Research on The Innovation of Children's Picture Books with The Empowerment of Augmented Reality Technology

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Abstract

Augmented Reality (AR), also known as mixed reality, technology is born out of Virtual Reality (VR) technology, the empowerment by which provides technical support for the seamless integration of traditional paper books and virtual environment. It has brought tremendous changes to the content production, interactive design, and even the reading medium as far as picture books are concerned, thus imparting a three-dimensional, real-time interactive and immersive reading experience to children. This article takes children's picture books empowered by AR technology as the research object to explain the implementation mechanism of AR technology in picture books, analyze why AR-empowered picture books are not yet mature and their market penetration rate is low, and propose an appropriate strategy to improve the situation of AR-empowered picture books accordingly. Specifically, the strategy includes strengthening the potential exploration of AR technology, integrating audience feedback, predicting market demand by process neural network, improving the quality of AR-empowered picture books, and grasping market demand.

Keywords: *Augmented Reality Technology; AR-empowered Picture Book; Immersive Reading; Multi-sensory Interaction; Process Neural Network*

1. INTRODUCTION

Advanced technology and complicated terminal equipment have enabled the digitization of picture books. AR technology, combining the virtual with the real, is developed on the basis of VR technology. Real-time interaction and three-dimensional registration are a technology that is realized by superimposing and integrating virtual information and real scenes through multi-sensor fusion and computer real-time calculation. The virtual reality space constructed by AR technology integrates two-dimensional plane and three-dimensional space, allowing readers to truly enjoy the 'immersive' reading experience. The integration of virtual reality, intelligent interaction, digital voice, and other technologies imparts children an interactive and immersive reading experience. Moreover, electronic sensory interaction design extends the reader's reading experience from visual effects to auditory and tactile effects. This article aims to explore the technical realization and market status of AR-empowered picture books, and propose appropriate development strategies accordingly.

2. AR TECHNOLOGY PROMOTES READING INNOVATION IN PICTURE BOOKS

AR technology has integrated many art forms into picture books. The way of creation and visual representation of children's picture books has been reshaped by digital images, audio processing, and dynamic image technology. The fast development of human-computer interaction or human-machine interaction (HCI or HMI) technology has radically changed the interactive design approach to children's picture books. AR-empowered picture books gradually enrich children's senses and expand their horizons as well.

2.1 AR technology promoting three-dimensional reading of picture books

The application of AR technology to children's picture books is realized mainly by using a camera to obtain the identification mark in the paper picture book, adopting the corresponding animation video or three-dimensional model, and then projecting the virtual image on the paper book through the display, consequently presenting a visual effect that fuses static pictures with dynamic videos, and combines real two-dimensional planes with virtual three-dimensional spaces (see Figure 1) in front of readers.
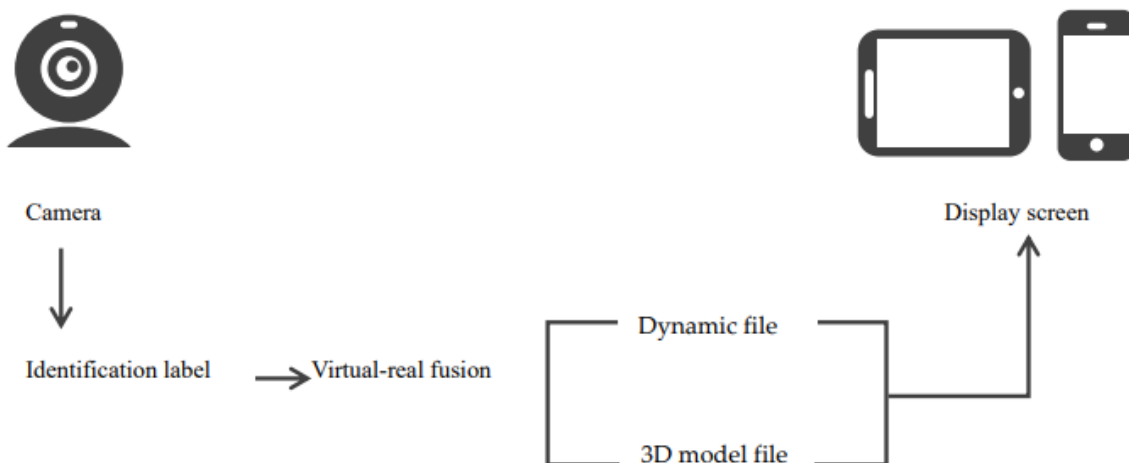

Figure 1 The basic working mechanism of AR technology in picture books

AR technology has made picture book reading change from traditional paper to media-paper integration. The paper books involved in AR technology are from paper media to electronic media, forming a secondary media transformation with visual leaps, which makes the conversion medium of virtual reading increase the doubling factor... [5] Digital media has great compatibility, making it integrate sound, animation, and three-dimensional model display with 'picture' and 'text' of traditional picture books, which not only enriches the reading experience but also breaks through the limitations of media. Traditional paper books, together with mixed media books and e-books also expand the platform for reading picture books, especially the prevalence of mobile terminals makes reading ubiquitous.

