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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

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



# 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<sup>1</sup>

<sup>1</sup>Jian 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<sup>2</sup>
    - 丙氨酸二肽的 C 端和 N 端

<sup>2</sup>Michel 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.

# 化学信息学

- 分子设计
  - 设计具有特定属性的分子结构<sup>3</sup>
    - 有机分子属性 QM9 数据库

<sup>3</sup>Mario Wieser. "Learning Invariant Representations for Deep Latent Variable Models". PhD thesis. University of Basel, 2020.





# 水文学 I

- 洪水预报
  - 金沙江流域洪水预报<sup>5</sup>
- 河流相关性
  - 长江上游河段（金沙江、岷江、沱江、嘉陵江）相关性<sup>6</sup>
  - 长江上游河段复合洪水事件分析<sup>7</sup>
- 水沙关系分析
  - 黄河西柳沟河流域径流量和输沙量数据分析<sup>8</sup>

<sup>5</sup>Lu Chen, Vijay P. Singh, and Shenglian Guo. "Measure of Correlation between River Flows Using the Copula-Entropy Method". In: *Journal of Hydrologic Engineering* 18.12 (2013), pp. 1591-1606, Lu Chen et al. "Copula entropy coupled with artificial neural network for rainfall-runoff simulation". In: *Stochastic Environmental Research and Risk Assessment* 28.7 (2014), pp. 1755-1767.

<sup>6</sup>Lu Chen and Shenglian Guo. *Copulas and its application in hydrology and water resources*. Springer, 2019.

<sup>7</sup>Xu Wang and Yong-Ming Shen. "A Framework of Dependence Modeling and Evaluation System for Compound Flood Events". In: *Water Resources Research* 59.8 (2023), e2023WR034718. DOI: 10.1029/2023WR034718.

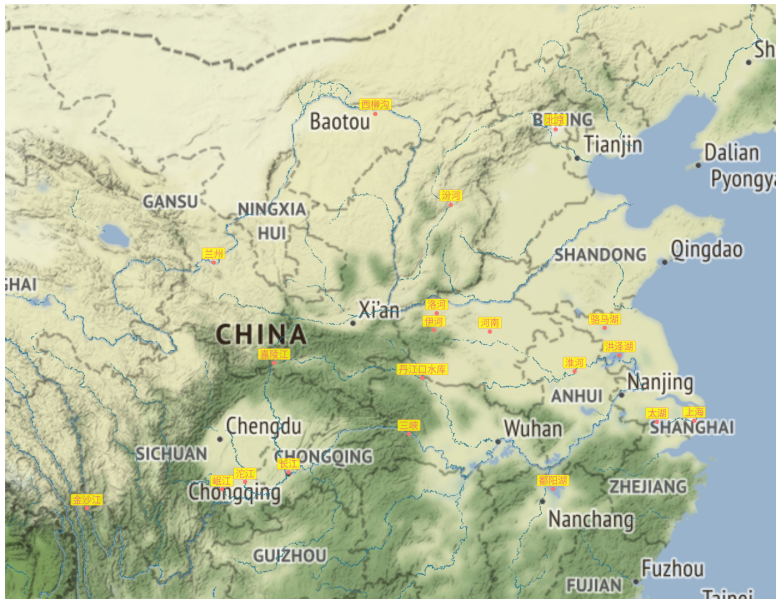
<sup>8</sup> Longxia Qian et al. "A New Estimation Method for Copula Parameters for Multivariate Hydrological Frequency Analysis With Small Sample Sizes". In: *Water Resources Management* 36.4 (2022), pp. 1141–1157. DOI: 10.1007/s11269-021-03016-w.

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## 水文学-国内应用地图





- 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<sup>25</sup>
    - 北京地区 PM2.5 和气象观测数据
  - PM2.5 浓度预测<sup>26</sup>
    - 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<sup>27</sup>
    - 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<sup>28</sup>
    - 广西地区台风灾害数据

<sup>25</sup>Jian Ma. "Estimating Transfer Entropy via Copula Entropy". In: *arXiv preprint arXiv:1910.04375* (2019).

<sup>26</sup> 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.

<sup>27</sup> **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.

<sup>28</sup> 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.





# 生态学

- 动物运动轨迹分析
  - Cylcop 算法包<sup>31</sup>

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<sup>31</sup>Florian 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>.

