pira

Consultancy report

Final report
IMSTAND(:)
Open Information Interchange study on image/graphics standards

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Conclusions

The measure of success for a graphic standard can be established on three levels.

1 The availability of systems which conform to its specification
2 The degree to which a standard is regularly employed in commercial applications
3 The establishment of a common perceptual framework for further activities, eg the concept of programmer portability as well as actual information interchange.

The expert input to the project recognised the following as being factors key to a standards' success which may be influenced beneficially by the OII Initiative.

- formal specification
- the availability of rigourous conformance tests
- previous agreement, amongst users, on the need for a standard in a particular application domain
- the standard should enable increased openness and offer a market advantage to product developers
- the existence of application profiles for particular market sectors.

The study has revealed that categorising standards by application domain is not satisfactory. It is clear that many standards cross application boundaries. The IPI-IIF standard offers the potential for a widely used, inter-disciplinary, multidimensional format. It promises the ability for transparent data exchange across the boundaries of application specialities.

An integrated vehicle for the transfer of image and non-image related attributes, in their widest sense, does not exist. Current graphic standards development focuses on the image data.

The process of standards development needs to be accelerated in order to catch and improve incipient de-facto standards. However, taken to its logical end this results in a paradoxical situation. It is recognised that standardising current practice is no longer timely enough (see DDES) but anticipating future practice is error prone.

Due to ambiguities in the drafting of standards people not directly involved with their development may interpret them differently. As standards become more complex so the danger of misinterpretation becomes greater. It is also noted that there is a need for the harmonisation of data modelling languages.

Conformance testing is often inadequate. For example SPDL is an open ended format, therefore, it is impossible to test an interpreter exhaustively against every possible production. Often the conformance statements in standards are already very poor often due to the difficulty adequately to describe conformance in a way that allows useful testing.

Users do not have the standards they require because they are often not vociferous enough. Frequently there is seen to be a conflict of interest between a proprietary standard, developed by a vendor group, and the requirements of the end users. The conflict, either real or imagined, relates to issues of openness and information interchange. The commercial value of official standards is only understood by a small minority of end users and the process of standards development, due to the very real cost of involvement, discourages their participation.

Markets and user issues for image interchange

The study has revealed that categorising standards by application domain is not satisfactory. It is clear that although official standards have been developed with clearly defined and commercially valuable objectives they have, in many instances, been overtaken by proprietary alternatives.

From the software developers' point of view the commercial desirability of "owning" a de facto standard is obvious. From the end users viewpoint, whatever the application domain, fitness for purpose is the governing factor.

Where computer graphics are related to commercial enterprise directly, productivity is the single most important factor. It was productivity which supported dedicated, high cost, specialised equipment in publishing and pre-press combined with the fact that their end product was a universal format - an image on film. System interconnectivity was of secondary importance. Equally in highly specialised areas, such as scientific and medical analysis, the need to translate data, outside the locally defined function, was not of sufficient importance to influence standards development. It should be recognised that in both engineering and medicine they are equally concerned with image data, meaning values which may be used to render an image (eg a set of x-ray attenuation values calculated from a set of measurements made by a CT machine), as well as image data which has been obtained by digitising a picture (eg a radiograph).

Over the last four years there has been a dramatic increase in the need for graphic information interchange. Where official standards have tried to address this need, the ISO/TC130/WG2 IT8 series is a case in point, they have failed to provide a practical working solution. The reason for this failure is a combination of the productivity limitations of the standard and the speed with which solutions have been provided by proprietary alternatives - notably TIFF combined with PostScript.

Each of the specialist application domains have developed standards that, with the exception of CGM, have largely addressed the need to transfer information within their own working environments. A good example of this requirement is demonstrated by the data communication needs of the folding box designers and manufacturers.

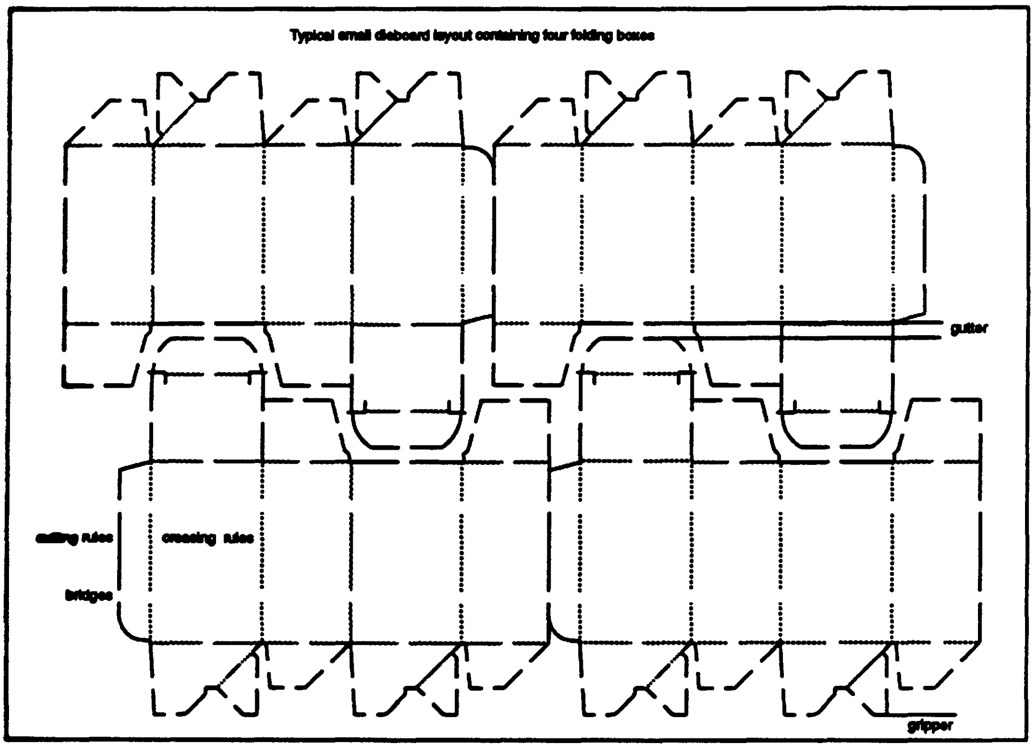
With the introduction of computer aided draughting systems for the design of folding boxes and automated CNC-controlled dieboard cutting machines (lasers and jigsaws) for their construction, communication protocols have been developed to meet the special requirements of both sides (DDES2 & CFF2).

In almost all cases folding boxes are designed by sample makers inside printing companies. The actual manufacture of the dieboards, needed for punching the carton blanks, is completed by independent, highly specialized trade shops.

Data exchanged between the designers and the dieboard manufacturers must not only include the shape of a certain package, but a host of other details which include; the number of stations; types of cutting and creasing rules; positions; widths of bridges; size of dieboard; gutter width and much more (see Figure 1).

The primary function of the cutter guide graphic, shown in Figure 1, is to provide construction data for the manufacture of the guide itself. It does, however, also represent a precise definition of the area of a pack. As such it is required by the art studio which will be creating the pack decoration. The outline provides the basis for layout and design assembly. Without direct information interchange the dimensions must be translated by the graphic designer. At this stage there is an obvious duplication of effort as well as a likely point for the introduction of errors.

Figure 1


Typical small dieboard layout containing four folding boxes

For some time specialist, design software, written for dedicated packaging workstations, has been able to import CAD outlines to provide the basis for accurate montage. For wider applications, intermediate translation software must be used.

Non-image (or non-image forming) information, incorporated within a graphic file structure, can be argued to be a universal requirement. Details of the history of an image are not part of current standards. There is no reference for the processing that has been undertaken prior to a files delivery.

In addition to non image but graphic related data, object information also has to be transmitted between production stages but the importance alters depending on the stage. The information could be order numbers, delivery dates, tracking of consumables, time charges at each workstation, etc. In fact the ideal situation can be identified as an integration of image data with a parallel, management information track.

In the case of medical imaging, 'management information' can be expanded past the point of a particular image's chronicle to include:

- a patient's medical history
- details of the examination which produced the image eg equipment settings and environment
- hospital management data eg appointment times, dates and a progress record of the treatment.

Data compression and increasing computer power reduce the importance of minimal file size. In the event that a single standard is developed for pan-industry applications the inclusion of some redundant information, relative to a specific production function, may be tolerated. This does, however, raise the question of confidentiality and qualifications for access.

In the main graphic file formats reflect the structure of a particular software product developer's requirements. If the product becomes widely distributed then this proprietary format takes on the additional role as a interchange or transfer medium. There are a great many different file formats, in every-day use, each related to combinations of particular software suites and hardware platforms.

There are two fundamentally different types of computer graphic files:

- Raster or bitmapped
- Vector

Raster files describe the colour (and therefore, tone) of every addressable position of a given image - the pixel. Complex pictures are built up by varying the attributes of the pixels within the image. The total image is stored as a reference grid, or map, of each pixel's value - hence the term bitmapped image. The size of raster files corresponds directly to the number of addressable positions and colours in the image. The actual size of the image, when reproduced, depends entirely on the resolution of the viewing or printing device.

Vector files, on the other hand, contain no information about specific dots. Instead, vector files are a list of mathematical descriptions of graphic objects used to create an image. They are the building components of the image rather than a representation of the finished graphic. In its simplest form, a line, a vector file contains the data as to the line's start position, its length, the direction it travels and its weight and colour. To become an image the vector must be drawn by an application. Because the image is redrawn, from fundamental instructions within the file, the resolution of the final result is dependent on the output, or viewing device. Vector images are not linked to any particular piece of hardware; it is up to the application software to interpret the instructions correctly.

