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ESRF - LUCID 2

TECHNICAL NOTE

ESRF

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Summary:

This note will describe the image processing software "Lucid2". Its purpose is to extract the target coordinates (if any) from specific ESRF images.

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1 TECHNICAL DESCRIPTION

1.1 PURPOSE

Lucid 2.0 is an image processing software which detects target of Synchrotron ESRF and returns its coordinates in an input image. As a python package, this software is based on OpenCV library and Numpy package.

1.2 REQUIREMENT

In order to execute lucid 2.0 the following package are required:

- Os Debian version 6 (squeeze)
- Python version 2.6
- Numpy 1.4.1
- OpenCV version 2.1

Treatments done are optimized to work with 500 x 700 image resolutions but the code is robust to other resolution.

1.3 INSTALLATION

In order to install the Lucid 2.0 package, the following steps are required:

- Uncompress the "Lucid 2.0" package
- In the extracted directory, run : "python setup.py install"

1.4 USE

Lucid 2.0 functionalities can be accessed after a package import in python script:

import lucid2

To use the find_loop function:

result = lucid2.find_loop(<filename>, IterationClosing=<IterationClosing>)

where:

- <filename> is the full path name of the image file to process
- <IterationClosing> is an optional integer parameter (default to 6) which defines the number of iteration to close shape contour

The result is a python tuple: *(<type>,<x>,<y>)*

Where:

- *<type>* is the type of the result :
  - *'coord'* if there is a result
  - *'No loop detected'* if there is no result

- *<x>, <y>* are the horizontal, vertical coordinates of the result if therer is a result -1, -1 otherwise

In case the input image could not be opened, an error message is returned.

