ENHANCING SURVEY PLANS IN ALBERTA: Digital Watermarking and Georeferenced Images

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ABSTRACT

A digital survey plan can be watermarked for security purposes by taking a digital image and embedding it to the digital survey plan in such a manner that it cannot be easily detected or removed. The image that becomes the watermark is often a recognizable logo. Using variable parameters input by the user, the logo is mixed using a watermark algorithm until it appears as no more than random black spots. These spots can be inserted into the survey plan as background noise, and just as easily removed if the input parameters are known. If the watermark is removed and the logo is not intact, then it suggests that the survey plan has been altered from its original state.

Georeferenced images as a backdrop for a survey plan are valuable in that they allow the user to clearly see the relationship of property boundaries to the physical assets on the parcel. The georeferencing process coregisters digitized aerial images and survey plans which permits image mosaicing and integration with other geocoded geographic features.

INTRODUCTION

This paper presents the results of research performed with respect to digital watermarking and imbedding georeferenced images in digital survey plans. The two issues to be addressed may be viewed separately, except that they both serve as possible new additions to the digital format for survey plans in Alberta. They are tied together in this article because they were researched together under a single research grant supported by ALSA.

This paper presents as a primary focus the results of the research done on digital watermarking. Georeferencing is mentioned and discussed. Both watermarking and georeferencing are additions that, if implemented in digital survey plans, serve to enhance the product being offered to users.

BACKGROUND FOR DIGITAL WATERMARKS

The Government of Alberta, through the Land Titles Office, has mandated that digital survey plans be the official document of record as of December 1, 1999. Survey plans that are stored digitally are the same plans as would be stored on paper, but the storage medium is now an electronic disk rather than mylar. Digital images on disk are computer files with a specific graphical format. A difficulty that exists in using computer files as official documents, as for example survey plans, is that a computer file's content can be easily altered. Consequently, there must be a security procedure that offers protection for copyright and that prevents unofficial alteration of digital files.

This topic of image security was discussed by Broadus (1999), who describes the use of digital signatures for protecting the integrity of digital plans. Digital signatures are a more general definition of digital watermarking, with the same objective, of securing the image against manipulation. Mr. Broadus reviews the trends in different US states towards use of digital signatures in all electronic communications. From conversations with Land Surveyors, Mr. Broadus states that very few have adopted the habit of adding a digital signature to their electronic correspondence, when there is no reason preventing them from doing so. The most likely result will be that the procedure will be mandated by legislation.

Watermarking computer images is a new area of research but it has roots in older disciplines. Hiding messages inside other messages, commonly used during times of war, is known as steganography, which is derived from Greek word meaning 'covered writing'. Marking an image such that the human eye cannot notice the additional marks requires comprehension about visual perceptibility limits. Digital image processing techniques and information transmission methods are also required. And to construct a mathematical algorithm that is secure, meaning that it cannot be easily deciphered, the watermark inventor must possess understanding of advanced mathematics and statistical probabilities.

DIGITAL SURVEY PLANS AND WATERMARKS

Different watermarking methods perform better when certain assumptions are made about the format of the document to be watermarked. Digital representations of paintings, for example, are usually in colour format, with one or two bytes representing each pixel. Therefore, there is high variability between pixels. Watermarking algorithms for colour images usually operate by applying subtle variances to pixel colours that cannot be discerned by the human eye. These general watermarking techniques fail when applied to the restricted formatting of survey plans. (note: A graphics file can be saved as a black and white image, a greyscale image, or as a colour image, thus requiring 1 bit, 1 byte, or multiple bytes, respectively to store each image pixel.) Survey plans in Alberta are in black and white, which requires only one bit per pixel. Plans are often uniformly white through much of the background of the image, making survey plans extremely simple images from a graphical viewpoint. It is much more difficult to hide a watermark within a survey plan because, in a sense, there is nothing to hide behind. Most watermarking schemes are, therefore, not applicable to survey plans.

A watermarking method that is applicable to digital survey plans in Alberta must apply to the graphics format used in registering survey plans and must include consideration of the procedures of registration. All survey plans in Alberta, when registered as the official document of record by the Land Titles Office (LTO), are converted to and saved as TIFF (Tagged Image File Format) files. It is this TIFF file then that is the document to be watermarked, as this is the official document. The version of the survey plan prepared by the surveyors, whether Autocad, Microstation, or another software package is used, never becomes the official registered version. It is always a TIFF file converted from these original versions that becomes the official document.

TIFF images can be used on all major platforms (Windows, Macintosh, UNIX, etc.). It allows storage of multiple bitmap images in one file and supports multiple compression algorithms. With the latest release (TIFF 6.0) supports 12 different data types that may be best represented as bits, bytes, integers, unsigned integers or even strings of indeterminate length. TIFF is one of the most versatile graphics file formats currently available.

