RESEARCH ARTICLE

Application of artificial intelligence and internet of things in medical imaging teaching

Zhenlun Li*

Department of Medical Imaging, Jiangxi Medical College, Shangrao 334000, Jiangxi, China

Received: April 11, 2023; **accepted:** June 20, 2023.

Medical imaging teaching is an image-based subject. During the learning process, students can improve their professional ability and ability to analyze and solve problems by analyzing and studying a large number of medical images. However, due to the limitation of medical imaging teaching resources in China, there are still problems in the teaching of medical imaging such as outdated teaching facilities, backward teaching models, and lack of practical experience for students. The components of the medical imaging teaching system in this study included the equipment for data acquisition, data storage, data processing, and teaching interactive. The Internet of Things (Iot) and artificial intelligence technology were integrated into the medical imaging teaching process to build a medical imaging recognition system. To help students better identify some images and integrate medical images with their own professional knowledge could promote the further development of medical image teaching. In order to verify the effectiveness of the model, 200 medical students from Guangxi University (Nanning, Guangxi, China) were included and divided into the experimental and the control groups. After learning the same contents in different learning formats, the performance of the experimental group that used the image library was found to be significantly better than that of the control group that used traditional teaching method. The results found that the AI and IoT-based medical imaging learning platform could help medical imaging teachers and students to obtain more medical imaging data and improve the utilization and sharing of teaching resources. It could also realize intelligent analysis of medical images to assist teachers in tasks such as diagnosis, segmentation, and classification, which could improve teaching efficiency and accuracy. Further, it could provide more application scenarios and cases for medical imaging teaching, expanded teaching contents and vision, and enhanced the relevance and practicality of teaching.

Keywords: artificial intelligence; internet of things; medical imaging teaching.

***Corresponding author:** Zhenlun Li, Department of Medical Imaging, Jiangxi Medical College, Shangrao 334000, Jiangxi, China. Email: li_zhenlun@outlook.com.

Introduction

Medical imaging is an important subject in medicine, involving diagnosis, imaging, and other aspects. It requires students to master multidisciplinary knowledge and skills. However, traditional teaching methods are teacher-centered, static, and limited in resources and cases, which may lead to poor learning outcomes and low efficiency for students [1, 2]. Medical imaging teaching is image-based and needs to analyze and extract information from images. Printing images on film may cause distortion and loss of information. Moreover, many images are similar and subtle differences may not be clear. Traditional teaching consists of three stages including theory, experiment, and independent learning. All of them use images as the main

contents, but the effect is not good [3, 4]. Artificial intelligence (AI) simulates human thinking to solve problems with natural science and philosophy knowledge, which can learn from data and make decisions, and has applications in many fields such as speech recognition and image recognition. The Internet of Things (IoT) connects people and things through the internet, and builds a communication network, which can sense and transmit data quickly, and often combines with artificial intelligence and big data to build intelligent systems [5, 6]. Artificial intelligence and machine learning can analyze and identify medical imaging data to assist physicians in diagnosis and treatment. In some previous studies, the software to identify chest X-ray images for new coronavirus infection was developed. Functional magnetic resonance imaging can explore the human brain structure and function and reveal neural mechanisms, which has been used to study Chinese language processing and cultural differences. High-resolution and high-sensitivity medical imaging devices and technologies can improve the quality and efficiency of medical imaging, which resulted in the development of ultrasound-based noninvasive blood flow imaging. Currently, medical imaging technology is developing rapidly in China. However, it is still lagging behind in teaching [7, 8].

The teaching level of medical imaging is improving recently. Some universities have adopted flipped classroom model for medical imaging teaching, which has improved students' learning motivation. In addition, the number of high-quality medical imaging instruments is growing every year. Some universities are integrating technologies such as the Internet of Things and artificial intelligence into medical teaching. However, the development is still in its infancy stage, and some imaging education still needs to be developed [9, 10]. In general, medical imaging teaching in China is lagging behind in facilities and modes that mainly cultivate students' image recognition and disease judgement abilities without practical experience and clinical cases [11]. Artificial intelligence and Internet of Things may help to build an intelligent medical imaging teaching system, display medical imaging information flexibly and vividly, assist teachers in diagnosis and other tasks, promote teaching innovation, stimulate students' active learning and exploration, and cultivate students' innovation and practice [12].

