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MICRO INSPECTION TECHNOLOGY (Edge of Light Optical Enhancement Technology) - UPDATE 1997

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TECHNICAL MEMORANDUM

Submitted by:

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NOTE: Further information about this report can be obtained by calling the CPRC information number (613) 998-6343

EXECUTIVE SUMMARY

Edge of Light scanning is an optical enhancement technique invented and being developed at the Institute for Aerospace Research at the National Research Council of Canada for the inspection of aircraft exterior surfaces for crack detection. With the development of a temporary film coating procedure, the technique was adapted to the inspection of paper surfaces. This led to investigation of counterfeit money, art forgery, handwriting impressions, altered credit cards and fingerprints.

The next step in deciding whether this technology has an application in the police and security community is to put the prototype system into use by police forces.

RÉSUMÉ

Le procédé de rehaussement optique à contre-jour Edge of Light fait appel à une amelioration technique inventée et mise actuellement au point par l'Institut de recherche aerospatiale du Conseil national de recherches du Canada qui devrait permettre de détecter la presence de criques sur les surfaces extérieures des aéronefs. Après la mise au point d'un procédé de pelliculage temporaire, cette technique a été adaptée à l'inspection des surfaces de papier, ce qui a abouti à la detection de la fausse monnaie, des oeuvres d'art contrefaites, des cartes de credits trafiquées et des empreintes digitales.

La prochaine étape nécessaire avant de decider de l'utilité de ce procédé dans les services de police et de sécurité consistera à mettre le système prototype à la disposition des forces policieres.

INTRODUCTION

In **1994,** the staff of the Institute for Aerospace Research (IAR) of the National Research Council of Canada (NRC), in collaboration with the Canadian Police Research Centre's Chief Scientist, experimented with the use of new optical techniques for the examination of surfaces for forensic purposes. A Technical Memorandum (TM-20-95) was prepared to report on potential applications for the "D Sight™" technology (D Sight'" is the property of Diffracto Limited).

This memorandum describes several potential applications of an IAR/NRC Edge Of Light (EOL) optical enhancement technology (patent pending), that may be of interest to the police and security communities.

BACKGROUND

In the summer of 1994 one of the authors (Mr. A. Marincak) modified the optics of a hand-held line scanner to acquire surface topographical details. Many imaging systems are known to produce a representation of the surface of an object. for example, the photocopier is one such system. The problem with such systems is that they do not make good representations of topographically rich surfaces due to the two-dimensional nature of such systems. NRC's EOL optical enhancement technology is capable of providing an enhanced representation of topographical detail in a two-dimensional image.

Since the IAR/NRC was already looking at the surface characteristics of genuine versus counterfeit paper currency notes, using D Sight™", it was most appropriate to try the EOL technique. Other surfaces scanned included credit cards, oil paintings, watercolor paintings, hand writing impressions and fingerprints.

EOL TECHNICAL DESCRIPTION

The optical path in the EOL scanner converts surface slope changes into light intensity variations. A light source passing through a slit is used to produce a rectangular band of light on the surface of the object to be scanned. The band has an edge zone where the intensity drops off rapidly. In the main zone of the band, the intensity is constant but at the edge the intensity does not fall to zero immediately due to diffraction effects, although it does fall off very rapidly with distance. The surface is scanned in this zone at a grazing angle. The intensity of light recorded is constant if the surface is smooth. A change in slope appearing in the edge zone changes the surface observation point causing a shift in intensity. The EOL scanner performance can be tuned by expanding or compressing the edge zone, varying the angle of illumination or changing the viewing angle. The scanner travels along the surface of interest providing a high resolution map of the surface topography.

At present, the IAR/NRC uses modified commercial Personal Computer grey scale line scanners. Since the EOL scanner converts slope to light intensity changes any color information is redundant. The available resolutions are from 100 dpi to 400 dpi.

POTENTIAL APPLICATIONS FOR EOL MICRO-INSPECTION

Notes:

1) All images presented in the figures are degraded due to the resolution of the printer.
2) The following examples have been investigated in exploratory studies and hence the results should not be considered optimal.
3) Images identified as 'normal scan' were collected with an unmodified hand-held line scanner.
4) Generally the paper specimens could not be imaged directly by the EOL scanning technology because of poor reflectivity. In order to 'see' the topography of these surfaces, an IAR/NRC process (patent pending) is used to conform various thin film materials to the surface. This process was developed to temporarily modify the reflective properties of materials and initially used with the D Sight™ inspection technique.
5) Some surfaces such as the oil paintings could be imaged directly with the EOL scanner but this does not necessarily preclude the use of the IAR/NRC thin film process.

Credit card

Figure 1 is of an altered credit card, supplied and manufactured by the RCMP. The three lines of numbers provide a clear comparison of the different dies that made the impressions. The bottom line shows the modification of the last three numbers and the trace signature of the original numbers. The EOL image of the rear surface provided further details of the individual characteristics of the dies used.

Figure 2 is of the same image as in l(a) and shows the results of applying an edge detection filter (2(a)) and the possible advantages of doing so. The view in 2(b) was produced by applying an 'emboss' filter.

An enlarged view of the front and rear surfaces of a second altered credit card are shown in Figure 3. Artifacts of the original impressions are evident in the sheet material and within the new impressions.

Handwriting on paper

The view in Figure 4 is an EOL scanned image of the second sheet in a pad of paper. The EOL image clearly shows the sequence of strokes in the impression made in the second sheet from the handwriting on the first sheet.

