Research on Digital Cultural Heritage Expansion Using AI Technology

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***Abstract*— Since the early 2000s, the digital transformation of the National Museum of Korea has led to the creation of numerous digital data related to artifacts. When the initial digital cultural heritage data began to be accumulated, the focus was on 'recording' rather than 'public disclosure', so the data disclosed to the public was extremely small. In addition, unlike systematically managed cultural heritage, 'replicated data' in digital form is relatively unstructured in terms of creation, management, and storage. To systematize the many digital data that are piled up in a disorderly manner, a lot of manpower and cost must be invested, but there are limits to solving this with limited resources. This study proposes a standard for classifying cultural heritage data by introducing artificial intelligence technology to solve these problems, and further suggests ways to use digital data more creatively using artificial intelligence technology.**

Keywords—Digital Heritage, Artificial Intelligence, NLP, Style Transfer

I. INTRODUCTION

Digital cultural heritage refers to the research, preservation, exhibition, management, recording, and dissemination of digital cultural heritage based on cultural heritage expertise and the convergence of advanced ICT and content. Since the mid-1980s, with the spread of computers, digital heritage using digital technology has gradually gained attention, with interest in the preservation of national cultural heritage and the activation of the cultural heritage industry increasing in countries with long histories, including Europe [1].

As digital technology has developed, the world has changed, and museums have also gradually begun to introduce 'digital'. The National Museum of Korea began to create digital data from the early 2000s, but its purpose was merely to Archive. However, a few years ago, research on how to use the data that had been accumulated so far has slowly begun.

When you think of the image of a 'museum', most people would think, 'I come to see the cultural heritage displayed in a glass showcase, which were used in the old days.' There are hundreds of thousands of exhibits in the museum's storage, but it is impossible to exhibit all of them, and even if the cultural heritage is changed and exhibited, there are limits to continuously attracting new visitors. To solve these concerns, museums are creating 3D assets using precision scanners and high-pixel cameras for major cultural heritages, and are creating realistic content with these results.

- (Text data) In order to manage text data using artificial intelligence technology, it is necessary to establish a systematic classification system, and then create a corpus and recognize named entities. This paper explains this series of processes in detail in Chapter 2.
- (Image data) In line with the digital age, museums have also made efforts to secure digital data, but with the development of information and communication technology, the digital data acquired in the past is no longer the latest technology. In a situation where a lot of manpower is needed to re-photograph the cultural heritage in the storage, we explore how to use the existing data using artificial intelligence technology. In addition, the National Museum of Korea is continuously developing elements that can attract the interest of online visitors. One of these elements is the development of technology that can style transfer cultural heritage images to suit the tastes of visitors using artificial intelligence technology, and this process is explained in Chapter 3.

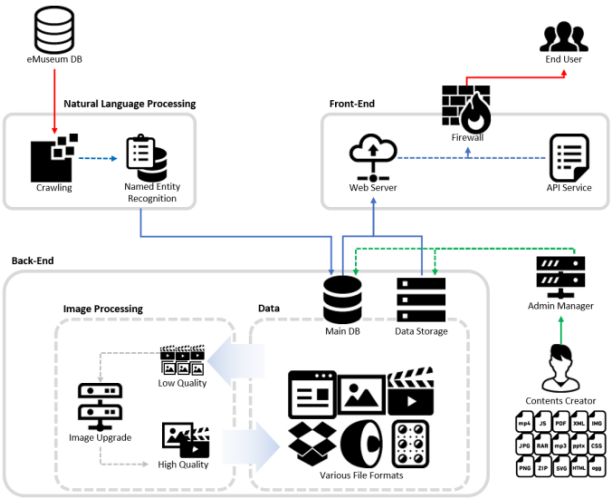

Fig. 1. System Diagram

II. NATURAL LANGUAGE PROCESSING

With the advancement of artificial intelligence, language models in natural language processing are one of the foundational technologies that are attracting attention in many fields and are being used in various areas. However, because most of the current research is centered on modern languages, there were problems with the results of artificial intelligence being too low to directly apply the existing algorithms and datasets to the museum system. Therefore, there was a need to create a new corpus centered on the professional language used in museums, and it is possible to improve the performance of the model by building a dataset trained on a language model based on cultural heritage [2].

