Chapter 5
Use of Digital Holography to Re-Encode and Image Chinese Movable Type Printing

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Abstract In the long history of the development of civilization, Chinese movable type printing has played a pivotal role for disseminating information and it can be seen as the ancestor of the modern information age. From traditional engraving to type, from clay to lead type, from laser printing to 3D holographic printing, the techniques of encoding have been gradually developed and recorded, and these printed texts convey the progress of mankind. A brief introduction to encoding in the context of Chinese cultural communication is presented and, specifically, the role of encoding will be explored. In addition, digital holographic printing is introduced as a new approach and new medium to explore the enlightenment conferred by Chinese movable type printing on today's society and especially the information revolution. Further, the future of encoding through the advanced technology of digital holographic printing is discussed. Two holographic artworks are presented to illustrate the principles expounded and the response to their display in national museums discussed.

5.1 Chinese Movable Type Printing

5.1.1 Introduction to Chinese Movable Type Printing

The invention of Chinese movable type is a remarkable milestone in the history of printing, as it ushered in a new printing era, well before the well-known developments in Europe. Chinese movable type printing has been used for nearly one thousand years and greatly promoted the development and exchange of world culture; in addition,

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it contributed to the historical progression of world civilization [1]. Movable type involves making individual movable characters in advance, which can then be chosen according to the manuscript, arranged in line on plates and finally printed on paper. All of the movable characters may be used repeatedly, as each of them can be separated and rearranged.

According to historical records from the ancient book MengXiBiTan [1] (see Appendix), Chinese movable type originated in the Qingli period (1041–1048 CE), during the Song Dynasty, with clay movable type characters invented by Bi Sheng (Fig. 5.1) [2]. It should be noted that this was around 400 years before the introduction of movable type in Europe by Gutenberg [3]. Later, with the progress of technology, movable type characters made of wood, tin, lead, copper, and further derivatives appeared [4]. Figure 5.2 shows the Uighur wood movable type examples which were found in cave sediments of the northern Dunhuang area of China in 1908: these were the earliest surviving examples of wood movable type in the world [5].

The invention of Chinese movable type printing enabled the simplification of the process of printing plate creation, reducing labor requirements, and improving production efficiency. However, Chinese movable type printing did not immediately replace engraving-type printing until the Qing Dynasty, when the government began to promote text-based cultural transmission. After this, the number of movable type books greatly increased. Printing techniques also varied, as the Qing government directly organized human labor and material resources to support the development.

Fig. 5.1 Replica of clay movable type characters based on Beisheng's technology, in the Chinese Printing Museum

Fig. 5.2 Uighur wood movable type examples, as found in 1908

For instance, during the Yongzheng period in the Qing Dynasty, copper movable type was used to complete as many as 160 million words on the integration of ancient and modern books [6] (Fig. 5.3). Further, in the Qianlong period, wooden movable type was used to print several thousand volumes of the Hall of Martial Valor book [6] (Fig. 5.4). Government participation was central in promoting the application of movable type and cultural communication with other countries.

Today, movable type, embracing many of the ideas of the ancients, still has great value. Its most valuable point is its encapsulation of creative ideas, that is, the transfer of whole-plate engraving printing into individual units, whether phrases or characters. In today's language, this may be called a code, symbol, or material carrier. This idea, in computer typesetting, is widely accepted as a general principle, which drives forward modern printing techniques [5]. Moreover, movable type printing is still popular among Chinese people.
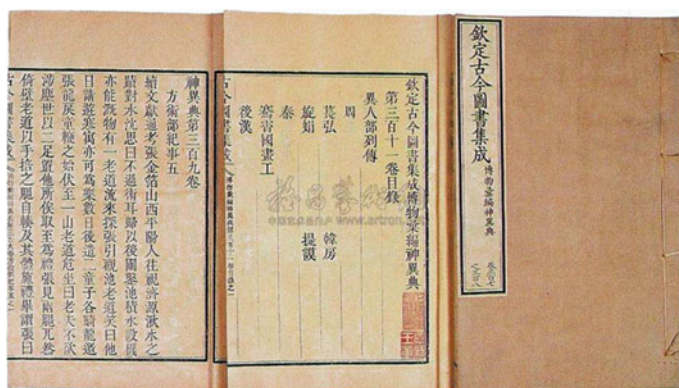

Fig. 5.3 The reference book—Qingding Ancient and Modern Integration

Fig. 5.4 The book—Hall of Martial Valor (Wuyingdian), one of the largest quantity of books produced by wooden movable type printing in China

5.1.2 The Influence of Chinese Movable Type Technology in the Wider World

Movable type was introduced into Korea not long after Bi Sheng invented it during the Song Dynasty. The original reason for using such an innovative printing technique in Korea was that Buddhist scriptures and Confucian classics imported from China were in short supply. In the beginning, Korea used ceramic movable type characters, but they were made in different sizes and this led to unsatisfactory printing quality until the Goryeo Dynasty, when copper movable type was gradually developed, which not only enhanced cultural identity between the two countries, but also promoted a new development of Asian culture [7].

