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Copula 熵

Jian Ma and Zengqi Sun. "Mutual Information Is Copula Entropy". In: *Tsinghua Science & Technology* 16.1 (2011). See also arXiv preprint arXiv:0808.0845 (2008), pp. 51–54

$$H_c(\mathbf{x}) = - \int_{\mathbf{u}} c(\mathbf{u}) \log c(\mathbf{u}) d\mathbf{u} \quad (1)$$

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- 测光红移
 - 测光红移准确度提升¹
 - 斯隆类星体巡天观测数据

理论物理学

- 相关粒子系统
 - 平衡态相关粒子系统中熵的推导和计算²

²Jian Ma. "On Thermodynamic Interpretation of Copula Entropy". In: *arXiv preprint arXiv:2111.14042* (2021).

理论化学

- 变构效应研究
 - 变构效应配位点和激活点热力学耦合模型³
 - 丙氨酸二肽的 C 端和 N 端

³Michel A. Cuendet, Harel Weinstein, and Michael V. LeVine. "The Allosteric Landscape: Quantifying Thermodynamic Couplings in Biomolecular Systems". In: *Journal of Chemical Theory and Computation* 12.12 (2016), pp. 5758–5767. DOI: 10.1021/acs.jctc.6b00841.

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水文学 III

- 中长期径流预报
 - 南水北调工程丹江口水库入库径流预报¹⁵
 - 洪泽湖和骆马湖长期径流预报¹⁶
- 流域分区¹⁷
- 多站点径流生成
 - 巴西雅瓜拉比-大都市水库系统¹⁸

¹⁵黄朝君 et al. “基于 Copula 熵-随机森林的中长期径流预报研究”. In: 人民长江 52.11 (2021), pp. 81–85.

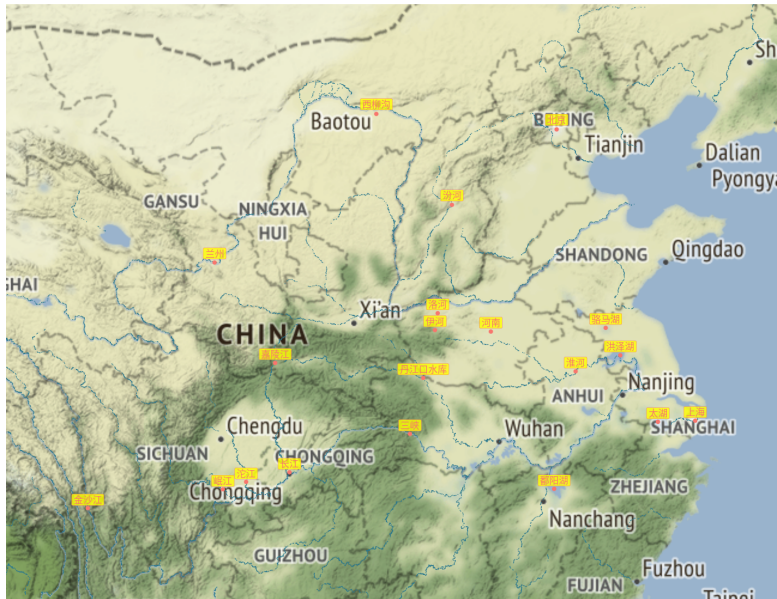
¹⁶Ran Mo et al. "Long-term probabilistic streamflow forecast model with "inputs-structure-parameters" hierarchical optimization framework". In: *Journal of Hydrology* (2023), p. 129736. DOI: 10.1016/j.jhydro.2023.129736.

¹⁷ 刘磊 et al. “基于非线性相关性和复杂网络的径流相似性分区”. In: 水科学进展 33.3 (2022), pp. 442–451.

¹⁸Victor Costa Porto et al. "A GLM copula approach for multisite annual streamflow generation". In: *Journal of Hydrology* 598 (2021), p. 126226.