In order to understand the stylistic characteristics of sentences specialized in traditional culture and the complex understanding of the language, it is necessary to build learning data, and fine-tuning for more accurate named entity

recognition is needed. Building a corpus reflecting the characteristics of cultural heritage is an effective method to improve the performance of Natural Language Processing using artificial intelligence technology, but so far there has been no Korean corpus specialized in cultural heritage, so we tried to build it anew. For this, the process of "Define a Word → Annotation Tool → Build Corpus → Named Entity Recognition" was performed [3].

A. Define a Word

Before building a corpus, the attributes of words must be defined. For this, we referred to the "Building entity name analysis corpus" published by the National Institute of Korean Language and conducted a classification work into 10 major categories and 94 subcategories through discussions with curators of the National Museum of Korea and experts in related industries [4].

TABLE I. DEFINE A WORD

No	Major Categories	Sub Categories
1	Person(PS)	ps_name, ps_mythical figure, ps_position, ps_noun
2	Location(LC)	lc_others, lcp_country, lcp_province, lcp_county, lcp_city, lcp_capitalcity, lcg_river, lcg_ocean, lcg_bay, lcg_mountaion, lcg_island, lcg_continent, lc_space
3	Artifacts(AF)	af_building, af_musical_instrument, af_road, af_weapon, af_transport, af_works, af_painting, af_documents, af_craft, af_monument, af_relic, af_intangible_heritage, af_pagoda, af_historical_sites
4	Civilization(CV)	cv_name, cv_tribe, cv_sports, cv_sports_inst, cv_policy, cv_tax, cv_law, cv_building_type, cv_clothing, cv_food_style, cv_food, cv_drink, cv_currency, cv_language, cv_relation
5	Date(DT)	dt_duration, dt_day, dt_month_dt_year, dt_season, dt_geoage, dt_dynasty
6	Event(EV)	ev_others, ev_activity, ev_war_revolution, ev_sports, ev_festival
7	Plant(PL)	pt_others, pt_fruit, pt_flower, pt_tree, pt_grass, pt_type, pt_part
8	Animal(AM)	am_others, am_insect, am_bird, am_fish, am_mammalia, am_amphibia, am_reptilia, am_type, am_part
9	Material(MT)	mt_metal, mt_rock, mt_soil, mt_jewelry, mt_grass, mt_wood, mt_bone, mt_paper, mt_skin, mt_fiber, mt_seed, mt_rubber, mt_synthetic, mt_others
10	Term(TM)	tm_color, tm_shape, tm_mark, tm_technique

B. Annotation Tool

After defining the attributes of words, the work of creating a corpus takes a lot of people and time. Because multiple workers have to perform annotation at the same time, we developed a separate web-based tool for tagging. After that, out of about 2 million artifact data registered in the e-museum operated by the National Central Museum, we targeted 40,000 data with detailed descriptions related to artifacts for annotation [5]. After that, because it contains many professional words related to cultural heritage, we conducted Annotation with the Korea National University of Cultural Heritage, which has a higher understanding of cultural heritage than the general public [6] [7].

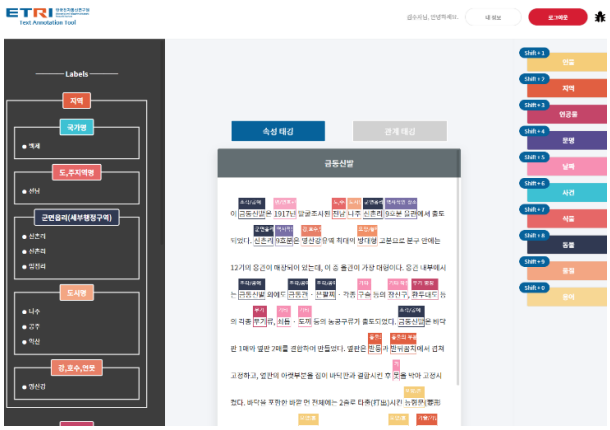

Fig. 2. Web based annotation tool

C. Build Corpus

The corpus based on cultural heritage was built using the beginning-inside-outside (BIO) technique, and finally, a total of 169,899 input-label pairs were built and divided into learning and testing at a ratio of 9:1. In this paper, we pre-trained the Robustly Optimized BERT Pretraining Approach (RoBERTa), a model based on Bidirectional Encoder Representations from Transformers (BERT), to build a corpus [8] [9] [10].