After the invention of Chinese movable type printing, Japan adopted the technique, mainly using wooden movable type printing characters to produce Buddhist scriptures for use among monks. A large number of Japanese books were printed, including the Japanese scripts modeled on Chinese cursive script [8]. Movable type printing was a major turning point during the process of social development as it improved the efficiency of mass book production and greatly promoted the dissemination of scientific, technical, and cultural knowledge. The spread of knowledge expanded from the aristocratic classes to the general population [8].

Vietnam commenced the use of movable type around 1841–1847 when the Vietnamese Dynasty bought a pair of Chinese wooden movable type sets and printed a large number of national legal books with it. This can be seen as the direct manifestation of Chinese type printing in Vietnam [7].

Besides Korea, Japan, and Vietnam, Chinese movable type printing also had a great influence on nations in other countries. In particular, Christian books in the Philippines were originally made by the ethnic Chinese people in local printing presses;

however, after 1608, the Filipinos set up their own printing houses. In addition, Iran was a transit station on trade routes, facilitating the introduction of China's printing technology into Europe and hence making great contributions to the westward spread of the technology [6].

Europeans' first contact with Chinese printing began in the Yuan Dynasty (1271–1368 CE), with the paper money brought by European businessmen and travelers returning from China [7]. Around 1450, A German inventor, Johannes Gutenberg, derived inspiration for a form of movable type printing from the technology of wine pressing machines [3]. Although this was more than four hundred years after Bi Sheng's invention, the European movable type printing techniques introduced significant progress in the use of fatty ink, movable type made of lead, etc. Its mechanical printing technology laid the foundation for modern printing. These machines greatly increased the speed of production and promoted the formation and dissemination of new ideas: this became the driving force of modern civilization, and advanced the modernization of European society.

5.2 Encoding in the Context of Chinese Cultural Communication

5.2.1 Re-Definition of Encoding Concepts

Encoding in semiotics can be interpreted as the process of creating a message transmission from an addresser to an addressee [9]; in psychology, encoding can be interpreted as the process of entering the memory system, storing, and subsequently retrieving [10]; in computers, encoding can be interpreted as the process of efficiently transferring or storing a sequence of characters (letters, numbers, punctuation, and symbols) into a professional format. In the book "Encoding and Decoding in the Context of Television Discourse," by contemporary cultural researcher Stuart Hall, encoding is interpreted as meaning production of a media message and this plays an important part in cultural communication, and similar processes [11]. Based on these concepts, encoding is a specific process and has different definitions in different discipline areas.

The present work attempted to identify the encoding of movable type printing in the context of Chinese cultural communication, hence encoding is defined for the present purpose as a transferring process from one role to another during the historical development of China's movable type printing. In a physical view, movable type printing breaks the earlier whole-plate engraving printing into individual units and this may happen during the processes of deconstructing phrases or words. In the psychological view, movable type printing evolves from transmitter to protector of information (in cultural context), and from protector to inheritor.

5.2.2   The Role of Enlightenment

The appearance of words can be regarded as the gestation phase of encoding. The invention of words was a great advancement for human civilization. In primitive ages in China, humans tied a number of different knots or different shapes of knots on ropes to express specific meanings: the so-called knot note (Fig. 5.5). Afterward, ancient humans portrayed certain things on stones and stone walls to convey certain meanings. This kind of pictogram directly gave birth to the origin of human writing: the archeological discoveries of ancient Egyptian hieroglyphic characters, Sumerian cuneiform characters, Chinese characters, and similar are all such.

Chinese characters have a long history, but the exact time of their emergence is still a historical mystery [5]. Judging from the archeological findings, the Oracle script system was fully developed in the Shang Dynasty, around 3500 years ago. Chinese characters are ideograms whose form and meaning are closely connected. Early characters were of pictographic form: with such a glyph, people could easily know what it stood for.

