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Chain code lossless compression using move-to-front transform and adaptive run-length encoding

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ABSTRACT

Chain codes are the most size-efficient representations of rasterised binary shapes and contours. This paper considers a new lossless chain code compression method based on move-to-front transform and an adaptive run-length encoding. The former reduces the information entropy of the chain code, whilst the latter compresses the entropy-reduced chain code by coding the repetitions of chain code symbols and their combinations using a variable-length model. In comparison to other state-of-the-art compression methods, the entropy-reduction is highly efficient, and the newly proposed method yields, on average, better compression.

1. Introduction

In the early days of the computer era, Freeman introduced a method for representing the boundaries of rasterised objects [1]. He coded the sequence of movements through the neighbouring boundary pixels using the 8-connectivity pixel paradigm. His numbering scheme $\{i|i=0,1,2,\ldots 7\}$ is used for coding movements, where $45^\circ \times i$ denotes a counter-clockwise angle regarding the positive x-axis. This code is known as the Freeman 8-directional chain code (FEDCC) (see Fig. 1a). The Freeman 4-directional chain code (FFDCC) can also be used, where an angle $90^\circ \times i$ is represented by the numbering scheme $\{i|i=0,1,2,4\}$ (Fig. 1b). Bribiesca introduced a control mechanism for Freeman's chain code by replacing codes 5, 6, 7 with $-3, -2, -1$ $(4=-4)$ [2]. The sum of the used Freeman chain code for any closed shape becomes 8 or -8. In this way the self-checking code is obtained.

Another popular chain code named the vertex chain code (VCC) was introduced by Bribiesca [3]. It is based on the shape code [4] that counts the number of touching pixels within each shape's vertex. Only three elements (1, 2, 3) determine the VCC, as shown in Fig. 2a. In order to encode 3D curves, Bribiesca used five symbols to describe relative changes in the orthogonal directions [5]. A differential chain code (DCC) was proposed by Nunes et al. [6,7], where the edges of the contour are coded instead of the pixels (see Fig. 2b). The walk through the edges is controlled by three codes: right (R), left (L), and straight (S). The initial coding direction has to be specified in order to reconstruct the shape.

Sánchez-Cruz and Rodríguez-Dagnino introduced the Three OrThogonal chain code (3OT) [8], which consists of three symbols and is defined as follows. If the current i-th coding direction is equivalent to the $(i-1)$-th direction, the symbol 0 is used. Otherwise, if the i-th direction is equivalent to the $(i-2)$–th direction, then the symbol 1 is used. In any other case, the symbol 2 is applied. The 3OT chain code also needs to specify the coding direction (see Fig. 3 for an example).

Chain codes are used in various applications for pattern recognition [9], image processing [10], font representation

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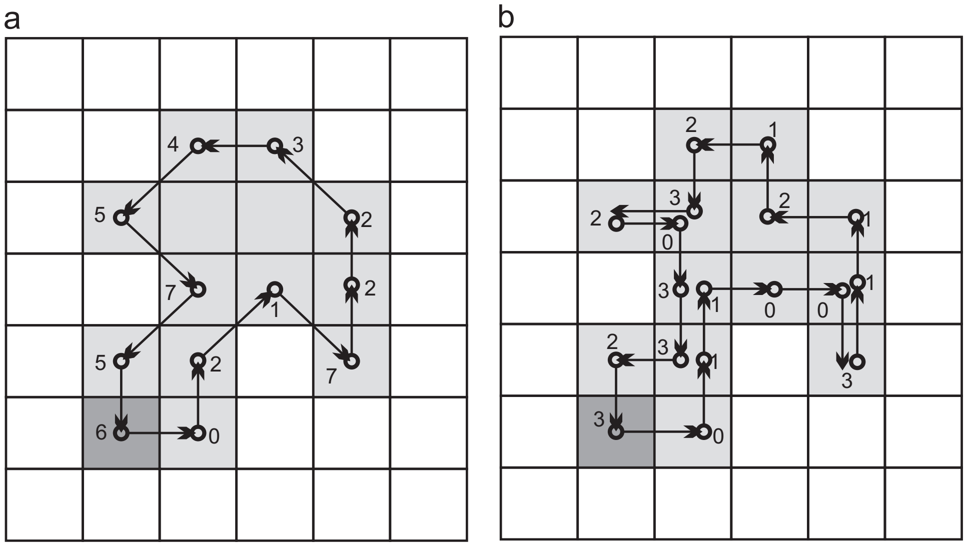

Fig. 1. (a) FEDCC, and (b) FFDCC chain codes.

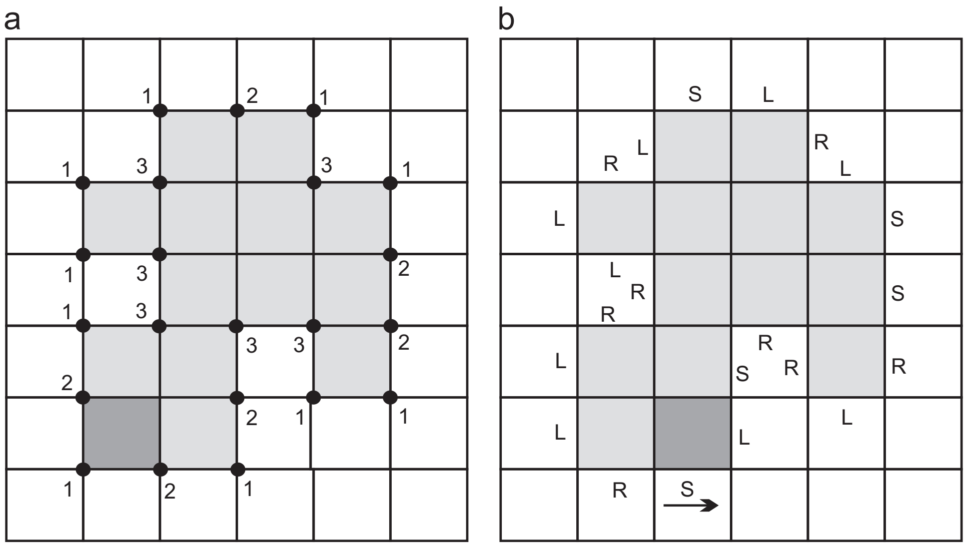

Fig. 2. (a) VCC, and (b) DDC chain codes.

[11], geographical information systems [12], engineering and materials [13], and computer-aided design [14]. Chain codes are frequently compressed in order to achieve more compact shape representation. This paper introduces a new efficient chain code compression algorithm based on move-to-front transform for entropy reduction and adaptive run-length encoding for compressing the repetitions of symbols' combinations.

This paper is organised into five sections. Section 2 concentrates on chain code compression related work. Section 3 firstly introduces a new representation of the directional difference chain code, followed by a detailed description of the new compression algorithm. Section 4 provides comparisons of the proposed method between the existing chain code compression algorithms, whilst Section 5 concludes the paper.

2. Related work

Data compression has a long tradition in computer science and therefore, various classifications exist regarding compression approaches. However, the classification to lossy and lossless methods has been accepted as the most fundamental [15]. Lossless methods are indispensable for text compression and for those applications where losses are unacceptable (e.g. medical images). Various approaches have been used for compression of digitalised geometric shapes. If the interior of a geometric shape is homogeneous, describing its boundary is sufficient. In such a case, the boundary can be expressed either by vertex-based coding [16,17] or with chain codes. Vertex-based coding is used for lossy compression, as the number of used vertices is related to the qualities of the