Fingerprints

Fingerprint images are often difficult to obtain depending on the surface they have been laid down on. Figure 5 is an EOL scanned image of a fingerprint on the glossy surface of a book cover. The fingerprint itself is not treated by any other means.
Figure 6 is an EOL scanned image of a fingerprint put down on the surface of a piece of glass. Again the print itself is not treated by any other means.

Art

A forged copy of a painting would attempt to mimic the materials and colours of the original. A genuine painting can be authenticated only by an art expert. With the EOL scanner it was found that a definitive record of the brush strokes or paint distribution on the original can be captured. This record could provide such specific detail of the original as to make it impossible to create an exact copy. The record, made of a small area of a painting, can be accomplished quickly.

For comparison, two views of the same area from an oil painting are provided in Figure 7. The EOL scan shown in Figure 7(a) indicates the unique brush strokes and paint thickness while still representing the different reflectivity of the colours. The image in 7(b) is from a normal line scanner which represents only the different colours. Figure 8 is a portion of the EOL scanned image in Figure 7, digitally enlarged.

Figure 9(a) is an EOL scanned image of a watercolor painting with an enlarged view, 9(b), of the boxed area. In the original of this image the distribution of the paint and some characteristics of the backing material were more defined. Whether this would be enough information to uniquely identify the painting remains to be decided by an art expert.

Paper Currency

Figure 10 includes two enlargements, for comparison, of the same view of a Canadian Tire™ coupon. The EOL image clearly shows the raised surfaces or topography of the intaglio printing and creases in the paper.

A genuine Canadian $20 note is shown in a normal line scan image in Figure 1 l(a). For comparison the same note was imaged with the EOL scanner and is shown in Figure 1 l(b). Some features of a genuine note are not topographical and as such do not register in the EOL view.

To illustrate that the information which is being represented in the EOL view is strictly topographical, two notes were placed under a sheet of aluminum foil using the IAR/NRC thin film process. Many topographical features from the genuine $20 Canadian note are evident whereas the only feature from the counterfeit are the creases.

Paper currency notes wear relatively quickly. Figure 13(a) is an EOL scan of a genuine note that has been in circulation yet still retains significant topographical detail. A counterfeit of the same pattern displays only the features from the bond paper which was used including the watermark (13(b)).

Often the paper stock used in counterfeit notes has been mechanically distressed in an attempt to mimic the feel of genuine currency paper. The counterfeit of a $50 Canadian note, shown in a normal scan in Figure 14(a), has evidently been distressed. The EOL scan of this note leaves no doubt that it is a counterfeit, 14(b).

A number of genuine foreign paper currencies were examined. As with Canadian notes it was found that certain features of a genuine note will not be evidenced in an EOL scan. Figure 15(a) is a normal scan of a mint condition 'specimen' of a $100 US note with the EOL scanned image shown in 15(b) for comparison. The serial numbers and the Treasury and Federal Reserve seals are features which are significant by their lack of representation in an EOL scanned image.

Figure 16(a) is an EOL scan of a typical counterfeit of a $100 US note. In this case some success has been achieved in the border areas and denominations but the creasing suggests that, for one thing, the paper could be suspect based on images of worn, genuine US notes.

The counterfeit note shown in an EOL scan in Figure 16(b) is evidence of the high degree of sophistication in counterfeiting from some sources. For whatever reason the portrait area did not receive the same attention as the remainder of the note.

FUTURE

EOL optical enhancement technology offers the police or security personnel a new way to look for and at evidence. The technique is simple to use and there is no need for extensive training. By having the ability to store and manipulate the images in computers, the investigator can readily compare past stored images to the article under investigation. Hard copies can also be printed for reporting and for use as evidence.

This memorandum describes the IAR/NRC EOL optical enhancement technology and profiles several possible situations where it might provide better than visual or microscopic information. In police identification work this could be instrumental in solving a crime.

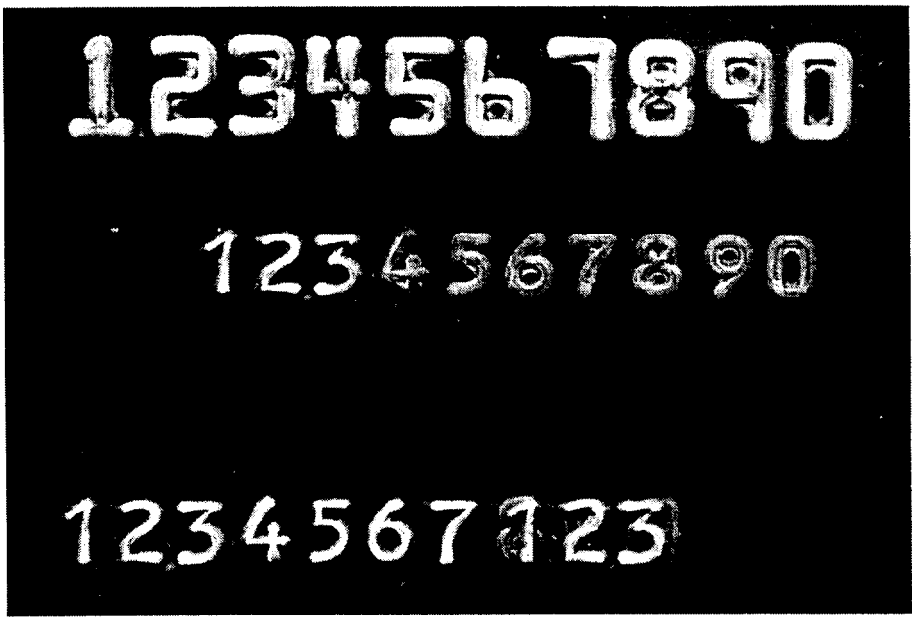
The IAR/NRC is interested in commercializing the EOL optical enhancement technology for police applications either directly or through partnerships. To demonstrate its usefulness and to gain insight on potential applications, the IAIUNRC is offering, through the CPRC, a prototype system for evaluation by selected police organizations. The EOL forensic prototype setup is initially being evaluated by the RCMP Central Forensic Laboratory in Ottawa.

