

An Overview and Applications of Val-Code®: Digital Watermarking Technology for Printed Documents

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Computer generated electronic documents can be protected from the threat of information leakage and tampering by using security technologies, such as encryption and digital signatures. Electronic documents can also be used directly as digital input on other computer systems. Once such an electronic document is printed out and made into a printed document, however, it can no longer be protected from information leakage and tampering and it also becomes difficult to directly utilize the document again as digital data.

In this paper, we provide an overview of Val-Code®*1) technology that we are developing to resolve such issues and introduce applications in which its features are incorporated.

Overview of Val-Code® Technology

Val-Code® technology is an application of the digital watermarking technology for printed documents. The transmission of digital information to printed document media is possible with this technology. In addition, security features, equivalent to digital watermarking technology for digital data, can be implemented on printed documents, including verification of content tampering¹⁾.

Fig.1 shows the process of printing watermarked documents with Val-Code® technology and verifying the document for recovering information from watermarked documents.

The basic unit of printing watermarked document is a micro dot pattern representing digital information, printed in a range of approximately 0.5mm in size, at 600dpi. Groups of such dot patterns are printed, superposed on the document, thereby watermarking arbitrary digital information on the printed document. Also, these dot patterns are not distracting for readers as they look like light and uniform background patterns on the printed document.

When verifying watermarked documents, the scanned image data of the printed document go through a certain process so that the watermarked digital information can be recovered. As explained later, it is also possible to verify if the printed document has been altered or not.

Watermarked documents can be printed using a general-purpose laser printer or an LED printer on a plain paper. An inexpensive general-purpose flatbed scanner can be used for verification.

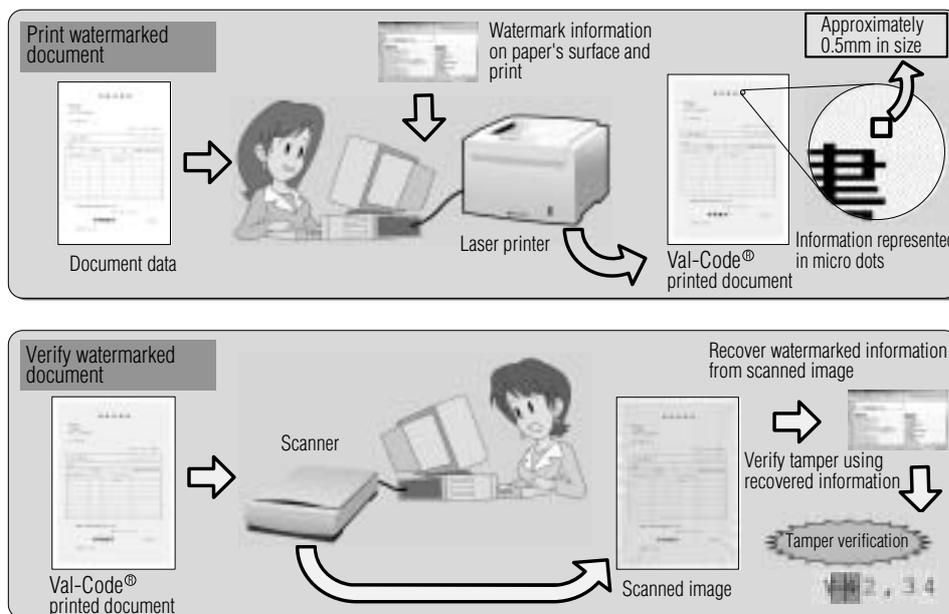


Fig. 1 Print and verify watermarked document with Val-Code® technology

*1) Val-Code and TrustPaper are registered trademarks of Oki Electric Industry Co., Ltd.

In addition, a high degree of resistance against folding and staining of the paper is realized²⁾ as watermark information is imprinted with an enhanced error correction coding, and detection of dot patterns that represent information is conducted with a special filtering process.

Basic Features of Val-Code® Technology

When image information is imprinted as watermarks on the document's face at the time of printing, it is then possible to detect the difference between the document at the time of printing and scanning. This is done by comparing the image's information, extracted during watermark verification, with the actual scanned image. Through this, the feature verifies whether the document has been altered through malicious tampering and detects whether man-made checkmarks or characters have been added, as well as determines the locations of such additions. If the content of the text information, which is identical to that of the document, is printed as a watermark, then the information can be verified prior to tampering³⁾.

