XISHAN 西山

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Model-Based Design - Driving Innovation in High-Precision Medical Endoscope Image Processing Algorithms

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MATLAB EXPO

Agenda

1. Company Overview
2. Surgical Scenarios
3. Current Limitations of Endoscope Systems
4. Dual-Drive Approach to Overcome Endoscope System Limitations
5. Rapid Algorithm to FPGA Code Conversion Using MATLAB

1.1 Xishan Technology

Leading Domestic Brand for Surgical Power Devices

Chongqing Xishan Technology Co., Ltd. was established in December 1999, focusing on surgical instruments, especially minimally invasive surgical instruments. The company engages in the R&D, production, and sales of surgical power devices, endoscopes, and energy surgical equipment, primarily used in neurosurgery, ENT, orthopedics, breast surgery, and other clinical departments.

Main Products:

1. **Surgical Power Devices**: Used for cutting, grinding, sawing, milling, and trimming bone and soft tissue in surgeries.
2. **Endoscopes**: Including ENT scopes, arthroscopes, foraminal scopes, laparoscopes, etc.
3. **Energy Devices**: Ultrasonic bone knives, plasma surgical systems, high-frequency surgical systems used in general surgery, ENT, orthopedics, etc.

Number of employees: 619

Key Achievements:

National High-Tech Enterprise

National Intellectual Property Demonstration Enterprise

National Specialized and New “Little Giant” Enterprise

Licensed for Class II and III medical device production

Mission and Vision:

- **Purpose**: Contribute to human health
- **Mission**: Empower doctors, assist patients in recovery
- **Strategic Positioning**: Provider of comprehensive solutions for minimally invasive surgical tools
- **Strategic Goals**: Become a world-class minimally invasive medical device technology company and a representative enterprise of Chinese medical devices

1.2 Company History

1999
Company establishment

2000
Obtained the first medical device product registration certificate (electric cranial drill)

2007
Established the product development approach of "specialized for specific departments"

2009
The industry standard for "Electric Bone Tissue Surgical Equipment," drafted primarily by the company, was officially released and implemented.

2011
- Product obtained CE certification
- First introduced venture capital investors

2015
•Successfully listed on the New Third Board
•Established the strategic positioning as a "provider of comprehensive minimally invasive surgical tool solutions"

2017
•The endoscope factory was completed and put into operation
•Comprehensively initiated the independent research, development, and manufacturing of the rigid endoscope product series

2020
•The breast lesion rotary cutting biopsy system obtained its registration certificate

2021
•Officially initiated IPO listing process
•Patent applications exceeded 1,000
•The foraminal endoscope obtained its registration certificate

2022
• Obtained registration certificates for energy surgical devices: ultrasonic bone scalpel, plasma surgical system, and high-frequency surgical system
•Honored with the national title of "Specialized, Refined, and Innovative" Little Giant Enterprise
•Passed the review by the Science and Technology Innovation Board Listing Committee

2023
Listed on the Science and Technology Innovation Board (STAR Market)

1.3 Endoscope Products

Sinuscope

Registration No.
20202060078

Foraminal endoscope

Registration No.
20212060246

Otoscope

Registration No.
20202060080

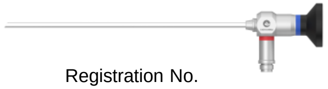
Laparoscope

Registration No.
2022060331

Laryngoscope

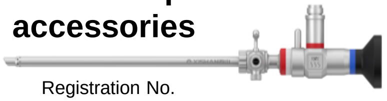
Registration No.
20202060079

Hysteroscope



Registration No.
20232180476

Arthroscope and accessories



Registration No.
20203060910

Endoscope imaging system
(Registration No. Yuxie Zhun 20212060140)

Endoscope Market Landscape

Market Space:

The total value of the Chinese rigid endoscope market is approximately 8 billion RMB. Karl Storz holds about 47% of the market share, Olympus holds about 23%, and domestic companies hold less than 10%. The low level of import substitution reflects the high entry barriers in the industry.

Development Goals:

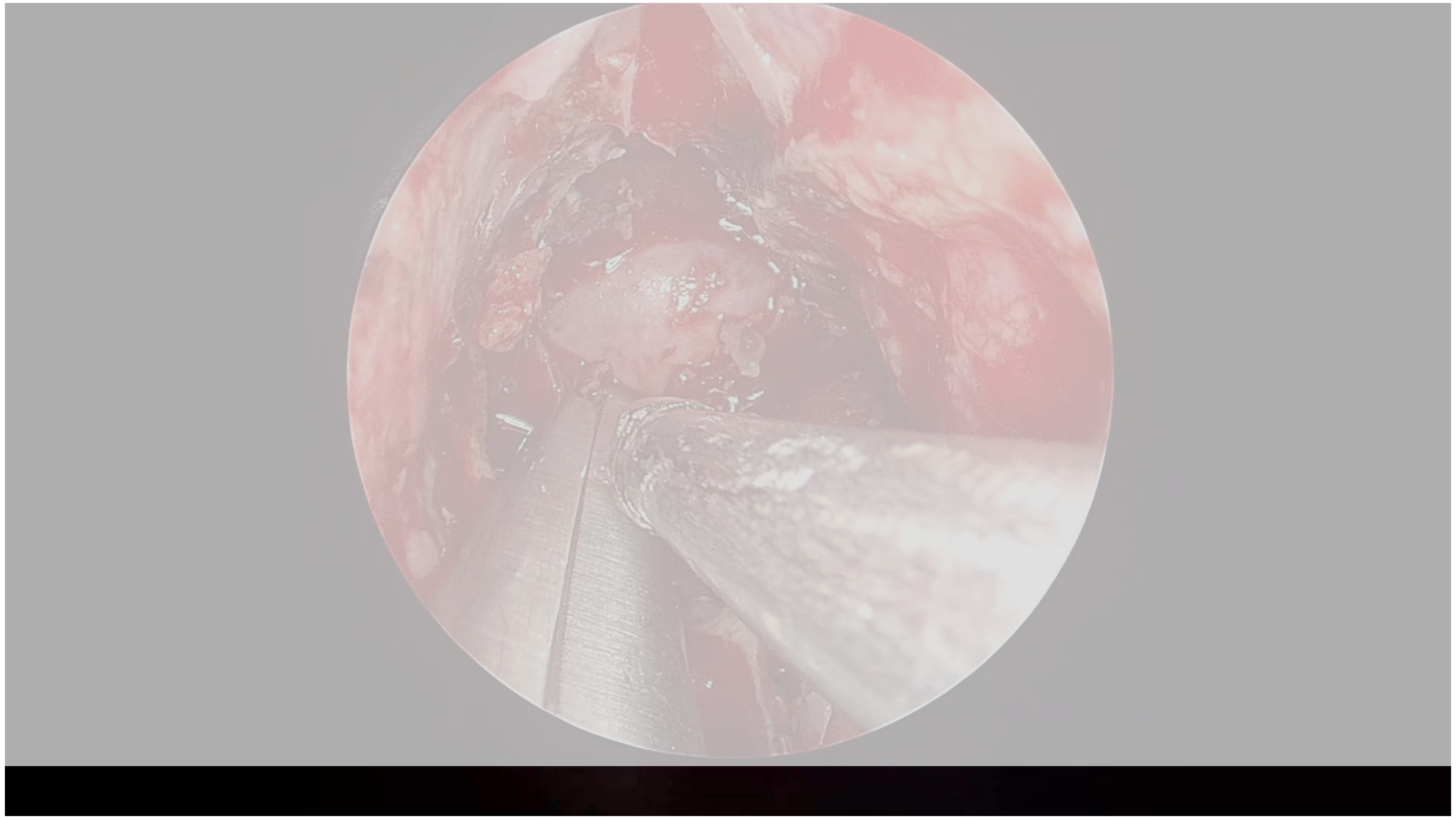
Position as a world-class company.

Product Highlights:

Self-developed lens optical materials and coating technology.

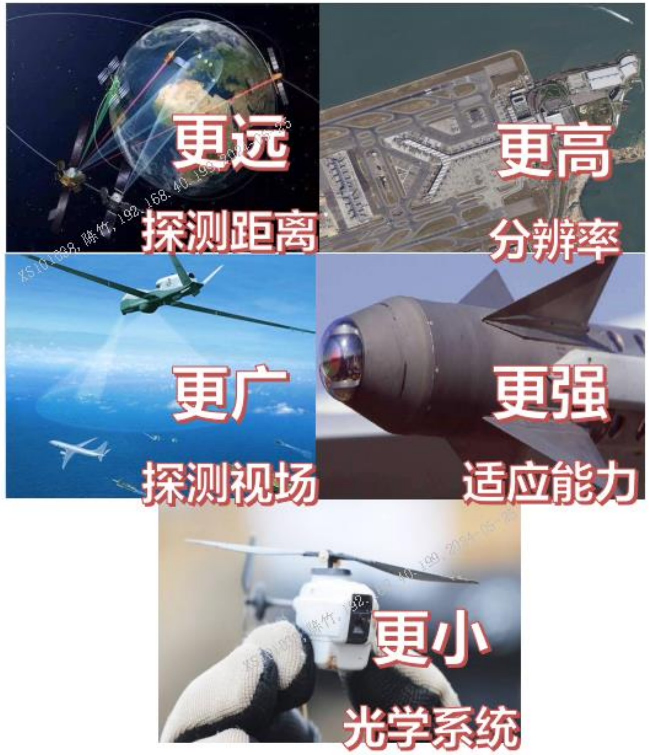
Note: Endoscope market data is sourced from "China Medical Devices" and Frost & Sullivan.

