TECHNICAL SPECIFICATION

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Electronic imaging — Guidance for selection of document image compression methods

Imagerie électronique — Guide pour la sélection des méthodes de compression d'image

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years with a view to deciding whether it should be confirmed for a further three years, revised to become an International Standard, or withdrawn. In the case of a confirmed ISO/PAS or ISO/TS, it is reviewed again after six years at which time it has to be either transposed into an International Standard or withdrawn.

Attention is drawn to the possibility that some of the elements of this Technical Specification may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 12033 was prepared by Technical Committee ISO/TC 171, *Document imaging applications*, Subcommittee SC 2, *Application issues*.

Introduction

With respect to the rapid increase of applications using digitization techniques, the role of compression methods has become a factor of growing importance for the management of the volumes of stored data.

The effects of the available compression methods vary greatly, depending on the source documents. For example, an Electronic Image Management (EIM) system configured for scanning and storing continuous tone images will have different image compression requirements as compared to an application involving only text.

Practical methods for analyzing user requirements for image compression in order to select accurate and optimal image compression schemes are complex. It was evidently useful to issue this Technical Specification in order to guide users and system developers in their selection of these methods.

Electronic imaging — Guidance for selection of document image compression methods

1 Scope

This Technical Specification provides information to enable a user or EIM integrator to make an informed decision on selecting compression methods for digital images of business documents. It is designed to provide technical guidance to analyze the type of documents and which compression methods are most suitable for particular documents in order to optimize their storage and use.

For the user, this Technical Specification provides information on image compression methods incorporated in hardware or software in order to help this user during the selection of equipment in which the methods are embedded.

For the equipment or software designer, it provides planning information.

This Technical Specification is applicable only to still images in bit-map mode. It only takes into account compression algorithms based on well-tested mathematical work.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Technical Specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this Technical Specification are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 12651:1999, *Electronic imaging — Vocabulary*

ITU-T Recommendation T.4:1999, *Standardization of Group 3 facsimile terminals for document transmission*

ITU-T Recommendation T.6:1988, *Facsimile coding schemes and coding control functions for group 4 facsimile apparatus*

3 Terms and definitions

For the purposes of this Technical Specification, the terms and definitions given in ISO 12651 and the following apply.

3.1
lossless compression
compression algorithm that is capable of recalling all of the original information of a compressed image

3.2
lossy compression
compression algorithm which loses some of the original information during compression, so that the decompressed image is only an approximation of the original

NOTE This type of algorithm is especially useful in image compression where details can be eliminated, because these details are not perceptible, or are minimally perceptible, to the human eye. In this case, the compression ratio is dramatically increased.

3.3
resolution
number of pixels per unit of length

3.4
dots per inch
dpi
number of dots that a scanner (printer) can scan (print) per inch both horizontally or vertically

3.5
brightness
visual sensation that enables an observer to detect luminance

3.6
contrast
difference between the highest and the lowest densities of an image

3.7
bit level
number of bits used to define a pixel

3.8
luminance
Y
luminous flux emitted from a surface

NOTE The former term was photometric brightness.

3.9
chrominance
Cr,Cb
colour portion of the video signal including hue and saturation but not brightness

NOTE Low chroma means the colour picture looks pale or washed out; high chroma means intense colour; black, grey and white have a chrominance equal to zero.

3.10
ITU-T Group 3 and Group 4
standard compression algorithms set by the ITU-T

3.11
Joint Photographic Experts Group
JPEG
popular name of ISO/IEC 10994 standard

3.12
Comité Consultatif International pour le Télégraphe et le Téléphone
CCITT
former name of the International Telecommunication Union – Telecommunication Standardization sector (ITU-T)

3.13
compression ratio
ratio between image size before compression and image size after compression

4 General

In a document imaging system, users are concerned about the quality of archived images, for two reasons: first, because it can affect the imaging system's future in the medium or even long term; and second because they must choose the imaging tools based on an evolving technology.

The digitization process, which by nature transforms an image conveying comprehensible information into a dematerialized one, changes the observer's perception of that image. The observer may consider the image as being improved, though more frequently he considers it degraded. In fact, images undergo a number of successive transformations at different points during the digitization process. At each of these stages, attempts are made to keep the image within acceptable legibility limits, but also to restrict its size to within acceptable economic limits.

