3. Experimental verification and summary

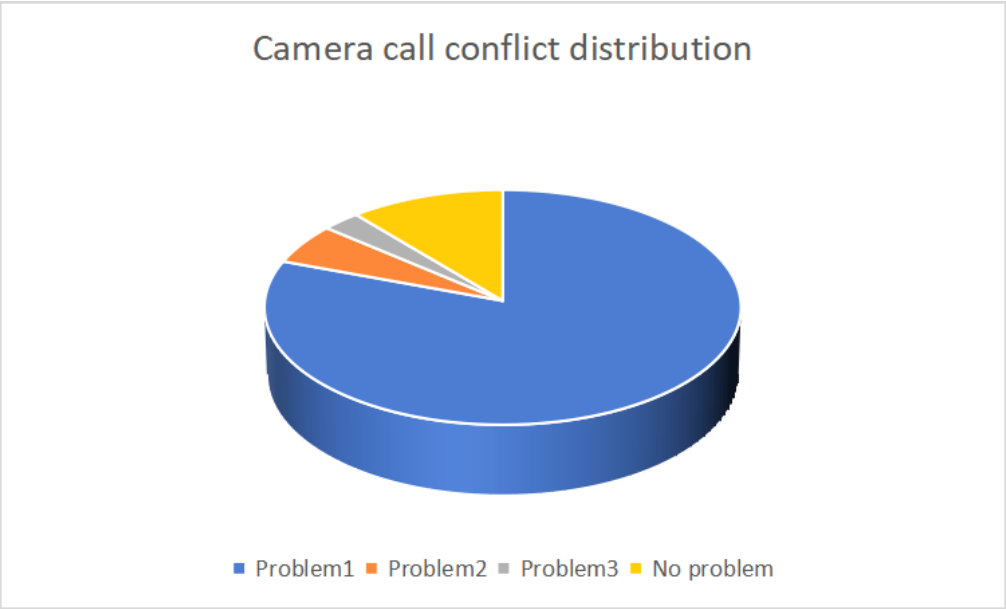
3.1 Camera call conflict

In view of the camera call conflict problem, we selected 36 software in the application market for testing, carried out statistics on the sub-problems of the software, and referred to problems 1, 2 and 3 for short respectively. The abbreviation and exception name have the following correspondence:

- Problem 1: Camera resources cannot be obtained after the FF mode focus switch
- Problem 2: Delay in obtaining camera resources after focus switching
- Problem 3: Camera options turn off automatically

We made statistics on the number of apps with the above abnormal problems and calculated the proportion of various problems in 36 apps. The statistical results are shown in the table below. It can be seen that 80.56% of the tested apps failed to obtain camera resources after switching focus of FF mode, which is reflected in the fact that the camera resources are still not available on the main screen after the floating window is closed. The camera picture is stuck, and the user must exit and restart or turn on the camera again, which greatly affects the user experience. In addition, 5.56% of the tested apps showed a delay in obtaining camera resources after focus switching, indicating that although the main screen APP could regain camera resources, the picture would be delayed for a period of time before recovery, which also seriously affected the smooth experience of users. In addition, 2.78% of the tested apps have the problem that the camera option is automatically closed, which requires the user to manually open it, increasing the complexity of operation. Finally, among all the tested apps, only 11.11% of the video apps with no problems showed that most apps did not handle the camera call conflict well. This abnormal conflict is widespread and greatly affects the user experience.

Camera call conflict	Problem1	Problem2	Problem3	No problem
Number of apps	29	2	1	4
APP ratio	80.56%	5.56%	2.78%	11.11%