Table 1

Format	Raster	Vector	Owner
BMP	✓		Microsoft Windows Bitmap - Microsoft Corporation
CDR		✓	Corel Draw format - Corel Systems Corporation
CUT	✓		Dr Halo paint software - Media Cybernetics
DRW		✓	Migrografx Designer
DXF		✓	AutoCAD drawing exchange format
EPS (EPSF)	✓	✓	Encapsulated PostScript - Altsys Corp/Aldus/Adobe
GEM		✓	GEM metafile format - Digital Research
GIF	✓		Graphics Interchange Format - CompuServe Inc
HPGL		✓	Hewlett Packard Graphics Language
IMG	✓		GEM Image File format - Digital Research
MSP	✓		Microsoft Windows Paint - Microsoft Corporation
PCL (HPCL)	✓		Hewlett Packard Printer Command Language
PCX	✓		Zsoft PC Paintbrush - ZSoft Corporation
PIC		✓	Lotus 1-2-3 graphic files - Lotus
PICT	✓	✓	Apple Computer Inc
PNTG	✓		MacPaint - Apple Computer Inc
SCR	✓		Screen capture format - Microsoft Corporation
TGA	✓		TARGA format - Truevision Inc
TIFF	✓		Tagged Image File Format - Aldus/Microsoft
WMF	✓	✓	Windows Metafile Format - Microsoft Corporation
WPG	✓	✓	WordPerfect Graphic file format - WordPerfect Corp

Table 1 presents some of the most popular, personal computer, proprietary, graphic file formats. In the course of this project over 80 different, proprietary formats have been identified and it is suggested that a complete list would be even larger.

In the cases of GIF, EPS, TIFF and PCX they are so widely adopted that they assume the status of de facto standards. There is a far greater variety of formats for MS-DOS than for any other operating system and it is common for the format to be identified by its three letter file extension. This can lead to confusion when different formats have the same extension - PIC, SCR, DRW and IMG are some examples. In the case of PIC there are at least four alternatives including both raster and vector formats. Table 1 refers to the most frequent interpretation of the extension.

Applications which allow the importation of information from other sources use specialist filters which translate the incoming information. They can be considered as a set of rules which have been constructed to cope with the peculiarities of structure and format for each application covered. The problem with a fixed set of rules is that they are valid only as long as the originating software remains unchanged. With the rapid development of software and the frequent issue of new versions, the useful life of input and output filters is relatively short. It is also true that in translating one file structure to another, via a set of fixed rules, the translation suffers due to ambiguities that defy a fixed definition. It is very common for import filters to have limitations in their ability to cope with the full range of functions which are supported in the native format. Typical limitations are lack of support for:

- gradient fills and patterns
- specific fonts, character spacing and orientation
- linked objects, such as text following a curved path
- translation of colour data.

In the worst cases "approximations" or "intelligent guesses" are performed by the filter and the result can require more work in the secondary application than if it had generated the graphic in the first place.

Figure 2 is an illustration of the problems associated with import filters and intermediate translation routines. The original graphic (1) is the handle of a plastic container. The drawing was created in specialist CAD software which was able to produce accurate plots from which construction measurements could be taken. The drawing was saved as a DXF file (2). At this stage the file was processed through two different channels.

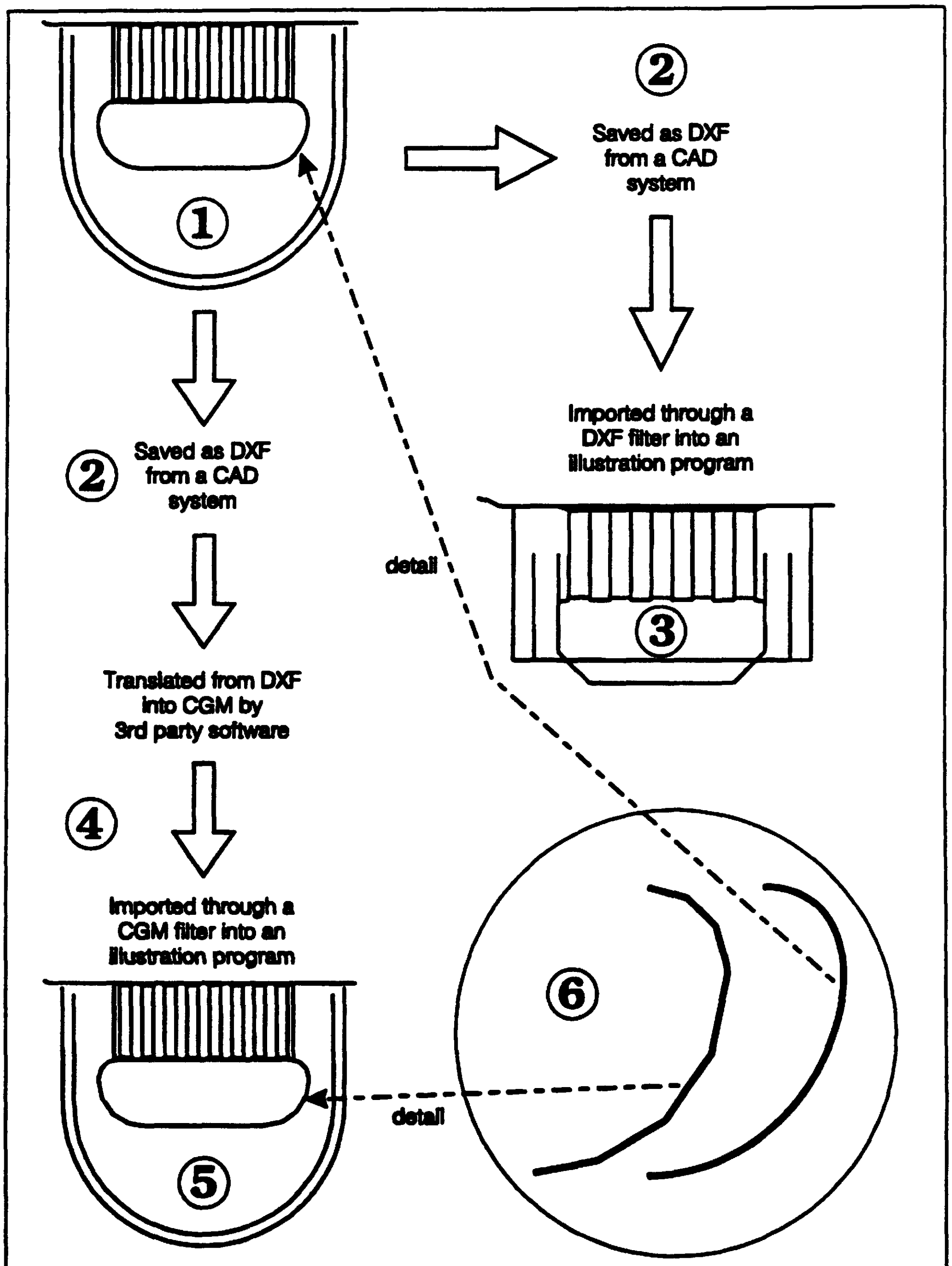
The DXF file was imported directly into a PC illustration program. The program was not satisfied with the structure of the DXF file and put up an error message indicating that it would make some 'assumptions' about the dimensions. The results of the assumptions are shown at (3).

The second route was to pass the DXF file through an independent graphics conversion program and translate the DXF file into a CGM file (4). The conversion program had no difficulty in performing the translation. The structure of the DXF file did not produce any error messages. The resulting CGM file was imported into the PC illustration software and the final result is shown at (5).

It is clear that the results of the two routes are widely disparate. The result at (3) is so far from the original that it is difficult to recognise its origin. The result at (5) makes an adequate template. The purpose of Figure 2 is to emphasise the disparity of the two routes, it is not a qualitative statement about the alternative file formats. The DXF was identical in both cases.

In converting information from one file source into another, either by importation into an application or by using external translation software, there are fixed rules. A raster source can only be translated into another raster file. A vector source can be translated into either a raster or a vector destination. Once a vector has been translated into a raster destination then it is subject to all the restrictions of reproduction resolution mentioned above.

Figure 2


①
②
Saved as DXF from a CAD system
Imported through a DXF filter into an illustration program
③
detail
②
Saved as DXF from a CAD system
Translated from DXF into CGM by 3rd party software
④
Imported through a CGM filter into an illustration program
⑤
detail
⑥

① as plotted directly from CAD software
② exported, from the CAD software, as a DXF, ASCII description
③ very poor rendering of the original via a basic DXF filter
④ 3rd party software used to translate the DXF into CGM
⑤ closer approximation of the original via the two stage translation
⑥ detail comparison showing the approximation of the curve as a result of the two translations

Translation from one system, or graphic, format to another is, at best, a minor delay which involves additional software expense (in pre-press it also involves additional hardware). But, at worst, translation can be the cause of file corruption, loss of data and scaling or colour inconsistencies. The incompatibility of successive versions of the same software is commonplace. Incompatibility of different software translations is inevitable, and has to be one of the strongest arguments for trans-application standards.

The publishing community is increasingly becoming involved in using digital images and has ever growing requirements related to image interchange. The issue of image interchange arises both in the process of publishing and in published products themselves. The publishing process has had a strong electronic component for some time, although increasing demands are continually made; the growth of electronic publishing has increased the demands related to the product.

The process of publishing, being very often a workgroup activity, implies exchange of information, including images, between those involved in the process. This is the case over a wide variety of publishing markets, for instance newspapers, magazines, journals, book publishing and technical documentation production. The move towards common open system platforms using common applications reinforces the similarity of the requirements these apparently varied markets have.

