IEEE 信息论学会广州分会季报

IEEE INFORMATION THEORY SOCIETY
GUANGZHOU CHAPTER NEWSLETTER

第四期, 2021 年 7 月 No. 4, Jul. 2021

主编序语

各位学者：

本期《分会季报》介绍了空间耦合 LDPC 码在编码调制和译码上的最新进展，其中，与 BICM 结合可实现迭代解调-译码，提升传输效率与性能，同时，尝试利用深度学习提升 Min-Sum 译码算法性能，收效显著。6 月 11 日，IEEE 信息论学会公布广州分会获得年度最佳分会奖，这是自该奖设立 20 年来首次颁发给中国大陆的分会，是对分会工作的肯定与鼓励。广州分会将秉持“促进交流 服务学群”的精神继续努力。

陈立

From the Editor-in-Chief

Dear Chapter Members,

This issue introduces some state-of-the-arts on spatially coupled LDPC codes, in particular, its coded modulation and decoding. Integrated with BICM for transmission, the iterative BICM-ID enhances performance of spatially coupled LDPC coded modulation systems. Meanwhile, deep learning technique is utilized to enhance performance of the Min-Sum decoding algorithm. On June 11, IEEE Information Theory Society announced that Guangzhou Chapter received Chapter-of-the-Year Award. This is the first time the Award is given to a mainland China Chapter over its 20 years history. We are delighted, and also encouraged. Guangzhou Chapter will continue to endeavor with its spirit of *Promote Exchanges and Serve the Community.*

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.

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最新结果 • RECENT RESULTS •

空间耦合原模图 LDPC 码的 BICM-ID 系统设计与优化

Design and Optimization of Spatially-Coupled Protograph LDPC-Coded BICM-ID Systems

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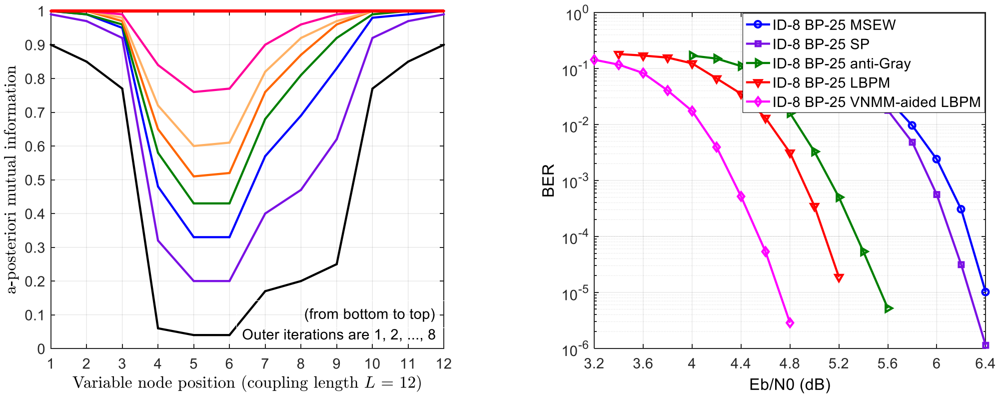
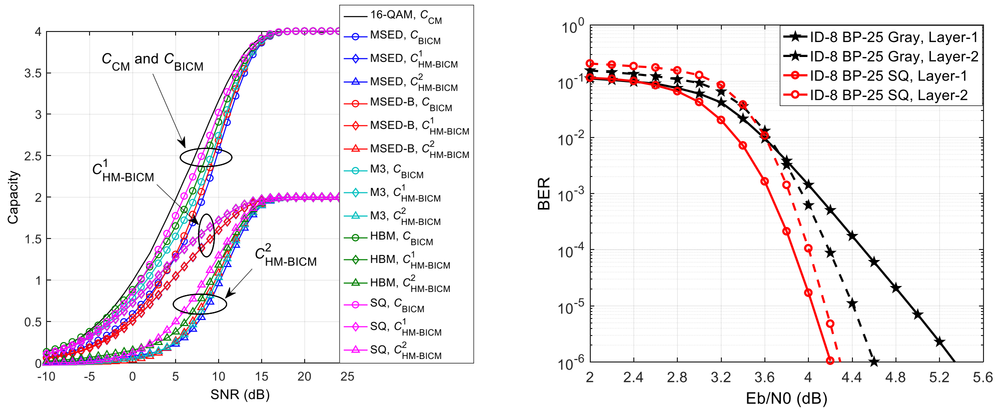
As a type of convolutional-based protograph LDPC codes, spatially-coupled protograph (SC-P) codes have been recognized as a dominant research direction in the coding community during the past decade. SC-P codes not only inherit all superiorities of protograph codes [1] (e.g., simple design and easy hardware implementation), but also achieve additional performance gain due to their convolutional property. The combination of such codes and BICM-ID technique has great potential to realize high-reliability, high-throughput and low-complexity wireless communications. For this reason, we conduct a study on tail-biting SC-P (TB-SC-P)-coded BICM-ID systems [2]. Specifically, we first develop a design method to formulate a type of new constellations, called *labeling-bit-partial-match (LBPM) constellations*, for high-order modulations, such as M-ary phase-shift keying (PSK) and quadrature amplitude modulation (QAM). The LBPM constellations can not only exhibit desirable BICM capacities, but also ensure excellent BICM-ID performance. Moreover, we conceive a new bit-level interleaving scheme, called *variable node matched mapping (VNMM) scheme*, tailored for use in TB-SC-P-coded BICM-ID systems. The proposed interleaving scheme can exploit the unequal convergence property of labeling bits within LBPM constellations and the structure feature of TB-SC-P codes to trigger the wave-like phenomenon in the decoding process, which can accelerate the convergence of a-posteriori mutual information (MI) corresponding to such codes. As a further advance, we propose a novel extrinsic information transfer (EXIT) algorithm, which can be utilized to evaluate the asymptotic convergence performance of the proposed VNMM-aided TB-SC-P-coded BICM-ID systems with different constellations. Fig. 1(a) depicts the evolution of a-posteriori MIs (i.e., decoding wave) of the (3, 6) TB-SC-P code with coupling length L = 12, while Fig. 1(b) verifies the superiority of the LBPM-mapped TB-SC-P-coded BICM-ID system with 16-QAM modulation. This figure also illustrates that the system performance can be further improved by exploiting the VNMM scheme.

