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人工智能视觉识别系统 在消毒供应中心外来器械接收清点环节中的应用效果

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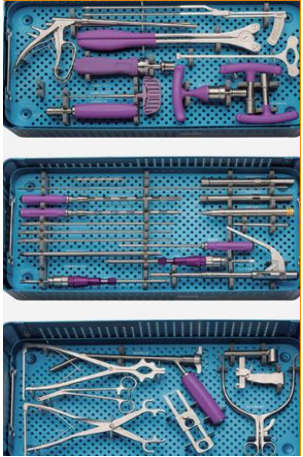
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A 背景与目标 | 研究背景简介



外来器械：处理过程复杂、挑战性高、关乎病人安危



A 背景与目标

I 临床背景分析

手术量增长与器械使用



随着医疗技术的不断进步和患者需求的增加，手术量呈现出逐年增长的趋势；为了适应多样化的手术需求，外来器械的使用也越来越频繁。

人工清点的挑战与局限



传统的人工清点模式存在着诸多的挑战与局限，如**效率低下**、**准确性**受人为因素影响大等，难以满足医疗质量安全要求与效率提升的**双重压力**。

人工交接模式：过程繁琐痛点、手工计数、容易混淆、追溯不完全



A 背景与目标 | 临床背景分析

外来器械接收过程中的瓶颈与痛点

运营方面

- 效率低: 耗时长
- 人力占用
- 低周转率
- 信息缺乏共享

质量控制

- 差错风险大
- 追溯困难
- 有异物遗留风险
- 设备管理成本高

员工安全

- 视觉疲劳: 看错/漏看
- 疲劳导致的记录错漏
- 员工压力大
- 满意度低

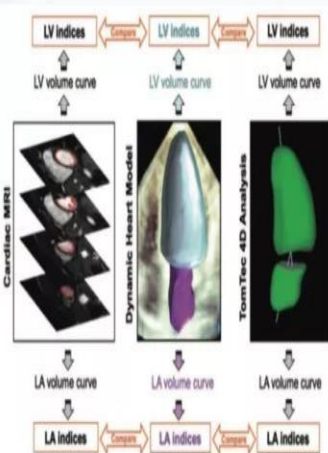
操作效率低下，安全风险增加，质量控制难度大



A 背景与目标

技术发展背景

基于AI的左心腔容积量化监测

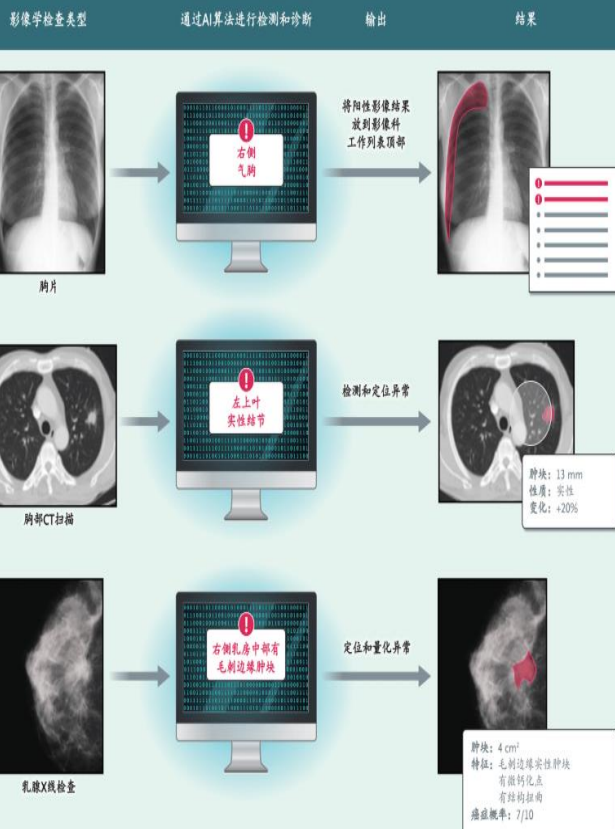


- 自动快速测量动态LV和LA体积，准确分析射血/填充参数；有助于提高测量准确度

Narang A1, Mor-Avi V1, Prado A, et al. European Heart Journal - Cardio

2020/1/10

GNA/HKSSMA



● 计算机视觉技术现状

计算机视觉技术在医疗领域的应用日益广泛，其在医疗图像识别、诊断等方面展现出巨大的潜力。

● 深度学习物体识别进展

深度学习算法在物体识别方面取得了最新进展，为人工智能视觉识别系统提供了强大的技术支撑。





A 背景与目标 | 文献查阅

中华医院感染杂志 2023 年第 23 卷第 2 期 Chin J Nosocomiol Vol. 23 No. 2 2023

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开放科学(资源服务)标识码(OSID):

人工智能系统在外来医疗器械交接中应用效果的多中心研究

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摘要 目的 探讨人工智能视觉识别系统在外来医疗器械包装质量的应用效果。方法 我院于 2022 年 1 月将采集在 CSSD 处置的外来医疗器械信息, 包括(图像、名称规格、数量)等传至人工智能视觉识别系统中存档, 实现图像数据分析与识别, 并预警提示。即选取 2021 年 2~12 月系统应用前我院消毒供应中心接收处置的 9 400 包外科外来器械为对照组, 2022 年 1 月~11 月系统应用后的 9 400 包为观察组, 比较 2 组医疗器械包装质量及管理工作情况(包装质量、平均耗时、使用满意度)。结果 观察组医疗器械包装质量优于对照组, 差异有统计学意义($P<0.05$)。包装平均耗时及使用满意度优于对照组, 差异有统计学意义($P<0.05$)。结论 人工智能视觉识别系统在外来医疗器械包装环节, 检查应用中效果较好。提升包装质量的同时, 也优化了外来医疗器械管理流程, 提高了手术室满意度和工作效率。