The usage of Chinese characters is closely linked with their transmission medium, but there were some limitations for expedient information transmission [12], for instance, scattered oracle bones were composed of animal bones with engraved symbols (Fig. 5.6); bronze inscriptions were heavy and difficult to move (Fig. 5.7); the words on bamboo slips were hard to modify (Fig. 5.8); silk as a writing substrate was expensive and susceptible to be eaten by insects (Fig. 5.9). The invention of paper was convenient for text recording, but it was not able to change the transmission mode of manual copying and thus still constrained the efficiency of transmission. Until the invention of whole-plate engraving printing, information could not be spread widely. Compared with manual copying, engraving printing had great advantages in saving time and improving efficiency, but it also had shortcomings: it was very costly as each version of the text required creation of a new set of plates. However, with the invention of movable type printing, whole-plate engraving printing was divided
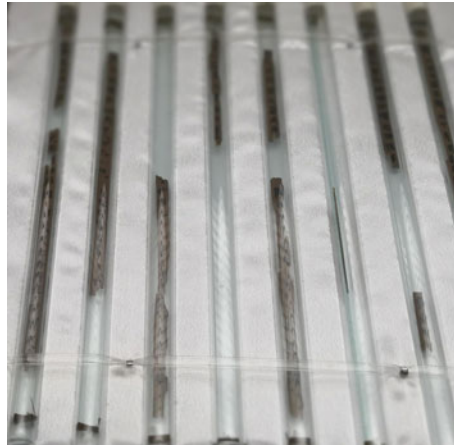

Fig. 5.5 An example display of a knot note

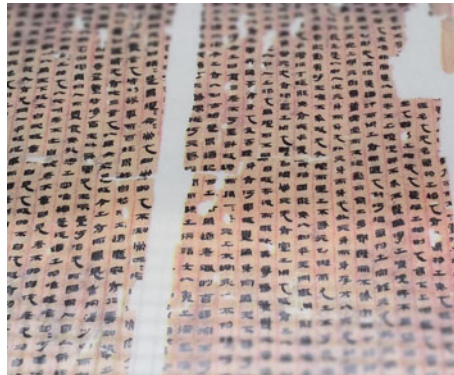**Fig. 5.6** Oracle bone with inscription in the China Printing Museum (late 2nd millennium BCE)

Fig. 5.7 Bronze tripod bowl cast for Duke Mao during the King Xuan period of the western Zhou Dynasty (828 BC–782 BCE): the vessel has 497 characters in 32 lines. (China Printing Museum display)

Fig. 5.8 Words on bamboo slips in China Printing Museum (140–110 BCE)

Fig. 5.9 Lao Zi silk manuscripts in the China Printing Museum, dated around 2000 years ago

into separate re-usable units, overcoming many of the above problems and starting widespread information transmission.

5.2.3 The Role of Encoding

With the development of information dissemination, the role of encoding evolved from transmitter to protector then to inheritor, or in a global view it can be considered as a navigator, directed toward civilization.

Whether as whole-plate engraving or movable type printing, the most obvious role at the beginning is as the information transmitter. In this process, information is

transferred from one form or format to another. It is also a medium for a communicator to translate its message or meaning into languages, images, symbols, and so on. In view of relationship between language and literacy, printing provides a platform for converting spoken language into written language, which promotes the development of language, especially the development of written language in the Chinese literary and grammar frameworks. Considering the relationship between written language and communication efficiency, movable type printing provides an acceleration effect, and a new language experience can be built on its platform. This process of evolution with experience is also a role of the transmitter. In other words, the transmitter influences the efficiency improvement between language and literacy.

If the transmitter only transmits information and lacks cultural connotation, it cannot assist in advancing human civilization. Therefore, during the encoding process, the dominant role is held by the transmitter while the recessive role is that of the culture protector. In ancient times, the advancement derived from printing could be identified with history, religion, politics, military matters, and many other issues where printing had important historical and cultural values. The role of protector is crucial in the transfer process, for instance there are still preserved the Vajra cchedikā Prajñā Pāramitā (in English: The Diamond Sutra) (Fig. 5.10) based on engraving printing. This was made in the Tang Dynasty (868 CE), while the encyclopedia MengXiBiTan [1] (see Appendix), based on movable type printing, was written in the Northern Song Dynasty (written c. 1086–1093 CE) [6]. There can be little doubt that the ancient imperial system also contributed in establishing special rules and orders for specific cultural preservation.

Protection aims at re-dissemination and then assured inheritance. As the foundation of modern printing, movable type printing is the basis of pre-digital era printing technology (digital printing can be argued to be closely connected—see Sect. 3.1).
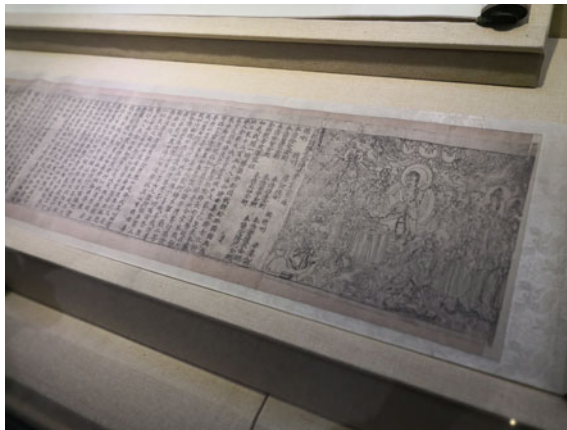
Fig. 5.10 Vajra Cchedikā Prajñā Pāramitā (The Diamond Sutra), printed in the Tang dynasty: this is a well-preserved piece with the name of the carving master and the year of carving (868 CE), it was discovered in the cave of Dunhuang in 1900. The picture on display is of a replica