1.5 ALGORITHM DESCRIPTION

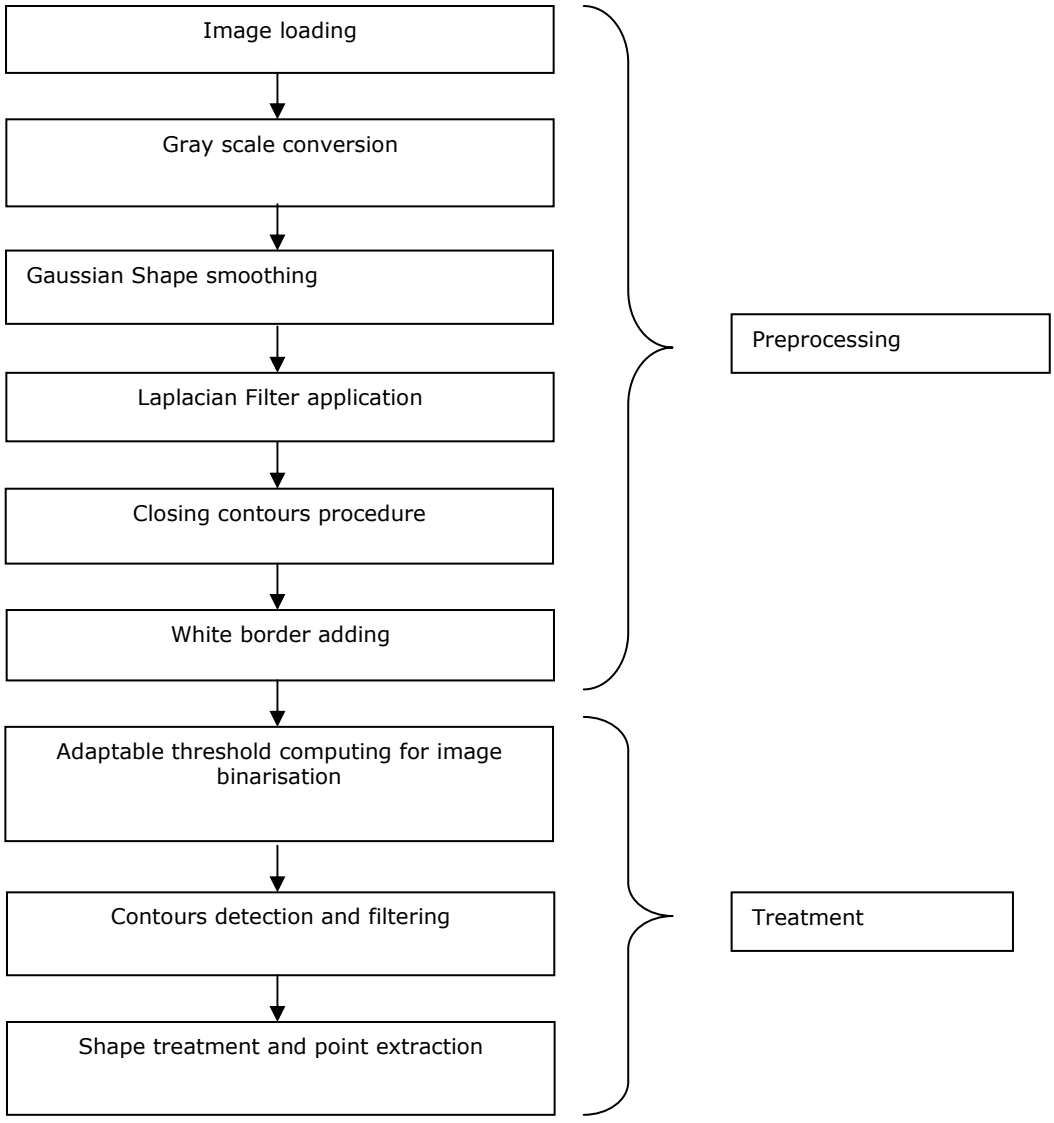

Figure 1: Algorithm general

1.5.1 Treatment description

1.5.1.1 Gaussian shape smoothing

The Gaussian shape smoothing is performed by OpenCV smoothing functions, which convolve the image by Kernel matrix. In this algorithm, the smoothing process is applied twice. In accordance with the assumption "target comes from left to right" requirement, the applied kernel is asymmetric. The values of the standard deviations used for Gaussian kernel calculation are the following:

- σ_x = 2.15 and σ_y = 1.85 for the smoothing applied before the Laplacian filter calculation
- σ_x = 3.65 and σ_y = 2.15 for the smoothing applied after the Laplacian filter calculation

1.5.1.2 Closing contours procedure

The closing contours procedure is carried out by the OpenCV function MorphologyEX. This function applies an iterative dilatation and erosion transformation using a kernel matrix defined by input parameters. The Kernel is asymmetric and is defined as 7 x 3 matrix using CreateStructuringElementEx from the Open CL library.

1.5.1.3 Adaptable threshold

The threshold is computed using the histogram of a filtered image without zero pixel value. It is set to the first ray sufficiently significant. In order to avoid background rays a third criterion is used on maximal value of the histogram at the current index. In practice, it leads to the following criterion:

$$\begin{cases} \Delta H > 0 \\ \dfrac{\Delta H}{H_i} > 0.1 \\ H_i < \sum H_i * 0.01 \end{cases}$$

Where H_i is the histogram of the filtered image truncated of zero indexes (black pixel).

1.5.1.4 Contours filtering

The functionality findContour of OpenCV library is applied on the previous binary image to extract contours. This contour sequence is filtered applying a criterion on Area and Length of contours. All contours which have a Length superior to 125 pixel or an area superior to 1.5 % of the image are kept. The Contour with the maximal area will be defined as the main contour.

1.5.1.5 Shape treatment

The figure below describes the shape treatment algorithm applied in order to extract target coordinates. Depending on the shape, there are 3 criterions used for coordinates extraction. The first one is a distance criterion. A high value (80 µm) has been defined in order to prevent the risk of irregularity accretion along abscissa axis. The risk of accretion along ordinate axis is lower due to asymmetric smoothing and asymmetric closure procedure.

