# Improving the Performance of Thinning Algorithms with Directed Rooted Acyclic Graphs

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## Abstract

Thinning is a fundamental algorithm used in many computer vision and image processing tasks, which aims at providing an approximate and compact representation of the elements (objects) inside images.

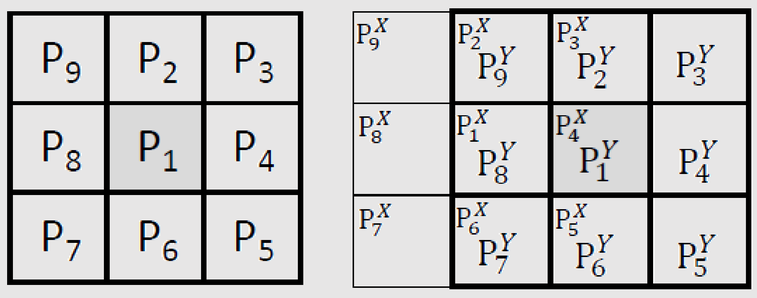
***Goal:*** **improve performance by reducing the average number of memory accesses to be performed using decision trees and Directed Rooted Acyclic Graphs.**

## Improving Thinning Algorithms

A lot of approaches have been proposed to improve performance of thinning algorithms:

- Look-Up Tables (LUT);
- Efficient neighborhood exploration based on decision trees;

What is missing?

