Real World Advantages of Moisture Discriminating Optics™ in Live Scan Digital Fingerprint Imaging

Introduction

Since its introduction in the late 1980's, live digital fingerprint imaging (commonly known as "live scan") technology has become widely used in civil applicant and criminal arrest fingerprinting. In the United States, many agencies have reached the goal of obtaining 80% or more of all exemplar fingerprint images through live scan imaging for identification and background investigation purposes. While today's FBI accredited live scan systems have the optical acuity to obtain consistently high quality images, in the real world of arrest and civil fingerprinting, live scan operators may frequently find it necessary to compromise image quality to meet production goals. This paper describes how the recent development of Moisture Discriminating Optics™ technology can help operators avoid these compromises, permitting the full advantages of live digital imaging to be realized by the fingerprint community.

Understanding Conventional or FIR Optics and the Characteristics of Moisture Discriminating Optics

All of today's FBI accredited live scan fingerprinting systems exploit a similar principle to obtain live images of plain and rolled fingerprint impressions without the use of ink and paper. This principle is an optical phenomenon known as "Frustrated (Total) Internal Reflection" sometimes referred to by the acronyms FTIR or FIR. To understand Moisture Discriminating Optics, it is first necessary to understand the principles of ordinary FIR optics.

When light passes from one medium to another (e.g. from air to glass) it is "refracted" or scattered in a predictable way. As depicted in the schematic in Figure One, light interacting with a glass (or plastic) prism experiences changes in medium as it enters the prism, as it reaches the air/glass interface at the top of the prism, and finally, as it passes out of the opposite face of the prism. At each of the discontinuities in medium, a portion of the light will be scattered (both reflected and bent in a different direction) in accordance with the "refractive index" of the media. In fact, light interacting with the top surface of the prism will normally be totally internally reflected, as if it would when encountering a mirrored surface with the angle of incidence equal to the angle of reflection. However, where fingertip ridge material is brought into contact with the top surface of the prism, there will be a change in the refractive index at that interface which "frustrates" the light's tendency to reflect, causing much of the incident light to scatter away from the normal angle of reflection. Live scan imaging systems take advantage of this well-known FIR phenomenon by "viewing" the reflected light from the prism with a solid state camera. Wherever the platen surface is clear, the camera will see a bright reflection, and wherever fingerprint ridges are in contact with the prism surface, the camera will see darker areas. The result is that the camera "sees" a clear, sharp fingerprint image that looks virtually identical to a fingerprint taken using black printer's ink on a white paper surface.

Figure One: Fingerprint Imaging Using the Principle of Frustrated Internal Reflection

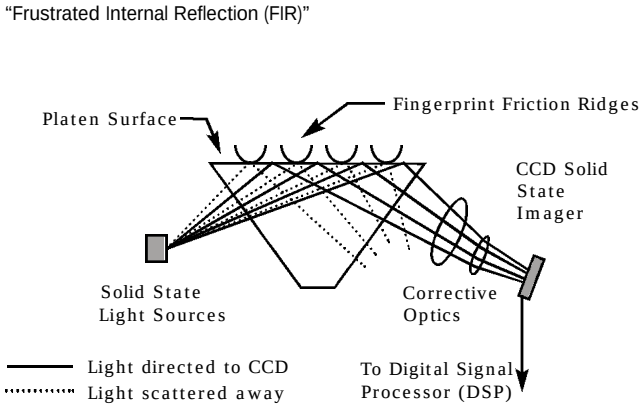
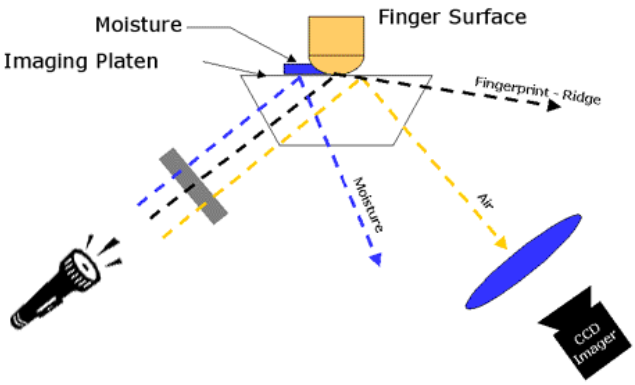


