Silhouette Coefficient Based Approach on Cell-Phone Classification for Unknown Source Images

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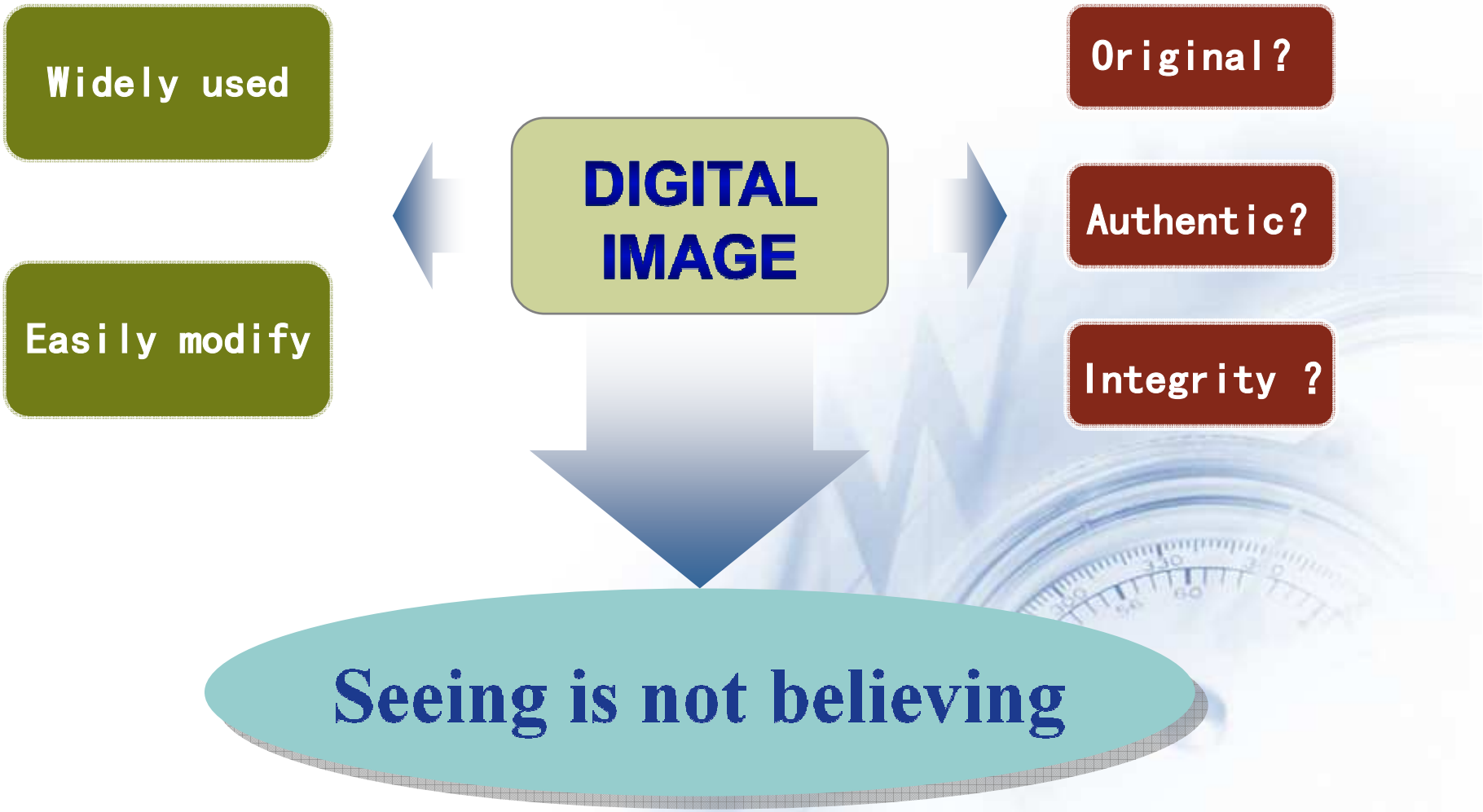
1. Research Background



