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个人简介

青岛理工大学副校长，国家自然科学基金杰出青年基金、国家自然科学基金优秀青年基金、山东省自然科学基金杰出青年基金、孙越崎青年科技奖获得者，山东省泰山学者特聘专家；中国力学学会流体力学专委会委员、渗流力学专业组副组长、山东岩石力学与工程协会副理事长、石油学报青年编委、中国石油大学学报（自然科学版）编委、石油科学通报副主编。一直从事“地下资源多相流动与智能化开采”方面的研究工作，以地下流体渗流、智能优化与机器学习理论为基础，以模型高效、精确的求解和计算方法研究为核心，开展了生产大数据分析、地层模型动态建模、高效开采理论与方法等基础性研究工作。获国家自然科学基金、863 项目、国家油气重大专项、中国石油重大项目等 80 余项项目资助。发表论文 220 余篇，SCI 论文 130 余篇，获省部级奖项一等奖 4 项、二等奖 3 项，编写著作 2 部。

学习经历

- 2005.9—2008.7，中国石油大学(华东)，石油工程学院，博士；
- 2002.9—2005.7，中国石油大学(华东)，石油工程学院，硕士；
- 1998.9—2002.7，中国石油大学(华东)，石油工程学院，本科。

工作经历

- 2008.7—2010.11，中国石油大学(华东)，石油工程学院，讲师
- 2010.12—2015.11，中国石油大学(华东)，石油工程学院，副教授
- 2015.12—2021.07，中国石油大学(华东)，石油工程学院，教授
- 2021.08—至今，青岛理工大学，土木工程学院，教授

学术兼职

- 中国力学学会流体力学专委会委员
- 中国力学学会流体力学领域渗流流体力学专业组副组长
- 国际数字地球学会中国国家委员会数字能源专业委员会副主任
- 山东岩石力学与工程协会副理事长
- 石油学报青年编委
- 中国石油大学学报（自然科学版）编委
- 石油科学通报副主编

教科研项目

纵向项目:

- 油藏开发智能实时优化，国家自然科学基金杰出青年基金项目
- 海上 CCUS 全流程安全监测系统集成及应用示范，重点研发计划
- 基于强化学习的离线-在线交互式油藏开发生产实时优化方法，国家自然科学基金面上项目
- 深层缝洞型碳酸盐岩油气藏开采机理及提高采收率技术研究，中石油重大科技项目
- 复杂油藏生产实时优化理论与方法，国家优秀青年科学基金项目
- 基于嵌入式离散裂缝模拟的裂缝性油藏缝网分布反演，国家自然科学基金面上项目
- 海上高含水期油藏大井距井网加密矢量优化与注采结构调整技术，国家重大科技专项
- 深水油气田智能完井关键技术，863 重大项目
- 自适应井网优化理论与方法研究，中央高校基本科研业务费专项资金
- 油藏生产动态实时优化方法研究，国家自然科学基金青年基金
- 海上大井距多层合采稠油油藏开发生产实时优化技术研究，国家科技重大专项
- 复杂地层井壁稳定控制及储层改造技术研究，国家科技重大专项
- 油田水驱体系最优调控理论方法研究，高等学校博士学科点专项科研基金
- 西非深水典型油气田高效开发模式与评价技术研究，国家科技重大专项
- 深水油藏生产实时优化调控理论研究，中央高校基本科研业务费专项资金
- 海上大井距多层合采稠油油藏开发调整技术政策研究，国家科技重大专项

横向项目:

- 不同油藏类型压驱适应性研究
- 低渗透油藏分层注采流动模拟研究
- 多井条件下注采耦合水驱波及影响因素测试
- 基于大数据的连通性定量表征及注采优化方法研究
- 油井多层合采产量自动劈分建模方法研究技术
- 海上整装多层油藏开发动态精细表征研究
- 基于机器学习的水驱油藏增产潜力预测方法
- 基于数据驱动的水驱油藏自动历史拟合方法测试
- 基于流场调控机器学习模型的油藏分注分采优化
- 基于数据与物理框架下的油藏离线建模算法研究
- 基于代理模型的海上油藏智能注采流场实时调控优化方法研究
- 油田近期可实施开发潜力综合评价方法研究
- 井组智能分层注采优化方法研究
- 砂砾岩油藏动态连通性判别方法研究
- 基于流场调控机器学习模型的方案优化方法研究及软件编制
- 基于模型驱动的油藏拟合与优化软件
- 数智云平台——智能举升工艺分析优化
- 多层合采产量劈分软件及增产措施判别与决策系统软件
- 基于机器学习的油藏开发井位优化方法
- 基于代理模型的老油田开发指标预测方法
- 大庆井下作业安全生产管理控制系统
- 加密井网重构及优化技术研究
- 页岩气藏数值模拟自动历史拟合技术研究
- 基于油藏数值模拟器代理模型的注采优化方法
- 油藏开发剩余油快速分析与高效注采优化研究
- 厚层油藏不同条件下高耗水层带形成时机测试
- 数据驱动的注采井生产动态实时优化方法研究