For further information regarding police applications of the EOL optical enhancement technology please contact call John Arnold, Chief Scientist, at (613) 993-3737.

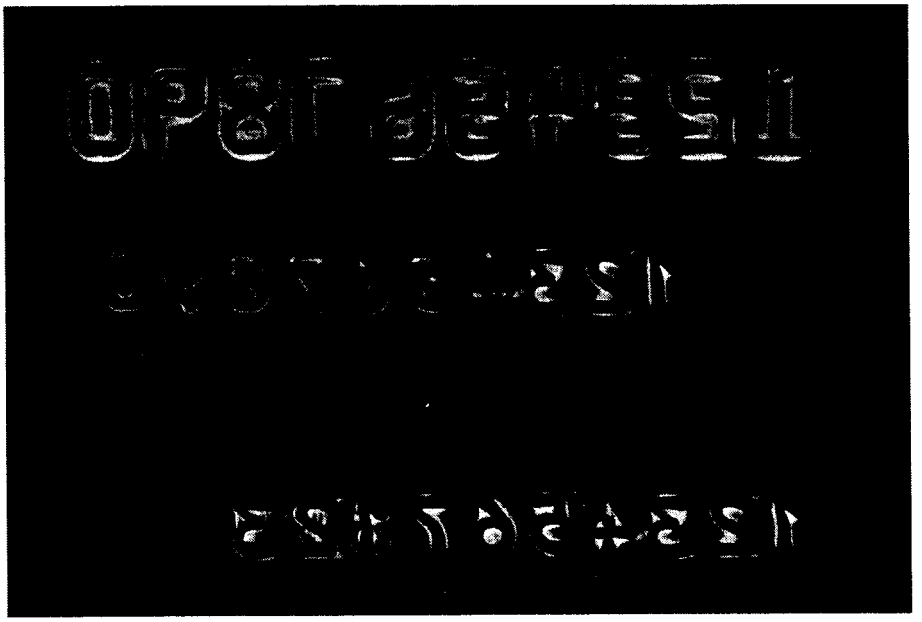
ACKNOWLEDGMENTS

The authors would like to thank the Ottawa Carleton Regional Police Service and the Royal Canadian Mounted Police for their co-operation.