This study explored the applications of artificial intelligence and Internet of Things in medical imaging teaching. The results of this study might be applied to improve teaching quality, teaching efficiency, and students' skills development. The study also dealt with the technical principles and methods of AI in medical imaging analysis, as well as the opportunities, applications, and risks of AI in medical imaging.

Materials and Methods

Design of medical image recognition system

The medical image recognition system was designed by using Internet of Things technology, artificial intelligence technology, and virtual device system, which mainly included teaching system, scoring system, question answering system, and image library (Figure 1). The systems could realize the functions of assisting students in learning and assisting teachers in teaching [13, 14]. The image teaching system was based on the image library, and through AI and IoT technology, the information in the image library could be displayed to students in a virtualized and flexible manner. Medical imaging learning required a lot of learning, and most of the imaging materials were similar with minor differences. The video teaching system could significantly improve the fun of students' learning. The core function of the system was to intelligently identify the feedback image information in medical images through AI technology to help students better understand medical image data. The system consists of three main modules: artificial intelligence module, IoT module, and teaching management module. The AI module was responsible for performing operations such as preprocessing, feature extraction, classification, segmentation, detection, recognition, *etc*. on image data, and

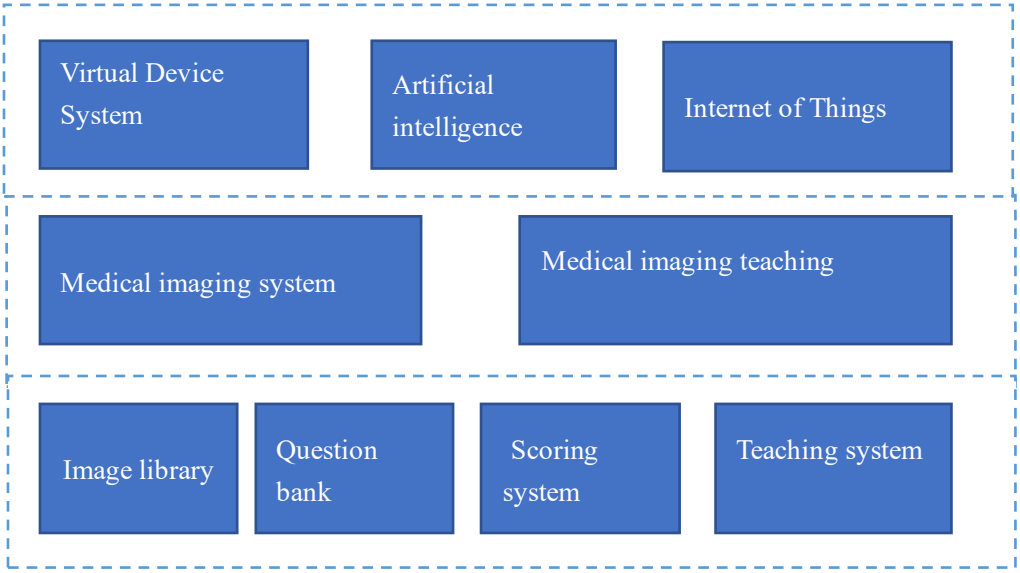

Figure 1. Medical image recognition system architecture.

generating corresponding teaching contents and feedback according to the needs of teachers and students. This module could also provide virtual reality or augmented reality simulation environments, allowing teachers and students to learn image knowledge and skills more intuitively and interactively. The IoT module was responsible for connecting image devices in different locations and transmitting and storing image data through wireless network. This module could also support multiparty video conferences and discussions, allowing teachers and students to collaborate and share image information and teaching experience remotely. Image library was a cloud-based storage application that aimed to provide users with a convenient way to store, manage, organize, and distribute images.

