Technologie digitálního snímání prstů

Technology of digital fingerprint scanning

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Bakalářská práce
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Univerzita Tomáše Bati ve Zlíně
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Téma práce:	**Technologie digitálního snímání prstů**

Zásady pro vypracování:

1. Seznamte se s fyzikálními principy různých technologií snímačů otisků prstů.
2. Vypracujte literární rešerši zaměřenou na základní principy automatizovaných elektronických biometrických autentizačních systémů založených na snímání otisků živých prstů.
3. Vypracujte metodiku testování kvality sejmutých otisků prstů nezávislou na algoritmickém zpracování.
4. Zaměřte se na predikci rušivých vlivů, které mohou ovlivňovat konkrétní typy snímačů otisků prstů.
5. Proveďte zkušební sady testů na dostupných snímačích s navrženou metodikou.

Rozsah práce:

Rozsah příloh:

Forma zpracování bakalářské práce: **tištěná/elektronická**

Seznam odborné literatury:

1. JEDLICKA, M.: Teaching materials, Police academy MV in Brno, 2005.
2. Kriminalistický sborník, 1995, Magnetpress Praha.
3. Drahansky, M.,Nötzel, R.,Bonfig K. W.: Sensoren zur Fingerabdruckerkennung, Brno, 2004.
4. http://fprints.nwlean.net
5. http://biometrics.cse.msu.edu
6. http://www.optel.pl
7. http://www.ntt.co.jp

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Ve Zlíně dne 13. února 2007

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ABSTRACT

Getting up elements of dactyloscopy methods and knowledge pieces. Resume basic principals of automatic electronic biometric authentization of alive fingerprints. Explore technologies of reading fingerprints and complete list of influences that may have the biggest impact on fingerprint recognition depending on the type of technology. Deduce generic tests of working and correct recognition under different types of influences. Watching the relation between quality of output image and different influences.

KEYWORDS

Biometric, fingerprint reader, dactylography, dactyloscopy, authentization, sensor, reader, optoelectronic, capacitive, thermo, electroluminiscent, ultrasonic, electric field, pressure, contactless, piezoelectric.

I'd like to thank to major JUDr. Miloslav Jedlička, teacher of the Secondary Police school of Ministery of Interior in Brno for his great expounding with the dactyloscopy, donating valuable documentation and for skilled consultations.

Prohlašuji, že jsem na bakalářské práci pracoval samostatně a použitou literaturu jsem citoval. V případě publikace výsledků, je-li to uvolněno na základě licenční smlouvy, budu uveden jako spoluautor.

Ve Zlíně ……………………….

Podpis diplomanta

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1 DACTYLOSCOPY BASE

There are many publications about dactyloscopy, its value, usege, history and various founders. It's worth mentioning that Dr. Robert Heindl[1] extracts in his masterpiece “System und Praxis der Daktyloskopie” (1927) from 867 books.

One of the first and probably the oldest proof of the knowledge of our ancestors about the existence of papilar lines on fingers, hands and foots can be found on a rock found in 1913 by an American explorer Garrick Maller in the Indiana State U.S.A. There are engraves called “petrogryfe” symbolizing a human hand on the rock. The age of the petrogryfes is estimated about some milleniums B.C.. Mr. Maller described them in his book "Picture Writing of the American Indians" but the purpose of their existence is still a mystery.

The knowledge of the dactyloscopy was proved for Assyrians, too. Sir Austen Henry Layard (1817 - 1894) worked for the British diplomacy in Asia and was also involved in archeology. He found a part of the Assurbanipals library founded in 9th century B.C. There were found fingerprints with names on fragments of potsherds there. For the first time archeologists thought that it was a coincidence and fingerprints had been made during making the potsherds. However placing of the fingerprints is not random. They were placed strictly next to the sign of each person and always on the same place. The same potsherds were found on archeology excavations in Greece, the territory of the Roman empire and Egypt. [1]

The first author, who wrote a document about fingerprints as an instrument of personal identification, was Kio Kung-yen [2] from China. There were found some documents which finish by a note saying that their validity was veryfied by a fingerprint. The Chinese knew the importance of fingerprints and used them in their buisness contracts. An old Chinese code of law commands to join a fingerprint on a divorce document (618 A.D.).

There is a literature from the dynasty Sung about making the fingerprints (1107 A.D.), too.

In Japan there was a method called a “bo-han” – thumb stamp. The left thumb was imprinted but only to criminals. This is the first noticed attempt of a dactyloscope registering of known criminals.

Scientist Jan Evangelista Purkyně (1787 – 1869) represents the first European dactyloscopy pioneer. He set up his 54 page writing "Comentatio de examine physiologico organi visus et systematis cutanei" (Briefing about physiological research of optical and skin organs) in Vratislav. The credit of this publication is in describing of papilar lines patterns and dividing them into 9 classes. He pointed a triangle formation of papilar lines called delta as an important classification mark but he didn’t mention fingerprints as an identification method.