- 强化水驱技术政策界限测试及应用
- 埕岛主体馆上段流场调整方法研究
- 断块油藏基于细分注水的层间注采调控优化方法研究
- 埕岛主体馆上段流场表征方法研究
- 埕北 22F 井区注采优化研究
- 储气库储层注采动态压力变化规律
- 河流相高含水油田油藏注采匹配优化方法研究
- 海上油田剩余油分布模式及均衡注采方法研究
- 特高含水期复杂断块油藏分区调控优化方法研究
- 锦州 9-3 与旅大 10-1 高含水、高采出程度油田增产挖潜技术研究
- 断块油藏高部位剩余油有效动用技术研究
- 埕岛油田中高含水期差异化注水技术政策研究合同
- 改善新北油田气顶边底水油藏水驱开发效果研究合同
- 老 168 块建模数模一体化研究
- 提高分层注水井注水有效性技术研究
- 张家垛油田曲塘区块 CO₂ 驱油藏工程参数及方案研究
- 油藏动态优化平台集成技术研究
- 多参数最优化调参技术研究
- 薄互层油藏层间干扰规律研究
- 油藏闭合管理系统优化
- 河 86 断块地质水平井开发方式研究
- 埕岛油田油藏动态优化方法及应用研究

学术成果

代表性著作

- 《智能油田开发理论与方法》，科学出版社，2018 年
- 《国外智能井技术》，石油工业出版社，2011 年

代表性论文：

人工智能与应用数学领域高水平期刊文章:

- [1] G. Xue, J. Wang*, K. Zhang and N. R. Pal*, High-Dimensional Fuzzy Inference Systems, in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 54, no. 1, pp. 507-519, Jan. 2024, doi: 10.1109/TSMC.2023.3311475.
- [2] Faliang Yin, Weiguo Li, Kai Zhang, Jian Wang*, Nikhil R. Pal, Pseudo inverse versus iterated projection: Novel learning approach and its application on broad learning system [J], Information Sciences, Volume 649, 2023, 119648, ISSN 0020-0255
- [3] Xiaoming Xue, Kai Zhang*, Kay Chen Tan, Liang Feng, Jian Wang, Guodong Chen, Xinggong Zhao, Liming Zhang, Jun Yao. Affine Transformation Enhanced Multifactorial Optimization for Heterogeneous Problems[J]. IEEE Transactions on Cybernetics, 2022, 52(7): 6217-6231.
- [4] Xiaoming Xue, Cuie Yang, Yao Hu, Kai Zhang, Yiu-Ming Cheung, Linqi Song, and Kay Chen Tan. Evolutionary Sequential Transfer Optimization for Objective-Heterogeneous Problems[J], IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION, <https://doi.org/10.1109/TEVC.2021.3133874>
- [5] Yi-Fei Pu, Xuetao Xie, Jinde Cao*, Hua Chen, Kai Zhang*, Jian Wang*. An Input Weights Dependent Complex-Valued Learning Algorithm Based on Wirtinger Calculus[J], IEEE Transactions on Systems, Man, and Cybernetics: Systems, 2021, 01 March 2021, doi: 10.1109/TSMC.2021.3055501
- [6] Liming Zhang, Saisai Wang, Kai Zhang*, Xiuqing Zhang, Zhixue Sun, Hao Zhang, Miguel Tome Chipecane, Jun Yao. Cooperative artificial bee colony algorithm with multiple populations for interval multiobjective optimization problems[J]. IEEE Transactions on Fuzzy Systems, 2019, 27(5): 1052-1065. doi: 10.1109/TFUZZ.2018.2872125.
- [7] Xiangyu Wang, Kai Zhang, Jian Wang*, Yaochu Jin. An Enhanced Competitive Swarm Optimizer With Strongly Convex Sparse Operator for Large-Scale Multiobjective Optimization[J]. IEEE Transactions on Evolutionary Computation, 2022, 26(5):859-871
- [8] Guodong Chen, Kai Zhang*, Xiaoming Xue, Liming Zhang, Chuanjin Yao, Jian Wang, Jun Yao. A radial basis function surrogate model assisted evolutionary algorithm for high-dimensional expensive optimization problems[J]. Applied Soft Computing, 2022, 116:108353
- [9] Xiaoming Xue, Kai Zhang*, Rupeng Li, Liming Zhang, Chuanjin Yao, Jian Wang, Jun Yao. A topology-based single-pool decomposition framework for large-scale global optimization[J]. Applied Soft Computing. 2020, 92: 106295.
- [10] Guodong Chen, Yong Li, Kai Zhang*, Xiaoming Xue, Jian Wang, Qin Luo, Chuanjin Yao, Jun Yao. Efficient hierarchical surrogate-assisted differential evolution for high-dimensional expensive optimization[J]. Information Sciences, 2021, 542: 228-246.
- [11] Tao Gao, Xiaoling Gong, Kai Zhang*, Feng Lin*, Jian Wang*, Tingwen Huang, Jacek M. Zurada. A recalling-enhanced recurrent neural network: conjugate gradient learning algorithm and its convergence analysis[J]. Information Sciences, 2020, 519: 273-288.
- [12] Fu S, Liu W, Zhang K, et al. Semi-supervised classification by graph p-Laplacian convolutional networks[J]. Information Sciences, 2021, 560: 92-106.
- [13] Jian Wang, Qin Chang, Tao Gao, Kai Zhang, Nikhil R. Pal. Sensitivity Analysis of Takagi-Sugeno F