2.2 AR technology promoting immersive & interactive reading experience

AR technology enhances readers' multi-sensory experience of picture books. Particularly, multi-touch, gravity sensing, voice interaction, gesture recognition, and other interactive approaches characterized by AR improve children's sense of involvement when reading picture books. And now picture book reading is no longer centered on unilateral information output, it enables children to be involved in interaction through sight, hearing, and touch during the reading process, thus improving their sense of participation and concentration.

Professor Lv Jingren pointed out in his book *Transition of Concept from Binding to Book Design* [2] that an ideal book should be characterized by beauty of harmony and contrast. Harmony satisfies readers' spiritual needs, while contrast provides a stage for reading pleasure that combines vision, touch and hearing, smell, and taste. In conclusion, it can give you wings of imagination. The introduction of AR technology has made it possible to visualize this concept in picture books.

2.3 Python-based implementation of human-computer interaction for children's picture books

Human-computer interaction is an important approach to promoting readers' immersive reading experience. The implementation of AR-empowered picture books is based on the Opencv library of python to capture the content of picture books, thus realizing human-computer interaction. The specific code is as follows:

(1) Capture camera

```
cap = cv2.VideoCapture("C:/Users/lenovo/Videos/wgs.mp4")

while (True):

    ret, frame = cap.read() key = cv2.waitKey(50) & 0xFF

    if key == ord('q'):

     break

cap.release()

cv2.destroyAllWindows()
```

(2) Picture book information detection

It includes mixed Gaussian, Bayesian, and ellipse models. Based on statistical data, it can map this information to YCrCb space, a two-dimensional space, in which these pixels are distributed to form an ellipse. After obtaining the ellipse, we only need to determine whether the coordinates (Cr, Cb) are within the ellipse. If it is within the ellipse, it can be judged as a pixel point; otherwise, it is a non-pixel point. The specific code is as follows:

```
def A(img):


    YCrCb = cv2.cvtColor(img,
cv2.COLOR_BGR2YCR_CB)

    (y,cr,cb) = cv2.split(YCrCb) #Split Y, Cr, and Cb

    cr1 = cv2.GaussianBlur(cr, (5,5), 0)

    _, skin = cv2.threshold(cr1, 0, 255,
cv2.THRESH_BINARY + cv2.THRESH_OTSU) res =
cv2.bitwise_and (img,img, mask = skin)

    return res
```

(3) Contour processing

Model training can be performed through data during the interaction process, and meanwhile, effective feature parameters are selected, so that the neural network can be matched with an appropriate decision tree to establish a recognition model. It is necessary to compare the functions because the collected position parameters are characterized by high precision.

k1: The object of SimpleOnGestureListener can be passed in through GestureDetector, so that GestureDetector can process different picture book content.

k2: Create a Listener to monitor the current panel operation in real time; on initialization, match the Listener instance with the current GestureDetector instance; and use onTouchEvent as the entry detection to pass the MotionEvent parameter.

k3: Use cv2.findContours and cv2.drawContours for contour processing. Various contours are required in the picture book capture, and the Sorted function is used to find the largest contour.

To determine the content capture function, experiments were carried out for three different capture functions. The following is the accuracy comparison of three experiments performed on k1, k2, and k3 (see Figure 2):
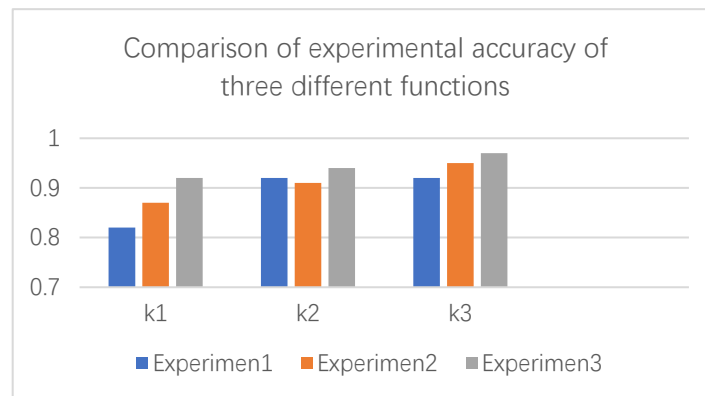

Figure 2 Accuracy comparison of k1, k2, and k3

It can be seen that when interacting with the content of the picture book, the accuracy of k3 is highest, so cv2.findContours and cv2.drawContours are selected for outer contour processing.