Every identification method hat to have a science base resulting from logical patterns. English scientist Francis Galton has created this theoretic science ground for dactyloscopy. He evaluated that there were 64 billions of miscellaneous variants of ordering of papilar lines on one finger. For all ten fingers we get 6410. Galton expected the maximum earth population 16 billions and by that he practicly eliminated the possibility of existence of two people with same fingerprints. He published his conclusions on 25th May 1888.[1]

Unfortunately this is not possible to use with full efficiency in an electronic verification because of technical matters and computation – time consuming. We verify just few kinds of markants (identification points) on one finger and mostly without the delta formation but these types of solutions are used only in commercial sphere and they have limited number of users.

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[1] Robert Heindl introduced the fingerprint classification system to Germany in 1900

Exactness of identifying through papilar lines is given by a large number of specific identification marks (markants) enabling thus a quite easy matching or diversifying of one papilar line one shape from another. For the electronic person identification we consider 8 matching markants as sufficient for a positive result of matching. Getting older, growing up or building up a human body, the papilar lines can get wider, higher or larger but their drawings, quantity and details (markants) cannot be changed. If a drawing of papilar lines, or their part, are mechanically damaged on the surface of the skin (lat. epiderm) the original drawing appears after some period again in the same shape. That means that the papilar lines on the inside part of the hand are not temporary built shapes of surface. They are special copies of the deeper skin part relief which is called corium. Existence of this layer causes a relatively high level of papilar lines drawing stability.

Hand calluses of a hard working man will damage the papilar lines drawing only temporary and do not make their identification impossible. The scars also cannot have a big influence on the drawings. The main type and shapes of a drawing stays the same and it’s still possible to classify and compare them. We can take fingerprints from a dead body too until its skin is completely destroyed by rotting processes.

It is proved by microscopic observing that the papilar lines drawings ground start to grow in the fourth embryonic month. The drawings in the epiderm start to be clearly noticeable in the fifth embryonic month. In the sixth month papilar lines start to grow on the surface of the skin devided by deep furrows. No other formation appears on the skin from this moment. Existing formations are getting stronger, furrows are getting wider and deeper and papilar lines are growing higher out of the skin surface. Fingerprints could be taken from the fetus in the last month of pregnancy.

1.1 Embryonic fingerprints evolution [3]

Papilar lines are so stable because of placing their ground under the skin surface into the corium of fingers, hands and foots. That enables to take the fingerprints from dead bodies partly destroyed by a rottness. The rotted skin surface is chirurgicaly removed and classical dactyloscoping is done.

"*Daily criminalistic experience and expert activities are probably the best proof of the stability and exactness of the dactyloscopy. Criminals, missing persons and dead bodies are identified by the dactyloscopic comparing of fingerprints taken tens years ago.*" [4]

There are some basic rules deduced from empiric observations and checked in practice. They are called "three dactyloscop principles":

a) There are no two people with the same papilar lines drawings.

b) Papilar lines drawings stay unchanged for the whole human life.

c) Papilar lines cannot be pruned away or changed without damaging the skin germ layer.

2 ELECTRONIC BIOMETRIC AUTHENTIZATION

2.1 Main principles

Electronic process of biometric authentification has a plenty of odds in comparison with manual methods. The speed is on the first place but the objectivity and the low mistake probability is a big advantage too (providing a good ethalon screening). The usual criminalistic practice is that system chooses a few candidates with similar fingerprints from a database and offers them to the specialists for a manual evaluation and correction. That's how e.g. the AFIS200 system located in the Criminalistic Institute in Prag delivered by De Lat Rue Printrac company works. Its cost was 100 mil. CZK[4].

This price is however absolutely unacceptable for the commercial sphere. That's why the usual systems use another principals. The main difference is in a considerabely smaller database of fingerprints and persons stored in the access systems against the criminalistic dactyloscopy mainframe – they usually store a fingerprint of only one finger not all of them neither the whole hand as the dactyloscopy system does. Therefore a much smaller compute and memory capacity is sufficient enough.

But commercial systems for access control or door opening and subject passing evidence must evaluate the stored fingerprint almost realtime else users come uncomfortable with the system. So these systems work with simplified models and most of them knows only two or one type of markants (fork and ending). They do not classify the fingerprints to the fingerprint types or do not compare delta formation – that's because of a comfortable fingerprint reading too.

The electronic equipment of a reader is nowadays a secondary question mainly thanks to a considerable miniaturization. The main scanning reader itself has the biggest impact on the quality and reliability of the fingerprint evaluation.

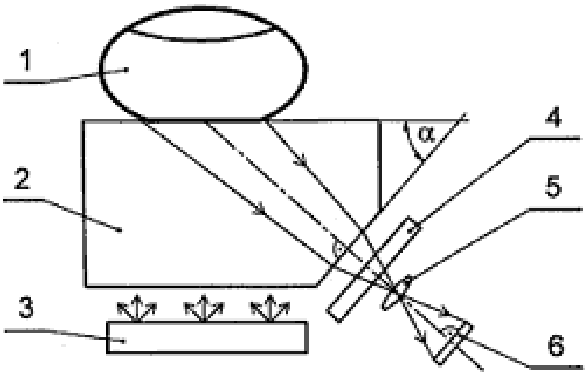
2.2 Sensor technologies

There are many kinds of fingerprint readers using various principles on the market and new technologies are still tested and developed.