Fig. 5.11 Brush pressing by a local craftsman onto wooden movable printing type in the Rui'an area of Zhejiang Province

Here, another role of encoding is linked to deep ethnic cultural conventions. For instance, wood type printing was derived from the custom of renewing genealogy records, especially in the southern part of Zhejiang Province, China: the clan concept of root-seeking remains quite strong there. Every clan's family tree is renewed every 12 years or so. Figure 5.11 shows the use of wooden movable type printing in the Rui'an area of Zhejiang Province. In the wider view of communication theory, the expansion of social and cultural communication has promoted the popularization of education and the exchange of knowledge. Additionally, mass production of printed books increases the chances of book retention, reduces the possibility of handwritten copies becoming extinct due to limited collections, and has a huge positive influence on cultural heritage.

Looking at the role of movable type printing in the history of civilization, it has always guided humans toward civilized societies. As a driver of social progress, movable type printing has effects on almost every aspect of modern civilization. Due to its roles as transmitter, protector, and inheritor, new ideas are quickly disseminated and popularized, and speculative thoughts are promoted.

5.3 Digital Holographic Printing

5.3.1 Modern Digital Printing

The rise of computer-mediated printing has caused a radical change in printing technologies, although this did not happen immediately. For many years the standard computer printers were the line printer and the electric typewriter, both of which

used metallic characters of a similar form to movable type, although not assembled in the same way as in a printing press: the daisy wheel printer can be said to be similar. Toward the end of the twentieth century, however, raster-based printers (e.g., laser and inkjet) became common and now totally dominate the market. These do not use hardware type characters in the same way as the earlier technologies, but the philosophical difference is not so great, since they store a vast range of characters in software, made available to the user as "fonts", exactly mimicking the jargon of the traditional movable type printing technician. The fundamental point here is that human readers have become completely attuned to the use of discrete characters, as established by movable type, and the raster-based systems have to display text in the same way for it to be meaningful.

A more radical difference with this technology is the ease of inclusion of illustrations, as these can be printed with exactly the same raster technology.

5.3.2 Digital Holographic Printing

Holograms can represent objects and scenes in three dimensions without the need for special viewing glasses. Computer-generated or computer-mediated holograms are intrinsically digital and hence also have a raster structure, but in three dimensions, hence the two-dimensional raster pixels are replaced by three-dimensional voxels in the software. However, the hologram is a two-dimensional object which contains the three-dimensional information. This means that a different implementation of raster pixels is required. Thus digital holographic printing is composed of a matrix of holographic pixels, also termed holopixels or hogels. Holopixels are created by the interference of three-color lasers in a holographic medium, such as a photopolymer or silver halide film.

A digital printed hologram can visually represent an object in a realistic way and it also can be a creative medium to re-interpret the object in a narrative way. In addition, digital holograms can be duplicated repeatedly through a digital holographic printer.

A digital holographic printer includes several components, such as the data source, tri-color lasers, a spatial light modulator (SLM), beam-steering optics, and a computer to show the images on the SLM and to control the whole system. The data sources should include a selection of resources, such as general artwork and illustrations, photographs taken by people, or digital imagery produced by software such as Maya, Sketch-up, 3D Studio Max, point clouds, and laser scans. The laser-writing scheme utilizes an object and reference beam pair. The object beam is modulated through the SLM using two-dimensional (2D) information synthesized from a scene.

Digital holographic printing as an artistic medium has been practically developed and applied in cultural presentations. For example, Fig. 5.12 shows a holographic artwork created by author Shuo Wang: in this artwork, the digital printed hologram, as an innovative medium, not only enables the viewer to recover an archeological excavation space as it appeared in 1980, and to have a realistic spatial visualization of it, but also the losses of archeological detail owing to the difficulties of conditions

Fig. 5.12 Digital holographic artwork representing a reconstruction of an archeological scene, by Shuo Wang

at that time could be bridged, bringing a profound influence upon archeological, historical, geological, and artistic representation of the priceless cultural relics that were recovered [12].