# 动物学

- 动物形态学
  - 鱼类形态相似度研究<sup>32</sup>
    - GatorBait 海洋鱼类外形数据库
  - 鲍鱼生长过程的形态学研究<sup>33</sup>
    - UCI 鲍鱼数据集

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<sup>32</sup>Francisco Escolano et al. "The mutual information between graphs". In: *Pattern Recognition Letters* 87 (2017), pp. 12–19. DOI: 10.1016/j.patrec.2016.07.012.

<sup>33</sup>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<sup>34</sup>
    - 南方（江南和华南）54 个地点未来气候变化数据和作物数据

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<sup>34</sup>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<sup>35</sup>

- 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<sup>36</sup>

- 故事讲述语音及相应的 EEG 数据

### ● 因果关系脑连接网络分析<sup>37</sup>

- 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

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<sup>35</sup>Stephanie 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.

<sup>36</sup>Pieter 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.

<sup>37</sup>Paolo 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<sup>38</sup>
    - 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<sup>39</sup>
  - 神经网络信息传输关系分析<sup>40</sup>

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<sup>38</sup> 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.

<sup>39</sup> 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.

<sup>40</sup> 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<sup>41</sup>
    - 用于情绪分析的生理信号 DEAP 数据集

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<sup>41</sup>Liesa 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<sup>42</sup>
  - 癌症分子机制数据
- 生物现象动态网络结构和功能<sup>43</sup>
  - 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<sup>44</sup>
  - 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<sup>45</sup>
  - 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

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<sup>42</sup>Agata Charzyńska and Anna Gambin. "Improvement of the k-NN Entropy Estimator with Applications in Systems Biology". In: *Entropy* 18.1 (2015), p. 13.

<sup>43</sup>Farzaneh 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.

<sup>44</sup>Mario Wieser et al. "Inverse Learning of Symmetries". In: *Advances in Neural Information Processing Systems*. Vol. 33. 2020, pp. 18004–18015.

<sup>45</sup>Qiang 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<sup>46</sup>

- UCI 心脏病数据

### ● 糖尿病病情管理<sup>47</sup>

- 美国 Health Facts 糖尿病救治网络数据

### ● 癌症预后<sup>48</sup>

- UCI 肺癌数据
- SEER 数据库乳腺癌临床数据

### ● 白内障术后角膜水肿风险预测<sup>49</sup>

- 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<sup>50</sup>

- 临床主动脉瓣置换手术前后射血分数数据

<sup>46</sup> 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.

<sup>47</sup> Radko Mesiar and Ayyub Sheikh. "Nonlinear Random Forest Classification, a Copula-Based Approach". In: *Applied Sciences* 11.15 (2021), p. 15. DOI: 10.3390/app11157130.

<sup>48</sup> 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.

<sup>49</sup> Yu 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.

<sup>50</sup> S.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>.



# 医学 II

- 认知医学

- 认知能力评估 / 痴呆症筛查<sup>51</sup>

- 北京和天津痴呆症老年人数据

- 运动医学

- 运动能力评估 / 跌倒风险预测<sup>52</sup>

- 天津和成都跌倒人群老年人数据

- 重复经颅磁刺激对帕金森病改善神经机制分析<sup>53</sup>

- 帕金森患者经颅磁刺激前后 EEG 数据

- 精神病学

- 抑郁症患者识别<sup>54</sup>

- 江苏常州抑郁症青少年患者 EEG 数据

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<sup>51</sup> Jian Ma. "Predicting MMSE Score from Finger-Tapping Measurement". In: *Proceedings of 2021 Chinese Intelligent Automation Conference*. See also bioRxiv 817338 (2019). 2022, pp. 294–304.

<sup>52</sup> Jian Ma. "Predicting TUG score from gait characteristics based on video analysis and machine learning". In: *Proceedings of 2023 Chinese Intelligent Automation Conference*. See also bioRxiv 963686 (2020). 2023, pp. 1–12, Jian Ma. "Associations between finger tapping, gait and fall risk with application to fall risk assessment". In: *arXiv preprint arXiv:2006.16648* (2020).

<sup>53</sup> 李润泽 et al. "重复经颅磁刺激改善帕金森病运动症状的脑功能网络分析". In: *生物化学与生物物理进展* 50.1 (2023), pp. 126–134.

<sup>54</sup> 张婷婷 et al. "基于 Couple 熵的抑郁症相干性反馈指标提取". In: *电子测量技术* 45.9 (2022), pp. 160–167.

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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<sup>57</sup>
  - 2018 年政府贫困家庭状况普查数据（四川省）
- 议价机制中的互惠行为和时间效应<sup>58</sup>
  - eBay 的 Best Offer 平台数据
- 产业链内部相关性分析<sup>59</sup>
  - 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<sup>60</sup>
  - 中国新能源汽车上市公司的百度搜索数据

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<sup>57</sup> Qingsong Shan and Qianing 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.

