INTELLIGENT CLASSROOM NOTE-TAKING APPLICATION SOFTWARE WITH HIGHER PERFORMANCE

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Abstract. In the process of multimedia teaching, it is common for learners to miss out on important notes and fail to summarize and organize the course content in a timely manner, resulting in a lower learning efficiency. Aim: This paper designs an intelligent classroom note-taking application software that combines traditional note-taking with the internet, based on the needs analysis of both teachers and learners. This software utilizes the single shot multibox detector and MobileNet to build a network platform, and establishes a MySQL-based database. It has been deeply developed using various intelligent algorithms and technologies, and includes modules for learning notes, searching, recognition, and recording. Through Testin and usage testing by learners and teachers, the proposed software has been proven to effectively recognize and record learning content, ensuring the recording and expansion of teacher's knowledge points, ultimately improving students' learning efficiency. Based on the current situation of classroom note-taking, this paper explains the level of learners' awareness of classroom note-taking and the problems of note-taking in the classroom, and summarizes the design ideas and basic requirements of a classroom note-taking application. The design process of an intelligent classroom note-taking application is proposed, and the design and development of the software is further completed.

Key words: Classroom, note-taking, application, software

1. Introduction. Since the 21st century, the rapid development of 4G (the 4th generation mobile communication technology) mobile Internet technology has changed every aspect of life, and also deeply affected the way of education, teaching and learning [1, 2, 3, 4]. Universities have delayed the start of school due to the epidemic, and learners have adopted a home-based learning model, such as using the tools of smart mobile terminals for independent, personalized and inquiry-based learning. In traditional classroom learning, learners often use pencil tools to collect and organize scattered knowledge in class, and then go through these materials and notes after class to further deepen their learning [5, 6, 7, 8]. However, in terms of the change of teaching mode caused by the epidemic, once video courses and live classes, which are previously used as an aid, become the main teaching method, learners cannot quickly adapt to the new teaching method leading to a decrease in their learning conscientiousness. Moreover, due to the special nature of video courses, it is difficult for learners to summarize and summarize the courses in time and to understand and remember the relevant knowledge points in time, thus creating certain difficulties in learning. Therefore, it is necessary to design applications for class notes. How to ensure the students' consciousness and quality of learning and how to summarize after class is set as the target of the research. By analyzing the needs of teachers and students, the direction of the product needed by users is clarified. This is conducive to the full utilization of students' independent learning time and the improvement of learning efficiency.

The learning software for students on the market today is mainly based on video courses [24, 10, 12, 13]. In [9], An experience with learning software for DaimlerChrysler is reported. It aims to study experience reuse and apply insights and collected experiences to ware process improvement. To address the difficulty of meeting requirements in authoring environments in real projects, especially in large development projects, [11] proposes an unsupervised approach. This approach recognizes templates from the requirements themselves by extracting the common syntactic structure of the requirements. The effective recognition of standard and non-standard templates strongly proves the effectiveness of the proposed method for learning software. In [12], a web application called QualiTeam is developed to enhance the quality of the teaching and learning process. The program provides concrete examples while helping students to cope with challenges. This motivates students

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to practice and clarify classroom topics in a timely manner. Their advantage is the high degree of freedom and the wide range of options available to students. But their disadvantages are also very obvious. It is difficult for students to organize and summarize the content of the video courses in time. The memory time for the knowledge points is short, so it is troublesome to try to go to the relevant videos to find the knowledge points. In addition, for the knowledge points that the teacher did not show on the lesson, students have difficulty to remember and understand them effectively. To sum up, learners need a tool to summarize what they have learned. They can recall the key points through the notes in the future review, and can expand on their existing knowledge to improve themselves.

By reviewing the relevant literature, the similar software is feasible in terms of development cost and time cycle. Whether in daily learning life or in video courses, students should summarize and summarize what they have learned in a timely manner. Therefore, this paper designs a smart classroom note-taking application that combines traditional notes with the Internet to assist daily learning. This prompts the use of students' independent learning time and enhances the recording and expansion of the teacher's classroom knowledge points.

Aiming at the problem that it is difficult to effectively combine traditional notes with video course learning, this paper designs a high-performance intelligent classroom note-taking application software, based on the theories of cognitive psychology, learning strategies and personal knowledge management. This software integrates a variety of intelligent algorithms and platforms such as TensorFlow to realize a deep development. The organic integration of classroom notes and video learning effectively improves the learning efficiency.