D. Named Entity Recognition

Named Entity Recognition (NER) technology is a study that predicts which entity a proper noun belongs to by interpreting the context of a language model from the entity information that can be recognized as an entity in a sentence. Through this research, we developed a visualization tool to visually see the inference results of the actual trained model. Figure 3 shows the appearance of NER applied to the detailed description on the right when an artifact is clicked in the system being developed for internal testing at the National Museum of Korea.

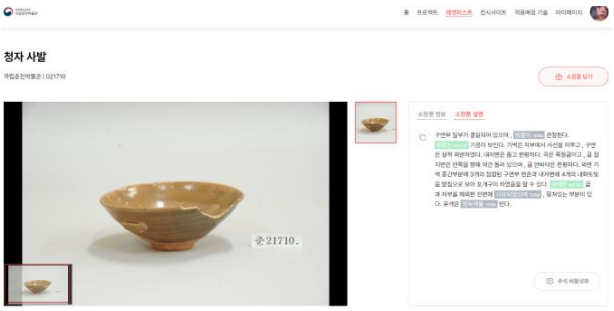

Fig. 3. Named entity recognition result web page

III. AI-BASED IMAGE PROCESSING

Cultural heritage is a cultural product of society that has value to be passed on to the next generation for future cultural development. Therefore, when preserving cultural heritage, it is stored and preserved with the most advanced technology of the time. With the advancement of image technology, black and white photos have become color photos, storage has moved from analog to digital technology, and digital technology has reached the stage of storing images in gigapixel units from low resolution to gradually high resolution. Therefore, museums are still constantly accumulating digital data with the highest existing technology.

However, in the case of cultural heritage that is difficult to reshoot, such as 'photo materials at the time of cultural heritage excavation', 'cultural heritage lost in a fire', and 'cultural heritage located overseas', there are cases where they only exist as photo materials. The technological advancement in the field of image restoration is very important to utilize the only remaining photo materials that can study the times of the time. For this, we tried actual restoration using open source-based super resolution and re-colorization technology, and further applied style transfer technology that can transform into various forms to utilize the stored cultural heritage images [11].

A. Super Resolution

The initial image upscaling technology was simply to enlarge the image and fill in the empty pixels, but it was not widely used because the quality of the image significantly decreased. However, with the advancement of deep learning technology, the technology for image analysis and predicting empty pixels using it has developed, and the image upscaling technology has reached a usable level. Figure 4 is 'Kim Hong-do's Shinseondo' (Collection Number: Yeok652, Seoul National University Museum) by Kim Hong-do, and the best quality released in the e-museum is 597 × 500 pixels. Using the ESRGAN algorithm, the result was converted to 2388 × 2000 pixels by upscaling 4 times, and the moire phenomenon was significantly reduced, which could be confirmed with the naked eye [12].

Fig. 4. Super resolution result(Kim Hong-do : Painting of Immortal Peach)

B. Re-Colorization

The re-colorization algorithm is a process of supplementing the color information of existing black and white or color-adjusted incomplete images or videos and converting them to color. For this, various algorithms have been developed, and in this paper, we tried to restore color with the DeOldify algorithm, which is open source-based on github and can be additionally learned among several algorithms [13].

DeOldify consists of three main steps. In the first step, a black and white image is converted to a color image using Generative Adversarial Networks (GAN). In the second step, ResNet is trained using the color image created in the previous step and the original image. Through this, ResNet performs the role of noise removal and image restoration. In the last step, a colorized image or video is created using the result of the DeOldify model [14].

Figure 5 is the result of super resolution and re-colorization of a glass plate image taken of the Gwanggaeto Stele (Collection Number: 1333, National Museum of Korea) located in Jilin, China. Through this, we can see the Gwanggaeto Stele, which only remains as a black and white photo, and the appearance of snow piled up during the winter at the time of shooting.