一. INTRODUCTION

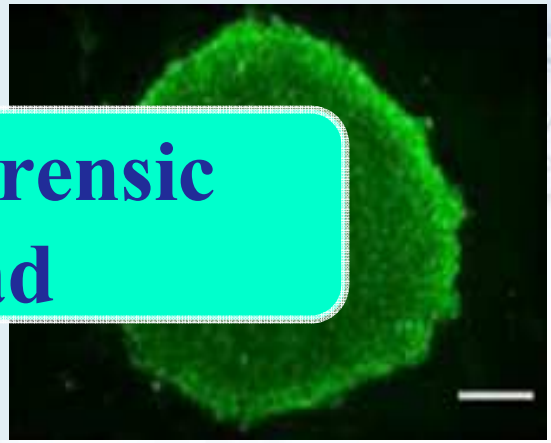
Military

Politics

Digital image

Society

Science



Digital image forensic looms ahead

2. Overview

Digital image forensic technology

- image steganalysis detection
- tamper image detection
- image source authentication

Image source authentication

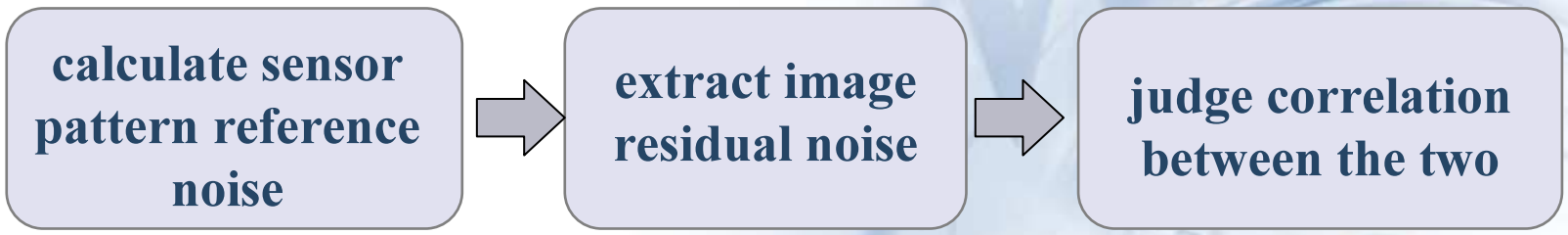
- initative watermark forensic
- passivity blind forensic

no preprocessing
more easy handing

3. Blind image source forensic：

a) Based on multi-dimensional statistical features

b) Based on sensor pattern noise



4. Similarities：

a) used for training the classifier

b) used for computing the reference pattern noise

Need a set of images with known source cell-phones as a prior knowledge

Can we hit the mark without a prior knowledge

一. INTRODUCTION

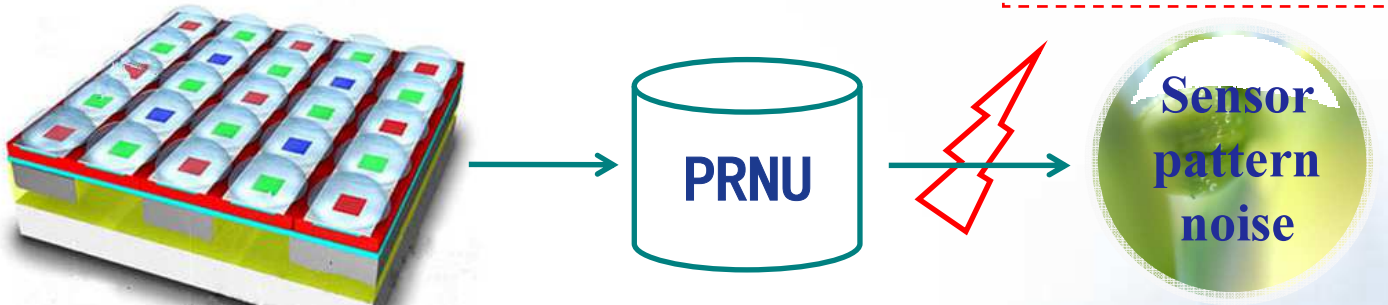
Aiming at solving the problem above:

———We propose silhouette coefficient based approach on cell-phone classification for unknown source images

