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The Integration of Computer Vision Technology and Chemistry Experiment: Identification of Acid and Base

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Abstract. Promoting the deep integration of artificial intelligence and education actively can facilitate educational change and innovation. Computer vision technology is one of the important technical means of artificial intelligence. Through integrating computer vision technology and chemistry experiment in middle school and demonstrating the necessity, we propose a design of computer vision experiment. For this experiment, we use the open source hardware mPython 2.0, the small ark AI vision module and the graphical programming software mPython 0.5.4 to integrate with the "acid and base identification" experiment. And the AI experiment device can identify the color of the acid and base indicator to obtain the acid and base value which can compensate for the needs of students with color recognition impairment. In this experiment, visual programming software is used to learn for high school students because it is simple and practical.

Keywords. Computer vision; Chemistry experiments; Laboratory equipment

1. Introduction

In 2015, Stanford AI Lab organized the competition of "Image Net" image recognition. The computer recognized images more correctly than human eye. In 2016, Alpha Go defeated the human Go champion Lee Sedol and then people re-examined the artificial intelligence represented by computer vision technology that are quickly applied to practice.

Professor Jeffrey Hinton of the University of Toronto, Canada, used deep neural networks in computer recognition image to improve the ability of computers to recognize images by more than a dozen percentage points.Hinton was awarded the 2018 Turing Award for his contributions to deep learning in artificial intelligence, and is also known as the "father of neural networks" and the "originator of deep learning". Computer vision is a cross-disciplinary discipline involving computer science, mathematics, engineering, physics, biology, and psychology, and was defined by Ballard & Brown (1982)[i] as the construction of a clear and meaningful description of a physical object from an image. Computer vision is mainly used in the fields of face recognition, image retrieval, game and control, monitoring, biometrics, and smart cars.

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2. Necessity

Nancy Henry (2020) investigated that approximately 8% of males and 0.4% of females have color vision abnormalities that result in the inability to discriminate between red or green in the United States.[ii]Although the Guidance on Physical Examination for Enrollment in General Higher Education Institutions indicates "abnormal color vision" as "disease ", the school concerned, especially in science and technology majors, may not be admitted, but students with abnormal color vision should also take the entrance examination for science and technology subjects normally.The students with congenital color vision abnormalities can not be deprived of the right to learn color recognition experimental courses for the fairness of the college entrance examination.To help the group of the students with color vision abnormalities to do color recognition experiments,the empowerment of new artificial intelligence technology is needed,so computer vision applications to primary and secondary school experimental teaching is very necessary.

3. Experimental Overview

The computer vision acid-base recognition experiment is applicable to secondary school chemistry experiments and includes chemical science concepts and artificial intelligence related principles such as computer vision techniques. For example, the acid-base indicator litmus becomes red when it encounters acid and programmed blue when it encounters base. The combination of the open source hardware mPython and the small ark AI vision module can be able to recognize the color change of the acid-base indicator.

Computer vision acid-base identification experiments are conducted in experimental groups of 3-4 students, according to the experimental investigation worksheet (see the reference support materials section for details),The experiments will be conducted in the order of "hardware construction", "project programming" and "experimental operation".

Experimental platform hardware mainly uses open source hardware mPython 2.0, small ark AI vision module 2.0 (hereinafter referred to as small ark AI), laptop (pre-installed window10 home Chinese version),mPython0.5.4 developed by programming language Shengshi,mainly by programming control system, image acquisition system and information output system.

3.1. Programming control system

Using a laptop (pre-installed with Window 10 Home Chinese version) to open the programming language Shengshi developed mPython 0.5.4 and call up the built-in (N+) Little Ark AI program is for programming combined with the mPython.

3.2. Image acquisition system (small ark AI module)

The Little Ark AI vision module is developed by Tao Li Science and Education (Shenzhen) Co., Ltd. and integrates K210 high-performance 64-bit dual-core chip with built-in AI hardware acceleration units (KPU, FPU, FFT, etc.), which can realize local vision algorithms for various scenes, support graphical and python code programming, and can realize intelligent control class applications such as artificial intelligence robots and creator wisdom works.

Little Ark has built-in face recognition, 20 categories of recognition, color recognition, QR code recognition, classifier object recognition and other functions. Complex training process and visual algorithm can be carried out to achieve artificial intelligence visual creation works. Onboard dual-core processor 64-bit; up to 400MHz overclockable to 600MHz main frequency; SRAM 6MB general-purpose memory + 2MB; A memory Fiash 16MB; pluggable FF card; 2-inch LCD screen 200-day pixel camera; 2 RGB indicators; two physical buttons; communication interface.

