ILLUSTRATION WATERMARKING: A NOVEL CONCEPT FOR DISSEMINATION OF E-LEARNING

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ABSTRACT
Demand on permanent availability and fast access to learning material competes with the reluctance to new and maybe unconventional concepts as well as the belief in traditional and familiar learning methods. In this extended abstract we propose an approach for combining learning content and learning media inseparably. Our solution depends on a particular form of robust digital watermarking, which means in short, a technique for embedding additional information into digital media. This additional information usually designated for copyright information and digital signatures will be used in our approach to carry e-learning material related to the conjunct media for illustrating purposes.

KEY WORDS
E-learning and E-training, Dissemination, Illustration Watermarking, Steganographic Illustrating

1. Introduction

As part of blended-learning concepts, e-learning is a major aspect taking place in modern learning process. The use of electronic media offers a variety of possibilities for presenting, visualizing and expounding certain issues in a way traditional media often cannot. Therefore electronic media helps to facilitate the idea of asynchronous learning, by which the learner should be able to study anytime and anywhere. On the other hand electronic media has always to be seen as a supplementation and not a replacement of the social learning process. As a result the appropriate application of e-learning is a crucial point in regard to learning success and learners satisfaction (q.v. [1]). Even so the benefit of electronic media with respect to illustrating capabilities and up-to-dateness is beyond controversy. As Edward I. Vockell noted in [2]: "One of the major strengths of the computer is that it can present the same information in many different ways."
Despite all new possibilities introduced with e-learning the last years have shown open problems regarding to acceptance and dissemination, which hinder the promising concept. In business environments, governmental institutions and healthcare the following three parties participating in the e-learning process can be identified in general: The provider, who designs and markets e-learning material and systems, the manager (or decision-maker) of a company (or institution), who ascertains whether and which e-learning solutions will be applied, and last but not least the learner, who finally uses the chosen solution. Not constrained by scenario personal requirements in reference to e-learning can be investigated in a similar manner.
All three parties suffer from their quite own problems. The provider has to carefully cost out the investment for putting e-learning solutions into practice. Production efforts and costs of e-learning material are often totally underestimated which results in projects doomed to failure. Furthermore the development of e-learning systems must deal with the rapid proceeding of computer technology. Technological progress makes the e-learning system developed today look outdated tomorrow. On the other hand the manager or decision-maker has to estimate the benefit of the provided solution for his company or institution, in other words he must evaluate the effectiveness of the learning system for his and the learner's concrete needs. Like the provider he has to measure the costs, whereby in this case not for implementation but for purchasing. Because of financial reasons he expects from the e-learning system that in the long run costs for education will decline. Last but not least, the learner largely decides about success or failure. One of the most critical aspects is the settlement of learner's claims. If the provided solution cannot satisfy the expectations of the user or is felt as an encumbrance to learning progress, the learner will refuse the system.
Covering the described scenario this paper addresses the problems identified above and presents our approach for meeting with the demands of all three parties. We propose the concept of illustration watermarking to combine e-learning content and digital media permanently. This steady combination is a form of true integration since e-learning content is not simply associated to digital media using metadata information, but physically embedded into the media. Binding content to digital media in this way has the advantage that dissemination becomes more

reliable and more easy, so that all three parties will benefit from that circumstance.
This paper is organized as follows. In the next section we introduce the term of illustration watermarking and the requirements for its application with respect to e-learning. We further describe the model of steganographic illustrating and present the workflow of a digital image as one of many e-learning media in the space of this model. In section "Content vs. Visualization" we show that e-learning content and visualization of e-learning content are independent in our approach to a large extent. The subsequent section addresses security related aspects like integrity, confidentiality and availability of e-learning content. Conclusion and ideas for further work are given in the last section.

2. Illustration Watermarking

In this section we present our model of steganographic illustrating and describe top down the framework that is needed for illustration watermarking. General information about digital watermarking can be found in [3] and [4], in this paper we can only give a short introduction to that topic.
Digital watermarking is defined in [3] as follows: "*Watermarking [...] is the practice of hiding a message about an image, audio clip, video clip, or other work of media within that work itself.*" In [4] the watermarking domain is divided into three main categories: copyright watermarking, integrity watermarking and annotation watermarking.