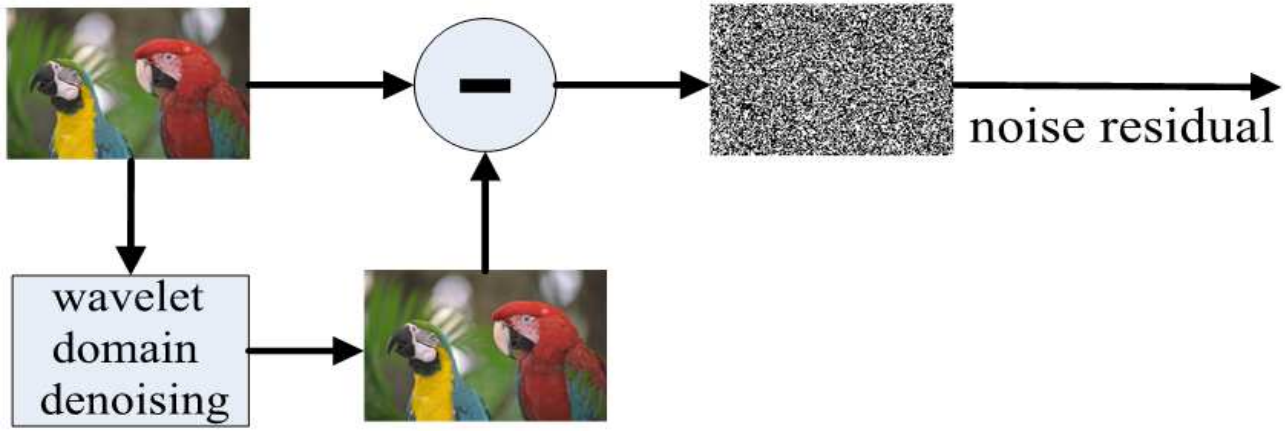
二. A GRAPH BASED APPROACH

1. Sensor pattern noise:

fingerprint of CCD



➢ attain the noise residual of image:

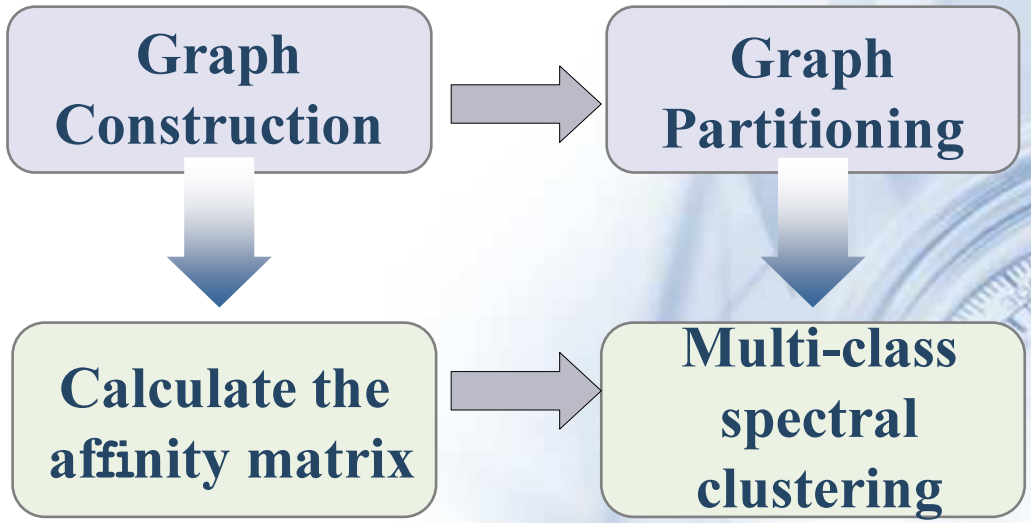


2. A graph based approach:

- **Reference:**

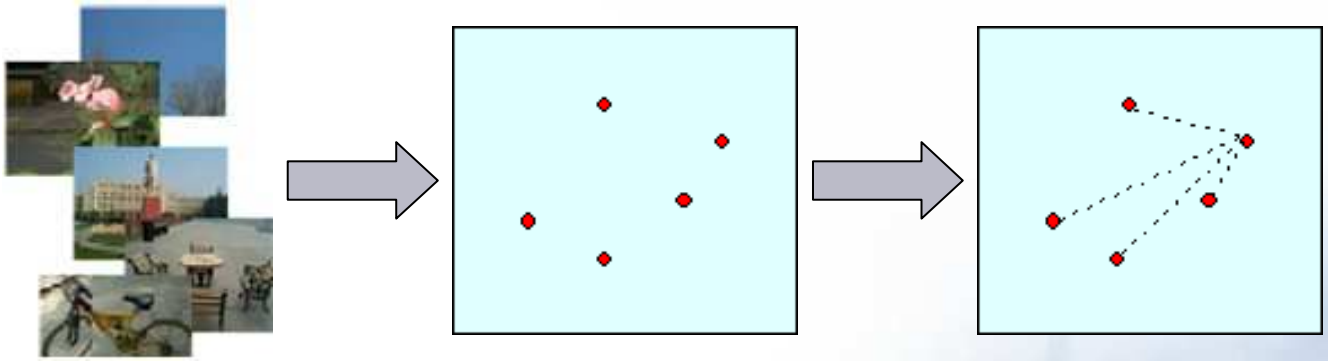
Bei-bei Liu, Heung-Kyu Lee, Yongjian Hu, Chang-Hee Choi：
On Classification of Source Cameras: A Gragh Based Approac
（WIFS，2010）

- **Overview of the approach:**



二. A GRAPH BASED APPROACH

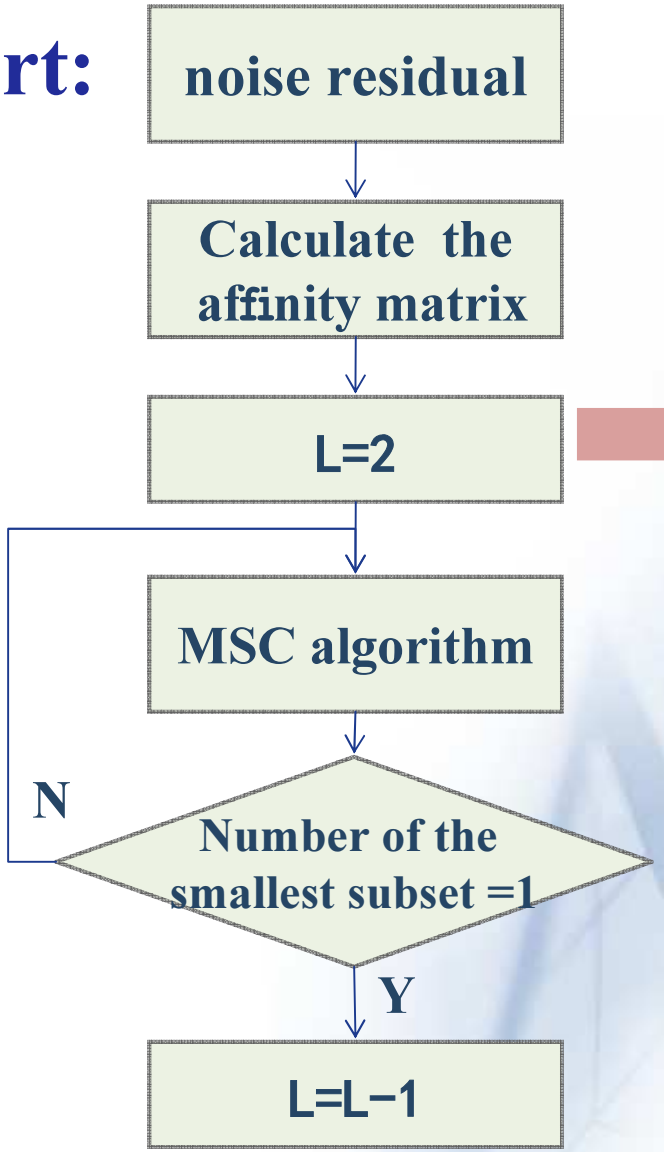
➢ Graph Construction



➢ Graph Partitioning

multi-class spectral clustering algorithm: The optimized partition indicator vectors are obtained by discretizing the L largest eigenvectors of normalized affinity matrix.