The outstanding performance of TB-SC-P codes makes them a promising coding scheme for future wireless scenarios with diverse quality-of-service (QoS) requirements, such as Internet of Things (IoT). Aiming to further explore the application of such codes, we carry out an investigation on TB-SC-P-coded M-ary hierarchical-modulated BICM-ID (HM-BICM-ID) systems [3]. To be specific, we first propose an information-theoretic methodology to calculate $(\log_2 M)/2$ different types of constellation-constrained average MIs for characterizing the performance limits of $(\log_2 M)/2$ different layers within an M-ary constellation in HM-BICM systems. Note that an M-ary HM mechanism is assumed to carry $(\log_2 M)/2$ transmitted coded-bit streams simultaneously. In the mapping process, these $(\log_2 M)/2$ coded-bit streams are successively assigned into $(\log_2 M)/2$ layers of a given M-ary constellation. In other words, every $\log_2 M$ coded bits output from such $(\log_2 M)/2$ coded-bit streams are grouped together in a sequential order and modulated into an M-ary transmitted symbol. Furthermore, we design a novel type of constellations, called *structural quadrant (SQ) constellations*, so as to provide desirable unequal error protection (UEP) for different transmitted data streams based on their importance and priorities. As a further insight, we modify the harmonic mean analysis, which is tailored for the conventional BICM-ID framework, to predict the non-feedback and iterative-feedback convergence performance of $(\log_2 M)/2$ layers within an M-ary constellation in HM-BICM-ID systems. We also conceive a multi-stream-based EXIT (MS-EXIT) algorithm and analyze the decoding thresholds for the TB-SC-P-coded HM-BICM-ID systems with different constellations. Referring to Fig. 2(a), the SQ constellation exhibits higher HM-BICM capacities than other existing counterparts, while Fig. 2(b) verifies that the SQ constellation realizes both outstanding layer-1 performance and layer-2 performance in HM-BICM-ID systems.



(a) (b)

Fig .1. 16-QAM BICM-ID systems: (a) Decoding wave of the (3, 6) TB-SC-P code with the VNMM-aided LBPM constellation; (b) BER curves of the conventional, LBPM and VNMM-aided LBPM constellations.



(a) (b)

Fig. 2. 16-QAM HM-BICM-ID systems: (a) Channel capacities of different types in the SQ constellation and existing counterparts; (b) BER curves of the layer-1 and layer-2 data streams for the SQ and Gray constellations.

References:

[1] Z. Yang, Y. Fang, Y. Cheng, P. Chen, et al., "Protograph LDPC-coded BICM-ID with irregular mapping: An emerging transmission technique for massive Internet of Things," *IEEE Trans. Green Commun. Netw.*, published online, vol. PP, no. 99, pp. 1-15, Feb. 2021.

[2] Z. Yang, Y. Fang, G. Zhang, F. C. M. Lau, et al., "Analysis and optimization of tail-biting spatially coupled protograph LDPC codes for BICM-ID systems," *IEEE Trans. Veh. Technol.*, vol. 69, no. 1, pp. 390-404, Jan. 2020.

[3] Z. Yang, Y. Fang, G. Han, et al., “Spatially-coupled protograph LDPC-coded hierarchical modulated BICM-ID systems: A promising transmission technique for 6G-enabled internet of things,” *IEEE Internet Things J.*, vol. 8, no. 7, pp. 5149-5163, Apr. 2021.

原模图 LDPC 码的深度学习译码方法
Learning to Decode Protograph LDPC Codes

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Protograph low-density parity-check (LDPC) codes have been selected as the coding scheme for data channels in the 5G new radio (NR) system. A number of iterative decoding algorithms of LDPC codes exist. Among these decoding algorithms, the standard sum-product (SP) or belief propagation (BP) algorithm [1] can achieve the optimal performance while its high decoding complexity hinders the practical use. Instead of the SP algorithm, the min-sum (MS) [2] algorithm and its variants, such as the normalized min-sum (NMS) and the offset min-sum (OMS) [3], have been developed to achieve the approximate the performance of the SP algorithm with much lower complexity, and thus they have been widely employed in practical systems.

The recent development of deep learning methods provides a new approach to optimize the BP decoding of linear codes. However, the limitation of existing works [4][5][6] is that the scale of neural networks increases rapidly with the codelength, thus they can only support short to moderate codelengths.

From the point view of practicality, we propose a high-performance neural min-sum (MS) decoding method [7] that makes full use of the lifting structure of protograph LDPC codes. By this means, the size of the parameter array of each layer in the neural decoder only equals the number of edge-types for arbitrary codelengths. In particular, for protograph LDPC codes, the proposed neural MS decoder is constructed in a special way such that identical parameters are shared by a bundle of edges derived from the same edge-type. To reduce the complexity and overcome the vanishing gradient problem in training the proposed neural MS decoder, an iteration-by-iteration (i.e., layer-by-layer in neural networks) greedy training method is proposed. With this, the proposed neural MS decoder tends to be optimized with faster convergence, which is aligned with the early termination mechanism widely used in practice. The optimized MS decoding can provide faster convergence and up to 1dB gain compared with the plain MS decoding and its variants with only slightly increased complexity. In addition, it can even outperform the sum-product algorithm for some short codes.

The LDPC coding scheme in 5G NR adopts the protograph structure, including two base graphs (BG1 and BG2), to meet the requirements of high reliability, high throughput, and low decoding latency. Hence, in this work, we choose 5G LDPC codes as a representative of the protograph LDPC code class to train and verify the proposed neural MS decoder. To the best of our knowledge, this is the first work to investigate neural decoding methods for protograph LDPC codes [7]. The novelty of this work can be summarized as follows:

***<u>Parameter-Sharing Mechanism</u>*:** The macroscopic structure of a protograph LDPC code can be captured by its small base graph. Taking advantage of this encapsulation property of protograph LDPC codes, an additional restriction is applied to the weights and biases: for any edge pair e_1 and e_2 belonging to the same edge-type, i.e., $e_1 \in \mathrm{E}_b$ and $e_2 \in \mathrm{E}_b$, (we define the set E_b denoting the Z-bundle of edges derived from e_b, and e_b is an edge in protograph), the same values are applied to the neurons corresponding to these two edges in hidden layer i, i.e.,

$$\alpha_{e_1}^{(i)} = \alpha_{e_2}^{(i)},\ \ \beta_{e_1}^{(i)} = \beta_{e_2}^{(i)}.$$

Moreover, one parameter array may be applied to multiple lifted codes derived from the same base code.

