96th International Association for Identification Ed. Conf.
Milwaukee, 10 August 2011

Development Techniques On Thermal Paper

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Summary

- Introduction
- Legal requirements in Italy
- Operational trials
- Materials and methods
- Experiments organization
- Results and discussion
- Conclusions
- Comment
- Ongoing experiment

THERMAL PAPER

- Techniques currently used for developing prints on porous items are not effective on thermal paper, because of the polarity of the solvents and/or because the processes involve a heating step.
- Many solutions have been proposed, but understanding what is the best method is still an open question.
- As reported in literature, thermal paper is constituted by different layers, designed to provide different functions.

The current processing techniques damage thermal paper:

- polar solvents dissolve the sensitizer within the active coat, thus the colorless dye and the co reactant react, forming a wide dark layer
- other layers remain unaffected and the current development solutions are able to react with the amino acids of the print.

We have, at least, 3 alternatives:

1. **Choose techniques solvent – free;**
2. **Substitute polar solvents with non polar ones;**
3. **Use a washing solution to remove the active coat**

LEGAL REQUIREMENTS IN ITALY

If we need to process articles during the investigative phase we have to:

- use developing techniques that avoid the item alteration (e.g. acetone based ninhydrin) as the fading or vanishing of printed and written information
- or we have to perform the treatment only after written permission of the prosecutor. In this case lawyers and consultants of the suspect could assist at every single operation

OPERATIONAL TRIAL

Set up of 3 trials:

1. explore the performance of 3 different techniques in the short term (1 to 10 days) and in the middle term (2 months);
2. To explore the performance of 6 different techniques in the long term (more than a year);
3. Add different techniques and study possible sequences (ongoing) to determine operational conditions

Trial 1

Techniques:

- VMD;
- Ninhydrin;
- 1,2 – Indanedione/Zn.

Materials:

One type of thermal paper;

Random number of donors (about 30), uncontrolled

- Prints 1 to 10 days old – short term trial;
- Prints from 1 day to 2 month old - mid term trial.

Color analysis of the substrate due to the thermal process

- VSC 2000 / HR for fluorescence, transmission, absorbance and reflection spectra in UV-Vis;
- FT-IR;
- Spectrum photometer for color analysis in the UV-Vis

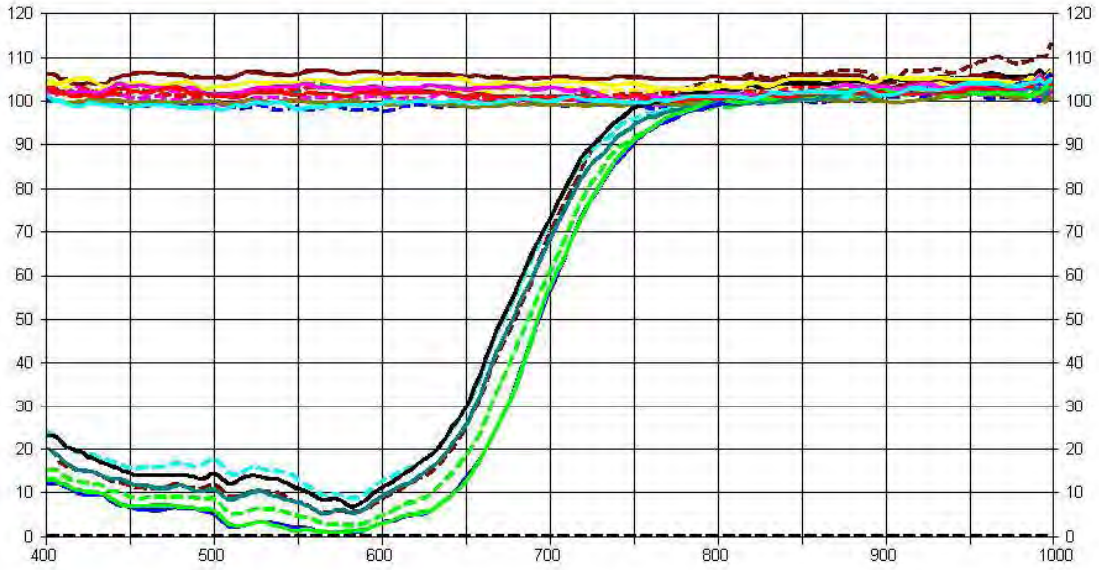
No sensitive variation due to the thermal reaction on the substrate.

Thus, we decided to use written tickets to evaluate the effects of the solvents on writings.

