An Application of a Halftone Pattern Coding in Augmented Reality

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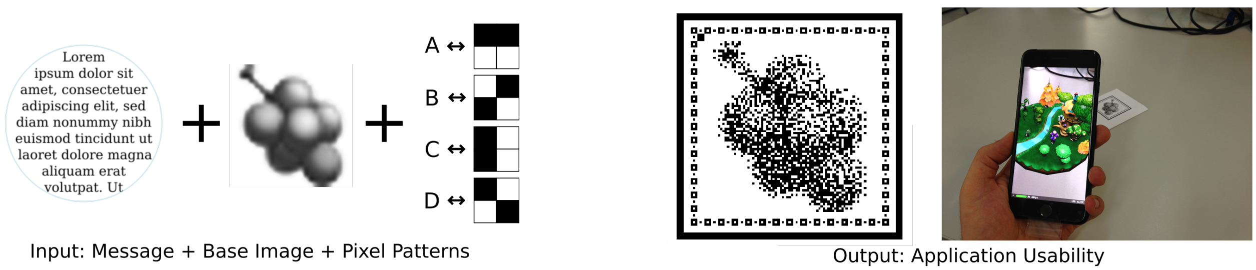

Figure 1: The marker creation input is the information to be coded, a base image (to define the overall appearance) and the dictionary. The application can detect a printed version of the marker, decode the message and use it for its specific purpose.

ABSTRACT

In this work, we will present a coding system using a halftone pattern (with black and white pixels) capable to be integrated into markers that encode information that can be retrieved a posteriori and used in the creation of augmented reality applications. These markers can be easily detected in a photo and the encoded information is the basis for parameterizing various types of augmented reality applications.

CCS CONCEPTS

• **Computing methodologies** → **Image processing**; **Mixed / augmented reality**;

KEYWORDS

Halftone Pattern Coding, Augmented Reality Application, Steganography

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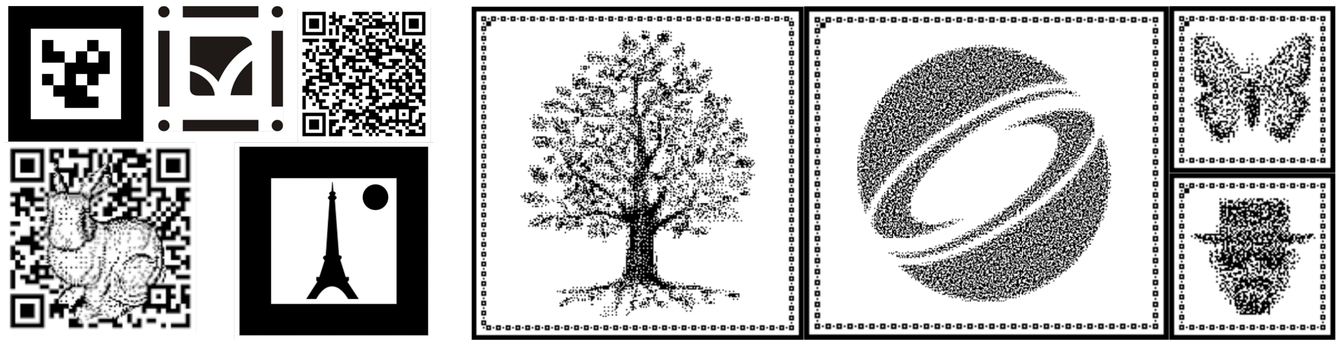
1 INTRODUCTION

We are presenting a technique to compose a marker capable of encoding information that can be retrieved a posteriori (even from a photo of a printed version of the marker) and can be used for various purposes, in this case for Augmented Reality applications. Figure 1 illustrates the pipeline of our method. Given a text, a base image, and a mapping between symbols and halftone patterns, the method output will be a halftone image with the given text encoded. The process of creating the markers will be better explained in Section 2.

Once the marker is created, we can print it, and capture a photo of it using a camera. From this photo, the encoded image will be reconstructed and decoded (obtaining the encoded text). The information encoded in it will be used for the specific purposes of the application, such as, the placement of virtual elements in the scene. In Section 3, we will show some possible Augmented Reality applications using such markers.

Most markers are images robustly detectable (used to place some virtual object) or an image easily recognizable (icons used to trigger some functionality). Our proposed marker, have both characteristics (detectable and recognizable). Furthermore, we can produce markers with good aesthetic appeal, and there is no prior limit of information.

Figure 2 illustrates a comparison between state of the art markers and those created using our approach. There are some techniques able to produce beautiful QR Code based markers [Chu et al. 2013; Cox 2012]. Although, techniques for aesthetic value improvement reduce the information size availability and increase the need of information redundancy (because of the need of changing of some modules used for information coding). Other examples, such as AR ToolKit, create beautiful icons in the markers but with no coded information [DAQRI 2017].



(a) (b)

Figure 2: Examples of markers: (a) used in most of applications and (b) our markers.

Our marker combines the usability of classical markers and possibility of creating beautiful models with considerable large amount of coded information (the quantity depends on the base image).

2 MARKER CREATION

Our method creates an image that encodes a given message using patterns of $k \times k$ black and white pixels. The process begins by determining an alphabet of symbols (which can be used to compose the message). Each symbol will be associated with a pattern (a specific arrangement of black and white pixels). We call this association between patterns and symbols a dictionary. Once the dictionary is defined, the process of creating the marker consists of placing, in the scanline order, the patterns associated with the message symbols.

Once the message has been encoded in the image, we can retrieve it through a photo or video of the printed image. In addition to the coded image, we added a specific border that is used for marker detection, rectification, and aiding image reconstruction (correction of possible distortion errors). Once the encoded image has been reconstructed, the information decoding process consists of scanning the image in the same order as the encoding and storing the dictionary symbols associated with the detected patterns.

One possibility when creating the markers is to use patterns of black and white pixels that are not in the dictionary to produce a nice aesthetic, as close as possible to the base image. For this, we adopt a process similar to what is done when using dithering to create halftone images [Ulichney 1993]. We can, for example, take a base image, quantify it in $N = k^2 + 1$ levels of grey, and for the i-th quantized color (with $i \in \{0, \ldots, N\}$) in the image, replace for a pattern with i white pixels and $N - i$ black pixels arranged in a way that does not appear in the dictionary. In some positions (chosen by taking a pixel whose color is related to a standard dictionary) we put the pattern of one of the symbols of the image sorted according to the message. This way, the decoding process continues the same, scanning the image in the scanline order and when it finds a pattern contained in the dictionary, its symbol is added to the message being decoded.

3 RESULTS AND CONCLUSIONS

We are introducing a new way to create markers that can be used in vast number of applications with different purposes. These markers can be used, for instance, in the transmission of textual information about an entity (i.e. a product, a person or a place) in a non-textual way (i.e. in an image). The alphanumeric message is decoded from a photo of the encoded image. Applications that transmit encoded textual information in images can be used in several contexts, such as, advertising, information on exhibitions and outdoors.

Another example of applications that can use our markers are those that exhibit virtual models over a real scene (Augmented Reality). The pose for these models will be extracted and calculated based on the planar transformation between the camera and the marker. Information about the model can also be decoded from the marker. An example of the use of our markers for this purpose is illustrated in Figure 1.

This new approach for marker creation, that encodes messages into images by using dictionaries which associate symbols with pixel distributions, can be used in the same way that classical markers are (can be robustly detectable and easily recognizable). Furthermore, it allows to code large messages that can contain not only descriptions of 3D models but also other types of information, such as, its relative positions, rotations and scales in the 3D scene.

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