1) **Optoelectronic readers**
2) **Capacity sensors**
3) **Thermo sensors**
4) **Electroluminiscent readers**
5) **Ultrasonic readers**
6) **RF sensors**
7) **Pressure and piezo sensors**
8) **Contactless readers**

2.2.1 Optoelectronic readers

They use mainly the CCD reader technology. Surface of the finger placed on the glass cuboid is illuminated and the deflected light is read by a CCD camera or a CCD matrix detector. These readers must be equiped with an optical correction system and must have an exact adjusting which makes them much more expensive. They are not suitable for mobile systems but they should be fixed on one place for getting best results. With a good setting they take sharp pictures with high resolution.



1.1 Optoelectronic reader (utility model –

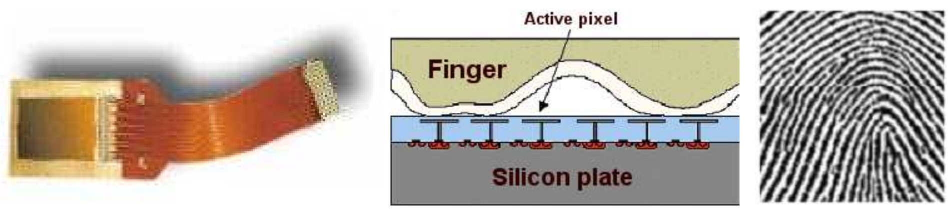
CZ – No. 6099) 1 Finger, 2 Cuboid, 3 Light,

4 Optical filter, 5 Object lens, 6 reader (CCD)

These readers are however sensitive for a very dry skin or on the other hand for a very greasy skin. Therefore their surface is sometimes equiped with a thin silicon foil which reduces these impacts and makes the output image sharper.

2.2.2 Capacitive reader

In comparison with the optoelectronical readers these readers are smaller and their production is cheaper and less difficult. The finger is taken directly in a digital form. The surface of a capacitive reader is overlayed with a layer of microelectrods placed on a silicon plate.

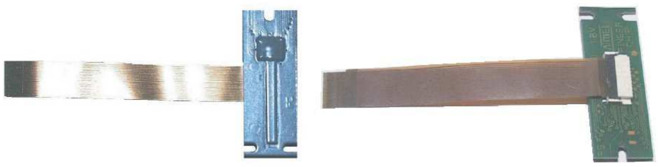


2.2 Capacitive reader [5]

This reader is the most common one. Like optoelectronic the capacitive readers have also problems with a very dry or too oily skin and they are quite sensitive on ESD (Electro-static discharge) because of a thin coating (only few microns) which is necessary to provide sufficient sensibility but their manufacturing is cheap and they are quite thin and that makes them ideal for market.

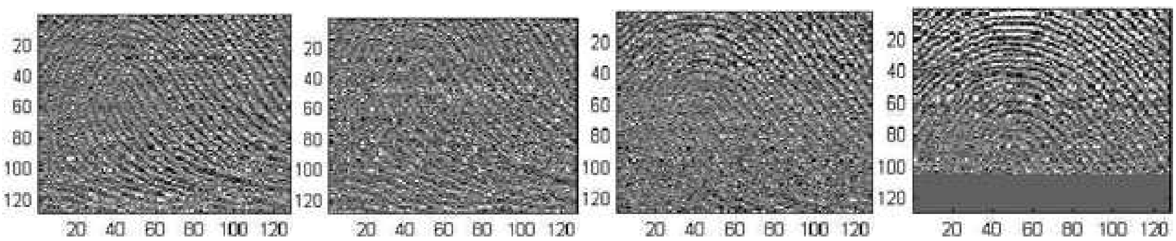
2.2.3 Thermo sensors

Their biggest advantage is in their small size. They are usually integrated into one chip which is as wide as a finger. They mostly work on a finger slide principle. The output images are however of a very poor quality depending on the speed of the finger swipe, body temperature etc.



2.3 Thermo sensor [6]

The output image of a finger consists of thinner strips taken during the finger swipe.

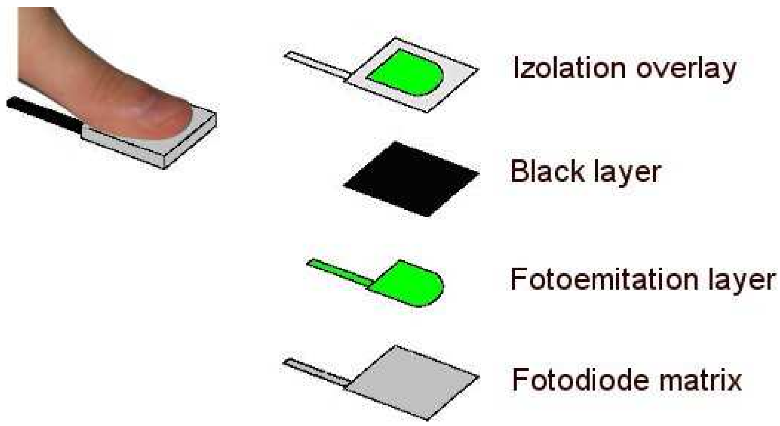


2.4 Four takings of the same finger by a thermo sensor [6]

This sensor is used on non critical places and is not suitable for rooms with wide temperature changing. Also the quality of the output image depends on the velocity of swiping. Despite that they are widely expanded mostly because of their small size and non expensive manufacturing.