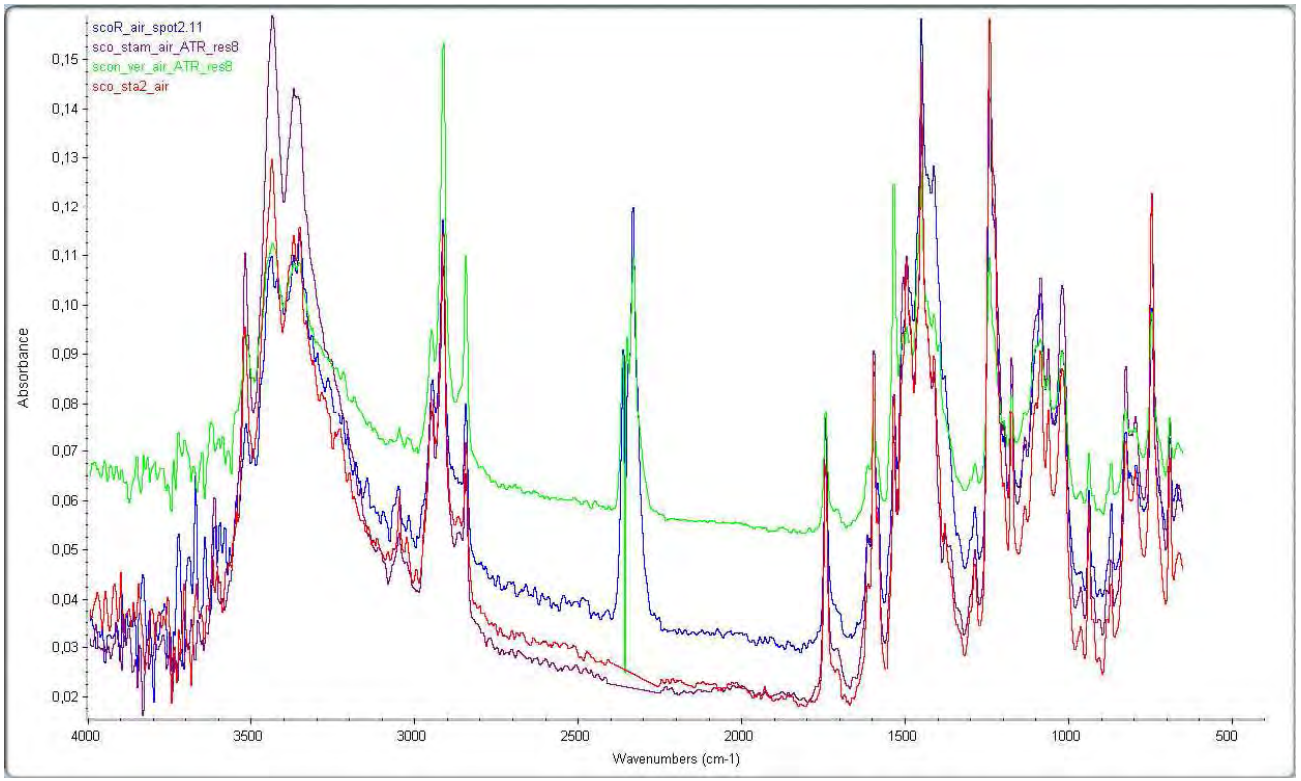
VSC

1	Ref	bianco su scontrino non stampato	11	Ref	testo scontrino bar
2	Ref	bianco su scontrino stampato n.34	12	Ref	bianco scontrino n.1
3	Ref	T di totale, esame sul carattere	13	Ref	testo scontrino n.1
4	Ref	bianco su scontrino stampaton.35	14	Ref	bianco scontrino n.2
5	Ref	E di euro su scontrino n. 35	15	Ref	tracciato scolorito scontrino 2
6	Ref	bianco su carta fax 8-06	16	Ref	traccaito scolorito
7	Ref	L di provinciale carta fax	17	Ref	bianco scontrino n.3
8	Ref	bianco su carta fax n.2	18	Ref	tracciato scontrino n.3
9	Ref	A di provinciale fax n.2	19		
10	Ref	biaco scontrino bar	20		

Ref = Riflettanza, Abs = Assorbimento, Flu = Fluorescenza, Tra = Trasmittanza, Nl = Normalizzato, difdw = Differenziale, Av = Media



FT-IR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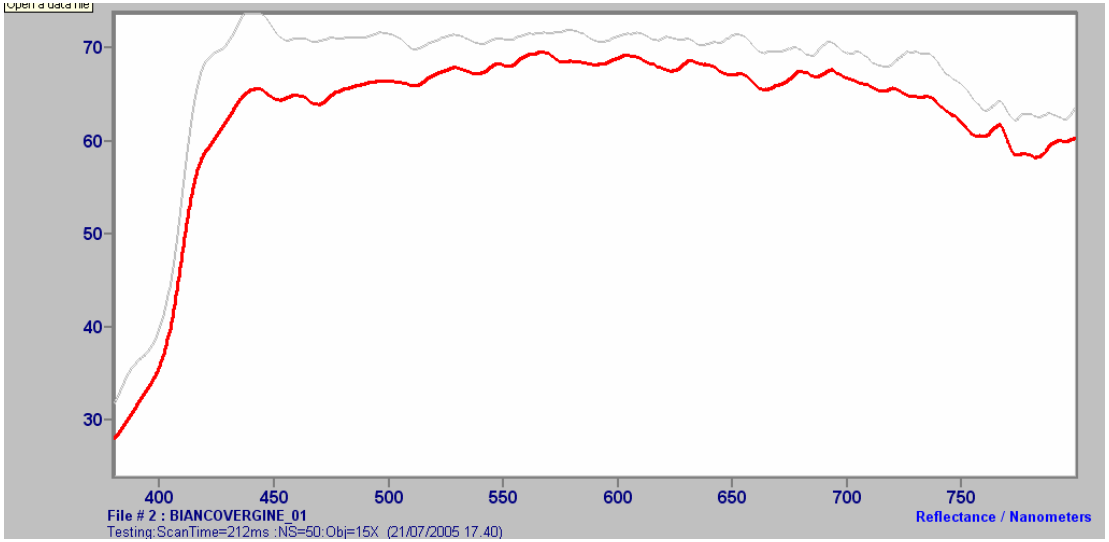
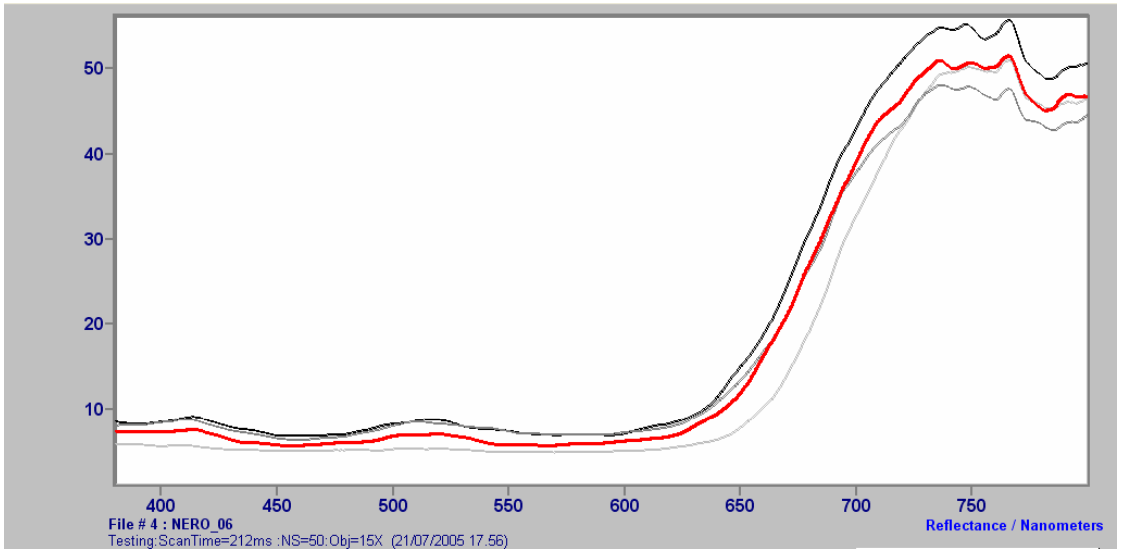
Wavenumbers (cm-1)

