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Application Effect of Artificial Intelligence Visual Recognition System on the Receiving and Inventory Process of Loaner Instruments

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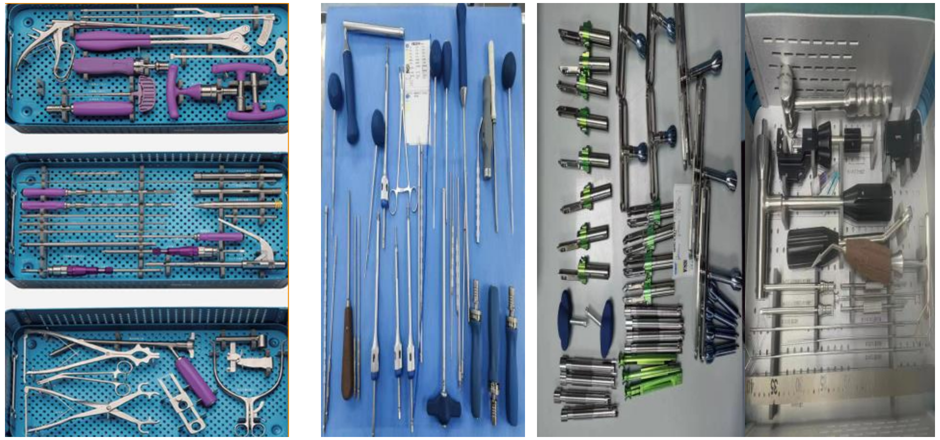
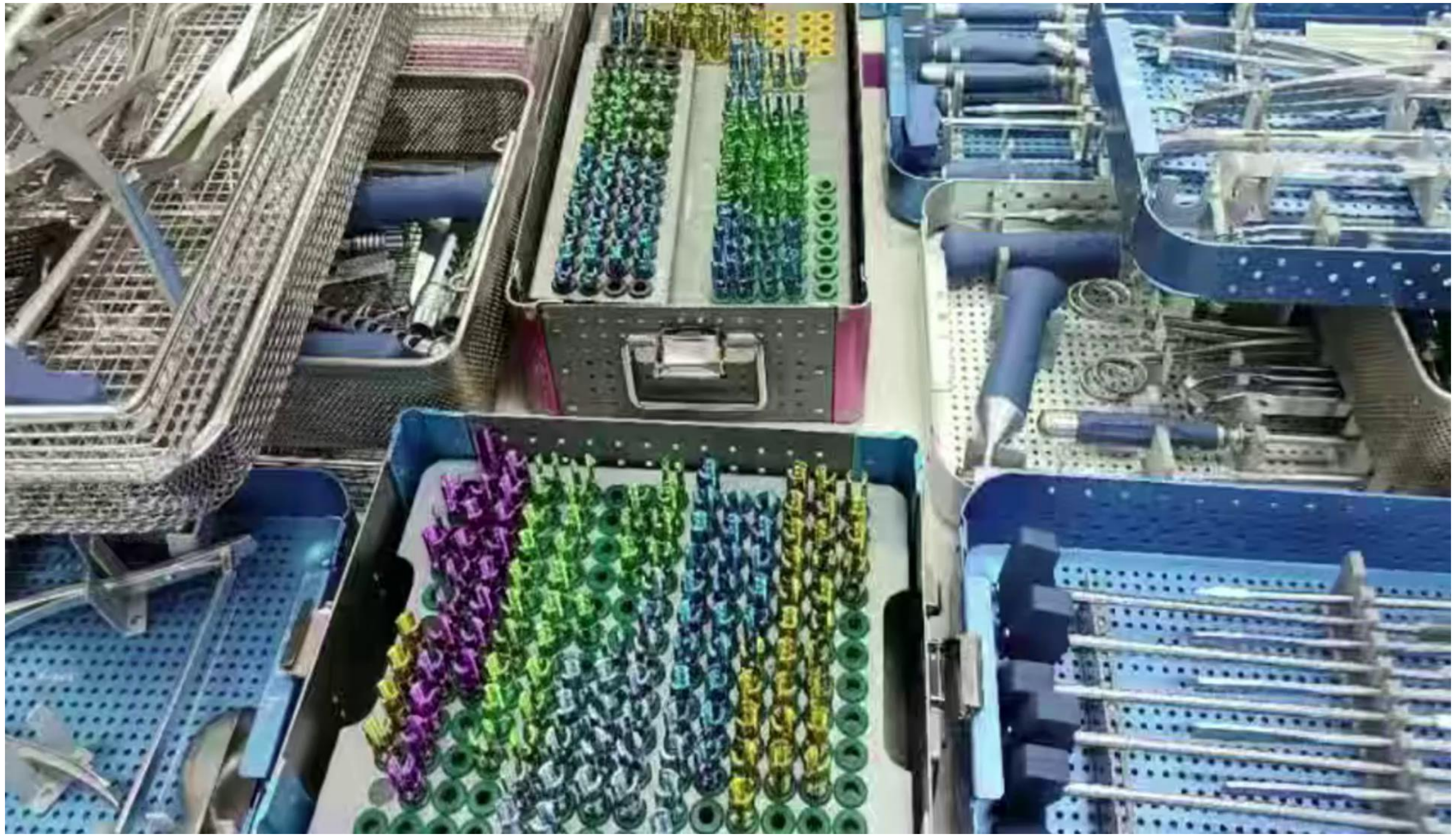
Content

A. Background and Objective

Research Background





On loan instruments : Reprocessing process is complex, challenging, but related to patient safety

A. Background and Objective Clinical Background Analysis

Growth in operations and instrument usage

With the continuous advancement of medical technology and the increase in patient demand, the number of surgeries has shown an increasing trend year by year; in order to adapt to diverse surgical needs, the use of on loan instruments has become more and more frequent.