The following lists illustrate requirements which exist across a broad spectrum of publishing. However, they are aspirations which it is foolish to isolate in one application domain as they are relevant to the interchange of information, expressed graphically, in whatever context.

Image archive/database

- incorporate images in databases (comprising text and image fields) in a standard way.
- hardware with storage capacity sufficient to hold large image databases on a scale not supported by current CD-ROM jukebox systems
- fast image input devices for efficient input of long series of images
- ease of retrieval of images held in image archive databases (and separately from other information stored eg structured text information)
- easy exchange of images between databases (migration support for moving images to slower or offline storage)
- image compression support for reduction of storage space
- ability to link databases containing images to other databases
- ability to incorporate retrieve and display images in CD-ROMs in a standard way

Application/user interface

- integration of viewer software, database access, printer drivers for quality hard copy etc. in a standard way
- availability of standard viewer application software on a wide variety of platforms
- availability of images at different levels of resolution for final output
- support of image compression techniques by application developers
- ease of integration of image handling functionality into applications
- adequate user interfaces for retrieval, browsing, selection and reading of documents with images on screen

Interchange over networks

- efficient and easy transfer of images over networks (local and distributed) eg between an editor's workbench and an image archive
- file transfer of images between different sites without loss of information
- file transfer of images (perhaps incorporated within other data) at a rate sufficient to allow interactive features such as browsing through pages
- ease of transfer of images between platforms

- image compression support for reduction of transmission times
- registration and identification of images
- feedback (automated ideally) to suppliers of images

Hypermedia

- import multimedia information into hyperdocuments
- create hyperlinks between images and other images or text
- format having 'placemarkers' for multimedia inserts even if the multimedia facilities are not fully in place

General

- full-text search of images of text pages
- resolution independence prior to output.
- full support for working in colour and transferring colour images
- ease of output of images to standard output devices
- output of images captured in colour as black and white
- photorealism - rendering of three-dimensional images that are virtually indistinguishable from photographs
- stability of the interchange standards over time

Image archive/database

- incorporate images in databases (comprising text and image fields) in a standard way
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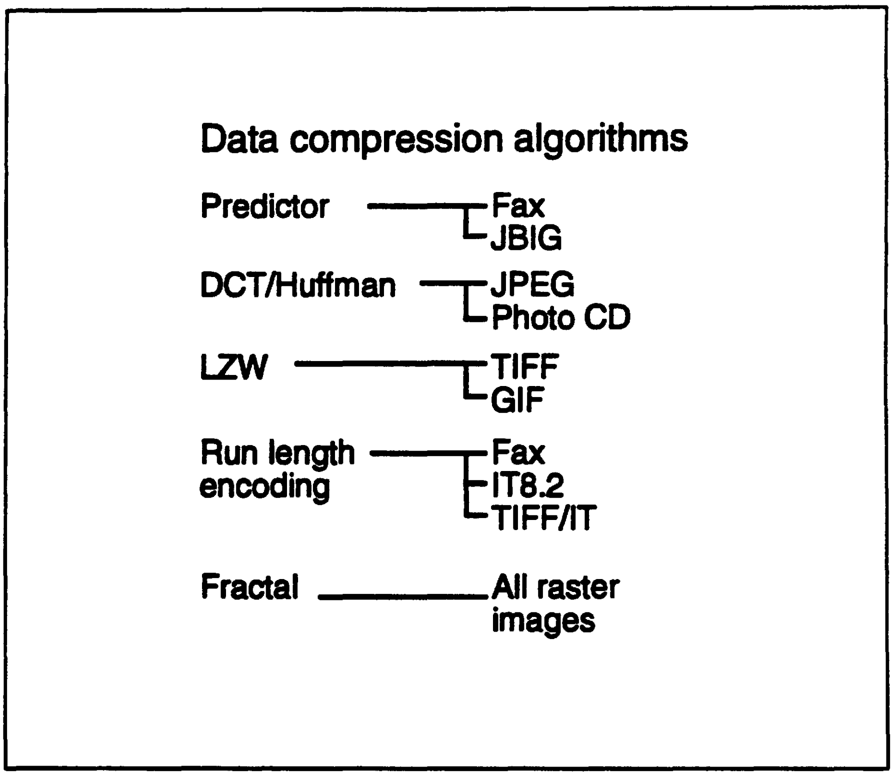
- ease of retrieval of images held in image archive databases (and separately from other information stored eg structured text information)
- easy exchange of images between databases (migration support for moving images to slower or offline storage)
- image compression support for reduction of storage space
- ability to link databases containing images to other databases
- ability to incorporate retrieve and display images in CD-ROMs in a standard way

The relationships of the graphic standards

Figure 3 relates standards to particular compression algorithms. Refer to appendix 1 for a more detailed description of the alternatives.

Figure 3



Data compression algorithms

Predictor — Fax, JBIG

DCT/Huffman — JPEG, Photo CD

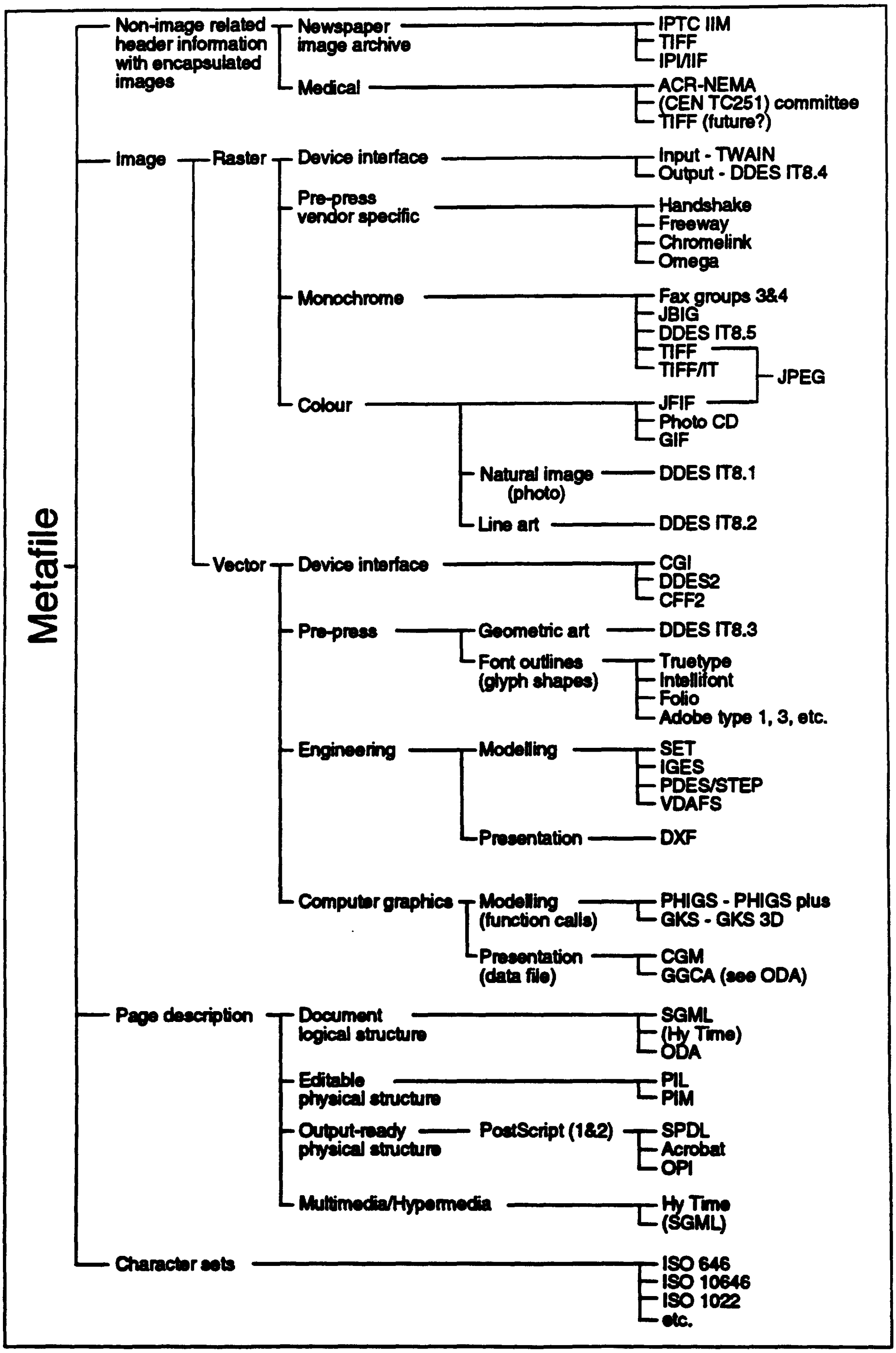
LZW — TIFF, GIF

Run length encoding — Fax, IT8.2, TIFF/IT

Fractal — All raster images

Figure 4 shows the relationships of the various graphic standards both to each other and to their application domains. Due to the complex overlapping of the capabilities of some of the standards, it should be realised that this figure represents just one, of many possible, interpretations.