LIST OF FIGURES

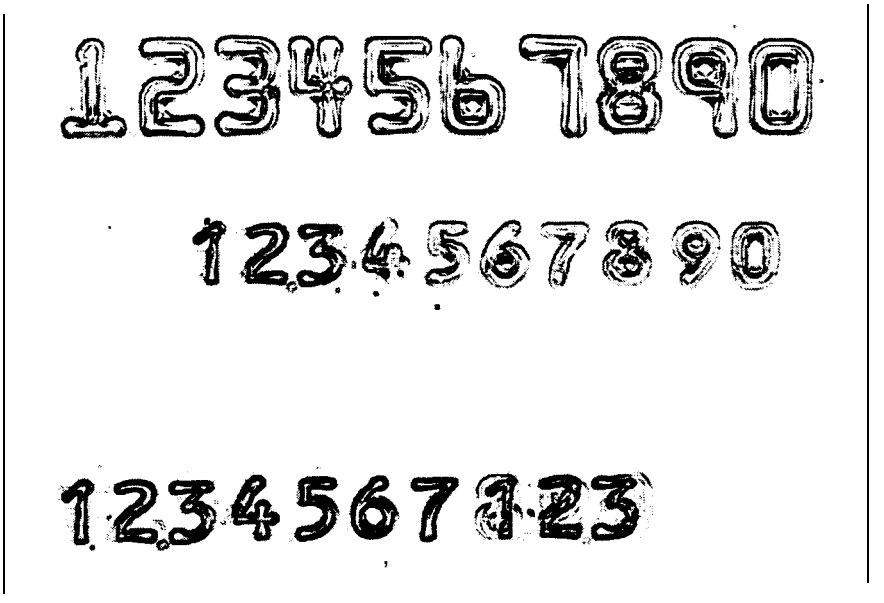


A) Front



B) Rear

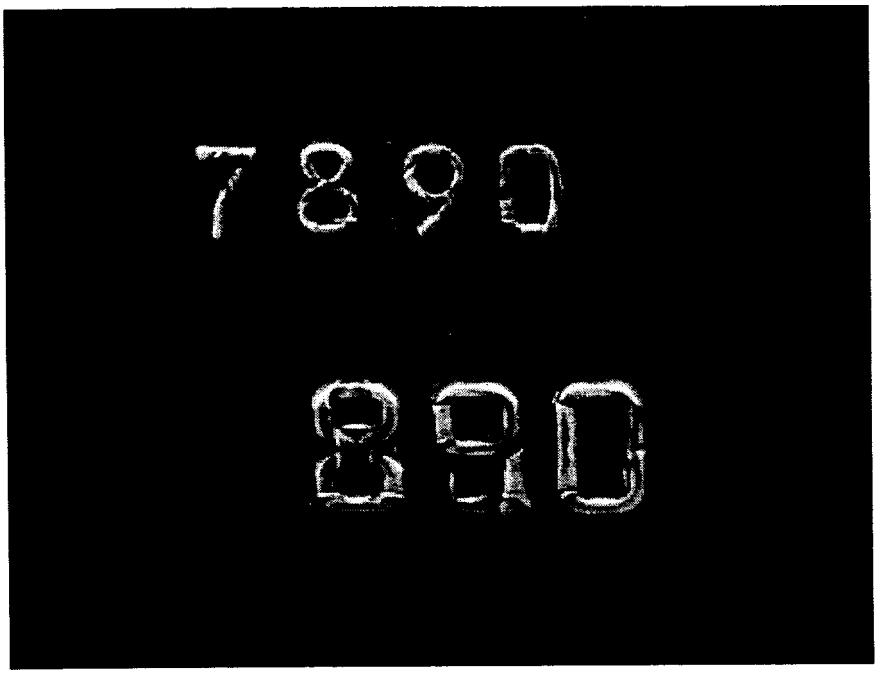
Figure 1. EOL scans: Altered Credit Cards (Note artifacts of original impressions).



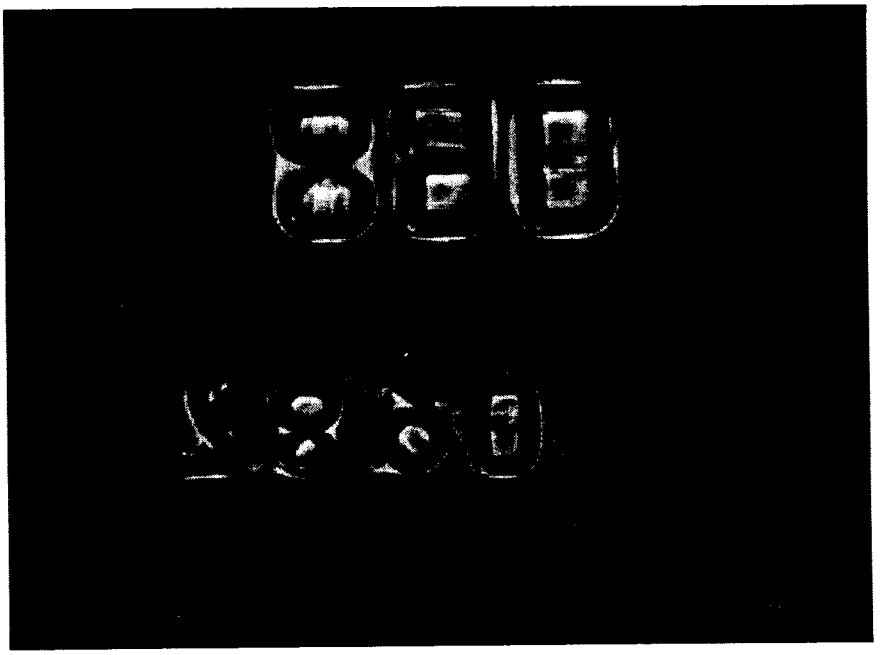
A) Edge Detect filter.

B) Emboss filter.

Figure 2. Modified EOL scan images.



A) Front.



B) Rear.

Figure 3. EOL scans: Altered credit card (Note artifacts of original impressions).

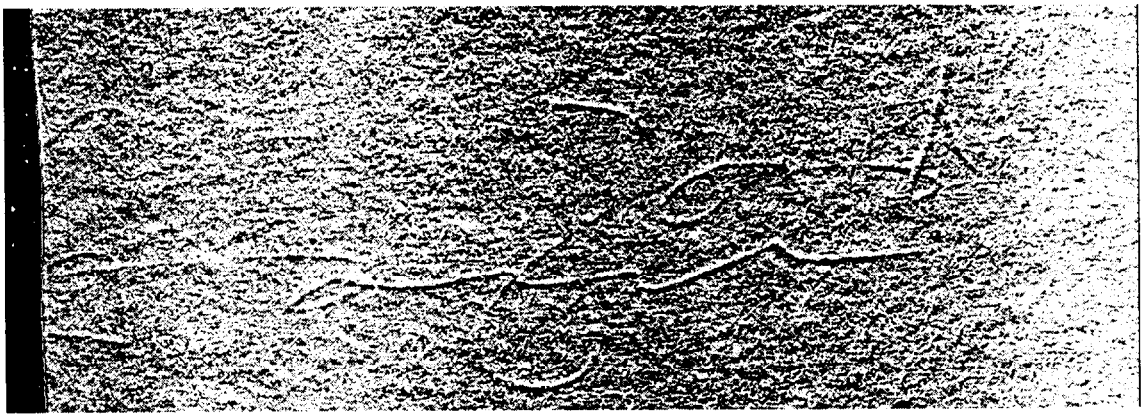


Figure 4. EOL scan of handwriting impression on second page from a pad of paper.

Figure 5. EOL scan of fingerprint on glossy book cover.