For example, semantic segmentation, here is mainly to recognize the semantics corresponding to color. The principle is to use the small ark AI vision module for colorimetric card color recognition. Little Ark recognizes different colors, and the RGB light of Little Ark lights up the corresponding color. The steps are as follows: the first step is to initialize the small ark and switch the mode to color

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mode. After initialization, we must wait for a few seconds because the small ark takes longer to boot up than the mPython; the second step is to learn the color and the recognition order. ID0 (ID identification number, same below, common abbreviation for open source hardware) is green.ID 1 is yellow. ID 2 is pink. For example, if the small ark gets ID0 data, the indicator lights up green; the third step, other ID judgment statements are also written, plus the previous procedures as well as repeated execution.

3.3. Information output system(mPython)

The mPython is developed by Shenzhen Shengsi Science and Education Culture Co., Ltd. and is a MicroPython microcontroller board, which well supports various functions on mPython software. The board contains accelerometer, keys, touch pins, sound and light sensors, 128*64 OLED screen, etc. It is mainly used for youth programming education. The mPython has a good open source, can be compatible with small ark AI, and can read the color values and calculate the programming and output the arithmetic results.

4. Experiment

In this case study, we selected "common acids and bases" in the second book of 9th grade chemistry of the Human Education Version, and used a computer vision device to deeply integrate with chemistry laboratory teaching. The experimental setup is as follows.

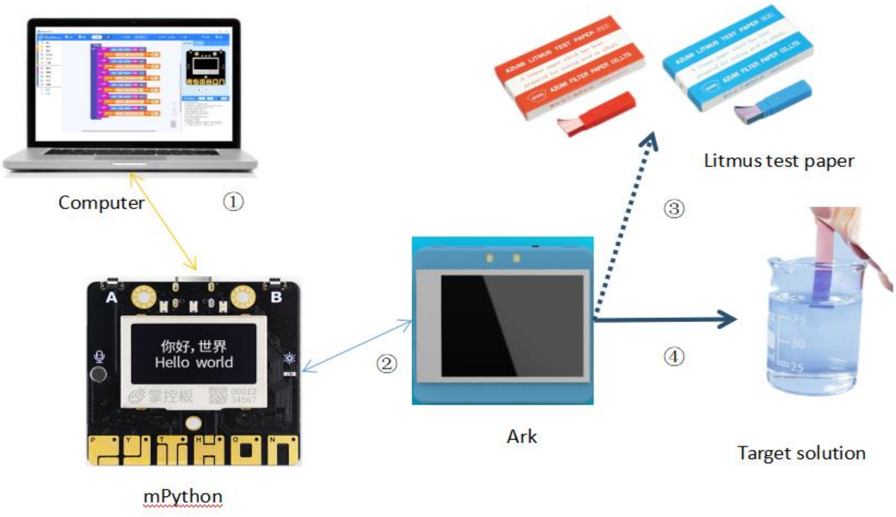

Figure 1. Experimental setup diagram

Specific process explanation:

Process ① Computer connected to the mPython for graphical programming, information input, data calculation and reading.

Process ② Open source hardware mPython connects to the small ark AI vision module for data transmission and acquisition, and the mPython displays the relevant information acquired by the small ark AI calculation.

Process ③The small ark AI acquires the colorimetric band information, records it, and feeds it back to the computer.

Process ④The Little Ark AI recognizes the color of the experiment target and feeds back to the control panel to display the result.

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Connection method:

Using DuPont wire to connect the small ark, the mPython (including the expansion board Bai Ling Pigeon) together to form a simple computer vision recognition device, as shown in Figure 4 above.

The experimental procedure is as follows.

Table 1. Python Code and Sketch Code

```
from nplus.ai import *
from mpython import *
import time
ai = NPLUS_AI()
time.sleep(1)
ai.mode_change(0)
time.sleep(3)
while True:
  if ai.get_id_data(0):
    oled.fill(0)
    oled.DispChar('acid', 0, 0, 1)
    oled.show()
  else:
    oled.fill(0)
    oled.DispChar('alkali', 0, 0, 1)
    oled.show()
  time.sleep(0.1)
```

Table 2. Experimental procedure of "common acids and bases"