Figure 4


Metafile
Non-image related header information with encapsulated images
Newspaper image archive
IPTC IIM
TIFF
IPI/IIF
Medical
ACR-NEMA
(CEN TC251) committee
TIFF (future?)
Image
Raster
Device interface
Input - TWAIN
Output - DDES IT8.4
Pre-press vendor specific
Handshake
Freeway
Chromelink
Omega
Monochrome
Fax groups 3&4
JBIG
DDES IT8.5
TIFF
TIFF/IT
JPEG
Colour
JFIF
Photo CD
GIF
Natural image (photo)
DDES IT8.1
Line art
DDES IT8.2
Vector
Device interface
CGI
DDES2
CFF2
Pre-press
Geometric art
DDES IT8.3
Font outlines (glyph shapes)
Truetype
Intellifont
Folio
Adobe type 1, 3, etc.
Engineering
Modelling
SET
IGES
PDES/STEP
VDAFS
Presentation
DXF
Computer graphics
Modelling (function calls)
PHIGS - PHIGS plus
GKS - GKS 3D
Presentation (data file)
CGM
GGCA (see ODA)
Page description
Document logical structure
SGML
(Hy Time)
ODA
Editable physical structure
PIL
PIM
Output-ready physical structure
PostScript (1&2)
SPDL
Acrobat
OPI
Multimedia/Hypermedia
Hy Time
(SGML)
Character sets
ISO 646
ISO 10646
ISO 1022
etc.

The graphic standards

Vector or geometric data

CFF2

Expanded name
Common File Format, Rev. 2

Areas covered
Vector and text interchange by modem or diskette

Standard details
Not approved by any standardization organisation

CFF2 has been developed upon the first revisions of DDES-IADD by some of the European packaging CAD-CAM suppliers but changed to the special requirements of the European users. It is widely used throughout Europe for communication in the converting industry. It especially takes care of the European multiple language structure.

Characteristics/description
The main idea of CFF2 is to enable senders/receivers of data needed for the manufacture of dieboards or artwork to overcome the language barrier. This is done by using decoding files resident in every machine enabling the user to work in his own language. Only a limited set of ASCII characters is allowed. KERMIT is often used as intercommunication protocol between different hardware.

Definitions for text and dimension lines are as well implemented in some systems.

Since CFF2 is not yet an official European standard, the full description and syntax may be obtained from one of the main suppliers of CAD-CAM-Systems for the packaging industry.

CGM

Expanded name

Computer Graphics Metafile

Area covered

Metafile

Sponsoring body and standard details

- ISO/IEC JTCI/SC24
- IS 8632 - 1989
- IS 8532 - 1992

Further details available from:

Local national standards organisations

Characteristics/description

CGM is a machine and operating system independent interchange format. It contains both elements to represent geometric graphics (e.g. polygons, circles) as well as raster graphics (e.g. pixel arrays). It contains a functional specification and multiple encodings for different purposes.

The Computer Graphics Metafile is the only standard for graphical database specification designed to serve a wide range of applications. CGM is a static picture-capture metafile. That is, it contains no elements (functions) with dynamic effects on partially defined pictures. A change of transformation to achieve zoom is an example of a dynamic effect. CGM is not an application programmer standard, as GKS and PHIGS are. Rather it is a specification for system designers and system implementers.

Usage (Market segment and penetration)

CGM is primarily intended for vector-based images and though it can carry raster components would not be considered for solely raster based images. It is also the basis of the "GGCA" ("Geometric Graphics Content Architecture") part of ODA.

CGM has since it was first published in 1987 gained a significant market. This is due to various facts, among which are the use in the US DOD CALS initiative as the graphic exchange format, and the use as the container for geometric graphic content architecture in ODA. Many graphics packages today are capable of generating and/or interpreting CGM files. With the publication of the new version (1992) the functionality has been broadened by many features earlier only available in PDLs like PostScript. The CGM of 1992 provides features not even available in PostScript level 2, e.g. colour interpolation for area fill which is very common in publishing applications. The early problems in computer graphics standards with fonts have also been greatly improved in CGM by the inclusion of a font name list which allows the use of professional fonts also in graphics. This altogether makes CGM a very good candidate for graphics exchange in publishing.

There are three standardised encodings: clear-text, character and binary. Clear-text is human-readable: character is more compact, but still uses "ASCII" characters, so can be interchanged without protocol problems: binary is more compact still, and quick to encode and decode, but completely unreadable. Thus the binary encoding may be more suitable for local storage and archive, the character for interchange, and the clear-text for development and debugging of applications.

These three encodings are standardised as part of the CGM standard. As an alternative to reduce data volume, however, the encoded data could be compressed using LZW (Lempel, Ziv and Welch) compression, or a similar algorithm. LZW is very widely used, though currently subject to patent claims by IBM and Unisys. LZW effectively replaces repetitions of character strings or bitstreams by short codes, and will therefore give high compression on the clear-text encoding, and significant but lower compression on the character and binary encodings.

CGRM

Expanded name

Information processing systems - Computer graphics - Computer Graphics Reference Model

Area covered

Sponsoring body and standard details

- ISO/IEC JTC1/SC24

ISO 11072 : 1992

JTC1 is the first (and only) Joint Technical Committee of ISO and IEC, and deals with Information Technology. SC24 is the Sub Committee of JTC1 which deals with Computer Graphics.

Further details available from:

Local national standards organisations

Characteristics/description

During the 1980s, SC24 and its predecessors developed what they now call the "first generation" of computer graphics standards, such as GKS, CGM, CGI and PHIGS. As this work was completed, it was realised that while each of these standards addresses particular requirements, the overall result is somewhat unsatisfactory, since on the one hand there is some duplication of material between the standards, while at the same time on the other hand there are significant differences in the view each one has of the computer graphics process, leading to difficulties in inter operating between the different standards.

It was therefore decided to stand back and take a broader view before embarking on the "second generation" of work. This "broader view" resulted in the CGRM (Computer Graphics Reference Model) ISO 11072. The CGRM is intended to provide the framework for development of all future computer graphics standards. Where possible, existing standards will be brought into line with it as they are revised.

The CGRM is based on a layered model, and thus has a superficial similarity to the ISO OSI 7-layer model. However, CGRM has only five layers. These lead from the abstract description of the object being modelled, through the definition of the viewing conditions, and the instructions to the renderer, to a raster image able to be displayed or printed without further processing. Thus the generality is lost as a particular image of the object is developed.

Usage (Market segment and penetration)

The intention is that future standardisation of computer graphic data formats and processing will be based on the CGRM layers, while continuing the existing practices of standardising different data encodings (eg clear-text and binary) to meet different processing requirements, and different language bindings of functions (eg C and Ada) to meet different implementation environments.

Thus CGRM is primarily intended for the developer of computer graphics standards, ie SC24 itself. However, it will also be "required reading" for the user of "second-generation" computer graphics standards, to gain an understanding of the model used in their development, and so of which standard is appropriate for a particular purpose, and how the standards fit together in the implementation as a whole. By "user" here is meant the system implementor: the end-user of a product based on such standards should not need even to have heard of CGRM.

DDES2-IADD

Expanded name

DDES	= Digital Data Exchange Specification
DDES2	= Version identifier of the IADD format
IADD	= International Association of Diecutting-Diemaking

Area covered

Vector and text interchange by modem or diskette.

Standard details
American National Standard
ANSI IT8.6-1991

Further details available from:
Local national standards organisations

Characteristics/description
The DDES2-IADD protocol is mainly used in the United States and Canada.

With the introduction of CAD-CAM systems for the design of folding boxes of both solid and corrugated packages on one side and automated CNC-controlled dieboard cutting machines (Lasers and jigsaws) on the other side, communication protocols have been developed to meet the special requirements of both sides. In almost all cases folding boxes are designed by sample makers inside printing companies, whereas the dieboards needed for punching the packages on so called Autoplatines are cut, ruled and rubbered by independent highly specialized trade shops.

The information exchanged between the parties must not only include the shape of a certain package, but the number of stations, types of cutting and creasing rules, positions, widths of bridges, size of dieboard, gutter width and many more.

DXF

Expanded name
Drawing Interchange Format

Area covered
Vector graphics principally used for CAD drawings.

Sponsoring body and standard details
Autodesk Inc

Further details available from:

Autodesk Inc
2320 Marinship Way
Sausalito, CA 94965, USA

Characteristics/description

The Drawing Interchange format is Autodesk's format for allowing the transfer of AutoCad drawings between CAD and illustration applications.

The ASCII encoded drawings may be re-created with a very simple interpreter but the file size is very large and not all drawing functions are supported by the format. Due to its pure ASCII text structure the drawing, and its attributes, can be changed by accessing the DXF file in isolation from its generating software.

Usage (Market segment and penetration)

This is used for interchange between CAD and other vector drawing packages with the emphasis on PC and UNIX computers. Most personal computer drawing and illustration software supports the import and export of this format.

GGCA

Expanded name

Geometric Graphics Content Architecture

Area covered

Vector graphics

Sponsoring body and standard details

- ISO/IEC, ECMA, CCITT
- IS 1989
- Part 8 of the ODA standard

Further details available from:

Local national standards organisations

Characteristics/description
Provides for inclusion of geometric graphics into ODA documents

Usage (Market segment and penetration)
see CGM

GKS

Expanded name
Graphical Kemel System

Area covered
vector graphics

Sponsoring body and standard details
ISO/IEC JTC1/SC24
IS 7942 - 1985
DP (Draft proposal) amendments and enhancements 1991

Further details available from:
Local national standards organisations

Characteristics/description
GKS is a machine, language, operating system, and device-independent specification of a set of services for displaying and interacting with 2D pictures.

- GKS specifies a basic set of graphics functions for applications that produce computer generated two-dimensional pictures on graphics output devices
- supports operator input and interaction by supplying basic functions for graphical input and picture segmentation
- allows storage and dynamic modification of pictures
- positioned at programmer-interface level
- once a segment is created, its contents can not be modified

Usage (Market segment and penetration)
This is in effect a subroutine library rather than a data format, and as such, standardised language bindings are provided for Fortran, Pascal, and C programs to invoke the functions.

