Assessment of cognitive Functioning system Based on computer graphics technology

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Abstract: Early detection of cognitive impairment is crucial for dementia prevention. We aim to assess those at risk of dementia's cognitive functioning system. We developed a computer graphics-based short-term memory and attention test system that utilizes a spot-the-difference task. The system can recognize the position and information of particular things in photographs and then substitutes the original object with a photo of a comparable entity. The system may effectively produce several spot-the-difference task pictures, decreasing the repetitiveness and tediousness of studies. Furthermore, it allows for remote, real-time judgment and helps healthcare professionals provide better telemedicine services. The findings revealed that the proposed strategies were effective.

Keywords: Medical-industrial Alliance, Assessment of Cognitive Functioning, spot-the-difference task, Object Recognition, Intelligent Graphics Processing

1. INTRODUCTION

Dementia is a clinical syndrome characterized by a progressive decline in two or more cognitive domains, including memory, language, executive and visuospatial function, personality, and behaviour, resulting in loss of ability to perform instrumental and basic daily activities[1]. Alzheimer's disease (AD) is the leading cause of dementia, accounting for up to 80% of all dementia diagnoses[2].

Although cognitive disorders are unavoidable, early detection and treatment can significantly reduce the severity of cognitive symptoms. Early detection of cognitive impairment is critical for dementia prevention and treatment[3].

For example, despite the widespread use of second-generation cholinesterase inhibitors for symptomatic treatment, treated patients showed significantly less decline in global cognitive function at one year, as well as treatment and time effects across executive and visuospatial function tests. There was a significant trend toward less after two years（Fig.1）[4][5].

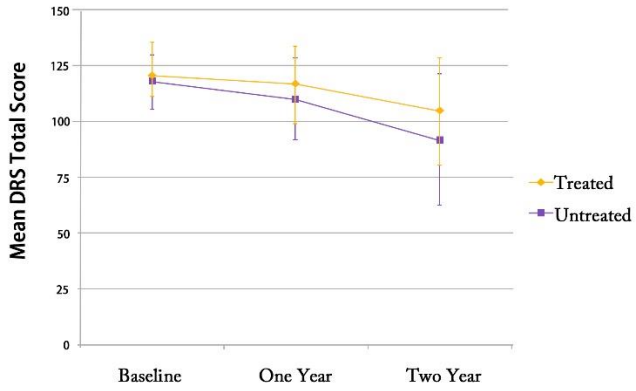


Figure 1, Change in mean Dementia Rating Scale total score over time of treatment effect.

The age-old trail-making test has proven to be an effective and versatile cognitive testing tool. TMT（Trail Mark Test） is widely used in medicine to monitor early cognitive diseases. American medical scientists in the 1950s proposed this method. Allow the patient to connect 25 letters, record the time each letter is connected, and analyze the patient's cognitive status.

With the advancement of technology, developers began experimenting with modern technology to monitor cognitive disorders. Researchers are attempting to use

virtual reality technology to help people with cognitive impairment complete certain tasks[6]. And the electronic version of TMT allowed the elderly to complete the test using modern technology. Compared to traditional test methods, these tests can collect the elderly faster and more accurately[7]. The information can be derived earlier and more intuitively from the data, which is extremely useful for doctors when assessing a patient's illness.

These studies have had a great deal of success in evaluating cognitive disorders. In addition, it has been demonstrated in medicine that these effects have a practical reference value for evaluating cognitive disorders [8]. However, some issues have emerged. The elderly are resistant to the use of emerging technologies. Even simple operations are difficult for the elderly to perform compared to normal people. As a result of their low acceptance of advanced technologies and boring and difficult test contents, patients may resist testing these advanced technologies.

Another notable issue is the test's singularity. Most of these studies focus on the accuracy of cognitive function assessment and rarely alter the test content. As a result, patients can only receive an assessment of their current cognitive function. However, the onset period of Alzheimer's disease with the highest proportion of cognitive symptoms is two years, and a single test cannot predict a patient's onset trend. They are making it impossible for patients to observe for an extended period of time. Long-term visits and observation (that is, regular testing) are critical for predicting illness and deciding on countermeasures [9].

We hope to solve these problems using new technological means and schemes. The researcher Shu Nishiguchi[10] used different tests to ask young and older people to do cognitive function tests separately. According to the findings, older people with higher risk and cognitive impairment have a longer searching time. Finding different tests, we believe, is an ideal scheme with simple test contents and accurate prediction results.

2. ASSESSMENT OF COGNITIVE FUNCTIONING SYSTEM

What we hope to provide is a system that will allow doctors to monitor the health of the patient in real-time on a daily basis. The test content is straightforward, simple for testers to learn and test, and capable of extracting effective evaluation value. And it can generate a large number of test contents, making it easier for patients to perform long-term tests. Doctors can access patients' test results remotely, allowing them to monitor their condition and take action in real-time.

2.1 Convenient IOS touch screen system



Figure 2, Two similar pictures.