The specific role of one of the digitization stages — compression — is to reduce the size of the image. Some compression methods are reversible in that the decompression algorithm restores the initial digital information. These methods are lossless and have no impact on the quality of the image as it is perceived by the human eye. Other methods are lossy, and may cause degradation perceptible to the eye. By adjusting parameters, the user can bring a lossy method within acceptable limits.

While numerous compression methods are described in technical literature, few are stable according to industrial standards. These are based on a limited number of principles: dominance of certain patterns, pattern repetition, and noticeable mathematical properties. In any individual method, the number of parameters the user can modify is small.

The choice of a method and compression parameters are for a large part determined by the characteristics of the document. Obviously, the graphical contents of a document play a key role in determining the method and its parameters. However, other factors characterizing the application context are also very important (see diagram).

A document's graphical contents are themselves important to the digitization process. Thus, a photograph cannot be digitized in the same way if it is in greyscale or based on a “pseudo-grey” process. In the first case, JPEG compression is used, while the second would require ITU or JBIG compression.

Before discussing compression methods, therefore, we need to review the types of documents and how they are represented following digitization. See Figure 1.

5 Type of document and digitization parameters

5.1 General

A document is a set of organized information intended for presentation to a human user. Documents can be a single page or a set of pages, and can contain arbitrary contents types, such as character content, graphical content, and various types of image content.

The following document content may be founded in various types of documents. The classification list hereafter is somewhat arbitrary, but for a given application, these distinctions may be used to understand how to handle a given document.

5.2 Types of documents

Here we will present only those documents (generally called “word processing documents”) that are most likely to be archived electronically. These documents include:

— black text on a white background, or less frequently, coloured text or a coloured background;

— photographs, black and white or colour;

— mixed documents containing both text and photographs reproduced by a printing process — black and white or colour.

