Importance of Open Discussion on Adversarial Analyses for Mobile Security Technologies

--- A Case Study for User Identification ---

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Mobile Security Technologies

Security Architecture

Operating Systems Security

Software Tamper Resistance

Mobile Code Security

Physical Tamper Resistance

Communications Security

Cryptographic Protocol

User Identification

……

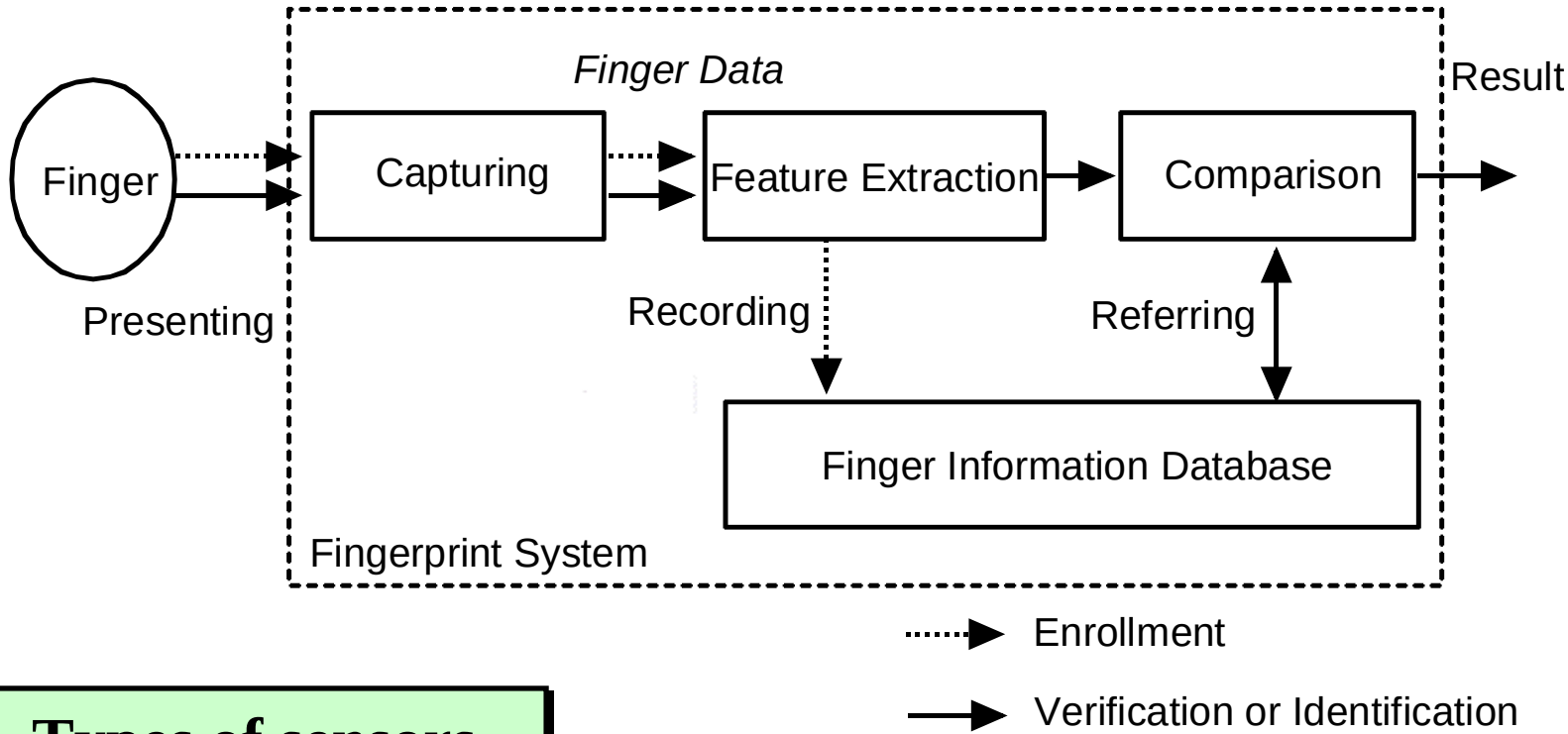
***Security assessment** of biometric user identification systems should be conducted not only for the accuracy of authentication, but also for security against fraud.*

In this presentation we focus on Fingerprint Systems which may become widespread for Mobile Terminals.

Examine Adversarial Analysis as A Third Party

- *Can we make artificial fingers that fool fingerprint systems?*
- *What are acceptance rates?*

Typical structure of a fingerprint system



Types of sensors

- Optical sensors
- Capacitive sensors
- Thermal sensors, Ultrasound sensors, etc.

"Live and Well" Detection

A Risk Analysis for Fingerprint Systems

Attackers may present

1) the registered finger,

by an armed criminal, under duress, or with a sleeping drug,

2) an unregistered finger (an imposter's finger),

i.e., non-effort forgery,

3) a severed fingertip from the registered finger,

4) a genetic clone of the registered finger,

5) an artificial clone of the registered finger, and

6) the others,

such as a well-known method as a "fault based attack."

Fraud with Artificial Fingers

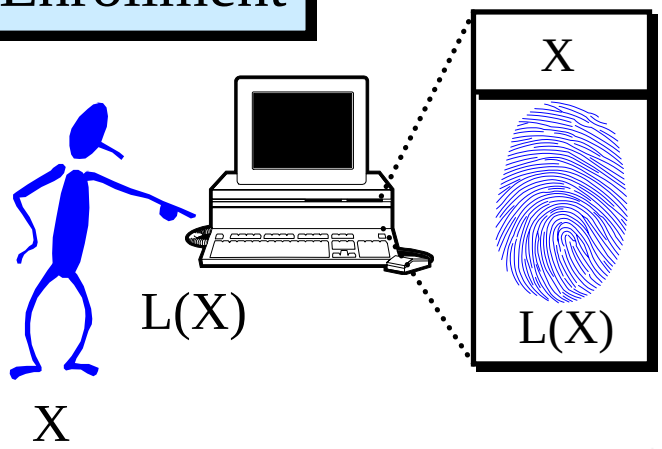
Part of patterns of dishonest acts with artificial fingers against a fingerprint system.