2. Surgical Scenarios



3. Current Limitations of Endoscope Systems

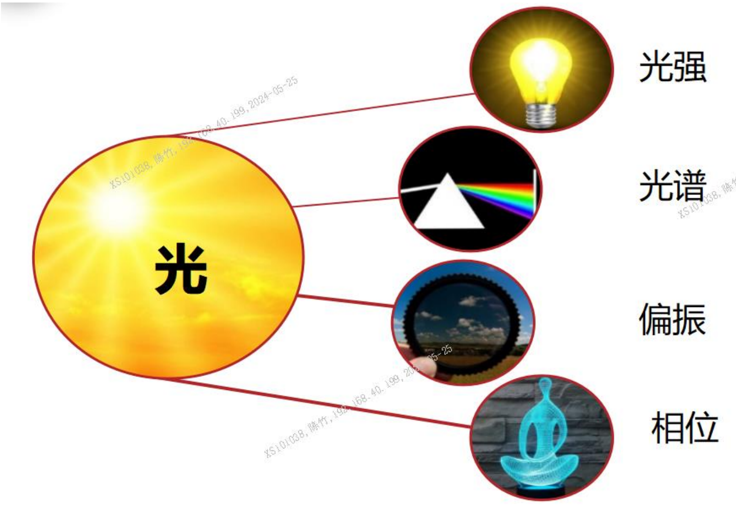
The limitations of traditional optical systems:
can’t see, can’t see clearly, can’t see far, large size.

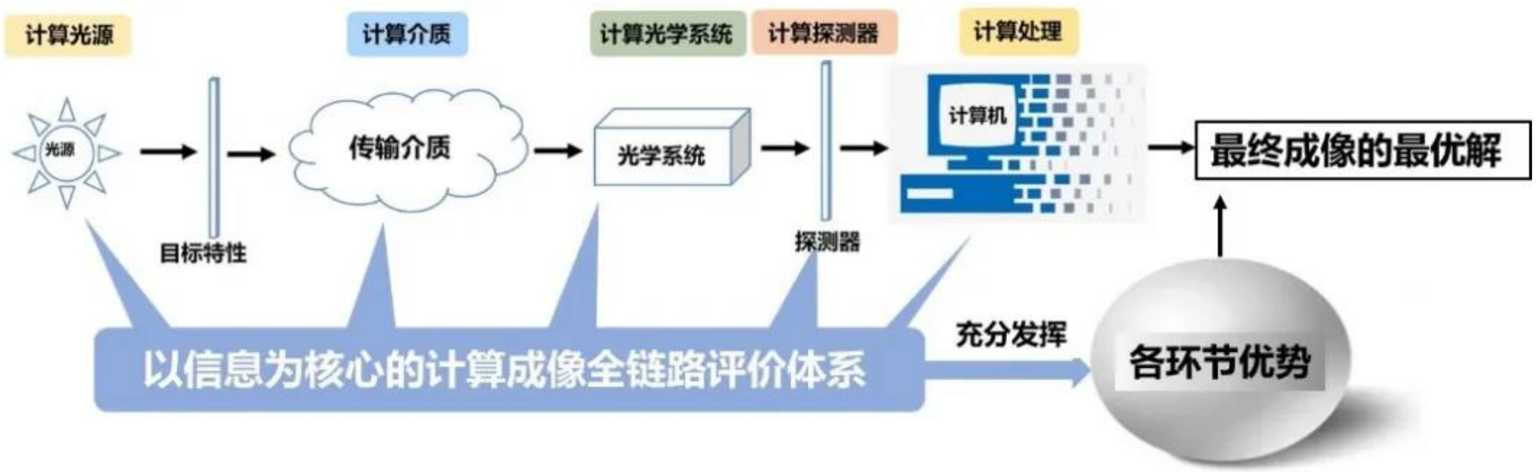


Aiming to quickly overcome these limitations and support clinical applications through a dual drive approach of "MATLAB" and "computational imaging"!

4.1 Introduction to Computational Imaging Technology

Computational imaging technology combines optics, sensor technology, computational algorithms, and system design. By incorporating computational processing during the imaging process, it surpasses the performance limitations of traditional imaging systems. The core idea of this technology is to introduce information processing at the image capture stage, thereby improving image quality, enhancing imaging functions, or reducing hardware complexity.

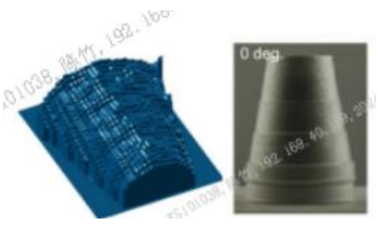


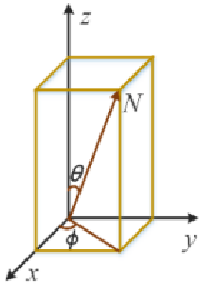


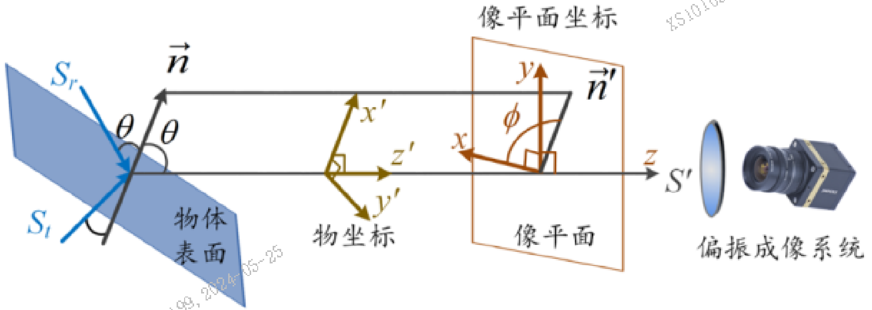
By acquiring more light field information, it enables higher-dimensional imaging.