COLOR SPECTRA

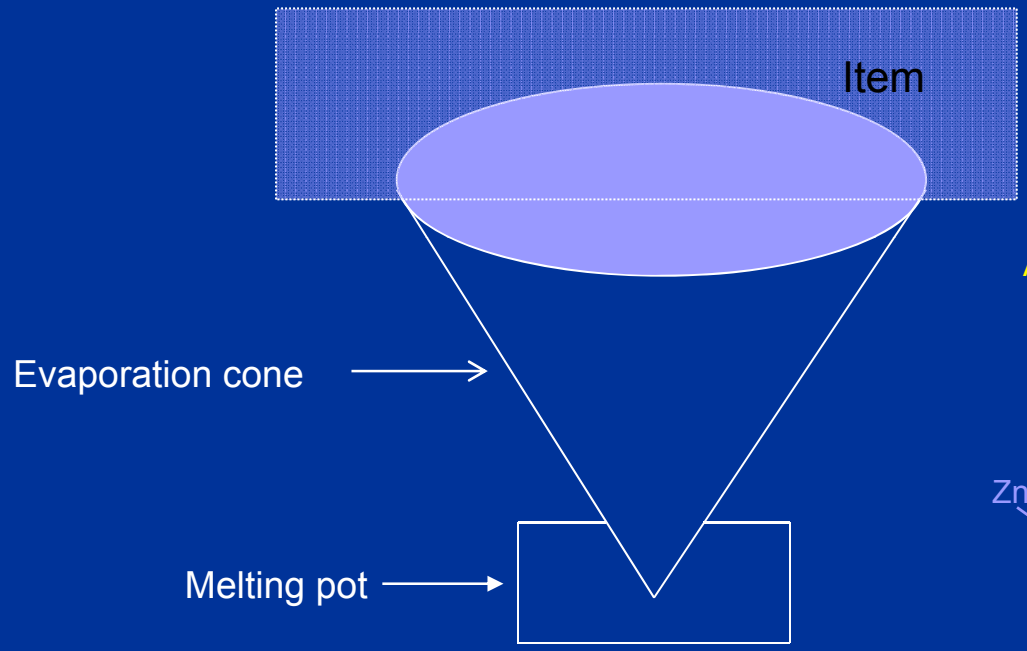
WHITE PAPER

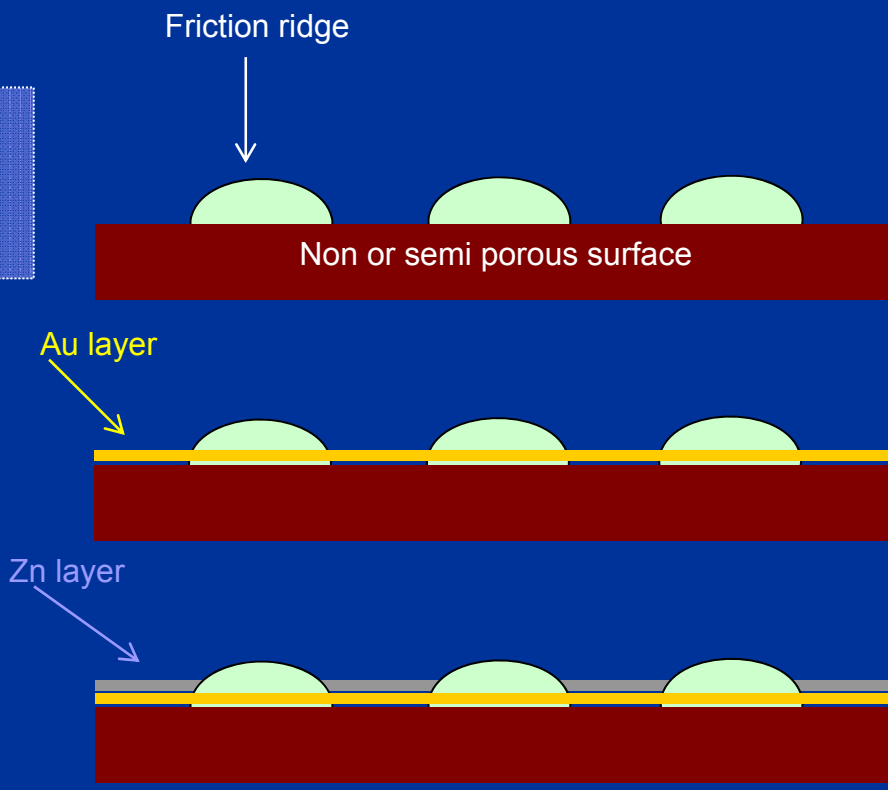


REACTED DYE



Vacuum metal deposition





VMD

Gold:

- ***Quantity 0.02 g;***
- ***evaporation time 4 sec.;***
- ***Intensity 105 A;***

Zinc:

- ***Quantity 0.5 g;***
- ***evaporation time 12 sec.;***
- ***Intensity 100 A;***

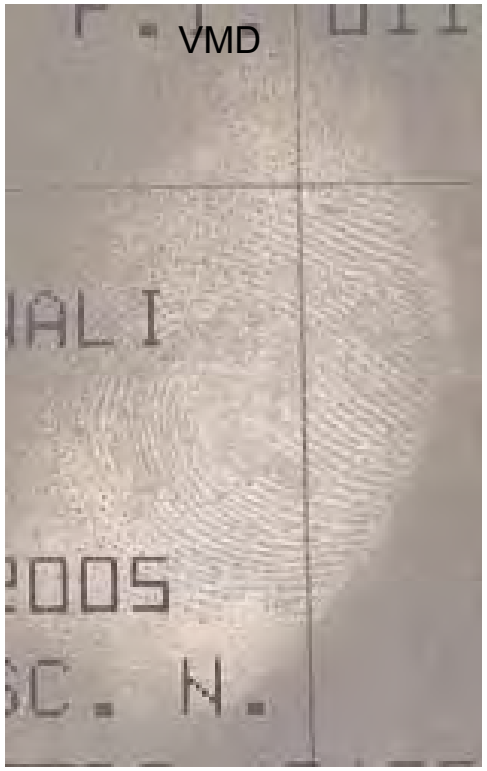
1,2-indanedione:

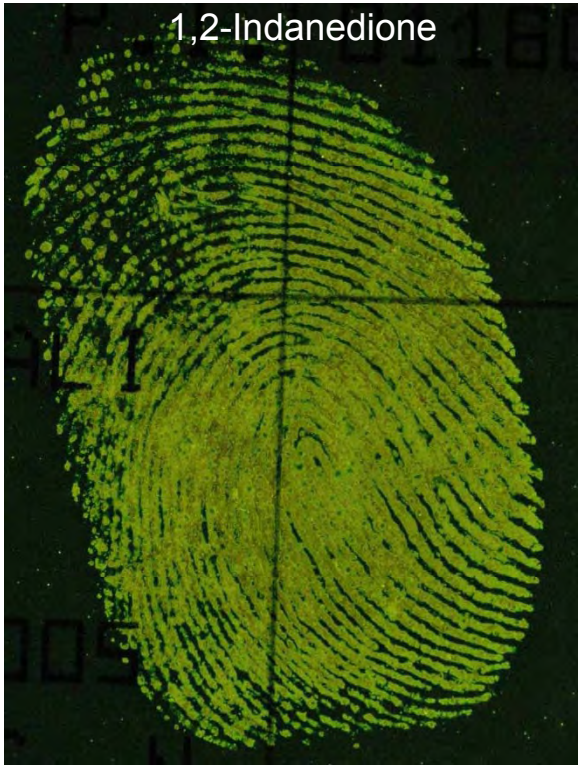
- solution: 1g/L
- Solvent: HFE7100 with 7% vol. ethyl acetate, 2 mL stock solution
- ZnCl2 stock in HFE7100 (2g/L in 5%vol EtOH 0.5%vol ethyl acetate)
- Observation: ALS green cut (495 – 540) with long pass filter 570nm (orange)
- only fluorescent mode considered;
- Developing without heating, at least 10 days in the dark