	Verification / Identification				
Enrollment	**L(X)**	**A(X)**	**L(Y)**	**A(Y)**	**A(Z)**
L(X)	**(1)**	**(2)**	**– ***	**–**	**–**
A(Y)	**–**	**–**	**(3)**	**(4)**	**–**
A(Z)	**–**	**–**	**–**	**–**	**(5)**

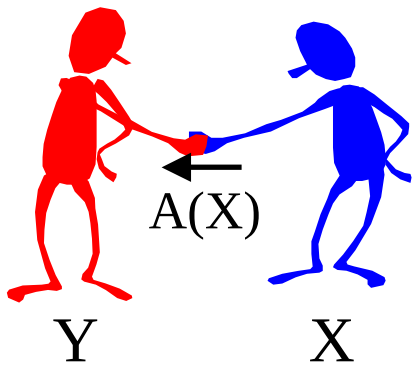
L(X): A Live Finger corresponding to Person X
A(Y): An Artificial Finger corresponding to Person Y
A(Z): An Artificial Finger corresponding to Nobody

Fraud with Artificial Fingers I

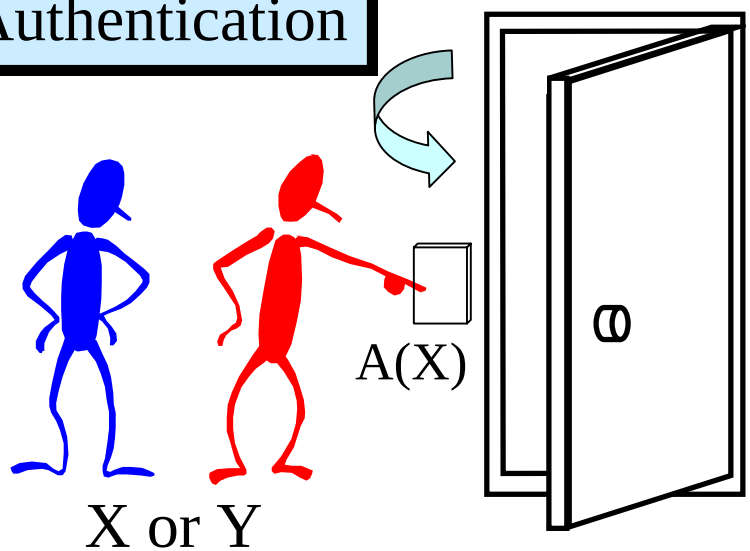
Enrollment



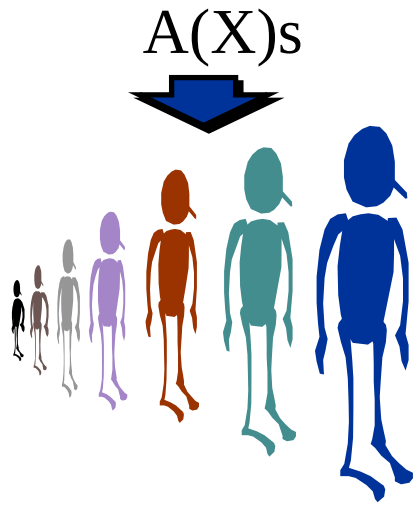
Y obtains A(X).



Authentication

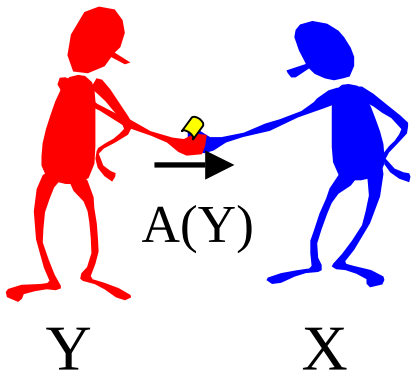


Distribution of A(X)s

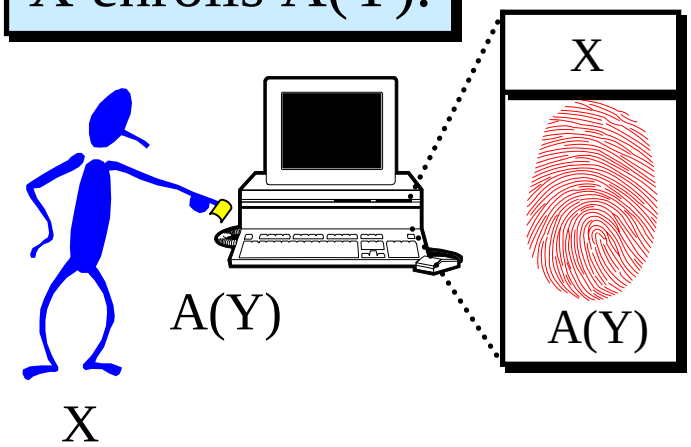


Fraud with Artificial Fingers II

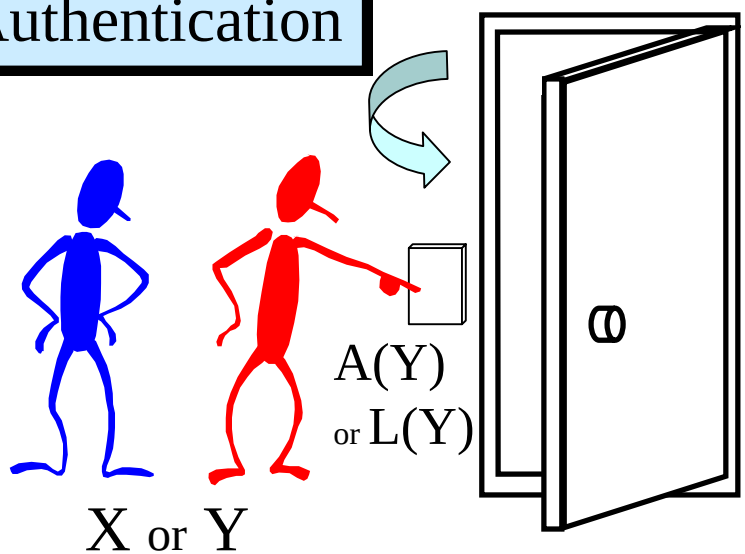
X obtains A(Y).



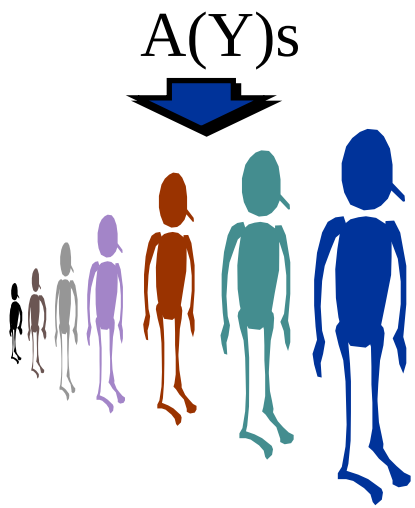
X enrolls A(Y).



