate Professor: The applicant should have strong scientific research and technological innovation capabilities, and have achieved high-level results in talent cultivation or academic research; have certain professional influence at home and abroad; have the potential to become academic leaders or outstanding scholars in the field of this discipline. In general, the applicant should not exceed 40 years old.

Assistant Professor: The applicant should have a broad academic vision, active innovative thinking, and a solid research foundation; have achieved relatively high-level professional achievements; and have great potential for academic development. In general, the applicant should not exceed 35 years old.

Postdoctoral: The applicant should have a PhD within the last 3 years, are familiar with the laws of higher education, understand the situation of higher education both domestically and internationally, possess an international academic vision, and have high academic standards and strong research capabilities. They should not exceed 35 years old.

How to Apply Applicants should first send their CV (including date of birth, education history, working experience, publications, awards, and etc.) to Professor Li Chen and copied to his assistant Sue Su (subj6@mail.sysu.edu.cn). The Lab and the School will review the applications. If suited, the applicants will be contacted. Further interview will be arranged for *Associate Professor* and *Assistant Professor* applicants.

新锐风采 • NEW TALENTS •

Jiawang Bai (白家旺) is currently a Researcher at Tencent. He obtained the Ph.D.degree in Computer Science and Technology from Tsinghua University in 2024, under the supervision of Prof. Shu-Tao Xia. Before that, he received the B.S.degree from Jilin University in July 2019. He has been a visiting Ph.D. of Learning and Vision Lab at the National University of Singapore under the supervision of Xinchao Wang. His research mainly focuses on Trustworthy ML, Foundation Model, and AIGC. He has published 10+ top-tier conference and journal papers, including TPAMI, ICLR, CVPR, and ECCV. He served as the Reviewer of IEEE TPAMI, IEEE TIP, IJCV, etc.

In the area of Trustworthy ML, his research reveals and addresses security risks in the stages of data preparation - data poisoning (IEEE TIFS 2023, BMVC 2023), model training - backdoor injection (CVPR 2024), deployment - weight perturbations (ICLR 2021, ECCV 2022, IEEE TPAMI 2023), and model running - adversarial examples (IEEE TPAMI 2022, ECCV 2020). Moreover, in terms of the foundation model, his research works contribute to improving the backbone (vision transformer) in pre-training (ECCV 2022) and exploiting foundation models with low resource consumption (NeurIPS 2023, ICML 2024, ECCV 2024). He was also the first to explore backdoor attacks on the vision-language foundation model via prompt learning (CVPR 2024).

部分重要学术论文：

[1] **J. Bai**, B. Wu, Z. Li, and S. Xia, Versatile weight attack via flipping limited bits, *IEEE Trans. Pattern Anal. Mach. Intell.*, 2023.
[2] K. Gao, **J. Bai**, B. Wu, M. Ya, and S. Xia, Imperceptible and robust backdoor attack in 3d point cloud, *IEEE Trans. Inf. Forensics Secur.*, vol. 19, pp. 1267-1282, 2023.
[3] B. Chen, Y. Feng, T. Dai, **J. Bai**, Y. Jiang, S. Xia, and X. Wang, Adversarial examples generation for deep product quantization networks on image retrieval, *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 45, no. 2, pp. 1388-1404, 2022.
[4] **J. Bai**, B. Chen, Y. Li, D. Wu, W. Guo, S. Xia, and E.-h. Yang, Targeted attack for deep hashing based retrieval, in *Proc. European Conf. Computer Vision (ECCV)*, Springer, pp. 618-634, 2020.
[5] **J. Bai**, B. Wu, Y. Zhang, Y. Li, Z. Li, and S. Xia, Targeted attack against deep neural networks via flipping limited weight bits, in *Proc. Int. Conf. Learn. Represent.*, 2021.
[6] **J. Bai**, L. Yuan, S. Xia, S. Yan, Z. Li, and W. Liu, Improving vision transformers by revisiting high-frequency components, in *Proc. European Conf. Computer Vision (ECCV), Springer*, pp. 1-18, 2022.
[7] **J. Bai**, K. Gao, D. Gong, S. Xia, Z. Li, and W. Liu, Hardly perceptible trojan attack against neural networks with bit flips, in *Proc. European Conf. Computer Vision (ECCV), Springer*, pp. 104-121, 2022.
[8] S. Yang, **J. Bai**, K. Gao, Y. Yang, Y. Li, and S. Xia, Not all prompts are secure: A switchable backdoor attack against pre-trained vision transformers, in *Proc. IEEE/CVF Conf. Comput. Vision Pattern Recg. (CVPR)*, pp. 24431-24441, 2024.
[9] T. Zhang, **J. Bai**, Z. Lu, D. Lian, G. Wang, X. Wang, and S. Xia, Parameter-efficient and memory-efficient tuning for vision transformer: A disentangled approach, in *Proc. European Conf. Computer Vision (ECCV), Springer*, 2024.
[10] **J. Bai**, K. Gao, S. Min, S. Xia, Z. Li, and W. Liu, BadCLIP: Trigger-aware prompt learning for backdoor attacks on CLIP, in *Proc. IEEE/CVF Conf. Comput. Vision Pattern Recg. (CVPR)*, pp. 24239-24250, 2024.