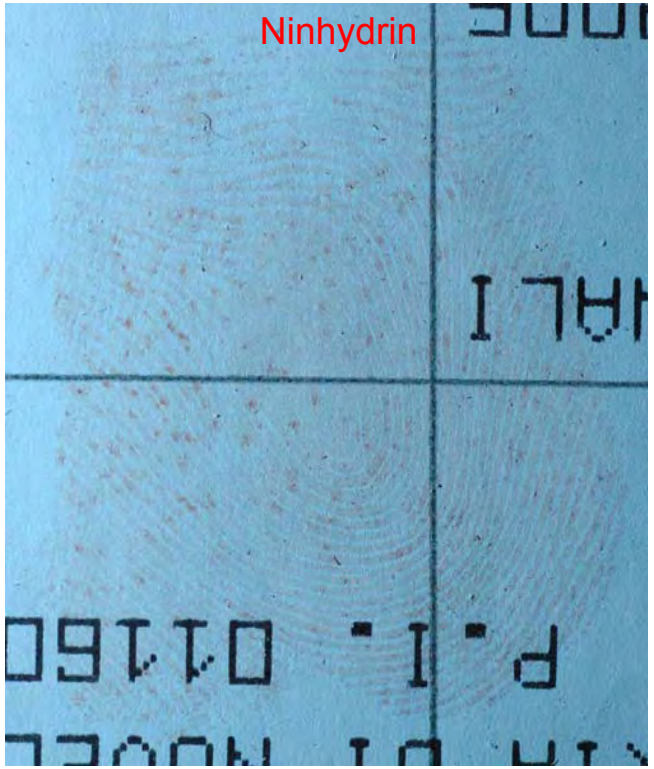
Ninhydrin:

- solution: 2g/L
- Solvent: HFE7100 with 7% vol. ethyl acetate
- Developing without heating, at least 10 days in the dark

RESULTS AND DISCUSSION







short term: all techniques are effective;

mid term VMD is not capable to develop latent prints, while IND and NIN are consistently better

Trial 2

Techniques:

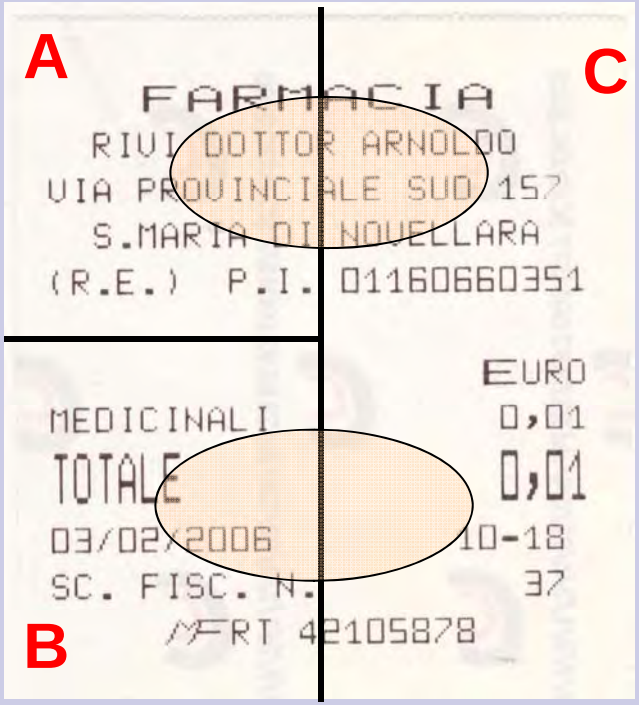
- VMD thanks to BOC Edwards;
- Ninhydrin HFE7100 based;
- 1,8-diazafluoren-9-one HFE7100 / HFE71DE based;
- 1,2–indanedione.
- p-DMAC fuming
- RTX immersion

Materials:

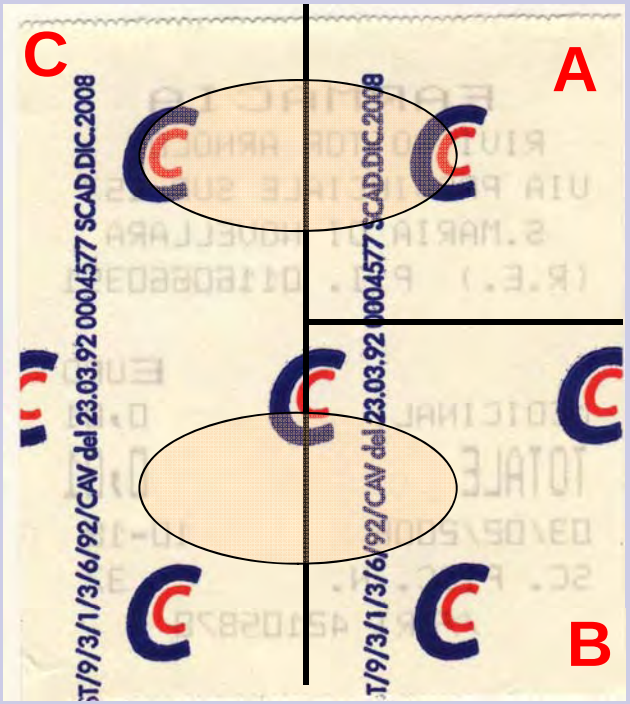
- One type of thermal paper;
- 5 donors;
- One donor for each receipt;
- All fingerprints deposited in one day

Depletion

Fingerprints deposited on both sides of each receipt



recto



verso

FOLLOWED PROCEDURE

- each receipt cut in three parts called A, B and C
- part C developed by BOC-Edwards VMD after 5 months since the deposition
- part A and B developed employing two different methods (e.g. part A with DFO and part B with Ninhydrin) after 1 year since the deposition like in a tournament

TOURNAMENT

Each match between two techniques was repeated

The two resulting best techniques, as they emerge from the matches, were selected to perform a side by side comparison on the remaining receipts

RESULTS AND DISCUSSION

VMD

No fingerprints developed after 5 months since the deposition time

NINHYDRIN

Pros: good development power (better than DFO, RTX and P-DMAC)

Cons: vanishing of the writings in some case

DFO

Solution: 0,25g/L; 30 mL Methanol, 20 mL Acetic acid;

725 mL HFE7100 and 275 mL HFE71DE

Developing: gentle heating at 35°C

Observation: ALS 495 – 550 nm with orange long pass filter

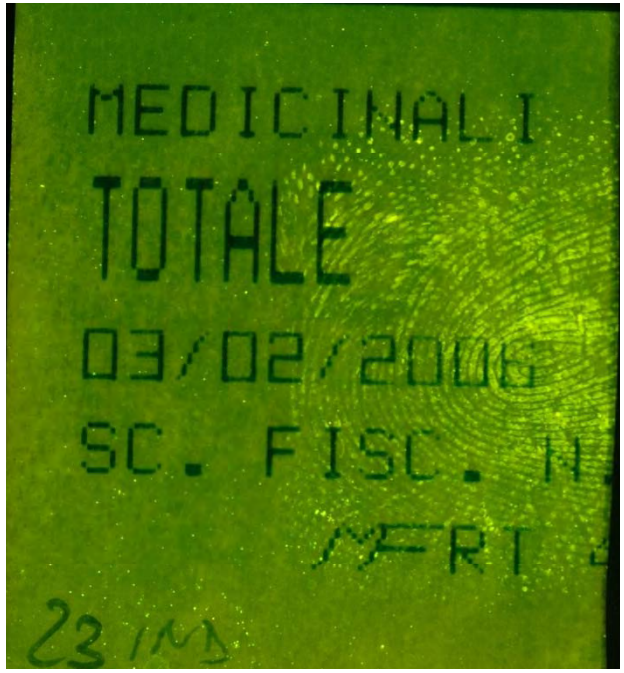
Pros: satisfying development power (better than RTX and P-DMAC)