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水文学-国内应用地图



气候学

- 气候变化对水文气象变量相关性的影响
 - 美国德州达拉斯地区降水和气温相关性关系分析²⁴
 - 达拉斯市沃斯堡 (Fort Worth) 地区降水和气温观测数据
- 气候评估
 - 欧洲城市气候分类²⁵
 - 欧洲 25 座城市气温和降水数据

²⁴ Zengchao Hao and Vijay P. Singh. "Integrating Entropy and Copula Theories for Hydrologic Modeling and Analysis". In: *Entropy* 17.4 (2015). pp. 2253–2280. doi: 10.3390/e17042253.

²⁵ **Francesca Condino**. “La divergenza di Jensen-Shannon nell’algoritmo di clustering dinamico per dati descritti da distribuzioni multivariate”. PhD thesis. Università degli Studi di Napoli Federico II, 2009.

气象学

- 大气污染气象成因分析
 - 北京地区气象因素对 PM2.5 浓度的因果关系分析²⁶
 - 北京地区 PM2.5 和气象观测数据
 - PM2.5 浓度预测²⁷
 - 北京地区 PM2.5 和气象观测数据
 - 上海和广州大气污染预测预警²⁸
 - 上海和广州 PM2.5 和气象观测数据
- 气象灾害预测
 - 广西地区台风灾情预测类²⁹
 - 广西地区台风灾害数据

²⁶ Jian Ma. "Estimating Transfer Entropy via Copula Entropy". In: *arXiv preprint arXiv:1910.04375* (2019).

²⁷ Xiaoxuan Wu et al. "Research on PM2.5 Concentration Prediction Based on the CE-AGA-LSTM Model". In: *Applied Sciences* 12.14 (2022), p. 7009. DOI: 10.3390/app12147009, Jieyin Chen. "Short-Term Prediction of PM2.5 Concentration based on Self-Attention Mechanism Improved Temporal Convolution Network". In: *2023 International Seminar on Computer Science and Engineering Technology (SCSET)*. 2023, pp. 528–534. DOI: 10.1109/SCSET58950.2023.00121.

²⁸ Jujie Wang et al. "A novel air quality prediction and early warning system based on combined model of optimal feature extraction and intelligent optimization". In: *Chaos, Solitons & Fractals* 158 (2022), p. 112098. DOI: 10.1016/j.chaos.2022.112098.

²⁹ 陈燕璇, 刘合香, and 倪增华. "基于 Copula 熵因子选取的 PSO-ELM 台风灾情预测模型". In: *气象研究与应用* 40.2 (2019), pp. 7–11.

环境学

- 大气污染传播路径分析
 - 兰州市大气污染传播路径预测³⁰
 - 兰州市环境气象检测网络 2017 年 PM2.5 观测数据
- 火电厂排放污染物管控
 - 火电厂氮氧化物排放浓度预测³¹
 - 宁夏某燃煤电厂运行数据

³⁰ 吴京鹏. “基于图嵌入表示的节点无特征网络链路预测研究”. 硕士学位论文. 西北师范大学, 2022.

³¹ 金秀章, 乔鹏, and 史德金. “基于 VMD-Bayes-Lasso 算法带误差补偿的火电厂 NO_x 浓度软测量”. In: 华北电力大学学报 (自然科学版) (2023).

生态学

- 动物运动轨迹分析
 - Cylcop 算法包³²

³²Florian H. Hodel and John R. Fieberg. "Cylcop: An R Package for Circular-Linear Copulae with Angular Symmetry". In: *bioRxiv* (2021), p. 2021.07.14.452253, Florian Hodel. *cylcop: Circular-Linear Copulas with Angular Symmetry for Movement Data*. CRAN. R package version 0.2.0. 2022. URL: <https://cran.r-project.org/package=cylcop>.

- ³⁴ Soumik Purkayastha and Peter X.K. Song. "Asymmetric predictability in causal discovery: an information theoretic approach". In: *arXiv preprint arXiv:2210.14455* (2022).

农学

- 作物产量预测
 - 气候变化对我国南方两季稻产量的影响及对策³⁵
 - 南方（江南和华南）54 个地点未来气候变化数据和作物数据

³⁵ Ziya Zhang et al. "Impact of climate change and planting date shifts on growth and yields of double cropping rice in southeastern China in future". In: *Agricultural Systems* 205 (2023), p. 103581. DOI: 10.1016/j.agsy.2022.103581.