The process of building an image library included the following steps of (1) collecting image resources from various sources; (2) using software or tools to process, edit, compress, and annotate image resources; and (3) choosing a suitable cloud service or platform to store, manage, and share image resources. In the process of using the image library, users needed to comply with relevant copyright laws and regulations and ensure that the image resources being used were legal and authorized. Users also needed to add watermarks or copyright statements to the image resources created by themselves to protect their intellectual property. The process of building a video teaching system included the following steps: (1) according to the target audience and course structure, determined the teaching goals and contents, and designed the video teaching plan; (2) according to the video teaching plan, chose suitable video production software or tools, and collected the required video materials, such as screen recording, webcam recording, slide recording, *etc*.; (3) used video production software or tools to process, edit, compress, and annotate video materials, and ensured that the video quality and format met the requirements; (4) chose a suitable video publishing platform or website, and uploaded the videos to that platform or website, and set the permissions, categories, tags, *etc*.; (5) chose a suitable video learning platform or website, and integrated the videos with the interaction, feedback, assessment, *etc*. functions on that platform or website, and promoted the video teaching course to the target audience. A video teaching system usually consists of three main parts including video

production, video publishing, and video learning. The video production part is responsible for collecting and processing video materials, and editing, compressing, and annotating them. The video publishing part is responsible for uploading videos to suitable platforms or websites and setting and managing them. The video learning part is responsible for providing students with the functions of watching and learning videos, and providing interaction, feedback, assessment, *etc*. functions.

The recognition of medical images mainly used AI technology, and the basic principles of AI technology for image recognition were shown in Formula (1)-(4). The image recognition process mainly included image data acquisition, preprocessing, feature vector extraction, and classification decision system construction. Formula (1) was for preprocessing the image.

$$KL(\text{data}) = \mathbf{E}_p \log\left(\frac{p}{q}\right) = \mathbf{E}_{x\sim p} \log\left(\frac{p(x)}{q(x)}\right) \quad (1)$$

where $p(x)/q(x)$ was binarized image. The image information was converted into digital information, which *KL*(data) was the data valided within the range of xp, otherwise it was a noise point. *KL*(data) was the final acquired image data [15, 16]. Formula (2) was mainly used for the extraction of feature vectors. The *KL*(data) feature information of the data hidden in the whole set of data was extracted and were stored in *JSD*(data*V*ector).

$$JSD(\text{data}V\text{ector}) = \frac{1}{2}\text{p+q}\left(p * \frac{p+q}{2}\right) + \frac{1}{2}\text{q*p}\left(\text{q} * \frac{p+q}{2}\right) \quad (2)$$

where *p* and *q* were two basic feature vectors. Formula (3) was a weighted product of the feature vectors, where *p* was considered as a weight [17, 18].

$$H(X) = -\sum_{i=1}^{n} p_i \log_2 p_i \quad (3)$$

$$I(a_i) = p(a_i)\log_2 \frac{1}{p(a_i)} \quad (4)$$

Formula (5) was a summary of the professional knowledge of medical imaging. Since medical imaging involves knowledge in multiple fields, it has a variety of contents. Therefore, the database of medical imaging expertise S_i in this study consisted of a basic database and an incremental database ΔS_i. Formula (6) and (7) were the operations on the medical image database data with the purpose to transform the data in the medical image database into the rules required for AI model training.

$$D\text{ata}B\text{ase}_z = S_i + \Delta S_i \quad (5)$$

$$S_z = S_i + \lambda \Delta S_i \quad (6)$$

$$e_i(t) = \lambda S_i(t) - S(t) \quad (7)$$

The core algorithms of the AI training model constructed in this study were Formula (8) and (9). The function of Formula (8) was to match medical image information with the rule database. The function of Formula (9) was to display the matching information in a flexible way to improve students' interest in medical imaging teaching [19, 20].

$$S(t_0, t_i) = \frac{1}{2}\sum_{i=1}^{n}\left[e_i(t)\right]^{\lambda} \quad (8)$$

$$d_i = Pr_{j_i}^{x_i} + Pr_{j_i}^{y_i} = Pr_{j_i}^{x_i} + f\left(NM_{i2}\right) \quad (9)$$

In order to make medical imaging information more expressive, the IoT technology was integrated into the AI system, so that the results of AI matching were not displayed in abstract data, but in various forms. The results of AI analysis were passed into the IoT system. The core principles of the IoT processing system were shown in Formula (10)-(13). Formula (11) was used to generate a specific information presentation form.

$$VAR = H_c\left(G(\text{dateset})\right) d_i \prod_{i \neq j} \frac{INFO_{i2}}{INFO_{i2} - INFO_{j2}} \quad (10)$$

$$s_i \cdot G + e \cdot D_i \prod_{i \neq j} \frac{INFO_{i2}}{INFO_{i2} - INFO_{j2}} = r_i \cdot x_i \quad (11)$$

$$K = \sum_{i=1}^{t} \frac{INFO_{i2}}{INFO_{i2} - INFO_{j2}} Pu_{j_i}^{x_i} \quad (12)$$

$$Pr_{j_i}^{y_i} \cdot \mathrm{G} = \sum_{i=0}^{t-1} a_i \cdot G \cdot INFO_{i2} \quad (13)$$