However, LTO constrains survey plans to the black and white format mentioned above. The plans are also compressed each time in a consistent format. The versatility of the TIFF graphics format then is not important in this area. The watermarking technique now to be discussed below was chosen because it was possible to adjust the technique so that it was applicable to the specific format of survey plans submitted in Alberta.

THE DIGITAL WATERMARK

This section discusses the watermark that was developed to work with land survey plans in Alberta. In 1998, Voyatzis and Pitas presented an algorithm for watermarking an image and the watermarking technique for land survey plans was derived from this algorithm.

The Mixing System method presented by Voyatzis and Pitas is applicable to either greyscale or colour images. Their method is more specific than the method currently used. In discussion of the method used to watermark survey plans, the spirit of the Mixing System method is visible and any major deviations from their system will be noted.

To demonstrate the successful application of the mixing method a program was written that performs the mixing procedure. The discussion written here uses outputted images from that program. In the example to be presented, the logo of the Alberta Land Surveyors Association (Figure 1) will be used to generate the watermark to be inserted into a document or survey plan.

The procedure of watermarking a survey plan requires that the identifiable image be transformed and resized into a watermark that can be hidden appropriately within the plan.

Alberta Land Surveyors' Association

Figure 1 – *ALSA logo*

As a first step, a logo image is taken, and by using a mixing equation, all pixels in that logo are uniquely relocated. Every pixel is located in an image by (x, y) or (column, row) coordinate values. To relocate these pixels and, thereby, mix the image, each pixel is repositioned by multiplying the original x and y by a 2x2 matrix which produces new x and y values, as seen in the following equation:

$$\begin{pmatrix} X_{NEW} \\ Y_{NEW} \end{pmatrix} = \begin{bmatrix} 1 & 1 \\ K & K+1 \end{bmatrix} \begin{pmatrix} X_{ORIGINAL} \\ Y_{ORIGINAL} \end{pmatrix}$$

The mathematical foundation for the Mixing System method is the 2x2 matrix that conforms to the condition that the matrix determinant is equal to one $[(K+1) - K = 1]$. The parameter K in the equation is the mixing parameter. K can be any positive integer value chosen and entered by the user.

Applying the above equation without further constraints would result in a new mixed image of larger dimensions than the original. In the x-direction, the dimensions would increase by (Xmax + Ymax). In the y-direction, the dimensions would increase by (K*Xmax + (K+1)*Ymax). To regulate the image size, the equation above must be multiplied by a modulus of the maximum desired dimension of the image. The outputted result will be a square matrix of size 'Dimension', adding to the equation as follows:

$$\begin{pmatrix} X_{NEW} \\ Y_{NEW} \end{pmatrix} = \begin{bmatrix} 1 & 1 \\ K & K+1 \end{bmatrix} \begin{pmatrix} X_{ORIGINAL} \\ Y_{ORIGINAL} \end{pmatrix} \textbf{ mod } Dimension$$

To mix the watermark extensively, the above equation can be reapplied to the resultant mixed logo, allowing an iteration procedure to develop. In the program written, the size of each mix result was maintained as a square matrix of size M, the maximum dimension of the logo. Every successive iteration serves to more extensively mix the original logo pattern, and each iteration produces a new MxM matrix. The number of iterations 'r' is an integer parameter chosen by the user.

Figure 2 shows the original logo and the results of the first few mixes (iterations). When the iteration procedure is complete, a final mix is performed in which the dimension parameter is changed from M, the maximum dimension of the logo, to N, the minimum dimension of the survey plan or image to be watermarked. N must always be significantly larger than M.

The final overlay involves two steps (see Figure 3). During Step # 1, the mixed logo is resized to the larger NxN dimensions. The watermark is now in the form required for application. A final parameter 's', the shift parameter, is chosen to dis-