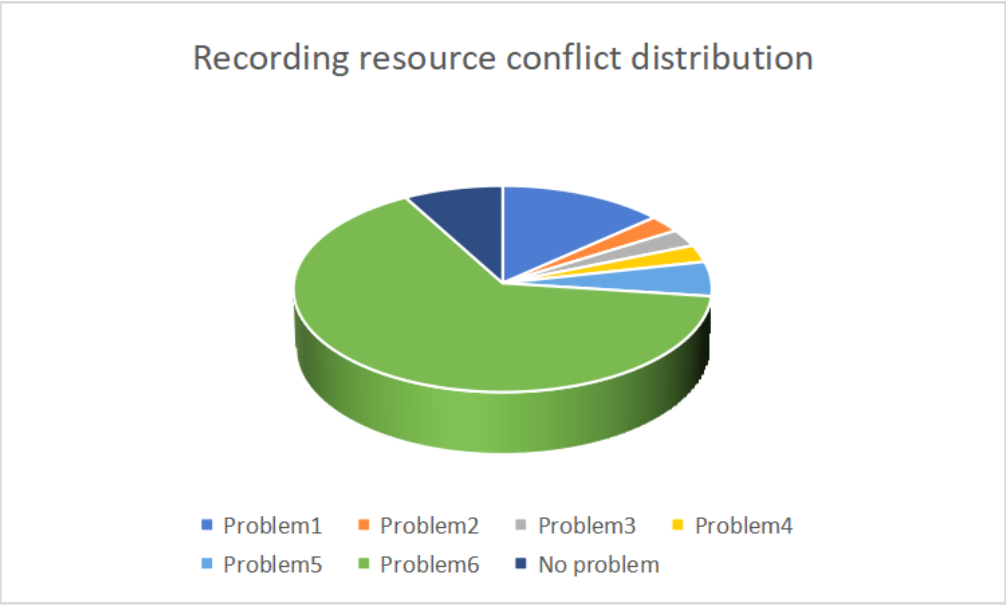
3.2 Recording resource conflict

To solve the problem of recording resource conflict, we selected 31 software in the application market for testing, and carried out statistics on the sub-problems of the software, and respectively referred to problems 1, 2, 3, 4, 5, 6 for short. The abbreviation and exception name have the following corresponding relationship:

- Problem1:Recording cannot be performed and cannot be sent
- Problem2:The message can be sent, but recording fails
- Problem3:The call is interrupted
- Problem4:The microphone is off
- Problem5:Low volume
- Problem6:No sound

We counted the number of apps with the above abnormal problems and calculated the proportion of various problems in 31 apps. The statistical results are shown in the table below. It can be seen that 77.42% of apps have no Recording resource conflict problem. The application located on the home screen cannot use audio resources, resulting in "no sound" for the receiver, which is contrary to the user's use logic and greatly affects the daily use of the APP. 16.13% of the test software could not record and could not send recorded messages. Even if the APP under the floating window closed the audio button, the user could not finish sending voice messages in the APP on the main screen because of the audio resources. In the test apps, 6.45% of the apps had the problem of decreasing volume, that is, the audio resources were occupied by other apps and the sound became smaller. For problem 2, 3, and 4, there is one abnormal APP record in each case, call interruption, microphone shutdown, and failure to send recording messages that can be sent but can be sent, all of which have a great impact on user use. Among the total test apps and the limited test range, only 3 apps had no abnormal problems, indicating that most apps in the market still lack effective means to deal with recording resource conflicts.

Recording resource conflict	**Problem1**	**Problem2**	**Problem3**	**Problem4**	**Problem5**	**Problem6**	**No problem**
Number of apps	5	1	1	1	2	24	3
APP ratio	16.13%	3.23%	3.23%	3.23%	6.45%	77.42%	9.68%



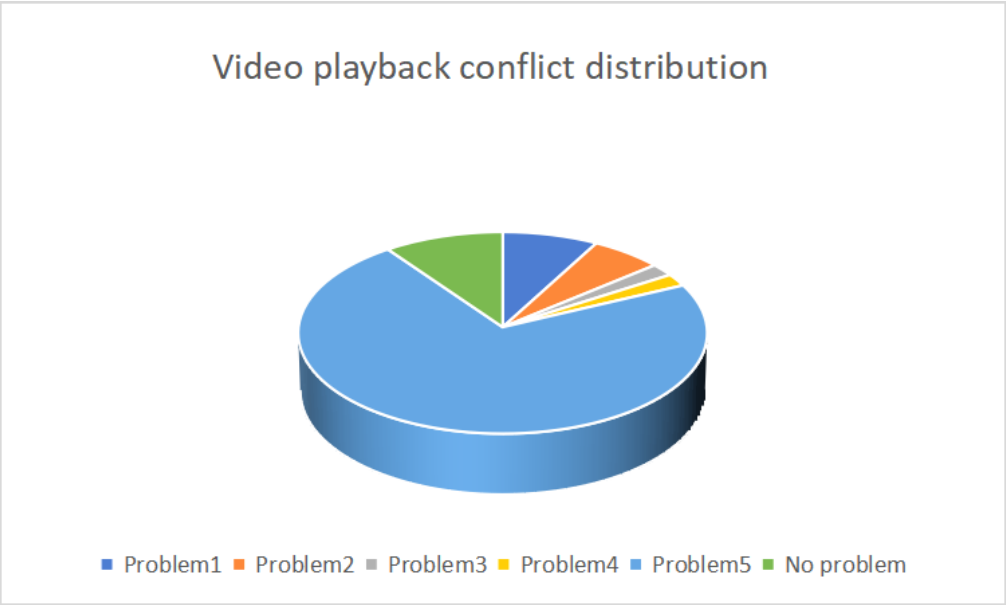
3.3 Video playback conflict

In view of the abnormal video playback conflict, 41 software were selected from the application market for testing, and the five seed problems of the software were analyzed statistically. Problems 1, 2, 3, 4 and 5 were respectively shortened for short. The abbreviation and exception name have the following corresponding relationship:

- Problem 1: Small window play is suspended
- Problem 2: The small window disappears
- Problem 3: Unable to open small window (when other apps are in PIP mode)
- Problem 4: Unable to open PIP mode, only background sound
- Problem 5: The PIP mode is not developed

We made statistics on the number of apps with the above abnormal problems and calculated their proportion in 41 apps. It is worth noting that some apps may have multiple abnormal sub-problems at the same time. Abnormal statistical results are analyzed and recorded in the following table. It can be seen that 85.71% of the test apps have the problem of undeveloped PIP window. As video apps, undeveloped PIP mode will greatly affect the user experience and does not conform to the design principles of mainstream video software in the market. For other abnormal problems, small window playback suspension accounts for 9.52% of the tested apps, which also shows that some apps in the face of two apps playing at the same time, the APP in the picture-in-picture mode will suspend playing and give up resources; The problem of vanishing of small window accounts for 7.14% of the tested apps. In other words, when there is video resource competition, the APP located in the small window will suddenly disappear, which will bring great trouble to users. In the test APP, there was one APP that could not open the small window, could not open the PIP mode and only had background sound, both accounting for 2.38%. Among all our test apps, only 11.90% have no problem video APP, indicating that most video playing apps have not handled the conflict in picture-in-picture mode, and this abnormal conflict still affects the user experience.

Video playback conflict	**Problem1**	**Problem2**	**Problem3**	**Problem4**	**Problem5**	**No problem**
Number of apps	4	3	1	1	36	5
APP ratio	9.52%	7.14%	2.38%	2.38%	85.71%	11.90%



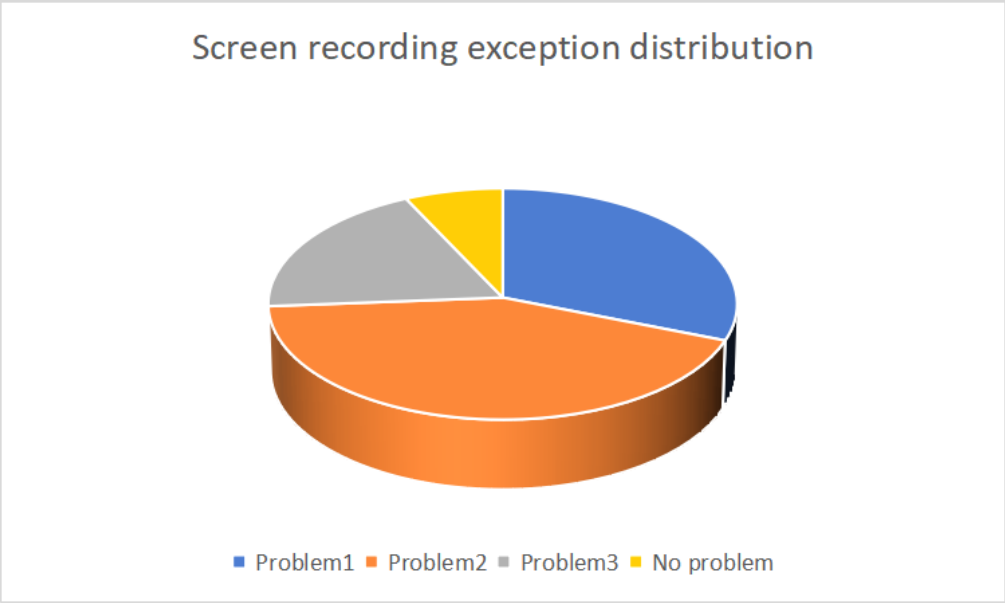
3.4 APP black screen exception during screen recording

In view of the abnormal screen-playing conflict, 42 software were selected from the application market for testing, and the test apps were all related to privacy protection, such as banking apps and shopping apps, etc., and the three seed problems appeared in the software were analyzed statistically, and the abbreviation of problems 1, 2 and 3 were respectively referred to as the following corresponding relationship between the abbreviation and the exception name:

- Problem 1: The black screen protection is not implemented for privacy-related applications
- Problem 2: The black screen scope is too large
- Problem 3: Incomplete black screen protection (keyboard action can still be seen)