Challenges and limitations of manual counting

The traditional manual inventory model has many challenges and limitations, such as low efficiency and accuracy greatly affected by human factors, which makes it difficult to meet the dual pressures of medical quality and safety requirements and efficiency improvement.

Manual handover mode: cumbersome process, manual counting, easy to get confused, incomplete traceability

A. Background and Objective Clinical Background Analysis

Current bottlenecks and pain points during receipt of loan instruments

Operation

- **Inefficiency: time Consuming**
- Manpower requirement
- Low turnover rate;
- **Information not shared**

Quality Control

- **High risk of error**
- **Difficulty in tracing**
- Risk of foreign body left behind;
- Equipment management costs

Staff Safety

- Visual fatigue: wrong sight and missed sight
- Human fatigue leading to mis recording and omission
- **High staff pressure**
- Low satisfaction

Low operational efficiency, increased safety risks, and difficulty in quality control

A. Background and Objective

Technology Development

Current Status of Computer Vision Technology

Computer vision technology is increasingly used in the medical field, and it has shown great potential in medical image recognition and diagnosis.

Progress in Deep Learning Object Recognition

Deep learning algorithms have made recent progress in object recognition, providing strong technical support for artificial intelligence visual recognition systems.

From Assisted Tools to Transformative Cores -- The AI Era

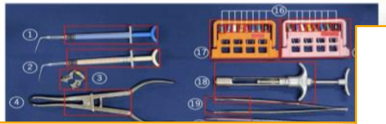
A. Background and Objective   Literature review

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

scientific reports

OPEN An efficient annotation method for image recognition of dental instruments

Shintaro Oka, Kazunori Nozaki & Mikako Hayashi



人工智能视觉识别系统在外来医疗器械检查中的应用效果

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

RESEARCH Open Access

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

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

Discussion

This study demonstrates the feasibility and effectiveness 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.

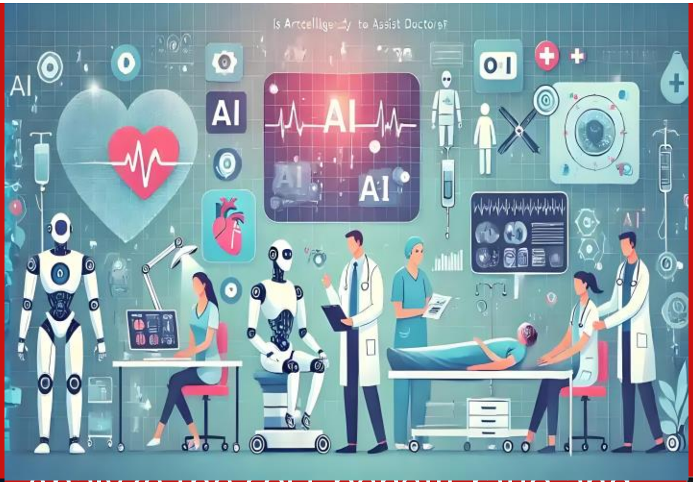
➢Literature Review: AI Applications in the medical field

A. Background and Objective

Research Objective Setting

AIM : The application effect and value of artificial intelligence visual recognition system in the CSSD loaned instruments receiving and inventory process

improvements of AI visual recognition systems in counting loaned instrument to ensure efficient and accurate medical processes.



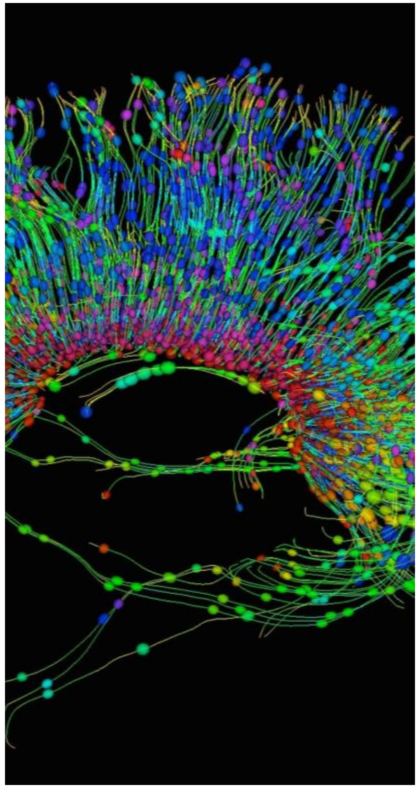
Long Term Goal

Establish standardized processes and quality control systems for intelligent equipment inventory to promote intelligent development in the medical field.

Analyze the cost-benefit ratio and personnel acceptance of system implementation, providing strong data support for decision-making 。

B. Research Details

System Technical Principles



Convolutional Neural Networks

In device image recognition, convolutional neural networks* automatically extract image features to achieve high-precision classification, providing technical support for foreign device recognition.

Deep Learning Algorithms

The algorithm module adopts advanced deep learning algorithms to continuously optimize the recognition model and improve the accurate recognition rate of instrument images under complex backgrounds.