3.Flow Chart:



Loop ending condition:

there must be at least two images from one cell-phone

4. Experiment

- **Experiment1: 8 cell-phones, 4 brands**

For each image, noise residual is computed on the green channel of the upper left 640×480 corner.

ID	Cell-Phone Model	Number	Resolution
1	Sumsung i9000	20	2560×1920
2	Sumsung SCH-W899	17	2560×1920
3	Sony Ericsson U20i	20	2592×1944
4	Sony Ericsson E15i	23	2048×1536
5	Motorola Milestone	20	1280×960
6	Nokia 7610	20	640×480
7	Nokia N73	22	640×480
8	Nokia E50	23	640×480

4. Experiment

- Experiment1 result: classification accuracies of 8 cell-phones:

Subsets	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8
1	18	0	2	0	0	0	0	0
2	0	16	0	0	0	0	0	0
3	0	1	17	0	0	1	2	1
4	0	0	0	21	0	0	0	0
5	0	0	0	1	20	0	3	0
6	0	0	0	0	0	18	0	1
7	0	0	0	1	0	0	17	0
8	2	0	1	0	0	1	0	21
Ave. Accuracy	90%	94%	85%	91%	100%	90%	77%	91%

4. Experiment

- **Experiment 2:Five cell-phones, three brands**

For each image, noise residual is computed on the green channel of the upper left 1280×960 corner.

ID	Cell-Phone Model	Number	Resolution
1	Sumsung i9000	20	2560×1920
2	Sumsung SCH-W899	17	2560×1920
3	Sony Ericsson U20i	20	2592×1944
4	Sony Ericsson E15i	23	2048×1536
5	Motorola Milestone	20	1280×960

4. Experiment

- **Experiment 2 result: classification accuracies of 5 cell-phones**

Subsets	SumS1	SumS2	SE1	SE2	Moto
1	19	0	10	13	3
2	1	10	0	2	15
3	0	7	10	8	2

Why?

According to the result, the partition stops when it finds that the number of the smallest subset equals to 1 with L=4, so the final result is L=3,not L=5.

It happens owing to the loop ending condition.