4.1 Introduction to Computational Imaging Technology

A Polarization Camera Can Also Achieve 3D Reconstruction







物体表面法向量模型

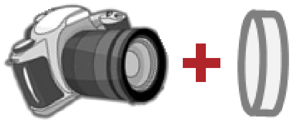
$$\vec{n} = \begin{bmatrix} n_x \\ n_y \\ n_z \end{bmatrix} = \begin{bmatrix} \cos\theta\cos\varphi \\ \cos\theta\sin\varphi \\ \sin\theta \end{bmatrix} = \begin{bmatrix} \tan\theta\cos\varphi \\ \tan\theta\sin\varphi \\ 1 \end{bmatrix}$$

偏振三维成像结果

系统结构简单

表面纹理信息
成像精度高

性价比高



一个最简单的偏振成像系统

偏振三维成像结果示例

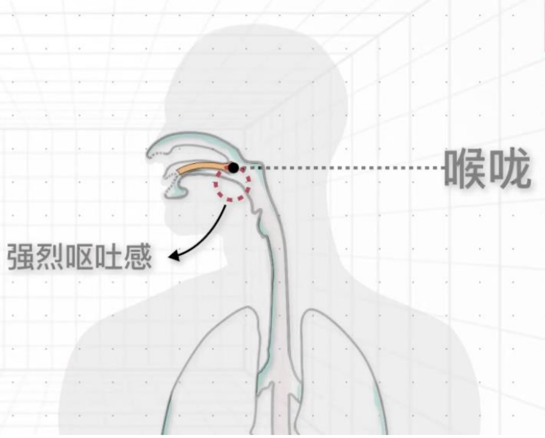
偏振信息解译

$$P = \frac{\left(n - \frac{1}{n}\right)^2 \sin^2\theta}{2 + 2n^2 - \left(n - \frac{1}{n}\right)^2 \sin^2\theta + 4\cos\theta\sqrt{n^2 - \sin^2\theta}}$$

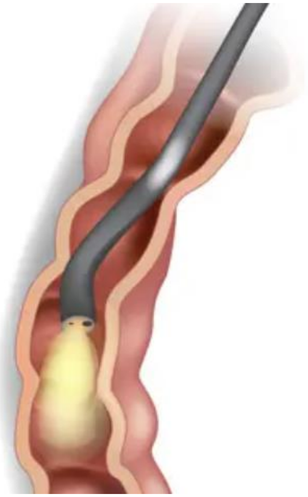
$$I\left(\phi_{pol}\right) = \frac{I_{\max} + I_{\min}}{2} + \frac{I_{\max} - I_{\min}}{2}\cos\left(2\left(\phi_{pol} - \varphi\right)\right)$$

Note: Content source - School of Optoelectronic Engineering, Xidian University.

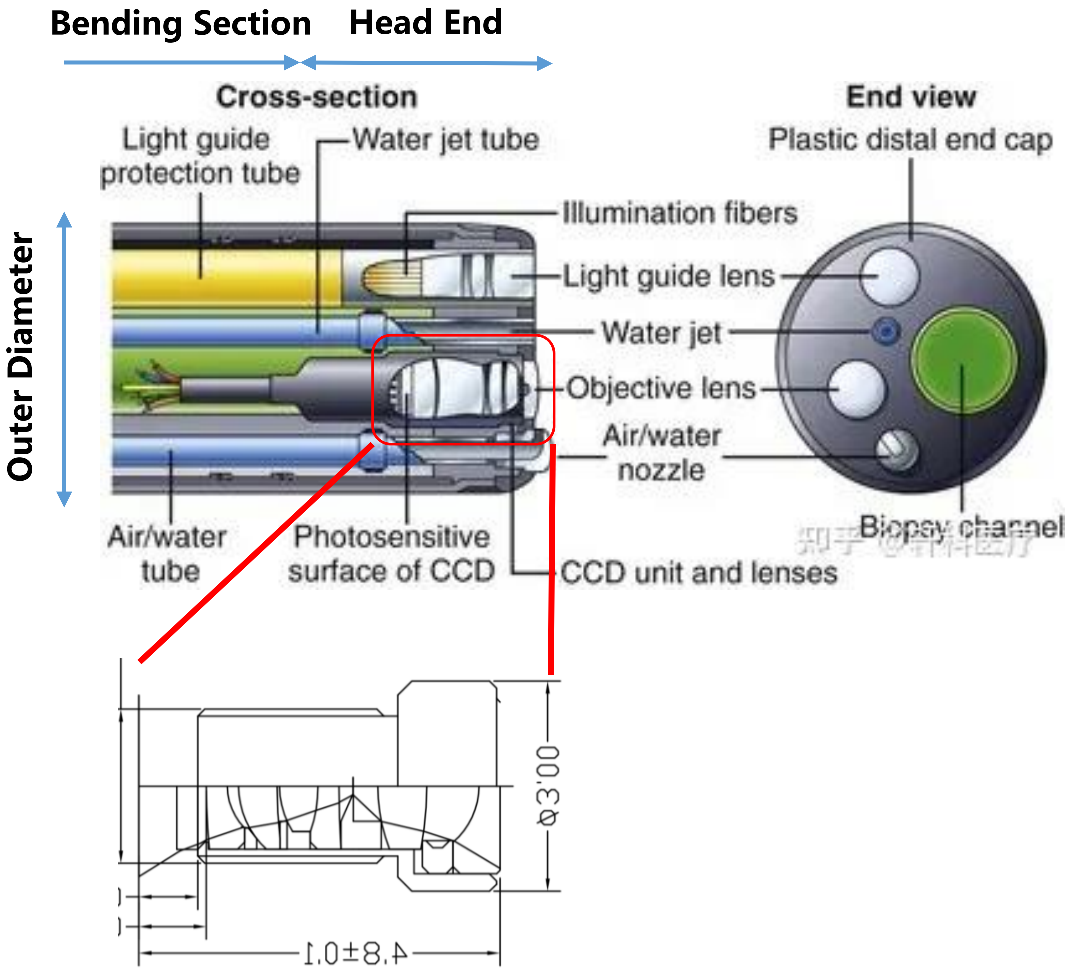
4.2 Limitations of Endoscope Systems - Space Constraints