The system consisted of three main parts including data acquisition, data processing, and data output. The data acquisition part was responsible for obtaining raw image data from different image devices including X-ray machines, CT, MRI, and converting them into standard formats such as DICOM format. The data processing part was responsible for performing operations which included preprocessing, feature extraction, classification, segmentation, detection, and recognition on image data, and using deep learning and computer vision algorithms and models such as convolutional neural networks, recurrent neural networks, generative adversarial networks, *etc*. for training and inference. The data output part was responsible for presenting the results obtained by the data processing part to the users in a visual or textual form and providing corresponding explanations and suggestions.

Research objects

200 students from Jiangxi Medical College of Nanchang University (Nanchang, Jiangxi, China) were included in this study as the research objects.

Statistical analysis

SPSS software (IBM, Armonk, New York, USA) was employed for the statistical analysis of this study. The independent-samples t-test was used to identify whether there were significant differences between the experimental group and the control group on various assessment indicators. The *P* value less than 0.05 was defined as a significant difference.

Results and discussion

System verification

In order to ensure the reliability of this study, the participants performed similarly in the three aspects of daily grades, final exams, and intelligence levels. The participants were divided into experimental and control groups, and the basic information of the students including converted data of usual grades, final grades, and intelligence levels was shown in Table 1 [21-22]. Different teaching methods were applied in different groups with the experimental group adopted the teaching plan combining the teacher's teaching and the medical image recognition system constructed in this study and the control group adopted the traditional teaching plan. The teaching contents were kept confidential to all students. Interviews and written tests were conducted on each group one day after the end of the teaching. The students' performance of each group was shown in Table 2. The results showed that the students in the experimental group scored higher than that in the control group in terms of the accuracy of case analysis, identification of symptoms, and correct judgment of diseases, which demonstrated that, to a certain extent, the medical information identification system built in this study could help students better for a good understanding of the expertise implicit in medical images [23, 24]. A questionnaire survey on the teaching quality among the students was conducted as well. The results of the survey were shown in Table 3 with the experimental group rating higher than the control group in terms of students' interest, depth of knowledge understanding, memory status after one day, students' learning initiative, and willingness to learn. The results from this study indicated that the medical information recognition system based on AI and IoT technologies could significantly improve students' learning effects and students' learning

Table 1. Specific information of the students in the experimental group and the control group.

Category	Usual performance	Final grade	Intelligence level
Experimental group	95	91.2	79.5
Control group	94.35	91.4	79.4

Table 2. The performance (score points) of the experimental group and the control group.

Group	Number of respondents	Accurate analysis of cases	Identify symptoms	Correct diagnosis of disease
Experimental group	100	97.34 ± 2.76	97.76 ± 3.42	94.54 ± 3.99
Control group	100	66.21 ± 11.25	63.23 ± 1.42	76.54 ± 3.12

Table 3. Teaching quality evaluation results.

Category	Experimental group (100)	Control group (100)	T	*P*
Student interest	10.21 ± 0.23	6.21 ± 0.21	223.620	< 0.05
Depth of knowledge	8.76 ± 0.53	5.33 ± 1.23	31.365	< 0.05
Memory after a day	7.33 ± 1.75	6.43 ± 0.12	6.283	< 0.05
Learning initiative	8.65 ± 1.4	4.08 ± 0.31	38.509	< 0.05
Willingness to learn	7.84 ± 1.54	5.12 ± 0.23	21.394	< 0.05

interest. It could also help students gain better experience and more learning experience in classroom learning. All of those results made the knowledge have certain theoretical feasibility and practical feasibility [25, 26].