2.2.4 Electroluminiscent reader

These readers work on relatively new principles. They contain a layer of a special polymer which emits light when in pressure. This layer is covered by a black overlay which prevents a contamination by a light from the surround. The other side of this layer is covered by a photodiodes field which catches the emitted light and digitalizes it. The principle of the reader is quite similar to the piezo reader but this reader takes images with a considerably higher quality.



2.5 Electroluminiscent reader

Thanks to the chemical-physical principle of these readers we can get an image with a high resolution. These readers are more sensitive for a physical damage and for pollution, e.g. by dust. The moisture and dry or greasy skin should not have a big influence on this reader but the manufacturer provides information only in Korean.

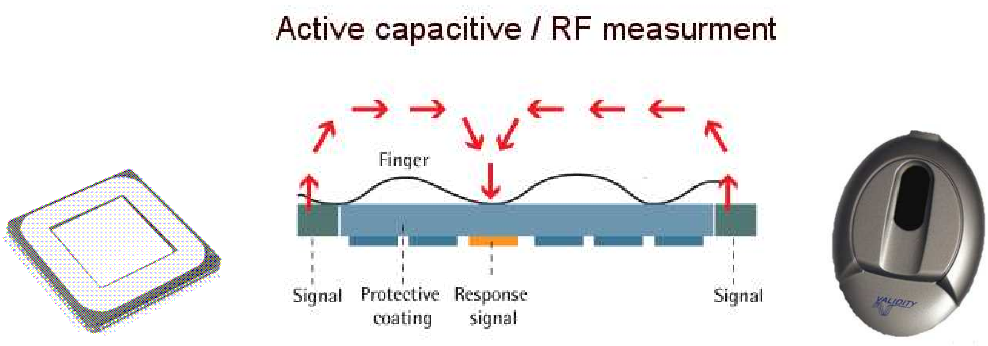
2.2.5 Ultrasonic reader

This type of a reader has been nowadays still in development. The devices are still very huge, their construction is complicated and they are very expensive. It takes still a long time to get an image and the results are still disputable. Their advantage is that it is not easy to cheat it by a fake fingerprint and also the ability to read a fingerprint from the deeper layer of the skin. That enables them to read fingerprints from dead bodies in a late phase of rotteness.

2.6 Ultrasonic reader – Optel Ltd R&D model of ultrasound camera; Picture taken by an ultrasound reader [7]

2.2.6 RF sensors/ E-Field sensor

RF sensor developed in 1998 creates an electric field from a ring around the sensing area which an array of pixels can measure variations in the electric field with, caused by the ridges and valleys in the fingerprint. According to the manufacturer, the variations are detected in the conductive layer of the skin, beneath the skin surface or epidermis.



2.7 E-Field sensor AuthenTec EntréPad® AES4000; Main principle; Validity VFS101 2D Swipe Sensor™ [6] [8]

This sensor could be sensitive on disturbtions in its RF modulation but the manufacturer doesn’t provide any closer details.

2.2.7 Pressure and piezo readers

One of the very first ideas how to get an image of papilar lines was to use their pressure on a surface. At first piezoelectric materials were used. But piezomaterials need a higher pressure for an emitation which reduces their sensibility. Later some new solutions were developed and some technologies has today been in the market (eg. Micro-electromechanical switches on a silicon chip, Conductive membrane on TFT or Conductive membrane on a CMOS silicon chip, eg. BLP-100 pressure sensor from BMF company developed by Sanyo company [12]). There also exist another technologies based not on a piezoelectric effect, using mostly silicon microswitches, but because of many difficulties with their manufacturing they still stay in laboratories only.

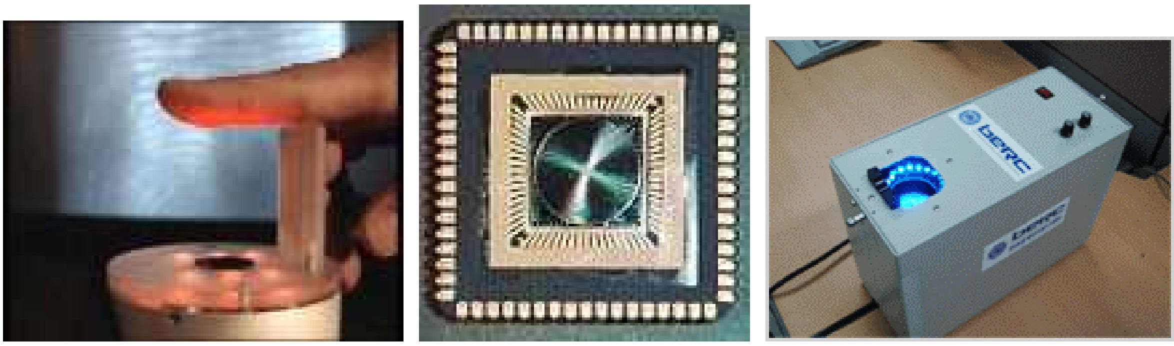
2.8 Prototypes of pressure non-piezoelectric sensors [9] [10]

NTT Microsystem Integration Laboratories, Michigan Univerzity, LighTuning Tech. Inc. (LTT), prototypes

Advantage of piezoelectric sensor is that they are not sensitive on the humidity of the finger and has low power consumption.