5.3.3 The Evolution of Chinese Movable Type Printing to Digital Holographic Printing

Understanding the past is an essential component for projecting developments in the future. Chinese movable type printing has developed in the course of its historical changes. The process has been complex and diverse with both positive and negative aspects, which are closely related to the social system, philosophies, aesthetics, and humanity of Chinese society in the context of historical development at the time [13]. With the initiation of the modern information age, the rise of digital holographic printing also needs to be explored in the context of today. Since the development of digital holographic printing and movable type printing occurred in very different historical periods, it is hard to compare them. However, if they are regarded as transmission media and linked in their aspect as information carriers with their respective medium characteristics, then they appear to have some similarities in particular periods in their history. Thus, some comparisons and suggestions of similarities may be attempted:

On the positive side:

1. They both are carriers of information, that is, media.
2. In different historical periods, both movable type printing and digital holographic printing have provided a new information dissemination platform for societies and have promoted language development globally. Compared to movable type

printing, digital holography carries more information or data and has the potential for the inclusion of highly realistic graphics.

3. Both movable type printing and digital holographic printing have opened up a new mode of information transmission in their respective times. With the development of movable type printing, efficient replication using various materials has been created; digital holographic printing will also replicate with more materials in the future, not be limited to glass and photopolymer, but the digital generation of characters gives infinite scope to replicate not only the entire Chinese alphabet, but characters from other languages, mathematical symbols and new, fictitious, creations.

On the negative side, neither of them has had a great speed of popularization. Chinese movable type printing was invented in the Song Dynasty but it was not widely used to replace engraving printing, which required intensive labor [4]. Currently, digital holographic printing is not widely used either. The main reasons are as follows:

1. From the perspective of aesthetics, Chinese scholars advocated the beauty of carving, so, movable type printing was not rapidly developed after engraving printing [14]. Similarly, the digital printed hologram is not at present as realistic as the traditional analogue hologram, and it cannot provide the same beauty and verisimilitude. This deficiency is expected to disappear as holopixel resolution increases.
2. From the perspective of the development period, after the invention of engraving printing, people constantly improved its technology. In the Song Dynasty, it was the golden era of engraving printing when Bi Sheng invented movable type printing [1]. Digital holographic printing also seems to have its rival technologies, such as head-mounted virtual reality displays, but the usage scenarios for these are very different.
3. From the perspective of economics, due to the features of Chinese characters, it is difficult for ordinary people to invest in the necessary labor and material resources (excepting the very wealthy) as it is very costly for one-time use. Before the emergence of movable type printing, there were numerous engraving workers. Because of that, the cost of engraving printing was lowered, but the cost of movable type printing was effectively increased. At present, it costs a great deal in time and money to produce a digital printed hologram, and digital holographic printers are at present very rare.
4. From the perspective of media-use habits, after movable type printing was invented, handwritten and engraved books were still generally used at that time. Now digital color printers and 3D display monitors are also competitors for digital holographic printing.

5.4 The Exploration of Encoding in the Future

The encoding of digital holographic printing can be seen as paralleled by movable type printing in some cases. In view of the medium features and advanced applications, digital holographic printing will also experience the roles of transmitter, protector, and inheritor. However, due to the rapid growth of information and the diversification of information media, digital holographic encoding ideally needs to be combined with artificial intelligence, so as to optimize it. For example, throughout the whole process of digital holographic modeling, this process can be performed with a large number of databases based on people's creative ideas, functioning as a replacement of manual modeling, improving the models, material, lighting, rendering and other steps, and designing the frame narrative through smart thinking. During the printing process, smart devices can hasten transmission speed, shorten printing time, and achieve efficient replication.