关键词 消毒供应中心; 人工智能; 视觉识别; 外来骨科医疗器械; 包装质量

Research and application of artificial intelligence visual recognition system in inspection package quality of external medical instruments in disinfection supply center

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Abstract Objective To explore the application effect of artificial intelligence visual recognition system on the packaging quality of external orthopedic medical devices in the Central Sterile Supply Department (CSSD). Method In January 2022, information on external orthopedic instruments disposed by CSSD were collected in our hospital, including images, names, specifications, and quantities and were archived in the artificial intelligence visual recognition system; so as to realize the image data analysis and backtracking and archive warning prompts. A total of 9,400 packages of orthopedic external instruments received and processed by CSSD of our hospital before the system application from February to December 2021 were selected as the control group, and a total of 9,400 packages after system application were selected as the observation group. The quality and management of medical device packaging (average packaging inspection time, user satisfaction) were compared between the two groups. Results The quality of medical device packaging and satisfaction with use in the observation group were better than those in the control group, and the difference was statistically significant ($P<0.05$). The average packaging time was lower than that of the control group, and the difference was statistically significant ($P<0.05$). Conclusion The artificial intelligence visual recognition system has shown good effectiveness in the packaging process of CSSD external orthopedic medical devices. While improving packaging quality, it has also optimized the management process of external orthopedic medical devices, and improved operating room satisfaction and work efficiency.

Keywords central sterile supply department; artificial intelligence; visual identity; foreign orthopedic medical devices; packaging quality

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scientific reports

OPEN An efficient annotation method for image recognition of dental instruments

Shintaro Oka^{1,2*}, Kazumori Nozaki^{2,3} & Mikako Hayashi^{2,3}

To prevent needless injury and leftover instruments, and to perform efficient dental treatment, it is important to know the instruments remained during dental treatment. Therefore, we will obtain a

RESEARCH Open Access

Artificial intelligence model for automated surgical instrument detection and counting: an experimental proof-of-concept study

Example S. Deol¹, Grant Henning¹, Spondon Basak^{1,2}, Ravneer A. S. Vaidya¹, Yishi Sharma¹, Nicholas L. Kavanagh¹, R. Jeffrey Kames¹, Bradley C. Lebowitz¹, Stephen A. Boorjian¹ and Abhinav Khanna^{1*}

Abstract Retained surgical items (RSIs) are preventable events that pose a significant risk to patient safety. Current strategies for preventing RSI rely heavily on manual instrument counting methods, which are prone to human error. This study evaluates the feasibility and performance of a deep learning-based computer vision model for automated surgical tool detection and counting.

Methods A novel dataset of 1,004 images containing 13,213 surgical tools across 11 categories was developed. The dataset was split into training, validation, and test sets at a 60:20:20 ratio. An artificial intelligence (AI) model was trained on the dataset, and the model's performance was evaluated using standard object detection metrics, including precision and recall. To simulate a real-world surgical setting, model performance was also evaluated in a dynamic surgical video of instruments being moved in real time.

Results The model demonstrated high precision (98.5%) and recall (99.9%) in distinguishing surgical tools from the background. It also exhibited excellent performance in differentiating between various surgical tools, with precision ranging from 94.0% to 100% and recall ranging from 97.1% to 100% across 11 tool categories. The model maintained strong performance on a subset of test images containing overlapping tools (precision range 89%-100%, and recall range 97.2%-98.2%). In a real-time surgical video analysis, the model maintained a correct surgical tool count in all non-transition frames, with a median inference speed of 40.4 frames per second (interquartile range: 4-9).

Conclusion This study demonstrates that using a deep learning-based computer vision model for automated surgical tool detection and counting is feasible. The model's high precision and real-time inference capabilities highlight its potential to serve as an AI safeguard to potentially improve patient safety and reduce manual burden on surgical staff. Further validation in clinical settings is warranted.

Keywords Retained surgical items, Computer vision, Artificial intelligence, Surgical tool detection, Surgical safety

Background Retained surgical items (RSIs) are surgical instruments or materials unintentionally left inside a patient's body after surgery [1]. RSIs are considered "never events," which are defined as serious, preventable incidents that should ideally never occur in healthcare settings [2]. Despite increased efforts to prevent RSIs, they remain a significant problem, with an estimated incidence of 1 in every 3000 surgeries [3]. The impact of RSIs on patients, healthcare providers, and the healthcare system is substantial, including physical and psychological harm to patients, emotional distress for survivors, and increased healthcare costs [4].

Traditional programs for preventing RSIs center around manual counting of surgical items, commonly conducted by nursing staff [5, 6]. However, such programs often require specialized personnel training, and can increase surgical duration [7]. Furthermore, manual counting is subject to human error due to communication breakdowns, time pressure, competing demands, and environmental distractions [8, 9-10]. Current programs recognize the limitations of individual manual surgical counts and seek to use several layers of security to prevent RSIs [6]. Depending on institutional policies, these can include the use of technologies such as radio-frequency identification (RFID) and endosseous

Study Design and setting We conducted an experimental proof-of-concept study to evaluate the feasibility and performance of a deep learning-based computer vision model for automated surgical tool detection and counting. The study was performed at the Department of Urology, Menn Clinic, Rochester, Minnesota, USA, between January 2024 and May 2024.