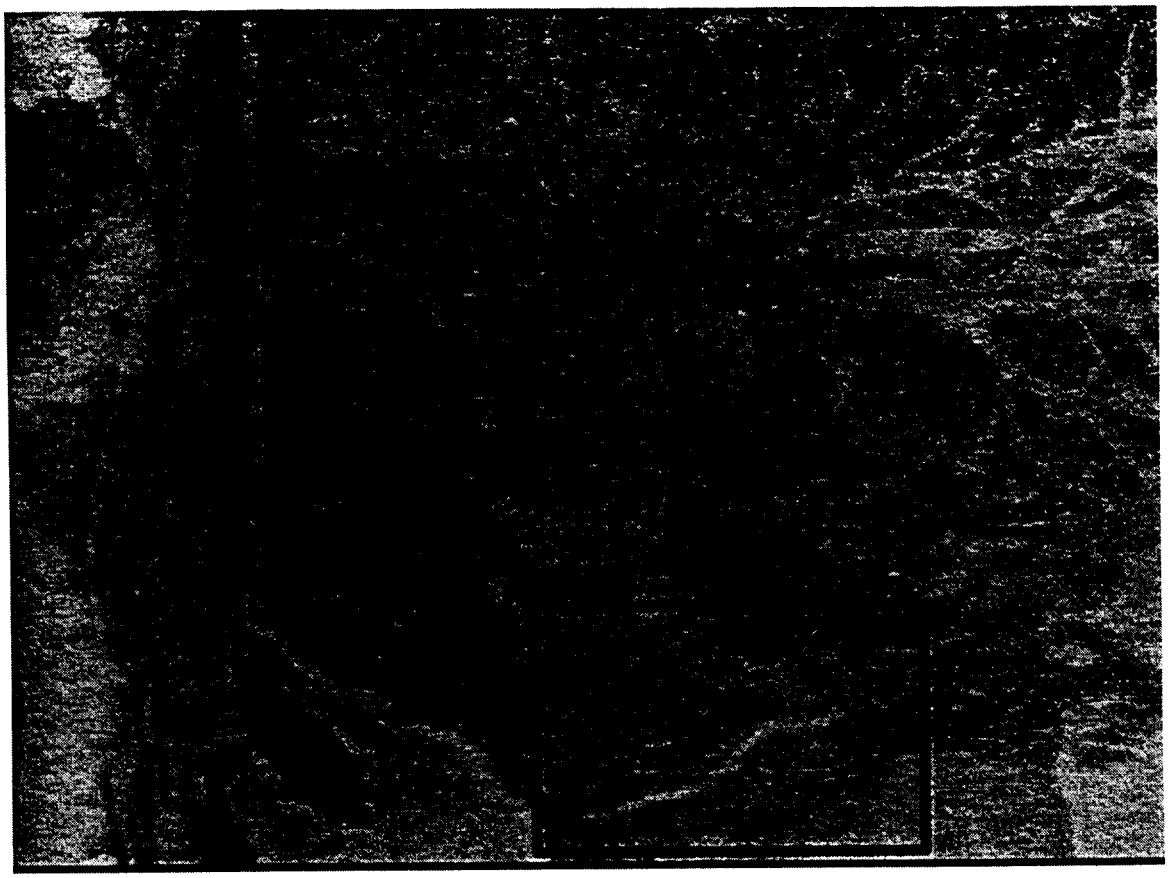
Figure 6. EOL scan of fingerprint on glass sheet
(Note: Fingerprints are untreated).

A) EOL scan.

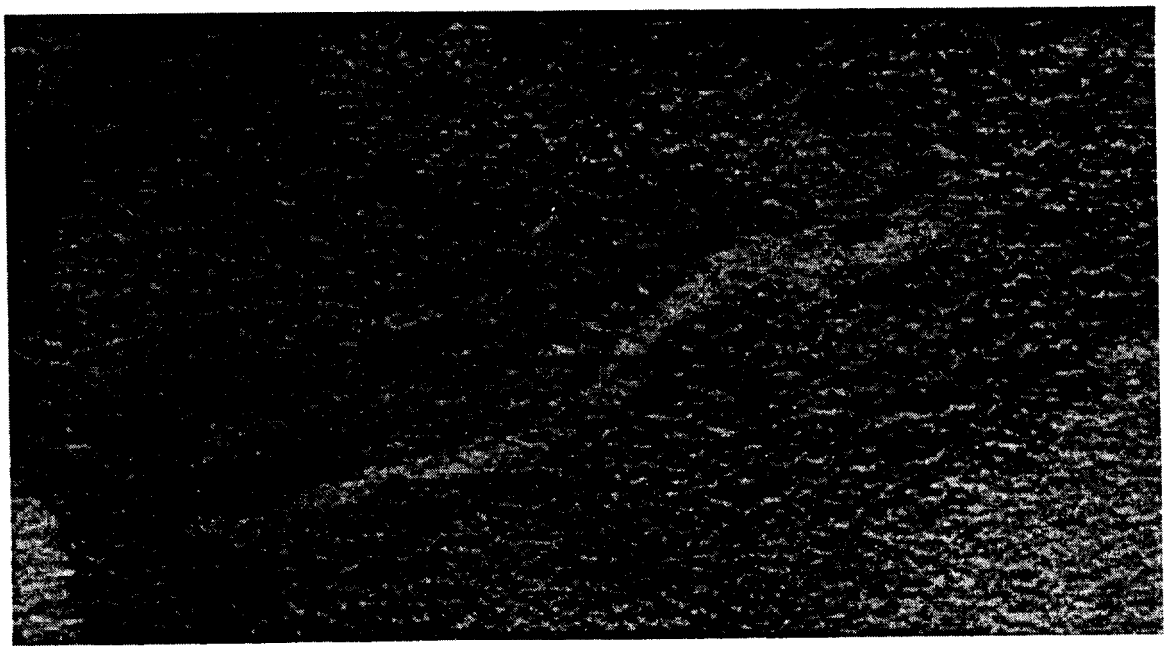
B) Normal scan.

Figure 7. Oil painting.

