BRIEF COMMUNICATIONS

'Fingerprinting' documents and packaging

Unique surface imperfections serve as an easily identifiable feature in the fight against fraud.

We have found that almost all paper documents, plastic cards and product packaging contain a unique physical identity code formed from microscopic imperfections in the surface. This covert 'fingerprint' is intrinsic and virtually impossible to modify controllably. It can be rapidly read using a low-cost portable laser scanner. Most forms of document and branded-product fraud could be rendered obsolete by use of this code.

Naturally occurring randomness in the physical properties of an attached tag or token is a means of ascribing a unique identifier to documents and objects[1–4]. We have investigated the possibility of using the intrinsic roughness present on all non-reflective surfaces as a source of physical randomness. This has the potential to provide strong, in-built, hidden security for a wide range of paper, plastic or cardboard objects.

Making use of the optical phenomenon of laser speckle[5], we examined the fine structure of different surfaces using the diffuse scattering of a focused laser. Speckle has been used for determining, among other things, surface roughness[6], small deformations of metal and wet paper[7], shear moduli of paper[8] and for visualizing blood flow *in vivo*[9].

Figure 1a shows the results of scanning a focused laser beam across a sheet of standard white paper and continuously recording the reflected intensity from four different angles by using four photodetectors. (See supplementary information for methods.) Statistical analysis indicates that there are pseudo-random fluctuations that have a minimum wavelength of 70 μm. The fluctuations from the mean intensity are digitized into ones and zeros to form the fingerprint code for the object.

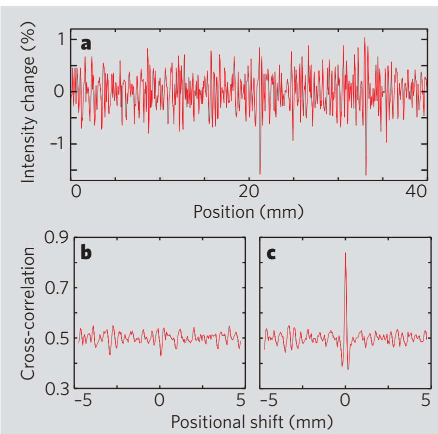

Figure 1 | Comparing document fingerprints. a, The fluctuation in diffuse intensity at one photodetector as a focused laser beam is scanned across a 40-mm length of white paper. b, Digital cross-correlation between two scans from different sheets of paper. c, Digital cross-correlation between two scans from the same sheet of paper.

Figure 1b shows the digital cross-correlation between this scan and a similar scan from a different sheet of paper from the pack. The absence of any strong peak indicates that the scans are independent of each other. By contrast, the digital cross-correlation between the original scan and a subsequent scan from the same sheet of paper taken three days later, with normal handling of the paper in between, shows a strong peak close to zero positional shift (Fig. 1c); this indicates that the scans are largely identical. Similar results were obtained from matt-finish plastic cards (such as credit cards), identity cards and coated paperboard packaging (as used to pack pharmaceuticals and cosmetics, for example).

Recognition was good even after the object had been roughly handled. For paper, this included screwing it into a tight ball, followed by smoothing to leave a badly creased surface; submerging it in cold water for 5 min, followed by natural drying; baking it in air at 180 °C for 30 min to scorch the surface; scribbling heavily over the scanned area with a ball-point pen and a thick black marker pen; or scrubbing the surface with an abrasive cleaning pad. Misplacements of the object on the scanner by up to ± 1 mm and 2° were judged acceptable.

The amplitude of the cross-correlation peak can be used to determine the probability of two objects sharing indistinguishable fingerprints. For the paper studied here, the probability was less than 10^{-72} (see supplementary information). Smoother surfaces, such as matt-finish plastic cards and coated paperboard, typically give probabilities of less than 10^{-20}. The speckle signal therefore serves as a virtually unique fingerprint for the object. Each fingerprint requires about 200–500 bytes of storage space.

Most existing security validation schemes rely on a proprietary manufacturing process that would be difficult for a fraudster to reproduce (for example, holograms or security inks). Our findings open the way to a new approach to authentication and tracking — even the inventors would not be able to carry out a physical attack on this fingerprint as there is no known manufacturing process for copying surface imperfections at the required level of precision. There is no need to modify the protected item in any way through the addition of tags, chips or inks, so protection is covert, low-cost, simple to integrate into the manufacturing process, and immune to attacks directed against the security feature itself.

Duck and weave: the microscopic patterns on the surface of paper will survive a thorough soaking.

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