<sup>58</sup> Leonie Bossemeyer. "Machine Learning for Causal Discovery with Applications in Economics". MA thesis. Ludwig-Maximilians-Universität München, 2021.

<sup>59</sup> 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.

<sup>60</sup> 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<sup>61</sup>

- 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<sup>62</sup>

- 大众朗逸汽车销售数据

## ● 社会学

### ● 分析教育、职业和收入上的性别不平等问题<sup>63</sup>

- 美国国家成年人收入调查数据（1994 年）

## ● 教育学

### ● 高中数学成绩与其他学科成绩相关性分析<sup>64</sup>

- 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

<sup>61</sup>Wuyue An, Lin Wang, and Dongfeng Zhang. "Comprehensive commodity price forecasting framework using text mining methods". In: *Journal of Forecasting* (2023). DOI: 10.1002/for.2985.

<sup>62</sup>Yu-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.

<sup>63</sup>Jian Ma. "Causal Domain Adaptation with Copula Entropy based Conditional Independence Test". In: *arXiv preprint arXiv:2202.13482* (2022).

<sup>64</sup>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.

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- Progress: 100%

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- 政治学
  - 分析政权领导力因素和政权危机之间关系<sup>68</sup>
    - 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<sup>69</sup>
    - 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<sup>70</sup>
    - 再生医学（干细胞）和白血病治疗相关资料数据

<sup>70</sup> 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<sup>71</sup>
  - 北方某地区能源系统运行数据
- 光伏发电功率预测<sup>72</sup>
  - 澳大利亚 Yulara 地区光伏电站数据
- 风电机组工况划分<sup>73</sup>
  - 广东某海上风电场 SCADA 数据
- 电力负荷预测<sup>74</sup>
  - 摩洛哥缔头万 (Tétouan) 城电力消费数据
- 风光储协同规划<sup>75</sup>
  - 某工业园区风光火储联合发电系统

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<sup>71</sup>Xueqian Fu et al. "Uncertainty analysis of an integrated energy system based on information theory". In: *Energy* 122.122 (2017), pp. 649–662.

<sup>72</sup>朱正林 and 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.

<sup>73</sup>崔双双 and 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.

<sup>74</sup>Jian Ma. "Identifying Time Lag in Dynamical Systems with Copula Entropy based Transfer Entropy". In: *arXiv preprint arXiv:2301.06037* (2023).

<sup>75</sup>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<sup>76</sup>
  - 贵州电网数据
- 用户线损贡献分析<sup>77</sup>
  - 辽宁电网数据
- 电价预测<sup>78</sup>
  - 2017 年美国 PJM 电力市场电价数据
- 锂电池容量估计<sup>79</sup>
  - NASA 锂电池退化数据
- 电力系统宽频振荡影响因素和传播路径分析<sup>80</sup>

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<sup>76</sup>Peili Liu et al. "Frequency Stability Prediction of Power Systems Using Vision Transformer and Copula Entropy". In: *Entropy* 24.8 (2022), p. 1165. DOI: 10.3390/e24081165.

<sup>77</sup>Wei Hu et al. "Research on User Loss Contribution Calculation of High-Loss Distribution Area Based on Transfer Entropy". In: *2022 China International Conference on Electricity Distribution (CICED)*. 2022, pp. 499–502. DOI: 10.1109/CICED56215.2022.9929052.

<sup>78</sup>Xiaoping Xiong and Guohua Qing. "A hybrid day-ahead electricity price forecasting framework based on time series". In: *Energy* (2022), p. 126099. DOI: 10.1016/j.energy.2022.126099.

<sup>79</sup>Jiabei He and Lifeng Wu. "Cross-conditions capacity estimation of lithium-ion battery with constrained adversarial domain adaptation". In: *Energy* 277 (2023), p. 127559. DOI: 10.1016/j.energy.2023.127559.

<sup>80</sup>冯双 et al. "一种电力系统宽频振荡影响因素和传播路径分析方法". Pat. CN114977222A. 2022.