Iteration-by-Iteration Greedy Training: Departing from the well-known multi-loss training method, we propose an iteration-by-iteration, i.e., layer-by-layer in neural networks, greedy training method by which only parameters of the last decoding iteration are learnable, and those for previous iterations are fixed. This training process is beneficial in three ways: (i) the actual network for training always has a shallow structure so as to avoid the vanishing gradient problem and reduce the training complexity; (ii) per-edge-type parameters and the greedy training method enable the neural MS decoder to mitigate the message correlation due to short cycles in the Tanner graph and tend to optimize the performance of neural decoders as early as possible, i.e., faster convergence, especially for some short codelength cases. This method is consistent with the early termination mechanism in the conventional LDPC iterative decoding; and (iii) the one-iteration training granularity enables the neural MS decoder to flexibly set up its decoding configurations, i.e., the number of iterations. In this way, many parameters in the optimized MS decoder can be reused rather than retrained for every different configuration. As shown in Fig. 1, the neural network is trained for $I_{\max}$ iterations, then for any neural decoder with I $(I \le I_{\max})$ iterations. It can be directly built by recycling the first I hidden layers in the trained neural decoder.

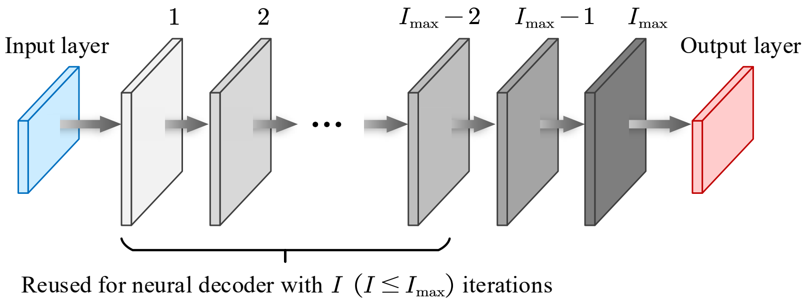


Fig. 1: A sketch of the reusability of hidden layers trained with the proposed iteration-by-iteration manner.

With $Z=3$ in Fig. 2(a), considering the SNR required to achieve $\text{BLER}=10^{-2}$, the neural MS decoder outperforms the standard MS decoder more than 0.5dB, and it is quite close to the standard SP decoder. Fig. 2(a) also gives the required SNRs to achieve $\text{BLER}=10^{-4}$, in this high SNR region, the neural MS decoder can even outperform the SP decoder at early iterations. In this case, we also show the performance of the neural MS decoder under the conventional multi-loss training with $I=25$. The proposed greedy training method tends to optimize the performance of neural decoders as early as possible, i.e., faster convergence. However, the traditional multi-loss training [6] tends to optimize the performance for the target number of iterations, i.e., good results can only be observed at the final output. Hence, given $I=25$, we can observe that these two training methods finally achieve similar performance when the number of iterations finally reaches 25, though the proposed training method still presents some gain at this point.

Fig. 2(b) shows the required SNRs to achieve $\text{BLER}=10^{-2}$ when $Z=16$. Though still better than the MS/NMS/OMS algorithms, the performance of neural MS decoding is slightly inferior to SP decoding. For the required SNRs to achieve $\text{BLER}=10^{-4}$ in Fig. 2(b), we observe that the neural MS decoder and the SP decoder achieve the same performance, which implies the superiority of the neural MS decoder in the high SNR region.

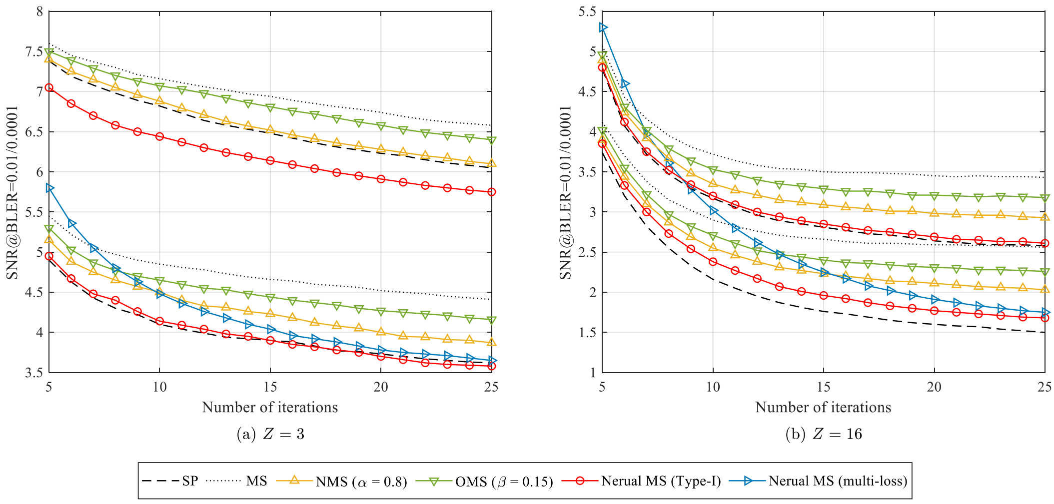


Fig. 2: SNR required to achieve BLER $= 10^{-2}$ or 10^{-4} under the AWGN channel, (a) shows the (150, 30) code with $Z = 3$, (b) shows the (800, 160) code with $Z = 16$.

In [8], we extend the method to design a neural layered MS decoder for protograph LDPC codes by exploiting their lifting structure. The proposed neural layered MS decoder can also achieve impressive error performance and faster decoding convergence as shown in Fig. 3.