Thin Outer Diameter



Short Head End

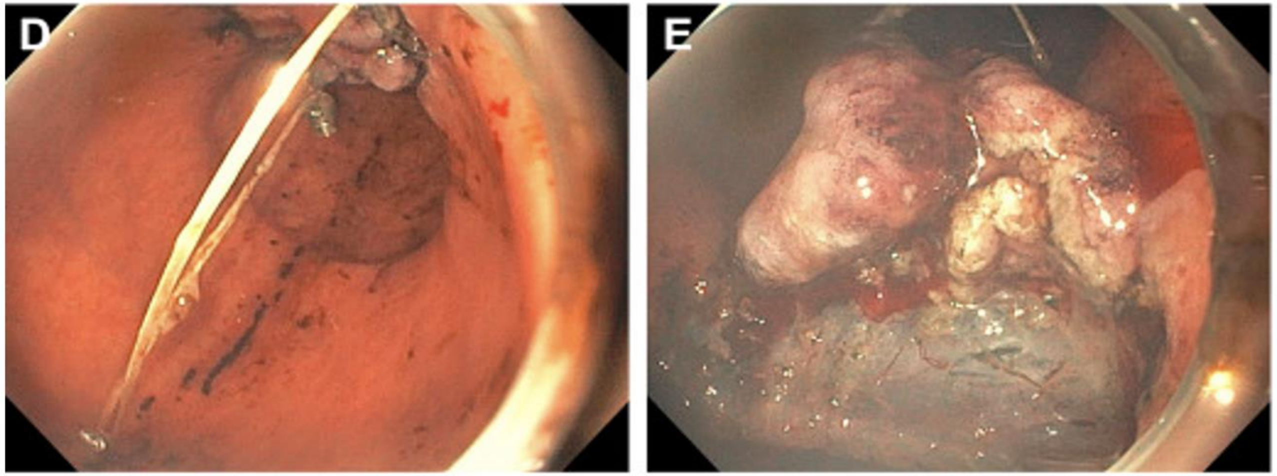


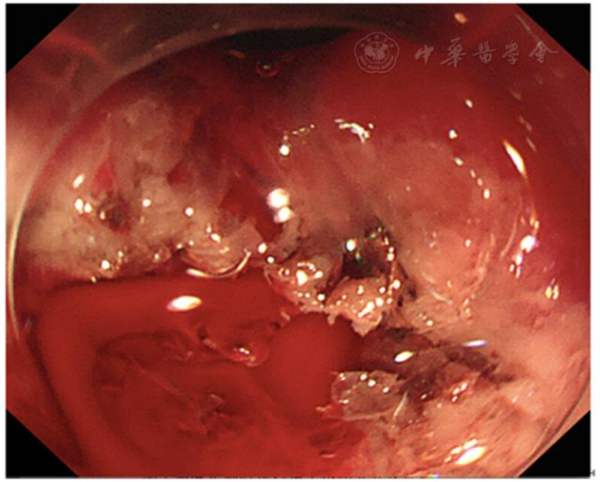
Dancing in shackles within limited space

4.3 Limitations of Endoscope Systems - Environmental Constraints

The natural body cavities are high-humidity environments filled with mucus and prone to bleeding.