# 工程学 III

- 食品工程

- 葡萄酒质量与理化成分关系分析<sup>81</sup>

- 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<sup>82</sup>

- 大连某教学楼供热监测数据

- 工程变形监测<sup>83</sup>

- 某隧道工程施工段围堰监测数据

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# 工程学 IV

- 交通运输
  - 大件货物运输方案制定<sup>84</sup>
    - 大件货物运输案例数据
  - 航空和高铁票价影响因素分析<sup>85</sup>
    - 京沪高铁和航空票价数据
  - 城市轨道交通客流分析和预测<sup>86</sup>
    - 苏州市轨道交通系统客流时序数据

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# 工程学 V

## ● 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<sup>87</sup>
  - 富士康生产线制造过程数据
- 装配质量控制<sup>88</sup>
  - 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<sup>89</sup>
  - 鞍钢热轧带钢工艺过程数据
- 钢铁工艺过程碳排放预测<sup>90</sup>
  - 某钢铁厂烧结过程数据
- 液晶显示器质量预测<sup>91</sup>
  - 薄膜晶体管液晶显示器生产数据

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<sup>91</sup>Hongxia Cai and Zhiqiang Rong. "Key Quality Feature Identification and Quality Prediction in Complex Manufacturing Processes". In: *2023 15th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC)*. 2023, pp. 229–232. DOI: 10.1109/IHMSC58761.2023.00060.

# 工程学 VI

- 可靠性工程
  - 系统退化过程建模<sup>92</sup>
    - 微波电子组件数据
  - 风电机组健康状态评估<sup>93</sup>
    - 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<sup>94</sup>
    - Tennessee Eastman 过程数据
  - 化工过程因果网络构建<sup>95</sup>
    - 连续搅拌槽式反应器数据和 Tennessee Eastman 过程数据

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<sup>92</sup>Fuqiang Sun et al. "A Copula Entropy Approach to Dependence Measurement for Multiple Degradation Processes". In: *Entropy* 21.8 (2019), p. 724.

<sup>93</sup>齐咏生 et al. "一种基于多维度 SCADA 数据评估风电机组健康状态评估方法". Pat. CN110442833A. 2019.

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# 工程学 VII

## ● 航空航天

- 飞行器总体参数分析和优化<sup>96</sup>
  - 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<sup>97</sup>
  - 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<sup>98</sup>
  - 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<sup>99</sup>

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- CAN 总线入侵检测<sup>100</sup>
  - 现代汽车 YF 索纳塔 CAN 数据

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<sup>100</sup> Sheng Gao et al. "Attack Detection for Intelligent Vehicles via CAN- Bus: A Lightweight Image Network Approach". In: *IEEE Transactions on Vehicular Technology* (2023), pp. 1–13. DOI: 10.1109/TVT.2023.3296705.

# 工程学 VIII

- 电子工程
  - 集成电路封装材料物理性能预测<sup>101</sup>
    - 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<sup>102</sup>
  - 6G 网络语义通信技术研究<sup>103</sup>
    - ImageNet-1k 数据集和 VOC2012 数据集
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  - 高光谱遥感数据分析<sup>105</sup>
    - 美国印第安纳 Indian Pine 高光谱遥感数据

<sup>101</sup> 刘勃. “基于机器学习的封装材料加速预测”. 硕士学位论文. 哈尔滨理工大学, 2022.

<sup>102</sup> Xu Wang et al. “Physical Layer Secret Key Capacity Using Correlated Wireless Channel Samples”. In: *2016 IEEE Global Communications Conference (GLOBECOM)*. 2016, pp. 1–6.

<sup>103</sup> 傅宇舟 et al. “面向 6G 网络的基于语义通信的端到端服务框架”. In: *移动通信* 47.6 (2023), pp. 35–40.

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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<sup>106</sup>
    - 沪深 A 股指数、沪深 300 指数数据
  - ST 股票分类<sup>107</sup>
    - A 股市场 ST 股票数据
- 金融问题建模
  - Copula 函数模型选择<sup>108</sup>
    - 标普 500 指数数据
- 股票相关性建模
  - R-vine copula 结构建模<sup>109</sup>
    - 德国 DAX 指数数据
    - 中证五大行业指数数据

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<sup>107</sup>朱仲儿. "多种机器学习方法的股票分类预测". 硕士学位论文. 上海师范大学, 2022.

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- 量化金融工具箱 MLFinLab<sup>110</sup>
- 金融系统性风险
  - 行业风险溢出效应分析<sup>111</sup>
    - 我国股票市场 11 个行业交易数据
  - 金融脆弱性度量<sup>112</sup>
    - 沪深 300 指数股票数据
- 信用风险评价
  - 信用风险卡模型建立<sup>113</sup>
    - 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<sup>114</sup>
    - 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



# Enjoy the Power of Copula Entropy!