Today GKS is a standard software delivered with many workstations as part of the operating system. It is bundled with the basic software delivered. It is difficult however to judge the number of applications really built on top of GKS. Besides GKS has laid the ground work for a common terminology and common concepts across the whole of computer graphics, and also has provided guidelines for the development of specific chip's functionality.

GKS-3D

Expanded name
Graphical Kernel System- 3 dimensions

Area covered
vector graphics

Sponsoring body and standard details
ISO/IEC JTC1/SC24
IS 8805 - 1988

Further details available from:
Local national standards organisations

Characteristics/description
GKS-3D is a machine, language, operating system, and device-independent specification of a set of services for displaying and interacting with 2D and 3D pictures. GKS is a subset of GKS-3D functionality.

- Graphics only
- Entirely a three dimensional system.
- GKS-3D extends each GKS primitive to three dimensions and adds one new primitive, fill area set.
- Central to the GKS-3D model is the concept of a single transformation pipeline that supports only 3D constructs and treats 2D operations as shorthand 3D operations.
- GKS-3D will behave like GKS when only 2D functions are used. Thus GKS programs will operate correctly within the GKS-3D environment.
- GKS & GKS-3D functions may be freely mixed.

Usage (Market segment and penetration)
GKS-3D is not as wide spread as GKS; for most 3D applications structuring is an important and required functional which is only supported to a nesting level of one.

IGES

Expanded name
Initial Graphics Exchange Specification

Area covered
Geometric (vector) and non-geometric entities

Sponsoring body and standard details

- NBS/ANSI
- Version 1.0 1980 (NBS)
- Version 2.0 1983 (NBS/ANSI)
- Version 3.0 1986
- Version 4.0 1987

Further details available from:

American National Standards Institute
11 West 42nd Street
13th Floor
New York
NY 10036
USA

Characteristics/description

- Principal standard for the exchange of product definition data in the US
- Two different data formats; ASCII and binary
- An IGES file is divided into 5 separate sections
- Originally conceived as a standard for drawing-oriented product models. For this reason it contains, in addition to geometric elements, numerous non-geometric elements
- The non-geometric entities serve to enrich the model (e.g. annotation and dimensioning appropriate to the model can be added)

Usage (Market segment and penetration)

Engineering modelling, CAD/CAM

Most CAD packages provide pre- and post processors for IGES. It was brought into being through a USA DoD initiative, and so was compulsory for suppliers to the US defence industry. This usage made it available to manufacturing industry in general. The DoD has developed military standards defining application profiles or levels of compliance for different industry sectors, eg mechanical engineering drawings, pipework layouts, circuit board designs.

The initial encoding is somewhat verbose (though still trivially small compared to a raster file) and very dated (Hollerith 80-column card images!), but it works: availability of the binary format is uncertain. It is not now intended to develop IGES further: the teams which worked on it are now developing STEP and PDES, which will succeed it.

PHIGS; PHIGS Plus

Expanded name

Programmer's Hierarchical Interactive Graphics System

Area covered

vector graphics

Sponsoring body and standard details

- ISO/IEC JTC1/SC24
- IS 9592 - 1990

Further details available from:

Local national standards organisations

Characteristics/description

PHIGS is a machine, language, operating system, and device-independent specification of a set of services for displaying and interacting with 3D geometric model.

- Aimed at applications that manipulate complex objects of 2D and 3D data in a highly interactive environment
- Not restricted to graphics. Provides data structure definition and editing facilities which are not necessarily related to graphical output.
- Positioned at programmer-interface level.
- Structures can be modified at any time in any way.

Usage (Market segment and penetration)

Today PHIGS is delivered with many especially high performance workstations. It has provided a significant impact on concepts of hierarchical graphical systems and is used (at least conceptually) in many applications. It is difficult however to judge the number of applications really built on top of PHIGS.

An amendment, "PHIGS-plus", includes various extensions, for example "NURBS" (non-uniform rationalised B-splines) an enhanced way of dealing with curved lines.

SET

Expanded name

Standard d'Echange et de Transfert

Sponsoring body and standard details

AFNOR, France 1985

Further details available from:

Association Francaise De Normalisation
Tour Europe
Cedex 7
F-92049 Paris la Defense
France

Characteristics/description

Chosen as the standard for several of the EEC co-operative projects such as Airbus and the Hermes Space Shuttle

Usage (Market segment and penetration)

SET is heavily used within the European aircraft industries but not much outside.

PDES/STEP

Expanded name

Product Data Exchange using STEP/Standard for the Exchange of Product Data

Area covered

STEP is a multi-part standard for the exchange of product model data. The earlier efforts of both the US (IGES, EDIF) and Europa (VDAFS, SET) have provided contributions to the development of STEP. STEP part 46 "Visual Presentation' is of specific significance to this report. It also has been harmonized with the developments in the area of computer graphics standards, e.g. with PHIGS.

Sponsoring body and standard details

- ISO CD 10303
- ISO TC184/SC4
- STEP is the international activity, PDES is the US one
- Work on PDES began 1984 led by NBS, now NIST

Further details available from:

Local national standards organisations

Characteristics/description

PDES and STEP are intended to allow the integration of systems that support design, design analysis, manufacturing, logistics functions and processes, and automatic, paperless updates of system documentation, for example engineering drawings and technical manuals. The geometry model will include solid representations, and related data will include manufacturing features, tolerance specifications, material properties, and surface finish specifications. Initial versions of PDES/STEP will only have functionality equivalent to existing standards such as IGES, with additional functionality to be provided in later versions. This should have advantages in easing migration.

Usage (Market segment and penetration)
STEP is a significant and well structured approach to the area of product model data. The development is not finished yet but it will probably be the main standard in this area of product model data exchange. It is both applicable in mechanical as well as electrical engineering. The reason for my emphasis on this standard development is that it has been developed driven the problems caused by the deficiencies of the earlier approaches, especially by the shortcomings of IGES (Which is currently used in many environments, but mostly only for 2D drawing exchange).

VDAFS

Expanded name
VDA Surface Interface

Sponsoring body and standard details

- Version 1.0 1986 (DIN Standard)
- Version 2.0 1987 (VDA Recommendations)

Usage (Market segment and penetration)
Mostly used in the German automobile industry

Raster graphics

DDES

Expanded name
"Digital Data Exchange Specifications" - first generation

Area covered
Raster image interchange on magnetic tape

Sponsoring body and standard details
The "DDES" Committee became ANSI-accredited as IT8.1, and this work is now carried out at the international level in ISO/TC130/WG2.

Characteristics/description
IT8.1 covers colour picture data
IT8.2 covers colour line-art data
IT8.5 covers monochrome image data.
IT8.3 covers geometric data, and is based on IGES.

All the above are based on the ISO 1001 (ANSI X3.27) standard for Volume and File Structure on Magnetic Tape.

(IT8.4 covers direct connection of a digital colour hardcopy device to an electronic prepress system, and is based on SCSI, not magnetic tape.)

Further details available from:
Local national standards organisations

Usage (Market segment and penetration)
The IT8.1 standard is quite widely implemented. IT8.2 has a number of implementations. Only one or two are believed to exist for IT8.5, and none for IT8.3, whose primary area of application (mask cutters) has more or less ceased to exist, except in Japan.

In general the IT8 standards have been well supported by Crosfield and Dainippon Screen of the "big four" vendors, and by many of the smaller and/or newer entrants to prepress, such as Agfa and Barco.

Compression: IT8.2, IT8.4 and IT8.5 include run-length encoding of the pixels for line-art images.

DDES is a prime example of a standard that, numerically, is widely implemented yet in reality is virtually unused. Because all the major pre-press system vendors have implemented the standard on their platforms there is a high potential for its use in the industry, based on the number of installations. However, the industry has found its use to be impractical and has virtually discarded it. Dissatisfaction with the standard is primarily due to the time it takes to translate between vendor's formats.

Justification for using the high cost, dedicated and largely closed, proprietary pre-press systems has always been their high productivity. Any standard which detracts from that high productivity is bound to fail particularly if there are alternative routes. Developments in the use of PostScript and TIFF, as means of transporting data between independent systems have undermined the need for the DDES standard.

DDES only addresses the medium of magnetic tape. As the use of direct communication, via ISDN lines, is being adopted by pre-press companies both for communication with other stages of production and, more slowly, for communicating with their client base the DDES standard, in its current form, will become obsolete.

Fax groups 3 & 4

Area covered
Bilevel raster image encoding standard

Sponsoring body and standard details
CCITT, Recommendations T.4 and T.6 respectively.

Further details available from:
CCITT (Comité Consultatif Internationale des Téléphones et Télégraphes
International Telecommunications Union (ITU)
Place des Nations
CH-1211
Geneva 20
Switzerland

Characteristics/description
Lossless compression based on run-length and Huffman encoding. Group 3 is 1-dimensional (compression within the line only) and is used in current fax machines on the public telephone network. Group 4 uses 2-dimensional compression (within the line and from

line to line) and will be available on fax machines for the ISDN network.

Usage (Market segment and penetration)
Also used for some document processing (archive and retrieval) applications.
TIFF "Class F" uses the fax encoding.

Fractal Transform coding

Area covered
Raster image compression method - see appendix (1)

Sponsoring body and standard details
Fractal Transform coding is a patented approach to image compression developed by Iterated Systems, Inc. in Norcross, Georgia, USA. Technical details of the compression method are not available publicly.