5.5 Artistic Works

5.5.1 Three Manifestations of a Chinese Movable Type Text

Based on the research on encoding of movable type printing, as well as the relationship between movable type printing and holographic printing from the perspective of media analysis, an artwork entitled "CUBES" was created to further explore the different roles in the future. The name "CUBES" involves two levels of significance: the straightforward meaning is descriptive of the artwork represented by different pieces in the form of small cubes; secondly, CUBES is an acronym, meaning "CUlture Broadly Encoding Spreading". The work was reproduced in the form of collocated wooden movable type, 3D printed movable type and holographic movable type, and the record of movable type printing in MengXiBiTan [1] was taken as the content (see Appendix). This follows the philosophy of the four "RE" creation methods (Re-definition, Re-creation, Re-construction, and Re-presentation) devized by author Shuo Wang [12], as well as holographic montage ideas. Each individual text component has been created in the 3D software: initially, the length, width, and height of the components have been calculated based on the wooden texts; furthermore, the polygonal modeling method follows the style of Chinese wooden engraving and the corresponding writing style, Fig. 5.13 shows holographic modeling of the content of MengXiBiTan and Fig. 5.14 shows the holographic rendering result, which simulates the effect of Chinese wooden engraving.
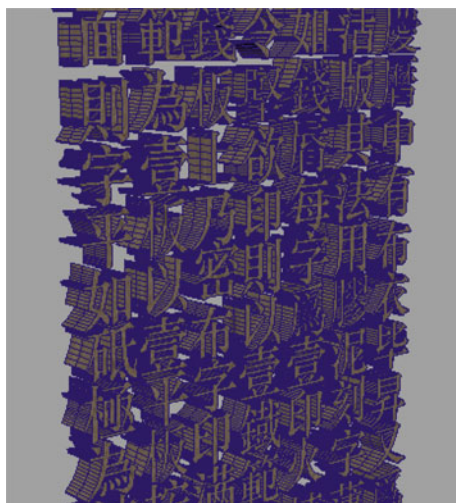
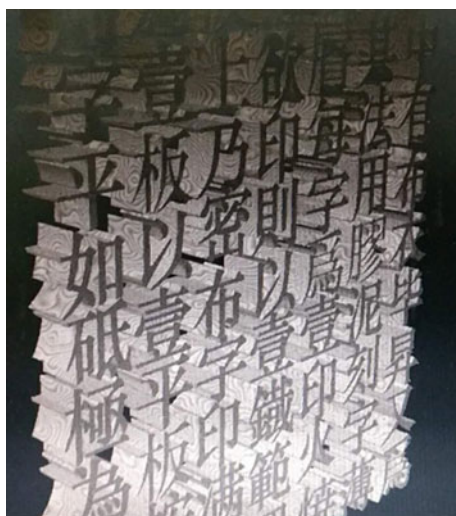**Fig. 5.13** The "CUBES" artwork: holographic modeling in Maya

Fig. 5.14 The "CUBES" artwork: rendering effect in Maya

5.5.2 Four Manifestations of Chinese Movable Type in a Hybrid Timeline

This artwork (Figs. 5.15 and 5.16) explores the different roles in the context of encoding. In addition, digital holographic printing was used as a new approach and
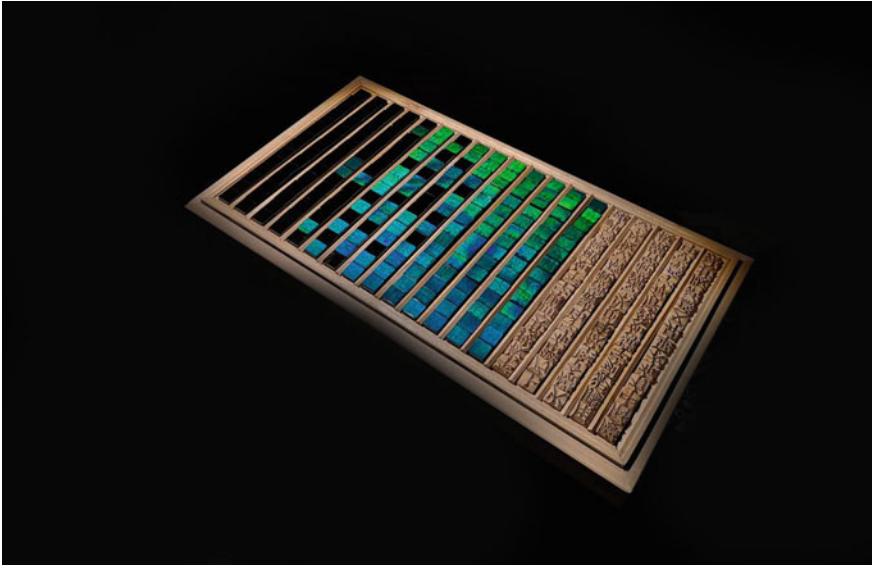
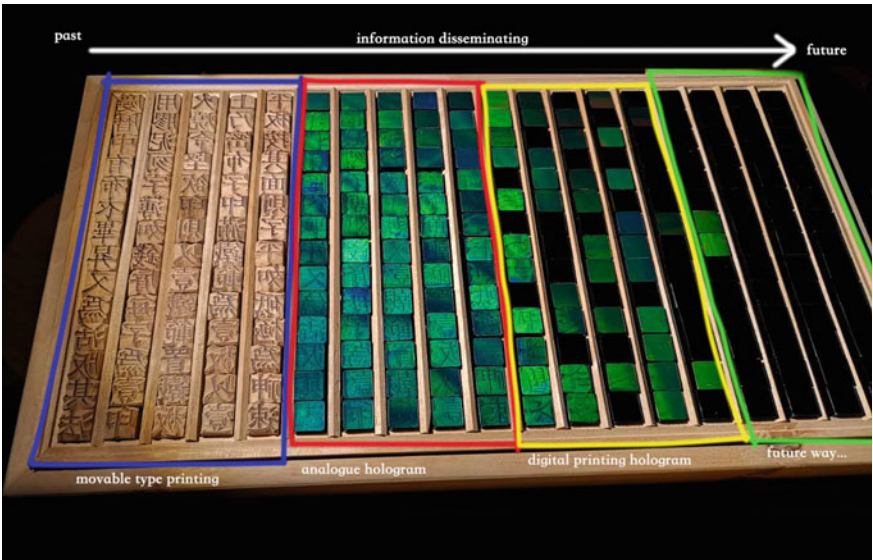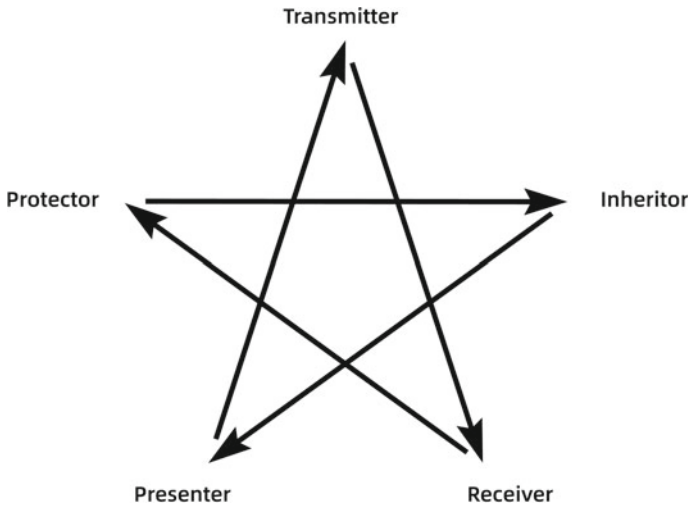**Fig. 5.15** Artwork: Hybrid Plate as a timeline