Figure 8. Enlarged view of area from EOL scan (Fig. 7).



A) EOL scan.



B) enlarged view

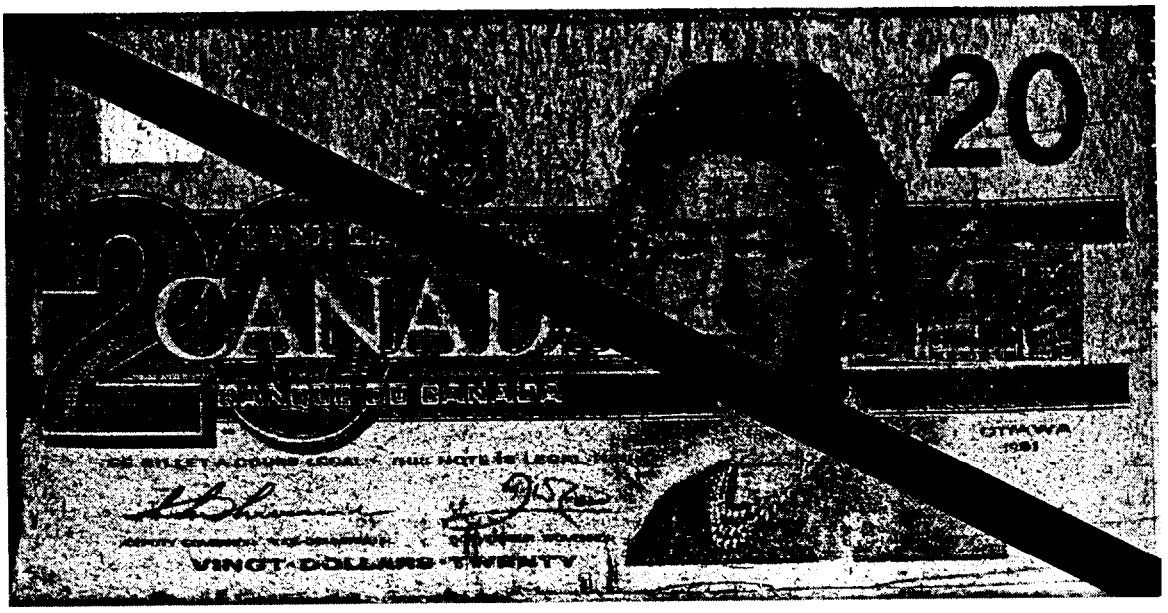
Figure 9. EOL scan of watercolour painting.

A) normal scan (enlarged view)

B) EOL scan (enlarged view)

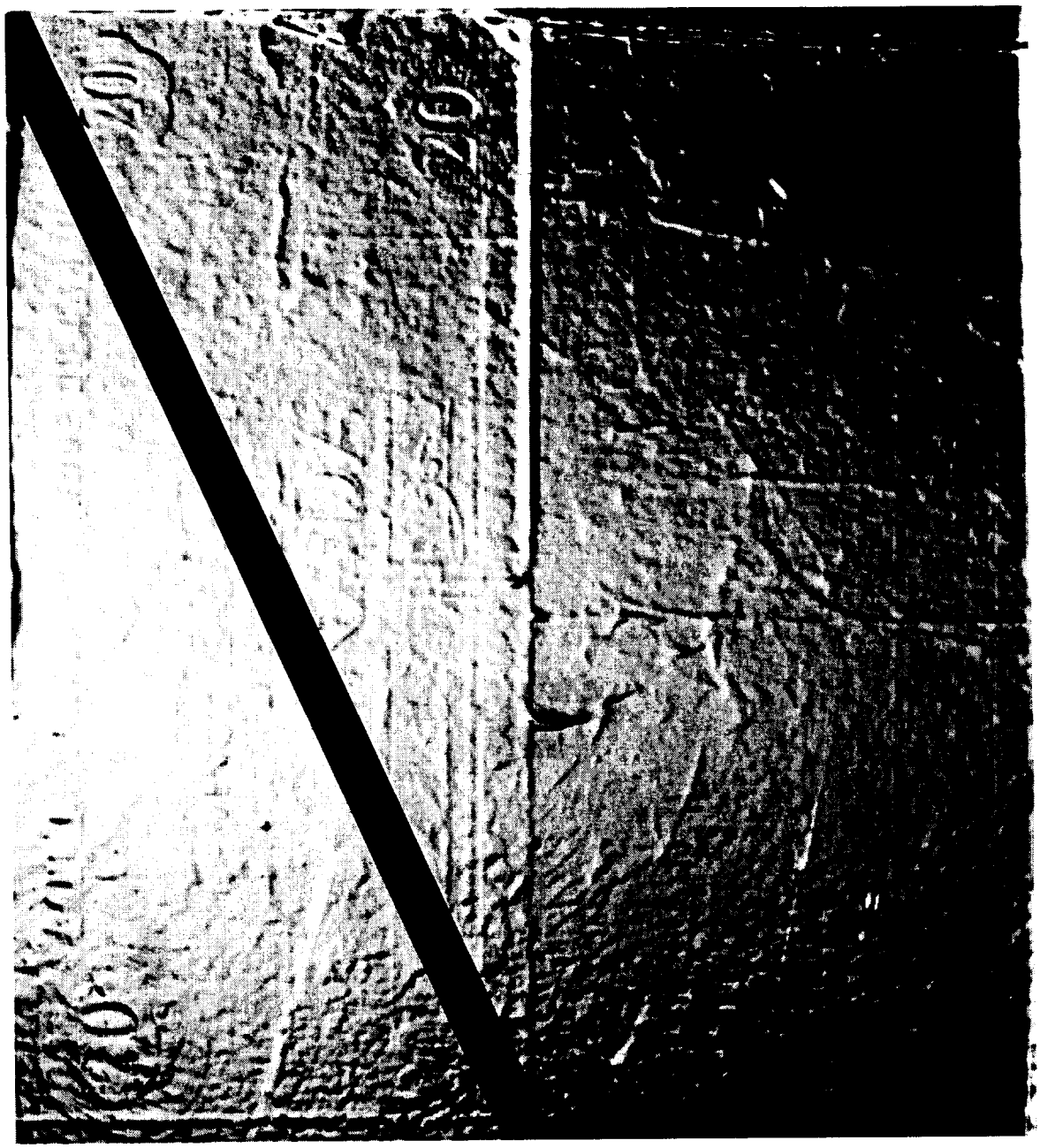
Figure 10. Canadian Tire coupon.