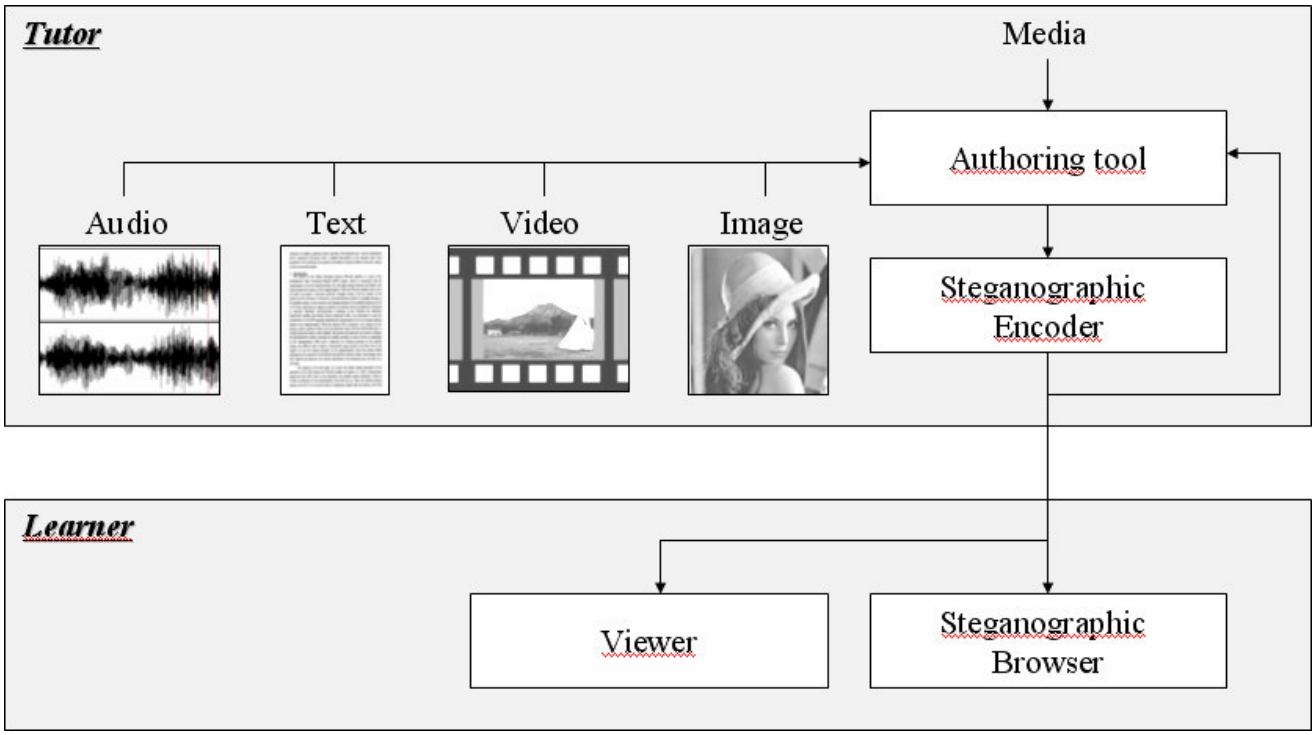

Figure 1 - Model of Steganographic Illustrating

Copyright watermarking is applied to secure ownership on copyrighted material, detect originators of illegally made copies, monitor the usage of the copyrighted multimedia data and analyse the spread spectrum of the data over networks and servers. Integrity watermarking aims at the protection of digital content in terms of embedding integrity information in the media for detecting content changes. Annotation watermarking (sometimes also called caption watermarking) is used to embed supplementary information directly in the media, so that the additional information cannot be separated from the media by accident (e.g. metadata like the ImageDescription field in the TIFF header can easily be taken away by converting the image from TIFF to JPEG).

For our context we focus on annotation watermarking for digital images that are bound to user-defined objects within the image. Defining objects within images is necessary for a content-related form of embedding, which is essential for e-learning purposes. In section "Combinability" we concentrate on this aspect. Furthermore we have to rely on assistance by the user since automated recognition of objects producing reasonable results is not possible in the majority of cases.
After explaining some needful terms we can now introduce illustration watermarking as an object based form of annotation watermarking carrying additional illustrative information of the medium while providing robustness to typical image processing.