新锐风采 • NEW TALENTS •

Xinyuanmeng Yao (姚忻圆梦) received the B.Sc. degree in Information and Computing Science from Minzu University of China, Beijing, in 2019. From 2019 to 2024, she pursued the Ph.D. degree in Cyberspace Security from Sun Yat-sen University, under the supervision of Prof. Xiao Ma.

She is a newly graduated Ph.D. in the area of information theory and coding. Her dissertation, titled "Research on Polar Coding Based on a Binary Balanced Tree," delves into the construction and application of length-flexible polar codes. This dissertation introduces a coding tree structured as a binary balanced tree (BBT) and proposes a novel coding scheme based on the coding tree, leading to a new class of length-flexible linear block codes: BBT polar codes. To reduce decoding latency, her dissertation further proposes a method to prune the coding tree based on dimension-constrained nodes and presents a partitioned successive cancellation decoding algorithm based on the pruned tree. Additionally, by integrating a classification enumeration (CE) coding approach with BBT polar codes, her dissertation presents a CE-BBT concatenated coding scheme. Based on the CE-BBT concatenated codes, an unequal message protection (UMP) scheme and a joint source-channel coding (JSCC) scheme are subsequently designed for short-packet communication scenarios. She will join Ningbo University of Technology as an Associate Researcher.

Her key publications include:

[1] **X. Yao**, X. Ma, A balanced tree approach to construction of length-flexible polar codes, *IEEE Trans. Commun.*, 72(2): 665-674, 2024.
[2] **X. Yao**, X. Ma, A new coding scheme for UMP and JSCC in short-packet communications, *IEEE Commun. Lett.*, 27(12): 3146-3150, 2023.
[3] **X. Yao**, X. Ma, A type-aware coding approach to joint source-channel coding, *IEEE Commun. Lett.*, 25(11): 3454-3457, 2021.
[4] **X. Yao**, P. Chen, B. Bai, X. Ma, Conditional error rate-based constructions of polar codes, *China Commun.*, Early Access, 2024.
[5] **X. Yao**, H. Wan, X. Ma, A type-aware coding approach for unequal message protection, *Phy. Commun.*, 53: 101721, 2022.
[6] **X. Yao**, X. Zheng, X. Ma, Trellis-based construction of polar codes for SCL decoding, in *Proc. IEEE Int. Symp. Inf. Theory*, Greece, 2024.
[7] **X. Yao**, X. Ma, A polar coding approach to unequal message protection, in *Proc. IEEE Int. Symp. Topics Coding*, France, 2023.

讣告 • EULOGY•

深切悼念我的老师 Lloyd R. Welch (1927-2023)
In Memoriam: My Mentor - Lloyd R. Welch (1927-2023)

沈颖祺
香港中文大学(深圳)
Kenneth Shum
The Chinese University of Hong Kong, Shenzhen
wkshum@cuhk.edu.cn

Lloyd Welch 教授从 1965 到 1999 年在南加州大学电子工程系担任教授，2003 年获得 Claude E. Shannon 奖，于 2023 年 12 月 28 日去世，享年 96 岁。我很庆幸能够修读 Welch 教授的两门课程，并从中获得了许多启发。

