

I. (Digital Subtraction Radiography)

x - 가 가 . 1986 Ruttimann ¹⁸⁾ robust digital method , 1988 Ohki ¹⁹⁾ least squares quadratic approximation method

. 1983 , Gröndahl ¹⁾

x - , (15, 20, 21) , 가 22) . 1990

2-4), 5), 6, 7), 8), 9, 10), 11, 12), 13)

Dunn ²³⁾

가 가 14-17)

projective invariants mathematical technique 가 ,

가 , 가

EMAGO package(Oral Diagnostic Systems, The Netherlands)

²⁴⁾.

, Interactive Data Language(IDL) 가

가

II.

, fortran, C C++

1.

25), 1977

David Stern

IDL(Interactive Data Language, Research systems, Inc. , U.S.A.)

IDL prototype 25),

IDL

(1)

Ruttimann 18)

26, 27),

Unix, Window, Macintosh, Linux 가 (cross-platform) 25),

"robust digital contrast correction method"

(Fig.1). 8

reference histogram, 가 16($p_i = 16$)

IDL

가 $S_k = \sum_{p_i} p_i$

$S_1 = 16, S_2 = 16 + 16 = 32, S_3 = 32 + 16 = 48$. q_j

histogram

$T_m = \sum_{q_j} q_j, T_1 = 1$

$= 1, T_2 = 1 + 7 = 8, T_3 = 8 + 21 = 29$

$S_1 = 16 < T_3 = 29 \quad S_2 = 32$

Emago

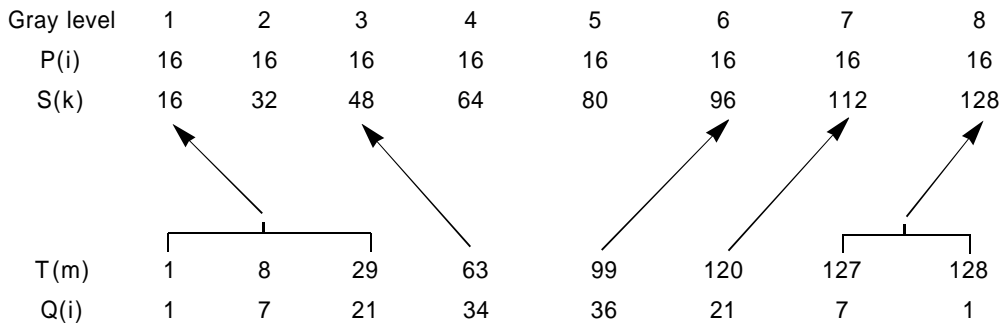


Fig 1. Principle of histogram modification for images with 8 gray levels

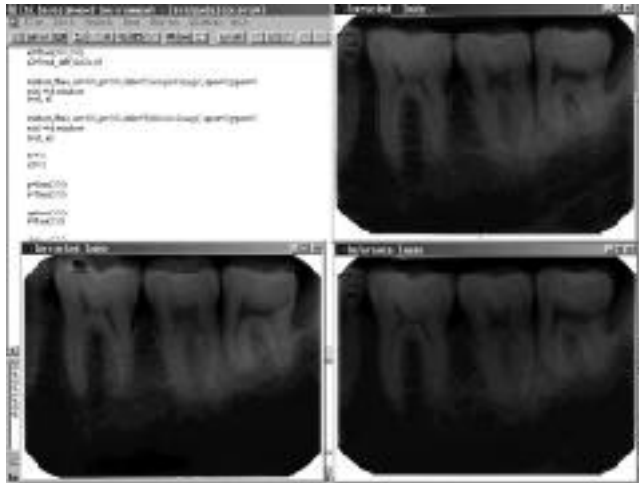


Fig 2. Image pairs(lower left and right) and contrast - corrected image(upper right), using the