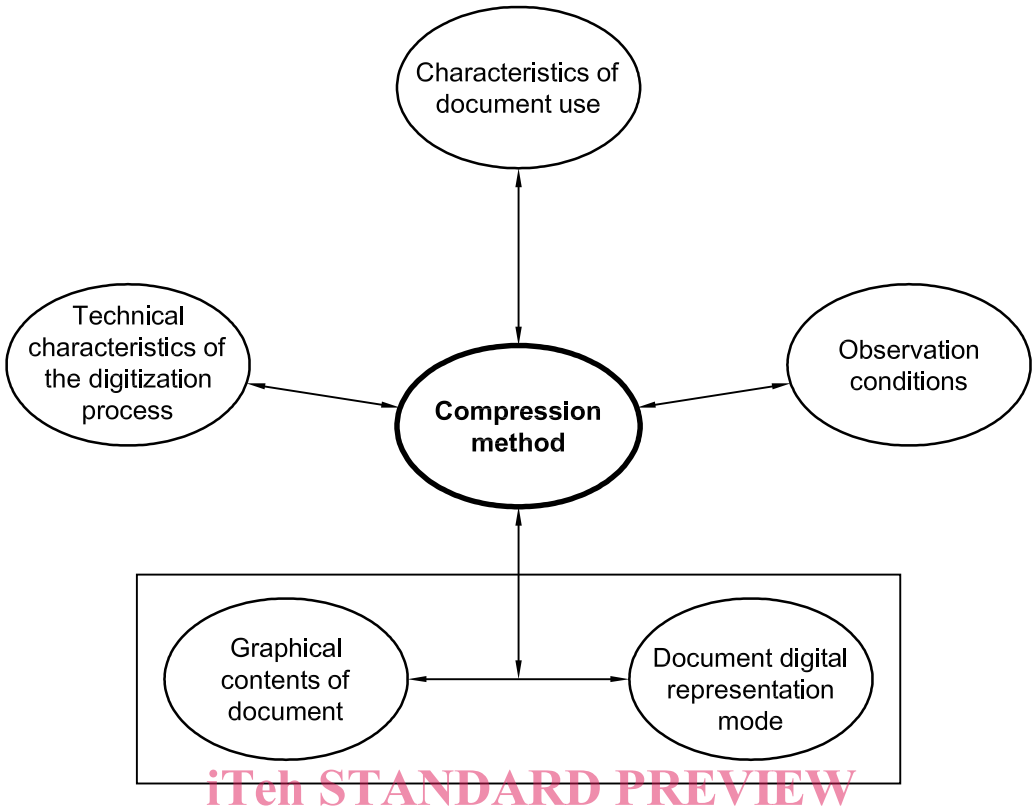

Figure 1 — Interactions with the compression method

5.3 Document classification and digitization

5.3.1 General

For the purpose of determining a compression scheme, documents may be described in the following five ways. For each type of document, digitization methods are briefly described.

5.3.2 Black and white documents

Digitizing pages printed in black and white (primarily text) generates bi-level images where each pixel is represented by a bit. This form of representation can also be applied to images in text documents with a coloured background or characters, as well as to line drawings.

The most important digitization parameter is resolution.

Resolution must be determined according to visual perception needs and on the limits of the complete imaging process (e.g. 200 dpi for word processing documents, 300 dpi for digitized books).

There are also other parameters, related to image processing, which vary according to the kind of image. If we know, for example, that the images to be digitized are text, we will try to produce black characters that are sharply defined against a white background. Thus, we have brightness (adjusting the colour of a pixel against a threshold) and contrast parameters (adjusting the colour of a pixel against that of the surrounding pixels).

5.3.3 Greyscale documents

This form of representation is applied to photographic documents, printed on paper from a black and white film.

Digitization changes an initially continuous document into a matrix of pixels whose intensity is encoded in a range of levels. Thus, 8-bit encoding produces 256 greyscales.

The number of greyscales or the bit level must be determined according to visual perception needs and the limits of the complete imaging process.

5.3.4 Pseudo-grey documents

This category includes images that simulate grey using a variable arrangement of black and white pixels. There can be two cases:

1) the source document is a photographic reproduction in a text; it was produced using a printing technique and is itself a pseudo-grey document (rastering uses black pixels of variable size);

2) the source document is a true photograph, but was digitized in pseudo-grey for performance reasons: to reduce the storage volume or transmission times on a network (the “half-tone” technique involves arranging a variable number of black pixels inside a matrix of fixed size).

5.3.5 Colour documents

This form of representation is applied to photographic documents, printed on paper from a colour film. Another application is digital colour capture of business documents where yellow highlights, colour boxes, pencil, red pen, etc. is a part of the information capture integrity.

Colour documents are intended to be restored in colour, but may also be reproduced in greyscale.

Colour representation is based on the neuro-physiological properties of the human eye, notably the “visual tri-variance” principle, which states that all colours can be produced by combining the three primary colours. Thus, a colour can be represented by three co-ordinates in a vector space based on primary colours, or by linear combinations of these co-ordinates.

The colour space most frequently adopted uses Red, Green and Blue. These colours are differentiated by the retinal cones in the eye. Another colour space decouples the variables into one “luminance” variable, and two “chrominance” variables. This colour space is used to transmit TV signal.

In a digitized colour image, each pixel is represented by assembling three components corresponding to the primary colours. The bit level adopted for a component determines the quality of hues; the standard of 8 bits per component can represent 256^3 = 16 million different colours. Representations on a total of 8 bits sent by data communication networks are also fairly frequent.

5.3.6 Mixed documents

Many documents to be archived are composed of pages of text containing graphic elements and/or photographic images. There is no completely satisfactory way of representing this type of document:

— a bi-level representation would make illustrations illegible;

— a greyscale or colour representation to preserve illustrations would provide the best quality, but would make storage volumes disproportionately large with respect to the importance of the illustrations (one must be aware of the possible trade-offs between resolution and bit level of greyscale or colour image files);

— a half-tone representation would decrease the legibility of the characters.

In mixed documents, text is considered more important, so a bi-level representation would be used to draw black characters on a white background. The photos would either be lost, or would have to be separated from the text for appropriate representation. In most cases, text and photos can be automatically and successfully separated using segmentation algorithms. Sometimes, segmentation can lead to loss of information (such as captions under photos, or unusual typographic arrangements).