Development strategies of medical imaging teaching

(1) Students were the main body of the classroom

Currently, the medical imaging teaching in China is mainly one-way teaching, adopting the teaching mode of teachers teaching and students listening. However, medical imaging teaching is subject-specific. The traditional teaching mode can only allow students to master basic knowledge, but it cannot cultivate students' practical experience. Therefore, in classroom teaching, the teacher should encourage students to become the main body of the classroom, let students lead the classroom, give students more chances to show, let students expose their own problems, so as to find and solve problems in the classroom, and truly improve students' practice ability. Traditional medical imaging teaching is mainly based on multimedia software such as PowerPoint slices, which can only be used to display medical images. However, due to the quality of projection equipment, students cannot see the details of the images clearly, which is not conducive to the development of students. By using the medical image recognition system as a teaching aid to integrate the medical image recognition system into classroom teaching, it will let students actively participate in learning [27, 28].

(2) Encourage interactive learning

The medical image recognition platform based on the IoT and AI technologies provided an interactive learning interface. Students could ask questions and find answers on the medical image recognition platform. In addition, this platform also provided a self-test port, which could better test students' practical ability. Students and teachers could communicate and discuss through this platform, and students could also exchange ideas with each other through this platform. As a teaching aid, this platform not only played a role in the classroom, but also a role after class, which

could greatly improve the shortcomings of the traditional teaching mode and improve the level of medical imaging teaching [29, 30].

(3) Provide rich teaching resources

Due to the lack of teaching resources, the traditional teaching mode restricts the development of students' practical ability. In order to solve this problem, the medical image recognition system based on AI and IoT stored a large amount of medical image information, which was openly provided to users. In addition, this platform also stored a large number of video and audio teaching files, so that students could access the latest teaching resources. Students could learn about the latest medical imaging images on this platform and could consult the interpretation of this image, which was not only a learning platform for students, but also an academic communication platform.

Conclusion

Traditional teaching is mainly divided into three links including theoretical teaching, experimental teaching, and independent learning. In these three stages, medical images with pictures as carriers are the main teaching content. However, displaying medical images in the form of pictures will cause problems such as picture distortion and information loss. Therefore, the teaching effect of traditional medical image teaching is not ideal. Due to the limitation of medical imaging teaching resources in China, there are problems in the teaching of medical imaging such as outdated teaching facilities, backward teaching models, and lack of practical experience for students. This study integrated IoT and AI technologies into the medical imaging teaching process to build a medical imaging recognition system, which could help students better to identify some images and integrate medical images with their own professional knowledge and to promote the further development of medical imaging teaching. The medical image recognition system developed by this study used AI technology as the underlying architecture to train AI algorithms through a large amount of data and used the IoT technology to display the results of AI classification in a visualized form. The results showed that the medical image recognition system demonstrated remarkable results in improving students' learning enthusiasm and learning effect. The results suggested that the development of medical imaging teaching should follow the strategies of (1) students become the main body of the classroom; (2) encourage interactive learning; (3) provide rich teaching resources.

References

1. Zhou G, Luan J, Ma B. 2022. Research on the mixed teaching mode of medical imaging based on Chaoxing Xuetong. J High Educ. 28(28):118-121.
2. Zhang X, He Y, Zhong H, Yu Y, Jia YJ, Yu N, *et al*. 2020. Reflections on online teaching of medical imaging under the background of epidemic prevention and control. Clin Med Res Pract. 22(22):186-187.
3. Jin R, Ding D, Chen X, Yang QX, Zhang QJ, Sun HH. 2020. The practice of remote online teaching of medical imaging under the background of the epidemic. Med Educ Res Pract. 4(04):718-721.
4. Zhang G, Wu Y, Sun S. 2020. Exploration and practice of ideology and politics in medical imaging courses. Sci Educ J (Early Issue). 4(04):122-123.
5. Yan D, Zhang W. 2019. Discussion on the role of PACS combined with PBL in the clinical teaching of ultrasound for five-year undergraduates in medical imaging. J Clin Ultrasound Med. 10(10):792-794.
6. Huang J, Jiang HN, Zhan SH, Cheng RX, Yang XR. 2019. The application of MOOCs in the standardized training and teaching of medical imaging residents. Med Health Equip. 6(06):91-95.
7. Xu DH, Luo ZB, Xu XH, Jie GL, Luo SC, Huang YH, *et al*. 2019. Research on Internet + medical imaging teaching mode based on online interactive teaching cloud platform. Med Educ Res Pract. 3(03):400-403.
8. Zhang GF, Li HF, Jin M, Huang TT, Cui HS. 2019. Analysis of the effect of mind mapping on the cultivation of clinical thinking ability in medical imaging practice teaching. Chin Health Ind. 10(10):139-141
9. Kui X. 2018. Application of PACS system in medical imaging teaching. Inf Rec Mater. 10(10):126-127.
10. Wang J, Wang J, Peng R. 2018. Reflections on the innovation and practice ability training mode of medical imaging professionals. China Med Educ Technol. 3(03):326-328, 333.
11. Xu Y, Liu Z, Gao J. 2017. A preliminary study on the digital teaching reform of medical imaging. J Clin Ultrasound Med. 8(08):570-571.