Authentication

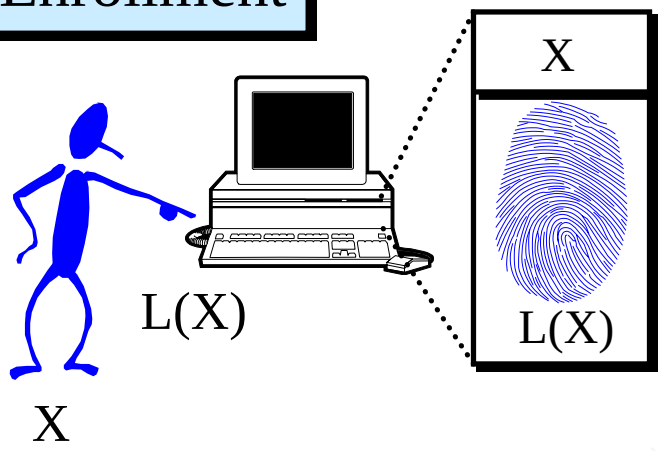


Distribution of A(Y)s

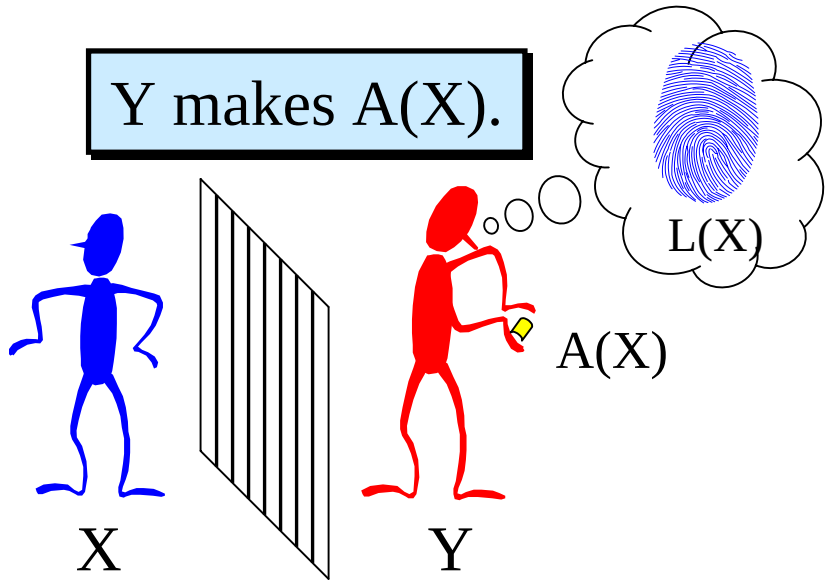


Fraud with Artificial Fingers III

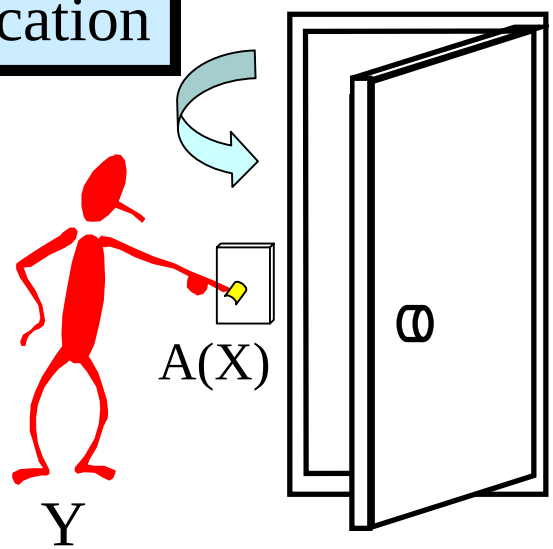
Enrollment



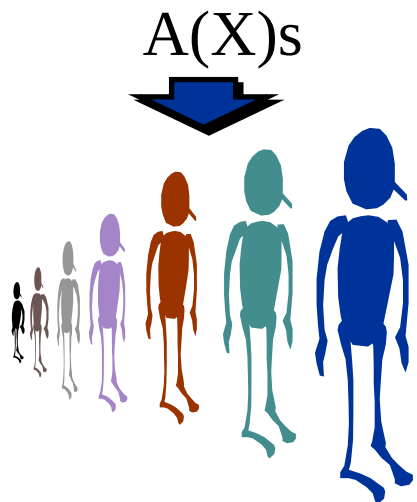
Y makes A(X).



Authentication



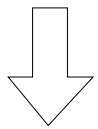
Distribution of A(X)s



Mapping a Fingerprint onto Artificial Fingers

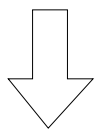
Finegerprint

e.g., Live Fingers, Generators, ...



Impression

e.g., Molds, Residual Fingerprints, ...



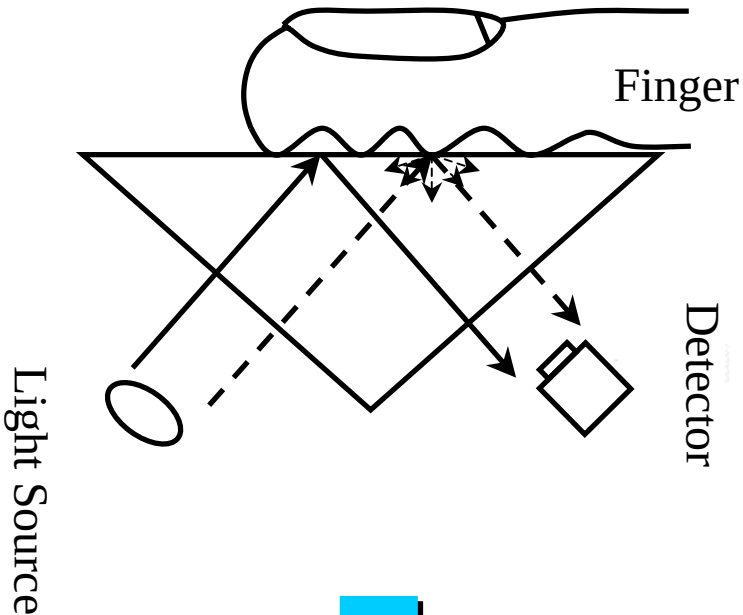
Artificial Finger

Process 0

(1) Finger
(2) Mold

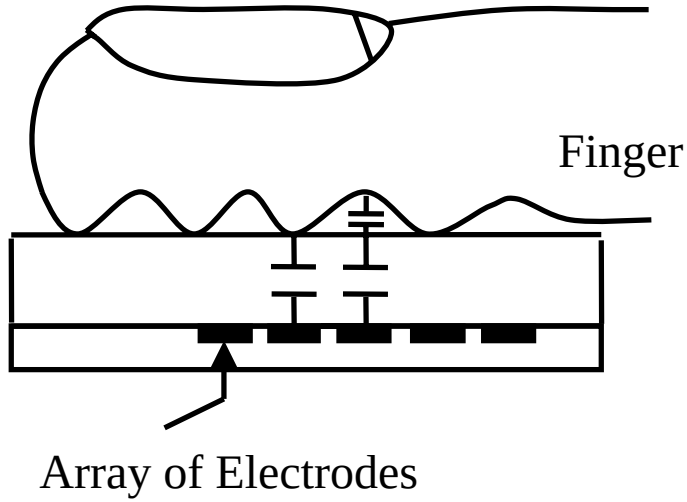
(3) Silicone Rubber Finger

Optical Sensor



Often Accepts
Silicone Rubber Fingers

Capacitive Sensor



Usually Rejects
Silicone Rubber Fingers

Our Result

Process 1

(1) Finger

(2) Plastic Mold

(3) Gummy Finger

Making an Artificial Finger directly from a Live Finger

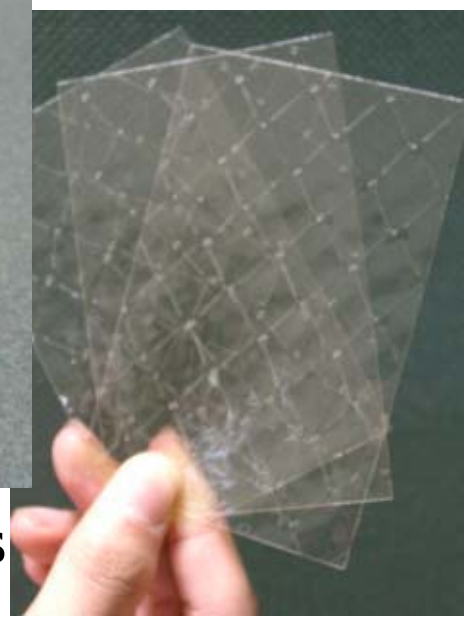
Materials

Free molding plastic
“FREEPLASTIC”
by Daicel FineChem Ltd.