第一门课程是 EE568《纠错编码》，主要讲授 Reed-Solomon 码。Welch 教授在课堂上花费了大量时间讲解代数和有限域的知识，特别强调如何用计算机实现有限域的算法，并还提供了相应的代码。课程的后半部则讲授了 BCH 码、RS 码以及 Welch-Berlekamp 解码算法。Reed 和 Solomon 在 1960 年提出了 Reed-Solomon 码的构造方法，但并未给出快速的解码方法。一般的教科书，如[3]，通常将 RS 码视为循环码，并介绍 Berlekamp-Massey 算法。而 Welch-Berlekamp 算法是一种针对原始 Reed-Solomon 码的快速解码方法，避免了复杂的 syndrome 计算。Welch 教授在课上幽默地说："They almost got it"。意思是说这并不是十分困难，如果 Reed 和 Solomon 能多想几步，他们也同样地得到这个算法。

但事实上，这个算法是在二十多年后才被提出的。Welch-Berlekamp 算法于 1986 年由 Berlekamp 和 Golomb 创办的 Cyclotomics 公司[4]申请了专利[9]。第一个版本的 Welch-Berlekamp 算法可以在 Welch 的一位博士生的论文中找到[6]。之后，Berlekamp 在一篇关于 Reed-Solomon 软解码的论文[2]中对该算法进行了修改。后来，Madhu Sudan 把这个算法推广到列表解码。

我修读的第二门课是 EE599《纠错编码专题》，主要内容是隐马尔可夫链和 Baum-Welch 算法。Welch 教授从最简单的马尔可夫链开始，推导出 Forward-Backward 算法，然后引入隐马尔可夫链，并讲解如何利用 Baum-Welch 算法估计未知参数。所有内容都被他讲得浅显易懂。Baum-Welch 算法的起源也颇为神秘，是 Welch 在普林斯顿国防分析研究所工作时与 Leonard E. Baum 一起研发的，后来 Welch 离开普林斯顿搬到南加州，并未与 Baum 发表论文。Baum-Welch 算法隐藏于 Baum 和其他同事的论文之中 [1]。现在，我们知道 Baum-Welch 算法是期望最大化(Expectation-Maximization)算法，应用到隐马尔可夫模型的一个特例。该算法不仅用于卷积码的译码，在语音处理和生物信息学等多个领域也得到了广泛应用[10]。

除此之外，Welch 教授还有其他多项突破性成果，包括信号最大互相关的 Welch 下界[11]、Gordon-Mills-Welch 序列家族[5][8]、以及 McEliece-Rodemich-Rumsey-Welch 渐近编码界[7]。这些理论成果在码分多址、等角紧框和渐近编码理论等领域产生了重要影响。

参考文献：

[1] L. E. Baum, T. Petrie, G. Soules and N. Weiss, A maximization technique occurring in the statistical analysis of probabilistic functions of Markov chains, *Ann. Math. Statist*., vol. 41, no. 1, pp.164-171, 1970.

[2] E. R. Berlekamp, Bounded distance + 1 soft-decision Reed-Solomon decoding, *Trans. Inf. Theory*, vol. 42, no. 3, May, 1996.
[3] R. E. Blahut, Algebraic codes for data transmission, *Cambridge University Press*, 2003.
[4] Cyclotomics, https://math.berkeley.edu/~berlek/cyclotomics.html
[5] B. Gordon, W. H. Mill and L. R. Welch, Some new difference sets, *Canadian J. Mathematics*, vol.14, pp.614-625, 1962.
[6] T.-H. Liu, A new decoding algorithm for Reed-Solomon code, PhD thesis, University of Southern California, 1984. (Available for download from the website of USC library)
[7] R. McEliece, E. Rodemich, H. Rumsey and L. R. Welch, New upper bounds on the rate of a code via the Delsarte-MacWilliams inequalities, *IEEE Trans. Inf. Theory*, vol. 23, no. 2, pp.157-166, 1977.
[8] R. A. Scholtz and L. R. Welch, GMW sequences, *IEEE Trans. Inf. Theory*, vol. 30, no. 3, pp.548-553, 1984.
[9] L. R. Welch and E. R. Berlekamp, U. S. Patent 4,633,470, Error correction for algebraic block codes, issued Dec. 30, 1986.
[10] L. R. Welch, Shannon Lecture, Hidden Markov models and the Baum–Welch algorithm, *IEEE Information Theory Society Newsletter*, Dec. 2003.
[11] L. R. Welch, Lower bounds on the maximum cross correlation of signals, *IEEE Trans. Inf. Theory*, vol. 20, no. 3, pp.397-399, 1974.