Intellectual Property Protection of Digital Cultural Heritage

Todor Todorov[1, 2][0000-0002-2443-4618], Shpend Lutfiu[2][0000-0002-2745-6484]

[1] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria
[2] St. Cyril and St. Methodius University of Veliko Tarnovo, Veliko Tarnovo, Bulgaria
t.todorov@ts.uni-vt.bg, shpendlutfiu@gmail.com

Abstract. Use of information and communication technologies are becoming a crucial part of our lives, which creates new opportunities for promoting Cultural Heritage through digital technologies and the internet. Use of techniques for intellectual property protection of digital content by cultural heritage institutions has gotten little attention up to this point. As technology evolves rapidly, concerns about protecting intellectual property have arisen, as digital content could be modified using freely available software. The paper focuses on watermarking techniques that could be used in the digitization process and analyses of algorithms for protecting intellectual property of digital heritage content.

Keywords: Cultural Heritage, Digital Content, Intellectual Property, Watermarking, Protection Framework Models.

1 Introduction

In many countries, the legal framework developed specifically for the protection of intellectual property of digital cultural heritage covers only tangible cultural heritage, including cultural monuments and nature reserves, leaving the protection of intangible cultural heritage uncovered (Pantalony, 2013), (Tsolis, et al., 2006), (Mendoza, De La Hoz, & Gómez, 2023), (Missier, 2014). Recently the slight changes have been made through Cultural Heritage Acts that define cultural heritage as tangible and intangible. As technology evolves rapidly, concerns about protecting intellectual property have arisen, as digital content could be tampered using freely available software (Liu J. , 2022), (Liu Y. , 2022), (Luchev, Goynov, Paneva-Marinova, Stoykov, & Pavlova, 2021). The paper focuses on watermarking models that could be used in the digitization process and analyses techniques, models, and algorithms for protecting intellectual property of digital heritage content. In Section 2 are presented general principles of copyright protection and watermarking systems. In Section 3 are presented developed algorithms and software realizations for image protection with digital watermarks.

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2 Intellectual Propriety Protection of Digital Content

2.1 General Principles

On Figure 1 are shown the main types of intellectual property rights for the protection of assets that are part of collections in cultural heritage institutions. These are (Borrissova, 2010), (Poulopoulos & Wallace, 2022):

- *Copyright* protected assets (images, audio-visual works, multimedia productions, databases of information about collections etc.);
- *Trademark* protected assets (heritage institution name and logos, exhibitions, and programs, works of art);
- *Patents and Trade Secrets* applicable in collections, academic activities and technologies;
- *Industrial design* constitutes the ornamental aspect of an artefact.

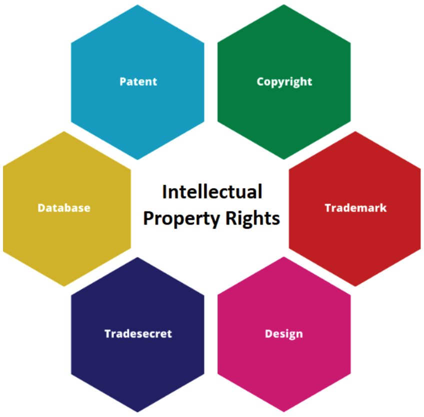

Fig. 1. Types of intellectual propriety rights protection.

Protected information assets were either held by or owned by museums as part of their technologies and digital data are described as "*a valuable resource that must be protected*" as a general security framework that should be considered when applying the techniques and algorithms for intellectual propriety protection. The use of digital marking techniques is crucial for the security of digital images by cultural heritage.

2.2 Digital Watermarking Systems and Algorithms

The system's fundamental input is represented by the information that will be hided as shown on Figure 2. Such data could be thought of as a binary string, which is often referred to as a watermark code. A chunk of data has the string "s" placed inside of it. Such a key, whose main objective is to introduce some secrecy inside the embedding stage, is typically employed to make it hard for unauthorized users who do not have access to such a key to retrieve the watermark (Copyright protection, n.d.).

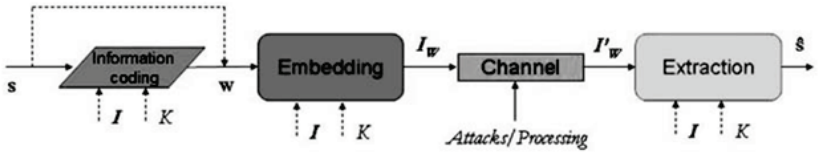

Fig. 2. Watermarking system.