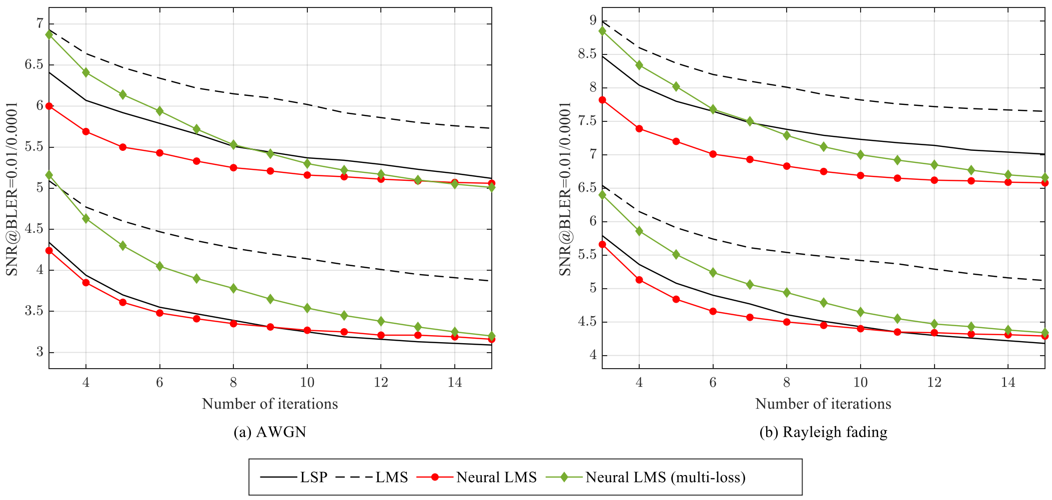


Fig. 3: Required SNR for BLER $= 10^{-2}$ or 10^{-4} in (a) the AWGN channel, (b) the Rayleigh fading channel, with $Z = 3$ and the layered decoding algorithms.

Reference:

[1] S. Lin and D. J. Costello, *Error Control Coding (2nd edition)*. Prentice-Hall, Inc., 2004.

[2] F. R. Kschischang, B. J. Frey, and H.-A. Loeliger, "Factor graphs and the sum-product algorithm," *IEEE Trans. Inf. Theory*, vol. 47, no. 2, pp. 498–519, Feb. 2001.

[3] J. Chen, A. Dholakia, E. Eleftheriou, M. P. C. Fossorier, and X. Y. Hu, "Reduced-complexity decoding of LDPC codes," *IEEE Trans. Commun.*, vol. 53, no. 8, pp. 1288–1299, Aug. 2005.

[4] E. Nachmani, Y. Beery, and D. Burshtein, "Learning to decode linear codes using deep learning," in *Proc. 54th Annu. Allerton Conf. Commun., Control Comput.*, pp. 341–346, Monticello, IL, Sep. 2016.

[5] L. Lugosch and W. J. Gross, "Neural offset min-sum decoding," in *Proc. IEEE Int. Symp. Inf.*

Theory (ISIT), pp. 1361–1365, Jun. 2017, Aachen, Germany.
[6] E. Nachmani, E. Marciano, L. Lugosch,W. J. Gross, D. Burshtein, and Y. Beery, “Deep learning methods for improved decoding of linear codes,” *IEEE J. Sel. Topics Signal Process.*, vol. 12, no. 1, pp. 119–131, Feb. 2018.
[7] J. Dai, K. Niu, et al., "Learning to decode protograph LDPC codes," *IEEE J. Sel. Areas Commun.*, vol. 39, no. 7, pp. 1983-1999, Jul. 2021.
[8] D. Zhang, J. Dai, K. Tan, K. Niu, et al., “Neural layered min-sum decoding for protograph LDPC codes”, *2021 IEEE Int. Conf. Acoustics, Speech and Signal Process. (ICASSP)*, pp. 4845-4849, Jun. 2021.

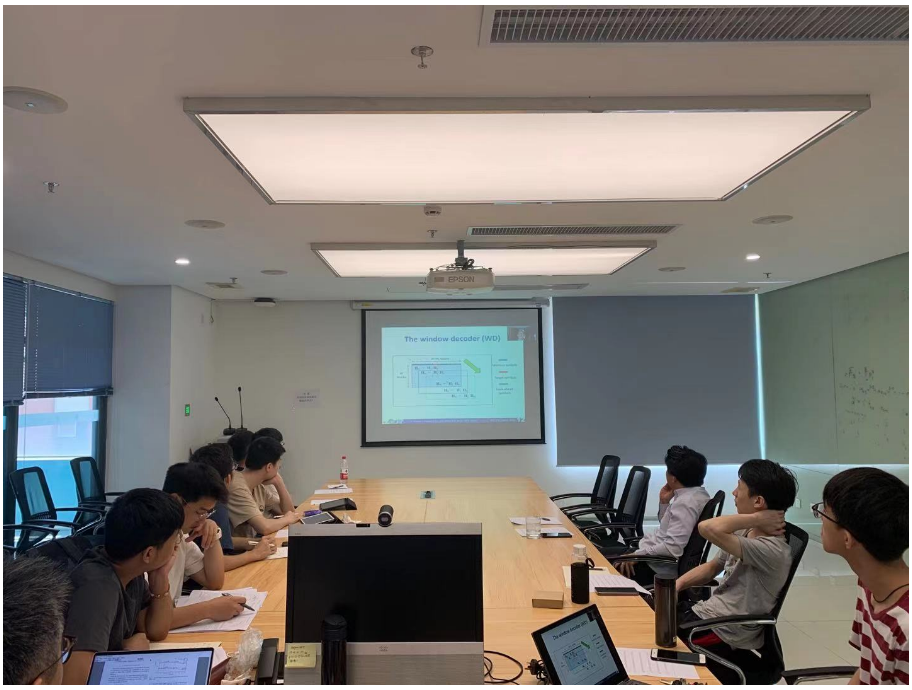
粤港澳大湾区信息论与人工智能研讨会（预告）
Greater Bay Area (GBA) International Workshop on Information Theory and Artificial Intelligence (Announcement)

The IEEE Information Theory Society Guangzhou Chapter and Tsinghua University Shenzhen International Graduate School (SIGS) are organizing the GBA International Workshop on Information Theory and Artificial Intelligence on Sep. 25, 2021, which will be free for registration. Many methods and ideas developed in information theory (IT) have been adopted to explain and uncover the internal mechanism in modern deep neural networks. Progress regarding an information theoretic understanding of deep neural networks has often been driven by the deep-learning-based application and induced phenomenon and is yet to be explored further. Moreover, the use of artificial intelligence (AI) techniques to study and improve the classical source coding and channel coding problem in information theory is also yet to be explored. This workshop aims to provide an opportunity for academic exchange on novel progress regarding the connection between IT and AI. This will be a hybrid conference where overseas scholars will participate online, and domestic ones will be onsite. Graduate students are encouraged to submit their most recent results to our Recent Results Poster Session. All are welcome!