Teaching process	Teaching content	Student Activities	Session Objectives
Scenario introduction	Using litmus paper, put in white vinegar, apple juice, soapy water, detergent solution, tap water, shampoo solution, and ask the students to say the color of the litmus paper after the test, some students have controversy, can we give us the answer through artificial intelligence? Inspire the students to be curious about artificial intelligence.	Knowledge of the acidity and alkalinity of common solutions through cooperative learning.	Use real cases as scenarios and use demonstrations to inspire curiosity.
Experimental Investigation	(1) Clarify the purpose of the experiment: to identify acidity and alkalinity using the AI experimental apparatus. (2) Conducting experimental groupings: Using the AI device for identification, students perform the actual operation with data recording. The specific process is to use litmus paper test, which can show acid and alkali depending on the color. Process ③ mainly uses supervised machine learning by discriminating the color, which, according to the color, corresponds to the acidity and alkalinity. Process ② is mainly using the mPython connected to the small ark AI device,	Add litmus paper, test white vinegar, baking soda solution, etc. Cooperate in experiments and directly or participate in experimental operations. Observe experimental phenomena and	Experimental investigations can be able to distinguish the acidity and alkalinity of common solutions through litmus paper and through semantic segmentation (color recognition) by computer vision.

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	will identify the acid, or alkali, information displayed on the mPython. Process ① is to use a laptop to program the board in Python. Process ④ is to use the experimental device to identify the acidity and alkalinity of the target solution and display it on the board. (3) Group work is for the analysis of experimental results to draw conclusions and present them.	record data and analyze results.	
Communication Expansion	Explaining other computer vision recognition techniques and provide equipment to guide students in their continued exploration.	Present experimental findings in groups and participate in discussions	By analyzing and summarizing the experimental phenomena, the common computer vision principles in the context of artificial intelligence technology are constructed.
Test Reviews	Distribute assessment test questions and conduct process evaluation	Time limited to complete the exercises	Assessment mastery