350JPY/35grams

Solid gelatin sheet
“GELATINE LEAF ”
by MARUHA CORP

200JPY/30grams



Making an Artificial Finger directly from a Live Finger

How to make a mold

Put the plastic into hot water to soften it.

Press a live finger against it.

The mold

It takes around 10 minutes.

Making an Artificial Finger directly from a Live Finger

Preparation of material

- A liquid in which immersed gelatin at 50 wt.% .



Add boiling water (30cc) to solid gelatin (30g) in a bottle and mix up them.

It takes around 20 minutes.

Making an Artificial Finger directly from a Live Finger

How to make a gummy finger

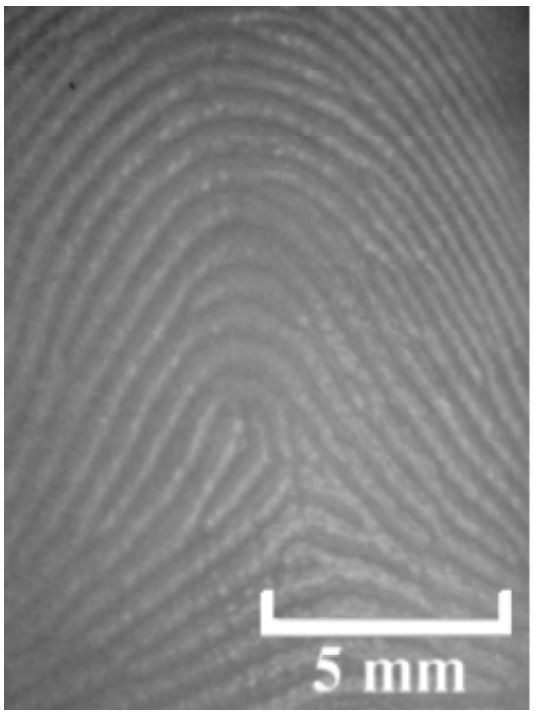
Pour the liquid into the mold.

Put it into a refrigerator to cool.

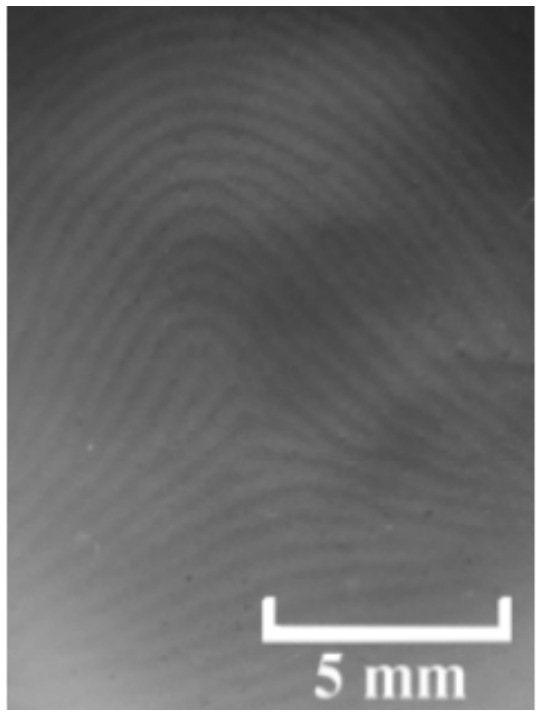
The gummy finger

It takes around 10 minutes.

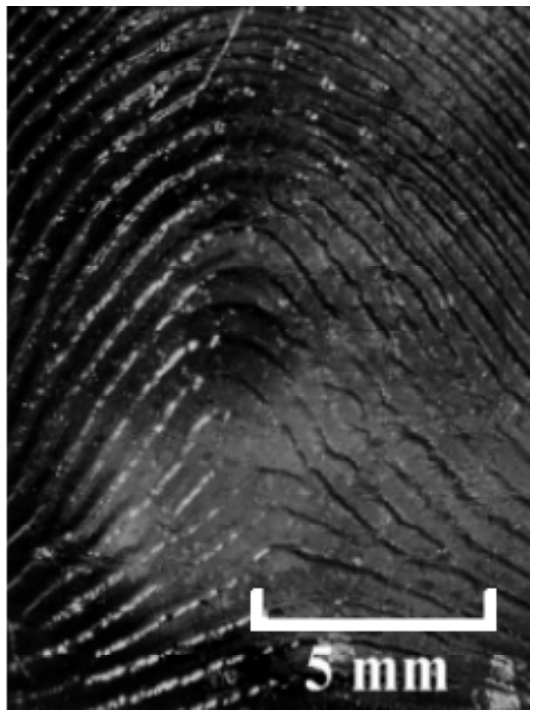
The photomicrographs of fingers



(a) Live Finger



(b) Silicone Finger



(c) Gummy Finger

Captured images with the device C (an optical sensor).

(a) Live Finger (b) Silicone Finger (c) Gummy Finger

Captured images with the device H (a capacitive sensor).

(a) Live Finger (b) Gummy Finger

***Subjects*: five persons whose ages are from 20's to 40's**

***Fingerprint systems*: 11 types**

We attempted one-to-one verification 100 times counting the number of times that it accepts a finger presented.