Figure Two: Moisture Effects on Conventional Frustrated Internal Reflection Optics



This FIR principle combined with modern advances in solid state (nearly monochromatic) bright light sources, high quality mass produced optics and CCD and CMOS solid state digital cameras, has made possible the widespread adoption of live scan fingerprint imaging. However, even with the most advanced high resolution imagers, these systems are not without their limitations in real world use. One of the most vexing problems has been the effect of moisture on imaging quality. As shown in Figure Two, ***conventional FIR optics will image moisture just as they image fingerprint ridges.*** That is, light interacting with moisture on the platen surface (or on the fingertips of the subject and therefore between the ridges and platen surface) scatters away from the camera and images as black just as does light interacting with skin ridge material. Moisture on the platen surface, therefore, obscures the details of the ridges themselves. Unfortunately, the physiology of human beings is such that the sweat pores are located within the papillar friction ridges of the skin. Thus, the very portion of the human hand that we wish to image is actually the source of the obscuring moisture. The only real remedy that is available for this problem is to extensively dry the subject's skin by cleansing, air drying and toweling. However, a subject under pressure tends to sweat profusely so that any attempt to dry is quickly overcome by the moisture pumping out of the sweat pores. Even for subjects who do not sweat profusely, drying off residual moisture also dries out the skin surface so that the friction ridges tend to lose their flexibility and fail to make good contact with the platen and are therefore not imaged clearly.

Early in the development of its live scan systems, Identix recognized *that* ***the moisture problem of conventional optics represents a substantial impediment to the effective use of digital fingerprint imaging.*** As a result, the Company researched heavily on methods to overcome this significant limitation.

In the mid-1990's, Identix obtained a patent on an innovative variant of internal reflection optics - a specialized optical arrangement between the light source, the platen and the imager (camera) - which could "discriminate" between skin ridge material and moisture so that they do not image in the same way. After substantial optical research efforts, Identix

Figure Three: Moisture Effects on Moisture Discriminating Frustrated Internal Reflection Optics

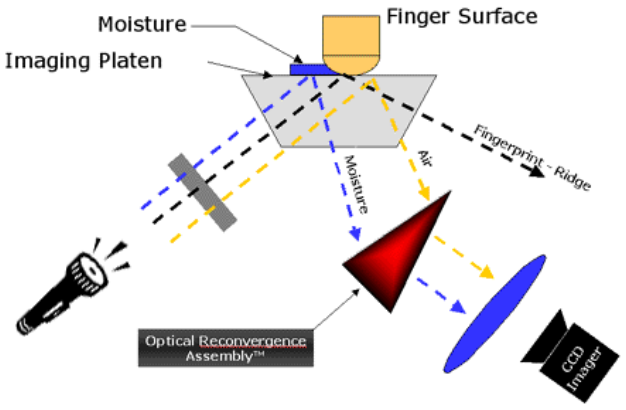


Figure Four: Galton Level 3 Detail from a Portion of a Human Fingerprint

found a way to realize this patented optical design technique. As shown in Figure Three, with Moisture Discriminating Optics, ***incident light interacts with moisture on the platen surface just as it would with a clear platen.***

This specialized optical arrangement means that the digital camera is able to discriminate between moisture and fingerprint ridges so that the camera does not "see" the moisture and the moisture does not obscure the details of the fingerprint ridges. Moreover, with Moisture Discriminating Optics, the presence of moderate amounts of moisture can actually be beneficial by helping to maintain good flexibility of the skin ridges so that they maintain good contact with the platen. The realization of Moisture Discriminating Optics, therefore represents a "breakthrough" in imaging quality for the use of live scan with real world subjects.