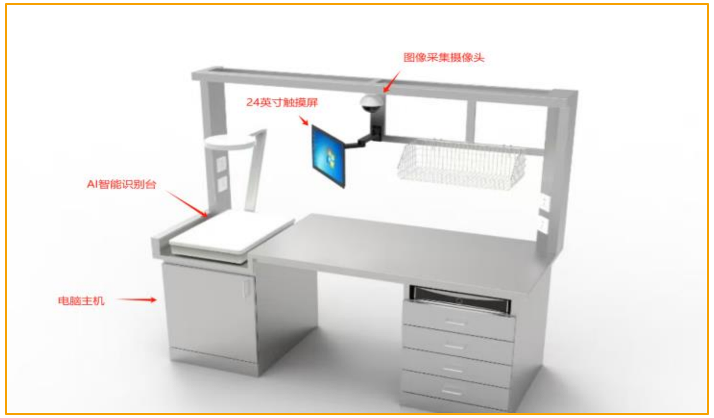
Note*: A convolutional neural network is a type of artificial neural network specifically designed to process data with a grid-like structure, most notably images. Through a unique operation called convolution, it can efficiently identify spatial patterns in images, such as edges, corners, object parts, and even entire objects.

B. Research Details

System Structure

Hardware composition

The system is equipped with high-definition cameras to capture clear images; the computing unit quickly processes recognition tasks; and the display terminal intuitively displays the results to ensure convenient operation.

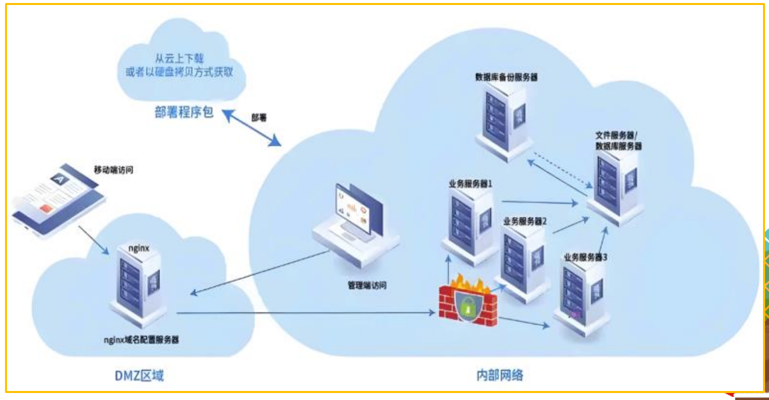


Software System

The image acquisition module enables efficient capture; the core of the recognition algorithm module is responsible for deep learning and model reasoning; the data management module ensures data integrity and security.

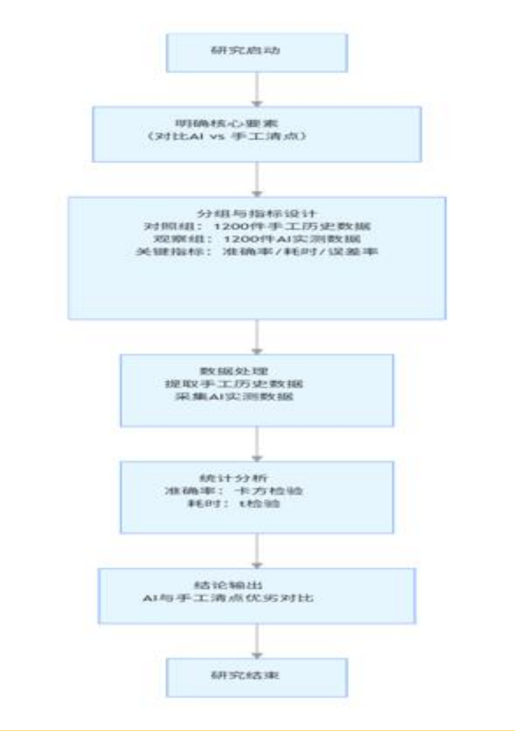
Network Architecture

Adopting a local deployment solution, data and processing equipment are stored locally to ensure data security and privacy, reduce network dependence, and improve system stability and response speed.



B. Research Details

Workflow Design



Standardized collection process

Establish detailed instrument image acquisition standards, including lighting, angle, resolution, etc., to ensure consistent image quality and lay a solid foundation for identification.

Collaborative identification mechanism

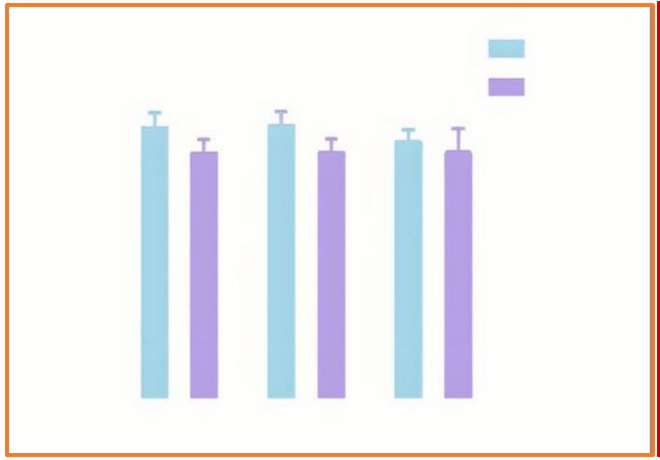
The system identifies the device in real time and quickly feeds back the results; at the same time, a manual review channel is established to conduct a second confirmation of suspected errors or complex devices.。

Exception handling process

Clarify the responsibilities and processes for exception handling, such as the response measures for blurred images, recognition failures, etc., to ensure that errors are corrected and handled in a timely manner 。