Further details available from:
Iterated Systems Ltd (European subsidiary)
Wyvols Court
Swallowfield
Nr Reading RG7 1PY
United Kingdom

Usage (Market segment and penetration)
Compression is much slower and more computationally intensive than decompression. This defines the applications, for which Fractal Transform coding is suitable, as offline rather than real-time.

Iterated Systems have a range of products available, including hardware-assisted compressors, software-only decompressors, and links into third-party DTP products and subroutine libraries.

Microsoft, under license, have used Fractal Transform coding for their recently released "Encarta" CD-ROM multimedia product.

Available in Europe from April 1993, Encarta is a 28 volume encyclopaedia containing text, animations, maps, drawings and graphs, audio and 7000 fractally compressed photographic images.

GIF

Expanded name
"Graphic Interchange Format".

Area covered
Raster image file format.

Sponsoring body and standard details
"Owned" by CompuServe Inc, but royalty-free limited-use licence available.

Further details available from:
Compuserve Incorporated
5000 Arligton Center Boulevard
Columbus Ohio 43220
USA

Characteristics/description
GIF (Graphics Interchange Format) from CompuServe has been developed solely for format transfer, irrespective of the system. A GIF graphic is stored as a sequence of pixels with RGB colour values. The position of individual pixels does not have to be indicated separately, since they are stored sequentially from top left to bottom right. All GIF files start with a signature (version number etc.). This is followed by the screen definition and the global colour scale of the GIF-generated hardware. Image definition, local colour scale and raster data follow. The raster data is compressed according to the LZW algorithm.

GIF files can hold multiple images, so that several definitions (and also raster data) follow one another in the file. Although it has a binary structure, GIF is used on various operating systems.

Usage (Market segment and penetration)
Particularly used for e-mail of images for viewing, on screen, over both the CompuServe and Usenet networks. The format is widely supported by many applications for image access/import.

IPI-IIF

Expanded Name
"Image Processing and Interchange : Image Interchange Facility"

Area covered
Data format and gateway functionality for raster image interchange

Sponsoring body and standard details
- ISO/IEC JTC1/SC24
- ISO/IEC DIS 12087 (comments due in June 1993)

Further details available from:
Local national standards organisations

Characteristics/description

IPI is a three part standard.

Part 1 provides a platform independent architecture and a set of common image-related data types, operations, etc.

Part 2 provides an API for a useful set of image processing primitives thus providing portability.

Part 3 provides an image interchange format richer than either CGM or any de facto format, like TIFF. It provides transparent data exchange.

The data format goes beyond the capabilities of TIFF by allowing more than two dimensions (eg xyzt) for the "sampling space". The descriptors are encoded in the ISO standard ASN.1 notation, which allows additional flexibility by a context-sensitive approach, and allows complex image data structures to be described and manipulated.

The gateway functions define the parameters for access to and manipulation of the image data structures.

Usage (Market segment and penetration)

IPI is a standard still under development. It is a very generic image standard in that the underlying image model is very broad.

Commercial implementations are not yet available, as the standard is only now becoming stable. A consortium which was planned to develop a general implementation failed to be established because of the difficulty in attracting funding in the current economic climate.

Images in IPI are not merely 2D, they can have up to five dimensions allowing to include both time varying images as well as multi-channel images (eg geo-sciences, fluid now, medical imaging), where there is currently no widely-used inter-disciplinary standard format: however, it is not clear whether it will displace TIFF for two-dimensional graphics images. With the addition of profiles for specific application areas this standard will provide a very good basis for future image based applications.

JBIG

Expanded name

"Joint Bilevel Image Group"

Area covered

Bilevel raster image encoding standard

Sponsoring body and standard details

Jointly "owned" by the CCITT and ISO/IEC JTCI/SC29 (ISO/IEC DIS 11544, CCITT T.82)

Further details available from:

Local national standards organisations

Characteristics/description

Lossless compression using predictor methods. More complex but more effective than the fax algorithms.

Usage (Market segment and penetration)

No values for compression ratios to hand, but assuming that it is comparable with proprietary schemes, I would expect from 3:1 to 10:1 on screened halftone data, and rather better on less "busy" images, eg line art.

JPEG and JFIF

Expanded name

"Joint Photographic Expert Group" - see appendix (1)

Area covered

"Photographic" raster image compression standard

Sponsoring body and standard details

Jointly "owned" by CCITT and ISO/IEC JTCI/SC29 (ISO/IEC DIS 10918-1, CCITT T.81).

Further details available from:
Local national standards organisations

Characteristics/description
For compression of monochrome or full-colour "grey-scale" images. Options within the standard:
- lossy vs lossless algorithm
- Huffman or arithmetic coding

The "baseline" version uses the lossy algorithm with Huffman encoding. Typical compression ratios: for the lossless algorithm up to 2:1; for the lossy algorithm, 8:1 for printed material, 30:1 for monitor displays. Sharp edges, as found particularly in synthetic images, lead to either poorer compression ratios or the appearance of artefacts in the image.

The JPEG standard only defines the bitstream of the encoded compressed image data, as it would be sent down the communication line in the originally envisaged primary application of photovideotext. For data processing purposes, the bitstream needs to be encapsulated within a file format, with some additional "header" information to provide a context for the reconstituted stream of pixels (eg how many rows of how many columns make up the given area). There are two "standardised" formats. At present the JFIF (JPEG File Interchange Format) defined by C-Cube is probably the most widely used, but TIFF 6.0 also includes fields (tags) to give JPEG capabilities, and the TIFF encapsulation of JPEG may gain the wider acceptance in the longer term.

Usage (Market segment and penetration)
Many implementations available, both hardware and software based, including a "free" software version. The algorithm is being included in a number of DTP packages which handle images.

Photo-CD

Expanded name
Photo Compact Disk

Area covered
Raster images

Sponsoring body and standard details
Kodak - proprietary standard

Further details available from:
Kodak Limited
Research & Development
Headstone Drive
Harrow Middlesex HA1 4TY
United Kingdom

Characteristics/description
Photo CD was introduced by Kodak as a means of storing on CDROM discs, high quality digital colour images captured from film. Each Photo CD disc can hold around one hundred 35mm images film. The technology was originally aimed at consumers although the target audience is about to be broadened to include the professional market. The consumer is able to display photographs on TVs using either a Photo CD player or a Philips CD-I system. Images may be selected for reprint or enlargement and images may be manipulated from PC and Macintosh systems equipped with a Photo CD-capable drive and the appropriate software.

Usage (Market segment and penetration)
Kodak's goals with this technology are:

- to make digital images are accessible to all
- to maximise quality
- to keep production costs low
- to provide image resolutions which match a wide range of user requirements.

Technical

The Kodak Photo CD Imaging Workstation is a set of products that scans film images, writes them to Photo CD discs, and prints them. The workstation includes:

- the Kodak Photo CD Scanner
- the Data Manager, a computer workstation used to check if adjust (if needed) scanned images before transferring them to Photo CD discs.
- the Kodak PCD Writer, which writes images to a Photo CD disc
- a printer which creates index prints and high-quality pictures from images stored on Photo CD discs.
- the Kodak PCD CD-ROM Drive, which reads Photo CD discs both when making prints and enlargements and when copying images from one disc to another.

Scanning

The key component of the system is the scanner. It is the speed and quality with which it can scan images that makes the whole Photo CD process viable.

The PCD Scanner scans 35mm film and produces an 8-bit (reduced from 12 bit) RGB digital image with a resolution of 2048 lines by 3072 pixels. This represents 18Mb of data per image. Since only 30 images could be stored on a single CD disc at this resolution the images are reduced by the PCD Data Manager by converting them from RGB to Photo YCC format, a proprietary Kodak format, and by compressing the images using a Huffman Encoding algorithm.

Scans are carried out in 6 seconds, which comprises 1s for a preview scan and 5 seconds for the full scan. The PCD Data Manager (a Sun Sparcstation II) automatically adjusts each image for exposure variations, lighting conditions and the make and type of film. The operator is able to view 6 images at a time at the Data Manager. Images taken in portrait mode can be flagged for rotation at this point. Images which are not wanted can be discarded.

Formats

Each image is written to a CD in an Image Pac file. These Image Pac files contain the image at five different resolutions. The range of resolutions is designed to cater for most possible requirements for the image, the two lowest providing thumbnail versions of the image (lowest being 128 by 192 pixels) and the 18Mb providing the amount of data required for top quality thermal printing etc. Between these two extremes are the TV resolution option and the higher resolution HDTV option. Kodak regard this HDTV option as future proofing the system. Both the HDTV and 18Mb options are Huffman encoded, the other three resolution images are uncompressed. These decomposition and compression techniques make it possible to store approximately 100 images on a Photo CD disc.

Writing the images

The Data manager writes the Image Pac file to the CD disc and also a copy of the lowest resolution image to an Overview Pac, which acts as a table of contents to the disc. This Overview Pac is printed giving an index of all the images on the disc and included with the disc returned to the customer.

Writing an image to a CD disc takes 20-22s, which is longer than the scanning time. Images are buffered prior to writing to help prevent a bottle neck. Kodak have also designed Photo CD Imaging Workstations with multiple writers (up to six) to cope with this problem.

Platforms

TV

The original intended platform for Photo CD was the television, the product being aimed directly at he home consumer.

Computer

In order for Photo CDs to be accessible through standard computer platforms, PC and Macintosh, it is necessary for CD ROM drives to be able to read the photo CD format. To this end

Kodak have been working with hardware vendors and peripheral manufacturers such as Apple, Sony, Philips, Toshiba, Pioneer.

