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The Smartphone as a Security Print Inspection Tool

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Abstract

There is currently substantial interest from the Security Print and Authentication industries in the use of smartphones to authenticate and verify products from printed features. Past meetings of this conference have shown some of the printed features that have been produced with this in mind. However, with the rapid evolution of smartphone vision systems there are now opportunities for a new generation of print features to provide extra layers of security to documents and packaging.

This work will illustrate the opportunity for a combined approach between print and electronic imaging communities to bring forward a new generation of features. However, it will also show that the different rates of secure document and smartphone product development cycles bring tensions that have yet to be resolved.

The work is illustrated with some practical examples of the imaging capabilities of current smartphones. It is shown that the close focus performance of today's mobile video frame capture enables considerable opportunity for print inspection and authentication.

Introduction

The smartphone has become a pervasive technology in modern society. In addition to the (sometimes peripheral) use as a voice telecommunications device it has a number of facilities that can aid the inspection and verification of security features. There is currently substantial interest from the Security Print and Authentication industries in the use of smartphones to authenticate and verify products from printed features and this conference has shown some of the printed features that have been produced with this in mind [1].

It would be easy and tempting but unrealistic to consider smartphone verification technology as a comprehensive authentication and track and trace tool for secure print. It needs to be implemented as part of an "ecosystem" that includes all our normal elements such as print features and intelligent design [2]. However, the rapid evolution of smartphone vision systems brings opportunities for a new generation of print features to provide extra layers of security to documents and packaging.

Smartphones for feature illumination

One useful facility is the incorporation of the light source. This can be used as a torch light to illuminate an optical feature such as a hologram as it approximates well to a point light source. It also finds application to visualize transmission features on a polymer banknote.

There are also some interesting uses of the display screen as an illumination source for a reflected feature. The polarized light output of LCD and some OLED screens has been used to interrogate some features. Perhaps more of interest is the HawkSpex® system from the Fraunhofer Institute for Factory Operation and Automation (IFF) which uses an app to change the color display illumination capabilities. Together with the color filter array in the camera this system produces additional color information on the object being examined; a forerunner to the hyperspectral systems to be discussed later.

Smartphone use to aid examination

One of the issues with the continuous evolution of optically variable features like holograms and color shifting inks is educating the consumer about what an authentic feature should look like. The smartphone platform, with the combination of Internet connectivity and display can be used to educate the public in this respect. A good example of this is provided by the introduction of the Bank of England £5 note where an app was released to provide information for retailers and the public on the security features [3].

We should remember that not all the mobile phones in the world can be described as "smart" and applications may need to take this into account. For example, in some Indian states tax stamps have also carried a human- readable 12- or 14-digit serial number which can be sent for validation via SMS to a designated number [4].

Machine vision validation

One key element in smartphone authentication solutions for secure print is the vision capability conferred by the camera system. The system description is important as this is increasingly more than just an image capture device – there is a whole image processing subsystem within the smartphone too. And developments in this area can be in part attributed to the machine vision capabilities of the device.

The security document market has a somewhat conservative outlook so the timescale for the adoption of new technologies can be somewhat lengthy. Fortunately there are existing examples of machine vision implementation, notably in e-gates at airport immigration and passport readers [5]. In terms of smartphone machine vision the visualization, reading and network access of information from 2D codes such as QR is currently the lead application, especially as some smartphone operating system and popular apps now have embedded QR code support.

One of the strengths of the smartphone platform is the fact that multiple inputs can be linked together to enhance security. For example, there are commercially available systems that lock together camera data from a QR code with electronic data from ID document acquired using the NFC capabilities of the smartphone. A high-end example of this sort of capability is the German ID document family (card and 2017 passport). On the passport a card access number is inkjet printed onto page 2 and via machine vision is used as the verification code to unlock the NFC capability. However, it is sensible to remember that not all smartphones currently feature NFC capability and that other RF technologies may yet usurp it.

It has already been demonstrated that smartphones can be used as real-time detectors of quasi-periodic patterns such as data bearing clustered-dot halftones where the clusters are shifted to record information [1]. 2D Fourier transforms can be computed at video frame rates and used to identify peaks in the frequency domain [6,7]. An example of this is shown in Figure 1.