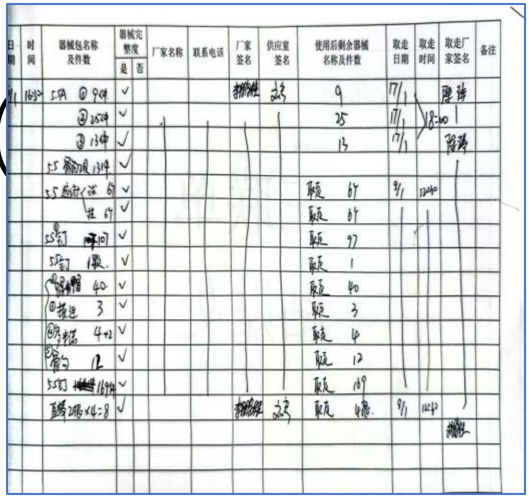
B. Research Details

Study Design



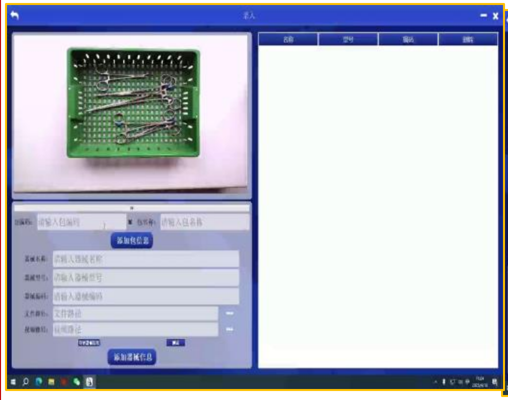
Controlled trial plan

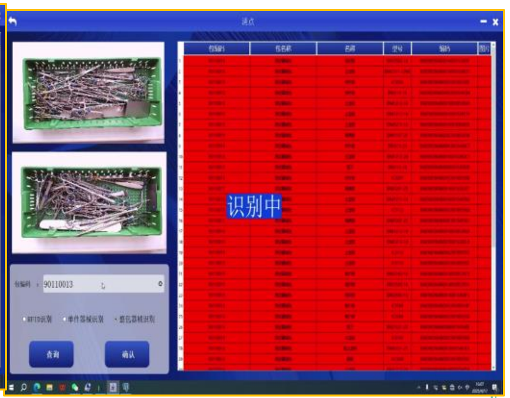
A control group and an experimental group were set up. The control group adopted the traditional manual counting mode, and the experimental group adopted the AI visual recognition system. The counting efficiency and accuracy of the two groups were compared.



Limited scope

The study is limited to a specific time period and specific device type to ensure the representativeness of the research sample and the reliability of the results, avoiding interference from irrelevant variables. 。





B. Research Details

Research Subject

Inclusion criteria for on loan instrment

The study was limited to devices of specific types, materials, and complexity to ensure the effectiveness and accuracy of the identification process and avoid interference from non-target devices.

&

Personnel training and operating procedures

Researchers need to receive unified training to ensure standardized operations, reduce human errors, and ensure the accuracy and reliability of research data.