The innovation of the classroom note-taking application software designed in this paper is:

1. Intelligence of functions and operations. By intelligently identifying the knowledge points of documents and video courses as well as expanded knowledge, and accurately recording all the knowledge points taught by the teacher and organizing and summarizing them according to the time line, it helps learners consolidate their understanding of certain fragmented and blurred memory knowledge points, saves learners' time in watching video courses, and improves the efficiency of recording notes. Meanwhile, this software comes with a keyword search function, which has the ability to easily locate the content you want to find from many notebooks, helping learners to solve the problems of blurred memory of knowledge points and final summarization review, etc.

2. Implementation of cloud sharing function. By sharing learners' notes to the cloud, it provides a platform for other learners to learn from.

3. The diversity of usage scenarios. The designed software can be used in daily meetings, large lectures and many other scenarios. The notes and semantic-to-text recognition mode can quickly and accurately summarize and sort out the content of meetings, saving time in organizing meeting minutes later. At the same time, the note-taking and sharing modes prompt more people to learn about the meeting content and work requirements. All these effectively ensure the universality of this software in different scenarios. The developed intelligent classroom note taking application has significant advantages in terms of responsiveness and usability over the existing applications. It operates with high effectiveness and low memory utilization.

2. Basic theory. There are few national and international studies devoted to classroom note-taking theory, but the role, principles, and strategies of classroom note-taking have been addressed in psychological and learning-related theoretical studies. This paper presents the theoretical foundations of classroom note-taking in terms of cognitive psychology, learning strategies, and personal knowledge management.

2.1. Cognitive psychology. Cognitive psychology incorporates the essence of information theory, cybernetics, systems theory, and computer science, among others, and revolves around the core view of information processing [13, 14, 15, 16]. It is an approach that advocates an experimental approach and an information processing perspective to the study of human mental processes. It believes that human memory is an information processing system and that the memory structure consists of three subsystems: sensory, short term and long term memory. These different types of memory differ in terms of the retention time and capacity of information. Experiments have proved that the picture representation form of knowledge is more beneficial to learners' memory than the text form, especially the vivid pictures are more effective for memory.
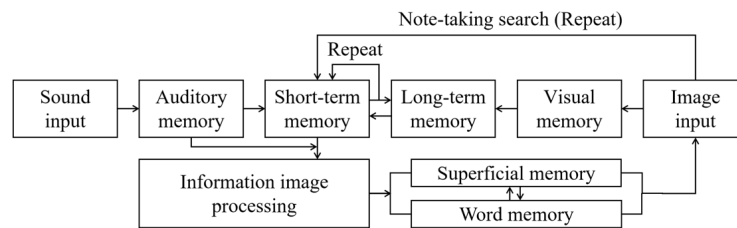
Fig. 2.1: A cognitive process model for classroom note-taking

This paper attempts to construct a complete and specific model for the cognitive processes in classroom note-taking, which includes input, information processing, comprehension, and memory of classroom information (Fig 2.1. Learners discern what the speaker says and writes on the board, Microsoft Office PowerPoint (PPT), etc. through auditory perception and visual memory. After processing the picture and sound information into meaningful short-term memory, this classroom information then entered long-term memory in the form of different representations of episodic and semantic memory. After the class, listeners subjectively and actively retrieve and retell the valid content that remains in the long term memory based on the relevant cues recorded in their notes. Such a process is similar to a kind of recording process of English listening notes.

At the same time, from the perspective of cognitive psychology and cognitive processes, learners taking notes in class not only improve their learning efficiency, but also facilitate their attention to be passively focused on the collection and capture of key information in vivid pictures. The resulting orderly cognitive chain of key content facilitates the management of future reviews. The way learners take notes and the instantaneous recording of information also directly affect the knowledge acquisition degree.

2.2. Learning strategy. Since the concept of learning strategies was introduced in 1956, a more complete concept has gradually emerged [19, 20, 21, 22]. It is a series of processes or steps that facilitate the acquisition and storage of knowledge and the use of information. Some scholars argue that it is essentially an intellectual activity or step of thinking, mainly in the extraction, analysis and encoding of information [23, 24, 25]. In this paper, the learning strategy is understood as a mode of thinking in which learners select, use and regulate learning procedures, methods, techniques, resources, etc. during the learning task. For example, the way they choose how to take notes on what they learn in class, how to review their notes from the learning task after class, etc.

Various definitions and classifications of learning strategies exist. However, the majority of scholars agree that it consists of a variety of methods and techniques that facilitate learning to occur and enhance learning outcomes [26, 27, 28]. During the classroom note taking process, learners are advised to choose the appropriate learning tools and more effective learning strategies for the situation at hand.