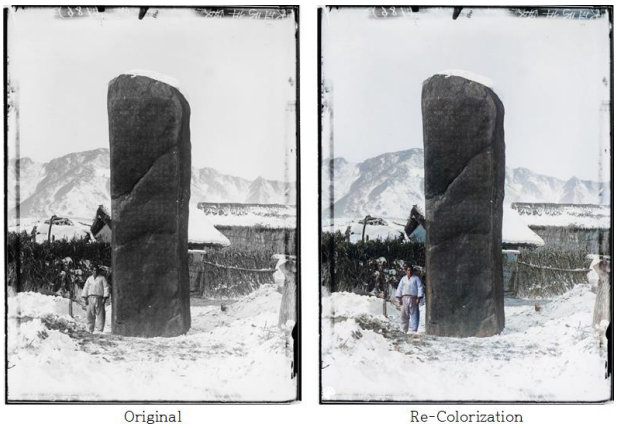

Fig. 5. Re-colorization result(East side of the Gwanggaeto Stele in Jilin, China)

C. Style Transfer

In this paper, we developed an algorithm that can create a new image while preserving the characteristics of traditional cultural heritage by tuning the existing StyTr2 style transfer framework to separate and recombine the content and style of the image [15].

We applied the work 'Starry Night' by Vincent Van Gogh using the developed algorithm. In Figure 6, you can see that the work of Gogh has been changed to the style of ink painting, which is a different look from the work we have been seeing so far.

Fig. 6. Style transfer result 1(Oil Painting → Ink Wash Painting)

Figure 7 is a process of applying Gogh's work to traditional artifacts, pottery, and if the overall style is changed, unnecessary backgrounds will also be changed, so a step of applying a mask was added to obtain the final result.

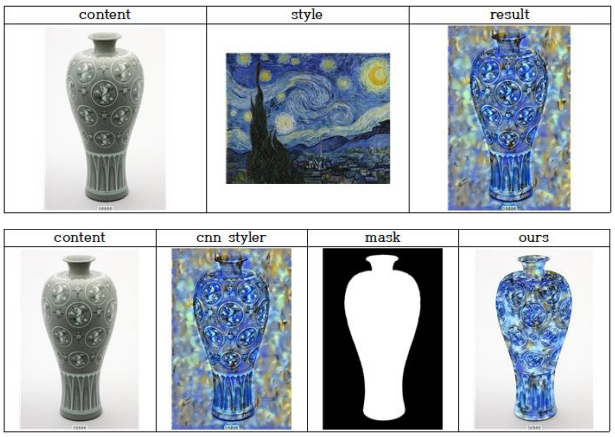

Fig. 7. Style transfer result 2(Ceramics → Oil Painting → mask → result)

IV. Discussions and Conclusions

The trend worldwide is for cultural heritage exhibited in traditional museums to gradually become digitized. In Europe, where there has been a long-standing interest in cultural heritage, digitization is being promoted around the Europeana platform. In Korea, the digitization of cultural heritage has been underway for over 20 years, centered around the National Museum of Korea [16].

Indeed, classifying and defining the vast amount of data accumulated over a long period of time requires a lot of manpower, cost, and time. However, it is almost impossible to handle this with limited manpower and budget. Therefore, by applying artificial intelligence technology, a new direction has been suggested for accessing cultural heritage data. This approach can potentially revolutionize the way we manage and utilize cultural heritage data, opening up new possibilities for research and preservation.

By developing a Korean-based traditional cultural heritage-specific named entity recognition system, a cornerstone has been laid for developing a named entity recognition model that can adapt well even to artifacts with sparse data. In addition, a relationship extraction system specialized in traditional cultural heritage is being developed to develop document-level or cross-document level relationship extraction technology beyond the existing sentence-level relationship extraction. Also, by building traditional cultural heritage data that includes expert-level terms, it is expected that an improved information search and question answering system can be developed using the traditional cultural heritage knowledge base.

From the passive viewing style of only looking at cultural heritage exhibited in museums, the introduction of style transfer technology has provided an opportunity for visitors to actively participate and view cultural heritage in various forms. Furthermore, a foundation has been established to build digital restoration technology that can draw the original form of cultural heritage that has already been lost or damaged.

Among the datasets used in artificial intelligence algorithms, the reality was that there were no datasets specialized in Korean cultural heritage, or if they existed, the datasets were not large. Through this paper, an opportunity was created to create a dataset of 2 million digital cultural heritage items held by the National Central Museum, and it is expected that this will provide an opportunity to apply to various artificial intelligence technologies centered on Korean cultural heritage in the future.

Acknowledgment

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