uzzy Neural Network. Information Sciences, 582: 725-749, 2022.

- [14] Liming Zhang, Chenyu Cui, Xiaopeng Ma, Zhixue Sun, Fan Liu, Kai Zhang*. A fractal discrete fracture network model for history matching of naturally fractured reservoirs[J]. Fractals, 2019, 27(1): 194-2008.
- [15] Kai Zhang*, Xiaopeng Ma, Yanlai Li, Haiyang Wu, Chenyu Cui, Xiaoming Zhang, Hao Zhang, Jun Yao. Parameter prediction of hydraulic fracture for tight reservoir based on micro-seismic and history matching[J]. Fractals, 2018, 26(2): 1840009.
- [16] Jiang Yunqi, Zhang Huaqing, Zhang Kai*, Wang Jian*, Cui Shiti, Han Jianfa, Zhang Liming, Yao Jun. Reservoir Characterization and Productivity Forecast Based on Knowledge Interaction Neural Network[J]. Mathematics 2022, 10: 1614.

行业领域高水平期刊文章:

- [1] Kai Zhang*, Wenhao Fu, Jinding Zhang, Wensheng Zhou, Chen Liu, Piyang Liu, Liming Zhang, Xia Yan, Yongfei Yang, Hai Sun, Jun Yao. Inversion Framework of Reservoir Parameters Based on Deep Autoregressive Surrogate and Continual Learning Strategy[J]. SPE Journal, 2023, SPE215821
- [2] Jialin Wang, Kai Zhang*, Liming Zhang, Jian Wang, Wenfeng Peng, Xia Yan, Haochen Wang, Huaqing Zhang, Yongfei Yang, Hai Sun, Piyang Liu, Haichuan Chen, Xiaokun Fang, Adaptive Basis Function Selection Enhanced Multisurrogate-Assisted Evolutionary Algorithm for Production Optimization [J]. SPE Journal, 2023, SPE217432
- [3] Chengzhe Yin, Kai Zhang, Liming Zhang, Zhenpeng Wang, Piyang Liu, Huaqing Zhang, Yongfei Yang, Jun Yao. Imbalanced Working States Recognition of Sucker Rod Well Dynamometer Cards Based on Data Generation and Diversity Augmentation[J]. SPE Journal. 2023, SPE-214661-PA.
- [4] Chao Zhong, Kai Zhang*, Xiaoming Xue, Ji Qi, Liming Zhang, Xia Yan, Huaqing Zhang, Yongfei Yang. Historical Window Enhanced Transfer Gaussian Process for Production Optimization [J]. SPE Journal, 2022, SPE-209813-PA.
- [5] Ji Qi, Kai Zhang*, Xiaoming Xue, Liming Zhang, Chao Zhong, Haochen Wang, Jun Yao. An Evolutionary Sequential Transfer Optimization Algorithm for Well Placement Optimization Based on Task Characteristics[J]. SPE Journal. 2022. SPE-212870-PA.
- [6] Kai Zhang*, Yanzhong Wang, Guoxin Li, Xiaopeng Ma, Shiti Cui, Qin Luo, Jian Wang, Yongfei Yang, and Jun Yao. Prediction of Field Saturations Using a Fully Convolutional Network Surrogate[J]. SPE Journal. 2021. SPE-205485-PA.
- [7] Xiaopeng Ma, Kai Zhang*, Jian Wang, Chuanjin Yao, Yongfei Yang, Hai Sun, and Jun Yao. An Efficient Spatial-Temporal Convolution Recurrent Neural Network Surrogate Model for History Matching [J]. SPE Journal, 2021, SPE-208604-PA.
- [8] Zhang Kai*, Zuo Yuande, Zhao Hanjun, Ma Xiaopeng, Gu Jianwei, Wang Jian, Yang Yongfei, Yao Chuanjin, Yao Jun. Fourier Neural Operator for Solving Subsurface Oil-water Two-phase Flow Partial Differential Equation[J]. SPE Journal, 2022, SPE-209223-PA.
- [9] Xiaopeng Ma, Kai Zhang*, Liming Zhang, Chuanjin Yao, Jun Yao, Haochen Wang, Jian Wang, Yongfei Yang. Data-driven Niching Differential Evolution with Adaptive Parameters Control for History Ma