Hypothesis We hypothesized that a deep learning-based computer vision model could accurately detect and classify surgical instruments in real-time from a standard surgical table, potentially serving as an AI safeguard against RSIs.

Primary and secondary outcomes The primary outcome was the model's performance in detecting and classifying surgical tools, as measured by precision, recall, and mean average precision, standard measures to benchmark the performance of computer vision models. The secondary outcome was the model's inference speed (frames per second) and its ability to maintain a correct surgical tool count in real-time.

Scientific Reports | (2024) 14:1824 |

www.nature.com/scientificreports/

Deol et al. Patient Safety in Surgery (2024) 18:24

the model could keep pace with the dynamic nature of a surgical procedure, correctly identifying tools as they are being used in real-time. All data analysis was conducted in Python using the PyTorch and Ultralytics packages [23].

Results The overall dataset consisted of 1004 images, of which 603 (7891) tool instances/images were used for model training, 201 (2667 tool instances) for internal validation, and 200 (2655 tool instances) for testing model performance. For detecting the presence or absence of surgical tools in the test dataset the model made 2,693 surgical tool predictions, of which there were 41 instances in which the model falsely identified the background as a surgical tool (false positive). Thus, the overall precision for distinguishing surgical tools from the background was 98.5%. Conversely, the model failed to identify a surgical tool in only three instances, incorrectly labeling a tool as background in all three instances (false negative). This translates to an overall recall (sensitivity) of 99.9%. The model's mean average precision 50–95 was 88.4%, and mean average precision 50 was 99.4%.

Model performance was also explored for differentiating between the 11 types of surgical instruments. The basin class exhibited a precision and recall of 100%, indicating that the model perfectly predicted all basin instances without any false positives or false negatives. Syringes also achieved a precision of 99.6% and a recall of 100%, demonstrating nearly perfect performance in identifying all syringe instances. The surgical scissors class attained a precision of 99.2% and a recall of 99.9%. In contrast, the scalpel class had the lowest precision at 94.0% and a recall of 97.1%. The precision and recall values for the remaining instrument classes can be found in Table 1, and a confusion matrix illustrating these results is presented in Fig. 2A.

Similar model performance was observed on the subset of test images containing overlapping tools. For identifying surgical tools from the background, the model achieved a precision of 89.2% and a recall of 97.2% (IQR: 3.1 ms) on a single NV12 model's ability to maintain for practical applications in supplementary Table 1.

Discussion This study demonstrates the feasibility of employing a deep learning-based computer vision model for the automated detection and enumeration of surgical instruments. The model achieved high precision and recall in distinguishing surgical tools from the background and in differentiating between various surgical instruments, even in challenging scenarios involving overlapping tools. In a real-time surgical video analysis, the model maintained a correct tool count during all non-transition times with an inference speed suitable for real-time use. These results highlight the potential for computer vision models to maintain an automated tool count during surgery which has the potential to reduce errors and thereby help improve surgical safety.

Our study's high precision and recall in detecting a broad array of surgical tools, even in challenging conditions with overlapping items, address some of the critical gaps in previous research, such as the need for robust detection across a diverse range of surgical objects and the demonstration of an inference speed suitable for practical real-world applications. Lavado et al. previously developed a computer vision model based on YOLOv3 for detecting surgical tools in cluttered trays and performed occlusion reasoning to determine which tool should be removed first following sterilization [24]. Their model was trained on only four different surgical tool classes and performed moderately well (mean average precision at 0.50 of 92.0%). In contrast, our model was trained on 11 different classes and achieved a mean average precision at 0.50 of 99.4%. Also, of note, Lavado et al. photographed surgical tools in a metallic background, whereas our models were trained on tools in a blue surgical cloth background, which is similar to most real-world surgical tray setups [24]. Jiang et al. examined automated

Instrument Class	Precision (%)	Recall (%)
Scalpel	94.02	97.12
Surgical skin pen	98.19	99.39
Forceps	99.24	99.62
Hemostat	95.21	99.93
Needle driver	96.60	99.65
Retractor	97.97	99.66
Breaker	98.88	99.25
Syringe	97.39	100.00
Surgical grasper	99.60	100.00
Basin	99.26	100.00
	100.00	100.00