神经科学 I

● 认知神经学

● 分析大脑认知活动的多模态数据³⁶

- 人脸检测任务 EEG 数据
- 听觉语音刺激任务和认知行为映射任务 MEG 数据
- 奖惩学习任务前脑岛 (anterior Insula) SEEG 数据

● 语音信息的编码和解析³⁷

- 故事讲述语音及相应的 EEG 数据

● 因果关系脑连接网络分析³⁸

- 注意缺陷多动障碍患者 EEG 数据
- 葡萄牙老年人静息态 fMRI 数据

³⁶Stephanie J. Kayser et al. "Irregular Speech Rate Dissociates Auditory Cortical Entrainment, Evoked Responses, and Frontal Alpha". In: *The Journal of Neuroscience* 35.44 (2015), pp. 14691–14701, Robin A. A. Ince et al. "The Deceptively Simple N170 Reflects Network Information Processing Mechanisms Involving Visual Feature Coding and Transfer Across Hemispheres". In: *Cerebral Cortex* 26.11 (2016), pp. 4123–4135, Robin A.A. Ince et al. "A statistical framework for neuroimaging data analysis based on mutual information estimated via a gaussian copula". In: *Human Brain Mapping* 38.3 (2017), pp. 1541–1573, Etienne Combrisson et al. "Group-level inference of information-based measures for the analyses of cognitive brain networks from neurophysiological data". In: *NeuroImage* (2022), p. 119347. DOI: 10.1016/j.neuroimage.2022.119347.

³⁷Pieter De Clercq et al. "Beyond linear neural envelope tracking: a mutual information approach". In: *Journal of Neural Engineering* 20.2 (2023), p. 026007. DOI: 10.1088/1741-2552/acbe1d.

³⁸Paolo Victor Redondo, Raphaël Huser, and Hernando Ombao. "Measuring Information Transfer Between Nodes in a Brain Network through Spectral Transfer Entropy". In: *arXiv preprint arXiv:2303.06384* (2023), 汪方毅 et al. "基于静息态 fMRI 区分健康老年人认知水平的 MVPA 方法研究". In: *磁共振成像* 14.6 (2023), pp. 18–25.

神经科学 II

- 运动神经学
 - 分析运动的肌肉组合协同策略³⁹
 - 伸手运动时肌肉 sEMG 数据
 - 自主运动肌肉疲劳状态 sEMG 数据
- 计算神经学
 - 神经元可塑性建模⁴⁰
 - 神经网络信息传输关系分析⁴¹

³⁹ 吴亚婷 et al. “多尺度肌间耦合网络分析”. In: 生物医学工程学杂志 38.4 (2021), pp. 742–752, Yating Wu et al. “R-Vine Copula Mutual Information for Intermuscular Coupling Analysis”. In: *Proceedings of the 11th International Conference on Computer Engineering and Networks*. 2022, pp. 526–534, David Ó’ Reilly and Ioannis Delis. “A network information theoretic framework to characterise muscle synergies in space and time”. In: *Journal of Neural Engineering* 19.1 (2022), p. 016031. DOI: 10.1088/1741-2552/ac5150, Shaojun Zhu et al. “Intermuscular coupling network analysis of upper limbs based on R-vine copula transfer entropy”. In: *Mathematical Biosciences and Engineering* 19.9 (2022), pp. 9437–9456, 金国美 et al. “基于小波包-Copula 互信息的肌间耦合特性”. In: 传感技术学报 35.10 (2022), pp. 1348–1353.

⁴⁰ Johannes Leugering and Gordon Pipa. “A Unifying Framework of Synaptic and Intrinsic Plasticity in Neural Populations.”. In: *Neural Computation* 30.4 (2018), pp. 945–986.

⁴¹ Ari Pakman et al. “Estimating the Unique Information of Continuous Variables in Recurrent Networks”. In: *Advances in Neural Information Processing Systems* (2021).