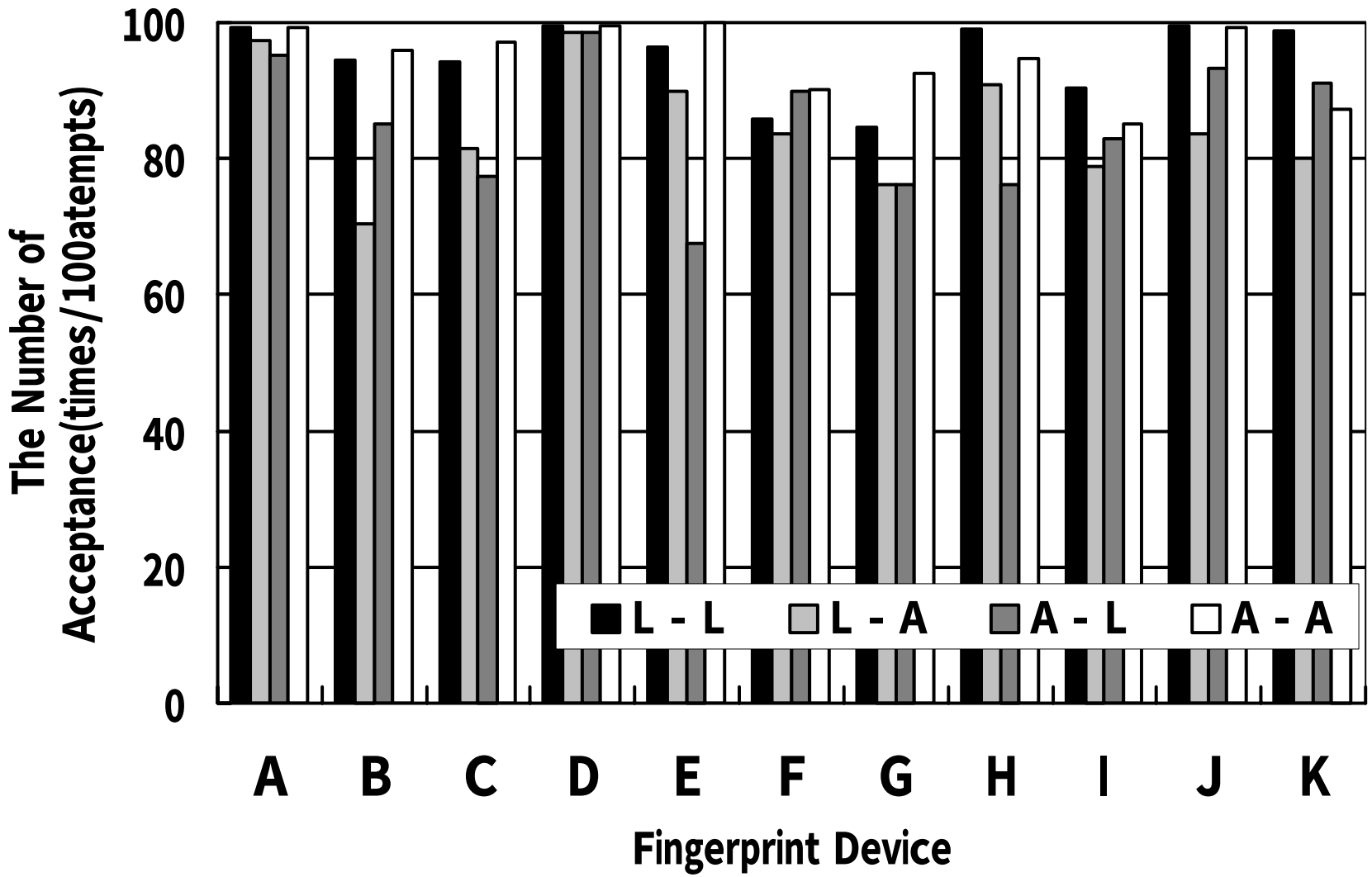
Types of experiments

Experiment	Enrollment	Verification
Type 1	Live Finger	Live Finger
Type 2	Live Finger	Gummy Finger
Type 3	Gummy Finger	Live Finger
Type 4	Gummy Finger	Gummy Finger

The List of Fingerprint Devices

	Hardware Specifications						Software Specifications			Methods for Verification
	Manufacturer / Selling Agency	Product Name	Type	Product Number	Sensor	Live and Well Detection	Manufacturer / Selling Agency	Product Name (Application)	Comparison Levels	
Device A	Compaq Computer Corporation	Compaq Stand-Alone Fingerprint Identification Unit	DFR-200	E03811US001	Optical Sensor	unknown	Compaq Computer Corporation	Fingerprint Identification Technology Software version 1.1	1 through 3	Minutiae Matching
Device B	MITSUBISHI ELECTRIC CORPORATION	Fingerprint Recognizer	FPR-DTmkII	003136	Optical Sensor	unknown	Sumikin Izumi Computer Service co. Ltd.	SecFP V1.11	Fixed	Minutiae Matching
Device C	NEC Corporation	Fingerprint Identification Unit (Prism)	N7950-41	9Y00003	Optical Sensor	unknown	NEC Corporation	Basic Utilities for Fingerprint Identification	Fixed	Minutiae Matching (Minutia and Relation)
Device D	OMRON Corporation	Fingerprint Recognition Sensor	FPS-1000	90500854	Optical Sensor	unknown	OMRON Corporation	"*YUBI PASS*" U.are.U Fingerprint Verification Software	Fixed	Minutiae Matching
Device E	Sony Corporation	Sony Fingerprint Identification Unit	FIU-002-F11	00709	Optical Sensor	Live Finger detection	TSUBASA SYSTEM CO.,LTD.	Fingerprint Identification Unit Windows 95 Interactive Demo Version 1.0 Build 13	1 through 5	Pattern matching
Device F	FUJITSU LIMITED	Fingsensor	FS-200U	00AA000257	Capacitive Sensor	unknown	FUJITSU LIMITED	Logon for Fingsensor V1.0 for Windows 95/98	Fixed	Minutiae Matching (Correlation)
Device G	NEC Corporation	Fingerprint Identification Unit (Serial)	PK-FP002	0300529S	Capacitive Sensor	unknown	NEC Corporation	Basic Utilities for Fingerprint Identification	Fixed	Minutiae Matching (Minutia and Relation)
Device H	Siemens AG (Infineon Technologies AG)	FingerTIP EVALUATION KIT	EVALUATION-KIT	C98451-D6100-A900-4	Capacitive Sensor	unknown	Siemens AG(Infineon Technologies AG)	FingerTIP Software Development Kit (SDK) Version: V0.90, Beta 3 "Demo Program"	Fixed	Minutia matching
Device I	Sony Corporation	Sony Fingerprint Identification Unit	FIU-710	3000398	Capacitive Sensor	Live Finger detection	Systemneeds Inc.	Good-bye "*PASSWORD*"s	1 through 5	Pattern matching
Device J	Secugen	EyeD mouse II	SMB-800	9650172004	Optical Sensor	unknown	Secugen	SecuDesktop 1.55 日本語版	1 through 9	Minutia matching
Device K	Ethentica	ethenticatior MS 3000 PC Card	MS 3000	M300F200991	Optical Sensor	unknown	Ethentica	Secure Suite Release1.0	Fixed	Minutia matching

Making an Artificial Finger directly from a Live Finger




Our Result
Process 2
(1) Residual Fingerprint
(2) Digital Image Data
(3) Printed Circuit Board
(4) Gummy Finger

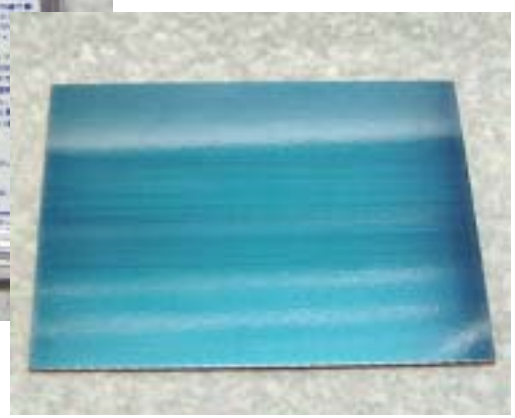
Making an Artificial Finger from a Residual Fingerprint

Materials

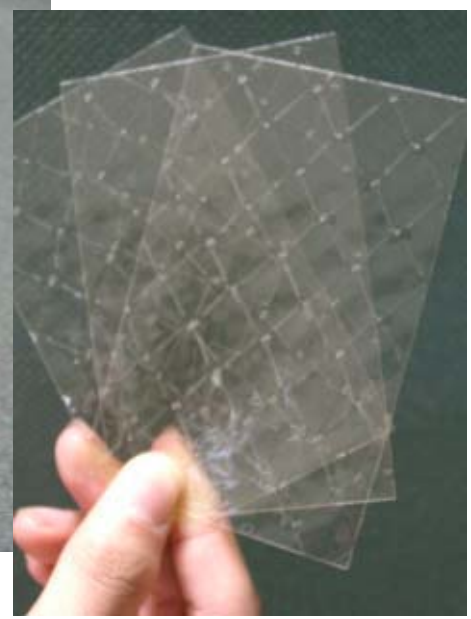
A photosensitive coated Printed Circuit Board (PCB)

“10K” by Sanhayato Co., Ltd .