文献查阅: AI 在医疗领域的应用



A 背景与目标 | 研究目标设定

目标： 人工智能视觉识别系统在CSSD外来器械接收清点环节中的应用效果及价值

主要目标

评估AI视觉识别系统在外来器械清点中的准确性和效率提升，确保医疗流程的高效与精准。



长期目标

建立智能化器械清点的标准化流程和质控体系，推动医疗领域的智能化发展。



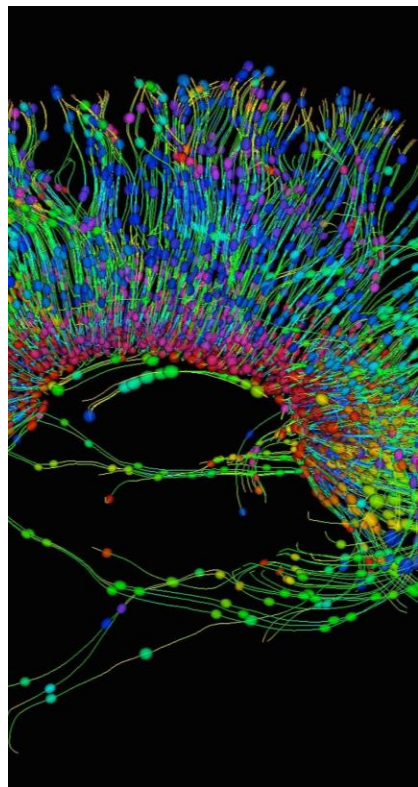
次要目标

分析系统实施的成本效益比和人员接受度，为决策提供了有力的数据支持。



B 研究内容

I 系统技术原理



卷积神经网络

在器械图像识别中，卷积神经网络*通过自动提取图像特征，实现高精度分类，为外来器械识别提供技术支持。



深度学习算法

算法模块采用先进深度学习算法，持续优化识别模型，提升复杂背景下器械图像的准确识别率。

注*：卷积神经网络是一种专门用来处理具有类似网格结构数据（最典型的就是图像）的人工神经网络。它通过一种叫做“卷积”的独特操作，能够高效地识别图像中的空间模式，例如边缘、角落、物体部分乃至整个物体。



B 研究内容

I 系统组成架构

硬件组成

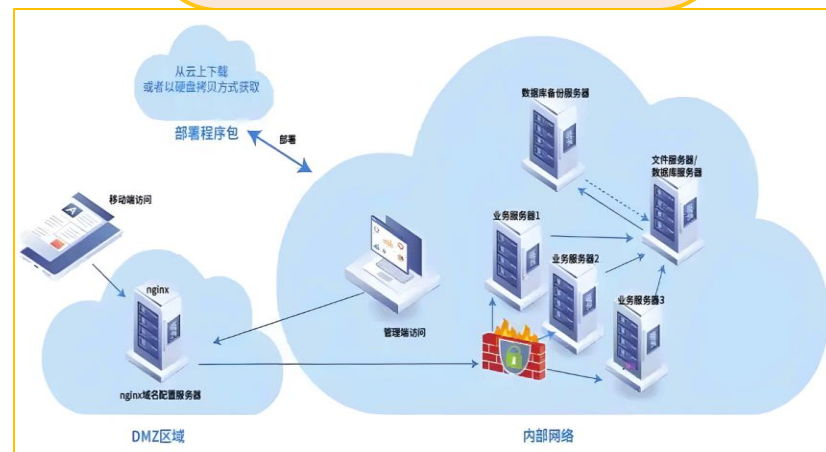
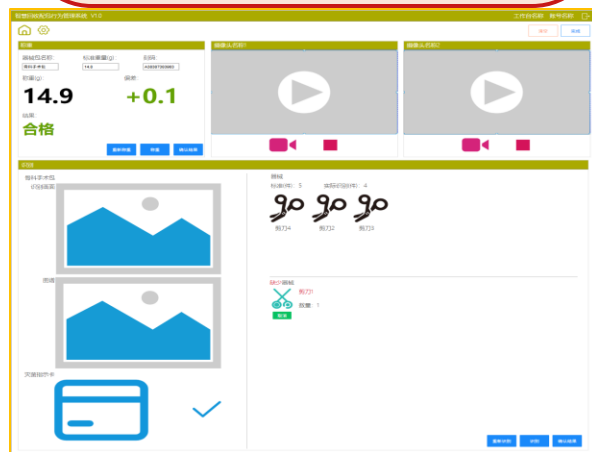
系统配备高清摄像设备，捕捉清晰图像；计算单元快速处理识别任务；显示终端直观展示结果，确保操作便捷。

软件系统

图像采集模块实现高效抓取；识别算法模块核心，负责深度学习与模型推理；数据管理模块确保数据完整与安全。

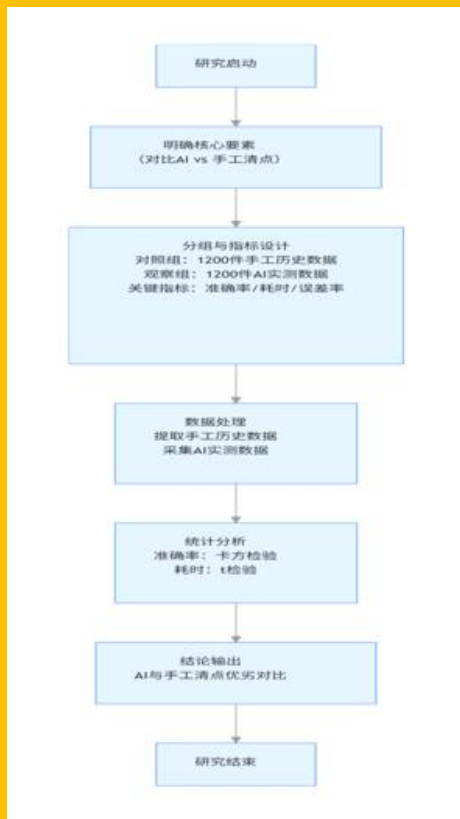
网络架构

采用本地部署方案，数据与处理设备本地存储，保障数据安全与隐私，减少网络依赖，提升系统稳定性与响应速度。



B 研究内容

I 工作流程设计



标准化采集流程

制定详细的器械图像采集标准，包括光线、角度、分辨率等，确保图像质量一致，为识别奠定坚实基础。

协同识别机制

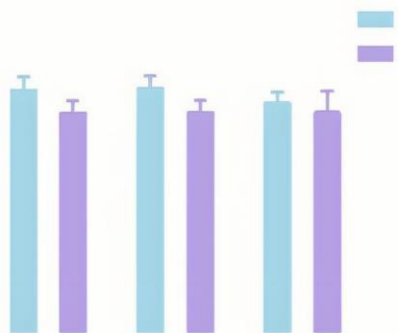
系统实时识别器械，快速反馈结果；同时，建立人工复核渠道，对疑似错误或复杂器械进行二次确认。