The watermarking process produces a watermarked image I_w. This can be represented with the following function: $I_w = E\ (I,\ w,\ K)$, where $w{=}I_e(s,I,K)$. The watermark extraction process extracts the watermark image W'. This can be represented as the following decoder functions: $W' = e\ (I_w,\ K,\ w,\ I)$. The essential characteristics of the watermarking process are capacity, imperceptibility, and robustness. (Hamza & Pradana, 2022), (Vasudev, 2016). **Capacity** (amount of information bits a watermark can carry) is a fundamental property of watermarking algorithms that makes a technique suitable or unsuitable for a particular application. **Robustness** of the watermarking signal refers to the ability of the hidden data not to be removed from the host asset by tampering, whether malicious or non-malicious. **Imperceptibility** is a key requirement in all watermarking applications. It means that the perceptual quality of the watermarked data must be kept high.

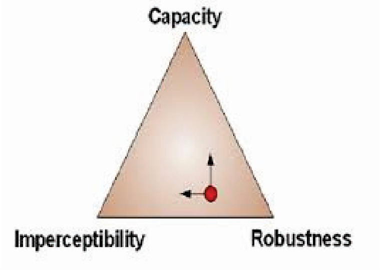

Fig. 3. Watermarking algorithms properties (Trivedi, Kumar, & Maheshwari, 2020).

From Figure 3 it is clear that capacity requirements compete with robustness and imperceptibility requirements. In Table 1 are provided descriptions of the most popular types of watermarks:

Table 1. Types of watermarking.

Type	Description
Visible	These watermarks are applied to the image and cannot be removed by cropping
Invisible	Various techniques are used to perform watermarking while obtaining an invisible watermark.
Fragile	These watermarks can be easily destroyed with a little manipulation
Private	These watermarks are used only on individual levels

If the watermarking is used only for security or copyright protection, three last watermarks are more suitable. However, if the watermarking process is not related to security purposes, the first three watermarks are used in the watermarking process.

3 Techniques for Protecting Intellectual Property Rights

The digital image watermarking has attracted the attention of researchers due to the possibility of misuse and copying of copyright information (Begum & Uddin, 2020). These technologies are required for various applications such as: authentication, operator awareness, material security and brand protection. Next are described software realization of two developed watermarking algorithms used for copyright protection. Security is a major concern in digital image watermarking technology.

3.1 Image Hiding Watermarking

The basic idea behind this technique is to combine pixels of two images – the original one and the one that is used as a watermarking signature. Each pixel is represented as a triple of RGB components.

To encode a pixel are taken the most significant four bits from each pixel of the original and signature images. The resulting pixel is then used to construct the watermarked image.

Decoding is performed with a similar reverse algorithm. Each pixel of the input image is divided into two parts. Respective pixels of the two output images are generated using four pixels from the input images and four random bits.

The software realization is performed using the Python language and the specialized libraries NumPy and OpenCV.

3.2 Least Significant Bit (LSB) Watermarking

In this technique only the least significant bits of the pixels of the original image are used to store bits from the signature message of the watermark. Again, the image is considered as an array of pixels presented with the RGB triple.

The ASCII symbols of the text message are converted into binary form and then are incorporated in the original image using LSB technique.

Extraction algorithm extracts the text content bit by bit, combines then and convert symbols back to ASCII.

Modifications could be made to this algorithm to improve its performance and robustness. Two bits could be encoded in each pixel instead of only one to extend the capacity. Also, a random number generator could be used to select the pixels for encoding. This technique improves the robustness of the algorithm. Again, the software realization is performed using the Python language.

3.3 Watermarking Web Services

For the purpose of research are created web services with endpoints that are used for online watermarking procedures using the techniques described in the previous sections. The backend side of the application runs Python scripts to perform watermark encoding or decoding. Encoding procedure takes input image and the secret message to be imbedded in. The result is the watermarked image. The input of the decoding procedure is the watermarked image, and the results is the extracted secret text. On Figure 4 and Figure 5 are presented the basic workflow of the web services.

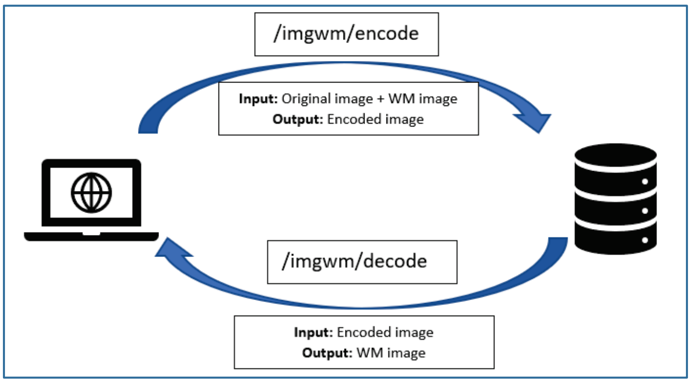

Fig. 4. Image hide watermarking.