320JPY/sheet



Solid gelatin sheet
“GELATINE LEAF ”
by MARUHA CORP



200JPY/30grams

Residual Fingerprint

- **Enhancing** ← Cyanoacrylate Adhesive
- **Capturing** ← *Digital Microscope*
- **Image Processing** ← *Adobe Photoshop 6.0*

Fingerprint Image

- **Printing** ← Transparent Film
- **Mask** ← *Inkjet Printer*
- **Exposing** ← *UV light*, Photosensitive Coated PCB
- **Developing**
- **Etching**

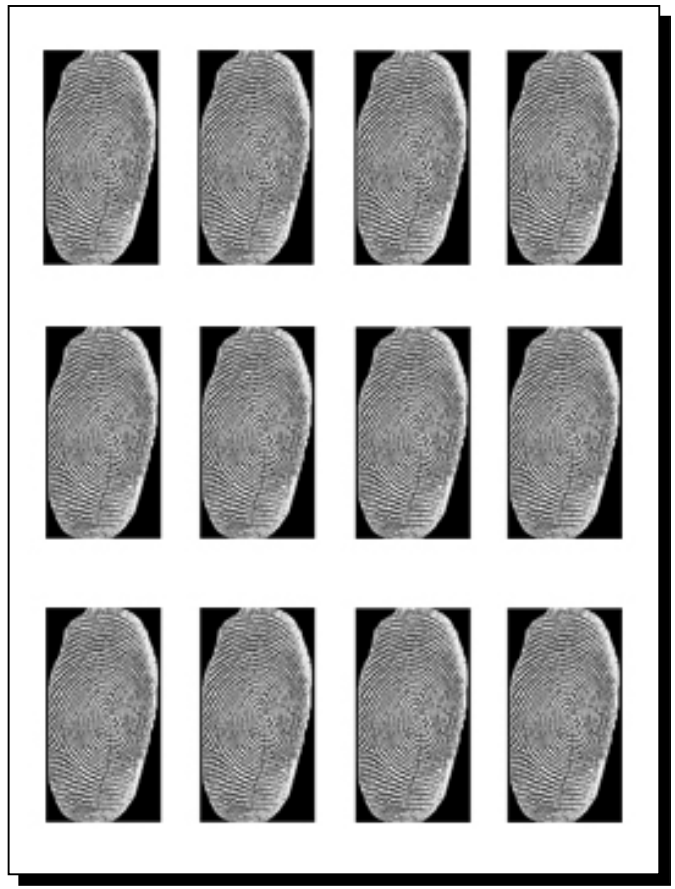
Mold

KEYENCE VH6300: 900k pixels

Canon BJ-F800: 1200x600dpi

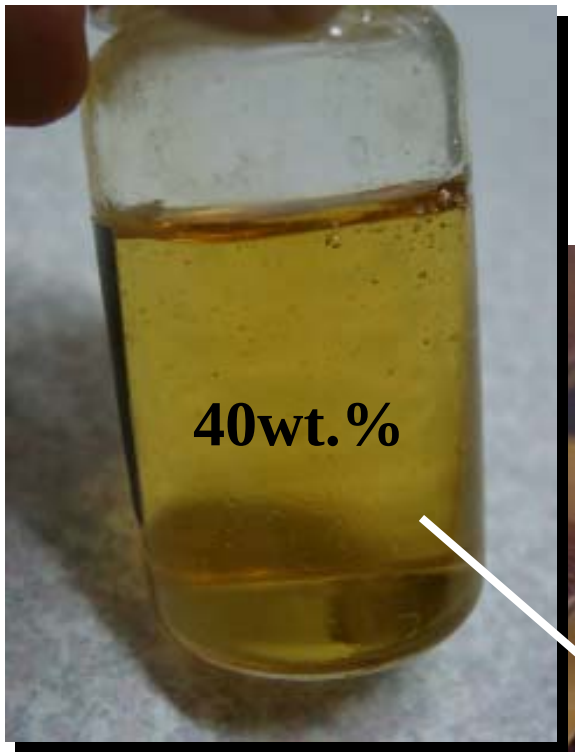
An Enhanced Fingerprint

A Fingerprint Image

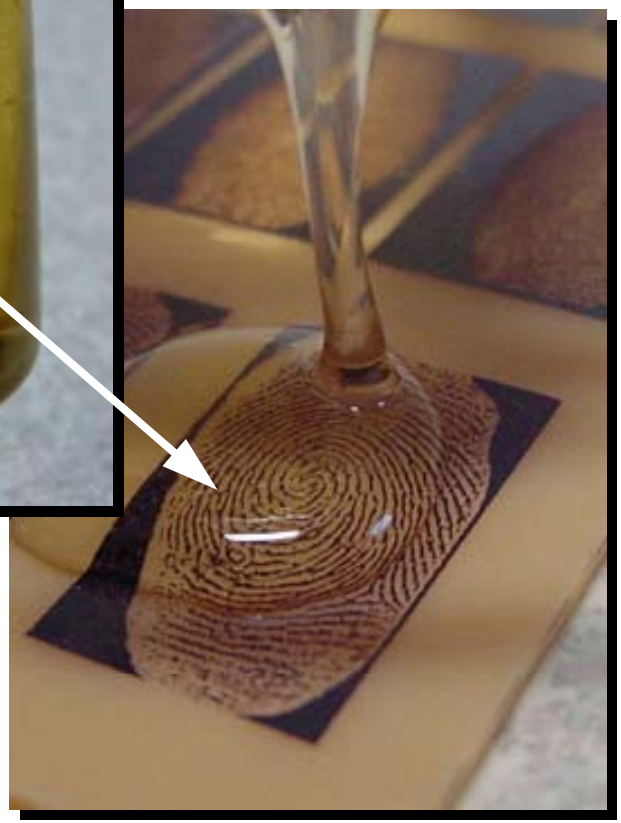


A Mask with Fingerprint Images

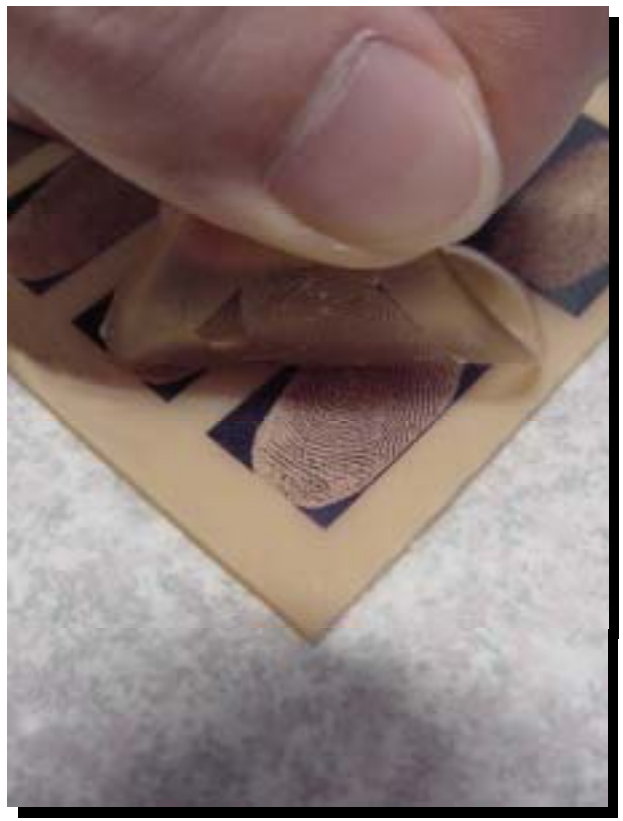
Gelatin Liquid



Drip the liquid onto the mold.