Cons: high background noise and fading of the text/writings

IND

Pros: good development power (like DFO and better than RTX and P-DMAC) and no fading of the text/writings

No cons

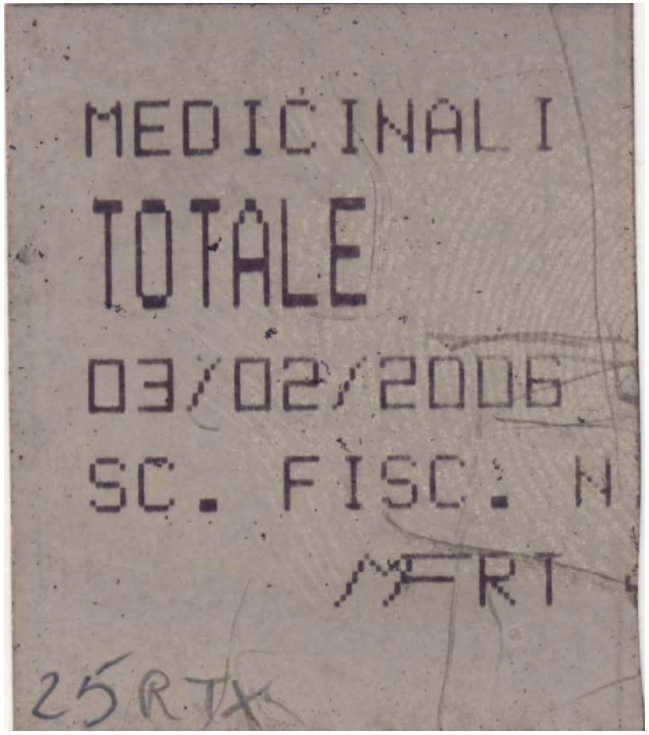


RTX

Method: immersion of the item in the commercial solution

Pros: no fading of the text/writings

Cons: low development power and alteration of the article surface (it becomes grey)



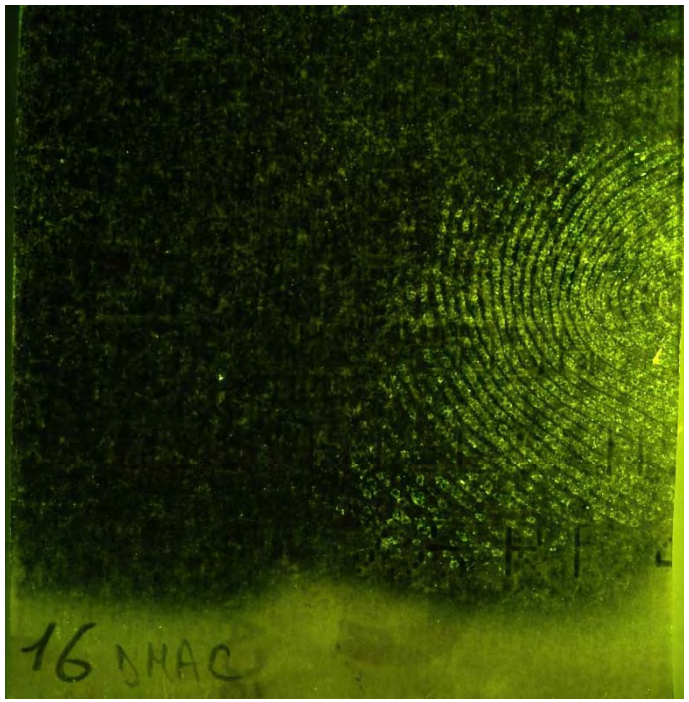
p-DMAC

Method: fuming with no ambient conditions control

Observation: ALS 495 – 550 nm with orange long pass filter

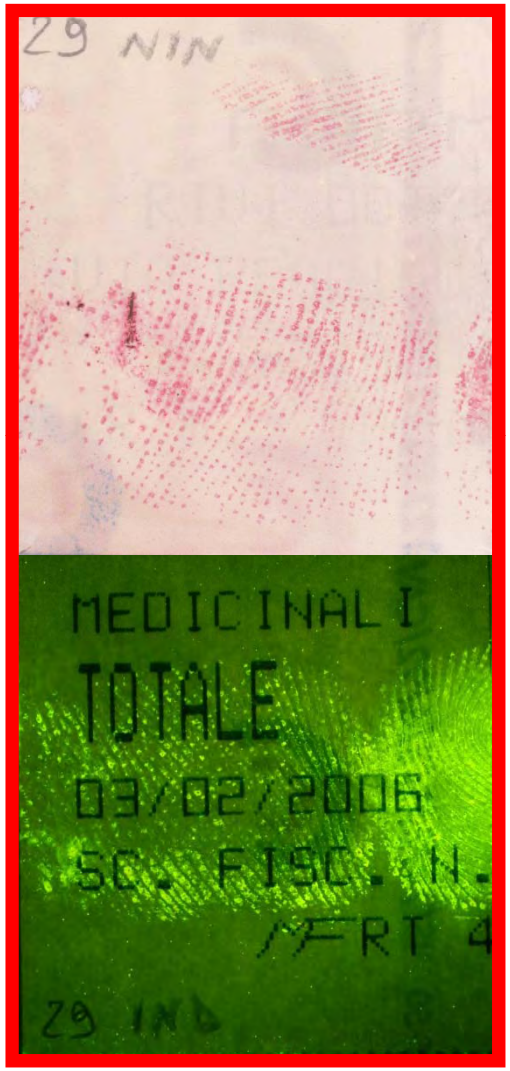
Pros: satisfying development power

Cons: no constant effectiveness, alteration of the article surface (it becomes yellow) and fading of the text/writings



The two best techniques, NIN and IND, selected as a result of the previous performed matches, are tested on the remaining receipts, with no sensitive differences. IND shows better contrast.