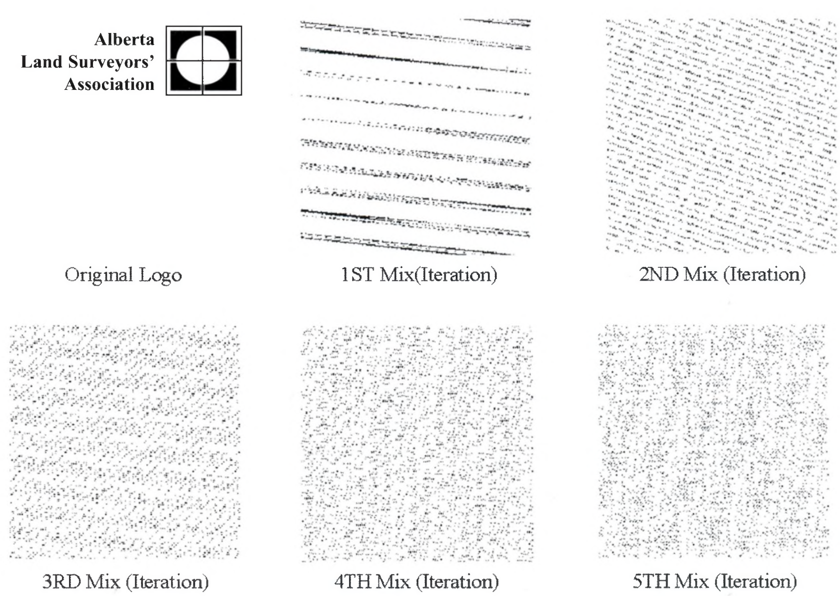

Figure 2 - *Original Logo and and Iteration Results*

place the watermark coordinates relative to the image. A second shift parameter applied in an orthogonal direction could also be used although this option was not used here. The mixed logo is overlaid onto the survey plan during Step # 2, shifted by the amount 's', and the plan is then watermarked.

In summary, the mixing of the logo is achieved by randomly choosing the set of mixing parameters discussed above: K - the mixing parameter, r - the iteration parameter, and s - the shift parameter. The dimension parameters, M from the logo size, and N from the survey plan size, should also be noted in case the watermark must later be removed.

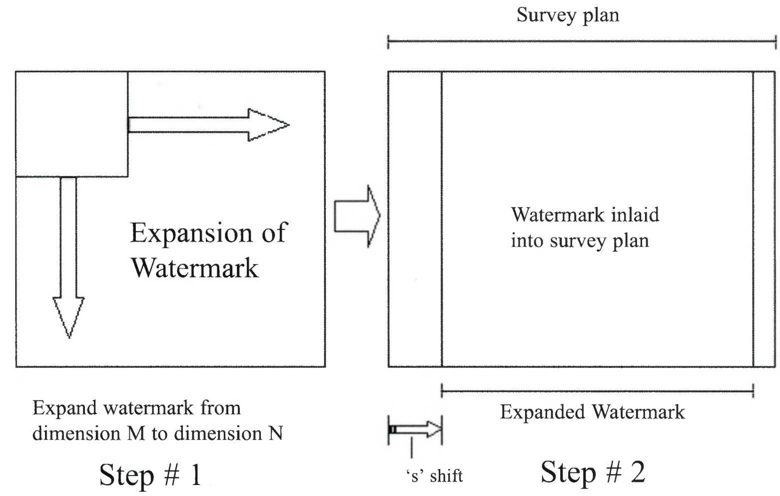

Figure 3 - *Mixed logo expanded and inlaid into survey plan*

DEWATERMARKING

If the parameters above are known, the logo can be removed as easily as it was attached. In the program, the user chooses the Dewatermark routine and the five parameters, K, r, s, M and N are requested as input. With the parameters available, the program then replicates the steps of watermarking the image, following the entire mixing procedure. The program copies the value found in the survey plan instead of inserting a value, and inserts this value into its original position in the logo. In this manner, the entire logo is rebuilt. If the plan has not been altered the logo will be intact in the rebuilt file. Assessment of the extracted logo then determines if the plan has been altered.

IMBEDDING GEOREFERENCED IMAGES

As a value-added feature, it is proposed to use large-scale digitized aerial images as a background for survey plans. This idea is based on the premise that many of the end-users would find survey plans more useful if they had recognizable features available when viewing the line-work on the plans. Georeferencing of digital images with survey plans is a feasible concept irrespective of whether the plans are recorded in a digital or mylar format. With current processing power and storage, it is now a relatively simple addition to survey plans to ensure that the background images are georeferenced. The process of georeferencing has been enhanced with the use of orthorectification, which is a process that employs the topography expressed in a digital form. The image displacement caused by the topography can then be removed during processing. However, certain residual discrepancies may persist due to the presence of artificial features.

The point to be emphasized is that an imbedded georeferenced image would represent an enhanced product relative to that currently being offered as survey plans. Survey plans should imbed if they are to remain current with other mapping now being produced by other spatial producers. A complete discussion of georeferencing is found in the paper by Cosandier and Chapman, 1995.

CONCLUSIONS

Watermarking of digital survey plans is simply a next step in the process of converting from paper to digital format that has been ongoing in all areas since the computer revolution began. Broadus noted that, "digital signature technology does a better job of protecting the integrity of a document than does a paper signature." (Broadus, 1999, p 68). Digital watermarking is better than traditional watermarking and the stamp of a surveyor or engineer.

The method demonstrated here is applicable to digital survey plans in Alberta. The research identified no other watermarking algorithm or technique that appeared applicable to Alberta's format for digital survey plans. The method demonstrated could be implemented by LTO under the current format for registering survey plans. If the registration format were to change and Alberta Land Surveyors are required to submit surveys in TIFF format, then surveyors could easily watermark their own plans using the method discussed.

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