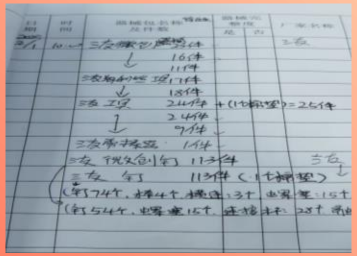
Set up inclusion criteria

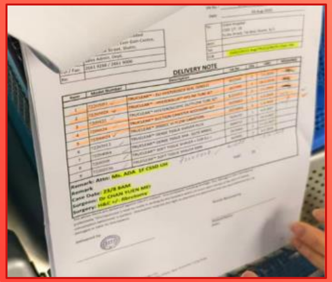
C. Research Method and Data Collection

Research Method

Comparison between traditional methods and artificial intelligence recognition

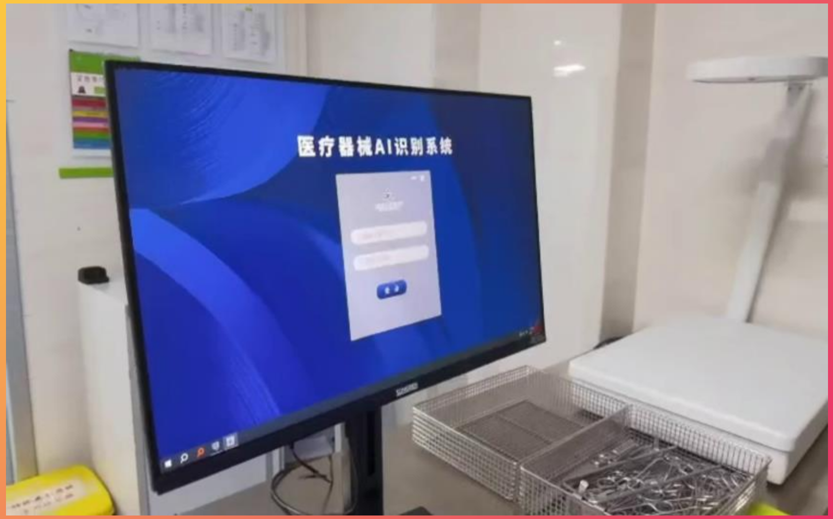
Traditional Method





VS

Artificial intelligence recognition



C. Research Method and Data Collection

Method of Data collection

Main evaluation indicators

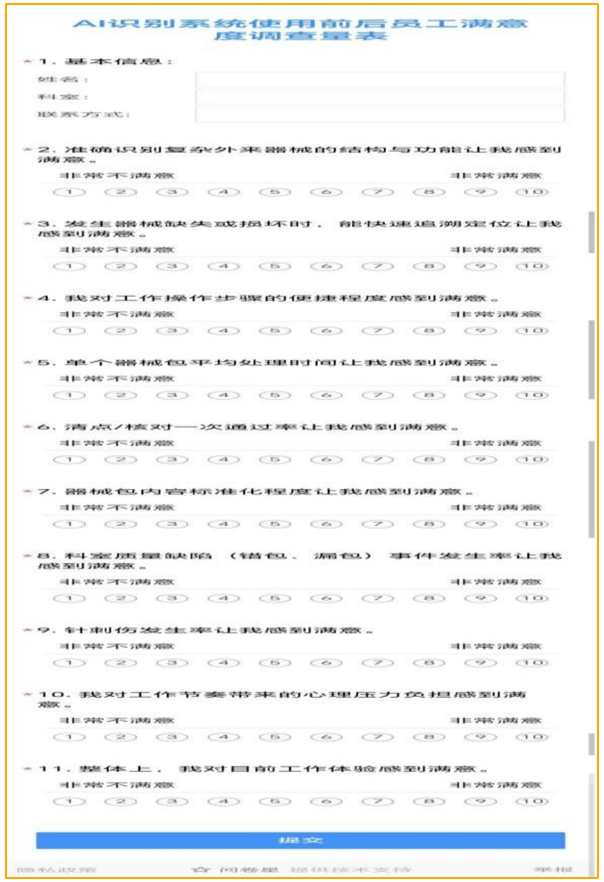
Recognition accuracy, inventory time, and error rate are used to comprehensively evaluate the performance of the AI visual recognition system to ensure that the data is accurate and effective.

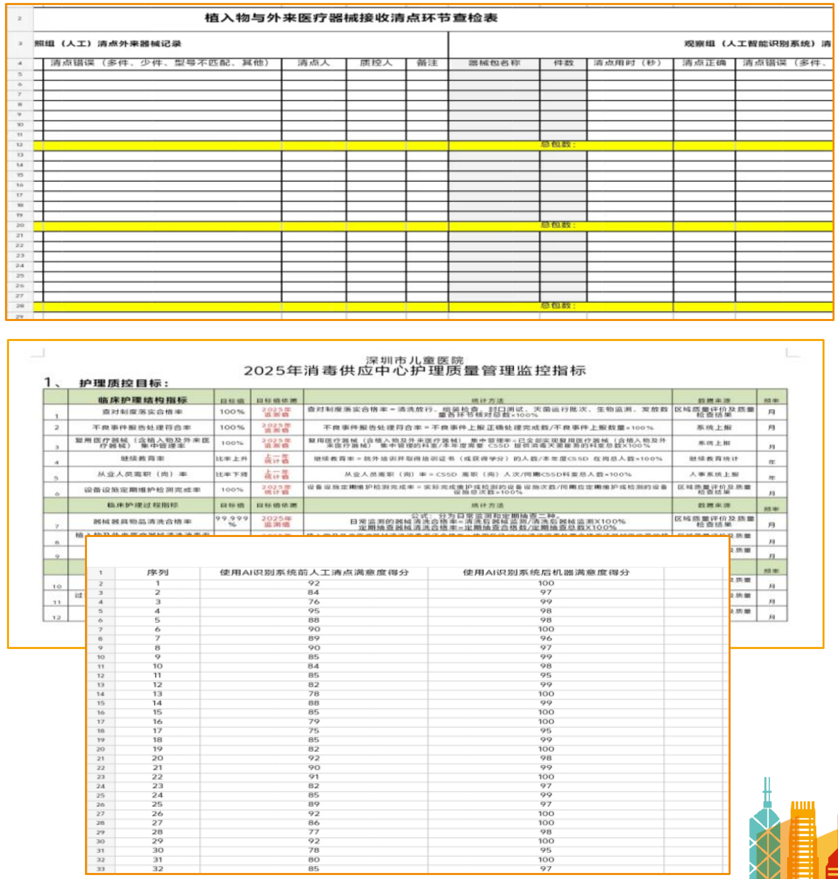
Data collection time and frequency

Collect data in real time and record key indicators at high frequencies to ensure the timeliness and integrity of data and provide a basis for system optimization.

Quality control and data review

Establish a strict quality control system, conduct multiple audits on the data to ensure its accuracy and reliability and eliminate outliers.





序列	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
1	92	100
2	84	97
3	76	99
4	95	98
5	88	98
6	90	100
7	89	96
8	90	97
9	85	99
10	84	98
11	85	95
12	82	99
13	78	100
14	88	99
15	85	100
16	79	100
17	75	95
18	85	99
19	82	100
20	92	98
21	90	99
22	91	100
23	82	97
24	85	99
25	89	97
26	92	100
27	86	100
28	77	98
29	92	100
30	78	95
31	80	100
32	85	97

C. Research Method and Data Collection

Statistical Case Study

Sample size calculation and efficiency evaluation

Based on previous data and expected effect size, accurately calculate the required sample size and evaluate the power of statistical tests to ensure reliable results.

Descriptive statistical analysis

Descriptive statistical analysis is conducted on the main indicators to reveal the data characteristics and lay the foundation for subsequent in-depth analysis.