Forensic Advantages of Moisture Discriminating Optics

The use of a live scan system with Moisture Discriminating Optics can provide immediate benefits in terms of the clarity and forensic utility of the digital fingerprint images that are captured from live subjects. This is particularly true when high resolution digital imaging (600 dpi or greater) is employed. Unlike conventional 500 dpi imaging, high resolution imaging has the potential to provide clear, repeatable images of not only Galton Type 1 (general ridge flow and pattern configuration), and Galton Type 2 (ridge endings, bifurcations, etc.) information, but also the minute dimensional attributes of the individual ridges known as Galton Type 3 detail (ridge path deviation, width, shape, pores, edge contour, incipient ridges, breaks, creases, scars and other permanent details). An example of such fine detail is shown in the blow-up of a fingerprint image in Figure Four.

Expert latent print (LP) examiners can use this fine detail (which is often called "ridgeoscopy" and "poroscopy") from good quality on-file exemplars to make high confidence matches on fragmentary latent fingerprints lifted from crime scenes.

Figure Five: Loss of Galton Level 2 and 3 Details in the Presence of Moisture without Moisture Discriminating Optics

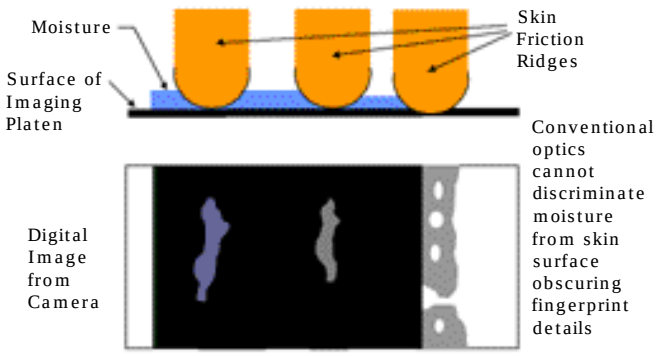
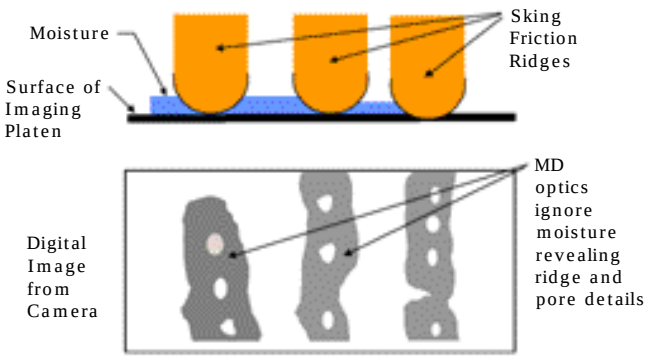


Figure Six: Preservation of Galton Level 2 and 3 Details in the Presence of Moisture on a Live Scan System with Moisture Discriminating Optics



Unfortunately, even with the highest resolution digital live scan imaging, these fine details can be "lost" through the obscuring effects of moisture. In fact, since the sweat pores are the principal source of moisture on the skin surface, these valuable points of identification may not image reliably using conventional FIR optics. Likewise, as shown in Figure Five, the fine details of ridge shape may be obscured by moisture, and even Level 2 details may be improperly coded due to bridging that can occur as a result of moisture, compromising even roll print to roll print comparisons.

Also as shown in Figure Five, moisture between the skin surface and the platen surface causes the fingerprint to imaged dark or even solid black, obscuring the ridge details. However, when this same situation is encountered by a live scan system with Moisture Discriminating Optics, the results can be strikingly different, as depicted in Figure Six.

(Note: Excellent references on the terminology of Galton Level 1, 2 and 3 detail may be found in the publications of David Ashbaugh and of the "SWGFAST" working group of the United States government law enforcement agencies).

The forensic usability advantage conferred by Moisture Discriminating Optics is more than just theoretical. In Figures Seven and Eight we see actual rolled fingerprint images taken with and without Moisture Discriminating Optics from the same human finger with identical moisture conditions.

The actual live scan images shown in Figures Seven and Eight clearly demonstrate the forensic imaging advantage that can come from the use of Moisture Discriminating Optics in live digital imaging systems. In fact, in a study undertaken by expert latent print examiners from the United Kingdom Automated Fingerprint Recognition (UKAFR) Consortium in October of 1999, the examiners found that the "ridgeoscopy" of images taken with Moisture Discriminating Optics provided better repeatability of pore presence/absence and of pore placement minutia points than images taken with either ink or with conventional live scan.