2.3. Personal knowledge management. Personal knowledge management is a branch of knowledge management [29, 30, 31, 32]. The main ways to divide knowledge management tools are:

1. The tools formed based on the knowledge process division are knowledge acquisition and classification, knowledge storage and management, knowledge retrieval, knowledge analysis and mining, and knowledge sharing.
2. The tools formed based on the knowledge type division are literature management tools, patent depth analysis tools, mind maps, cloud-based notes and web depth information management tools, and social networking tools. The impact of personal knowledge management on classroom note-taking will be described from three aspects: 1) the ability to classify and manage personal note knowledge in an orderly manner, especially the classification of key contents; 2) the increase of more ways to learn and process information; 3) the ease of finding and retrieving relevant knowledge efficiently and quickly.

3. Core technology. There is a wide variety of foreign note-taking tools, and many of them are powerful with the support of hardware. Take eClass, E-notes and myBase as examples, they can realize various forms

Table 3.1: Comparisons of existing note-taking tools

Tool	Basic function	Photo function	Circle function
eClass	Video and audio recording, communication and sharing within the local area network	Yes	No
E-notes	Lecture notes with extensive teaching contents	No	
myBase	Information access, editing, viewing, indexing, searching and sharing	No	
OneNote	Support built-in search function for picture and audio repositories, and the ability to record notes during the recording process	Yes	
Evernote	A note editing platform that can save complete web pages and store text and photos	Yes	
Wiz	Knowledge manager, sync tool, editor, viewer, web capture tool and document import tool	No	
Youdao Cloud Note	Text, photo, album and handwritten notes	Yes	
DaubNote	Multi-platform login, photo recognition text, social sharing and book sweep	Yes	

of text input, voice recording, video and audio recording, screenshot, document upload and download, sharing resources and other functions [33, 34, 35, 36, 37]. However, their specific operations and applications are difficult to meet the efficacy of note taking, and there is no software that can go through the cell phone mobile terminal to record notes with the camera and edit photo notes at any time. Although domestic scholars are late to study classroom notes, there are a considerable number of note-taking software, such as Wiz, Youdao Cloud Note, and DaubNote [38, 39, 40]. They are mostly used for data storage and online socialization.

3.1. Tool comparison. To design a tool suitable for taking notes in the classroom, the functions of the mainstream existing tools are compared (Table 3.1).

The functions of these software in Table 1 vary and are well referenced. Most of the software meets the basic needs of students to record, manage and share their notes. However, there are few course notes software that are simple to use, highly operational, and can be used on mobile terminals. The following details the technology of the classroom note-taking application software designed in this paper.

3.2. Technique details. Five core technologies are used in this software.
1. TensorFlow is created by developers and engineers on the Google Brain team. It has been used for research in machine learning and deep neural networks and has been used in numerous fields [41].
2. OpenCV is a cross-platform computer vision and machine learning software library that runs on most operating systems. It provides interfaces to most languages such as Python, Ruby, MATLAB, etc., and implements many common algorithms in image processing and computer vision [42].
3. OCR (Optical character recognition) is a process of acquiring text and layout information. Baidu's OCR service relies on excellent deep learning algorithms and massive quality data, with an accuracy rate of 99% for keyword segments [43].
4. Ali real-time speech recognition has the ability to do real-time recognition of audio streams of unlimited duration. It has built-in intelligent sentence breaking, which provides the start and end time of each sentence. It can also be used in scenarios such as real-time live video captioning, real-time conference recording, real-time courtroom trial recording, and intelligent voice assistant [44].
5. Luban is an image compression tool for Android. It first sends nearly 100 images of different resolutions, and then compares the original and compressed images. The resulting reverse-derived compression algorithm has become the core algorithm of Luban [45].