- tching and Uncertainty Quantification[J]. SPE Journal. 2021, SPE-205014-PA.
- [10] Faliang Yin, Xiaoming Xue, Chengze Zhang, Kai Zhang*, Jianfa Han, Bingxuan Liu, Jian Wang, Jun Yao. Multifidelity Genetic Transfer: an Efficient Framework for Production Optimization[J]. SPE Journal, 2021, SPE-205013-PA.
- [11] Haochen Wang, Jianfa Han, Kai Zhang*, Chuanjin Yao, Xiaopeng Ma, Liming Zhang, Yongfei Yang, Local Surrogate-Model-Assisted Differential Evolution for Waterflooding Production Optimization [J]. SPE Journal, 2020, 25(1): 105-118, SPE-199357-PA.
- [12] Xia Yan, Zhaoqin Huang, Jun Yao*, Yang Li, Dongyan Fan, Hai Sun, Kai Zhang. An efficient numerical hybrid model for multiphase flow in deformable fractured-shale reservoirs[J]. SPE Journal, 2018, 23(4): 1412-1437.
- [13] Wenhui Song, Masa Prodanovic, Javier E Santos, Jun Yao*, Kai Zhang, Yongfei Yang. Upscaling of Transport Properties in Complex Hydraulic Fracture Systems[J]. SPE Journal, 2022: 1-19.
- [14] Li Yingwen, Yang Yongfei*, Dong Mingzhe, Liu Changfu, Iglauer Stefan, Kang Lixin, Yao Jun, Zhang Kai, Sun Hai, Zhang Lei. Effect of Pore Structure and Capillary Number on Gas-Water Flow Patterns in Carbonate Rocks[J]. SPE Journal, 2022, SPE-209615-PA.
- [15] Zhang Liming, Wu Jinlian, Zhang Kai, Wang Zhongzheng, Yan Xia, Liu Piyang, Wang Qiang, Fan Ling, Yao Jun, Yang Yongfei, Yu Zhigang. Diagnosis of pumping machine working conditions based on transfer learning and ViT model [J]. Geoenergy Science and Engineering, 226: 211729, 2023.
- [16] Ji Qi, Yanqing Liu, Yafeng Ju, Kai Zhang, Lu Liu, Yuanyuan Liu, Xiaoming Xue, Liming Zhang, Huaqing Zhang, Haochen Wang, Jun Yao, Weidong Zhang. A transfer learning framework for well placement optimization based on denoising autoencoder [J]. Geoenergy Science and Engineering, 2023, 222:211446.
- [17] Behzad Saberali, Naser Golsanami*, Kai Zhang*, Bin Gong, Mehdi Ostadhassan. Simulating dynamics of pressure and fluid saturation at grid-scale by a deep learning-based surrogate reservoir modeling based on a fast-supply hybrid database and developing preliminary insights for future gas hydrate exploitations in China[J]. Geoenergy Science and Engineering, 2023, 222:211415
- [18] Xiaopeng Ma, Kai Zhang*, Hanjun Zhao, Liming Zhang, Jian Wang, Huaqing Zhang, Piyang Liu, Xia Yan, Yongfei Yang. A vector-to-sequence based multilayer recurrent network surrogate model for history matching of large-scale reservoir. Journal of Petroleum Science and Engineering[J], 2022, 214:110548
- [19] Wang Zhongzheng, Zhang Kai*, Zhang Jinding, Chen Guodong, Ma Xiaopeng, Xin Guojing, Kang Jinzheng, Zhao Hanjun, Yang Yongfei. Deep reinforcement learning and adaptive policy transfer for generalizable well control optimization. Journal of Petroleum Science and Engineering[J], 2022, 217: 110868.
- [20] Zhang Kai*, Wang Qiang, Wang Lingbo, Zhang Huaqing, Zhang Liming, Yao Jun, Yang Yongfei. Fault diagnosis method for sucker rod well with few shots based on meta-transfer learning[J]. Journal of Petroleum Science and Engineering, 2022, 212: 110295.
- [21] Qiang Wang, Kai Zhang*, Hanjun Zhao, Huaqing Zhang, Liming Zhang, Xia Yan, Piyang Liu, Ling Fan, Yongfei Yang, Jun Yao. A novel method for trajectory recognition and working condition diagn