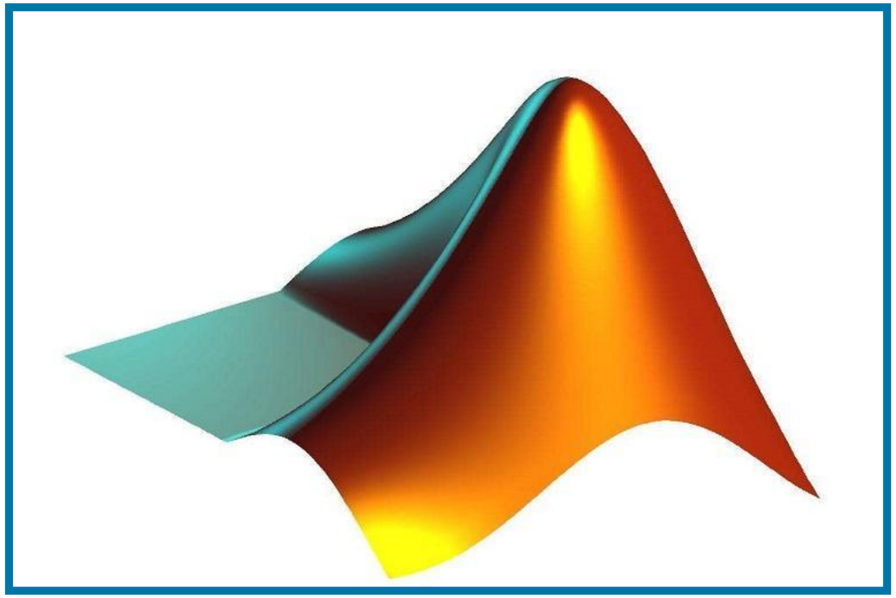
During endoscopic examinations, the endoscope’s head end is constantly moving, making it easy for mucus, smoke, and blood to contaminate the field of view.





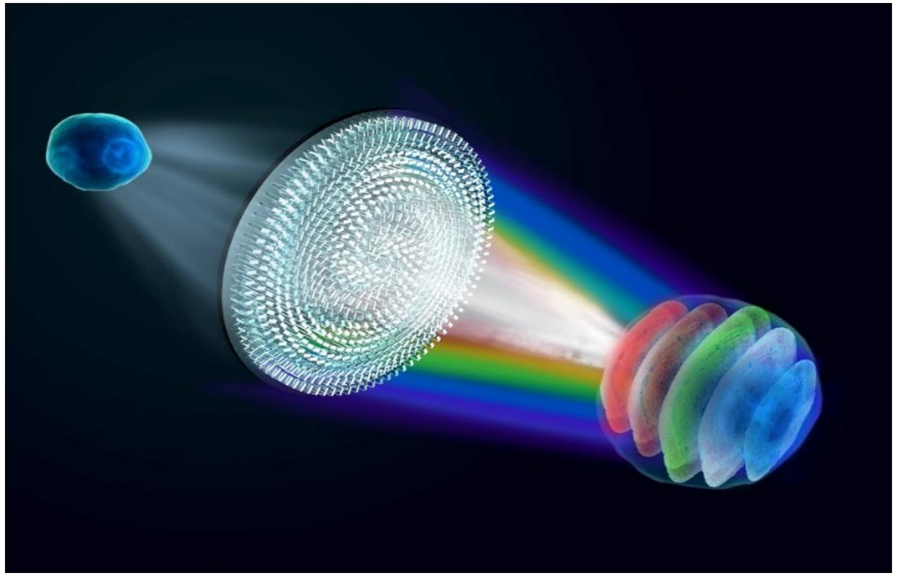
4. Dual-Drive Approach to Overcome Endoscope System Limitations