心理学

- 生物心理学
 - 情绪刺激下心跳诱发脑电位的时间交互现象⁴²
 - 用于情绪分析的生理信号 DEAP 数据集

⁴²Liesa Ravijts. "Revealing temporal interactions around the heartbeat-evoked potential modulated by emotional perception". MA thesis. Ghent Univeristy, 2019.

生物学

- 系统生物学

- 生物信号调控和传导⁴³
 - 癌症分子机制数据
- 生物现象动态网络结构和功能⁴⁴
 - 酵母细胞周期数据

- 生物信息学

- 分析基因数据，研究生命和疾病机理⁴⁵
 - 肝炎病毒感染治疗基因表达谱数据
- 筛选与癌症有关的变异基因⁴⁶
 - cBioPortal 癌症基因组数据
 - 美国亚利桑那州立大学癌症基因组数据

⁴³Agata Charzyńska and Anna Gambin. "Improvement of the k-NN Entropy Estimator with Applications in Systems Biology". In: *Entropy* 18.1 (2015), p. 13.

⁴⁴Farzaneh Farhangmehr et al. "An information-theoretic algorithm to data-driven genetic pathway interaction network reconstruction of dynamic systems". In: *2013 IEEE International Conference on Bioinformatics and Biomedicine*. 2013, pp. 214–217.

⁴⁵Mario Wieser et al. "Inverse Learning of Symmetries". In: *Advances in Neural Information Processing Systems*. Vol. 33. 2020, pp. 18004–18015.

⁴⁶Qiang Wu and Dongxi Li. "CRIA: An Interactive Gene Selection Algorithm for Cancers Prediction Based on Copy Number Variations". In: *Frontiers in Plant Science* 13 (2022), p. 839044. DOI: 10.3389/fpls.2022.839044.

医学 I

- 临床医学

- 心脏病诊断⁴⁷

- UCI 心脏病数据

- 糖尿病病情管理⁴⁸

- 美国 Health Facts 糖尿病救治网络数据

- 癌症预后⁴⁹

- UCI 肺癌数据

- SEER 数据库乳腺癌临床数据

⁴⁷ Jian Ma. "Variable Selection with Copula Entropy". In: *Chinese Journal of Applied Probability and Statistics* 37.4 (2021). See also arXiv preprint arXiv:1910.12389 (2019), pp. 405–420.

⁴⁸ Radko Mesiar and Ayyub Sheikh. "Nonlinear Random Forest Classification, a Copula-Based Approach". In: *Applied Sciences* 11.15 (2021), p. 15. DOI: 10.3390/app11157140.

⁴⁹ Jian Ma. "Copula Entropy based Variable Selection for Survival Analysis". In: *arXiv preprint arXiv:2209.01561* (2022), 付金露. "基于特征选择的乳腺癌患者预后模型研究". 硕士学位论文. 江西财经大学, 2023.

医学 II

● 临床医学

- 白内障术后角膜水肿风险预测⁵⁰
 - 临床白内障超声乳化手术患者数据
- 主动脉瓣置换手术射血分数分析⁵¹
 - 临床主动脉瓣置换手术前后射血分数数据
- 脑肿瘤医学影像组学诊断模型构建⁵²
 - 重庆医科大学附属第一医院、西南医院和四川省肿瘤医院脑肿瘤患者数据
- 基于脉搏波的高血压和糖尿病健康状态分类⁵³
 - 高血压和糖尿病患者脉搏波数据

⁵⁰Yu Luo et al. "Research on Establishing Corneal Edema after Phacoemulsification Prediction Model Based on Variable Selection with Copula Entropy". In: *Journal of Clinical Medicine* 12.4 (2023), p. 1290. DOI: 10.3390/jcm12041290.

⁵¹S.M. Sunoj and N. Unnikrishnan Nair. "Survival Copula Entropy and Dependence in Bivariate Distributions". In: *REVSTAT-Statistical Journal* (2023). URL: <https://revstat.ine.pt/index.php/REVSTAT/article/view/560>.

⁵²潘红宇. "基于影像组学与深度学习的脑肿瘤图像分类研究". 硕士学位论文. 西南大学, 2023.