- osis of sucker rod pumping systems based on high-resolution representation learning[J]. Journal of Petroleum Science and Engineering, 2022, 218: 110931.
- [22] Xiaoming Xue, Guodong Chen, Kai Zhang*, Liming Zhang, Xinggang Zhao, Linqi Song, Menghan Wang, Peng Wang. A divide-and-conquer optimization paradigm for waterflooding production optimization[J]. Journal of Petroleum Science and Engineering, 2022, 211: 110050
- [23] Xiaopeng Ma, Kai Zhang*, Jinding Zhang, Yanzhong Wang, Liming Zhang, Piyang Liu, Yongfei Yang, Jian Wang. A novel hybrid recurrent convolutional network for surrogate modeling of history matching and uncertainty quantification [J]. Journal of Petroleum Science and Engineering, 2022, 210:110109.
- [24] Jun Yao, Yandong Nie, Zihao Zhao, Xiaoming Xue, Kai Zhang*, Chuanjin Yao, Liming Zhang, Jian Wang, Yongfei Yang. Self-adaptive multifactorial evolutionary algorithm for multitasking production optimization[J]. Journal of Petroleum Science and Engineering, 2021, 205: 108900
- [25] Xiaopeng Ma, Kai Zhang*, Liming Zhang, Yanzhong Wang, Haochen Wang, Jian Wang, and Jun Yao. A distributed surrogate system assisted differential evolutionary algorithm for computationally expensive history matching problems [J]. Journal of Petroleum Science and Engineering, 2022, 210:110029.
- [26] Zhang Kai*, Wang Zhongzheng, Chen Guodong, Zhang Liming, Yang Yongfei, Yao Chuanjin, Wang Jian, Yao Jun. Training effective deep reinforcement learning agents for real-time life-cycle production optimization[J]. Journal of Petroleum Science and Engineering, 2022, 208: 109766.
- [27] Kai Zhang*, Xiaoya Wang, Xiaopeng Ma, Jian Wang, Yongfei Yang, Liming Zhang, Jun Yao, Jian Wang. The prediction of reservoir production based proxy model considering spatial data and vector data[J]. Journal of Petroleum Science and Engineering, 2022, 208:109694.
- [28] Zhong Chao, Zhang Kai*, Xue Xiaoming , Qi Ji, Zhang Liming, Yao Chuanjin, Yang Yongfei, Wang Jian, Yao Jun, Zhang Weidong. Surrogate-reformulation-assisted multitasking knowledge transfer for production optimization[J]. Journal of Petroleum Science and Engineering, 2022, 208: 109486.
- [29] Joshua Kwesi Desbordes, Kai Zhang*, Xiaoming Xue, Xiaopeng Ma, QinLuo, Zhaoqin Huang, Sun Hai, Yao Jun. Dynamic production optimization based on transfer learning algorithms[J]. Journal of Petroleum Science and Engineering, 2022, 208: 109278
- [30] Kai Zhang*, Xinggang Zhao, Guodong Chen, Mengjie Zhao, Jian Wang*, Chuanjin Yao, Hai Sun, Jun Yao, Wei Wang, Guodong Zhang. A double-model differential evolution for constrained waterflooding production optimization[J]. Journal of Petroleum Science and Engineering, 2021, 207: 109059
- [31] Jianwei Gu*, Wei Liu, Kai Zhang, Liang Zhai, Yigen Zhang, Fuzhen Chen. Reservoir production optimization based on surrogate model and differential evolution algorithm[J]. Journal of Petroleum Science and Engineering, 2021, 205: 108879.
- [32] Mengjie Zhao, Kai Zhang*, Guodong Chen, Xinggang Zhao, Chuanjin Yao, Hai Sun, Zhaoqin Huang, Jun Yao. A surrogate-assisted multi-objective evolutionary algorithm with dimension-reduction for production optimization[J]. Journal of Petroleum Science and Engineering, 2020, 192: 107192.
- [33] Xinggang Zhao, Kai Zhang*, Guodong Chen, Xiaoming Xue, Chuanjin Yao, Jian Wang, Yongfei Yang, Hui Zhao, Jun Yao. Surrogate-assisted differential evolution for production optimization with nonl