12. Gong F. 2017. Discussion on the teaching of medical imaging from the perspective of dialectics of nature. Med Theory Pract. 2(02):306-307.
13. Li MZ, Tao J, Hu JH, Bu XB, Li CJ. 2016. Exploration and practice of medical imaging experiment teaching reform. China Med Educ Technol. 6(06):717-719.
14. Yang HT, Lv JF, Ouyang Y, Lv FR, Luo TY. 2016. Using PACS case retrieval to implement case-based teaching in the teaching of medical imaging. Chin Med Educ Technol. 1(01):101-103.
15. Shen B, Wang K, Zhao D, Wang K, Sun XL, Zhang T, *et al*. 2015. Discussion on the application of PACS-assisted teaching in medical imaging practice teaching. Adv Mod Biomed. 3(03):523-525.
16. Shen BZ, Zhao DL, Wang KZ, Wang K, Sun XL, Wang D. 2015. Application of PBL teaching method combined with PACS system in medical imaging teaching. Adv Mod Biomed. 3(03):529-532.
17. Zhang SL, Zhang XJ, Qian LL, Yang D, Liu HL. 2014. Construction of applied talent training model for medical imaging. Basic Med Educ. 12(12):1066-1068.
18. Zhang C, Zheng CB, Gao JR, Huang CJ. 2014. Progress in practical teaching of medical imaging. PLA Hosp Manag J. 7(07):674-675.
19. Jiang H, Li D, Hao X, Dong X, Lai W. 2013. Application of PACS system in medical imaging practice teaching. China Med Educ Technol. 5(05):565-567.
20. Xu G, Jin C, Qiang Y. 2013. Discussion on the teaching reform strategy and trend of medical imaging. Northwest Med Educ. 4(04):817-820.
21. Ma Y, Zhang S, Chen Y. 2013. Application of case-based teaching method in medical imaging teaching. J Bengbu Med Coll. 4(04):479-481.
22. Yuan XP, Chen JY, Li Y, Liu QX, Lin XF. 2012. Application of TBL teaching method in multimedia teaching of medical imaging. Chin Med Educ Technol. 6(06):696-698.
23. Lu X, Wang XL, Rong YT, Chen GH, Ma H, Lu CL, *et al*. 2012. Application and thinking of case-based PBL teaching in English medical imaging teaching. Northwest Med Educ. 5(05):990-993.
24. Wang YR, He YL, Yin Q, Duan SJ, Xiong XS, Qin Y, *et al*. 2012. Construction and application of self-learning system of medical imaging based on network environment. Chin Med Educ Technol. 1(01):52-55.
25. Hu JF, Wu B, Tang HY, Zhao J, Liu ZX, Tang H. 2012. Research on the clinical teaching mode of medical imaging based on the network. Chin Med Educ Technol. 1(01):62-64.
26. Du W, Liu L, Tang YL, Xu JF. 2012. Application of PBL+LBL in medical imaging teaching for South Asian students. Northwest Med Educ. 1(01):72-74, 103.
27. Wang YR, Yin Q, Duan SJ, Xiong XS, He YL, Qin Y, *et al*. 2011. Model construction and management of PACS system resource library for medical imaging teaching. Northwest Med Educ. 5(05):962-964.
28. Shi R, Zhai R. 2011. Experience in teaching medical imaging in clinical medicine. Northwest Med Educ. 1(01):211-212.
29. Heng SC, Cheng Y, Yu JM, Li B, Xiao LZ. 2010. Clinical teaching experience of oral and maxillofacial medical imaging. Northwest Med Educ. 4(04):834-837.
30. Zhang JX, Chen JF, Shi F, Yu MH, Gu SY, Zhang XZ, *et al*. 2008. Reform and research on the practice teaching link of medical imaging specialty. Chin Gen Med. 8(08):820-821.