2.2.8 Contactless reader

Contactless readers are based on the optic technology but in a bit different way than optoelectronic readers. The reader unlike conventional fingerprint recognition methods does not require a direct contact between the sensor and the skin surface. The light reflected by the finger is caught by a CMOS sensor which generates the finger image. It’s similar to a primitive photography.



2.9 TST Touchless technology sensors [11] [6]

However the finger must be placed in the strictly specified area beyond the reader or the image is blury or fuzzy.

3 TESTS

At first we must summarize the main influences that could have some effect on the fingerprint readers and pick up those which may have the biggest impact on the quality of taken images.

3.1 Influences

For the main influences I comprehend temperature, light, humidity, electromagnetic field, physical pollution, physical damage, vibrations, and air pressure. I picked up temperature, light, humidity and physical pollution as the most changing and common influences, which should be tested closely.

3.2 Generic tests

Based on the main influences I have deduced following generic tests that should be made.

I. Temperature

a) Low finger and sensor temperature

b) Low finger and high sensor temperature

c) High finger and low sensor temperature

d) High finger and sensor temperature

II. Light

a) Work in the darkness

b) Work in the bright light

c) Work in the darkness with light coming through the finger

d) Changing light during the measurement

III. Humidity

a) Dry finger on dry reader
b) Dry finger on wet reader
c) Wet finger on dry reader
d) Wet finger on wet reader

IV. Electromagnetic field

V. Physical pollution

a) Work in the environment with different types of the dust
b) Work with fingers polluted by different types of sand
c) Work with fingers polluted by muddy water (after drying out)
d) Pollution by human and animal hair
e) Fingers polluted by glue
f) Fingers polluted by a fix, ink or other types of paints

VI. Physical damage of the finger

a) Scars
b) Burns
c) Calluses
d) Chemical damage
e) Rash

VII. Vibrations

a) Low vibrations of the finger (slow movement of the finger)
b) High vibrations of the finger (fast moving with the finger)

c) Low vibrations of the reader

d) High vibrations of the reader

VIII. Air pressure

a) Low (at least under 980 hPa)

b) High (at least above 1050 hPa)

Results of the following tests with devices is very interesting

3.2.1.1.1 Device	3.2.1.1.2 Test group
Optoelectronic	**II. III. V. VI. VII.**
Capacity	**I. III. IV. V. VI.**
Thermo	**I. III. V. VI.**
Electroluminiscent	**II. III. V. VI. VIII.**
Ultrasonic	**III. VII. VIII.**
RF	**I. III. IV. V. VI.**
Pressure	**I. V. VI. VIII.**
Contactless	**II. III. V. VI. VII.**

Tab. 3.1

Unfortunately I must exclude some kinds of tests because of their difficult implementation. Primary the physical damage of the finger and changing the air pressure. I had to exclude the electromagnetic field disturbance tests also because I didn’t have proper equipment for realizing them. In the humidity tests we can overpass the III. d) and e) tests because they have sense only with touchless sensors which are not easily available.

3.3 Devices donated for testing

Devices donated for testing were based on capacity, optoelectronic and electroluminiscent readers. All of them are intended for low or middle end trading. None of them is high professional but low end devices usually take the biggest part of the market. Therefore their tests are the most interesting. However there was no opportunity to get an image from some of the devices so the testing would be limited only to values yes-no which is not acceptable for our usage. For the extended testing we should have a wider spectrum of various types of fingerprint readers. I could only test the proposed method of testing with donated devices but making some results about physical principles of devices with such small number of samples would be very debatable.

3.3.1 Intagral Plus Biometrix

Biometrix attendance clock is developed by an Israeli company Micronet[2] and in Czech Republic sold by Holding CoNet s.r.o.[3] which donated this device for the testing. This low-end device has an capacitive reader. There was no avaible software to download the images of fingerprint for this reader even after several contacting the manufacturer.

3.3.2 Synel Print-X FP-S

Synel Industries is a company specialized for attendance and access control systems. They resell wide spectrum of terminals but I have found out that it's only an OEM reseller and technical support on special requests is on a poor quality. Most of their readers are based on capacitive fingerprint readers and I found a way how to extract it from the service program Falcon.

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[2] http://www.micronet.co.il
[3] http://www.conet.cz

3.1 Synel Print-X module

The main problem with commercial readers is that they cannot storage the whole image of a fingerprint because of their storage capacity and the laws for personal information protection. Usually they only show the fingerprint on the screen but storage only markants of it. For my test I used the terminal SY Print-X in FP-S model which is connected by com port and I storaged the image of the fingerprint by screen capture.

3.4 Applied tests

For capacitive reader I have decided to carry out tests from test groups **I. III. V.** (***I.*** *Temperature,* ***III.*** *Humidity,* ***V.*** *Physical pollution)* I don't have the equipment necessary for the test group **IV.** – the electromagnetic field tests and I also omitted the test group **VI.** – the physical damage of finger tests.