The concept behind illustration watermarking will be enhanced by the model of steganographic illustrating (q.v. Figure 1). Our model consists of the *authoring tool*, the *steganographic encoder* and the presentation tool (or *steganographic browser*).
The authoring tool is used by the lecturer to select user-defined objects within a digital image and choose the information for embedding. The selection of the desired objects enables the author to integrate a set of learning material into the media. The information to embed can be all kind of data, e.g. simple text, an audio file, an image file or a video file.
After the selection of image, objects and information by the lecturer the steganographic encoder merges the objects and the information. After processing all objects selected for embedding the steganographic encoder outputs the enriched image and the embedding process has finished.
For retrieving the information from the marked image a steganographic browser used by the learner acts as presentation tool and content viewer. This tool may be implemented in various ways, e.g. as a client-side stand-alone application, a web browser plug-in or a server-side web application. The steganographic browser locates the embedded information. Then it extracts and decodes the data and displays the learning material. Subject to the application the displayed information does not need to be static so that the learner can interact with the medium. The visualization possibilities depend on the features of the steganographic browser, so that content and visualization are separated from each other.
Steadily bound to the digital media the information can be instantaneously spread with the image, video or audio file and these media types are the most spread at all. Therefore e-learning content can be made available to nearly everyone in principle, if appropriate viewers are provided free of charge.
Considering the assets and drawbacks of traditional e-learning systems, the major benefit of our solution is the steady fusion between media and content, whereby presentation of the content is detached and can be separately performed by an appropriate presentation tool. Therefore dissemination of digital media - like common image, audio and video files - results in dissemination of e-learning content, which is due to the wide distribution of digital media in our opinion a promising approach for an efficient spreading of e-learning material. Currently we are working on a prototypic implementation of the described environment.

3. Content vs. Visualization

Like stated in the introduction e-learning technology ages really fast. In contrast the learning content generally remains current for a long time. For example, mathematical foundations of computer science as a learning subject will in all likelihood remain valid for a longer time than any current e-learning system will remain in productive use. Therefore it seems necessary to separate the e-learning material from its presentation to achieve an easy portability of the content to a new presentation form. The basic idea is not new and already practiced by many approaches extending e-learning systems by metadata models like XML (q.v. [5], [6], [7], [8]). But contrary to our approach these systems rely on a loose binding between learning material and learning media represented by XML schemes and database solutions. Information and media are associated, but not integrated. Therefore dissemination of e-learning means dissemination of many associated components.
In contrast our illustration watermarking scheme seamlessly integrates content and media for simplifying dissemination of e-learning material, while omitting content visualization details. The embedded content represents information about what to display and not how this has to be done. So visualization questions are completely handled by the presentation tool and are not part of the e-learning content bound to the digital media. This means, enhancement of presentation can be simply achieved by updating the presentation tool and therefore, despite the steady binding between e-learning content and digital media, the up-to-dateness of content is independent of the up-to-dateness of visualization capabilities.

4. Availability, Confidentiality, Integrity

Beside the necessity of independence of content and visualization there are more important requirements (q.v. [9]) related to e-learning solutions which decide about success or failure of the used model for dissemination.
Embedding e-learning content in digital media like images, audio and video files will significantly increase the *availability* of e-learning resources. In this context availability refers to the availability of information resources. Generally an information resource that is not available when it is needed is at least as bad as none at all. It may be much worse, depending on how reliant the learner has become on receiving actual e-learning content on demand. An unreliable system makes users nostalgic for the days of traditional learning.
If e-learning content is available and accessible to most users it forms a great benefit for the learner but on the other hand it is challenging to protect the provider's rights. Due to the costs for design and implementation of e-learning content in reference to time and money the provider has an natural interest in obtaining an adequate compensation for his investment. Therefore e-learning content has to be protected in a way so that only authorized learners, whose manager (or decision maker) has paid for the content, are able to access the embedded information. Using strong encryption algorithms guarantees that only possession of the right key grants access. Key licenses can be offered by the provider of the e-learning content, who will receive the license fee. Similar concepts are already used in Digital Rights Management Systems (q.v. [10], [11]). These