Statistical methods for intergroup comparisons

Appropriate inferential statistical methods were used to compare the differences in main indicators between different groups and reveal the advantages of the AI visual recognition system.

Paired Samples Statistics

	Mean value (E)	Number	Standard deviation	Mean standard Error
Pair 1 - Control group	85	47	5.473	.798
Research group	98	47	2.126	.310

Paired Samples correlation

	Number	correlation coefficient	Significance
Pair 1. Control group & research group	47	-.015	.921

Normality test

	Kolmogorov-Smirnov(K)a			Shapiro-Wilk		
	statistics	df	significance	statistics	df	significance
difference	.077	47	.200*	.979	47	.553

*. The lower limit of true significance

a. Lilliefors significance correction

D. Result Analysis

Major Results Analysis

AI system recognition accuracy

The AI system's recognition accuracy is as high as 99.2%, significantly better than the 88% of traditional methods.

Improved inventory efficiency

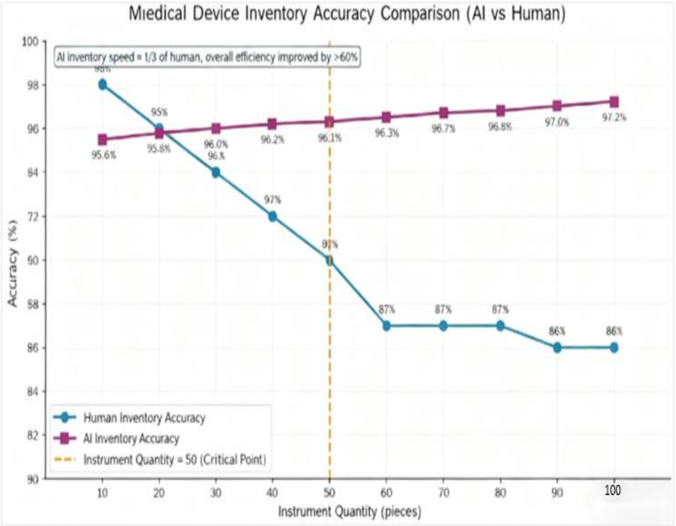
The AI system improves inventory efficiency, effectively shortens working time and improves overall efficiency.

Differences in device recognition performance

There was a significant difference in recognition performance between simple and complex instruments, but the impact on overall accuracy was minimal.

Average time/pack for counting instrument before and after using the AI recognition system

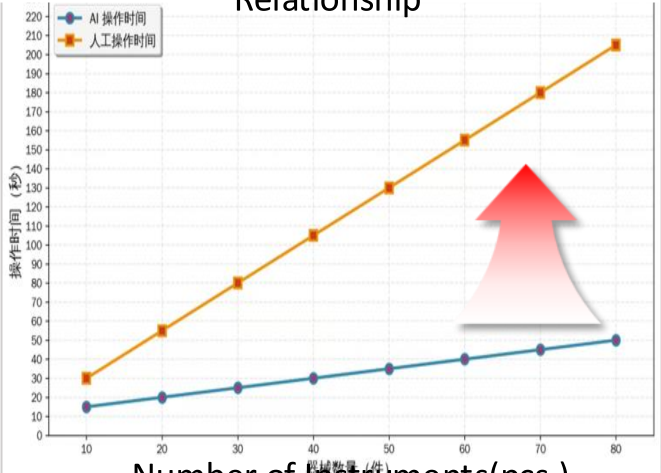
pachages	Experimet group (AI) (n=1200)	Control group (manual) (n=1200)	Z-score	P-score
<20 pcs/package (n=246)	10.70 (9.80, 11.70)	22.40 (20.90, 23.62)	-13.598b	<0.001
20-50 pcs/package (n=862)	36.25 (33.20, 40.30)	92.40 (89.20, 95.30)	-25.434b	<0.001
>50 pcs/package (n=92)	56.75 (54.32, 59.17)	146.50 (142.22, 150.47)	-8.331b	<0.001



The accuracy of counting instrument packages before and after using the AI recognition system

Classification	Indicator	Experimet group (AI) (n=1200)	Control group (manual) (n=1200)	X^2 value	P-score
<20 pcs/package (n=246)	Accuracy rate of Instrument inventory (%)	244 (99.2%)	237 (96.3%)		0.039b
20-50 pcs/package (n=862)	Accuracy rate of Instrument inventory (%)	835 (96.9%)	803 (93.2%)	22.881	<0.001
>50 pcs/package (n=92)	Accuracy rate of Instrument inventory (%)	88 (95.7%)	80 (87.0%)		0.021b

Machinery Quantity vs. Time Relationship



Number of Instruments(pcs.)