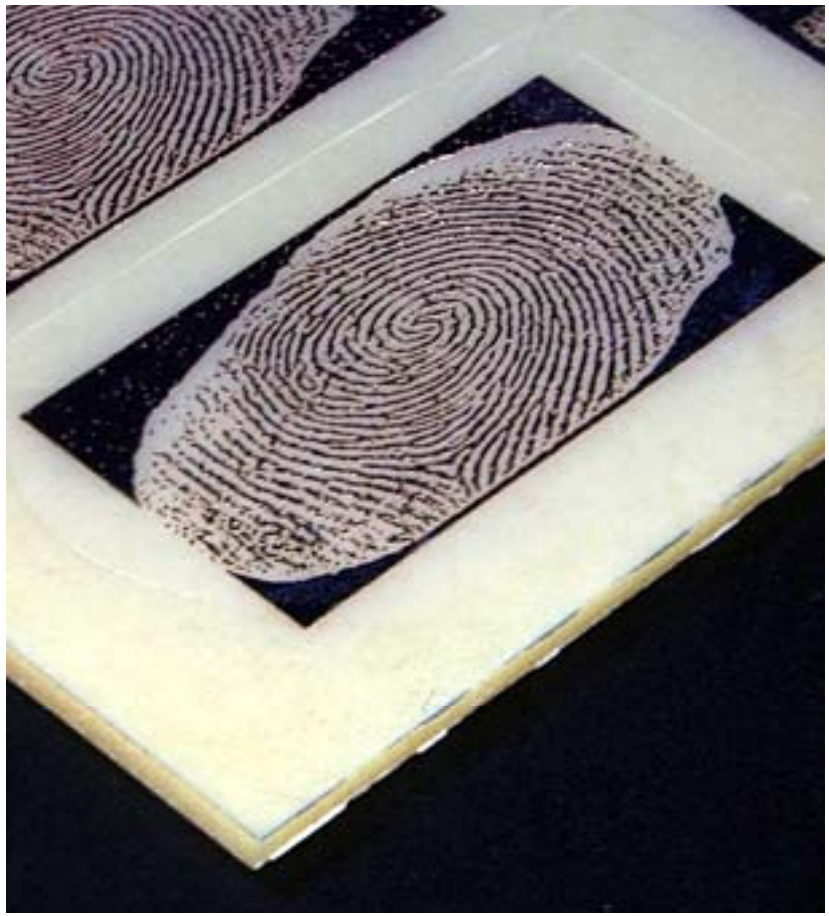


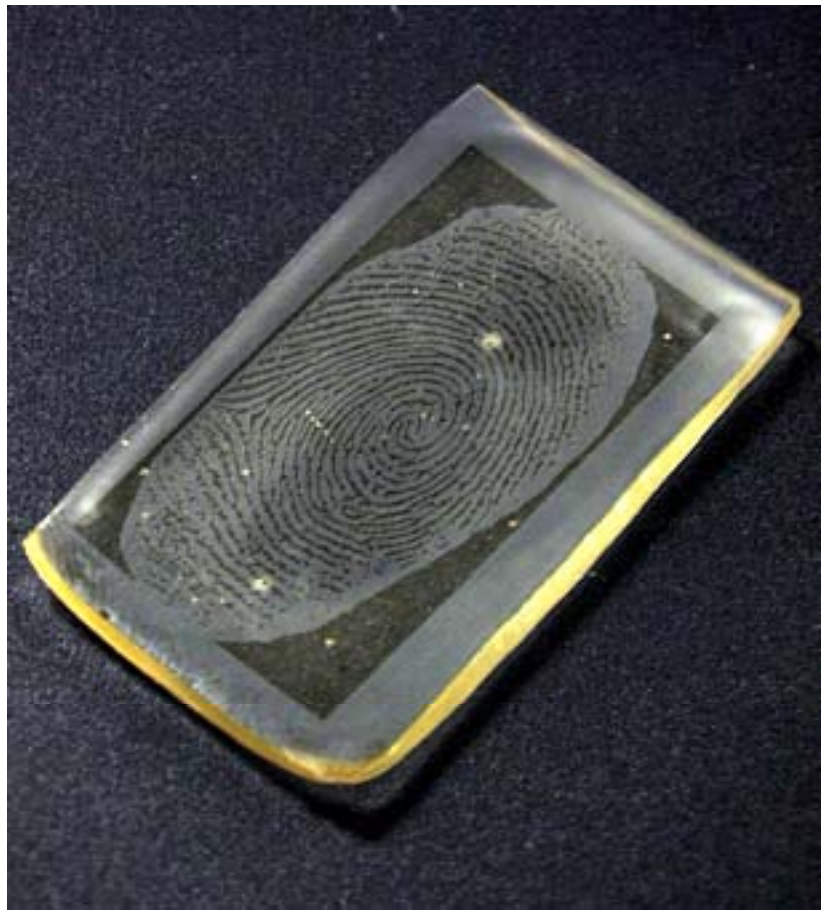
Put this mold into a refrigerator to cool, and then peel carefully.



型の上へ流す

The Mold and the Gummy Finger





Mold: 70JPY/piece
(Ten molds can be obtained in the PCB.)