requirements in regard to protection and encryption we will summarize under the term of *confidentiality*.
Furthermore to meet learner's demands e-learning content must be freely accessible to a certain extent, since the learner must be able to satisfy himself that the protected content has the desired quality. The concept of partial encryption described in [12] can help to provide a preview of the content, which is free available but has a decreased quality (e.g. a short summary of a detailed content). Introducing previews due to learner's demands a security problem may arise. If content can be previewed then there might be a chance for an attacker to manipulate the genuine preview or even the content itself. To prevent manipulation and to guarantee the learner that he uses the original and unmodified content, *integrity* of e-learning material must be assured. Integrity refers to the trustworthiness of information resources. It includes the concept of data integrity, which means that data have not been changed inappropriately, whether by accident or deliberately malign activity. It also covers source integrity, which means that the data actually came from the person or entity you think it did. Data integrity and source integrity can be assured by digital signatures and digital certificates explained in [13], and applied to e-learning content during embedding process by the steganographic encoder. On the basis of the embedded information, the digital signature and the digital certificate, the steganographic browser can verify the integrity of the provided e-learning material. If an attacker tries to manipulate the embedded information, the signature gets invalid. If he pretends to be the original provider of the content, verification of the certificate will fail.

5. Combinability

All requirements described in the previous section are taken into account by steganographic illustrating. In addition there is one aspect mentioned before we concentrate on in this section: the object-based approach.
Even though annotation watermarking algorithms may be robust to some typical image processing operations and therefore the embedded information could be extracted after cutting out some parts of an image, there may be a semantical gap between the original image and the cropped image since the embedded information belongs to the entire image in general. For example let us assume the original image shows a windmill on a green hill under a blue sky next to a big house, and the annotation watermark is a string containing "windmill" (q.v. Figure 2). Thus the content of the original image is additionally described by the annotation watermark.
A common application for this form of annotation may be a vocabulary-learning tool. If an attacker cuts out the windmill such that only the green hill, the blue sky and the house remain, the relationship between the marked image and the embedded information is violated. The problem is that the embedded information is spread over the whole image and not directly stored in the related objects within the image. In the described situation the information has to be bound rather to single objects than to the entire image which is provided by an object-based approach.
Common watermarking schemes usually do not support object-based information embedding. There is one scheme developed by Digimarc Corporation that uses single objects for embedding but the watermark information is limited to URLs and depends directly on the size of the object (q.v. [14]). Additionally there are algorithms providing region-based watermarking but in this case the main goal is to provide rather integrity than object-based annotation (q.v. [15]).

Figure 2 - Image containing embedded message

Binding information to single objects within images has the additional benefit that cutting out and recombining these objects to new images will leave the embedded information unaffected while merging known content to new e-learning material. We introduce the term *combinability* for describing the possibility of combining single objects containing e-learning content to new images representing new content. Using the embedded information as keywords the combination can be performed without user assistance.

6. Conclusion

In this work we described the difficulties, which in our opinion hinder the dissemination of e-learning. We introduced the term of illustration watermarking and proposed our model of steganographic illustrating, based on the approach presented in [16]. This model enables the three mentioned parties - provider, manager and learner - to profit by the use of e-learning applications. Furthermore we identified security related requirements like availability, identity and confidentiality that can be covered by our approach. In addition to this concept paper, further - and most of all - practical research is needed. We have to demonstrate that by putting our approach into practice common problems in reference to

dissemination of e-learning can be overcome and all participants may benefit from that model. Therefore we have to enhance our prototypic tools for images in the next step. Moreover we plan to extend our implementation to handle video and audio files as well. By doing that dissemination is not limited to images any longer and more media types can be used for embedding. We think, last but not least due to the benefit for the participants, dissemination of e-learning by dissemination of digital media will become more popular than before. Of course, dissemination of e-learning cannot be reduced to distribution of digital media, but in conjunction with content viewers free of charge and worked out security concepts like Public Key Infrastructures (PKI) e-learning material is in fact securely and gainful brought into the world.

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