⁵³汤宇飞. "基于脉搏波的糖尿病和高血压诊断算法研究". 硕士学位论文. 中国矿业大学, 2023.

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社会科学 I

● 经济学

- 扶贫政策效果评估，用于政策目标人口鉴别⁶⁰
 - 2018 年政府贫困家庭状况普查数据（四川省和河南省）
- 议价机制中的互惠行为和时间效应⁶¹
 - eBay 的 Best Offer 平台数据
- 产业链内部相关性分析⁶²
 - 国内畜禽养殖产业链主要上市企业股票价格数据
- 投资者情绪分析⁶³
 - 中国新能源汽车上市公司的百度搜索数据

⁶⁰ Qingsong Shan and Qianning Liu. "Binary Trees for Dependence Structure". In: *IEEE Access* 8 (2020), pp. 150989–150998. DOI: 10.1109/ACCESS.2020.3017529. 罗良清 et al. "中国贫困治理经验总结：扶贫政策能够实现有效增收吗？". In: *管理世界* 38.2 (2022), pp. 70–83. Haonan Zhang, Jiapeng Dai, and Yousaf Ali Khan. "Poverty improvement policies and household income: Evidence from China". In: *Heliyon* (2023), E21442. DOI: 10.1016/j.heliyon.2023.e21442.

⁶¹ Leonie Bossemeyer. "Machine Learning for Causal Discovery with Applications in Economics". MA thesis. Ludwig-Maximilians-Universität München, 2021.

⁶² 韦颖璐. "基于 pair-copula 熵的相关性度量". 硕士学位论文. 苏州大学, 2021.

⁶³ Muye Han and Jinsheng Zhou. "Multi-Scale Characteristics of Investor Sentiment Transmission Based on Wavelet, Transfer Entropy and Network Analysis". In: *Entropy* 24.12 (2022), p. 1786. DOI: 10.3390/e24121786.

社会科学 II

● 管理学

● 商品期货价格预测⁶⁴

- 国家统计局猪肉价格数据和大连商品交易所大豆期货价格数据

● 单周期库存管理⁶⁵

- 大众朗逸汽车销售数据

● 中国企业海外并购影响因素分析⁶⁶

- Wind 数据库经济数据

● 社会学

● 分析教育、职业和收入上的性别不平等问题⁶⁷

- 美国国家成年人收入调查数据（1994 年）

⁶⁴Wuyue An, Lin Wang, and Dongfeng Zhang. "Comprehensive commodity price forecasting framework using text mining methods". In: *Journal of Forecasting* 42.7 (2023), pp. 1865–1888. DOI: 10.1002/for.2985.

⁶⁵Yu-Xin Tian and Chuan Zhang. "An end-to-end deep learning model for solving data-driven newsvendor problem with accessibility to textual review data". In: *International Journal of Production Economics* (2023), p. 109016. DOI: 10.1016/j.ijpe.2023.109016.

⁶⁶王琳君. "中国企业海外并购的影响因素和绩效评价研究". 博士学位论文. 中国科学院大学, 2022.

⁶⁷Jian Ma. "Causal Domain Adaptation with Copula Entropy based Conditional Independence Test". In: *arXiv preprint arXiv:2202.13482* (2022).

社会科学 III

- 教育学
 - 高中数学成绩与其他学科成绩相关性分析⁶⁸
 - 某市 2013 级理科学生高一、高二期末成绩和高三两次模考成绩
- 计算语言学
 - 城市热线派单系统知识图谱构建⁶⁹
 - 济南市民热线数据
- 新闻传播学
 - 上海新冠疫情下的公众情绪变化⁷⁰
 - 微博平台“上海疫情”主题数据
- 法学
 - 社区属性与社区犯罪关系分析⁷¹
 - 美国社区与犯罪数据集

⁶⁸ 柳琼. “基于 Copula 和 MI 理论的相关性度量及其应用研究”. 硕士学位论文. 三峡大学, 2018.

⁶⁹ 陈作海, 钱恒, and 高永超. “一种基于知识图谱的城市热线派单方法及系统”. Pat. CN115860436A. 2023.