5. Analysis:

precondition: There must be at least two images from one camera

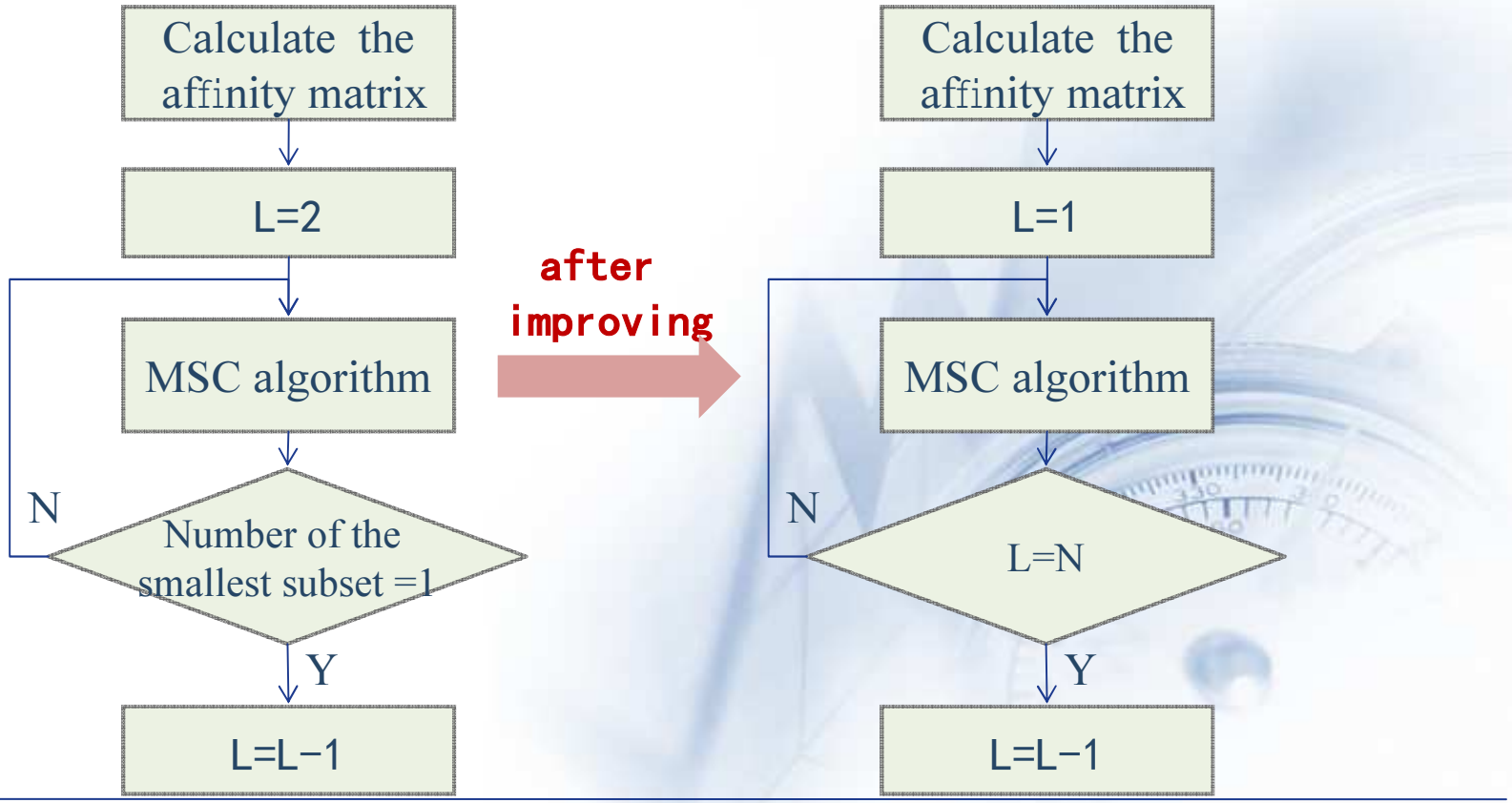
instability: The classification stops when an image is classified wrong into a subset alone

result: incomplete classification

三. IMPROVEMENT

1. The improvement of the approach

- Cancel the limiting condition
- Traversing method：attain N possibilities of classification by MSC, then extract the optimal classification