Fig. 5.16 Interpretation of this artwork

**Fig. 5.17**   The psychological and philosophical view of encoding

new medium to explore the enlightenment conferred by Chinese movable type printing on today's information revolution. This artwork consisted of a wooden plate and 266 individual blocks, including wooden movable type blocks, analogue holographic blocks, digital holographic blocks, and black blocks, these four parts (Fig. 5.2) briefly present a timeline of the information dissemination from ancient times to the future.

In creating this work, the author Wang assumed two roles/identities in the creation process: information receiver and information presenter. Furthermore, he attempted to explore the relationships among transmitter, receiver, presenter, protector, and inheritor to address the psychological and philosophical views of encoding (Fig. 5.17).

Considered as a receiver, the information received was drawn from the content of the "Ancient Chinese Wikipedia"—MengXiBiTan [1], In the process of receiving the information, the whole content has been summarized into 70 characters, and the these characters have been engraved into wooden blocks, based on the traditional method of Chinese wooden engraving: this aims to present the ancient method of information transmission for audiences.

Considered as a presenter, two approaches have been explored, based on the medium characteristics of analogue holography and digital printing holography. Initially, the 70 characters were produced using a Holo-Camera (Fig. 5.18): these holographic blocks can be seen as one of the modes of protection for wooden blocks (via substitution, since the 70 wooden blocks are considered as heritage objects); additionally, they can encapsulate the moment of creation of the wooden blocks, which provides a spatial view for audiences.

As a further insight, in the process of the digital holographic modeling, other spatial aspects of the characters can be discerned, as well as the opportunity to re-interpret the character in a narrative way. In this artwork, when each character was
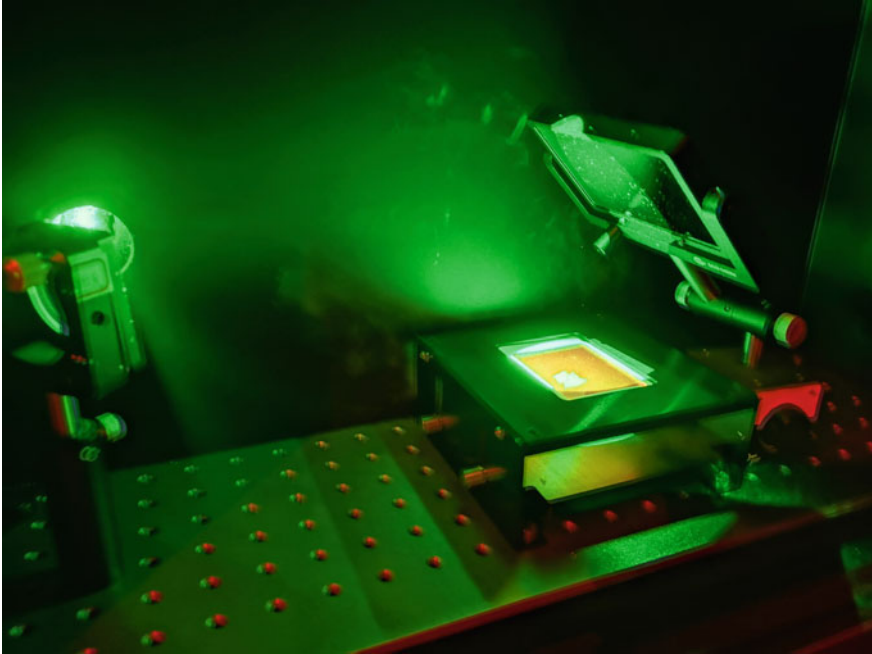
Fig. 5.18 Using a Holo-Camera to produce the analogue hologram