Organizers: IEEE Information Theory Society Guangzhou Chapter, Tsinghua University Shenzhen International Graduate School (SIGS)
Co-chairs: Shu-Tao Xia, Li Chen, Jianmin Lu
Venue: Information Building, Tsinghua University Shenzhen International Graduate School (SIGS), Shenzhen, Guangdong, China.
Dates: Sep. 25, Beijing Time
Local Arrangements: Bin Chen, Xijun Wang, Congduan Li, Mengyao Ma
Contact: itguangzhou@163.com
Registration: WeChat will open in August. You may also register via itguangzhou@163.com

中山大学信息编码与智能传输实验室 ITW 2020 学习研讨班
ITW 2020 Seminar of ICIT Lab at SYSU

5 月 19 日上午，由陈立教授带领的中山大学信息编码与智能传输实验室举办了一场研讨活动，对 ITW 2020 的部分文章进行了集体学习和讨论。ITW 是由 IEEE 信息论学会主办的信息论领域的重要国际会议。本次会议采取了线上报告的形式，文章作者通过视频报告的方式向参会者分享成果。按照安排，实验室团队先听取了 LDPC 码的相关报告，其中包括关于自适应掺杂及双向滑窗译码的相关研究。此后，团队集中学习了关于 Reed-Muller 码的相关研究工作。Reed-Muller 码作为一种经典编码，与 Polar 码密切相关，拥有丰富的代数结构和应用潜力。相关报告内容也有部分与实验室团队相关，引发了团队的深入思考与讨论。通过本次研讨活动，实验室团队拓宽了研究问题的角度，提高了对信息论领域新进展的认识。相关的思考与讨论巩固了团队良好的学术氛围，思想碰撞的火花也有助于进一步推动科研工作。



IEEE 信息论学会广州分会喜获学会年度最佳分会奖
IEEE Information Theory Society Guangzhou Chapter Received Chapter-of-the-Year Award

2021 年 6 月 11 日，IEEE 信息论学会宣布广州分会获得本年度最佳分会奖(Chapter-of-the-Year Award)，信息链接：https://www.itsoc.org/news/2021-itsoc-chapter-year-announced。该年度奖项表彰为会员提供杰出服务和活动的分会。在 2020 年，广州分会克服疫情影响，充满活力，举办多场学术活动，促进了信息论的研究，因而受到表彰。这也是自该奖设立 20 年来，首次颁发给中国大陆的分会。

继 2018 年 IEEE 信息论年会(ITW 2018)成功举办后，IEEE 信息论学会广州分会于 2019 年 11 月成立。广州分会扎根粤港澳大湾区辐射华南，秉持“促进交流 服务学群”的宗旨开展工作，促进信息论研究，服务人才培养。粤港澳大湾区是国家的信息技术创新产业中心，拥有华为、腾讯、中兴等大型科技企业和多所著名高校。分会将在高等教育和知识创新上发挥重要作用，服务区域社会的科技和经济发展。自成立以来，分会除了推广 IEEE 会员资格外，还组织了季节性的学术会议，创办了《IEEE 信息论学会广州分会季报》，为区域内的学者们提供形式多样的交流平台。

以下是 2020 年广州分会的活动回顾:

1. 中山大学网络信息论与编码研讨会

2020 年 9 月 26 日，由 IEEE 信息论学会广州分会、中山大学电子与信息工程学院和电子与通信工程学院主办，中国电子学会信息论分会协办的“中山大学网络信息理论与编码研讨会”在中大南校园新数学楼 209 讲学厅成功举办，50 余位来自全国各地的专家学者参加了这场学术活动。

2. 中山大学数学与编码国际研讨会

2020 年 12 月 2 至 3 日，由 IEEE 信息论学会广州分会、中山大学电子与信息工程学院和电子与通信工程学院主办的“中山大学数学与编码国际研讨会”在中山大学学人馆多功能厅成功举办。本次会议采用了线上线下结合模式，境外报告者作线上报告，境内报告者和参会者现场交流，共 15 位国内外知名专家进行了报告，80 余位来自全国各地的专家学者参加了这场学术活动，50 多位海外学者在线参加了研讨会。

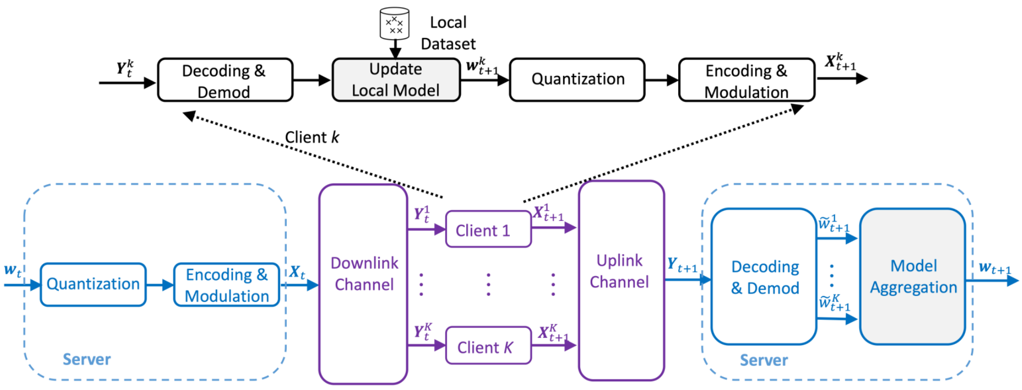
3. IEEE 信息论学会广州分会季报

IEEE 信息论学会广州分会希望通过办《IEEE 信息论学会广州分会季报》为学者提供一个稳定高效的知识交流平台。学术文章的撰写追求科学严谨，写稿、审稿、修正并最终发表的周期较长。《季报》主要刊登介绍性的通讯稿，便于大家更及时地发布科研成果甚至猜想，获得关注与交流，以期与学术文章形成良性互补，进一步推动信息论和编码领域的知识创新与应用。现已出版三期：第 1 期，2020 年 7 月；第 2 期，2020 年 10 月；第 3 期，2021 年 2 月。