异常处理流程

明确异常处理职责与流程，如图像模糊、识别失败等情况的应对措施，确保差错得到及时纠正与处理。

B 研究内容

I 研究设计



对照试验方案

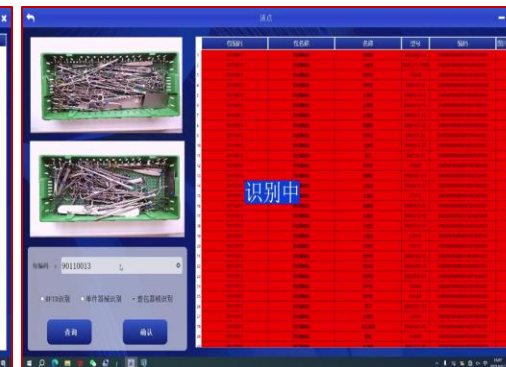
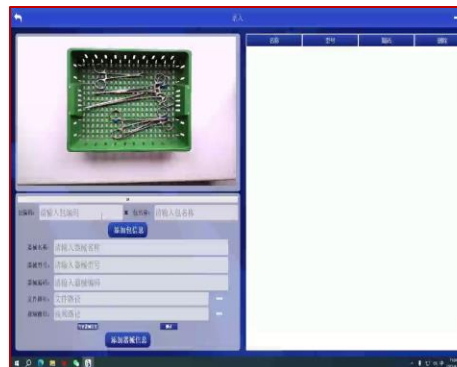
设置对照组与实验组，对照组采用传统人工清点模式，实验组采用AI视觉识别系统，比较两组的清点效率和准确率。



日期	器械名称及件数	器械完整度	厂家名称	联系电话	厂家签名	使用科室器械名称及件数	取走日期	取走时间	取走厂家签名	备注
11/16/20	1. 止血钳 ② 90	✓			张明 23	9	7/1		唐海	
	② 200	✓				25	7/1		唐海	
	③ 130	✓				13	7/1		唐海	
	1. 止血钳 ② 90	✓				止血钳 89	9/1	12:40		
	2. 止血钳 ② 90	✓				止血钳 89				
	3. 止血钳 ② 90	✓				止血钳 97				
	4. 止血钳 ② 90	✓				止血钳 1				
	5. 止血钳 ② 90	✓				止血钳 80				
	6. 止血钳 ② 90	✓				止血钳 3				
	7. 止血钳 ② 90	✓				止血钳 4				
	8. 止血钳 ② 90	✓				止血钳 12				
	9. 止血钳 ② 90	✓				止血钳 189				
	10. 止血钳 ② 90	✓				止血钳 88	9/1	14:30		

限定范围

研究限于特定时间段和特定器械种类，确保研究样本的代表性和结果的可靠性，避免无关变量干扰。



B 研究内容

I 研究对象

设置纳排标准及人员培训操作程序

外来器械纳入标准

研究限于特定种类、材质及复杂程度的器械，确保识别过程的有效性与准确性，避免非目标器械的干扰。

&

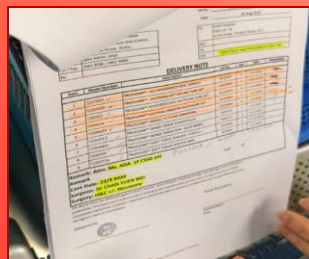
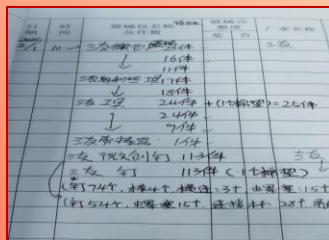
人员培训与操作程序

研究人员需接受统一培训，确保操作标准化，减少人为误差，保证研究数据的准确性和可靠性。



传统方法与人工智能识别对比

传统方法



VS

人工智能识别



数据收集方法

建立严格的质量控制体系，对数据进行多重审核，确保数据的准确性和可靠性，剔除异常值。

[illegible]

C 数据分析

I 统计分析方案



样本量计算与检验效能

根据前期数据和预期效应大小，精确计算所需样本量，并评估统计检验的效能，确保结果可靠。

描述性统计分析

对主要指标进行描述性统计分析，揭示数据特征，为后续深入分析奠定基础。



组间比较统计方法

采用适当的推断统计方法，比较不同组间的主要指标差异，揭示AI视觉识别系统的优势。

配对样本统计				
	平均值(E)	数字	标准偏差	标准误差平均值
配对 1 使用AI识别系统前人工清点满意度得分	85.00	47	5.473	.798
使用AI识别系统后机器满意度得分	98.00	47	2.126	.310