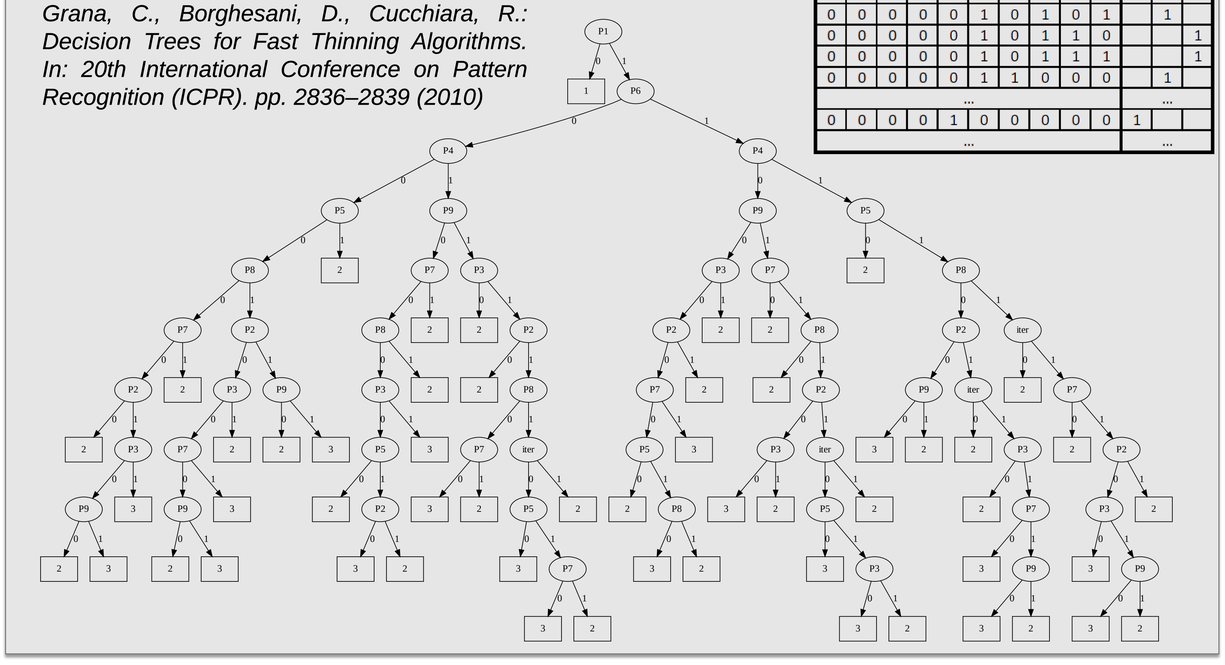



## Modelling the Problem with Decision Trees

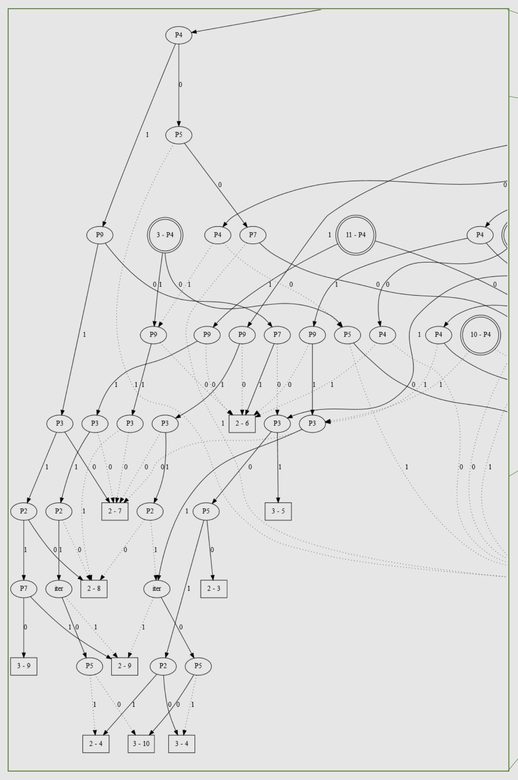
The neighborhood exploration technique based on decision trees has been experimentally proved (on the Zhang-Suen algorithm) to be able of dramatically reducing the number of memory accesses that need to be performed.

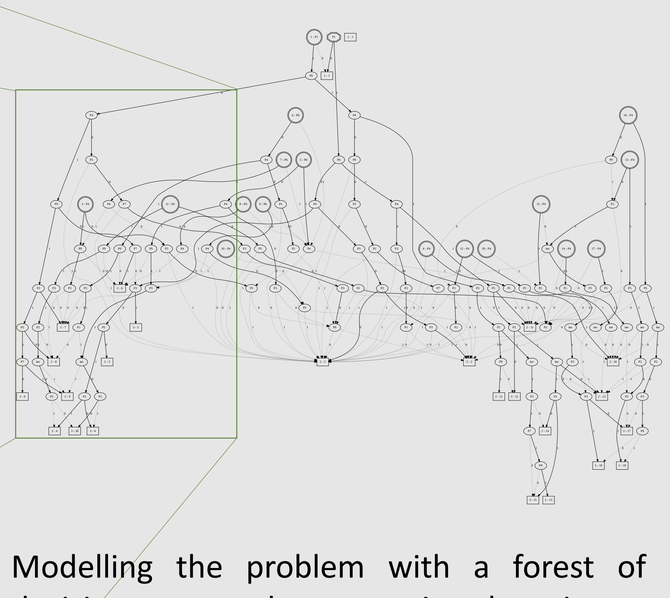
*Grana, C., Borghesani, D., Cucchiara, R.: Decision Trees for Fast Thinning Algorithms. In: 20th International Conference on Pattern Recognition (ICPR). pp. 2836–2839 (2010)*

| Conditions | | | | | | | | | | Actions | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| iter | P5 | P6 | P7 | P4 | P1 | P8 | P3 | P2 | P9 | nothing | don't remove | remove |
| ... | | | | | | | | | | | ... | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | | | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | | | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | | | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | 1 | |
| ... | | | | | | | | | | | ... | |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| ... | | | | | | | | | | | ... | |




## … and Directed Rooted Acyclic Graphs DRAG





Modelling the problem with a forest of decision trees and compressing them into a DRAG allows to:

- reduce the average number of memory accesses;
- take advantage of instruction cache.