Rapid algorithm deployment to FPGA



MATLAB

Enhances image quality and functionality beyond traditional imaging systems



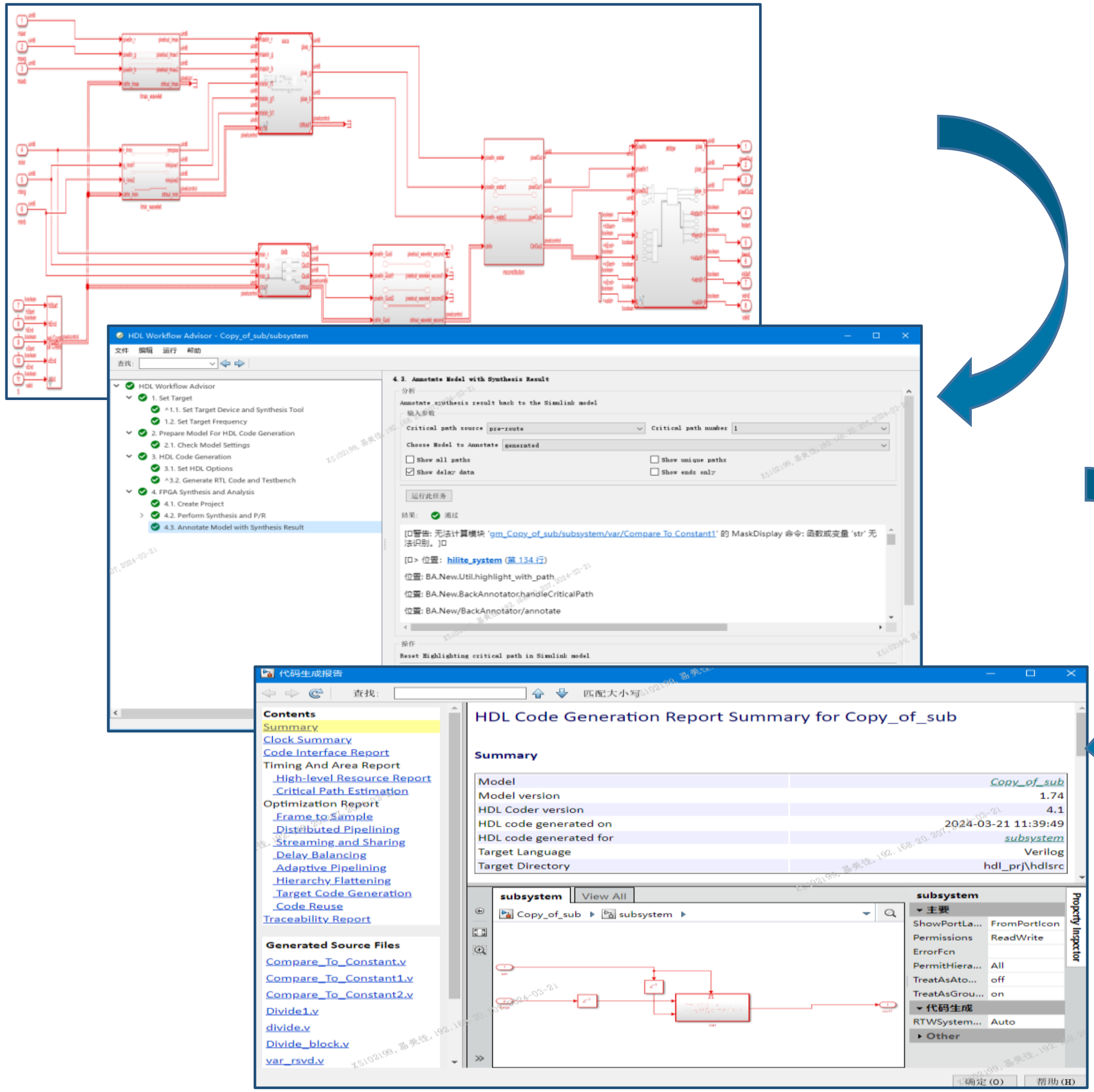
Computational Imaging Technology

Dual Drive

5.1 Challenges in Implementing High-Performance Medical Image Processing Algorithms on FPGA

- Algorithm development cycles are long, and experimental scenarios/data are often insufficient.
- The complexity of hardware and software environments makes real-time evaluation of algorithm performance and resources difficult.
- Algorithms need to be handed over to the FPGA team for implementation, requiring scheduling and planning.
- There are multiple ways to implement the same algorithm, making it impractical for the FPGA team to implement all versions.
- Significant differences exist between algorithm simulation results and FPGA implementation effects, necessitating rapid prototyping for comparison.
- HDL code simulation is slow, and design modification cycles are long, requiring higher abstraction levels to speed up iteration efficiency.
- Diverse and high-demand customization requirements in the domestic market make it challenging to respond quickly.