4. System design. First, the theoretical basis for the development of the intelligent classroom note-taking application is laid out from the theories related to classroom note-taking. By analyzing the requirements of the classroom note-taking application software, we find the basis for software development and design. Then, we
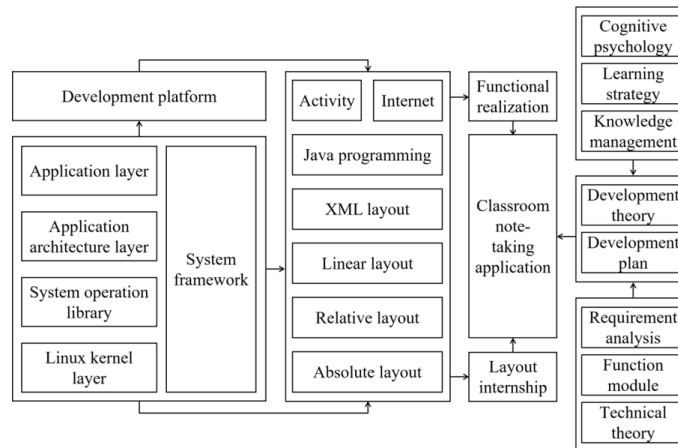
Fig. 4.1: System structure of the designed software

analyze the technology required to implement the layout and functionality of this software, and describe the design and development process of this software. Finally, testing and modification are performed.

4.1. System structure. Figure 4.1 illustrates the system structure of the designed application software.

The implementation steps of the proposed system are as follows. Step 1: When the software is opened, the screen displays modules such as My Home, Course Library, Recognize, Search, and Study Notes. Step 2: By clicking My Home, users can see My Uploads, Personal Center, Settings, About Us and other functional modules. All notes that have been uploaded can be seen by clicking on My Uploads. Step 3: Click Recognize to create a new note to compose a note. It records the class in real time and supports voice to text conversion. Once the note is built, this system also recognizes the title of the note, core concepts, and related knowledge points. Step 4: Click on Course Library to select notes from different courses for further sharing of notes and learning documents. Step 5: Click on Study Notes to view various categories of study notes for learning. During the learning process, a share anytime anywhere is implemented for the better notes. Step 6: Learners can use Search to make inquiries and possibly share via keywords.

4.2. Core algorithm.

4.2.1. Target detection. SSD (Single shot multiBox detector) is a model that directly generates class probabilities and location coordinates of objects without generating candidate regions [46, 47]. Using SSD, the final detection result can be obtained after only a single detection. MobileNet is a network structure used in the SSD process for feature extraction. Combining SSD with MobileNet not only preserves the network structure of the original SSD model, but also ensures the accuracy of the model. Based on this, this paper transforms the original large number of redundant parameters in the model into small parameters. This not only reduces the amount of network computation, but also reduces the hardware resource consumption and effectively improves the model performance.

4.2.2. FAST feature point extraction. FAST (Features from accelerated segment test) is a simple and fast feature extraction algorithm, which is widely used in real-time detection because of its fast computing speed and good feature extraction effect [48, 49, 50]. The fixed threshold value in traditional FAST leads to poor robustness. Meanwhile, it is difficult for FAST to achieve better detection results for images with uneven illumination and different local contrasts. Adaptive thresholding is introduced so that the threshold value changes with the local contrast of the image to improve the FAST-based feature point extraction effects.

4.2.3. BRIEF feature description. BRIEF (Binary robust independent elementary features) is an algorithm for computing feature descriptors, which serves to alias the feature points [51, 52]. So, feature points
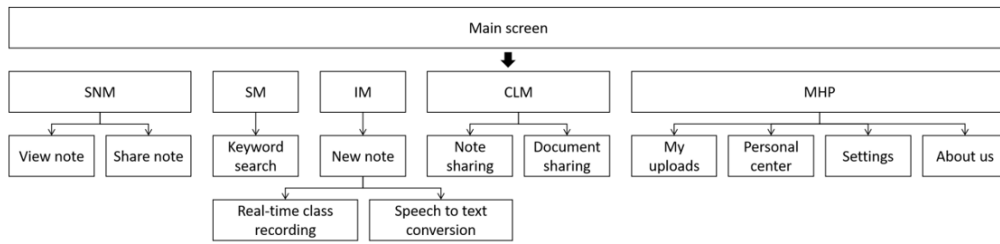
Fig. 4.2: System modules and functions

need to be extracted beforehand. Here, the image feature points are extracted beforehand using FAST, and then the binary descriptors of the features are created in the feature point neighborhood using BRIEF. Since the operation of BRIEF is based on the specific pixel values of the image, it is more sensitive to noise and does not carry rotation and scale invariance. ORB (ORiented Brief) is an algorithm after improving the BRIEF algorithm. It does not use direct comparison of pixel points, but chooses a small patch centered on a pixel as the comparison object, obviously improving the noise immunity.

4.2.4. Laplace operator. The Laplace operator is one of the simplest isotropic differential operators with rotational invariance and is particularly suitable for highlighting isolated points, isolated lines or line endpoints in an image [53]. Like the gradient operator, the Laplace operator also enhances the noise in the image. When using this operator for edge detection, the image needs to be smoothed first.