3.5 Used method of testing

At first I had to make an ethalon which every sample will be referred to. Commercial products usually take only one fingerprint capture to make the ethalon but I decided to take three to make the tests more fault tolerant.

3.2 The three raw captures ethalons

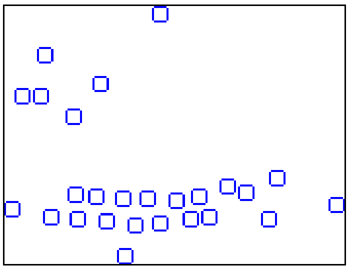
From the captured ethalons I extracted all the markants which are on all of them and make a markant map. Standard method is to make a wire model of the captured fingerprint and find markants on it.

3.3 The markant map with markants [5]

Making the wire model is the first point where the used algorithm takes the biggest impact. By making the algorithm too much tolerant we wouldn't find any markants but making it too strict we will find too many false markants.

3.4 Ethalon1 with a wire model; wire model; wire model with a markant map

After getting the markant map we can use it for evaluatation of each captured fingerprint. To avoid errors made by moving the finger it's usual to find the fixed point in the fingerprint and orientate the markants to that. We have to count with possible deformation of the finger and be prepared to rotate and stretch the markant map.



3.5 The markant map of used ethalons

There will be two values gained from the test fingerprints. The number of missing markants and number of false markants. By missing markant I count every markant which is on the markant map but not on the testing capture. By false markant I count every markant which is on the testing capture but not on the markant map. It's expectable that there will be nonzero number of false markants on every capture because of the method how I get the ethalon. For further tests we can make a *fuzzy markant map* which contains markants from all of the ethalon captures but with a different weight. Markant engaged in every ethalon capture would have the highest weight and markant contained only on one ethalon capture would have the lowest one. But for our purposes the simple markant map is more sufficient. We also operate in the area of the markant map only.

3.6 Example test

I have tested the device Synel Print-X in the FP-S implementation. Due to the nonlaboratory conditions the testing values of the tests are only raw.

3.6.1 Temperature test of SY Print-X

Changing the temperature of the tested finger is always joined with changing its humidity because the skin reacts on the higher temperature by sweating. I have changed the fingers and readers temperature by hot air and by ice in the plastic bags. The high level of temperature was 50°C and the low level 10°C.

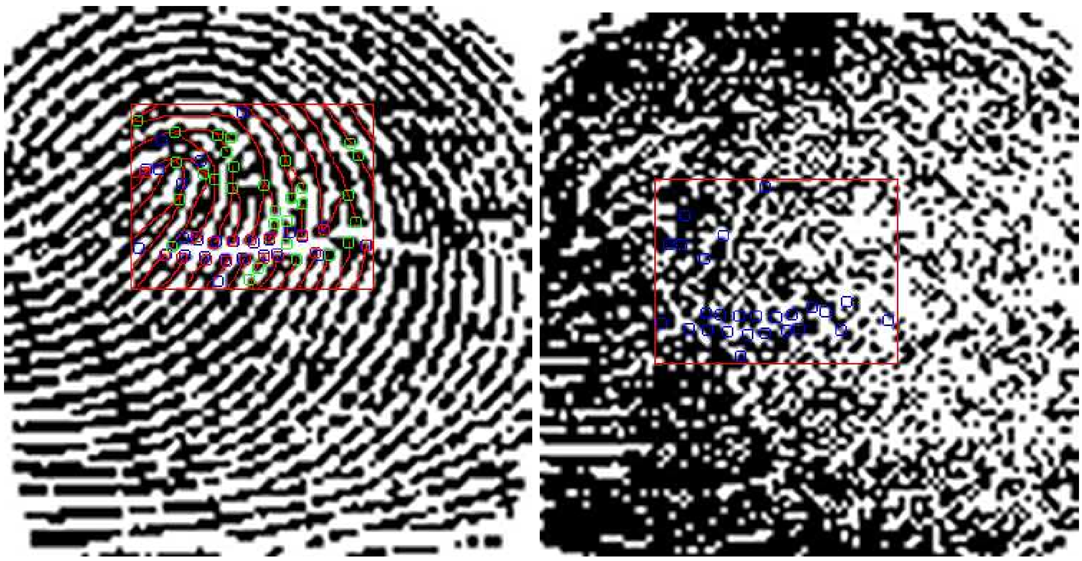
3.6 Devices used for temperature tests

The testing proceeded by heating or cooling the finger until the target temperature was reached. In that moment I captured the image and started to evaluate it by the markant map. On the example images are showed the markants from original markant map as blue, the markants which correspond to the ethalon are red and the false markants are green. The delay between each measurement when I was evaluating the capture was long enough for regenerating the fingers and readers original temperature so for every capture I had to heat or cool the finger. For the reader I applied the same process. Originally I wanted to heat the reader by a lamp to simulate heating by a sun but after some tries I refused that because it took a long time. Cooling the finger and reader produced a condensation moisture as I expected. I had been removing them by a paper tissues. The room temperature was stable 23°C.