The Photo CD Access Toolkit is available for software developers. They can use this to make the necessary enhancements to allow their products to access Photo Cd images. It comprises a library of C programming language functions.

In order to allow users to access Photo CD images using their Macintosh and Macintosh CD ROM drive, Kodak will supply Photo CD Access Software for £35. However, as noted in section x below (Using the Photo CD technology - feedback) the combination of Macintosh and Macintosh CD ROM drive is the only one that Kodak currently guarantee will work.

CD-I

Photo CD images are currently accessible by CD-I, but a format conversion from Kodak YCC to CD-I is required. This currently takes around 15s; Philips are working to reduce this to 5s.

Future Developments

New disc formats

Pro Master Disc

Kodak plan to continue developing the Photo CD concept. Several new formats of the CD disc will be announced in 1993.

One format will be designed to cater for the professional user. A new multi-format scanner will be available which can take 120mm film and a variety of other sizes including 6"x7", 6"x8", 6"x9". The Kodak Pro Photo CD Master Disc will store images scanned at resolutions of 4k x 6k, which will occupy 72Mb of disc space. Scanning time for these images will be around 90s. It will only be possible to store approximately 25 images on a disc. For security, encryption of the image will be possible on the pro Master Disc. The user may manipulate and write back the image to the disc, but will need the appropriate Kodak hardware in order to do this.

Portfolio Disc

Also in 1993 is planned the option to allow users, by means of an authoring package, to write off low-resolution images to create a Portfolio Disc. It will be possible to write up to 800 images per disc. Sound and text can also be added, making this a multimedia facility.

Catalogue Disc

A Catalogue Disc format will allow 6-12 thousand images/disc. Software will be embedded to allow the user to browse through the collection of images on the disc.

These additional formats add new functionality to the Photo CD product. There is a danger, however, that the introduction of these multiple disc formats will damage Photo CDs reputation in the marketplace, as users become confused by the variety of formats and the requirement for different software and configurations to access each one.

New products

PhotoEdge - Image Enhancement Software

Kodak are planning the release of the product PhotoEdge in 1993. This will be an image enhancement package. The functionality will be very much more limited than products such as PhotoShop; the aim is to allow manipulation of the whole image for characteristics such as contrast and colour.

Renaissance - Software for Graphic Designers

This software, developed by Atex, was retained by Kodak following the recent sale of Atex. It enables Mac imaging on the PC.

Shoebox - Image Organiser

Due for release in mid 1993, this product will have versions which run on the Macintosh and PC. Shoebox is in essence image database software. It will allow images to be organised for searching and sorting. It will allow multiple images to be displayed at once, and keywords and text to be assigned to images for example.

Kodak are also planning a jukebox with a capacity of 100 CD discs (each containing 100 images) to be available in mid 1993. They say it will be possible to link up to five of these jukeboxes together. The thumbnail images will provide a means of searching amongst such a collection of Photo CDs.

Image libraries have shown great interest in Photo CD and the Shoebox product may offer them an initial application that could be useful for organising their collections of images.

Kodak Picture Exchange

The Photo CD initiative is regarded as so significant at Kodak that they are planning to branch into an area quite outside their normal line of activities. They have plans to set up as publishers themselves and act as image brokers providing a link between image providers (photo agencies, publishers, museums) and users of images (designers and art directors, publishers, corporate image users). They envisage Photo CD being the medium in which the images are held and exchanged. Kodak would be placed in the role of significant telecommunications, database and service managers.

Kodak are planning to trial the concept in the US in 1993, followed by Europe in early 1994.

TIFF

Expanded name

"Tag Image File Format"

Area covered

Raster image file format

Sponsoring body and standard details

Under the benevolent development of Aldus Corporation and Microsoft: a version is also being formally standardised by the ANSI IT8 and ISO/TC130 Committees

Further details available from:

Aldus Europe Ltd
Craigcook Castle
Craigcook Road
Edinburgh
Scotland EH4 3UH
United Kingdom

Alternatively:
Aldus Corporation
411 First Avenue South
Seattle
Washington 98104 USA

Characteristics/description

Defines a tag-based file descriptor that can characterise almost any form of 2D raster data. "Private" tags may be obtained to allow additional parameters to be added to the descriptor.

Usage (Market segment and penetration)

Very widely implemented in DTP and desktop applications. TIFF is used not only by scanners as a digital image interchange format but has also been adopted by some application developers as a memory format. It has been adopted as the image file interface between DTP and high-end applications.

The wide variation between requirements for different applications has led to partial implementations, in which valid files cannot be read. This situation is being addressed by the TC130 activity, which aims to standardise the TIFF subset required for Graphic Technology applications.

"Standard" TIFF allows the use of PackBits, LZW, Fax and JPEG compression schemes.

TIFF/IT

Expanded name

TIFF for Image Technology

Area covered

Raster Image file format

Sponsoring body and standard details

A first version is being prepared by ANSI IT8 and will be the IT8.8 standard. Parallel work is being done in ISO/TC130/WG2.

Further details available from:

Local national standards organisations

Characteristics/description

TIFF/IT forms a "second-generation" standard, to fulfil three purposes:

- provide the functionality of IT8.1, 2 and 5 to other media than magnetic tape
- provide a data format for "high resolution edge" information
- provide a format standard for the subset of TIFF which is appropriate for prepress applications.

It is specifically designed so that any fields additional to TIFF 6.0 take default values equivalent to TIFF 6.0 practice, so that existing implementations, such as Photoshop, should already be compatible with it.

Usage (Market segment and penetration)

Currently in ANSI public review: not yet in Committee Draft at ISO (note: the ISO "fast track" procedure will not be used in this case, so that other national comments, particularly from Japan, can be addressed).

It is intended that the TIFF/IT (IT.8) standard will reduce the variation between TIFF implementations which has led to a reputation of valid TIFF files often being unreadable from application to application.

Document/metafile

Acrobat (Carousel)

Area covered

Page description language. Subset of Postscript

Sponsoring body and standard details

Adobe Systems Inc - proprietary standard, due for release early 1993

Further details available from:

Adobe Systems Europe BV
Office Centre
Jozef Israëlskade 48c
1072 SB Amsterdam
The Netherlands

Characteristics/description

Acrobat (previously known as CAROUSEL) is a development of the Adobe company. Acrobat is based on what Adobe term a Portable Document Format (PDF), which remains close to Postscript but has a range of compression options available to reduce file sizes. It is currently a fixed page format, but there is the possibility of a revisable form at a later stage. Also the ability to include video and audio inserts may be included at a later date. Various 'byte accelerator' techniques have been included in the format so that searching for words and phrases is fast. Key features in PDF are a set of 'hot links', 'thumbnail' icons of pages, chapter outlines and page annotations.

The 'chapter outlines' feature enables information to be added to a text eg summaries, indexing information. The thumbnail icons for the document pages facilitate fast browsing and random access. Page annotations act as electronic Post-Its and are user specific; they are not integrated within the document.

PDF has a set of markers for these hyperfacilities, which can either be added to existing Postscript or passed down from 'front-end' text-processing packages into the final Postscript.

Acrobat Distiller

The conversion from Postscript to PDF is carried out by the Distiller program which is part of the Acrobat suite of software. Existing hyperfacility markers are converted during the conversion process. Alternatively hyperfacility markers can be added manually during the distillation process from Acrobat viewers (see Viewers below). A reverse process will enable printable Postscript to be recovered from PDF. The problems for the Distiller program is that it must be able to take any legal Postscript, at Level 1 or Level 2, and distil it to PDF which will be acceptable to all Acrobat viewers on all supported platforms.

Acrobat Viewers

Acrobat viewer software allows the user to view distilled Acrobat pages on a platform of his choice. Functionality of the viewer includes, panning, zooming, scrolling, skip pages and navigating around the document. Existing hyperfacility markers will be interpreted and can also be inserted by the user if required.

Adobe plan viewer software for all the popular hardware platforms. It will be possible to print out all or part of a document to a Postscript printer.

Production issues

A future release of Distiller will be a 'publisher's version' containing some automatic indexing and linking tools. Optimum use of Acrobat will be achieved by creating the hypertextual links in the original document and passing these down into the final Acrobat form. This will be assisted if future versions of popular DTP packages are made Acrobat-friendly and if they are enhanced to produce PDF output. The extent to which suppliers take up this challenge will determine the extent to which Acrobat becomes a useful interchange standard for formatted data. As with PostScript, Adobe say they intend to release full details of the

Acrobat format; this should enable third parties to produce cloned versions of Acrobat viewers.

Fonts

A key difficulty for Acrobat to overcome in the electronic distribution of a formatted document is the availability of screen fonts at the receiving workstation to match those in the document.

One solution is to distribute the screen fonts with the document, but this can potentially lead to problems with copyright. Alternatively the screen and printer fonts that a document needs can be bundled into the PostScript for the document itself, but this can lead to very large files.

Adobe have employed their Multiple Master Font technology as the solution within Acrobat. Font characters from a generic font are fitted on the fly to the font metrics of the original font used for any fonts which are not available (either not at the receiving workstation or not available for copyright reasons).

Usage (Market segment and penetration)

Acrobat and SGML could evolve as mutually supportive, with Acrobat giving SGML additional impetus if it becomes successful. The hypertextual possibilities within Acrobat are related to the structure of a document. Automated production of Acrobat hyperlink codes would follow more naturally from data structured using SGML and a Document Type Definition.