D. Result Analysis

Secondary Outcome Analysis

Costs and benefits of System Utilization

Staff acceptance and satisfaction

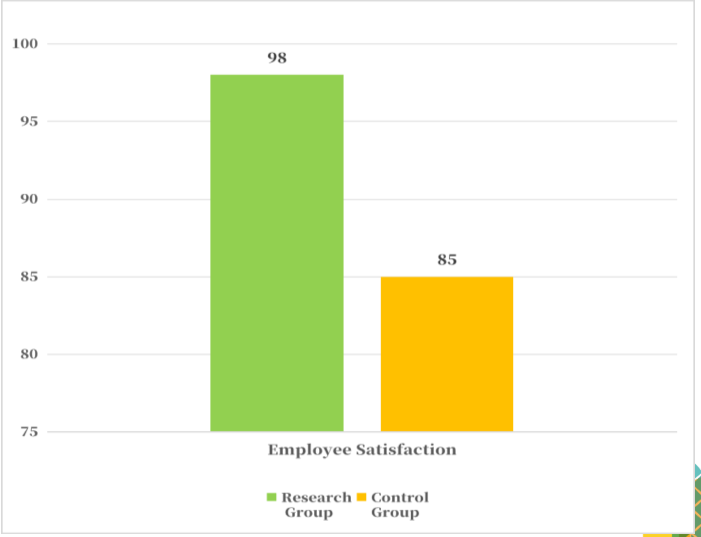
System stability and reliability

Traceability system management quality

indicator	Experimet group(AI)	Control group (manual)
The completion of instrument inventory work can be ensured to be recorded	Y	N
The information on the type an quantity of instruments can be ensured to be recorded	Y	N
It can facilitate the implementation of full-process quality traceability	Y	N
Can it reduce the operational difficulty for staff?	Y	N
Can it display the usage information in real time?	Y	N

Employee satisfaction before and after using the AI recognition system

indicator	Experimet group(AI) (n=47)	Control group (manual) (n=47)	t-score	P-scroe
Staff Satisfaction	98.00±2.126	85.00±5.473	-15.102	<0.001



D. Result Analysis

Abnormal situation analysis

Case study on Identification failure

Conduct in-depth analysis of cases of recognition failure to identify reasons including poor instrument image quality and difficulty in recognizing special materials.

Systematic Errors and Human Factors

By comparing recognition failure cases caused by system errors and human factors, the difference between the two and their respective proportions can be clarified.

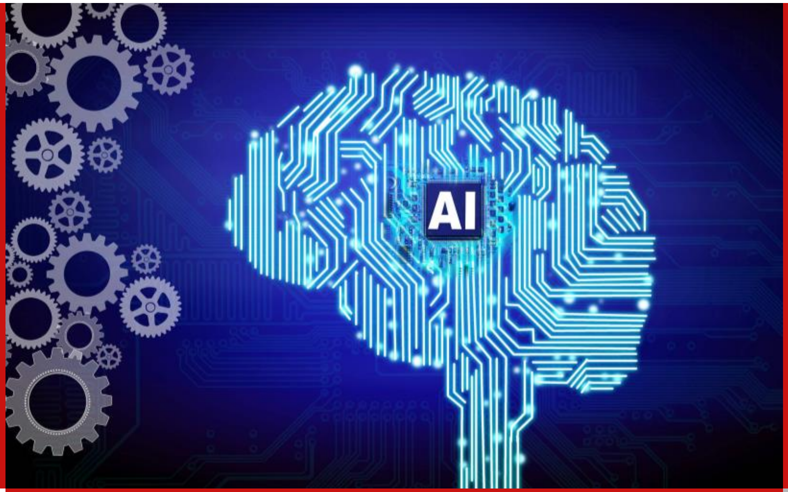
Verification of the effectiveness of improvement measures

Based on the analysis of the causes of recognition failure cases, improvement measures are proposed and implemented, such as optimizing the image acquisition process and enhancing the ability to recognize special materials.

E. Recommendation Technical optimization suggestions

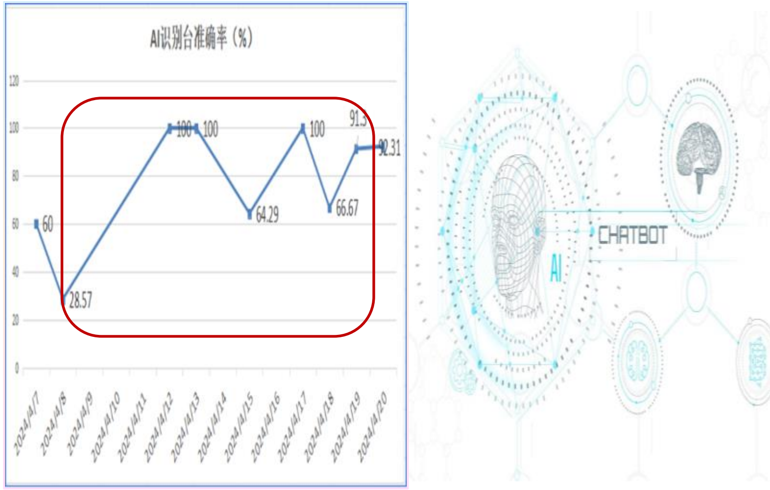
Algorithm model optimization

Continuously collect data, optimize algorithm models, improve recognition accuracy and efficiency, and ensure the ongoing enhancement of AI system performance.



System integration and compatibility

Strengthen system integration capabilities, improve compatibility with other medical systems, and realize data sharing and process collaboration.



Hardware equipment upgrade

As technology develops, timely upgrades to high-definition camera equipment, computing units and other hardware to ensure system speed and stability 。

E. Recommendation

Process Enhancement Recommendations

Image acquisition specifications

Develop detailed standardized image acquisition specifications to ensure image quality and reduce recognition errors caused by unclear images.

Human-machine collaborative optimization

Optimize the human-machine collaborative working mechanism, clarify the responsibilities and interaction methods between AI systems and personnel, and improve overall work efficiency.

E. Recommendation

Training and promotion

Operator training

Design training courses for operators, covering basic operation, maintenance and troubleshooting of AI systems to improve personnel skills.