分会将一如既往的为华南乃至全国信息论学者提供交流平台，共同促进信息论的研究，促进高等教育和知识创新。

中山大学陈翔老师课题组郑斯辉同学获 IEEE ICC 2021 最佳论文奖
Sihui Zheng from SYSU Xiang Chen's Research Group Received the IEEE ICC 2021 Best Paper Award

2021 年 6 月，由 IEEE 主办、原定于加拿大蒙特利尔召开的国际通信大会(ICC)在互联网上以虚拟会议形式召开，该会议是世界通信行业规模最大、最具影响力的标志性学术会议之一。中山大学电子与信息工程学院 I3C 实验室硕士研究生郑斯辉与其导师陈翔副教授完成的论文《联邦学习上下行链路通信设计和分析》(Design and Analysis of Uplink and Downlink Communications for Federated Learning)获本届大会最佳论文奖(Best Paper Award)。该论文的合作者还有弗吉尼亚大学的沈聪教授。



联邦学习/联盟学习(Federated Learning, FL)技术是近年来备受关注的一种分布式人工智能架构，在该架构中由一个中心服务器调度多个用户设备进行协作训练，最终得到高精度的神经网络模型，而不需要收集用户数据，具备显著的隐私保护优势。然而，目前深度神经网络的庞大规模以及机器学习训练的迭代特性导致该过程需要大量模型的广播和回传，导致 FL 技术面临着通信开销巨大的瓶颈问题。

论文围绕上述问题，从通信的角度对 FL 过程模型的量化传输展开了研究。论文对 FL 和无线通信融合的系统框架进行了分析，在此基础上针对上下行链路的特点进行了量化方案设计。在上行链路中，论文将问题聚焦在“对何量化”以及“如何量化”两个问题，指出可以基于 FL 的流程特点采用差分传输，从而提高有限量化位宽下的传输精度；同时还设计了一套完整的量化方案，并引入随机舍入进行优化。对于下行链路而言，采用的是广播信道，这导致差分传输不再适用，因此论文提出一种分层量化方案，可跟踪神经网络各层的动态范围并进行量化参数的精细化匹配。除此之外，论文还从理论上分析了不同量化方案的收敛性能，明确了不同方案的收敛条件，提供了更加完备的理论支撑。论文的实验结果验证了方案的优越性——对于目前 FL 研究普遍使用的数据集而言，所提方案可以降低超过 80%的通信开销，某些情况下甚至可以达到极致的 1-比特量化，可以有效提高 FL 的通信效率。最终该论文在今年 ICC 提交的论文中脱颖而出，获得了最佳论文奖。

机会信息 • OPPORTUNITIES •

博士生招聘，俄亥俄州立大学
Research Assistant Openings, The Ohio State University

Prof. Xinmiao Zhang is looking for highly-motivated Ph.D. students to join her lab (vlsiArc.engineering.osu.edu) at the Department of Electrical & Computer Engineering of The Ohio State University. Our graduate program is ranked at 22nd in the most recent US News ranking.

In particular, 2 RA positions are available in Fall 2021 for error-correcting codes, cryptography, and their hardware accelerator design. These projects are in collaboration with high-tech companies. Internships may also be available through the project. Good math and analytical background is required. Prior experience on error-correcting coding, digital communications, or related topics is preferred. These research does NOT require advanced knowledge on circuit design. Basic understanding of digital logic design from a sophomore course is sufficient.

The research of our group spans the areas of coding schemes and system architecture design for next-generation memories and digital communications, hardware security, post-quantum cryptography, and machine learning. Our research translates theoretical advancements to highly efficient practical implementations through integrated algorithmic and architectural optimizations. Students interested in these research areas are also encouraged to apply.

Interested students may send the CV and transcripts in PDF to Prof. Zhang (zhang.8952@osu.edu). Applications can be submitted through https://gpadmissions.osu.edu/apply/grad.html to apply our Ph.D. program, and the deadline can be extended.

机会信息 • OPPORTUNITIES •

副教授/助理教授/博士后招聘，中山大学
AP/Postdoc Positions Opening, Sun Yat-sen University

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

The Information Coding and Intelligent Transmission (ICIT) Laboratory of the School of Electronics and Information Engineering, Sun Yat-sen University is recruiting *Associate Professors and Research Associates* at home and abroad, and sincerely invites young talents to join. The lab is directed by Prof. Li Chen.

1. Recruit Field

Information theory and coding, computation for information theory, intelligent networks

2. Recruit Positions

- *Associate Professor:* The applicant should have a PhD degree from a well recognized University or research institute, a strong independent research capability and high academic achievements. Applicants should demonstrate their potential in academia, and have at least 3 years working experience at home or abroad. In general, the applicant should not exceed 40 years old.
- *Research Associate:* The applicant should have a PhD degree and an appropriate amount of publications. They should not exceed 35 years old.

3. How to Apply

- Applicants should first send their CV (including date of birth, education history, working experience, publications, awards, and etc.) to Prof. Li Chen.
- The lab and the school will review the applications and if suited, the applicants will be contacted. They will be sent the application form, and guided the preparation of other application materials, including references.
- A school interview will be further arranged. If approved, a University interview will be needed for *Associate Professor* applicants.

新锐风采 • NEW TALENTS •

Bin Chen (陈斌) received the B.S. and M.S. degrees in mathematics from South China Normal University, Guangzhou, China, in 2014 and 2017, respectively, and Ph.D. degree from the Department of Computer Science and Technology, Tsinghua University, Beijing, China, in 2021. He is currently a Post-Doctoral Researcher with the Shenzhen International Graduate School, Tsinghua University, Shenzhen. From December 2019 to May 2020, he visited Prof. En-Hui Yang (IEEE Fellow) at the Department of Electrical and Computer Engineering, University of Waterloo, Canada. He has published more than 20 papers in IEEE TIT, TCOM, ISIT, AAAI, ECCV, ACM MM etc. He also served as a Guest Editor of Entropy, PC member for AAAI-21, IJCAI-21, KSEM-21, ISPA-21, and the reviewers for IEEE Trans. Information Theory, IEEE Trans. Communications, IEEE Communications Letters, Data Compression Conference (DCC), etc. His research interests include coding for distributed storage systems, data compression and deep learning for image retrieval.

His key publications include:

[1] **B. Chen**, W. Fang, S. Xia, J. Hao and F. Fu, "Improved bounds and singletonoptimal constructions of locally repairable codes with minimum distance 5 and 6," *IEEE Trans. Inf. Theory*, vol.67, no. 1, pp. 217–231, Jan. 2021.

