Counterfeit Currency Detection Techniques

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Counterfeiting, of whatever kind, has been occurring ever since humans grasped the concept of valuable items, and there has been an ongoing race between certifier (banks, for example) and counterfeiter ever since. This article summarises some of the current methods used to secure and validate paper currency.

Subsections

First-Line Inspection Methods

First-line inspection methods are used on-the-spot by vendors and retailers to determine, at best guess, the authenticity of currency being exchanged. The disadvantages of these methods are that they are generally easier to counterfeit than second-line inspection characteristics, since they're just as visible to the counterfeiter as to the verifier, and the methods used to apply them are usually inexpensive. However, the visibility of these features means that the general population is aware of the security measures and can spot many fraudulent notes quickly.

Varied-Density Watermarks

By varying the density of the paper a banknote is printed on in a controlled manner, thin watermarks can be applied. These are visible when a bright light shines onto the rear of banknote, and the varied paper density causes varying intensities of light to pass through, causing the watermarked image to appear on the other side of the note.

Ultraviolet Fluorescence

Embedding fluorescent fibres into the paper, or printing ultra-violet ink onto the paper, creates a form of optical verification easily used at counters, checkouts, etc. By exposing the note to ultra-violet light, the ink or fibres fluoresce, revealing a coloured pattern not visible under natural light.

Intaglio Printing

This gives a more complex and reliable first-line inspection method, since it is the printing process itself that serves to vouch for the authenticity of the document. The note is subjected to a high-pressure printing process that strengthens and slightly raises the paper's surface structure. Using different alignments of lines printed in this manner, a *latent image* can be produced which changes appearance depending on the angle at which the note is viewed.

This method can also be used with *optically-variable ink* to produce interference which shows different spectral colours when viewed from different angles.

Microtext

It is very common for banknotes to have incredibly small text printed at much higher resolutions than most commercial copiers, scanners or printers are capable of. When a copying or scanning attempt is made, the insufficient resolution causes the text to become illegibly blurred, announcing the illegitimacy of the note. This method requires specialised printing equipment but ultimately adds very little cost to the manufacture of the currency.

Holograms and Kinegrams (DOVIDs/ISIS)

These techniques are becoming more and more regularly used in modern anti-counterfeiting measures, once used mostly on credit/debit cards but now increasingly on new bank notes and cheques. In producing *diffractive optically-variable image devices* (DOVIDs), iridescent foils are added to the printed currency usually after printing. Kinegrams and holograms used in DOVIDs are produced by embossing *microprofiles* with thermoplastic films. The hologram itself is applied using the interference of light from different sources in a specific pattern, and kinegrams are produced with achromatic and polarisation effects. The result is a seemingly 3D full-colour image when illuminated from different angles.

ISIS uses stacked quantities of thin films to create a similar effect, with each layer having different refractive properties. The refraction of light when viewed is such that a spectral pattern has been extracted and a full-colour image is produced which varies under different viewing angles.

Second-Line Inspection Methods

A *second-line inspection method* is one that cannot be verified by the naked eye alone, and requires an extra device to perform a verification function. These are more secure and harder to counterfeit than visual methods, but the extra security adds extra cost at both the manufacturing and verification ends.

Isocheck/Isogram

Related to intaglio printing (described above), these methods rely on a specific pattern of dots and/or lines to cause a *moiré pattern* when printed or scanned. Hidden watermarks can also be applied in these patterns such that when a special filter is placed between the viewer and the note, the hidden verification is revealed and verifies the note as genuine.

Fibre-Based Certificates of Authenticity

Based on the characteristics of fibre-optic light transmission, this method makes use of unique configurations of fibres embedded in the paper.

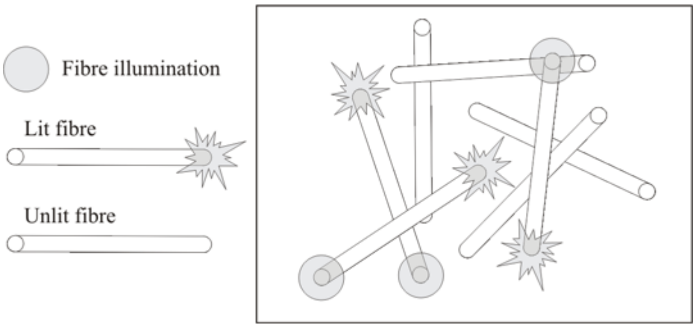

Figure 1: Conceptual scanning of embedded fibres

Using a scanner to illuminate one end of an embedded fibre, the other corresponding end of that fibre will become illuminated. By using the position of both illuminated ends (the one deliberately illuminated, and the one illuminated as a result), the certifier has a “fibre signature”. This string can then be converted into a bit string and combined with any extra data that is required (e.g. value, serial number, source, etc.). This is in turn combined with a cryptographic hash of itself and is signed using a private key, with the corresponding public key made available. The final result of these steps can then be encoded onto the banknote (this method is suitable for certifying a wide range of other documents too) in the form of a barcode or verification number of some kind.

Verifying the authenticity merely involves inverting the above process. The control number is verified using the public key corresponding to the private key initially used. The hash function is inverted and the original data string extracted. The note is then scanned using the same fibre illumination method described above, and if the extracted data matches the scanning observations, the document is genuine.

This technique can add a large cost to the manufacturing process of banknotes, but is highly secure and very difficult to illegitimately replicate. It may be excessive for smaller-value currencies, but for large-value notes, cheques or money orders this method provides a guarantee of the authenticity of the claim.

Colour and Feature Analysis

Several image-processing software packages now include a secret detection algorithm to prevent banknotes from being manipulated in their applications. Possibly by searching for a specific geometric pattern—five 1mm-large circles arranged like a four-pronged star is the primary candidate, visible in Euro notes, pounds sterling notes and older now-obsolete European currency—they classify images of banknotes and refuse any further processing. This prevents amateur/casual counterfeiting taking advantage of cheaper and higher-quality scanning and printing equipment (see http://www.rulesforuse.org/).

Several techniques, such as wavelet compression, noise removal, shearing and mean filtering, provide methods of filtering images for specific features that give away genuine currency. These features are embedded very subtly and are usually dependent on a number of different variations that do not remain true during copying processes.

Further Reading

Hardin, R. W., *"Optical Tricks Designed to Foil Counterfeiters"*. *OE Reports* Number 191, International Society for Optical Engineering, November 1999. http://www.spie.org/web/oer/november/nov99/cover2.html (accessed 30/1/06).

Chen Y., Mihcak, M. K., Kirovski, D., *"Certifying Authenticity via Fiber-Infused Paper"*. Microsoft Research. http://research.microsoft.com/~kivancm/publications/fibercoa.pdf (accessed 30/1/06).

Murdoch, S. J., *"Software Detection of Currency"*. University of Cambridge Computer Lab, 2004. http://www.cl.cam.ac.uk/users/sjm217/projects/currency/ (accessed 25/1/06).