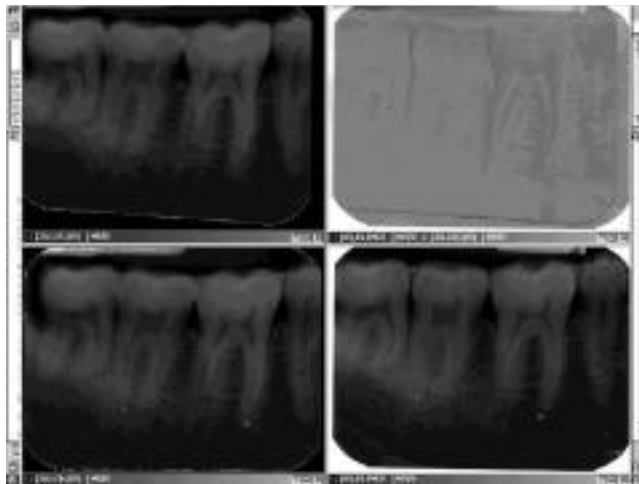


Fig 3. Image pairs(lower left and right), geometric - corrected image(upper left) and subtracted

$S_3 = 48 < T_4 = 63$ $S_4 = 64$ }
 , q - histogram 1, 2,
 3 1 , 4 , (2)
 IDL package geometric
 3 . q - histogram warping procedure 4
 landmark
 IDL procedure polywarp2 procedure
 . Fig 2 image
 subtraction procedure
 (-)

Fig 3

128

Systems, Inc., U.S.A.), Emago software package (Oral Diagnostic Systems, The Netherlands)

2. 가 (2)

(1) 2

2 XCP

128 4 32

, 6 XCP

RINN XCP , Optosil 4

32 32 image pair (

Umax Powerlook) Optosil

PowerWave604/120 Macintosh XCP

(Power Computing Co., U.S.A.), Pentium 4 32

166MHz IBM (Sambo Co, 6 XCP

Korea) Macintosh

NIH Image v 1.58 (NIH, 4 32 32 image pair (

U.S.A.), Adobe PhotoShop v. 4.0)

(Adobe Systems, Inc., U.S.A.), IBM

IDL v. 5.0 (Research



Fig 4. Image pair(A,B) of non - standardized films and subtracted image(C) in F group



Fig 5. Image pair(A,B) of standardized films and subtracted image(C) in S group



Fig 6. Image pair(A,B) of non - standardized films and subtracted image(C) in EC - EG group



Fig 7. Image pair(A,B) of non - standardized films and subtracted image(C) in EC - IG group



Fig 8. Image pair(A,B) of non - standardized films and subtracted image(C) in IC - IG group

transparency unit
480*360*8 bit
(EC - IG)
(Fig 7).
image pair IDL
(IC - IG)
image pair NIH Image Adobe Photoshop () (Fig 8).
F , S
) (Fig 4, 5).
image pair Emago 가 (ROI, region of interest) 가
, transformation (EC - EG) image pair
(Fig 6).
pair Emago similarity
IDL Jandel SigmaStat v 2.0 (Jandel Corporation, U.S.A.) , paired

Table 1. Raw data of standard deviations of gray values of subtracted images in each group

	S group	F group	EC - EG group	EC - EG group	IC - IG group
1	4.12	7.79	7.40	4.93	3.54
2	4.15	10.11	6.90	7.61	4.23
3	3.58	6.13	8.10	7.38	3.73
4	3.18	8.25	11.52	5.98	4.91
5	2.89	4.68	7.00	5.49	3.46
6	4.39	4.73	8.67	7.65	3.78
7	2.40	7.30	7.94	4.88	3.99
8	3.56	8.95	6.75	3.43	3.17
9	3.72	8.29	13.36	8.96	5.27
10	3.16	10.64	5.75	3.21	3.74
11	4.98	12.02	9.16	6.83	3.97
12	3.63	8.13	6.52	5.54	3.37
13	3.35	9.65	6.82	5.20	3.09
14	2.94	7.15	11.62	7.27	4.62
15	4.50	5.06	7.26	7.68	4.53
16	3.33	8.37	6.42	4.77	2.90
17	2.88	5.29	5.71	7.45	3.05
18	4.74	6.29	8.39	4.45	2.29
19	3.80	5.96	5.00	5.71	4.33
20	3.31	7.89	6.26	7.69	3.17
21	2.47	11.49	11.17	8.21	5.32
22	2.79	8.21	8.24	4.76	3.34
23	3.72	7.10	5.40	7.46	2.45
24	2.41	8.62	6.14	5.00	3.50
25	2.82	7.10	6.45	5.65	3.38
26	3.33	11.14	7.33	5.57	5.81
27	3.67	11.55	11.31	11.38	6.44
28	3.07	10.20	10.96	4.51	4.52
29	2.74	11.38	7.33	7.96	3.19
30	2.86	7.88	6.66	7.54	2.96
31	3.21	7.80	9.55	8.30	4.19
32	3.05	8.18	7.95	7.50	3.58
mean	3.40	8.23	7.97	6.44	3.87
sd	0.66	2.07	2.10	1.77	0.95

multiple comparison test(Student - Newman - Keuls method)

Table 1

IDL

Emago

III.