[2] **B. Chen**, S. Xia, J. Hao and F. Fu, "Constructions of optimal cyclic (r, δ) locally repairable codes," *IEEE Trans. Inf. Theory*, vol.64, no. 4, pp. 2499–2511, Apr. 2018.

[3] **B. Chen**, W. Fang, S. Xia, and F. Fu, "Constructions of optimal (r, δ)-locally repairable codes via constacyclic codes," *IEEE Trans. Commun.*, vol.67, no. 8, pp. 5253–5263, Aug. 2019.

[4] Y. Feng, **B. Chen**, T. Dai, S. Xia. "Adversarial attack on deep product quantization network for image retrieval," *34th AAAI Conf. Artificial Intelligence (AAAI-20)*, New York, USA, Feb. 2020, pp. 10786-10793.

[5] J. Bai, **B. Chen**, Y. Li, D. Wu, W. Guo, S. Xia, E.. Yang, "Targeted Attack for Deep Hashing based Retrieval," *13th European Conf. Computer Vision (ECCV-20)*, pp.618-634, Apr. 2020, virtual conference. (Oral, Top 2%)

新锐风采 • NEW TALENTS •

Huazi Zhang (张华滋) received his B.Sc. and Ph.D. degrees from Institute of Information and Communication Engineering in 2008 and 2013, respectively, from Zhejiang University. From 2011 to 2013, he was a visiting researcher with the Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC, USA. From 2013 to 2014, he was a Research Fellow with the School of Computer Engineering, Nanyang Technological University, Singapore. From 2014 to 2015, he was a Research Scholar with the Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL, USA.

He joined Huawei Technologies Co., Ltd in 2015. Since then, he has been engaged in research projects on polar coding, including universal rate matching / practical reliability ordering, code constructions, blind detection, hybrid automatic repeat request (HARQ) and high-efficiency decoder implementations. His current research interests are coding and information theory, with focus on algorithm design and hardware implementations for future wireless communication systems.

His key publications include:

[1] J. Tong, X. Wang, Q. Zhang, **H. Zhang**, S. Dai, R. Li and J. Wang, "Toward Terabits-per-second Communications: A High-Throughput Implementation of GN-Coset Codes," *IEEE Wireless Commun. and Netw. Conf. (WCNC)*, 2021, pp. 1-6.
[2] X. Wang, J. Tong, **H. Zhang,** S. Dai, R. Li and J. Wang, "Toward Terabits-per-second Communications: Low-Complexity Parallel Decoding of GN-coset Codes," *IEEE Wireless Commun. and Netw. Conf. (WCNC)*, 2021, pp. 1-5.
[3] X. Wang, **H. Zhang,** R. Li, J. Tong, Y. Ge and J. Wang, "On the Construction of GN-coset Codes for Parallel Decoding," *IEEE Wireless Commun. and Netw. Conf. (WCNC)*, 2020, pp. 1-6.
[4] J.Tong, **H. Zhang,** X. Wang, S. Dai, R. Li and J. Wang, "A Soft Cancellation Decoder for Parity-Check Polar Codes," *IEEE 31st Annual Int. Symp. on Personal, Indoor and Mobile Radio Commun. (PIMRC)*, 2020, pp. 1-6.
[5] L. Huang, **H. Zhang**, R. Li, Y. Ge and J. Wang, "Reinforcement Learning for Nested Polar Code Construction," *IEEE Global Commun. Conf. (GLOBECOM)*, 2019, pp. 1-6.
[6] L. Huang, **H. Zhang**, R. Li, Y. Ge and J. Wang, "AI Coding: Learning to Construct Error Correction Codes," *IEEE Trans. Commun*, vol. 68, no. 1, pp. 26-39, Jan. 2020.
[7] X. Wang, **H. Zhang**, R. Li, L. Huang, S. Dai, Y. Huangfu and J. Wang, "Learning to Flip Successive Cancellation Decoding of Polar Codes with LSTM Networks," *IEEE 30th Annual Int. Symp. on Personal, Indoor and Mobile Radio Commun. (PIMRC)*, 2019, pp. 1-5.
[8] **H. Zhang**, J. Tong, R. Li, P. Qiu, Y. Huangfu, C. Xu, X. Wang and J. Wang, "A Flip-Syndrome-List Polar Decoder Architecture for Ultra-Low-Latency Communications," *IEEE Access*, vol. 7, 2019, pp. 1149-1159.
[9] J. Tong, **H. Zhang**, L. Huang, X. Liu and J. Wang, "An Asymmetric Adaptive SCL Decoder Hardware for Ultra-Low-Error-Rate Polar Codes," *IEEE 16th Int. Symp. on Wireless Commun. Syst. (ISWCS),* 2019, pp. 532-536.
[10] **H. Zhang**, R. Li, J. Wang, S. Dai, G. Zhang, Y. Chen, H. Luo and J. Wang, "Parity-Check Polar Coding for 5G and Beyond," *IEEE Int. Conf. on Commun. (ICC),* 2018, pp. 1-7.
[11] X. Liu, Q. Zhang, P. Qiu, J. Tong, **H. Zhang**, C. Zhao and J. Wang, "A 5.16Gbps decoder ASIC for Polar Code in 16nm FinFET," *IEEE 15th Int. Symp. on Wireless Commun. Syst. (ISWCS),* 2018, pp. 1-5.

[12] M. Zhao, G. Zhang, C. Xu, **H. Zhang**, R. Li and J. Wang, "An Adaptive IR-HARQ Scheme for Polar Codes by Polarizing Matrix Extension," *IEEE Commun. Lett.*, vol. 22, no. 7, pp. 1306-1309, July 2018.
[13] **H. Zhang**, R. Li, J. Wang, Y. Chen and Z. Zhang, "Reed-Muller Sequences for 5G Grant-Free Massive Access," *IEEE Global Commun. Conf. (GLOBECOM),* 2017, pp. 1-7.
[14] **H. Zhang**, K. Sun, Q. Huang, Y. Wen and D. Wu, "FUN Coding: Design and Analysis," *IEEE/ACM Trans. Netw.*, vol. 24, no. 6, pp. 3340-3353, December 2016.