Industry promotion

Formulate a multi-center promotion and application strategy, pilot it in some hospitals first, and then gradually expand it to a wider area after summarizing the experience.

F. Conclusion and Implication Main Research Conclusions

AI Vision Advantages

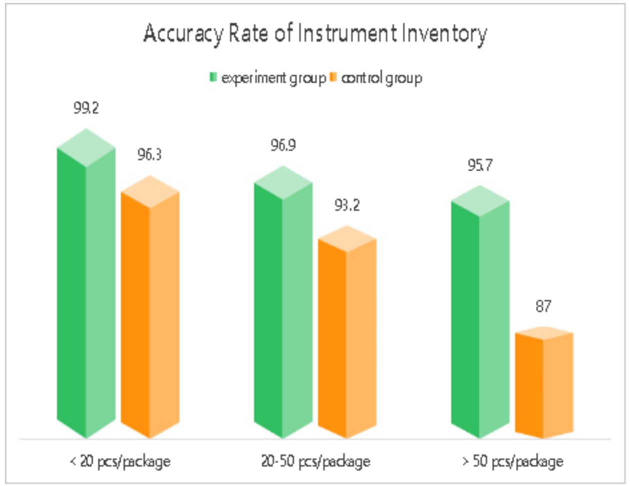
Accurate identification, efficient inventory, reduced labor costs, and improved CSSD efficiency and quality 。

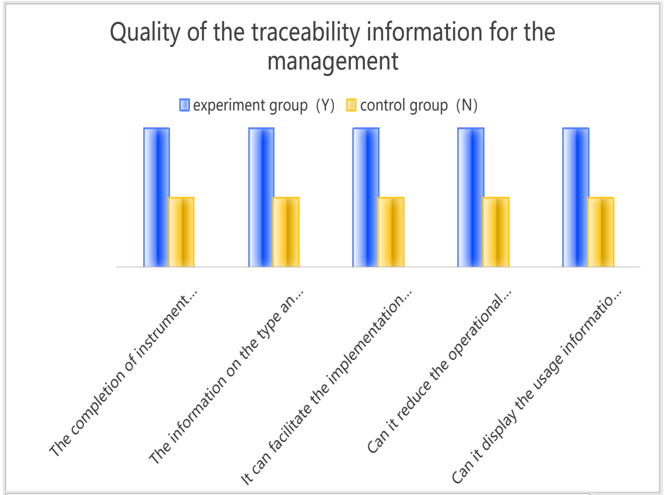
Limitation Factor

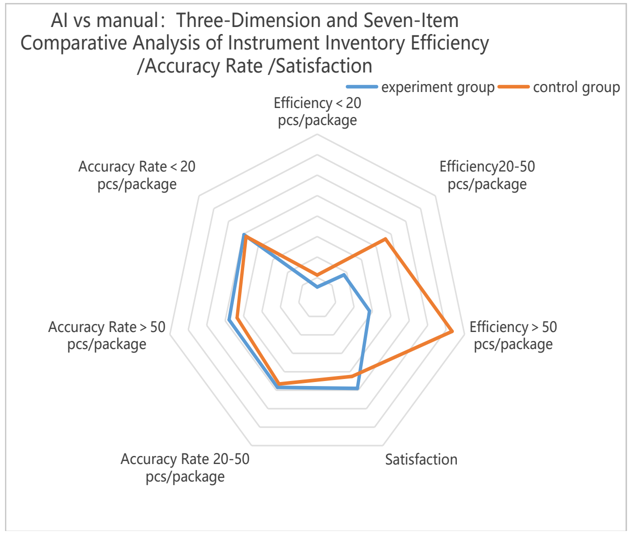
The technical threshold is high, the equipment cost is high, customization is required, and it is greatly affected by environmental factors.

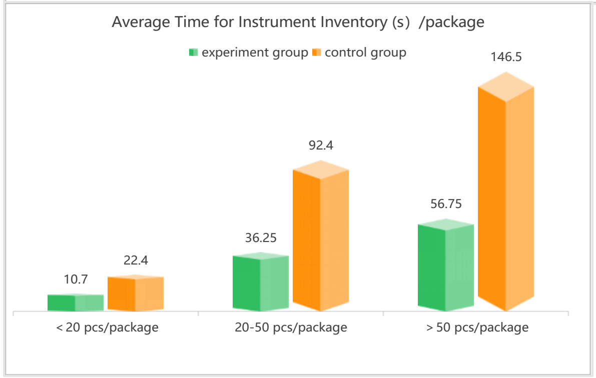
Technology Outlook

As technology matures and costs decrease, the application prospects of AI visual recognition systems are broad and will lead to innovation and upgrading of CSSD management.









F. Conclusion and Implication

Practical Significance

Management Implications

The AI visual recognition system helps the disinfection supply center achieve process optimization and intelligent management, improving work efficiency and quality.

Contribution to medical safety

Through accurate identification and efficient inventory, we can reduce medical risks, strengthen the medical quality and safety line, and protect patient safety.

F. Conclusion and Implication

Research Limitations and Prospects

Limitation Analysis → **Research Direction** → **Follow-up Evaluation**

The sample size of this study is limited and does not cover all types of devices; the scope of research needs to be expanded in the future to consider more influencing factors.

Explore the application effects of AI visual recognition systems in different medical institutions and design more efficient algorithms and processes 。

Continuously monitor system performance and results, adjust optimization plans in a timely manner, and ensure the timeliness and practicality of research results.

Thank you for your attention