4.3. Database design. The server-side database uses MySQL, which is the most popular relational database management system (RDBMS) [54]. Also, it is one of the best RDBMS applications in terms of WEB applications. And the Android side database uses SQLite, which is the most widely deployed SQL database engine in the world. It has the advantages of miniaturization and full functionality, making it the top solution for Android as a built-in database.

4.3.1. User table. User represents the user table, which is used to store user data, while id is a auto-increment primary key that identifies each user. Mobile and email represent the user's cell phone number and email address, respectively, while token is used to store the user's identity token.

4.3.2. Note table. Note represents the note table, which is used to store each note. Also, type represents the type of the note, its possible values are speech, ppt, knowledge, etc. After capturing the image, filename represents the image file name.

4.4. System module. As shown in Figure 4.2, this software contains a study note module (SNM), a search module (SM), an identification module (IM), a course library module (CLM), and a my home page (MHP).

4.4.1. SNM details. The knowledge points in IM are included in SNM, where users can view the content of previously recorded notes as well as the key points. SNM supports functions such as viewing large images and marking key points to reduce the burden of recording notes for students. Students can also share their notes, so that more students can participate in the discussion of the notes. Fig 4.3 illustrates the flow chart of SNM.

The section called My Notes is located on the first page of the software when it is opened. The first image in each notebook is set as a preview. Users can find the notebook they want to view by previewing when the title was created. The viewed notes display the PPT and the corresponding notes. Clicking on a notebook in My Notes will take you to the module called Notes View Editor, which is used to browse and edit the notes. Everything in the notebook expands on the timeline. Clicking on 'Show' allows you to fully replicate the class and automatically scroll through the timeline while listening to the instructor. Repeated playback of voice clips is allowed. Also, the ability to view larger images is provided for PPT. A separated structure is used
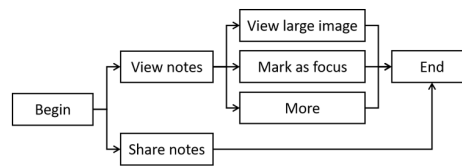
Fig. 4.3: A flow chart of SNM.

to design the editor's interface. Specifically, above and below the PPT are the recording function and notes, respectively. Finally, each note can be annotated on both the recording and viewing editing pages to ensure that no sentiment is missed. Tapping on the annotation function pops up a separate dialog box for entering the annotation content. The annotations are displayed at the bottom of the PPT.

4.4.2. SM details. In SM, the identified content in the notebook can be retrieved by typing in keywords. Clicking on an image will take you to that note to find the content. This is a convenient and quick way to easily retrieve existing knowledge and deepen students' understanding and organization of existing knowledge.

The search interface is simple and clear. After entering the keywords of knowledge points in the text box, the system matches the text in the annotations and displays the PPT and the corresponding notes. Relevant results are displayed below the text box. At the same time, the searched matching content is marked in red.

4.4.3. IM details. After entering IM, the user first has to set the permissions for camera, microphone, storage space and hover window. After the permission is turned on, the camera starts to recognize and shoot the course. Place the PPT or board in the designated recognition area, and the proposed software will recognize the content and give the analysis. The recognized content will be automatically recorded in the notebook. When switching the PPT, the content will be automatically recorded to prevent confusion of knowledge points during later review. Clicking on images to view text, annotate, highlight, and delete knowledge points is allowed. The search function is used to quickly retrieve knowledge points and locate notes. At the same time, the real-time lecture recording function is embedded with a speech-to-text function, which can record the lecture content and convert it into text for users' reference. IM is useful not only for identifying and analyzing knowledge points, but also for summarizing and summarizing what was said in class in chronological order. If students look at a single knowledge point, they may not know how that knowledge point is derived. However, with the class content recorded by IM, it is possible to find the required knowledge points in the timeline. The content before and after is connected by this recording method, which deepens the students' understanding of the content and knowledge.

Using the recording module in IM, the newly captured content will be displayed in the interface and users can go through it freely. Clicking the blinking rec button prompts a quick setup. In this interface, a quick press of the volume button twice triggers a forced capture. During the recording process, users can perform operations such as converting text, annotating, marking as key, deleting, etc. on the notes. IM uses an interface distribution with PPT on the left and annotation on the right.