linear state constraints[J]. Journal of Petroleum Science and Engineering, 2020, 194: 107441.

- [34] Liming Zhang, Chao Xu, Kai Zhang*, Chuanjin Yao, Yongfei Yang, Jun Yao. Production optimization for alternated separate-layer water injection in complex fault reservoirs[J]. Journal of Petroleum Science and Engineering[J]. 2020, 193: 107409.
- [35] Guodong Chen, Kai Zhang*, Xiaoming Xue, Liming Zhang, Jun Yao, Hai Sun, Ling Fan, Yongfei Yang. Surrogate-assisted evolutionary algorithm with dimensionality reduction method for water flooding production optimization[J]. Journal of Petroleum Science and Engineering, 2020, 185: 106633.
- [36] Hao Zhang, Kai Zhang*, Liming Zhang, James Sheng, Jun Yao, Jian Wang, Yongfei Yang. Construction and optimization of adaptive well pattern based on reservoir anisotropy and uncertainty[J]. Journal of Petroleum Science and Engineering, 2019, 181: 106252.
- [37] Kai Zhang, Xiaoming Zhang, Liming Zhang, Jun Yao*, Xia Yan. Inversion of fractures based on equivalent continuous medium model of fractured reservoirs[J]. Journal of Petroleum Science and Engineering, 2017, 151: 496-506.
- [38] Kai Zhang, Xiaoming Zhang, Wei Ni, Liming Zhang, Jun Yao*, Lixin Li, Xia Yan. Nonlinear constrained production optimization based on augmented Lagrangian function and stochastic gradient[J]. Journal of Petroleum Science and Engineering, 2016, 146: 418-431.
- [39] Kai Zhang, Ranran Lu, Liming Zhang*, Xiaoming Zhang, Jun Yao, Rupeng Li, Hui Zhao. A two-stage efficient history matching procedure of non-Gaussian fields[J]. Journal of Petroleum Science and Engineering, 2016, 138: 189-200.
- [40] Kai Zhang, Yuxue Chen, Liming Zhang, Jun Yao*, Wei Ni, Haiyang Wu, Hui Zhao, Jungln Lee. Well pattern optimization using NEWUOA algorithm[J]. Journal of Petroleum Science and Engineering, 2015, 134: 257-272.
- [41] Kai Zhang, Gaoming Li*, Albert C. Reynolds, Jun Yao, Liming Zhang. Optimal well placement using an adjoint gradient[J]. Journal of Petroleum Science and Engineering, 2010, 73(3-4): 220-226.
- [42] Kai Zhang*, Hao Zhang, Liming Zhang, Ping Li, Xiaoming Zhang, Jun Yao. A new method for the construction and optimization of quadrangular adaptive well pattern[J]. Computational Geosciences, 2017, 21(3): 499-518.
- [43] Kai Zhang, Wenjuan Zhang, Liming Zhang, Jun Yao*, Yuxue Chen, Ranran Lu. A study on the construction and optimization of triangular adaptive well pattern[J]. Computational Geosciences, 2014, 18(2): 139-156.