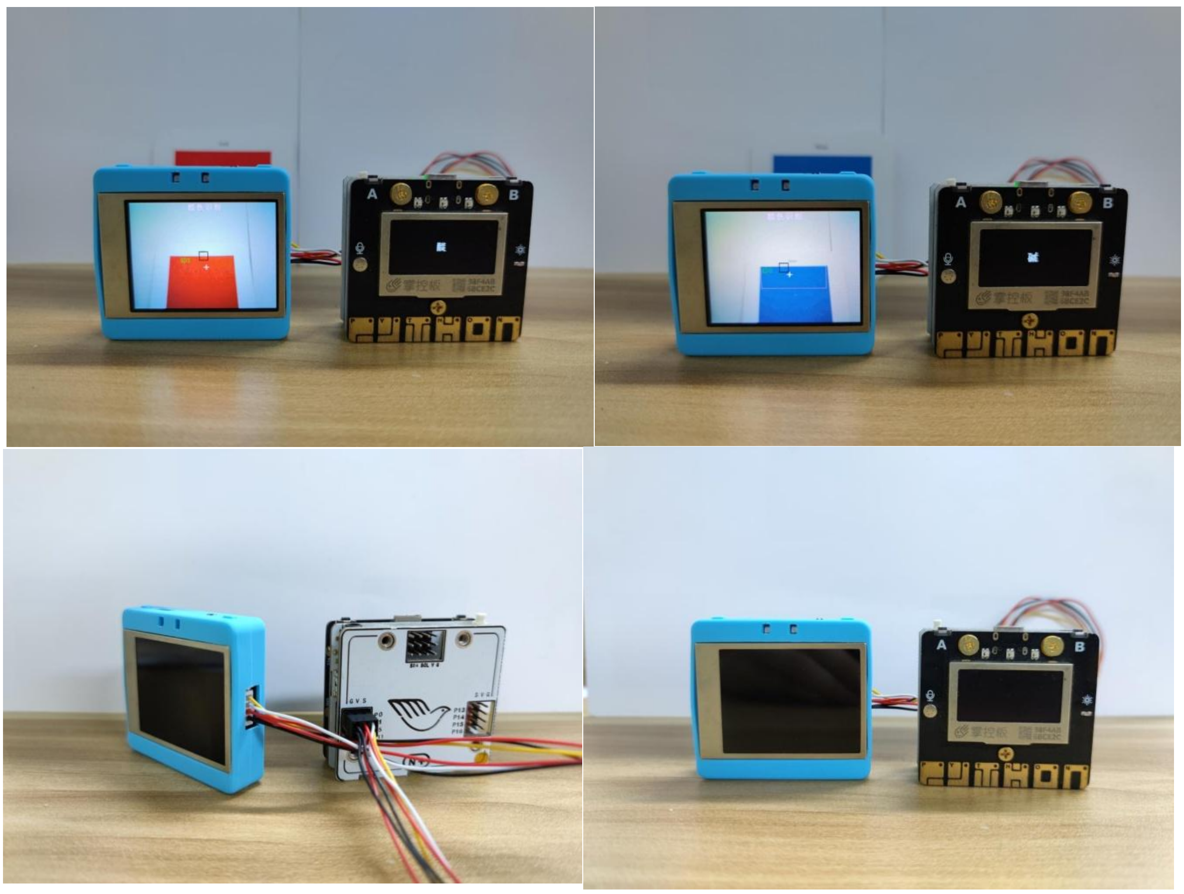

Figure 5. Experimental process record

5. Discussion

Computer vision technology extends one of the five human senses, that is, it extends human vision, and the future of artificial intelligence technology is toward the direction of human-machine integration. With the rapid development of artificial intelligence technology, text recognition technology, image recognition technology, natural language processing technology and machine learning technology have been introduced into people's lives one after another. Although people are already accustomed to using computer vision technology, such as the operation of "intelligent flower recognition", "intelligent search" and other smart phone software. Besides, people enjoy the convenience of the "face recognition" "license plate recognition", but the integration of computer vision technology into primary and secondary school teaching is still far from enough. Therefore, at present, this research is very necessary.

First,the personalized experimental teaching is in need. Traditional experiments can only obtain one-sided and limited knowledge content such as textbooks and teaching materials, and teachers' guidance can only rely on teachers' reference books and some preparation materials, which are very limited in content and cannot meet the personalized needs of "teaching to students according to their abilities".For example, using software for plant cognition such as "Shape and Color" and "Flower Mate", students can access the plant classification system of the Institute of Botany of the Chinese Academy of Sciences and obtain detailed plant classification information, so that they can do personalized learning without looking up the plant classification manual.

Second,the advantages of the experimental process of "portfolio assessment" is obvious. According to Zhong Qiquan (2004), file bag evaluation "focuses on collecting works that show learners' efforts and progress in a certain learning area, investigating each learner's acquired experiences and their questions and interests, exploring the learning process in each time period, and grasping each learner's learning trajectory by compiling a 'growth file'". The "growth profile" is developed to capture each learner's learning trajectory." [iii] Traditional experimental evaluation cannot be easily completed by organizing and summarizing the data information in the experimental process, which is laborious and time-consuming, especially for recording the valuable process learning information such as students' failed attempts in experimental teaching. Combined with computer vision motion capture technology to complete the recording of the experimental process, all the experimental process of students data, automatically generate experimental learning "file bag evaluation", which helps the experimental process of self-assessment, other assessment, teacher assessment.

Third,computer vision technology can be used to avoid the danger of the experimental process. Some of the chemical experiments will be exposed to flammable and explosive substances, and the remote operation through computer vision devices can prevent teachers and students from being hurt.

6. Conclusion

Looking into the future, the integration of AI technology and experimental teaching in primary and secondary schools can be divided into three steps:

The first step is to use existing developed AI algorithms and hardware devices to combine with experimental teaching for teachers and students, such as the use of small ark AI vision module for "common acids and bases" experiment. This step requires teachers and students to master the initial knowledge of graphical programming and open source hardware building foundation. With the opening of the AI education teacher training program and the promotion of the national AI literacy teacher training, the government, enterprises and schools jointly put primary and secondary schools AI laboratory into use. This step of experimental teaching will be realized soon.

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The second step is to allow teachers and students to use the already developed AI algorithms to develop their own hardware devices suitable for experimental teaching. The vast majority of non-computer teachers and students do not need to master the underlying logic of artificial intelligence, but they need to be able to use the already developed artificial intelligence algorithms combined with advanced IoT experimental instrument sensors so that they can develop new artificial intelligence-enabled scientific experiments.

The third step is for faculty and students to work together to put new AI algorithms into use in experimental teaching. MIT President Schwarzman said the goal of the AI Institute is to "educate the bilinguals of the future" ."bilinguals," the president means people who are skilled in the use of artificial intelligence technology in fields such as biology, chemistry, politics, history and linguistics.[iv]In the farther future,artificial intelligence era aborigines will have the ability to develop new algorithms for experimental teaching AI with the efforts of generations of faculty and students.

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