⁷⁰ Bowen Zhang et al. “Changes in Public Sentiment under the Background of Major Emergencies – Taking the Shanghai Epidemic as an Example”. In: *International Journal of Environmental Research and Public Health* 19.19 (2022), p. 12594. DOI: 10.3390/ijerph191912594.

⁷¹ Mario Wieser. “Learning Invariant Representations for Deep Latent Variable Models”. PhD thesis. University of Basel, 2020.

社会科学 IV

- 政治学
 - 分析政权领导力因素和政权危机之间关系⁷²
 - 雪城大学莫伊尼汉全球事务研究所国际政治领导力数据集
- 军事学
 - 目标意图识别⁷³
 - 空中飞行目标示例
- 情报学
 - 颠覆性技术科学-技术-产业互动模式分析⁷⁴
 - 再生医学（干细胞）和白血病治疗相关资料数据

⁷²Stuart William Card. "Towards an Information Theoretic Framework for Evolutionary Learning". MA thesis. Syracuse University, 2011.

⁷³张可 et al. “一种基于动态贝叶斯网络的目标意图识别方法”. Pat. CN114997306A. 2022.

⁷⁴许海云 et al. “颠覆性技术的科学-技术-产业互动模式识别与分析”. In: 情报学报 42.7 (2023), pp. 816–831.

工程学 I

● 能源工程

- 能源网络管理，研究天气因素与能源网络的耦合⁷⁵
 - 北方某地区能源系统运行数据
- 光伏发电功率预测⁷⁶
 - 澳大利亚 Yulara 地区光伏电站数据
- 风电机组工况划分⁷⁷
 - 广东某海上风电场 SCADA 数据
- 电力负荷预测⁷⁸
 - 摩洛哥缔头万 (Tétouan) 城电力消费数据
 - 美国亚利桑那居民建筑综合能源负荷 2018 年数据
- 风光储协同规划⁷⁹
 - 某工业园区风光火储联合发电系统

⁷⁵ Xueqian Fu et al. "Uncertainty analysis of an integrated energy system based on information theory". In: *Energy* 122.122 (2017), pp. 649–662.

⁷⁶ 朱正林 和 张冕. "基于 AO 优化 VMD-CE-BiGRU 的光伏发电功率预测". In: *国外电子测量技术* 41.10 (2022), pp. 56–61.

⁷⁷ 崔双双 和 孙单勋. "分工况下风电机组各变量相关性研究". In: *综合智慧能源* 44.12 (2022), pp. 49–55.

⁷⁸ Jian Ma. "Identifying Time Lag in Dynamical Systems with Copula Entropy based Transfer Entropy". In: *arXiv preprint arXiv:2301.06037* (2023), Qin Yan et al. "Short-term prediction of integrated energy load aggregation using a bi-directional simple recurrent unit network with feature-temporal attention mechanism ensemble learning model". In: *Applied Energy* 355 (2024), p. 122159. DOI: 10.1016/j.apenergy.2023.122159.

⁷⁹ 董海艳 et al. "一种含源荷时序相似度约束的源储协同规划配置方法". Pat. CN114421538A. 2022.

工程学 II

● 能源工程

- 电网频率稳定性预测⁸⁰
 - 贵州电网数据
- 用户线损贡献分析⁸¹
 - 辽宁电网数据
- 配电网拓扑辨识⁸²
 - 接入风机和光伏的家庭负荷配电网仿真数据
- 电价预测⁸³
 - 2017 年美国 PJM 电力市场电价数据
- 电力系统宽频振荡影响因素和传播路径分析⁸⁴
 - 直驱风机并网系统和含风电场的四机两区系统仿真数据

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工程学 III

- 能源工程
 - 锂电池容量估计⁸⁵
 - NASA 锂电池退化数据
 - 能效异常原因诊断⁸⁶
 - 空压机系统运行数据

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工程学 IV

- 食品工程
 - 葡萄酒质量与理化成分关系分析⁸⁷
 - 葡萄牙绿酒葡萄酒理化成分与质量评价数据
- 土木建筑
 - 建筑能源系统节能技术⁸⁸
 - 大连某教学楼供热监测数据
 - 工程变形监测⁸⁹
 - 某隧道工程施工段围堰监测数据