4.4.4. CLM and MHP details. Users can share and discuss their study notes and documents in CLM. Each study note has been added with a comment area for mutual communication and sharing of review materials. CLM supports a variety of document formats such as announcements, final papers and exams, and supports local downloads. MHP contains My Uploads, Personal Center, Settings, About Us, etc. The proposed software supports third party login. Once logged in, you can manage your personal information in MHP. The interface of CLM implements the functions of PPT previewing and provides a library of notes and discussions for easy communication with each other.

5. Results and analyses. This section first introduces the system environment, followed by qualitative and quantitative testing of the proposed software, and finally further testing based on specific test examples.

5.1. System environment. Table 5.1 records the system environment information of this software.

Table 5.1: Information about the system environment

Type	Information	Type	Information
Operating system	Ubuntu 18.04 LTS	Server software	Nginx 1.16.1
Development tool	Android Studio v3.3.2	MySQL version	5.5.62
Development language	Java, Html, JavaScript (Client), Python (Server)	Redis version	5.0.5
Cloud server platform	Alibaba Cloud's lightweight application server	Python version	3.7
Server operating environment	Ubuntu 18.04.2 LTS	Client running platform	Android 5.1 and above

Table 5.2: Results of performance tests

Test items	Specific contents	Test results
Compatibility	Install	Pass
	Start	Pass
	Traversal	Pass
	Monkey	Pass
	Script	–
	Uninstall	Pass
Performance	Installation time (s)	3.149
	Start-up time (s)	0.704
	Traversal time (min)	1.017
	Monkey (min)	1.016
	Script run (min)	–
	Unloading time (s)	0.547
	AV of OR (%)	7.17
	PV of OR (%)	35.7
	AV of MU (MB)	185.21
	PV of MU (MB)	256.01
	Total flow consumption (B)	1.1501797E7
	Uplink flow (MB)	0.94
	Downlink flow (MB)	10.03
	Maximum FPS	89.0
	AV of FPS	82.93
	Minimum FPS	44.0
	Average battery temperature (℃)	27.0

5.2. Performance test. The designed application software is tested using the testing tool Emmagee (Table 5.2) [55]. The average and peak values, and frame per second are defined as average value (AV), peak value (PV), and FPS respectively. The occupation ratio (OR) of the central processing unit (CPU) of less than 8%, and the memory usage (MU) of less than 260 MB, strongly indicate the competitive performance of this software.

Based on a live classroom, the functionality of the software is tested. The main task is to test the operation of the main functions. The relevant results are shown in Table 5.3.

A comparison with the mainstream tools in Table 3.1 is shown in Table 5.4, for a same test task.

Table 5.4 shows that the proposed software has the lowest AV of OR (7.02%) and PV of OR (36.21%), and the highest AV of FPS (83.35Hz). This software's AV of OR is 8.25% lower than the worst-performing E-notes (15.27%). This software's PV of OR is 21.9% lower than the worst-performing E-notes (58.11%). This software's AV of FPS is 38.45Hz higher than the worst-performing eClass (44.9Hz). The proposed software shows competitive advantages in both OR and FPS.

Table 5.3: Test results of main functions

Test modules	Test contents	Test results
Photo-taking function	Can normally call the photo, and can quickly focus and then take pictures	
Circle function	Can circle on the instant photo to emphasize the corresponding content	
Graffiti function	Can doodle on instant photos to complete custom graphic circles	Normal use
Straight line function	Can draw straight lines on instant photos	
Recording function	Can achieve instant recording	
Study digest	Can mark learning experiences and recorded contents	

Table 5.4: Comparisons between multiple note-taking tools

Tool	AV of OR (%)	PV of OR (%)	AV of FPS (Hz)
eClass	11.3	53.02	44.9
E-notes	15.27	58.11	52.28
Wiz	8.46	40.37	69.95
Proposed software	7.02	36.21	83.35

5.3. Case-based test. Based on the system and module testing done earlier, it is necessary to further design test cases to test various functions of the software. First, the proposed system is tested without turning on the permissions. Results show that the system is unbootable. This ensures the controllability of the system. Then, test cases are set up in major dimensions such as system login, recording video and identification to test the system in all aspects. Relevant settings are shown in Table 5.5.

In Table 5.5, this system is able to fulfill multiple devices logging into the same account. A number of functions, such as creating new notes, writing notes, real-time classroom recording, converting voice to text, recognizing knowledge points of notes, viewing notes, sharing notes, etc., run normally. Video recording and document recognition meet the use of classroom notes and have a certain accuracy. On the basis of the above test results, this system is applicable to a wide range of scenarios of teacher teaching and student learning.