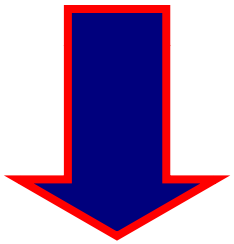
The judgment was based on a pool of fingerprint experts who evaluated the marks on the items



NIN vs IND

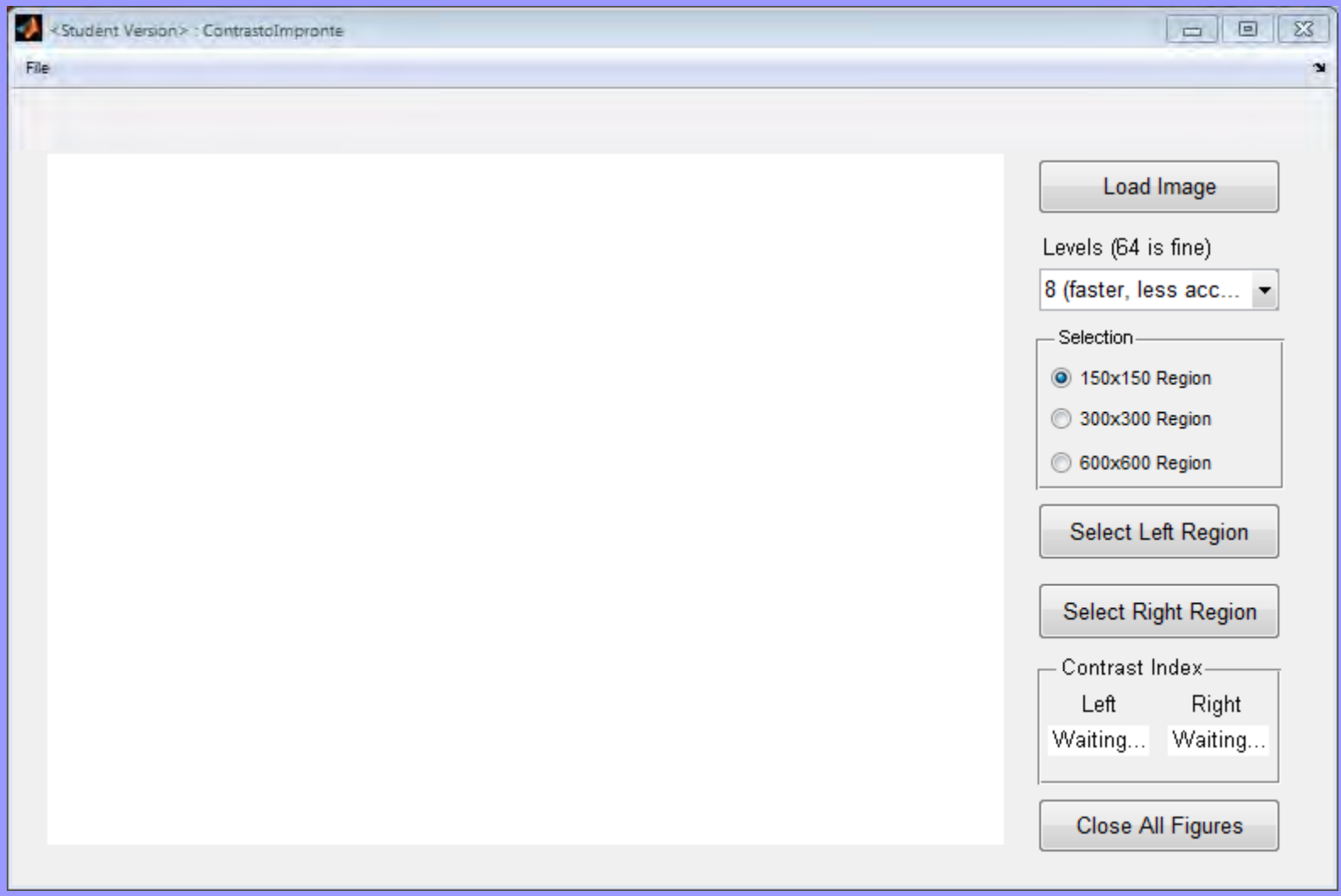
Ongoing work

- Different types of thermal papers, from many countries, random aging of the prints, fresh print added;
- To determine the working sequences of the different techniques