Because of the system's universality, our overall test is performed on an IOS system. Allow the elderly to look at two similar images, as shown in(Fig .2), find the differences, and touch the differences on the screen. Record the time the patient discovered the different positions, the time he finished the test, and the number of wrong touches. This can be used as a baseline to assess the degree of cognitive impairment in the elderly. Intelligent devices can record these data more accurately than traditional note tests[11].

2.2 Automatic difference identification system

We attempted to distinguish the difference in early development by setting the box area as shown in (Fig. 3). When the patient touches the box, it is marked as positive (that is, when the patient confirms the difference), and when the patient touches the outside of the box, it is marked as negative (that is, it is recorded as positive when the patient confirms the wrong difference).



Figure 3 box mark

The basic system requirements for patients to complete the test can be met by this design. However, when the edge (non-difference) of the box clicked by the patient is

generated, the patient confirms the difference, resulting in the wrong record. And, if you want to use different images for testing, the positions of these boxes must be reset by technicians, which is inconvenient for patients who require long-term testing.

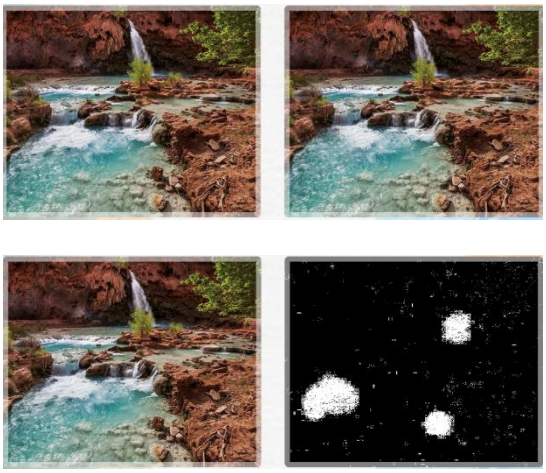


Figure 4 Compare images Pixels.

Using computer graphics technology, we effectively solved the problems listed above. By calculating and comparing the pixel values of the two images, the same value is recorded as 1, and the different value is recorded as 0, resulting in a black-and-white image that distinguishes different areas(Fig4). The edge of the difference is then calculated using edge tracking and classification techniques, and different differences are distinguished and assigned serial numbers（Fig.5）. The difference can be detected, and the test task can be generated automatically.

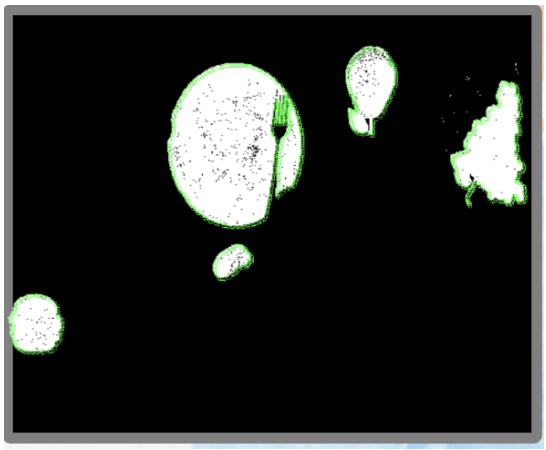


Figure 5 Contour Tracking

2.3 interactive interface design

Although locating various tests is a straightforward task, it is assumed that the patient is already suffering from cognitive impairment. We intend to create a more humanized interactive interface for the system.

When the patient clicks out of the screen, a red mark indicates that the patient touched the incorrect area. The green mark indicates that you have touched the correct area. Attach a prompt chart to suggest that this area has been confirmed when the patient confirms the difference. Due to the differences between different pictures, the system can provide corresponding prompts to patients based on the number of differences. If the difference in the image is not obvious and the patient is still unable to find it after a long observation period, the system will provide a prompt button. After the patient presses the button, a green box will be used to indicate the difference, allowing the experiment to proceed（Fig.6）.



Figure 6 Test Interface

2.4 Automatic test picture generation system based on yolo5 image recognition.

More tests must be generated by the system in order to meet the requirement of long-term patient monitoring. At the moment, this system can generate tests automatically from two similar images. However, the images used for testing are still those created by technicians with tools like “photoshop tool”.

We hope that the system can generate similar images on its own. We propose that the system identify the items in a photo and replace the original items' pixels with similar items, resulting in a "fake" picture that will be compared to the original picture as a test picture.

We propose using the YOLOv5 object recognition model for object recognition. The model YOLOv5 is a powerful objection detection algorithm at present to better apply in the actual environment [12]. We can detect a photo's position, name, and size using the YOLO5 model(Fig7).

The system can find similar pictures of items using the recognized name. Then replace the pixels of similar items with those of the original items by using position and size(Fig.8).