5.4. Validation and Testing. The purpose of this section is to evaluate the usability of the proposed software. The functional architecture, interaction design, navigation design, visual interface design, iconography and other elements of the software are investigated and evaluated for user satisfaction. Also, improvements are made to the problems found.

Users use the designed software to complete nine tasks (Table 5.6) through the mobile phone interface. The purpose and content of the test are indicated to the users before the formal test, and the users' usage behavior is observed and problems encountered in the operation are recorded during the test. After the test is completed, users are interviewed in detail and asked to fill out an evaluation questionnaire. The questionnaire uses a 7-point Likert scale, with 7 levels from very dissatisfied to very satisfied.

A total of 8 users are selected for this test, including 5 male and 3 female (4 from both Arts and Science categories). All of them are aged 20-26 years old, and are experienced in mobile internet and mobile app usage.

The software performs well in terms of usability. In Table 5.7, the software has the highest level of satisfaction in terms of functional design (5.85) and learning and mastery (5.95). This indicates that the design is reasonable and simple, and is in line with the user's perception. An additional ease of learning and mastery indicates that users recognize the usefulness and usability of the software. However, the satisfaction levels for interaction, usage performance, visual design and icon design are relatively low. This is due to the focus of the software on functional design and architecture and less on visualization. Overall user satisfaction is better (5.825).

6. Discussion. This study designs and develops a software that meets the needs of college students for classroom note-taking, which has distinct advantages over similar products. The shortcomings are:

1. The application effect of the proposed software has not been tested extensively. It is planned to promote

Table 5.5: Case test results

No.	Test items	Test contents	Prerequisites	Test data	Test steps	Expected output	Actual results	Test
1	No permissions on	Application for camera, microphone , storage space, hover window, etc. permissions	Normal page display and network connection	No permissions on	1) Click to record 2) Permission Request 3) No Permission on	Unable to access the recording screen and reapply for permission	Failure to enter the recording interface and re-accept permission requests	Pass
2	Recording video and recognition	Recognition accuracy in case of clear recording contents	Normal network connection and all permission requests have been granted	Example PPT files	Aim the sample PPT at the camera hover window to ensure a clear shot	Display a clear picture in sample PPT, and the recognized content is consistent with the content shown in the picture	Clear picture display in sample PPT, with functions such as annotation mark deletion of pictures and keeping the content consistent	
3	Video recording accuracy test	Recognition effect in case of blurred recording contents	Normal network connection and all permission requests have been granted	Example PPT files	Misalign the sample PPT with the camera hover window and take a shaky shot with the device to create a blurring effect	Display 'Blurred picture'	Display 'Blurred picture'	
4	Recognition based on different PPT	Recognize different PPT to test automatic recording	Normal network connection and all permission requests have been granted	Different example PPT files	1) Click record to enter the recording interface 2) Create a new notebook 3) Recognize the difference PPT	Switch different PPT files, accompanied by automatic recording	Clear display of sample PPT pictures, consistent contents, and PPT files are automatically recorded when switching	
5	Same account login for multiple devices	Test whether data can be saved properly when multiple devices log into the same account	Normal network connection and all permission requests have been granted	Different devices and same account	1) Click 'My' with a different device to enter the login screen 2) Login to the same account and use the recording function	Different devices can properly save data changes under the same account	The login status of all devices can be saved normally, and the software can cope well with simultaneous login of multiple devices	
6	Audio test	Click on an audio while playing another audio	Normal page display and network connection	Audio	1) Click on the notebook 2) Click on the audio play button under a text to play that audio 3) Click on the audio play button under another text to play that audio	The previous audio playback is paused, and the next audio file is played, without overlapping between audio playback	The previous audio playback is paused, and the next audio file is played, without overlapping between audio playback	

Table 5.6: Description of tasks

Type	Description
Software guidance	Navigating the software guide page
Software login	Navigating the software guide page
New notes	Add/remove notes as needed
View notes	View notes already taken
Take down notes	Add new note content (try multiple forms of adding)
Search notes	Search notes by keywords
Share notes	Share notes with classmates or course library
Real-time video recording	Turn on the live video recording function and test the effect at different times
Speech to text	Turn on voice recognition and test the effect of different voices

Table 5.7: Satisfaction results

No.	Form of question	Survey purpose	Average satisfaction value
1	Whether the software features are useful or not	Functional design satisfaction	5.85
2	Whether the software is easy to use	Interaction satisfaction	5.4
3	Software utilization error rate	Usage performance satisfaction	5.525
4	Whether the software is easy to learn and master	Learning and mastery satisfaction	5.95
5	Whether the software interface is aesthetically pleasing	Visual design satisfaction	4.875
6	Whether the software icon is easily recognizable	Icon design satisfaction	5.5
7	Overall software experience	Overall satisfaction	5.825

this software among the college student group in order to further improve the software by collecting feedback [56, 57].