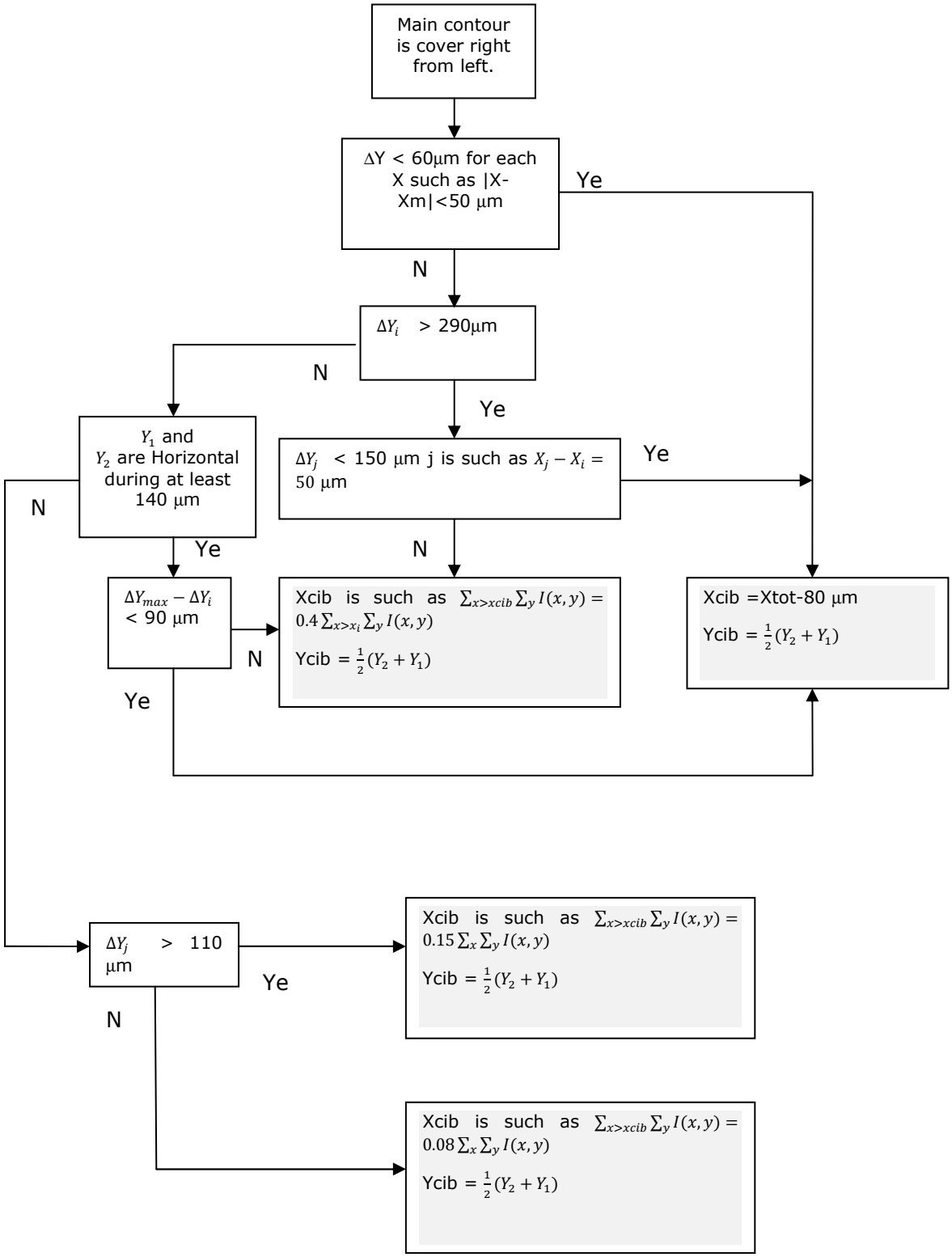

Figure 2: Shape treatment algorithm

2 VALIDATION

The validation process is based on input samples provided by ESRF. This set of files consists of 57 images files from which 6 were dismissed at the beginning of development process. Robustness tests were added for image format input and the resolution. Results of the validation process are given in the following table.

98 % of contractual test are OK according to the project requirement. The only KO result has to be excluded because the target area is lower than 5% of the image.