## Comparative Evaluation

The proposed approach has been applied on three well known thinning algorithms and evaluated by comparing their performance with state-of-the-art implementations:

- Zang and Suen (ZS) Zhang, T., Suen, C.Y.: A Fast Parallel Algorithm for Thinning Digital Patterns. Communications of the ACM 27 (3), 236–239 (1984).
- Guo and Hall (GH) Guo, Z., Hall, R.W.: Parallel Thinning with Two-Subiteration Algorithms. Communications of the ACM 32 (3), 359–373 (1989).
- Chen and Hsu (CH) Chen, Y.S., Hsu, W.H.: A modified fast parallel algorithm for thinning digital patterns. Pattern Recogn. Lett 7 (2), 99–106 (1988).

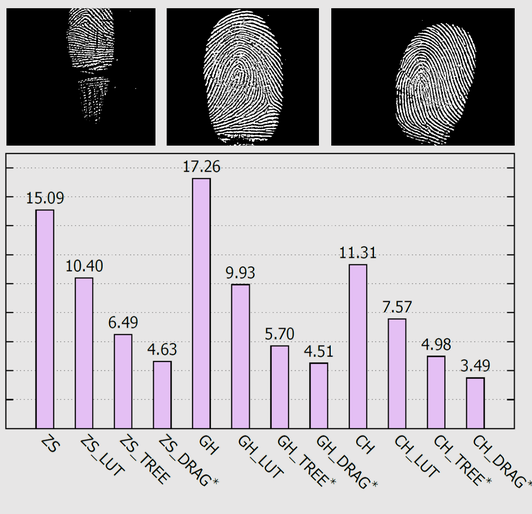
To ensure reproducibility an open-source benchmark has been designed and released. Check-out the code on GitHub:

THeBE

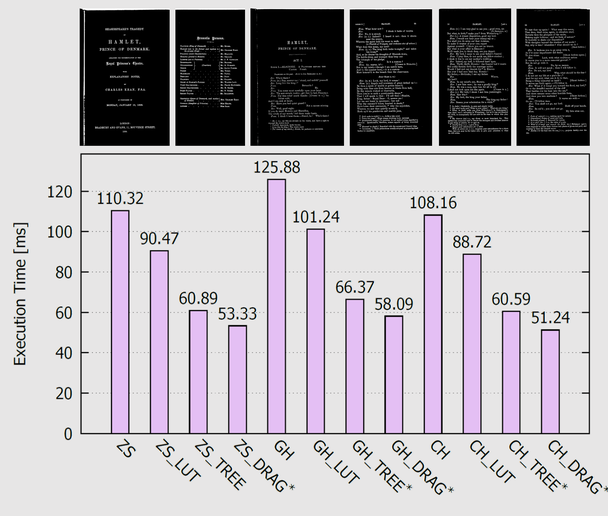
Test environment is an Intel Core i7-4790K CPU with Windows (64 bit) OS. Source code has been compiled with MSVC 19.16.27030.1 with optimizations enabled. Tests have been performed on four different datasets that cover most of the scenarios in which the thinning operation is usually applied.

Both "standard" and LUT versions of the algorithms implemented for the comparison also use prediction, avoiding to read pixels that have already been read in the previous step.

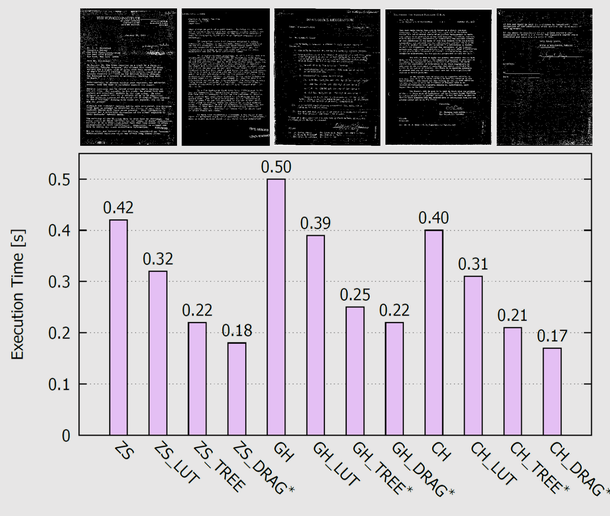
Fingerprints




Hamlet




Tobacco800

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