A digital signature with a public key can be assigned to the information included in the background. Attempts to use a forged document as the printed original can be detected by verifying the digital signature at the time the watermarked document is verified.

Also, since it is not possible to reproduce the backgrounds evenly with ordinary copiers, once a watermarked document is printed, watermark verifications cannot be made with copied documents. Research is ongoing to ensure the uniqueness of printed documents by using this characteristic. If the research is successful, then it will be possible to determine that "The printed document in question has been printed by a person with the appropriate authority".

It is also possible to add decorative effect to the background, in the form of corporate logos, patterns and landscapes, by using multiple patterns with varying dot concentrations (densities) to implement expressions with gradations. (Fig. 2 shows an example of a document that has a watermark with such a background image. Fig. 3 is an enlargement of a section, which shows that information is inserted in the background image portions as well.)

Applications for Deterring Tamper and Forgery

As mentioned above, security features for printed documents that had been impossible in the past can be realized using Val-Code® technology. This technology can be used as a security solution for important printed documents in a wide range of applications.

By using the feature that makes it possible to verify documents, to determine whether malicious tampering had been made and even add security with a digital signature, it is also possible to use the same technology as it is, to deter fraudulent acts. These could include the tampering and forgery of important papers, such as various certificates and contracts. We are proposing such an application as TrustPaper® *1) solution.



Fig. 2 Example of a watermarked document with a background image



Fig. 3 Enlarged portion of a background image of a watermarked document

Printed documents, for which security assurance is desired, such as resident certificates and tax certificates, are currently printed on copy guard paper that displays letters, such as "COPY" when a copy is made. However, these clearly indicate messages only when copies are made, but it is not possible to detect any additions or tampering that may have been done on the original printed document itself. On the other hand, since LED printers with a high resolution have become more affordable, it has become possible to alter printed

documents by simply making additions with a printing quality that is equivalent to the original printing. By using the TrustPaper® solution, whether the printed document is authentic can be verified.



Fig. 4 Example of a tamper verification result screen of TrustPaper®

For example, in an application for resident certificates, in addition to the information needed for the tamper verification, information on the document, such as the name of the householder, and information on who printed the document with digital signature, can be watermarked when printing. When verification is made, the validity of the signature of the information on the person who printed the document will be verified as well as whether tampering has been made. If tampering has not been made and the document has been printed by an authorized personnel, then it would be possible to determine that such a document is an authentic resident certificate. Fig.4 shows an example of the verification result.

With TrustPaper®, all the information needed to verify tampering of a printed document is watermarked in the paper. Therefore, all processes can be completed offline with verification possible even in an environment where network access to the resident certificate database is not available.

Application for Secret Printing

Critical information can be watermarked imperceptibly in printed documents by utilizing the feature of Val-Code® that watermarked information in the background cannot be perceived by human eyes. The watermarked critical information can be displayed only on a computer screen, when the printed document is scanned by a person who holds key information for decrypting, using special application software. This feature is called secret printing and its process flow is shown in Fig. 5.

Secret printing allows readers with different authorities to view content according to the level of their authorities. For example, in an application for reporting internal business trips where the reports are circulated for approval, one could assume that items, such as "place" and "expenses" would be printed with visible letters, while items, such as "outcomes" and "bank account" could be printed invisibly. The manager to whom the person reports to may verify the "place" and "expenses" on paper, while the confidential information such as "outcomes" is to be read by using a special program. Approvals of business trips can be conducted in this manner. The accounting personnel may view the "bank account" item of the already approved document (which is recorded invisibly with Val-Code® for privacy protection reasons), by using a special program and then reimburse the expenses to the account indicated.

Application for Tracking Information Leakage

When Val-Code® is printed with a resolution of 300dpi or less and then duplicated with an ordinary copier, watermarks on printed document can be verified. This can be extremely effective, if used to trace the source of a leakage, if the information is leaked from a printed document. This can be done by including authentication information in the watermark about the person printing the document, as well as other information, such as date, time and the location of printing. Similar functions can be realized by printing two dimensional bar codes as well, but with two-dimensional bar codes, tracking is not possible if the bar code portion of the printed document is erased. The inserted information printed in the background, using Val-Code® technology, on the other hand, is difficult to separate from the printed document, making it a more effective means for tracking.