其他文章:

- [1] Jingqi Lin, Kai Zhang*, Liming Zhang, Piyang Liu, Wenfeng Peng, Huaqing Zhang, Xia Yan, Chen Liu, Yongfei Yang, Hai Sun, Jun Yao. Towards efficient and accurate CO₂ sequestration optimization: Integrating hierarchical spatio-temporal information into deep-learning-based surrogate models[J]. Fuel, 2024, 356:129343
- [2] HaoChen Wang, Kai Zhang*, Nancy Chen**, WenSheng Zhou, Chen Liu, JiFu Wang, LiMing Zhang, ZhiGang Yu, ShiTi Cui, MeiChun Yang. Better use of experience from other reservoirs for accurate production forecasting by learn-to-learn method. Petroleum Science. 2024, 21:716-728

- [3] Jinding Zhang, Xin Guo, Zihao Zhao, Kai Zhang*, Xiaopeng Ma, Weifeng Liu, Jian Wang, Chen Liu, Yongfei Yang, Chuanjin Yao, Jun Yao. A local parameterization-based probabilistic cooperative coevolutionary algorithm for history matching[J]. *Mathematical Geosciences*, 2023: 1-30.
- [4] Jialin Wang, Liming Zhang*, Kai Zhang, Jian Wang, Jianping Zhou, Wenfeng Peng, Faliang Yin, Chao Zhong, Xia Yan, Piyang Liu, Huaqing Zhang, Yongfei Yang, Hai Sun. Multi-surrogate framework with an adaptive selection mechanism for production optimization [J]. *Petroleum Science*, 2023, ISSN 1995 - 8226
- [5] Wenhao Fu, Kai Zhang*, Xiaopeng Ma, Piyang Liu, Liming Zhang, Xia Yan, Yongfei Yang, Hai Sun, Jun Yao. Deep Conditional Generative Adversarial Network Combined With Data-Space Inversion for Estimation of High-Dimensional Uncertain Geological Parameters[J]. *Water Resources Research*, 2023, 59(3): e2022WR032553.
- [6] Zhao Zhang*, Xia Yan, Piyang Liu, Kai Zhang, Renmin Hana, Sheng Wang. A physics-informed convolutional neural network for the simulation and prediction of two-phase Darcy flows in heterogeneous porous media[J]. *Journal of Computational Physics*, 2023, 477:111919
- [7] Yunqi Jiang, Wenjuan Shen, Huaqing Zhang, Kai Zhang*, Jian Wang*, and Liming Zhang. An Interpretable Recurrent Neural Network for Waterflooding Reservoir Flow Disequilibrium Analysis[J]. *Water*, 2023, 15:623
- [8] Piyang Liu, Kai Zhang*, Jun Yao. Reservoir automatic history matching Methods, challenges, and future directions[J]. *Advances in Geo-Energy Research*, 2023, 7(2):136-140
- [9] Yunqi Jiang, Huaqing Zhang, Kai Zhang*, Jian Wang*, Jianfa Han, Shiti Cui, Liming Zhang, Hanjun Zhao, Piyang Liu and Honglin Song. Waterflooding Interwell Connectivity Characterization and Productivity Forecast with Physical Knowledge Fusion and Model Structure Transfer[J]. *Water*, 2023, 15: 218
- [10] Behzad Saberali, Kai Zhang*, Naser Golsanami*.Data-Driven Proxy Modeling of Water Front Propagation in Porous Media[J]. *International Journal of Computational Fluid Dynamics*, 2022, DOI: 10.1080/10618562.2022.2153835
- [11] Haochen Wang, Kai Zhang*, Xingliang Deng, Shiti Cui, Xiaopeng Ma, Zhongzheng Wang, Ji Qi, Jian Wang, Chuanjin Yao, Liming Zhang, Yongfei Yang, Huaqing Zhang. Highly Accurate Oil Production Forecasting under Adjustable Policy by a Physical Approximation Network[J]. *Energy Reports*, 2022, 8: 14396-14415.
- [12] Kai Zhang*, Haiqun Yu, Xiaopeng Ma, Jinding Zhang, Jian Wang, Chuanjin Yao, Yongfei Yang, Hai Sun, Jun Yao, Jian Wang, Multi-source information fused generative adversarial network model and data assimilation based history matching for reservoir with complex geologies[J], *Petroleum Science*, 2021, <https://doi.org/10.1016/j.petsci.2021.10.007>.
- [13] Dongyan Fan, Hai Sun, Jun Yao, Kai Zhang, Xia Yan, Zhixue Sun. Well production forecasting based on ARIMA-LSTM model considering manual operations[J]. *Energy*, 2021, 220:119708
- [14] Xiaoling Gong, Ling Yu, Jian Wang*, Kai Zhang*, Xiao Bai, Nikhil R. Pal. Unsupervised feature selection via adaptive autoencoder with redundancy control[J]. *Neural Networks*, 2022, 150:87-101
- [15] Huaqing Zhang, Yunqi Jiang, Jian Wang*, Kai Zhang*, Nikhil R. Pal. Bilateral Sensitivity Analysis