3.7 Example of results of the tests I. c) and I. b)

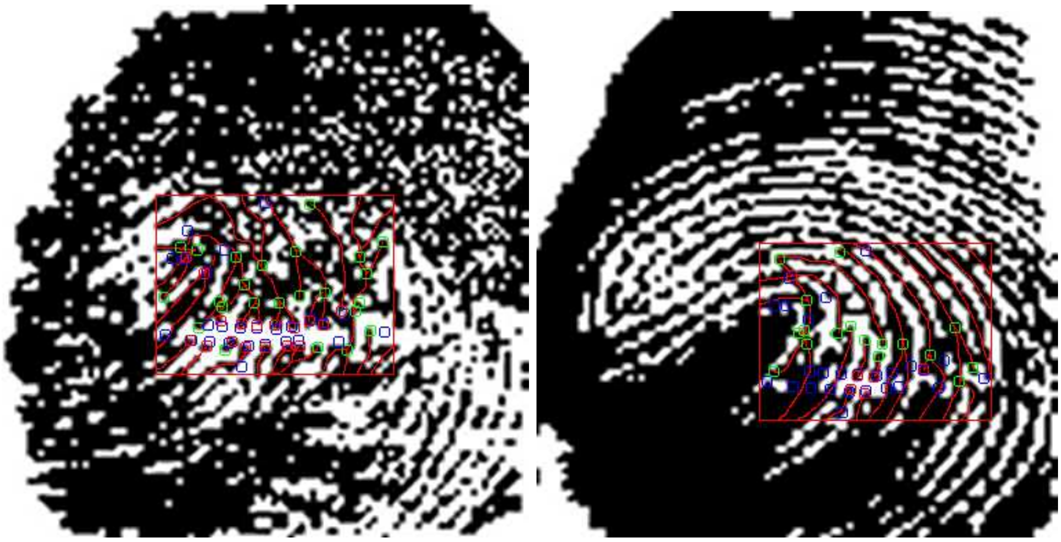
3.6.2 Humidity test of SY Print-X

The driest environment I was able to make was in 42% air humidity. Wet environment was made by a full water contact. I applied the water by a wet sponge.



3.8 Example of results of the tests III. a) and III. d)

It was completely unable to read the fingerprint on the tests with wet finger and wet reader (test group III. d)) as shown on example. Sometimes the software refused to read the finger reporting error of reading.

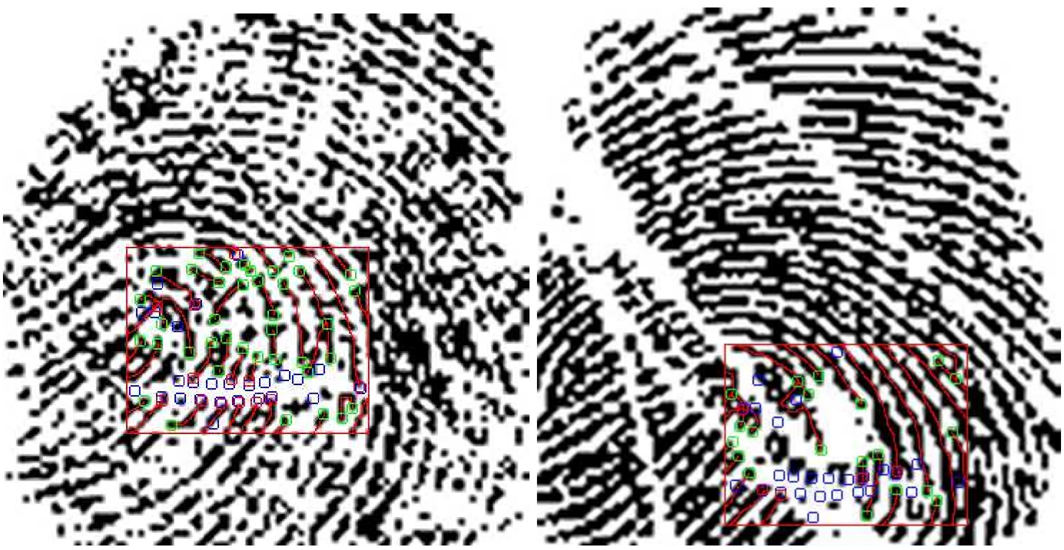


3.9 Example of the tests III. b) and III. c)

I was surprised that the results of the tests III. c) (Wet finger on dry reader) were worse than the results of the tests with dry finger and wet reader (III. b)). I expected almost same results for both test groups.

3.6.3 Physical pollution tests

I applied tests V. a), b), d) and f) – pollution by dust, sand, hair and paints. For dust pollution I used dust from the computer as an example of standard room dust. For hair pollution I used hair from my cat. For paint I used dry out water colors.



3.10 Example of the tests V. a) and d)

The pollution by the dust (test group V. a)) made the reading of the fingerprints relief harder but there were still enough positive markants for identification. This pollution only produced higher level of false markants because of discontinuing the papilar lines.

The pollution by an animal hair (test group V. d)) made the identification a little bit harder because the hair appeared on the capacitive reader as an unreadable area. The results depended on the position of the hair. It was unable to read the markants when the hair interfered their area. It also produced false markants. On the other hand it was quite hard to get the hair on the finger or reader and is more probably in wet environment. Therefore the results of the combination of wet finger with animal hair should be also interesting.