, IDL

EC - IG

IDL

(ROI,

IC - IG

region of interest)

, IC - IG

Table 2. Results of paired multiple comparison test(Student - Newman - Keuls method) among each groups

	S group	F group	EC - EG group	EC - IG group	IC - IG group
S group		***	***	***	*
F group			~	***	***
EC - EG group				***	***
EC - IG group					***
IC - IG group					

* : Statistically significant(P<0.05)

*** : Statistically significant(P<0.001)

3.87 , EC - IG (P<0.001). 6.44 IDL V.

Emago EC - EG Emago 가 , IDL 가 , EC - IG , EC - IG 6.44 , EC - EG 7.97 가 , IDL 22). , IDL 23, 28, 29)가 , IC - IG S , Emago 1996 Emago 24). Emago EC - EG , F , IC - IG 4 landmark 3.87 S 가 IDL 3.40 IDL (p<0.05), EC - EG (p<0.001). EC - EG 7.97 F 8.23 (p>0.05). XCP paired multiple comparison test Table 2 , Emago

, IDL 가 12.40 ,
 , Emago occlusal stent 19.68
 IDL Emago
 , IDL 가 6.44 ,
 가 Emago
 IDL 3.40
 Emago IDL 가 -
 255 255 512
 , 0 255 256
 Emago
 Ruttiman ¹⁸⁾ robust
 digital contrast correction method가 1/2 ,
 (projective standardization)
 Emago Dunn ²³⁾ 6.40
 projective invariants mathematical
 technique nonlinear 9.84 3.40
 geometric warping 가 .
 (similarity)
 가 가 (ROI)
 IDL
 (registration) 가 3.87 ,
 가 22, 30 - 32), 3.40
 0.47
 23, 33) 33)
 van der Stelt ²²⁾ Emago
 . Dunn ²³⁾ ,
 4 Emago 9.8
 landmark , 6.1 ,
 (projective standardization) IDL

3.87

IDL

가

Likar Pernus³⁴⁾

ODTF(optical density thickness function)

, CDF(cumulative density function)

Emago

LSQA (least square quadratic approximation)

256

가

ODTF ³⁵⁾

0.47

CDF ¹⁸⁾ Ohki

LSQA

¹⁹⁾

가

(densitometric image analysis)

가

ODTF

V.

CDF

LSQA

CDF

가

Emago

가

ODTF

IDL

IDL

Ruttimann robust digital

contrast correction method

geometric warping procedure

IDL

script

procedure

, IDL

32 image pair

32 image

graphic user pair

interface(GUI)

1. IDL

Emago
(p<0.001).

2. IDL

Emago
(p<0.001).

3. IDL

Emago

(p<0.001),

(p<0.05), 256

가

0.47

가 ,

2 ,

VI.

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- Abstract -

Contrast and geometric correction of non-standardized radiographs in digital subtraction radiography

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The purposes of this study were to develop the computer program for the contrast and geometric correction in digital subtraction radiography with the IDL (Interactive Data Language) and compare the results with this program for the correction of the non - standardized radiographs to those of standardized radiographs and those with "Emago" software, the commercial program for the correction. The procedures were written for the contrast correction and subtraction with the geometric correction, using IDL. 32 pairs of periapical radiographs of premolar and molar portion of two dry human mandibles were taken at two different occasions with XCP film holder (non - standardized films) and another 32 pairs with customized XCP film holder (standardized films). Subtraction of standardized film pairs was performed. Subtraction after the contrast and geometric correction of non - standardized films was performed using the newly developed program and Emago software. Standard deviations of grey levels of the subtracted images by the newly developed program

were compared with those of the standardized group and Emago - corrected group. Standard deviations of grey levels of new program - corrected group were much smaller than those of the Emago - corrected group ($p < 0.001$) and slightly larger than those of standardized group ($p < 0.05$). However, the difference was very minute. This study indicates that the newly developed program written with IDL may substitute the mechanical standardization for digital subtraction radiography.

key words : digital subtraction, geometric correction, contrast correction