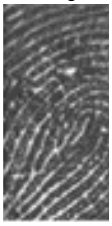
Figure Seven: Comparison of Actual Fingerprints Taken With and Without Moisture Discriminating Optics

Without Moisture Discriminating™ Optics

With Moisture Discriminating™ Optics

Figure Eight: Close Up Details from Images in Figure Seven

Without Moisture Discriminating™ Optics



With Moisture Discriminating™ Optics

Magnified Images of Moist Fingerprint

Operational Advantages of Moisture Discriminating Optics in Criminal Arrest Processing

Imaging of live subjects in the "real world" of criminal arrest fingerprinting can be very challenging. Arrested subjects may be uncooperative and are usually under stress so that they may sweat profusely during processing. Live scan operators in this environment are often overworked, may not be well trained in the science of fingerprints, and are often distracted by other responsibilities beyond arrest processing. Booking room live scan operators may not have the time that they need to ensure that the subject's skin surface is properly dried and conditioned to obtain optimal quality fingerprints. In fact, many arrest fingerprints, taken with ink or with conventional live scan systems are later found to be of substandard quality for forensic investigation and latent examination purposes.

The introduction of Moisture Discriminating Optics into the world of booking gives live scan operators a significant boost to obtaining the best quality live digital images of arrestee fingerprints. Rather than having to ensure that the subject's skin and the platen surface are completely dry, yet adequately supple (by the application of greaseless skin conditioners such as Corn Huskers®, lotion), with Moisture Discriminating Optics, the operator can quickly and efficiently obtain acceptable and even good quality prints from each subject. Thus, Moisture Discriminating Optics effectively removes one of the main barriers to high quality arrest fingerprinting and eliminates the "speed versus quality" tradeoff that would otherwise be made.

Operational Advantages of Moisture Discriminating Optics in Civil Applicant Processing

The task of the live scan operator responsible for the acquisition of fingerprint images for criminal background checks is likewise very challenging in the "real world". Whereas central bureaus will often accept less than perfect fingerprints from arresting agencies, these same bureaus are free to reject civil applicant submissions on quality grounds. Thus, civil live scan operators are faced with the challenge of recording "readable" fingerprints on each and every record. A failure to achieve this goal will often result in great frustration for the applicant (who must be re-fingerprinted) and for the potential hiring agency (who must bear the cost of resubmission and the cost of delays in hiring for needed personnel).

Figure Nine: Live Scan Digital Imaging of Plain and Rolled Fingerprint Impressions

Furthermore, while arrested subjects, on average, tend to be drawn from a narrow range of age/gender (typically males aged 18-40 years), persons applying for positions of trust (e.g. foster parents, bank employees, brokerage employees) will span a much broader age range (typically 18-75) and will be from both sexes. While too much moisture is also a problem in civil applicant fingerprinting, an even more common problem in fingerprinting of older subjects and women is an inability to achieve sufficient "coupling" between the subject's skin and the platen surface, particularly during rolled fingerprint imaging. Lack of coupling results from too little skin moisture. Unfortunately, with conventional live scan systems there are very few skin preparation fluids that can soften the skin surface without obscuring ridge details. ***A very important advantage of Moisture Discriminating Optics is that live scan operators can actually use water-based fluids to soften the skin and to ensure good coupling during fingerprint rolling and plain impression imaging*** (see Figure Nine).

Again, Moisture Discriminating Optics is a significant advantage for the live scan operator who must consistently obtain high quality fingerprints for the largest possible range of skin conditions that may be correlated with age, gender, race, and vocation.

Conclusion

The use of live scan systems with Moisture Discriminating Optics leads to a high probability of success in the capture of "readable" and forensically useful fingerprint records in the real world of criminal arrest and criminal history background checks. Efficient, high quality imaging saves both time and money and helps to ensure the continuing safety and civil liberties of the public at large.