in the processing of being created, the structure revealed a layer of new meaning and spirit.

In such an era, facilitating the production of the hybrid printing plates, each individual block carries different dimensions of time and space, from the ancient wooden type block to the latest digital holographic blocks. Thus technology, medium, and culture have been developing together: they act the different roles in the process of information dissemination. Hence the development of printing technology and culture has always been developing in a synergistic way.

5.6 Conclusions

The historical development of Chinese movable type printing has been reviewed and its influence on the World's culture emphasized. The encoding of movable type printing has been explored and this expanded to include the evolution of Chinese movable type printing to digital holographic printing, including reinterpretations of the concept of encoding. Art works have been presented that demonstrate the coexistence of ancient movable type printing and modern digital holographic printing and the insights that can be drawn from this. The power of the holographic image has been demonstrated since, when the artwork was illuminated by the appropriate light source, virtual (holographic) character cubes, and real character cubes were combined

together, thus presenting a new form of encoded space within the culture of human communication. In addition, the artwork reflects the passage of thousands of years of historical space and time, linked through the continuity of Chinese characters. The re-encoding of Chinese movable type printing reveals that this printing technology continues to develop from the past to the future—in digital holographic forms—with the potential to inform new interpretations of human communication.

Appendix: Records of Movable Type Printing in MengXiBiTan

MengXiBiTan is a book written by Shen Kuo, a scientist in the Northern Song Dynasty. It was written around 1086–1093 (CE) and documented Shen Kuo's views and opinions in his life. It is regarded as an Encyclopedia of ancient China by western scholars, with many foreign language versions published around the world.

In the Tang Dynasty, people had not yet adopted engraving printing to print books on a large scale. In the Five Dynasties (907–960 CE), namely, the Later Liang Dynasty (907–923), the Later Tang Dynasty (923–936), the Later Jin Dynasty (936–946), the Later Han Dynasty (947–950), and the Later Zhou Dynasty (951–960), Feng Dao began to print the Five Classics with the engraving printing technique. After that, various classics and books were printed. During the Qingli period, a civilian named Bi Sheng created movable type printing. His method was to use clay to engrave characters and the thickness of each word was like the edge of copper coins. Each character was a matrix, hardened by firing. Firstly, he set up a piece of iron plate, covering it with turpentine and wax mixed with burnt paper ash. When printing, he put an iron frame on the iron plate, then arranged the word (i.e., character) matrix appropriately and closely. He filled the iron frame as one printing plate, then held it near the fire to bake; when the rosin and other bonding materials began to melt, he pressed the surface with a flat plate. In this way, the pattern on the plate was flat and smooth. If people wanted to print only two or three books, this method would not be convenient; but this method would be particularly efficient for tens or even hundreds of books. Usually two iron plates were produced while printing. One plate was used for printing and the other one for arranging the matrix. As soon as one plate finished printing, the other one would be ready to use. The process was quite fast with two plates. Each word had several matrix elements. For example, the Chinese words "之" and "也" usually had more than twenty matrix elements in case of repetitive characters in one plate. When the words were not used, they would be marked by pronunciations with paper strips. Each rhyme part was marked with a label, then stored in a wooden lattice. If an unfamiliar character was needed but unprepared, people engraved it and then grilled it with a grass fire, hence it could be made very quickly. The reason why people did not use wood to make movable type matrices was that the texture of the wood varied between sparse and dense. Once stained with water, it would expand, and easily got stuck to the frame, making it hard to remove. Thus, clay was a better choice. After the matrix was used, the coating material could be melted by fire. Wiped by hand, the matrix would fall off and not be contaminated

by coating material at all. Bi Sheng's matrices were understandably still treasured by his cousins and nephews after his death.

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