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SVM based layout retargeting for fast and regularized inverse lithography

Key words: Inverse lithography technology, Optical proximity correction, Layout retargeting, Support vector machine

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Introduction

- In the past 20 years, various methods have been proposed to solve the optimization problem of inverse lithography technology (ILT). However, no matter which methods are being used, ILT is always time consuming due to the slow convergence of the optimization process.

- In traditional model-based optical proximity correction (OPC), the layout retargeting method is always used to generate a better initial guess. However, no layout retargeting method has been proposed for ILT algorithms.

- In this paper we propose a support vector machine (SVM) based layout retargeting method to generate a good initial input mask and accelerate the convergence for ILT.

Framework of our method

The layout retargeting method proposed in this paper is designed to generate an initial mask close to the optimized mask so as to accelerate the convergence of the following optimization process of ILT. For this purpose, SVM is employed to establish the relationship between the pixel values in the final optimized mask and target layout patterns. Three steps are involved in our method:

- Identification of undefined area
- Construction of the SVM models
- Pixel-based layout retargeting and complexity reduction

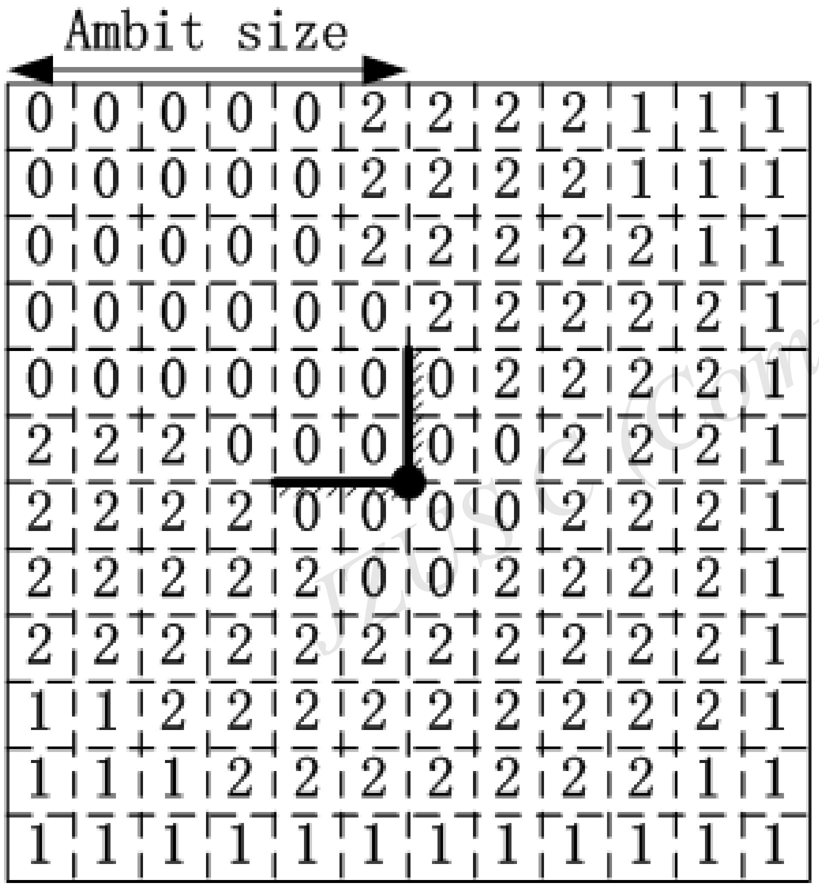
Framework of our method

1. Identification of undefined area

- To reduce the pixels that need to be predicted by SVM, target layout patterns are divided into defined areas and undefined areas in our layout retargeting method. Defined areas are defined as those in which pixels always flip or do not flip; undefined areas are those in which pixels are not fixed on flipping.
- The optimized masks of the training layout patterns are scanned to identify the undefined areas in concave area, convex area, and edge area, respectively.

Framework of our method

Example of identified undefined area in concave area



Pixels with a value of 2 are the identified undefined areas; pixels with a value of 0 mean that pixel values in these points are all 0 in the optimized masks of the training layout; pixels with a value of 1 mean that pixel values in these points are all 1 in the optimized masks of the training layout.

Framework of our method

2. Construction of the SVM models

- To supervise the training process of the SVM model, training data consisting of pixel values of the optimized mask and corresponding contexts on the training layout is sampled to construct the training data set.

- A concentric square sampling method proposed by Gu is used to create feature vectors for the contexts of the pixels.

- The sequential minimal optimization (SMO) algorithm is used to construct the SVM models for the undefined areas.

Framework of our method

3. Pixel-based layout retargeting and complexity reduction

- Values of pixels in the undefined areas of the original layout are predicted in the SVM prediction process according to their contexts.
- Pixels not in the undefined areas are divided into two conditions: pixels in concave area, convex area, and edge area are set to the same values of corresponding location in these three areas, respectively; pixels not in these areas are set to 0 for a dark-field mask.
- To remove the irregular patterns, a spatial filter is applied to the retargeted layout for complexity reduction.

Major results

We compare the regularized LSB-ILT algorithm with and without our layout retargeting method. The experimental results are as follows:

Target	Area (μm^2)	Iters[a]	Iters[b]	ε	Rtime[a] (s)	Rtime_{re} (s)	Rtime_{ilt} (s)	Rtime[b] (s)	η
SLP1	0.41	250	67	73.2%	1271	14.20	354	368	71.0%
SLP2	0.45	250	64	74.4%	1392	16.06	359	375	73.1%
SLP3	0.86	250	60	76.0%	2731	28.40	677	705	74.2%
SLP4	0.94	250	71	71.6%	2954	31.78	863	895	69.7%
SLP5	1.34	250	64	74.4%	4259	46.41	1118	1164	72.7%
MLP1	3.96	250	79	68.4%	12 482	119.60	3822	3942	68.4%
MLP2	4.95	250	62	75.2%	15 478	168.22	3977	4145	73.2%
MLP3	5.28	250	80	68.0%	16 381	181.36	5337	5518	66.3%
MLP4	4.80	250	73	70.8%	15 230	143.25	4643	4786	68.6%
LAP1	10.31	250	87	65.2%	31 869	367.12	11 366	11 733	63.2%
LAP2	9.63	250	83	66.8%	30 018	328.15	10 724	11 052	63.2%
LAP3	13.52	250	85	66.0%	41 391	471.42	14 504	14 975	63.8%
Average				70.8%					69.0%

Conclusions

- Supervised by the optimization results of conventional ILT algorithms, the SVM models are constructed and used to generate the initial input mask, which is close to the final optimized mask, for the optimization process in ILT.

- Experiments showed that with our layout retargeting method, the number of iterations needed in the optimization process and runtime of the whole process in ILT are reduced by 70.8% and 69.0% respectively, without increase of mask complexity.