3.11 Example of the test V. f)

Results of the test V. b) (pollution by sand) are quite similar to the results of the tests with dust. I had quite soft sand and further tests should test more types of the sand.

The tests with paints (test group V. f)) proofed that the capacitive readers are not affected by this type of pollution. The number of false markants were low and predictable because of the method I used for getting the ethalon and the number of missing markants is minimal.

4 CONCLUSION OF TESTING

I made 10 tests from each test group. Evaluating the results of the tests showed that this kind of reader is not very sensitive to the temperature changes but it is very sensitive to the higher humidity and also to the pollution by animal hair and dust as I expected. Higher humidity disables the capacity effect which capacity readers use. Animal hair and room dust reacts as an isolating material and produce higher level of false markants. The room dust pollution makes identification a little bit harder but still capable. The pollution by the dry out water colors almost doesn’t take effect.

The results of applied tests proofed the abilities of the capacitive readers as a solid device for a low prize. The only area where can capacitive readers have problems is the environment with higher humidity.

5 APPENDIX A – THE RESULT TABLES

Results of the test group I. a) - Low finger and sensor temperature

I. a)		
Test no.	Missing markantss	False markants
1	8	10
2	7	11
3	7	11
4	5	10
5	9	13
6	6	12
7	5	11
8	10	22
9	11	10
10	8	9

Results of the test group I. b) - Low finger and high sensor temperature

I. b)		
Test no.	Missing markantss	False markants
1	8	9
2	9	19
3	8	12
4	7	10
5	8	10
6	10	11
7	8	13
8	7	9
9	9	11
10	8	10

Results of the test group I. c) - High finger and low sensor temperature

I. c)		
Test no.	Missing markantss	False markants
1	9	14
2	10	13
3	7	15
4	11	14
5	8	14
6	10	12
7	9	12
8	9	15
9	8	17
10	11	10

Results of the test group I. a) - High finger and sensor temperature

I. d)		
Test no.	Missing markantss	False markants
1	11	13
2	9	14
3	10	12
4	11	16
5	9	23
6	10	12
7	7	13
8	8	13
9	9	16
10	10	11

Results of the test group III. a) – Dry finger on dry reader

III. a)		
Test no.	Missing markantss	False markants
1	9	30
2	7	25
3	8	12
4	10	21
5	7	9
6	8	18
7	7	15
8	5	14
9	6	18
10	6	22

Results of the test group III. b) – Dry finger on wet reader

III. b)		
Test no.	Missing markantss	False markants
1	10	24
2	15	10
3	12	15
4	14	20
5	23	2
6	19	20
7	22	9
8	15	13
9	19	8
10	22	9

Results of the test group III. c) – Wet finger on dry reader

III. c)		
Test no.	Missing markantss	False markants
1	20	17
2	26	2
3	25	5
4	21	15
5	15	19
6	18	8
7	16	11
8	20	8
9	23	3
10	26	0

Results of the test group III. d) – Wet finger on wet reader

III. d)		
Test no.	Missing markantss	False markants
1	26	0
2	26	0
3	26	0
4	26	0
5	26	0
6	26	0
7	26	0
8	26	0
9	26	0
10	26	0

Results of the test group V. a) – Pollution by the room dust

V. a)		
Test no.	Missing markantss	False markants
1	13	37
2	11	22
3	5	28
4	7	42
5	18	31
6	15	24
7	12	25
8	8	29
9	10	15
10	9	33

Results of the test group V. b) – Pollution by the fine sand

V. b)		
Test no.	Missing markantss	False markants
1	16	19
2	14	24
3	18	31
4	20	18
5	24	24
6	21	22
7	8	31
8	19	18
9	12	30
10	16	25

Results of the test group V. d) – Pollution by the animal hair

V. d)		
Test no.	Missing markantss	False markants
1	21	20
2	16	25
3	8	18
4	18	34
5	22	27
6	7	41
7	21	33
8	25	29
9	17	24
10	12	34

Results of the test group V. f) – Pollution by the dry out water paints

V. f)		
Test no.	Missing markantss	False markants
1	5	14
2	4	16
3	5	13
4	5	10
5	4	17
6	7	16
7	3	14
8	5	15
9	7	12
10	3	10

REFERENCES

[1] Jedlicka, M.: Teaching materials, Police academy MV in Brno, 2005

[2] Joseph-Toussaint, Reinaud: Relation des voyages faits par les Arabes et les Persans L° Inde et a la Chine, Paris, 1845, ISBN 3-8298-1154-3.

[3] http://www.rodina.cz

[4] Kriminalistický sborník, 1995, Magnetpress Praha

[5] Drahansky, M.,Nötzel, R.,Bonfig K. W.: Sensoren zur Fingerabdruckerkennung, [dissertation], Brno, 2004, ISBN 3-933609-19-4

[6] http://www.conet.cz

[7] http://www.optel.pl

[8] http://www.validityinc.com

[9] http://www.eecs.umich.edu

[10] http://www.ntt.co.jp

[11] http://www.tst-ag.com

[12] http://www.sanyo.co.jp