Meanwhile, a variety of contours are required in the book capture, and the Sorted function is used to find the largest contour. The specific code is as follows:

```
def B(img):


    #binaryimg = cv2.Canny(Laplacian, 50, 200)

    h = cv2.findContours (img,
cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_NONE)

    contour = h[0]

    contour = sorted (contour, key = cv2.contourArea,
reverse=True)

    #contourmax = contour[0][:, 0, :]

    bg = np.ones(dst.shape, np.uint8) *255

    ret = cv2.drawContours(bg,contour[0],-
1,(0,0,0),3)

    return ret
```

3. MARKET STATUS OF AR-EMPOWERED PICTURE BOOKS

AR-empowered picture books have attracted the attention of many readers as soon as they came out, but they also face many problems and challenges in the marketing

3.1 Application form of AR technology in picture books being limited

AR-empowered picture books can integrate reading, watching, listening, and playing, but the current picture books lack innovation and technical potential, in addition to limited available products. The themes of AR-empowered picture books often focus on popular science, In particular, dinosaurs and science and technology topics are mostly popular (as shown in Table 1，The data comes from the real-time retrieval of Dangdang Bookstore's official website in June 2022), which makes the content production and interaction methods of picture books very limited.

Table 1: Dangdang Bookstore AR picture book sales list TOP20

List	AR picture book bestseller list product name	Theme
1.	How the Subway is Built, Operated and Designed (3 volumes in total)	Metro-related science knowledge
2.	Getting Closer to Math: The Secrets of Time Travel	Mathematical knowledge
3.	Penguin Mengmeng AR Pillowside Fairy Tale Picture Book (10 volumes in total)	Fairy tales
4.	Chinese Idiom Story (Phonetic AR Teaching Edition)	Idiom story
5.	Wandering Earth	Cosmic science picture book (adapted from the movie)
6.	Close to Math: The Wonderful Time Travel	Mathematical knowledge
7.	Red Glory: The Special Mission of Soldier Shunliu	Historical story
8.	Cute Chicken Squad AR Story Picture Book	Fairy tales
9.	Dinosaur Survival Adventure	Dinosaur science picture book
10.	Chicken Ball Growth Picture Book Series(6 volumes in total)	Fairy tales
11.	Little Dinosaurs Grow Up（Series Picture Books）	Dinosaur science picture book
12.	Abuke's Stereo Notes: Exploring Aerospace Technology	Science and Technology Picture Books
13.	Lida Xing's Dinosaur Science Picture Book Series for Children(4 volumes in total)	Dinosaur science picture book

14.	Abuk's Stereo Note: Exploring the Mysteries of Weapons	Science and Technology Picture Books
15.	Dinosaur Survival Adventure (Series Picture Books)	Dinosaur science picture book
16.	Little Ant 4D Magic Picture Book (15 volumes in total)	Anti-abduction education picture book
17.	Abuke's Stereo Note Series - Second Series (7 volumes in total)	Science and Technology Picture Books
18.	Demystifying the Sea World	Marine life science picture book
19.	Engineering Vehicles That Build Buildings	Construction machinery popular science picture book
20.	Flying Dragon Brothers Adventures	Adventure story

As far as picture book content production is concerned, there are two main forms of AR technology implementation in picture books currently on the market. The first is to convert the graphic content such as pictures, text, and colors in the picture book into visual digital information by scanning the identification mark on it, which is then projected to the picture book. Meanwhile, dynamic information, such as audio sound effects and video animation, is loaded to achieve the combination of static and dynamic images. The second is to load a three-dimensional model after scanning the logo on the picture book to achieve an immersive reading experience through physical simulation technology. The AR information of the former is the same as the content of the corresponding paper book, resulting in a lack of complementary information and novelty, which may easily cause readers to abandon AR-empowered books. Although the latter uses three-dimensional and all-round virtual images to present abstract scientific concepts or data intuitively and perceptually, thus producing an amazing reading experience at the beginning, the current AR-empowered picture books have certain shortcomings in the artistic quality, unity of design, only having part of the content to be displayed delicately, and most virtual scene models being not detailed enough to attract readers' attention for a long time.