A) Normal scan



B) EOL scan

Figure 11. Genuine $20 Canadian note (1986 pattern).



A) Genuine B) Counterfeit

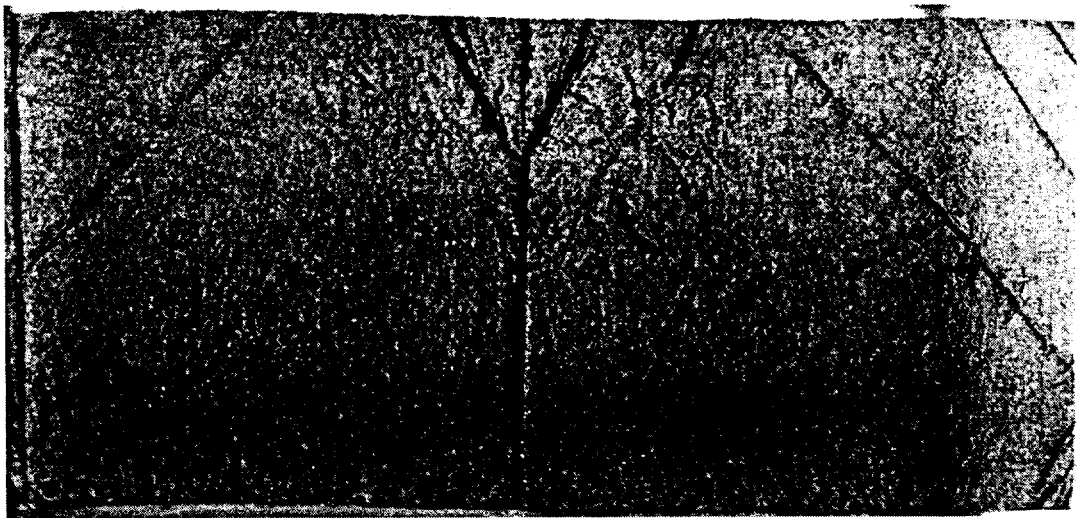
Figure 12. EOL scan of notes under metal foil (NRC process).

A) Worn, genuine.

B) Counterfeit,
(Note watermark in bond paper)

Figure 13. EOL scans of Canadian $20 notes
(1969-75 pattern).

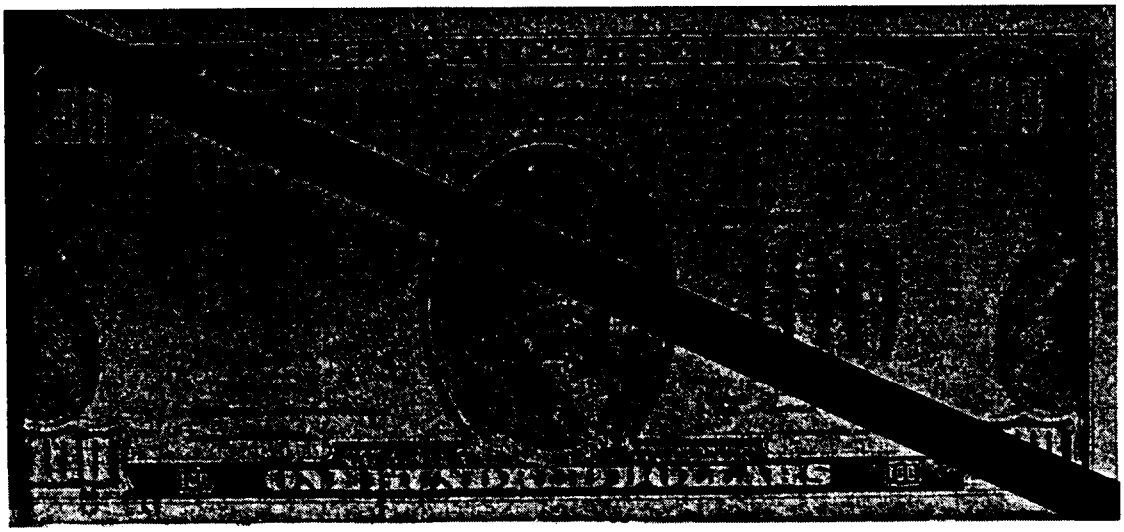
A) Normal scan.



B) EOL scan.

