# ON THE DEFINITION OF REFERENCE SKELETONS FOR COMPARING THINNING ALGORITHMS

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**ABSTRACT**

This paper describes a method to define reference skeletons for binary images of handprinted and typed characters. These reference models are used to compare visually the outputs of thinning algorithms. Three types of perception experiments using eleven thinning algorithms are reported.

**RESUME**

Cet article décrit une méthode pour définir des squelettes de référence à partir d'images binaires de caractères manuscrits ou typographiés. Ces modèles sont utilisés pour comparer visuellement les sorties de différents algorithmes d'amincissement. Trois expériences de perception utilisant onze algorithmes d'amincissement sont présentées.

Keywords: thinning algorithm, reference skeleton, handprinted and typed characters

## INTRODUCTION

Thinning algorithms are used for the preprocessing of binary images into connected skeletons, generating a structure of unit thickness which can be analysed for its representation into primitives. These ideas were developed about 20 years ago [1] and since that time several algorithms have been found useful in numerous applications: inspection of printed circuit boards, counting asbestos fibres on air filters, analysis of chromosome shapes; examination of soils cracking patterns; classification of finger prints, recognition of characters etc. The major functions of thinning in image processing and pattern recognition are: to reduce data storage, to reduce transmission time and to facilitate the extraction of morphological features from digitized patterns.

Most existing algorithms produce a skeleton by successive stripping of the edge points of the binary pattern. Each algorithm has its own set of stripping rules. This results in different skeletons, each one having a different degree of distorsion.

Comparison of the algorithm performances is generally based on execution time and memory requirements. However the degree of distortion is difficult to analyse quantitatively and comparative studies are generally limited to the evaluation of the connectivity of the final output, its symmetry and the ability of the algorithm to retain end points [2,3].

The purpose of this study is to define reference skeletons for some binary images of handprinted and typed characters from which the outputs of thinning algorithm can be compared visually. In the first part of this paper, the method for defining reference skeletons is presented. Three types of visual comparison experiments are then described and discussed in the second part.

## METHOD

Figure 1a shows the set of ten handwritten characters and two typed characters that were used for this experiment. These specimens were selected since they reflect the main structural properties of alphanumeric characters and also of other types of lines. The characters were digitized with an OCR scanner (Microtek Inc.) at 200 dpi. and the resulting images were then printed on large scale (see a few specimens in figure 1b)

Copies of these outputs were presented to a group of 33 human subjects. About one half of this group was already familiar with thinning algorithms. Each subject was given an instruction sheet describing the purpose of thinning algorithms and asking her/him to mark with a pencil the dots of the enlarged images that she/he considers as part of the character skeleton that is, dots that best represent the shape of the character.

After these manual thinning operations, the 33 sample skeletons of each character were input to a microcomputer with the help of a digitizer and an interactive software specifically developed for this purpose. Figure 2a shows the typical distributions of the skeletons for some characters.

Each distribution was then analysed visually to define the most probable reference skeleton for each character, according to the following rules:

1) The skeleton is continuous and composed of the pixels of highest relative frequency that is the pixels most often selected by human subjects.
2) The skeleton is of unit thickness. At the junction of segments, node of degree higher than 2 are accepted if the global shape of the character is preserved.
3) If two adjacent pixels are of equal relative frequency, only one is kept, according to the gradient analysis of the surrounding.
4) For end points, the skeleton is truncated as