As for the interactive experience, some AR-empowered picture books only convert the graphics of paper picture books into digital graphics buttons. Although others can achieve 360-degree observation, zoom operation, and simple interaction for the virtual house through the touch screen, the breadth and depth of the application of AR technology still need to be explored.

3.2 High cost, insufficient promotion, and low penetration rate of AR-empowered picture books

Although AR-empowered picture books have prominent features and obvious advantages, their popularity is relatively low due to the high cost. As Neil Postman said, "Each technology is double-edged, namely the product of a combination of pros and cons." [3] On the one hand, developing AR technology products requires a lot of scientific research and experimental demonstrations, increasing the cost of relevant funding. On the other hand, Playing with AR-empowered picture books need complicated equipment, thus increasing the reading cost. Besides, there is a certain gap in the acceptance of AR-empowered picture books, due to differences in regional development and family economic ability.

The reasons why the market penetration rate of AR-empowered picture books is generally low include, in addition to the cost, insufficient promotion and publicity coverage, which led to consumers' lack of understanding of digital picture books and consequently their unwillingness to purchase them. The concept of immersive experience and interactive reading is still far from the consumption vision of most families, and readers do not know at all or have a little understanding of its technical advantages, operation methods, and reading experience, thus failing to make them form consumption desires.

4. DEVELOPMENT STRATEGY FOR AR-EMPOWERED PICTURE BOOKS

4.1 Actively promoting R&D of digital technology and enriching its application as well

The development of AR-empowered picture books relies on further R&D of relevant technology, and it also should focus on expanding the application scope and methods of existing technologies. On the one hand, it is necessary to explore the application depth and breadth of existing digital technology, expand the theme of picture book design, and increase the radiation scope of digital technology. On the other hand, it is urgent to follow the development of AR technology, stick to innovation, increase the scientific research investment in AR-empowered picture books, and actively promote the development of picture books with the application of new technologies. The development of AR technology provides a strong guarantee for the interactive design of picture books. The high speed, low latency, and stable transmission of 5G networks make it possible to upgrade the interactive mode. Interaction design has changed gradually from traditional command interaction and Graphical User Interaction (GUI) to the emerging Natural User Interface (NUI). The new AR interaction design concept attempts to reduce users' learning burden caused by interface operation, and break away from the constraints of input devices by realizing 'natural interaction' with the system through a combination of voice, gestures, eyes, and other approaches.

4.2 Internet data strengthening audience participation and optimizing picture book creation

The easy access to the Internet has provided the public with the necessary technical support for participation in reading evaluation, thus narrowing the distance between publishing institutions, picture book authors, and readers. As Professor Yu Guoming of Renmin University of China said, "The public is now using the massive information in the era of big data to re-aggregate and mine value of data and information, and focusing on the integration of knowledge, innovation, and judgment, which reflects the change from solving problems to creating content." [1] Readers now can evaluate picture books through online purchasing platforms, picture book reading APPs, or other channels. Particularly, data such as the sales volume, evaluation numbers, and the keywords contained in a book directly reflect readers' reading experience, which is critical for publishing institutions and picture book creators to make corresponding adjustments promptly, optimize the quality of picture books, and timely launch AR-empowered picture books that meet market demand.

4.3 Process neural network monitoring market demand

Promoting the development of AR-empowered picture books relies not only on technical application and artistic creation but also on the timely grasping of market preferences and forecasting of market demand. Process neural network is established by extending the traditional neural network model to the time domain, The difference from traditional neurons is that the inputs and weights of process neurons can be time-varying, that is, they can be time-dependent functions. [4] This reflects the cumulative effect of continuous input over a period of time. Therefore, we can accurately predict the trend of market demand by combining the process neural network with the market conditions of AR-empowered picture books. The introduction of a process neural network is critical to predicting market demand effectively and adjusting market planning promptly accordingly.

5. CONCLUSION

The application of AR technology to picture books has brought a new reading experience to children. However, there is still a long way to go before ushering in the prosperity of AR-empowered picture books. The principal missions include innovation of concepts, development of a variety of products, enhancing the fun and artistry of picture books, and predicting market demand effectively.

FUND PROJECT

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