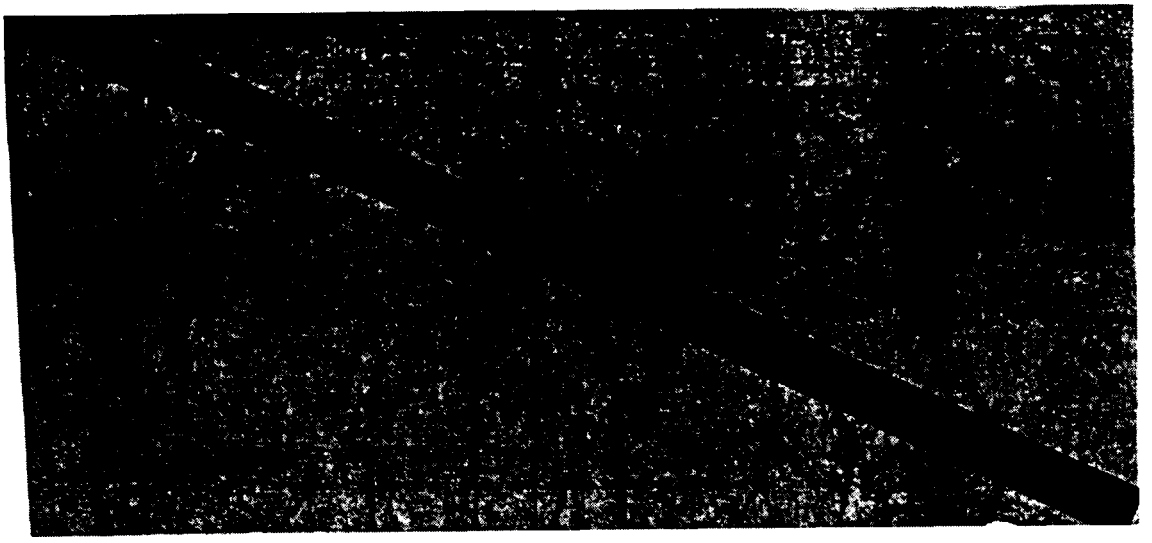
Figure 14. Counterfeit $50 Canadian note (1979 pattern).

A) Normal scan.

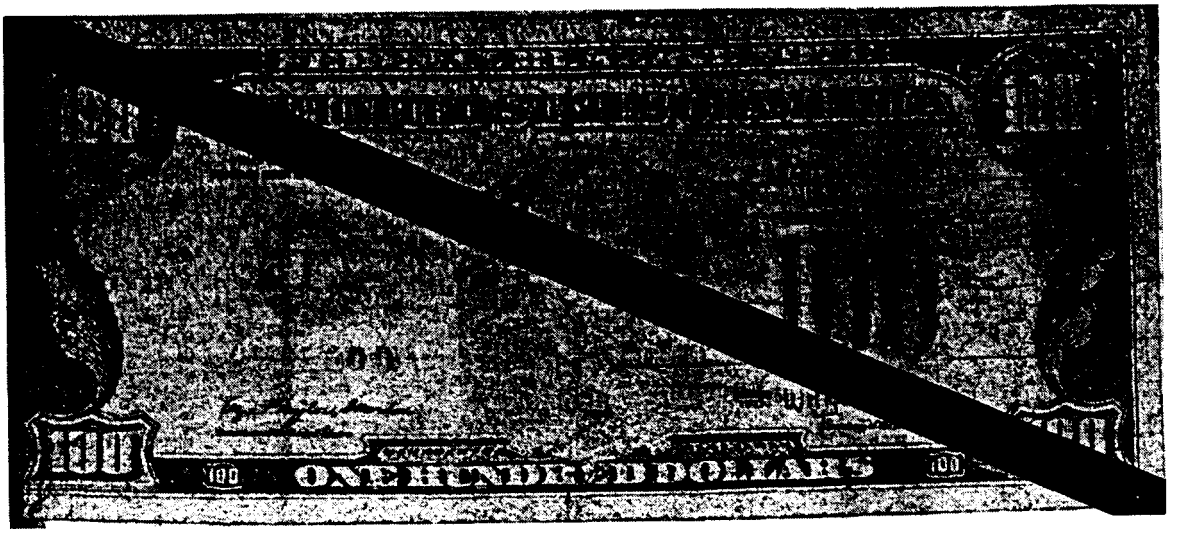


B) EOL scan.

Figure 15. Genuine US $100 note.



A) EOL scan. Typical counterfeit.



B) EOL scan. Sophisticated counterfeit.
Figure 16. Counterfeit US $100 notes.

Figure 17. EOL handheld scanner on Solid Film Highlighter vacuum table with PC host computer.

ADDENDUM

The EOL technology was exhibited in public for the first time at the Ottawa-Carleton Regional Innovation Forum Roundtable II, April 8-9, 1997. In addition to the hand-held scanner (Figure 17) and a similar unit configured to detect corrosion and cracks on aircraft, the new EOL flatbed scanner was demonstrated (Figure 18).

The IAR/NRC thin film process has been renamed 'Solid Film Highlighting' and received U.S. patent protection.

The EOL flatbed scanner allows for legal size documents to be imaged on the Solid Film Highlighter vacuum table. The figure shows the flatbed scanner partly rotated off of the vacuum table surface on a height adjustable mast. The mast allows for the adjustment of the scanner for imaging any object placed under the scanner. IAR has developed software to command changes in the scanners' optical train from normal scanning to EOL scanning.

On the Solid Film Highlighter vacuum table may be seen a document which has two separate test prints. The top image is by the intaglio printing process while the bottom was done with offset printing. Note that on the monitor only the intaglio printed image shows in the EOL scan because offset printing does not leave any topographical features on the surface.

Figure 18. EOL Flatbed Scanner on adjustable height mast over Solid Film Highlighter vacuum table.