配对样本相关性			
	数字	相关系数	显著性
配对 1 使用AI识别系统前人工清点满意度得分 & 使用AI识别系统后机器满意度得分	47	-.015	.921

配对样本检验								
	配对差值					t	自由度	显著性（双尾）
	平均值(E)	标准偏差	标准误差平均值	差值的 95% 置信区间				
				下限	上限			
配对 1 使用AI识别系统前人工清点满意度得分 - 使用AI识别系统后机器满意度得分	-13.000	5.901	.861	-14.733	-11.267	-15.102	46	.000

常态性检验						
	Kolmogorov-Smirnov(K) ^a			Shapiro-Wilk		
	统计	df	显著性	统计	df	显著性
差值	.077	47	.200 ^a	.979	47	.553

*. 这是真正显著性的下限。

a. Lilliefors 显著性校正



D 结果分析

AI系统识别准确率

AI系统识别准确率高达99.2%，显著优于传统方法的88%。

清点工作效率提升

AI系统使清点效率提升，有效缩短工作时间，提高整体效率。

器械识别性能差异

对简单与复杂器械的识别性能存在显著差异，但对整体准确性影响较小。

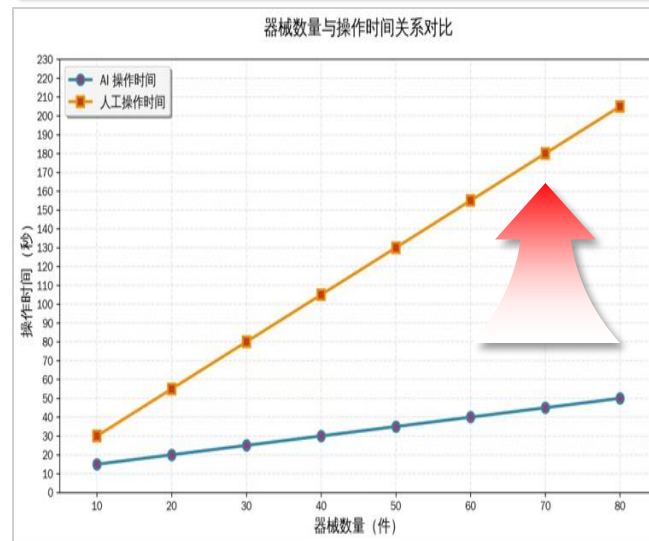
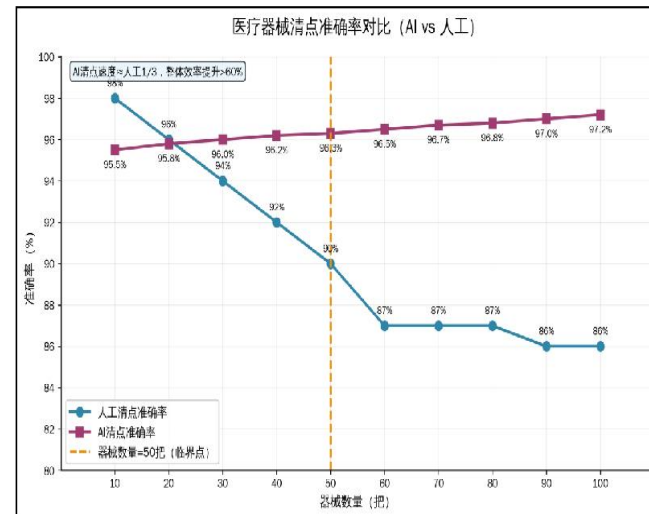
I 相关结果分析

使用AI识别系统前后清点器械平均时间/包

指标	研究组 (n=1200)	对照组 (n=1200)	Z 值	P 值
<20 件/包 (n=246)	10.70 (9.80, 11.70)	22.40 (20.90, 23.62)	-13.598 ^a	<0.001
20-50 件/包 (n=862)	36.25 (33.20, 40.30)	92.40 (89.20, 95.30)	-25.434 ^a	<0.001
>50 件/包 (n=92)	56.75 (54.32, 59.17)	146.50 (142.22, 150.47)	-8.331 ^a	<0.001

使用AI识别系统前后清点器械包正确率

分类	指标	研究组 (n=1200)	对照组 (n=1200)	χ^2 值	P 值
<20 件/包 (n=246)	器械包清点正确率 (%)	244 (99.2%)	237 (96.3%)		0.039 ^b
20-50 件/包 (n=862)	器械包清点正确率 (%)	835 (96.9%)	803 (93.2%)	22.881	<0.001
>50 件/包 (n=92)	器械包清点正确率 (%)	88 (95.7%)	80 (87.0%)		0.021 ^b