1. UV light 254nm narrow band filter;
2. Black magnetic powders (SEM characterization);
3. Nin and/or Ind

Software to help establish a robust, objective and unbiased standard of evaluating the compared techniques….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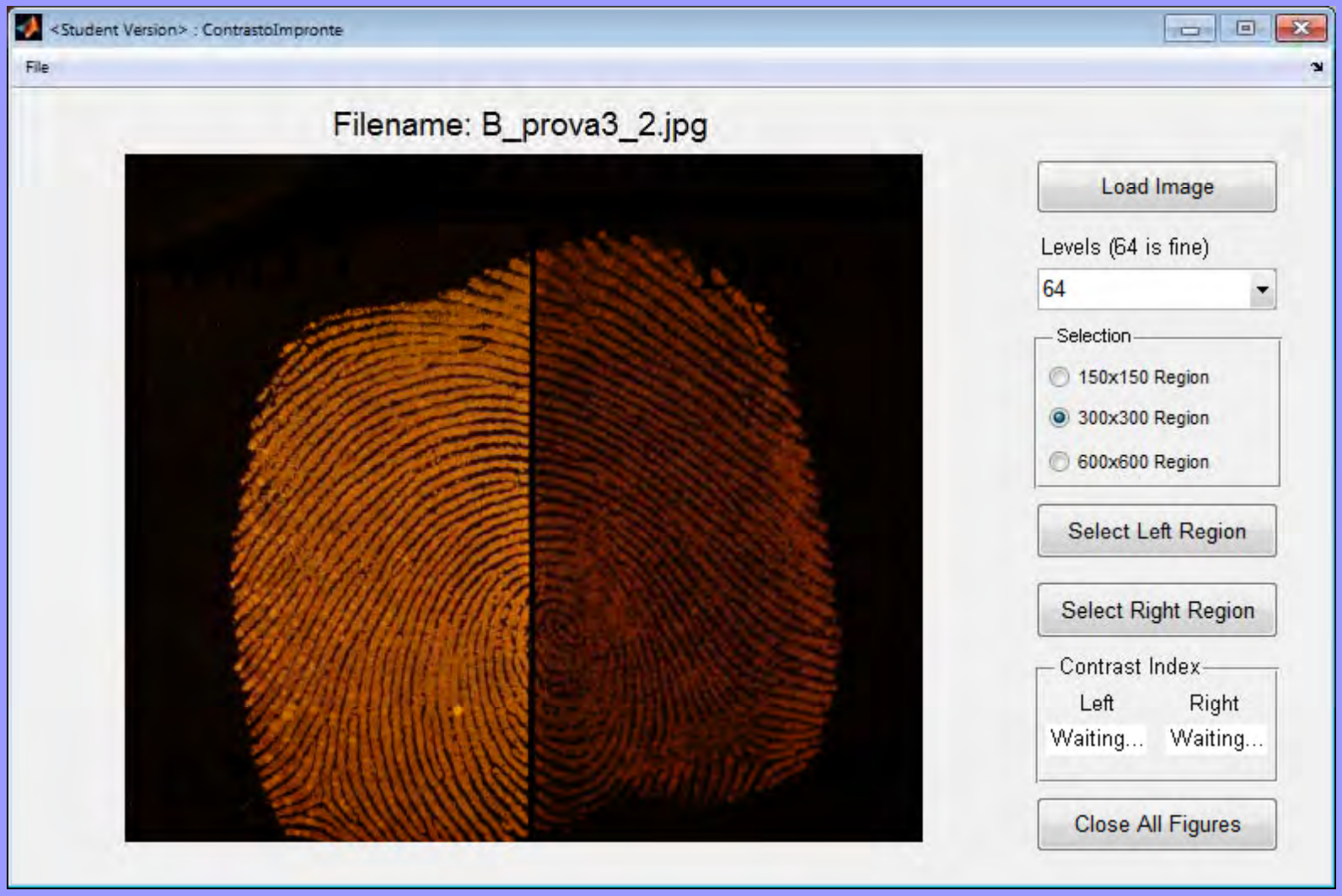
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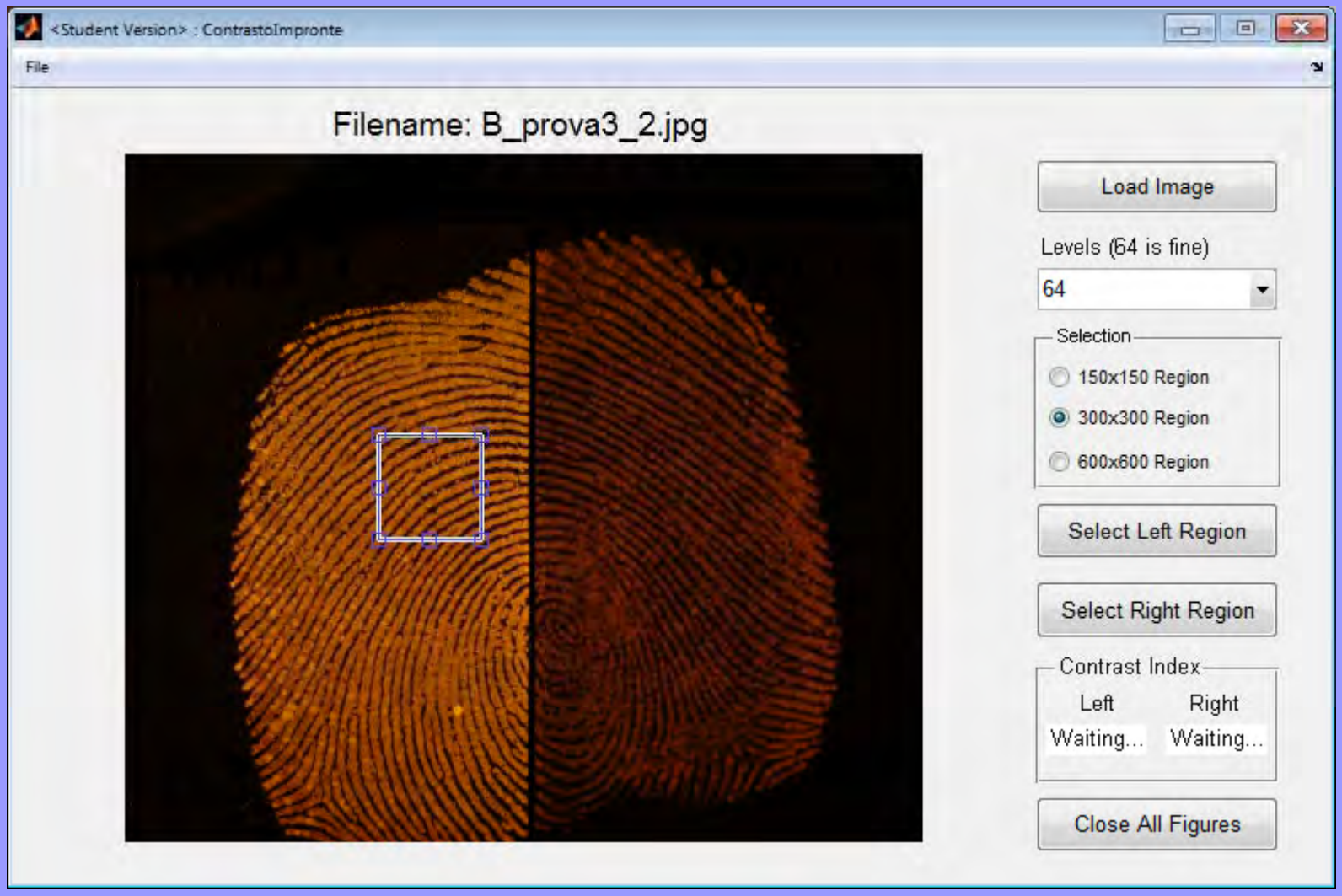