We counted the number of apps with the above abnormal problems and calculated their proportion in 42 apps. It is worth noting that some apps may have multiple abnormal sub-problems at the same time. Abnormal statistical results are recorded in the following table. It can be seen that 43.90% of the test apps have the problem that the scope of black screen is too large. When users record the screen, the ideal state should be to protect the privacy content in the floating window, but the space outside the floating window should still be visible. Application scenarios such as screen recording and conference presentation will be severely affected. 31.71% of the test apps had abnormal problems involving privacy applications without black screen protection. During our test, we found that some apps, such as "Xiaohongshu", which has over 100 million user traffic, still did not protect the password floating window input interface, which greatly damaged the password privacy security and account security of users. Although 19.51% of the test banking apps only carry out black screen for a limited range of floating Windows, the system keyboard is used in the process of inputting personal information and personal password, the user's click operation on the keyboard can still be seen in the recording results, which makes the black screen protection for floating Windows invalid because the attacker can obtain the user's password through orderly keyboard input. This greatly affects the user's account security and property security. Among the apps tested by us, only 7.32% of privacy apps have ideal float window protection, indicating that most apps in the market still have such a defect in design, which will greatly harm the security of users' personal property and privacy information.

Screen recording exception	Problem1	Problem2	Problem3	No problem
Number of apps	13	18	8	3
APP ratio	31.71%	43.90%	19.51%	7.32%



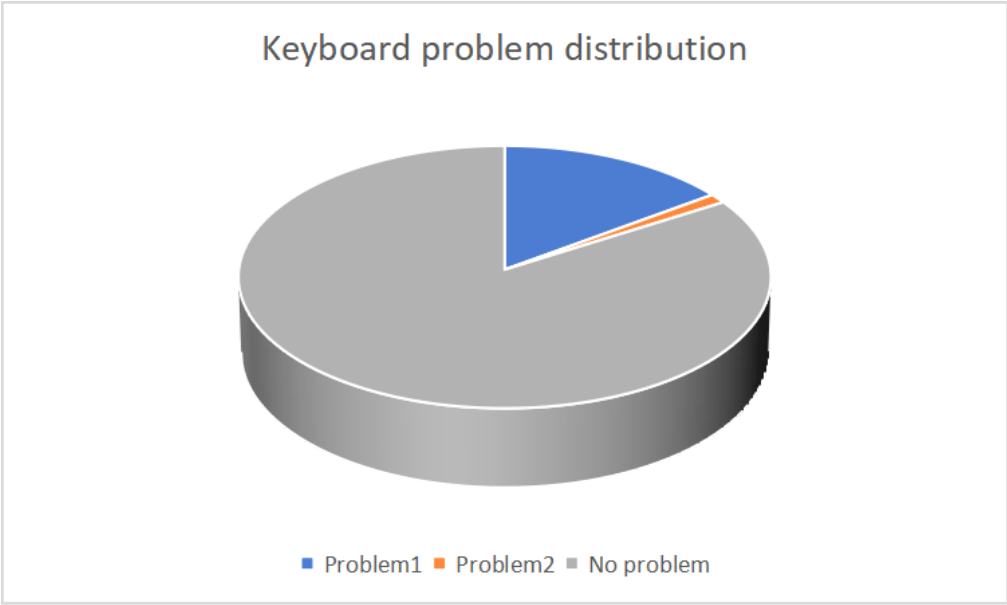
3.5 Keyboard problem

In view of the abnormality of keyboard problems, 87 software were selected from the application market for testing. All the test apps needed keyboard input, involving banking apps, shopping apps, login password input apps, etc., and the two seed problems appeared in the software were counted respectively, which were referred to as problems 1 and 2 for short. The abbreviation corresponds to the exception name as follows:

- Problem 1: Occlusion problem
- Problem 2: An incorrect keyboard is displayed

We counted the number of apps with the above abnormal problems and calculated their proportion in 87 apps. It can be seen that 14.90% of the tested apps had occlusion problem, which was manifested as that the keyboard of an APP was not timely withdrawn, resulting in two keyboards blocking the screen at the same time. 1.15% of the tested apps had a pop-up error keyboard problem. By analyzing the types of apps with different problems, it can be found that exceptions often occur in banking apps. Banking apps often design their own internal keyboard, resulting in errors when switching with the system's own keyboard. At the same time, we also found that excellent apps such as China Merchants Bank have perfected the design of the internal keyboard, thus avoiding the above two kinds of anomalies. To sum up, more than 15% of the apps tested by us still have anomalies, which are concentrated in banking apps. Since banking apps are related to users' property and privacy security, keyboard problems will greatly endanger users' personal property security and privacy information security.

Keyboard problem	Problem1	Problem2	No problem
Number of apps	13	1	73
APP ratio	14.90%	1.15%	83.90%


Keyboard problem distribution
Problem1
Problem2
No problem