D 结果分析

I 相关结果分析

系统使用成本
与效益

人员接受度
与满意度

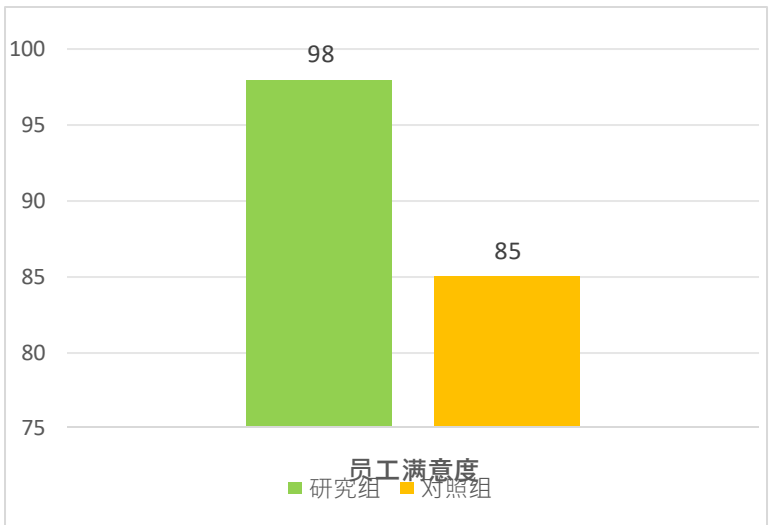
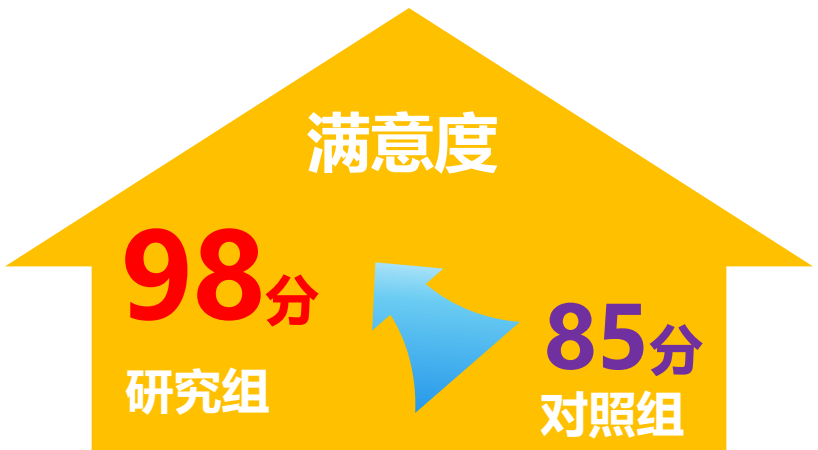
系统稳定性
与可靠性

追溯系统管理质量

指标	研究组	对照组
是否确保记录器械清点工作已完成	是	否
是否确保记录器械种类和数量信息	是	否
是否能帮助实施全流程质量追溯	是	否
是否能降低工作人员操作难度	是	否
是否能实时显示使用信息	是	否