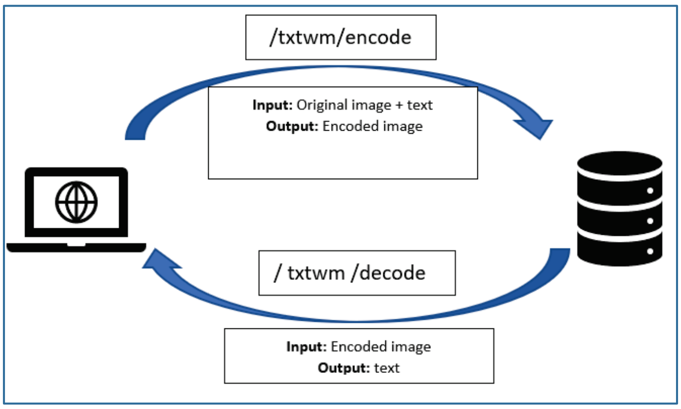

Fig. 5. Text watermarking.

4 Conclusions

Digital archiving requires the copyright protection of collected data, especially for distribution and remote access by users of digital information. The key general aspects of digital watermarking approaches for copyright protection of digitised data have been covered in the paper. Some algorithms and software applications are developed and presented. At the current level of technology, watermarking of digital images is a welldeveloped area that could be practically used for copyright protection of works of art in museums and galleries.

References

Begum, M., & Uddin, M. (2020). Digital Image Watermarking Techniques: A Review. *Information, 11*(2), Article 110. https://doi.org/10.3390/info11020110

Borrissova, V. (2010). *Digitizing Cultural Heritage in Bulgaria.* WIPO.

Copyright protection. (n.d.). Retrieved 3 25, 2023, from http://what-when-how.com/digital-imaging-for-cultural-heritage-preservation/copyright-protection-of-digital-images-of-cultural-heritage-part-1/

Hamza, R., & Pradana, H. (2022). A Survey of Intellectual Property Rights Protection in Big Data Applications. *Algorithms, 15*(11), Article 418.

Liu, J. (2022). Digitally Protecting and Disseminating the Intangible Cultural Heritage in Information Technology Era. *Mobile Information Systems*, Article 1115655.

Liu, Y. (2022). Application of Digital Technology in Intangible Cultural Heritage Protection. *Mobile Information Systems*. Article 7471121.

Luchev, D., Goynov, M., Paneva-Marinova, D., Stoykov, J., & Pavlova, L. (2021). Synergy of national cultural heritage and technology. *Digital Presentation and Preservation of Cultural and Scientific Heritage*, *11*, 281-286.

Mendoza, M. A. D., De La Hoz Franco, E., & Gómez, J. E. G. (2023). Technologies for the Preservation of Cultural Heritage—A Systematic Review of the Literature. *Sustainability, 15*(2), Article 1059. https://doi.org/10.3390/su15021059

Missier, P. (2014). *Technology for the copyright protection of digital images.*

Pantalony, R. (2013). *Managing Intellectual Property for Museums.* WIPO.

Poulopoulos, V., & Wallace, M. (2022). Digital Technologies and the Role of Data in Cultural Heritage: The Past, the Present, and the Future. *Big Data Cogn. Comput, 6*(3), Article 73. https://doi.org/10.3390/bdcc6030073

Trivedi, N. K., Kumar, S., & Maheshwari, S. (2020). Principles of Digital Watermarking: Present Scenario and Future Scope. In L. Gaur, A. Solanki, V. Jain, & D. Khazanchi (Eds.), *Handbook of Research on Engineering Innovations and Technology Management in Organizations* (pp. 325-349). IGI Global.

Tsolis, D., Nikolopoulos, S., Karatzas, E., Sioutas, S., Hondrou, E., Mouriki, A., . . . Papatheodorou, T. (2006). Watermarking and digital rights management - a pilot DRM system implementation and technical guidelines to cultural digitization projects. In *7th International conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage* (pp. 117-121). Eurographics Association.

Vasudev, R. (2016). A Review on Digital Image Watermarking and Its Techniques. *Journal of Image and Graphics, 4*(2), 150-153.

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