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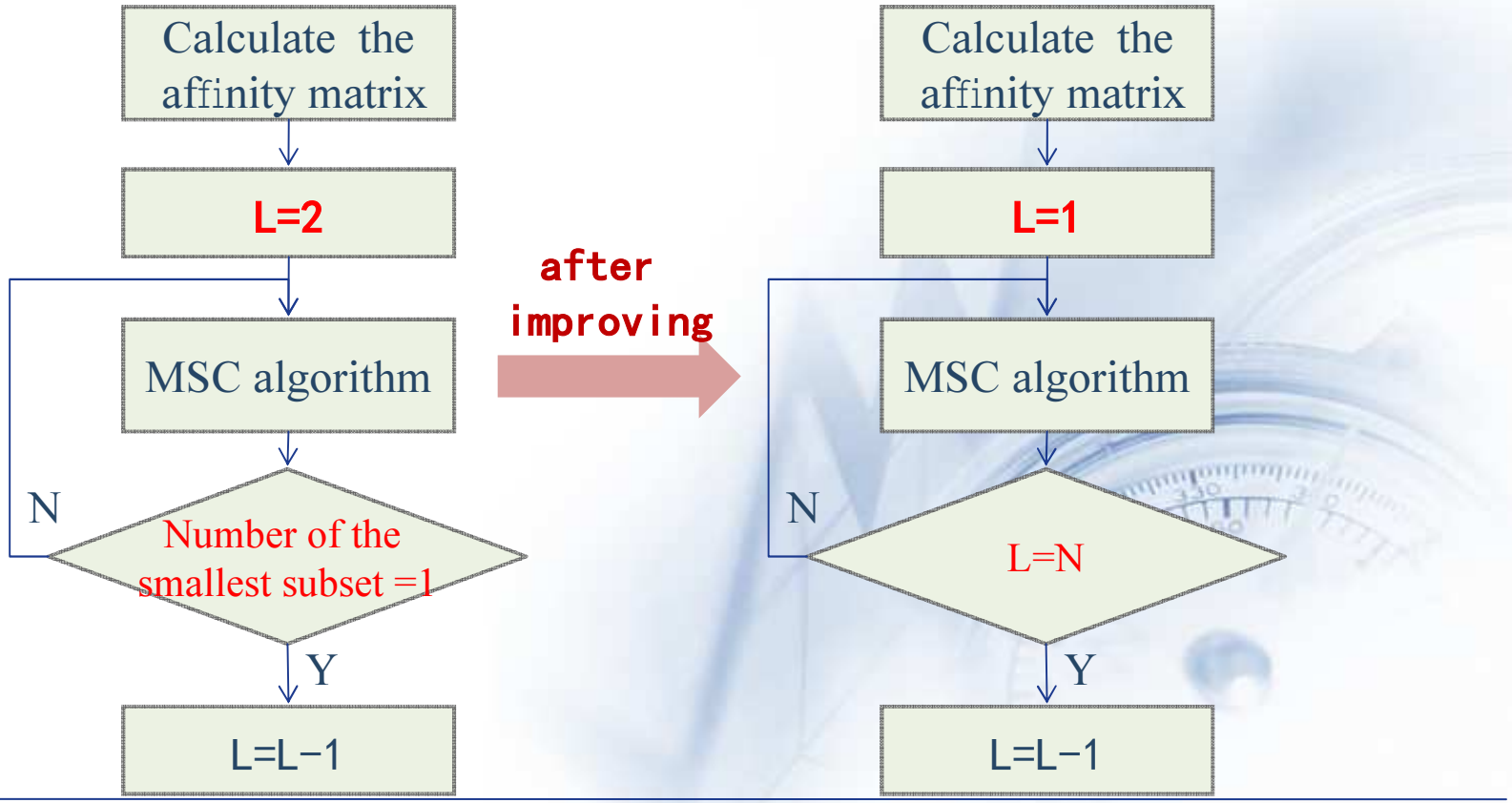

2. Silhouette coefficient based approach

How to extract the optimal classification?

◆The use of silhouette coefficient combines both the measures of cohesion (inside clusters) and separation (among clusters)

✓ a_i (cohesion): the average correlation of n_i to all other noises in the same cluster.

✓ b_i (separation): the average correlation of n_i to all other noises in each of the other clusters, taking the average value with respect to all clusters.

$$s_i = \frac{b_i - a_i}{\max(a_i, b_i)} \qquad SC_q = \frac{1}{N}\sum_{i=1}^{N} s_i$$

◆ The partition: $q^* \Leftarrow \min_q(SC_q)$

3. Experiment

- **Experiment1: 8 cell-phones, 4 brands**

For each image, noise residual is computed on the green channel of the upper left 640×480 corner.

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5	0	0	0	1	20	0	3	0
6	0	0	0	0	0	18	0	1
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Ave. Accuracy	90%	94%	85%	91%	100%	90%	77%	91%

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- **Experiment 2:Five cell-phones, three brands**

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Ave. Accuracy	90%	94%	85%	91%	100%

3. Experiment

- The graph based approach is described as A, the improved approach is described as B. The comparison of A and B approaches :

Subsets	A					B				
	ID1	ID2	ID3	ID4	ID5	ID1	ID2	ID3	ID4	ID5
1	19	0	10	13	3	18	0	2	0	0
2	1	10	0	2	15	0	16	0	1	0
3	0	7	10	8	2	0	1	17	0	0
4						0	0	0	21	0
5						2	0	1	1	20
Ave. Accuracy	90%	59%	50%	0%	0%	90%	94%	85%	91%	100%

Thank You !

Questions, please?