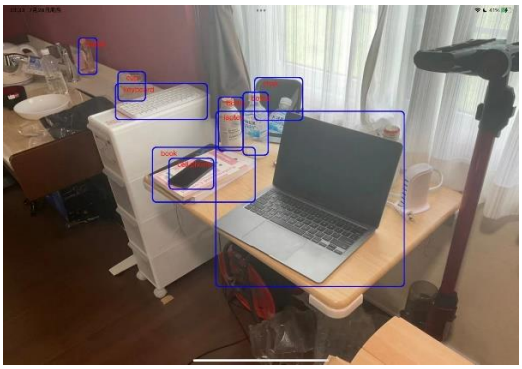


Figure 7 YOLO5 model recognition



Figure 8 Fake Image product

2.5 Auxiliary online evaluation system

The evaluation system's goal is to assist doctors in better judging patients' cognitive impairment. The demand system can obtain patients' basic data. The system obtains the main evaluation data, such as the time it takes patients to find each difference, the number of times they click on the wrong area, the number of times they click on the right area, and whether they use the prompt button or not, and so on. Because the sizes of the replaced fake pictures differ, the larger the specified size, the greater the difficulty coefficient of the picture, and the smaller the picture, the lower the difficulty coefficient.

The collected data is stored in two databases, one online and one offline. Offline is a local database that uses the SQLite database. SQLite is a very flexible database creation tool. Unlike other relational databases such as MSSQL(Microsoft Structured Query Language Server), SQLite databases are self-contained and portable. An SQLite database file can be run on all supported platforms, including, of course, iOS8. MySQL Database Service is a fully managed database service that allows you to build cloud-native applications with the world's most popular open source database. [13][14].

This system supports converting data into graphs for doctors' reference to make it easier to observe the patient's condition. The graphic illustration is based on the patient's test results. The data stored locally can be drawn in the doctor's application interface after it has been uploaded to the network database. A histogram represents the interval between the two differences.

3. EXPERIMENT

Patients with two different age brackets were tested: the patients aged 20-25 (Fig.9)and the patients aged 30-45(Fig.10). Some samples were extracted from the tested patients as a reference. A test chart with five differences was adopted in the experiment. The difficulty coefficient of the five differences ranged from high to low, and the time interval between the finding of the two differences was recorded.

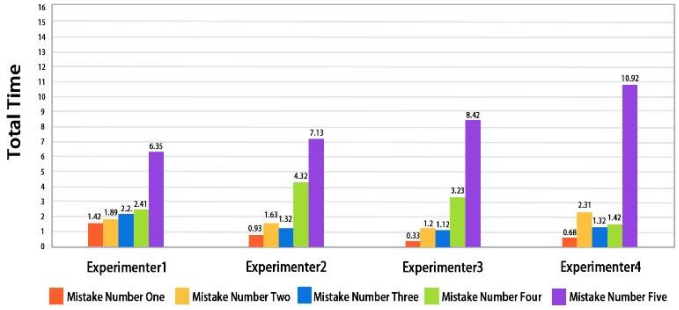


Figure 9 aged 20-25 test result

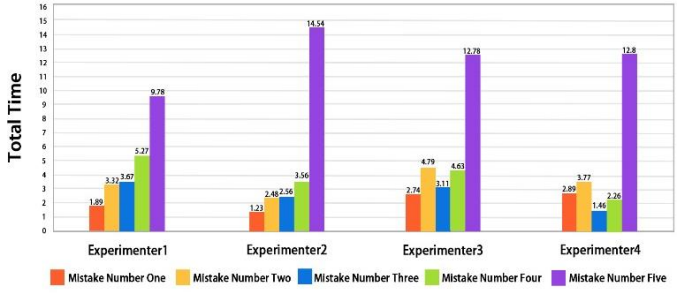


Figure 10 aged 30-45 test result

According to the results, it was found that although the difference is not large, it can be observed that the test results of patients aged 20-25 are slightly superior to those aged 30-45.

Name / Test data	Experimenter 1	Experimenter 2	Experimenter 3	Experimenter 4
Total Time	37.91	65.03	57.06	44.35
Total errors	0	2	1	1

Table 1 aged 30-45 TMT test result

To verify whether the assessment system is informative for the assessment of cognitive disorders. We asked four testers in the 30-45 age group to take the TMT test. The test results are shown in Table 1. The results show that those who spent more time on the TMT test also spent more time on finding spot-the-difference tests, which proved that the cognitive impairment evaluation function of the system could provide appropriate evaluation data with the reference value.

4. CONCLUSION & FUTURE WORK

In this paper, we built a system to help doctors detect cognitive impairment in patients in real-time. The system uses computer graphics technology to complete automatic test generation based on the discovery of various tests. This system can mine deeper patient data than traditional cognitive impairment detection methods. The system employs a deep learning model to recognize standard daily life images and generate fictitious images to generate a large number of test data sets that can assess the patient's cognitive impairment over time.

Doctors can remotely monitor the patient's condition information using this system's online database. So that patients can receive better medical care. The recorded data provides valuable references for early cognitive monitoring. This information will assist potential cognitive patients in carrying out the necessary prevention and treatment.

Limited by conditions, data collection from patients with a high risk of cognitive impairment is failed. It plans to refer to the data of patients with various age brackets in the future to debug the system functions and provide more accurate and reasonable data. The system's data are time and the number of errors recorded by the system. Although it has first-class evaluation value, it is hoped that deeper reference data of patients can be tapped. It is planned to tap patient data such as line of sight or deeper data with intelligent devices such as eye trackers.

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