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File Name	X ref	Y ref	X lucid2	Y lucid2	X difference	Y difference	Result	Comment
lucid_id231_1bLoX1.png	343	81	342	83	-1	2	status	
lucid_id231_7Qd3YC.png	300	29	295	24	-5	-5	OK	
lucid_id231_AGbcch.png	372	238	356	238	-16	0	OK	
lucid_id231_JKTiuu.png	303	460	294	465	-9	5	OK	
lucid_id231_KdTQy1.png	377	473	357	450	-20	-23	OK	
lucid_id231_oXUOCZ.png	351	382	337	379	-14	-3	OK	
lucid_id231_STkNwT.png	424	315	423	325	-1	10	OK	
lucid_id231_vCHuL5.png	364	247	353	245	-11	-2	OK	
lucid_id231_WC8jlh.png	439	373	450	375	11	2	OK	
lucid_id231_WV6bqp.png	441	159	442	151	1	-8	OK	
lucid_id232__fvtmc.png	211	123	221	114	10	-9	OK	
lucid_id232_0DM6jF.png	178	179	178	189	0	10	OK	
lucid_id232_0H_yZz.png	393	252	383	252	-10	0	OK	
lucid_id232_1yCqcV.png	437	209	419	218	-18	9	OK	
lucid_id232_7kbOAa.png	155	178	137	178	-18	0	OK	
lucid_id232_fvAN2L.png	235	150	244	146	9	-4	OK	
lucid_id232_LJNtdB.png	415	234	401	227	-14	-7	OK	
lucid_id232_z06fA7.png	342	246	345	245	3	-1	OK	
lucid_id29__mjqQC.png	567	298	561	290	-6	-8	OK	
lucid_id29_1A4n7X.png	343	250	340	250	-3	0	OK	
lucid_id29_9Ya04Z.png	437	416	416	409	-21	-7	OK	
lucid_id29_DcS7Es.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id29_FpQAXQ.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id29_miUfrk.png	343	242	337	240	-6	-2	OK	
lucid_id29_Wls68D.png	411	290	396	288	-15	-2	OK	

lucid_id30a1__FMaa3.png	441	237	449	228	8	-9	OK	
lucid_id30a1_01RaHN.png	410	68	406	66	-4	-2	OK	
lucid_id30a1_07MIdJ.png	329	269	323	267	-6	-2	OK	
lucid_id30a1_0glw3W.png	478	310	470	312	-8	2	OK	
lucid_id30a1_0o1a7g.png	334	234	331	233	-3	-1	OK	
lucid_id30a1_0ZCrfC.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id30a1_55pois.png	304	439	306	435	2	-4	OK	
lucid_id30a1_6T7xiT.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id30a1_BNn9Rq.png	475	349	466	345	-9	-4	OK	
lucid_id30a1_iV__nh.png	474	267	462	262	-12	-5	OK	
lucid_id30a3_1ryK2i.png	450	284	445	284	-5	0	OK	
lucid_id30a3_iXyoVf.png	168	17	192	26	24	9	OK	
lucid_id30a3_jOz38r.png	155	252	166	249	11	-3	OK	
lucid_id30a3_lZm9fv.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id30a3_Ng3LqO.png	-1	-1	-1	-1	0	0	OK	No target
lucid_id30a3_nxXSJE.png	233	273	254	273	21	0	OK	
lucid_id30a3_o4ZNHg.png	466	268	456	265	-10	-3	OK	
lucid_id30a3_WvWpGp.png	246	248	262	248	16	0	OK	
lucid_id30a3_ZAaV0W.png	354	252	364	246	10	-6	OK	
lucid_id30b_3Fniec.png	299	133	314	135	15	2	OK	
lucid_id30b_DLuv5h.png	295	134	314	135	19	1	OK	
lucid_id30b_j1IZdk.png	445	145	454	133	9	-12	OK	
lucid_id30b_p6IY4Y.png	470	315	473	292	3	-23	OK	
lucid_id30b_TDT4E5.png	292	353	294	354	2	1	OK	
lucid_id30b_ZNHf84.png	450	348	466	344	16	-4	OK	
lucid_id232_0px8WP.png	225	9	-1	-1	-226	-10	KO	target area is less than 5%

Tableau 1: Validation results

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