征稿启事 • CALL FOR PAPERS•

IEEE GLOBECOM Workshop on Channel Coding beyond 5G

https://globecom2021.ieee-globecom.org/workshop/ws-07-workshop-channel-coding-beyond-5g

Call for Workshop Papers

Channel coding is a fundamental component in wireless communication. From 2G to 5G, wireless systems have always adopted state-of-the-art channel coding technologies. For example, convolutional codes for 2G, turbo codes for 3G and 4G, as well as polar and low-density parity-check (LDPC) codes for 5G. In turn, the standardization and applications of state-of-the-art channel coding technologies have accelerated the research and development of channel coding. What will channel coding be as the standards continue to evolve? According to past experiences, channel coding schemes need to deliver performance surpassing previous generations: faster data rates, higher reliability, lower complexity, and lower power consumption. They also need to meet a more diverse range of KPIs that are not present in previous generations. As for 6G, some applications will raise the peak data rate to the Tbit/s level (the current eMBB data plane decoding rate is 10-20 Gbit/s), eliminating the block decoding error floor for URLLC, and improving the short block length decoding performance for mMTC toward the finite-length performance bound. In contrast to past experiences, the channel coding performance now has almost reached the theoretical Shannon limit for an additive white Gaussian noise (AWGN) channel, and Moore's law almost reached the physical limits. Will future standards follow the same path that led us to where we are now, or take a different path guided by new theoretical foundation or evaluation methodologies? Do we need revolutionary channel coding schemes, or design principles? Many fundamental problems remain open.

This workshop aims at bringing together academic and industrial researchers to discuss channel coding beyond 5G. Topics of interest include but are not limited to:

- Novel design principles and coding schemes toward 6G
- Channel coding requirements and applications for 6G
- Polar coding and decoding
- Probabilistic coding, e.g., turbo, LDPC, etc.
- Algebraic coding such as RM, BCH, RS, AG codes, etc.
- High-throughput coding schemes
- Coded shaping and modulation
- Rate matching and HARQ schemes
- Coding and decoding schemes for URLLC/mMTC/etc
- Artificial intelligence/machine learning based coding
- Joint source and channel coding
- Efficient decoding algorithms
- Hardware architecture and implementations
- Testbed and field trials of channel coding schemes
- Performance bounds on coding and decoding

Workshop Co-Chairs

- Dr. Wen Tong, Huawei Technologies Co., Ltd., Canada
- Prof. Erdal Arıkan, Bilkent University, Ankara, Turkey
- Prof. Emanuele Viterbo, Monash University, Australia

Executive Committee

- Prof. Alexander Vardy, University of California San Diego, USA
- Prof. Lajos Hanzo, University of Southampton, UK
- Dr. Huazi Zhang, Huawei Technologies Co., Ltd., China

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Technical Program Committee

- Prof. Baoming Bai, Xidian University, China
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- Prof. Li Chen, Sun Yat-sen University, China
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- Dr. Bin Li, Huawei Technologies, China
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- Prof. Rongke Liu, Beihang University, China
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- Prof. Xiao Ma, Sun Yat-sen University, China
- Prof. Marco Mondelli, Institute of Science and Technology, Austria
- Prof. Kai Niu, Beijing University of Posts and Telecommunications, China
- Mr. Mohammad Rowshan, Monash University, Australia
- Prof. Ido Tal, Technion, Israel
- Prof. Stephan ten Brink, University of Stuttgart, Germany
- Prof. Peter Trifonov, ITMO University, Russia
- Prof. Lele Wang, University of British Columbia, Canada
- Prof. Norbert Wehn, University of Kaiserslautern, Germany
- Prof. Min Ye, Tsinghua-Berkeley Shenzhen Institute, China
- Prof. Jinhong Yuan, University of New South Wales, Australia
- Prof. Zhaoyang Zhang, Zhejiang University, China

Important Dates

Paper submission deadline: ~~July 5, 2021~~ **July 15, 2021**
Acceptance announcement: September 15, 2021
Final paper submission: November 15, 2021

Submission Guidelines

The workshop accepts only original and previously unpublished papers. All submissions must be formatted in standard IEEE camera-ready format (double-column, 10pt font). The maximum number of printed pages is six including figures without incurring additional page charges (6 pages plus 1 additional page allowed with a charge for the one additional page of USD 100 if accepted)

征稿启事 • CALL FOR PAPERS•

Entropy 征稿：信息论与深度神经网络
Call for Papers: Entropy
Special Issue "Information Theory and Deep Neural Networks" of Entropy

Information theory answers two fundamental questions in communication theory, but its impact has expanded far beyond the field of communication. Many methods and ideas developed in information theory have been adopted to explain and uncover the internal mechanism in modern deep neural networks. For example, the information bottleneck has served as a tool in explaining the representation learning; mutual information has been adopted in deriving various types of generalization bounds in a deep neural network; quantization and other data compression techniques have been applied in the design of lightweight deep neural networks, namely model compression. Progress regarding an information theoretic understanding of deep neural networks has often been driven by the deep-learning-based application and induced phenomenon and is yet to be explored further.

Neural networks have a long history, aiming to understand how the human brain works and how what we call intelligence is formed. Neural networks with many layers, known as deep neural networks (DNNs), encompassing convolutional neural networks (CNN) and recurrent neural networks (RNN), have become popular and achieved state-of-the-art performance in various computer vision tasks. However, the use of deep neural networks to study and improve the classical source coding and channel coding problem in information theory is also yet to be explored. There have been some advances in applying DNNs to compressed sensing, image and video compression, channel decoding, and joint source-channel coding.

This Special Issue aims to provide an opportunity for the presentation of novel progress regarding the intersection between information theory and deep neural networks. Specifically, the information theoretic analysis and interpretation of DNN-based applications and induced phenomena, in addition to the design of improved coding schemes by DNNs in signal processing, data compression, channel coding or other topics in information theory, fall within the scope of this Special Issue. Contributions addressing any of these issues are very welcome.

Keywords:

information theoretic techniques; statistics; deep learning; model compression; data compression; compressed sensing; optimization; generalization; generative adversarial networks; graph convolutional networks; joint source-channel coding; applications

Deadline for manuscript submissions: ***15 August 2021***.

This special issue belongs to the section "**Information Theory, Probability and Statistics**".
https://www.mdpi.com/journal/entropy/special_issues/deep_neural_net

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