Gummy Finger: 50JPY/piece

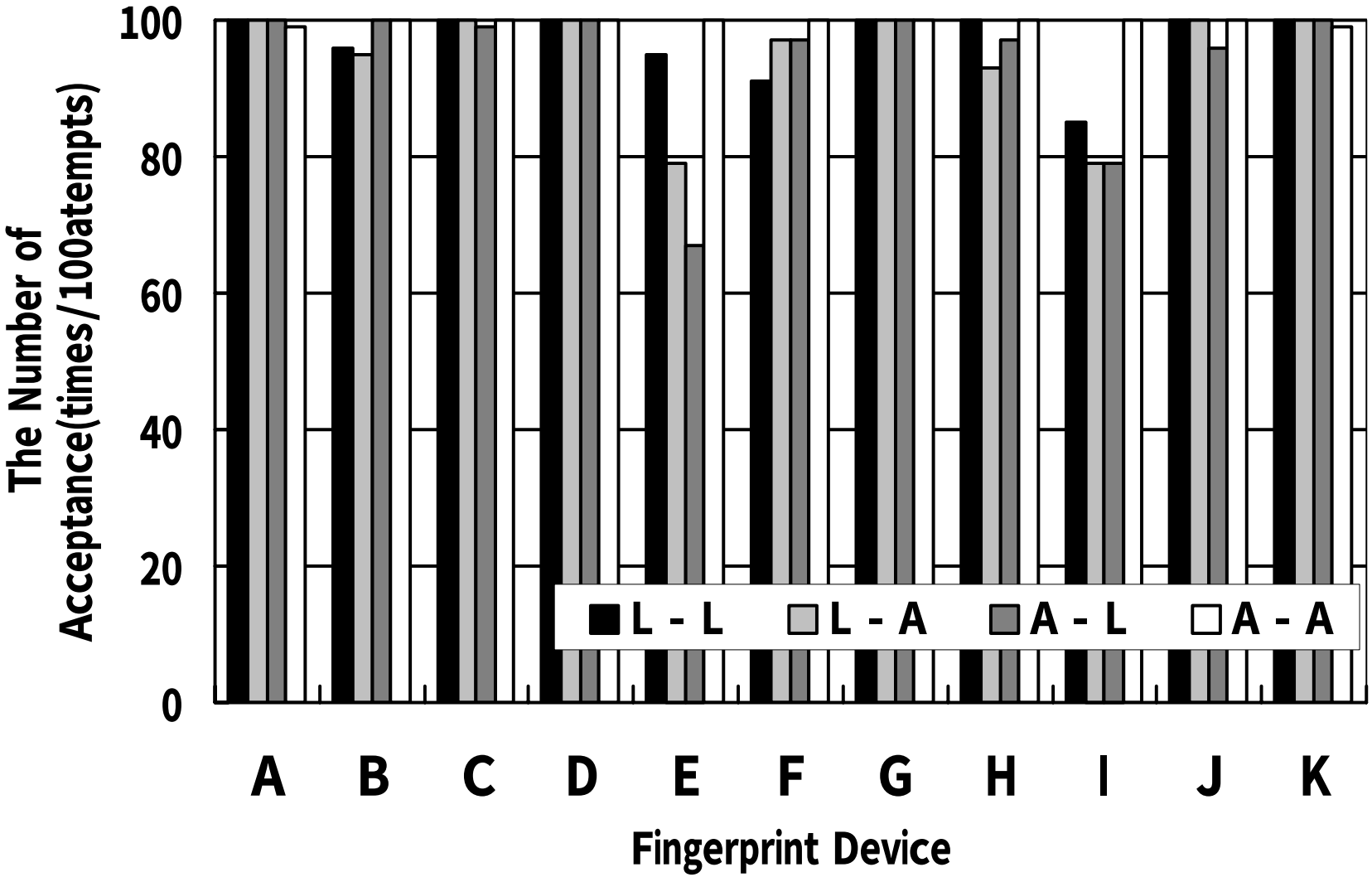
Resolution of Fingerprint Images

Pores can be observed.

Enhanced Fingerprint

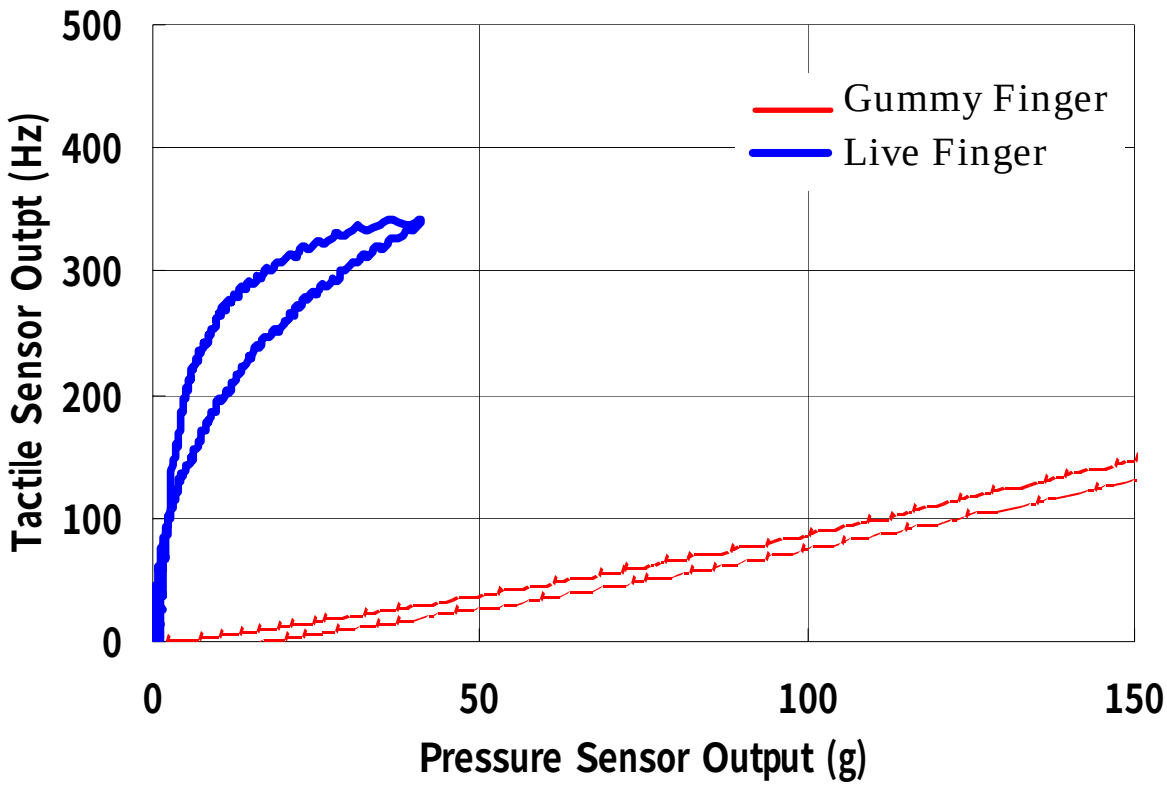
Captured Fingerprint Image of the Gummy Finger with the device H (a capacitive sensor)

from Residual Fingerprints (for 1 subject)



Characteristics of Gummy Fingers

	Moisture	Electric Resistance
Live Finger	16%	16 Mohms/cm
Gummy Finger	23%	20 Mohms/cm
Silicone Finger	impossible to measure	impossible to measure



The compliance was also examined for live and *gummy* fingers.

Conclusions

- ***There can be various dishonest acts using artificial fingers against the fingerprint systems.***
- ***Gummy fingers, which are easy to make with cheep, easily obtainable tools and materials, can be accepted by 11 types of fingerprint systems.***
- ***The experimental study on the gummy fingers will have considerable impact on security assessment of fingerprint systems.***
- ***Manufacturers,vendors, and users of biometric systems should carefully examine security of their system against artificial clones.***
- ***How to treat such information should be an important issue.***

For Details

- *Paper:*

T. Matsumoto, H. Matsumoto, K. Yamada, S. Hoshino, "Impact of Artificial "Gummy" Fingers on Fingerprint Systems" Proceedings of SPIE Vol. #4677, Optical Security and Counterfeit Deterrence Techniques IV.

- *Send any comments to*

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