AI识别系统使用前后员工满意度

指标	研究组 (n=47)	对照组 (n=47)	t值	P值
员工满意度	98.00±2.126	85.00±5.473	-15.102	<0.001



D 结果分析

I 异常情况分析

识别失败案例原因分析

对识别失败的案例进行深度分析，找出原因包括器械图像质量不佳、特殊材质识别困难等。

系统误差与人为因素

通过对比系统误差和人为因素导致的识别失败案例，明确两者之间的区别和各自占比。

改进措施的效果验证

在识别失败案例的原因分析基础上，提出并实施改进措施，如优化图像采集流程、增强特殊材质识别能力等。

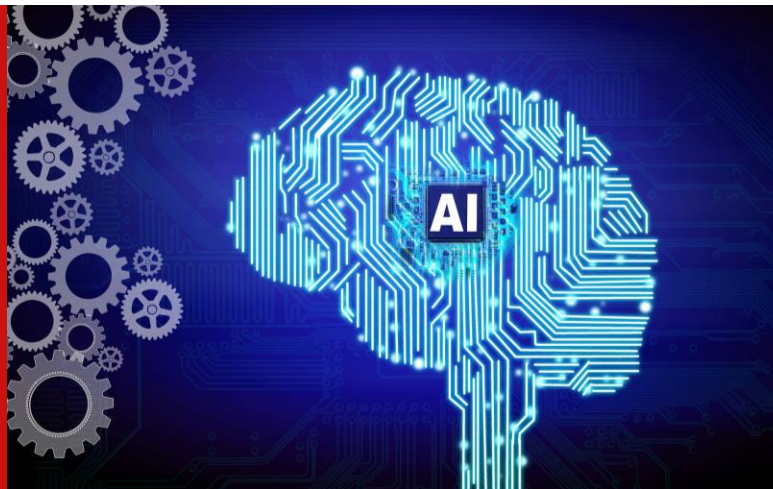


E 进一步建议

I 技术优化建议

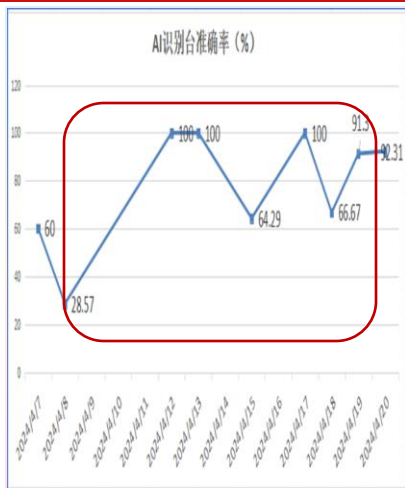
算法模型优化

持续收集数据，优化算法模型，提升识别精度与效率，确保AI系统性能持续提升。



系统集成与兼容

加强系统集成能力，提升与其他医疗系统的兼容性，实现数据共享与流程协同。



硬件设备升级

随着技术发展，适时升级高清摄像设备、计算单元等硬件，保障系统运行速度与稳定性。



E 进一步建议

流程改进建议

图像采集规范

制定详细的标准化图像采集规范，确保图像质量，减少因图像不清导致的识别错误。



基于XXX实现器械识别的
可视化信息展示

- 快速精准识别器械
- 提供可视化器械信息
- 辅助操作人员熟悉器械处理方法
提供相关注意事项，操作手册等协助新人操作员快速熟悉

人机协同优化

优化人机协同工作机制，明确AI系统与人员的职责与交互方式，提升整体工作效率。



E 进一步建议

培训推广建议

操作人员培训

设计针对操作人员的培训课程，涵盖AI系统基本操作、维护保养及故障处理，提升人员技能。

行业内推广

制定多中心推广应用策略，先在部分医院试点，总结经验后逐步推广至更广泛区域。



F 结论与启示

AI视觉优势

精准识别，高效清点，降低人力成本，提升CSSD效率与质量。

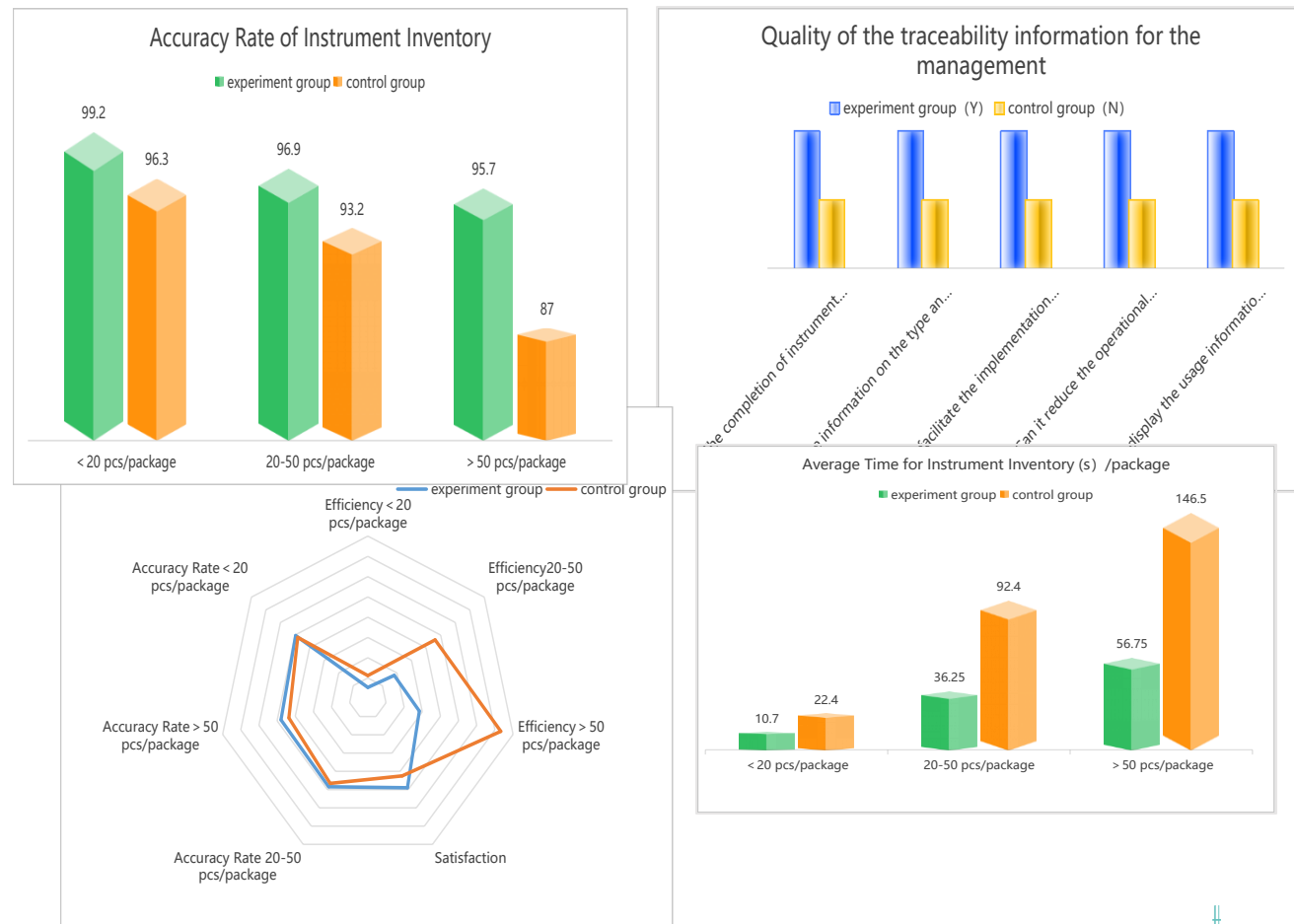
限制因素

技术门槛高，设备成本高，需定制化，且受环境因素影响大。

技术前景

随着技术成熟与成本降低，AI视觉识别系统应用前景广阔，将引领CSSD管理创新升级。

主要研究结论



F 结论与启示

实践意义



管理启示

AI视觉识别系统助力消毒供应中心实现流程优化与智能化管理，提升工作效率与质量。



医疗安全贡献

通过精准识别与高效清点，降低医疗风险，强化医疗质量安全防线，守护患者安全。



F 结论与启示 | 研究局限与展望

局限分析

本研究样本有限，未涵盖所有器械类型；未来需扩大研究范围，考虑更多影响因素。

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研究方向

探索AI视觉识别系统在不同医疗机构的应用效果，设计更高效的算法与流程。

随访评估

持续监测系统性能与效果，及时调整优化方案，确保研究成果的时效性与实用性。





感谢您的聆听



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