5.2 Rapid Algorithm to FPGA Code Conversion Using MATLAB



1. **HDL Coder automatically generates standardized code.**

2. **Various resource and timing optimization strategies.**

3. **Generates comprehensive reports for traceability.**

5.2 Rapid Algorithm to FPGA Code Conversion Using MATLAB

MATLAB Platform

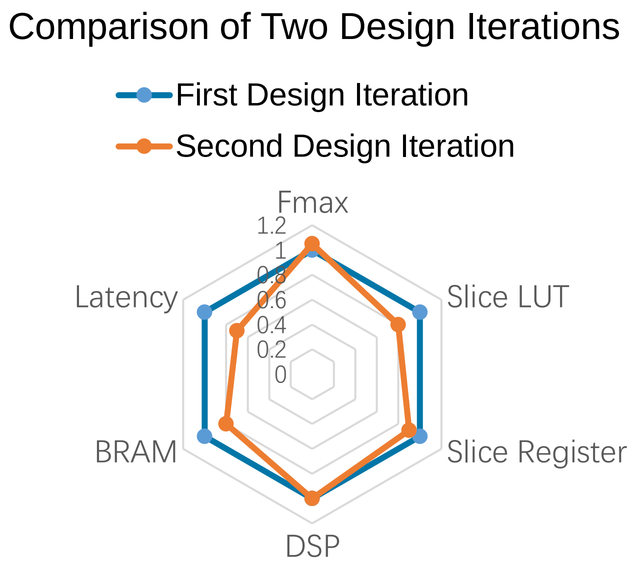
Computational Imaging Technology

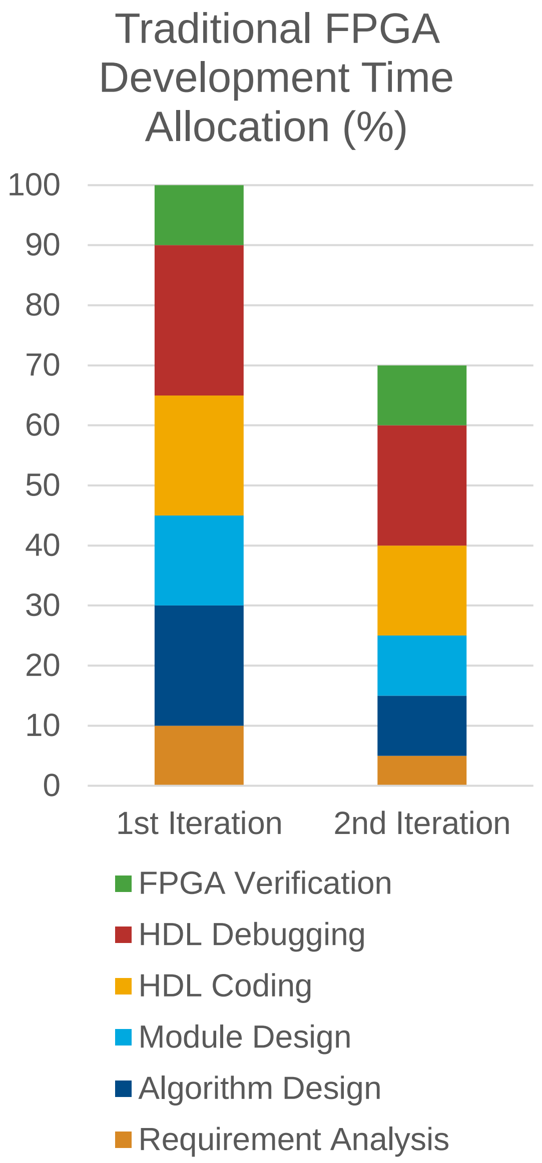
1. MATLAB: Facilitates rapid iteration and validation of algorithm requirements.
2. Simulink: Quickly deploys algorithm models based on hardware architecture.
3. HDL Coder: Automatically generates code with high standardization, execution efficiency, maintainability, and portability.

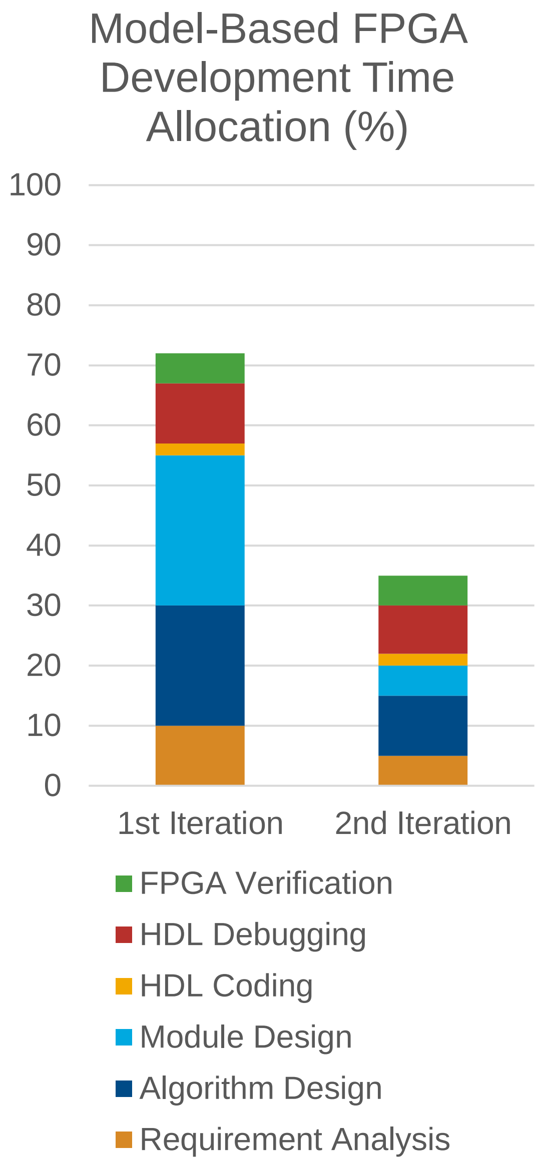
Rapid Algorithm Deployment to FPGA

5.3 Advantages of Model-Based FPGA Algorithm Development

- Accelerate Design Iteration and Improve Development Efficiency.
- Models are easier to modify, allowing for quick implementation of design changes.
- The generated code is highly readable and easy to integrate.
- Facilitates design reuse through modular development.
- Ensures that all performance metrics are balanced and meet expectations after implementation.







Collaboration Between Xishan Technology and MathWorks

Initial Contact	Workshop	Guided Project Technical Engagement	MathWorks Training	MBD Accelerating R&D
Preliminary technical contact	Hands-on practice for engineers Quick ramp up of tool usage Acquiring essential knowledge for tool usage	Setting project goals based on actual R&D needs Dedicated personnel for implementation Joint advancement by both parties Regular progress communication Modeling guidance and Q&A Relevant topic discussions	Step-by-step series of courses Professional instructors for explanations and Q&A Systematic improvement of tool usage skills	Optimizing experimental processes through simulation Accelerating prototype development with code generation Enhancing product quality through testing and verification

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Thank you

MathWorks®