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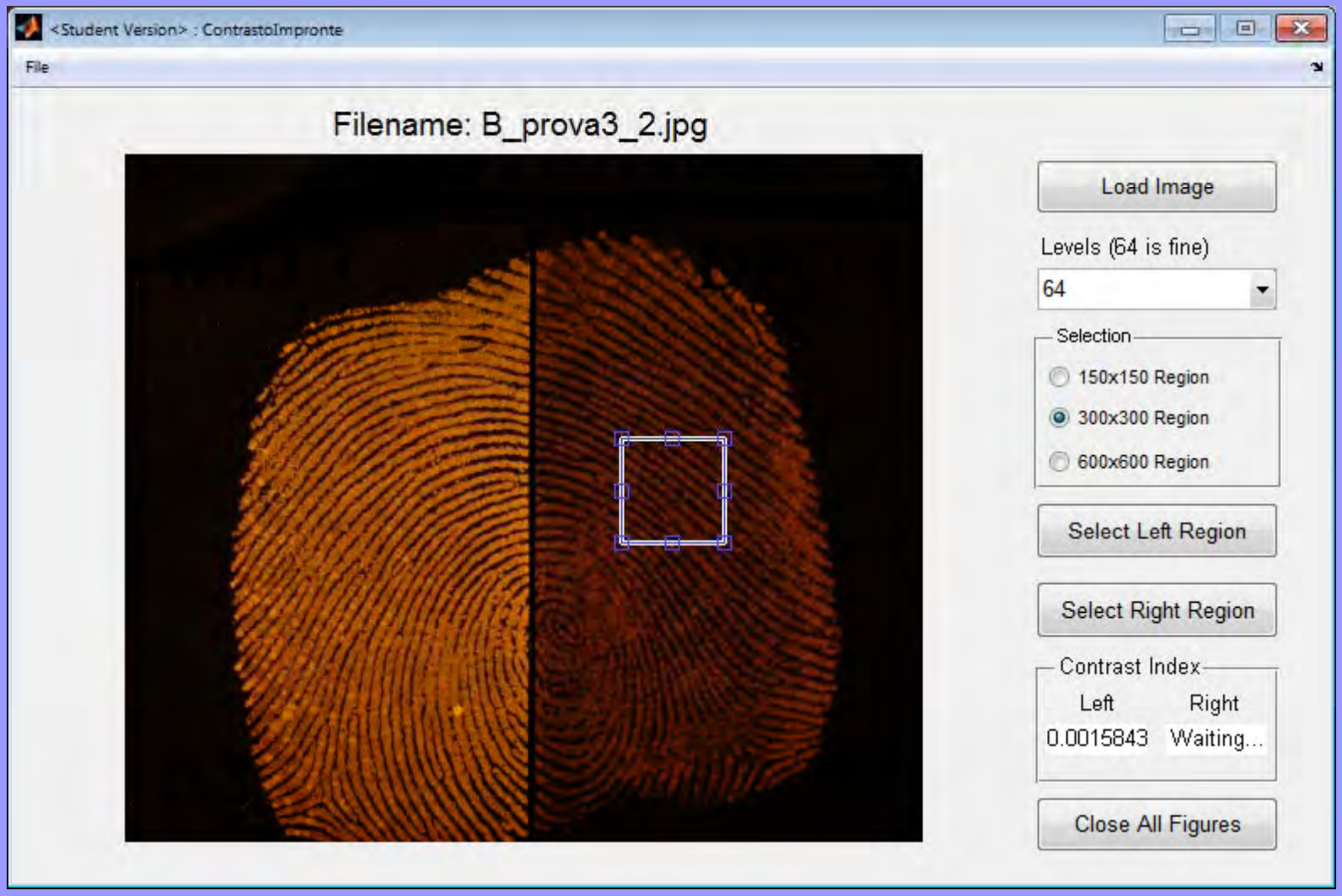
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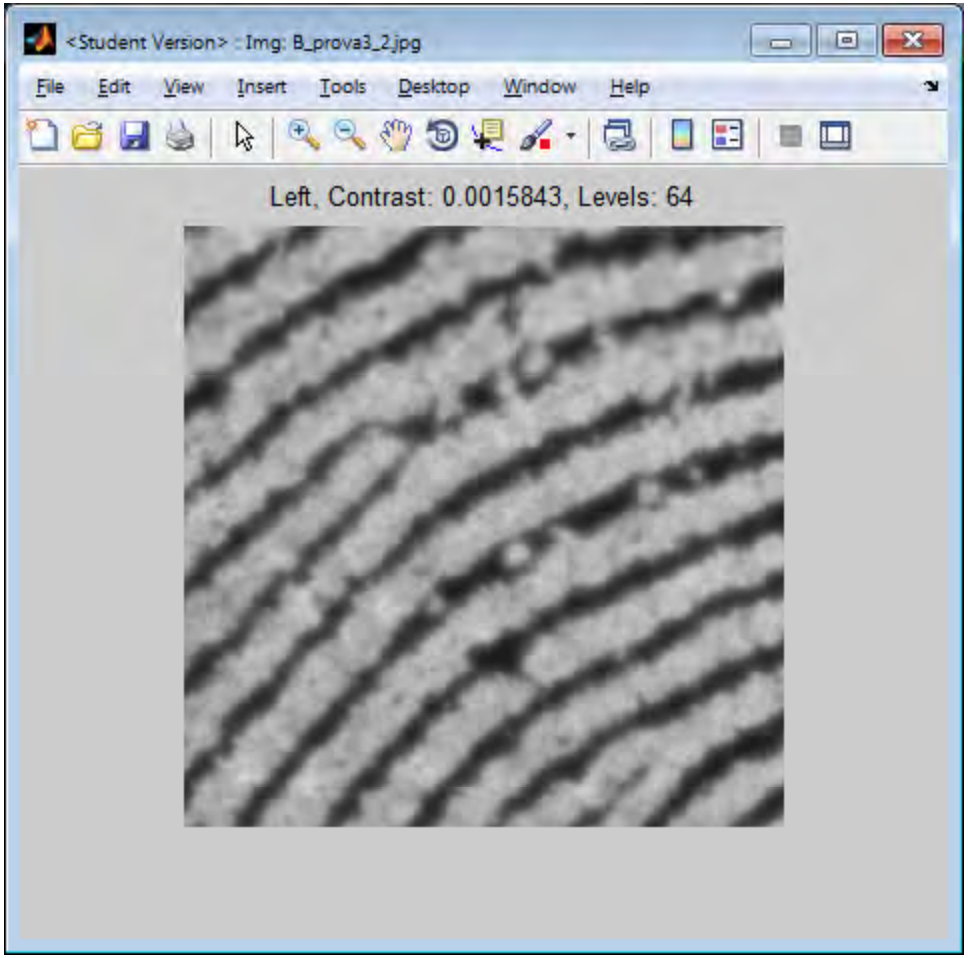
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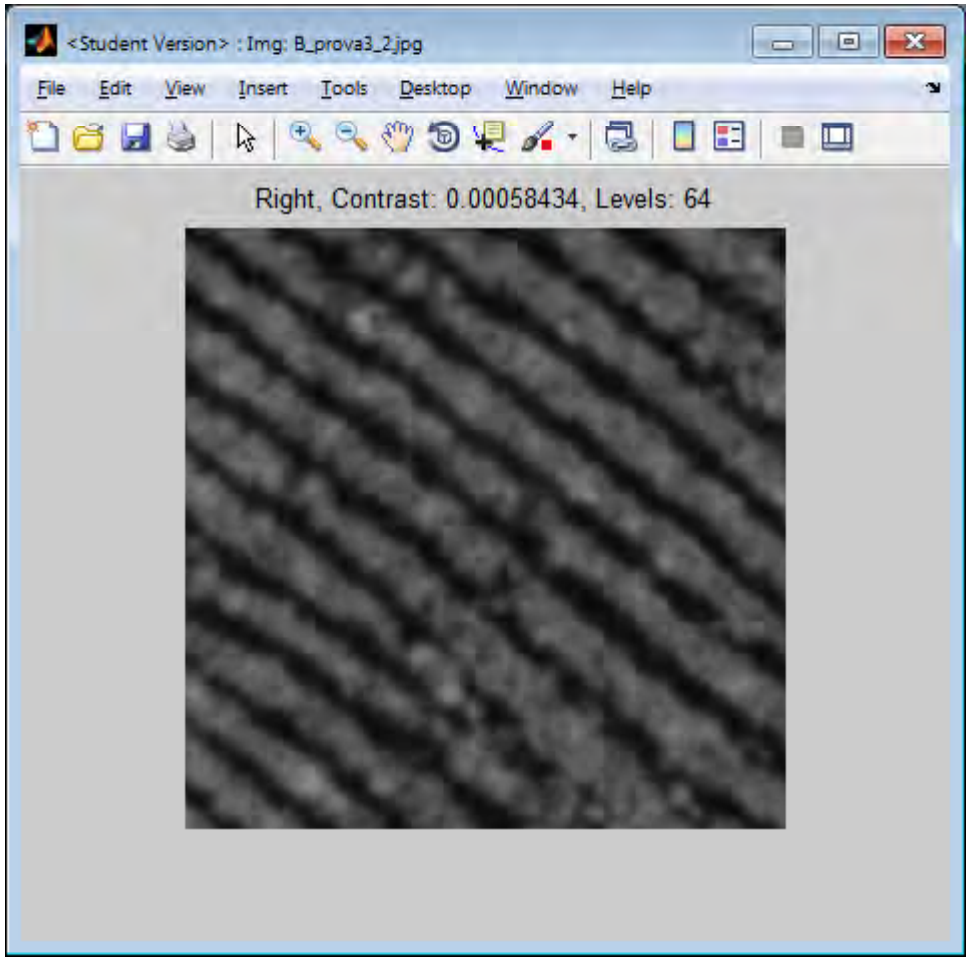
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