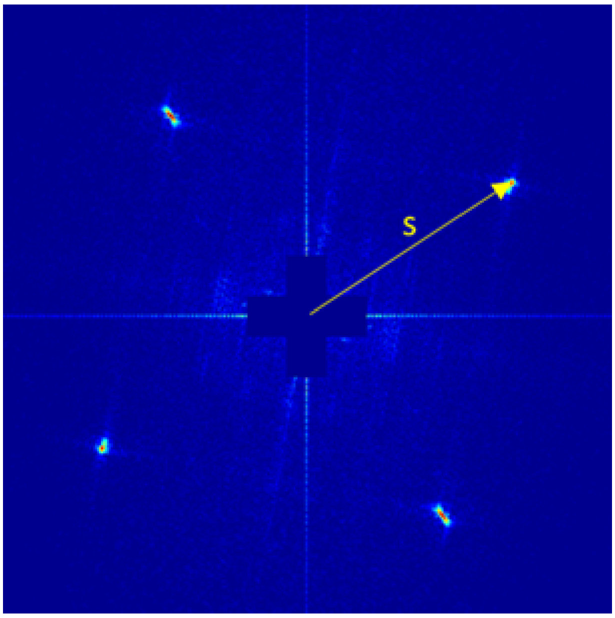

Figure 1. Example peaks in the frequency domain that can be generated at video rates.

Along with being an efficient way to detect quasi-periodic security marks, the peaks will also accurately identify the rotational angle, and deliver spatial dimensions. When the printed pattern period and camera characteristics are known, the Fourier peaks will determine both the capture resolution and camera-to-document distance; in this sense the mobile device can even be used as a range finder as depicted in Figure 2.

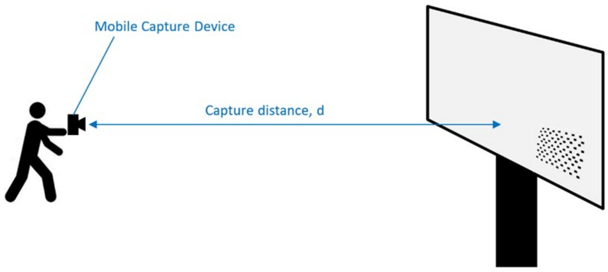

Figure 2. Smartphone used as a frequency-domain-based range finder.

When the document distance is known but the printed pattern resolution is not, the peaks will determine the printed pattern resolution and physical size. Using a thin lens model for the mobile camera, the relationship between a Fourier peak distance from the DC term shown as the length "s" in Figure 1, and the camera-to-document distance is a linear one. The smartphone is an effective tool for both near and far field inspection.

Camera performance

It would be convenient to assume that all smartphones have equal vision capabilities as this has implications for the deployment of smartphone authentication programs. This is patently not the case and an understanding of the parameters that govern camera performance will be of great assistance to better machine vision authentication solutions. The imaging science knowledge within IS&T is of obvious benefit here, as is the knowledge embedded in the International Standards community around Photography – ISO TC 42.

The role of ISO TC 42 (Photography)

There are a number of International Standards created by ISO TC 42, and in particular their Working Group 18 (Electronic still picture imaging) that are of particular interest to smartphone programs in secure documents. We cite 2 examples here but there are more that are pertinent to the testing of smartphones for document examination.

Noise performance of smartphone cameras can be a significant issue as the pixel sizes shrink due to design pressure to reduce sensor and lens sizes. The evaluation of image noise performance is covered by ISO 15739:2017 [8]. Using this methodology different smartphone makes and models have been evaluated, showing significant differences [9].

Colorimetric accuracy is another consideration when considering smartphone authentication. In defense of the industry we should recognize that smartphones are not intended for such work. The predominant customer requirement is for a subjectively pleasing image rather than one that is a hard representation of reality and each manufacturer / model / device may produce a different result. ISO TC 42 has done an excellent job of laying out some of the issues involved in attempting color accuracy from digital camera systems in ISO 17321 [10].

The lesson for security print feature verification is that not all mobile solutions are equal and an app that works well on one may not work as well on another.