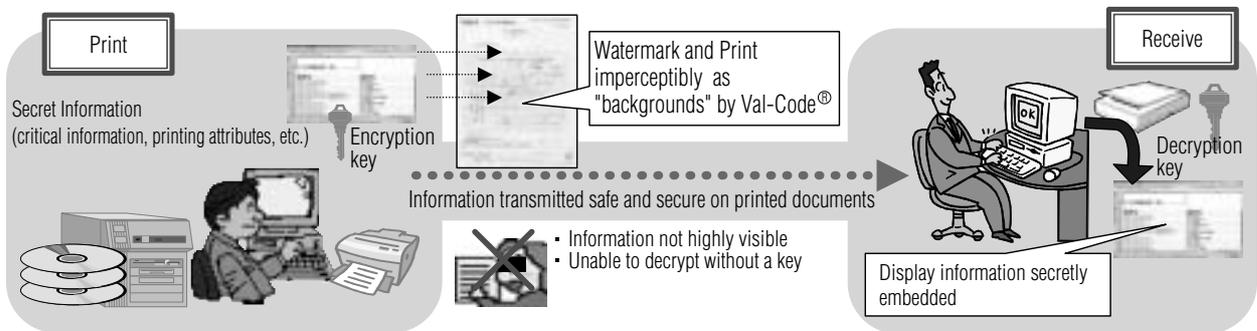


Fig. 5 A flow chart of Secret Printing

Application for Supporting Data Entry

The tamper detection feature of Val-Code® technology can also be used to verify whether a checkmark or writing has been added to a document.

When using OCR and OMR to perform an optical verification of markings and characters on sheets, it is necessary to prepare and refer to a separate format of information that indicates where on the sheet the information can be located, during verification. With Val-Code® technology, on the other hand, since the paper itself can be used as a media for the format of information, the system configuration can be made simple and the operation will also be easy.

In addition, dot patterns that represent information can also be used as markers, to indicate coordinates on a paper and these can be used to determine the locations of subjects for recognition within a scanned image with a high degree of accuracy. However, special ink is not required for the printing and special markings do not need to be printed even though the recognition accuracy is high. Aside from these, its highly resistant characteristics against folding and staining of paper, as well as its recognition of information with low cost scanners, make it easy to configure an information entry support system for verifying and compiling content, on which people have manually written information, with a high degree of accuracy, ease in use and at a low cost.

We are offering the AnswerRead™²⁾ solution for such purposes. The AnswerRead™ is a solution that supports data entry of information that has been hand written on paper media, such as application forms or questionnaires.

The information of such a paper media is currently being entered manually by operators. By using Val-Code® solution, information in check boxes can be entered automatically. Also, if columns need to be entered manually by operators, including fields used to enter special scripts, such as Kanji characters and since Val-Code® can detect the existence of entries if no entry is detected, then such a column can automatically be skipped to the next column. Also, if constraint conditions exist peculiar to questionnaires, such as “select one only” or “select up to three”, then these can be entered in the watermark printing of Val-Code® and simple checks of the entered data can be performed as well. Fig.6 shows an example of an automated entry of the response data on a questionnaire using the AnswerRead™ solution .



Fig. 6 Example of an automated entry screen of AnswerRead

²⁾ AnswerRead is a registered trademark of Oki Electric Industry Co., Ltd.

Conclusion

In this paper, we provided an overview of Val-Code® technology and introduced its applications.

In cooperation with Information-technology Promotion Agency, Japan (IPA), we are currently working on further development of Val-Code® technology to improve its tamper detection accuracy. We are also working on a technical development to further extend and identify new applications, as well as to develop prototypes for such applications.

In addition, we established an in-house venture company, Val-Code Venture Unit in May 2003, which promotes commercialization of these applications in new markets. The unit will be making its utmost efforts this year to pursue these markets by leveraging our strong relationship with financial and government institutions.

References

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