2. The functions of the software are not comprehensive enough, such as the lack of sharing, classroom video recording and other personalized functions. We hope to add more functions to keep up with the times [58, 59, 60].

3. The aesthetics of the software needs to be improved. In addition, possible theoretical and methodological deficiencies need to be addressed [61, 62].

4. Privacy protection and data security need to be strengthened [63, 64, 65, 66].

    (a) Strengthening laws and regulations and privacy protection policies: Develop software use systems based on laws and regulations and privacy protection policies established by the government and relevant organizations. These systems should cover regulations for data collection, use, sharing and storage to ensure that personal privacy is adequately protected;

    (b) Anonymization and encryption: For sensitive personal data, the use of anonymization and encryption is an effective means of protection. By removing personally identifiable information or encrypting personal data, the risk of privacy leakage can be reduced.

    (c) Data access and usage authority control: the artificial intelligence system should implement a strict access and usage authority control mechanism. Only authorized personnel can access and use specific data to ensure data security and privacy.

    (d) Security auditing and monitoring: A security auditing and monitoring mechanism is established to monitor and record data access and operations in the artificial intelligence system in real time, so that potential security risks can be discovered and responded to in a timely manner.

    (e) Transparency and Interpretability: The increased transparency and interpretability of artificial intelligence algorithms and models prompts review and validation to minimize the risk of data misuse or system attack.

Data show that in January 2023, the number of active people of note products on the whole network was 43.199 million, and the number of active people of note products has reached ten million, with a huge user scale and a large market potential [67, 68]. With a per capita usage time of 0.7 hours, note-taking products have quietly occupied daily usage time and become part of life and work. With the increase in the number of knowledge workers, the demand for domestic efficiency office applications will continue to expand.

The note-taking product industry has entered the market maturity period, with a large overall user volume and an objective number of active people. However, as a tool-type application, the product coverage scene is small. This industry will generally meet the user growth difficulties, and it is difficult to see explosive growth in the short term [69]. The next step is to make good product operation and optimization, serve some user groups well, and improve the brand effect and product recognition. The designed software has a simple style, easy operation, low cost for users to get started, and good overall performance. But in terms of function and experience, such as the editing of notes is not rich and perfect. More polishing is needed in the details. In the future, user needs will become more and more diverse and personalized. While meeting the needs, the operation should also be simplified.

With the implementation of informatization teaching, students' knowledge and skills have been accumulated, and their information and professional qualities have been greatly improved [70, 71]. The amount of information in the classroom has exceeded the traditional mode in the past due to the variety of ways of displaying knowledge resources, quick access, easy sharing, fast updating, and huge quantity. When students are confronted with this information, sometimes it is too late for them to digest it. Therefore, convenient and efficient knowledge access poses a challenge to students' personal knowledge management. Classroom note-taking application is a personalized learning tool for students, and it is also applied more in students' learning. Students can study and think independently without the guidance of the teacher and complete their learning tasks skillfully and efficiently with the help of the application software [72, 73, 74].

7. Conclusion. Based on the current situation of classroom note-taking, this paper explains the level of learners' awareness of classroom note-taking and the problems of note-taking in the classroom, and summarizes the design ideas and basic requirements of a classroom note-taking application. The design process of an intelligent classroom note-taking application is proposed, and the design and development of the software is further completed. Specific achievements are listed below.

1. Theories related to classroom note-taking are reviewed, such as learning strategies, cognitive psychology, and personal knowledge management. The characteristics and habits of learners taking notes in the classroom are analyzed, as well as learners' confusion about note-taking and the need for a classroom note-taking application. Based on this, the design idea of the smart classroom note-taking application is developed, which provides a valuable reference for similar works.

2. Based on the design idea and basic requirements of the intelligent classroom note-taking application software, the design process and detailed description of the software are proposed, combined with the questionnaire and theory.

3. By combining the artificial intelligence and traditional computer vision, the proposed software can record and sort through the lesson content by time, enhancing systematization and efficiency. In addition to local functionality, the software offers a course library function, which allows learners to easily access all shared notes and documents via the web.

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