The issue of camera resolution

This another area where ISO TC 42 can contribute, using the work documented in ISO 12233 [11]. However, in this case the issues are a little wider, in terms of both industry education, public perception and imaging science. Within the secure document industry there are still those who equate resolution with number of pixels as an easy single figure metric, rather than what object is to be imaged and how it will be evaluated.

This industry is open to the use of magnifying accessories for smartphones if the native resolution needs to be boosted. A current example of this is the Surys Optokey™ 2 level smartphone system where second level authentication requires a magnifier attached to the phone's camera lens.

Even without magnifying assistance, the close focus performance of today's mobile video frame capture enables considerable opportunity for print inspection and authentication.

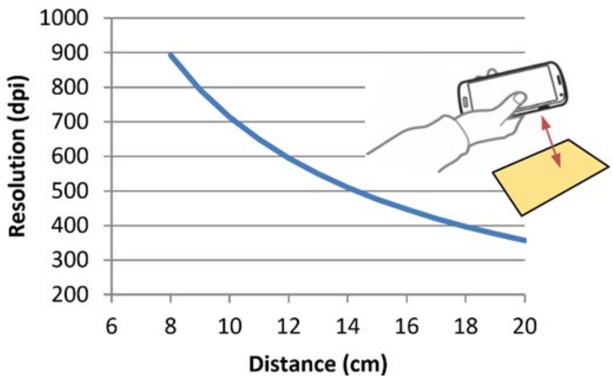

Figure 3. Close-focus mobile video capture resolution as a function of distance

Figure 3 shows the typical mobile video frame capture resolution as a function of camera-to-document distance. 900 dpi can be achieved at the close focus limit of 8.5 cm for standard HD video. Still-frame photo capture, which uses the full sensor, is even higher but less convent that continuous video because of its slower capture speed.

The future

There are a number of technologies set for implementation on the smartphone platform that could well be deployed for secure print verification.

Stereo vision

One change that is already taking place is a general increase in the number of cameras incorporated in the smartphone. This change is in part to implement a machine vision application – facial recognition. The aim of this is to enable the camera systems to optically verify that the person accessing certain applications is authorized to do so.

But of more significance to secure print verification is the implementation of forward looking stereo vision for AR/VR applications. Together with the image processing capabilities of the smartphone platform this could provide a verification platform for a variety of moving image features such as embossed holograms and features comprising lens arrays.

Multi and hyper spectral imaging

The number of imaging systems incorporated into smartphones is increasing. Some of these are to improve picture resolution but others will take the imaging capability outside of RGB color space, producing opportunities for new authentication routes. One early extension has been into the field of near infrared (NIR) imaging, an area already well explored in printed security features [12]. NIR capability now feature in some smartphones for biometric authentication and this trend looks set to continue into rearward looking NIR for AR/VR applications.

Perhaps even more interesting for security print authentication is the potential of hyperspectral imaging [13]. Driven by customer needs for food and drug provenance early smartphone implementations featuring hyperspectral cameras are beginning to appear, as an example the Changhong H2 smartphone.

Future technology platforms

When considering smartphone programs for secure print verification we should remember that the smartphone platform is only around 10 years old and in that time has already been through a number of product generations. By comparison, an identity document such as a passport is a stable technology over a 10-year lifetime. Where this technology lead, especially as the smartphone market reaches saturation and commoditization in an open question. In the case of long lifetime identity documents it may be necessary to keep this disparity of product life cycle times in mind.

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Author Biography

Alan has 35 years experience across the digital print and imaging industry, starting as an image physicist in the photographic industry. He has been involved in secure documents for the past 15 years, both within the industry and as an external consultant. He teaches courses at security and imaging conferences. Over the last 5 years he has been investigating the applicability of smartphone technology to the secured document industry and is currently compiling a guidebook on this topic.

Alan is a past President of the IS&T, a past Chair of the Institute of Physics Printing and Graphics Science Group and a Fellow of both the Institute of Physics and The Royal Photographic Society. He is based in the UK and is a Visiting Academic at the University of Manchester Centre for Digital Fabrication. He chairs a number of committees developing International Standards in Photography, Printed Electronics and Wearable Smart Devices