- s: A Better Understanding of a Neural Network and Its Application to Reservoir Engineering[J]. International Journal of Machine Learning and Cybernetics, 2022, <https://doi.org/10.1007/s13042-022-01511-z>
- [16] Liming Zhang, Chuangde Zhang, Kai Zhang*, Lei Zhang*, Jun Yao, Hai Sun, Yongfei Yang. Pore-scale investigation of methane hydrate dissociation using the lattice boltzmann method[J]. Water Resources Research, 2019, 55(11): 8422-8444.
- [17] Liming Zhang, Ji Qi, Kai Zhang*, Lixin Li, Xiaoming Zhang, Haiyang Wu, Miguel Tome Chipecañe, Jun Yao. Calibrate complex fracture model for subsurface flow based on Bayesian formulation[J]. Petroleum Science, 2019, 16(5): 1105-1120.
- [18] Liming Zhang, Ji Qi, Lixin Li, Kai Zhang*, Zhixue Sun, Yongfei Yang, Qin Luo. A forward modeling method based on electromagnetic theory to measure the parameters of hydraulic fracture[J]. Fuel, 2019, 251: 466-473.
- [19] Liming Zhang, Chenyu Cui, Kai Zhang*, Yi Wang, Zhixue Sun, Jun Yao, Qin Luo. Reducing fracture prediction uncertainty based on time-lapse seismic (4D) and deterministic inversion algorithm[J]. International Journal for Uncertainty Quantification, 2019, 9(2): 187-204.
- [20] Liming Zhang, Kai Zhang*, Yuxue Chen, Meng Li, Jun Yao, Lixin Li, Jungln Lee. Smart well pattern optimization using gradient algorithm[J]. Journal of Energy Resources Technology, 2016, 138(1): 012901.
- [21] Kai Zhang, Liming Zhang, Jun Yao*, Yuxue Chen, Ranran Lu. Water flooding optimization with adjoint model under control constraints[J]. Journal of Hydrodynamics, 2014, 26(1): 75-85.
- [22] 张凯, 赵兴刚, 张黎明, 张华清, 王浩臣, 陈国栋, 赵孟杰, 姜云启, 姚军. 智能油田开发中的大数据及智能优化理论和方法研究现状及展望[J]. 中国石油大学学报(自然科学版), 2020, 44(4): 28-38.
- [23] 马小鹏, 张凯*, 陈昕晟, 曹庆平, 姚传进, 谷建伟. 基于集合光滑的深度学习自动历史拟合方法[J]. 中国石油大学学报(自然科学版), 2020, 44(4):68-76.
- [24] 王塞塞, 张黎明*, 王建, 吴义志, 张凯. 基于多目标算法的断块油藏生产优化研究[J]. 特种油气藏, 2019, 26(5): 124-129.
- [25] 张凯, 马小鹏, 王增飞, 刘凡, 马玮, 姚军. 一种强非均质性油藏自动历史拟合混合求解方法[J]. 中国石油大学学报(自然科学版), 2018, 42(5): 89-97.
- [26] 张凯, 张秀清, 张黎明, 张进, 孙海, 黄朝琴, 姚军. 基于改进的同步扰动随机逼近算法的聚表二元驱优化[J]. 中国石油大学学报(自然科学版), 2017, 41(5): 102-109.
- [27] 张凯, 龙涛, 吴义志, 李萍, 尚洋洋, 张黎明. 断块油藏高部位剩余油径向钻孔产能预测[J]. 油气地质与采收率, 2017, 24(5): 120-126.
- [28] 姚军*, 孙致学, 张凯, 曾青东, 严侠, 张敏. 非常规油气藏开采中的工程科学问题及其发展趋势[J]. 石油科学通报, 2016, 1(1): 128-142.

代表性专利:

- [1] 一种基于迁移学习的油井酸化措施效果预测方法
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- [7] 一种考虑时序性及细分任务的自适应代理策略优化方法
- [8] 一种基于深度自回归网络和持续学习策略的历史拟合方法
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