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工程学 V

- 交通运输
 - 大件货物运输方案制定⁹⁰
 - 大件货物运输案例数据
 - 航空和高铁票价影响因素分析⁹¹
 - 京沪高铁和航空票价数据
 - 城市轨道交通客流分析和预测⁹²
 - 苏州市轨道交通系统客流时序数据

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工程学 VI

● 制造工程

- 制造质量管理，研究优化制造过程参数，预测产品质量⁹³
 - 富士康生产线制造过程数据
- 装配质量控制⁹⁴
 - 江淮汽车某型汽油发动机关键零部件装配过程数据
- 工业过程故障监测⁹⁵
 - 鞍钢热轧带钢工艺过程数据
 - 田纳西伊斯曼过程数据
- 钢铁工艺过程碳排放预测⁹⁶
 - 某钢铁厂烧结过程数据
- 液晶显示器质量预测⁹⁷
 - 薄膜晶体管液晶显示器生产数据

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工程学 VII

● 可靠性工程

- 系统退化过程建模⁹⁸
 - 微波电子组件数据
- 风电机组健康状态评估⁹⁹
 - 内蒙古某风场的风机 SCADA 数据

● 化学工程

- 化学过程故障监测和诊断¹⁰⁰
 - Tennessee Eastman 过程数据
- 化工过程因果网络构建¹⁰¹
 - 连续搅拌槽式反应器数据和 Tennessee Eastman 过程数据

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工程学 VIII

● 航空航天

- 飞行器总体参数分析和优化¹⁰²
 - 美国喷气战斗机总体设计参数数据
- 卫星在轨健康状态监测¹⁰³
 - 真实卫星遥测数据
 - NASA 公开的 SMAP 和 MSL 数据集
- 涡扇发动机健康状态监测¹⁰⁴
 - NASA 格林中心引擎性能退化模拟数据
- 机场间航班延误因果关系分析¹⁰⁵

● 车辆工程

- CAN 总线入侵检测¹⁰⁶
 - 现代汽车 YF 索纳塔 CAN 数据

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工程学 IX

- 电子工程
 - 集成电路封装材料物理性能预测¹⁰⁷
 - CuNi 合金体系材料强度和稳定性计算数据
- 通信工程
 - 通讯网络加密技术研究¹⁰⁸
 - 6G 网络语义通信技术研究¹⁰⁹
 - ImageNet-1k 数据集和 VOC2012 数据集
- 高性能计算
 - 高性能计算能源效率优化¹¹⁰
- 信息安全
 - 深度神经网络对抗攻击防御算法¹¹¹
 - CIFAR-10 和 CIFAR-100 数据集

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- 测绘遥感
 - 高光谱遥感数据分析¹¹²
 - 美国印第安纳 Indian Pine 高光谱遥感数据

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金融工程 I

- 投资组合优化
 - 股票资产相关性网络分析¹¹³
 - 沪深 A 股指数、沪深 300 指数数据
 - ST 股票分类¹¹⁴
 - A 股市场 ST 股票数据
- 金融问题建模
 - Copula 函数模型选择¹¹⁵
 - 标普 500 指数数据
- 股票相关性建模
 - R-vine copula 结构建模¹¹⁶
 - 德国 DAX 指数数据
 - 中证五大行业指数数据

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金融工程 II

- 量化金融工具箱 MLFinLab¹¹⁷
- 金融系统性风险
 - 行业风险溢出效应分析¹¹⁸
 - 我国股票市场 11 个行业交易数据
 - 金融脆弱性度量¹¹⁹
 - 沪深 300 指数股票数据
- 信用风险评价
 - 信用风险卡模型建立¹²⁰
 - 信用卡客户数据
- 金融产品价格预测
 - 基于因果关系的迁移学习价格预测模型构建¹²¹
 - 国际主要金融指数、能源期货价格和农产品价格数据

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My Golf



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