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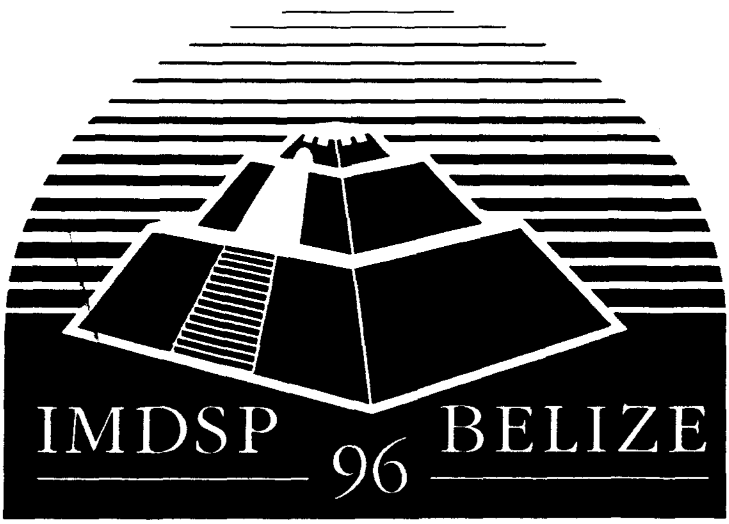

# STRUCTURAL MODELS FOR IMAGE COMPRESSION: A COMPARISON

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### ABSTRACT

In this work, the concept of structural coding will be explained. A classification of different structural coding techniques and a comparison among their performance will be presented.

## 1. INTRODUCTION

Images or image sequences cannot be simply described as mere realizations of stochastic processes. Images are formed from the projection of 3D world objects onto a plane, with portions of one object occluding portions of another one.

In order to understand the 2-dimensional arrangement of objects, it is essential to keep the structure with which visual information is organized. The concept of the *structuring element* is introduced for this purpose. A structuring element is an organized set of pixels with certain local properties. For example, a contour segment is a structuring element: the local property being that it is defined by a series of pixels having maximum local gradient in one direction. More abstract models for structuring elements can be used by combining different less abstract structuring elements. In a video-telephony application, a human face can define such a structuring element. In this case a series of low-level abstract structuring elements, i.e. contour segments, special regions (such as eyes, mouth), are combined with certain spatial constraints so as to form a human face.

A structural coding scheme has the following caracteristics:

1. A structuring element is identified by some relational properties between groups of pixels, which are basically spatial for image compression (spatio-temporal for video compression). These properties denote a local organization. A structural element property implies certain contraints on neighboring structuring elements (for example, there cannot be two neighboring contour lines).

2. Given the structuring element characteristics, specific coding methods can be developped, which **must not** change the structuring element characteristics (e.g., a contour segment cannot become a region), but which allow for a change in position, shape or appearance (luminance) of this element. In other words, structuring elements are invariant under compression. Moreover, the relationship that exists between two structuring elements is also invariant.

3. An image is represented as a combination of structuring elements of eventually different types, depending on how "easy" their identification is from the source signal (e.g., it may not be that simple to extract a face from an image sequence) and how "accurate" this representation is desired. These structuring elements are organized one with respect to the other. When distortion is introduced, it is defined differently for each type of structuring element, according to the allowable changes in position, shape and appearance, so as to keep the spatial organization between structuring elements possible and the structuring element own characteristics unchanged.

In the next section, a possible classification of structural coding methods will be described.

## 2. CLASSIFICATION OF STRUCTURAL CODING METHODS

Structural coding can be divided into 4 main categories:

1. Contour based representations (Synthetic highs based coding [1], Directional decomposition based coding [2], Sketch based representation [3])

2. Operator or Feature based representations (Anisotropic nonstationary predictive coding [4], Texture based coding, Fractal based coding [5], Symmetry based coding [6])

3. Segmentation based representations (Region-based coding [7], quadtree/octree based coding [8], Binary space partitioning tree based coding [9])

4. Model-based representations (application specific, e.g. head and shoulder model for video-telephony such as wireframe [10], analysis-synthesis SIMOC method, etc.).

Most structural coding methods require to perform an analysis of the local image structure (edge detection, uniform texture identification, symmetry detection, face extraction, etc.). This has been the limiting factor for its

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success, given the ill-conditioned problem of pattern identification for arbitrarily complex natural scenes.

The following table summarizes the various techniques used in structural coding identifying for each one of them the type of structuring element used, the range of low bit-rates for which the particular method gives visually acceptable results, the type of artefacts created by the method as bit-rate is reduced, its use for video compression by extending the approach to the temporal domain.

Among all the *structural coding* methods we claim that, the most probably appealing is the segmentation based coding one [7] as it relates the most to the physical nature of objects in a given scene. In this case, the structuring element is a region with the same attribute: uniform texture, uniform motion, uniform chrominance characteristics, etc. The problem is to identify these regions with a certain accurancy in the original image at the lowest possible rate for a given reconstruction quality. Coding will involve the description of the region shape and location on one hand, its appearance on the other hand (i.e. the luminance/chrominance information)[1].

| Method | Feature Rep. | | | |
|---|---|---|---|---|
| | APC | TC | FC | SC |
| Str. El. | Dir. E | T.P. | C.T. | S.A. |
| bpp | .27-.5 | .002 | .5-1 | .5-.8 |
| Vid. Cod. | No | No | No | No |

| Method | Contour Rep. | | |
|---|---|---|---|
| | SH | DD | SC |
| Str. El. | E | Dir. E | E. |
| bpp | .4-1 | .15 | .05-.15 |
| Vid. Cod. | No | No | Yes |

| Method | Segmentation Rep. | | |
|---|---|---|---|
| | AS | $2^nT$ | SC |
| Str. El. | A.R. | S.R. | C.P.R. |
| bpp | .08-.25 | .2-.4 | .1-.2 |
| Vid. Cod. | Yes | Yes | No |

| Method | Model Rep. | |
|---|---|---|
| | H&S | W |
| Str. El. | H.S. | F. |
| bpp | .05 | .001 |
| Vid. Cod. | Yes | Yes |

[2]

[1] It is important to note that both shape, location and appearance have strong ties between neighboring regions. In effect, once a region position and shape are known, part of the position and shape of its neighbors is known as well. In the case of appearance, the problem may seem less obvious, but given the segmentation criterion used, knowing one region appearance implies some knowledge on the apperance of its neighbors.

[2]

SH : Synthetic Highs
Str. El. : Structuring Element
DD : Directional Decomposition
E : Edge
S : Sketch based representation
Dir. E : Directional Edge
APC : Anisotropic Predictive Coding
TC : Texture Coding
T.P. : Texture Primitive
FC : Fractal Coding
C.T. : Contractive Transformation
SC : Symmetry based Coding
S.A. : Symmetry Axis
AS : Arbitrary Segmentation
A.R. : Arbitrary Region
$2^nT$ : $2^n$ Tree representation
S.R. : Square Region
BSPT : Binary Space Partitioning Tree representation
C.P.R. : Convex Polygonal Region
HS : Head-and-Shoulder model based coding
H.S. : Head-and-Shoulder primitives
W : Wireframe model
F. : Face primitives

## 4. CONCLUSION

In this work, the concept of strutural coding methods has been analyzed and a possible classification of these techniques has been proposed.

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