Adobe's Acrobat initiative must be taken seriously at this stage, given PostScript's dominant market position and given that Acrobat is in essence a subset of PostScript and the priority Adobe are giving it in their strategic plans. Adobe would like to establish Acrobat as the document interchange standard for the future. They would like to see Acrobat viewers becoming a standard feature of every workstation. As well as being a multimedia publishing format, Adobe see Acrobat as central to the future of office technology

HyTime

Expanded name

Hypermedia/Time-based Document Structuring Language

Area covered

'Hyperdocuments' that link and synchronise static and time-based information

Sponsoring body and standard details

- ISO
- IS 10744 1992

Further details available from:

Local national standards organisations

Characteristics/description

HyTime is an SGML application that provides a "description language" for representation of hypertext links, time scheduling and synchronisation in multimedia documents which, are among the significant aspects of hypermedia that are not covered by existing standards. In keeping with the character of SGML itself, it seeks to standardise as much as necessary and as little as possible: the emphasis is on identifying objects and providing addressing mechanisms and not on establishing particular systems or policies for developers or users. HyTime is independent of basic media content notations, of link types, processing and presentation semantics.

Usage (Market segment and penetration)

The standard has been published for a year and there is much interest in Hytime across a broad market spectrum. Applications of Hytime are not yet available and it is likely to take time for there to be so. This is partly a consequence of the complexity and broad scope of the standard. As a result of the separable structure of the standard, it is likely that 'Hytime engines' will tend to concentrate on specific aspects of the standard as opposed to providing full coverage of all possible functionality allowed for. This may lead to different 'Hytime engines' gaining penetration in differing markets.

IPTC IIM

Expanded name
"International Press Telecommunications Council Information Interchange Model"

Area covered
Tagged envelope structure for carrying image files

Sponsoring body and standard details
Developed by the IPTC, whose members are news agencies and digital wirephoto services, and their customers

Further details available from:
International Press Telecommunications Council
8 Sheet Street
Windsor
Berkshire SL4 1BG
United Kingdom

Characteristics/description
Provides a mechanism for carrying either raw pixel data, or standardised or proprietary data formats from a registered list, and supplying the additional descriptive data necessary for the distribution and use of the images in newspaper production environments

Usage (Market segment and penetration)
This format is being implemented by the majority of newsphoto service providers as they replace their analogue services with digital ones.

ODA

Expanded name
Office Document Architecture and Interchange Format

Area covered

Document structuring

Sponsoring body and standard details

- ISO/IEC
- IS 8613

Further details available from:

Local national standards organisations

Characteristics/description

ODA is a multi-part international standard. It defines an architecture for office documents that describes a document in terms of its content and two hierarchical structures: logical structure and layout structure. It defines a method for describing key characteristics of a document in a document profile that can be interchanged in advance of the document itself. It also defines two encodings of this architecture for document interchange: one using ASN.1, and a second using SGML.

The eight parts published to date are:

- Introduction and general principles
- Document structures
- *(Left for future instructions)*
- Document profile
- Office document interchange format (ODIF)
- Character content architecture
- Raster graphics content architecture
- Geometric graphics content architecture

Usage (Market segment and penetration)

The document structure adopted by ODA is more than adequate for office and business correspondence, and sufficient for "content-driven" publications such as books, (learned) journals, reports, "serious" magazines and newspapers, etc, where the design is based on rectangles. However, it is not currently adequate to cover "layout-driven" publications such as modern catalogues and brochures, "tabloid" newspapers and magazines, etc, where irregular and "diagonal" layouts are often used.

The 1989 version of ODA makes use of the 1987 release of CGM (Computer Graphics Metafile) as a means of incorporating geometric graphics. It is intended that the 1993 release of ODA will make use of an amendment to the 1993 release of CGM.

For the time being, only one of the CGM encodings, the binary one is used within ODA. The amendment will allow all three encodings.

There is the ability within ODA to change some of the presentation attributes of the graphics which are incorporated. The dimensions can be altered and the orientation of graphics can be changed, although only through integral steps of 90 degrees ie 90, 180, 270 and 360. Clipping is available as a functionality.

Defaults are defined within CGM for attributes such as line type and line colour. It is possible within ODA to carry out some factorisation of the defaults eg make all the lines within a graphic a specific colour with one global change of the default line colour.

Current version of ODA allows for the inclusion of one picture within a metafile.

Raster graphics can also be included within an ODA file. As with the geometric graphics of CGM, attributes can be changed. They are similar; picture dimension, orientation, clipping. Fax group 3 and group 4 encodings can be included in ODA files as well as bitmaps. ODA is restricted to handling rectangular areas for incorporating graphics.

In the currently available 1989 version of ODA, pixels only have two states, set and not set. The new 1993 version will incorporate the ability to include coloured raster graphics.

The concept of tiled raster graphics will be included in the 1993 release. This aims to deal with the limitation that graphics such as fax encodings have defined size limits in terms of pixels/line and lines/picture. The extension to the raster functionality will allow a two-dimensional array of tiles, to be used to form larger pictures.

There is some discussion regarding the use of the IIF (Image Interchange Format) within ODA. IIF is basically an 'umbrella' standard above several different existing image standards including JBIG, JPEG and MPEG. A major aim of IIF is to include still and moving images; existing vector graphics standards could simply have been extended if the aim had been only to encompass still images. IIF includes the concept of two dimensional and three dimensional images; the third dimension can be the temporal one which comes into play for the moving image standards.

OPI

Expanded name
"Open Prepress Interface"

Area covered
PostScript language comment conventions for placement of publication-quality, separated images

Sponsoring body and standard details
Specification owned by Aldus Corporation

Further details available from:
Aldus Europe Ltd
Craigcook Castle
Craigcook Road
Edinburgh
Scotland EH4 3UH
United Kingdom

Alternatively:
Aldus Corporation
411 First Avenue South
Seattle
Washington 98104 USA

Characteristics/description
Allows the placement of image file separations to be carried out in either a PostScript or a non-PostScript environment, allowing traditional prepress systems to be used with DTP "front-ends".

The Open Prepress Interface (OPI) is a set of PostScript language comment conventions that allow prepress systems to incorporate high-resolution colour images into publications produced with a page layout program. OPI provides end-users with an effective way to send information from personal computer page layout software to colour prepress systems.

To use OPI, the end-user, who is now a prepress customer, prepares a PostScript file that includes OPI comments. The prepress system then processes this stream by extracting the raster image layout information.

Although OPI was primarily intended to be used to communicate with dedicated high-end colour prepress systems, it can also be used with separation programs running on desk top computers.

In a typical high-end scenario, the prepress customer takes original photographs to a colour prepress vendor before creating the publication in which the photographs will be placed. The prepress vendor creates two versions of each scanned image: a high-resolution version, which is stored on disk or tape, and a lower resolution colour Tag Image File Format (TIFF) version, which is sent to the customer.

The prepress customer places the TIFF files into the publication, using DTP software to size, position, and crop the image as needed. OPI compatible software includes special PostScript language comments to specify each image's filename and positioning, as well as any size and cropping adjustments. The prepress system will use these comments to plan the high-resolution images into the publication at the correct size and position.

Usage (Market segment and penetration)

As it is vendor specific its market penetration is governed by the success of the supporting companies. The most common examples of its commercial application can be found in newspapers and magazines.

PIM/PIL

Expanded name

Page Imaging Model/Publishers' Interchange Language

Area covered

An editable page description language

Sponsoring body and standard details

Being developed by IT8/SC1, to which the PPISC (originators of PIL) has become a Working Group, as the IT8.9 standard

Further details available from:

Local national standards organisations

Characteristics/description

The need for a "revisable-form" page description language, which addresses graphic arts prepress practices but is fully editable on receipt, has long been felt. IT8 has been working on this for some time, and when it became clear that Adobe's promise of an "Interchange PostScript" would not materialise in the short term, the work continued. IT8's weakness in text handling was recently addressed by the addition of the PPISC group. A PostScript-like encoding has been adopted for the forthcoming IT8.9 standard.

Usage (Market segment and penetration)

PIL is out for ANSI public review, on the way to becoming IT8.9 part 1. PIM is set to become a functional superset of PIL with a PostScript-like encoding, and will be submitted for pubic review at IT8.9 part 2 later this year. The PIM (IT8.9 part 2) activity aims to provide true editability of page plans, and to be displayable in simplified form on a standard PostScript device, but will not be a full implementation of PostScript.

Postscript (Levels 1,2)

Area covered
Vector and Raster graphics

Sponsoring body and standard details
Adobe Systems Inc - de facto standard
First release Level 1 1985
Level 2 1990

Further details available from:
Aldus Europe Ltd
Craigcook Castle
Craigcook Road
Edinburgh
Scotland EH4 3UH
United Kingdom

Alternatively:
Aldus Corporation
411 First Avenue South
Seattle
Washington 98104 USA

Characteristics/description
Postscript can be considered from several points of view

- general-purpose programming language with powerful built-in graphics primitives
- page-description language that includes programming features
- interactive system for controlling raster output devices (displays and printers)
- under restricted conditions an interchange format. An arbitrary PostScript file cannot be known to be editable on receipt, though it is possible if enough restrictions are placed on the originator of the file.

Postscript's most obvious language features are that it is an interpreted language, it is stack-based, and it is heavily oriented toward graphics and typography. This design makes it useful as a device-independent page description language for imaging on raster devices. The language evolved from a printer control language into a communications medium on host computers. It is a hybrid between high-level and low-level languages. It is high-level in the sense that there are individual operators that encompass very powerful functionality, whereas manipulation of objects on the operand stack more closely resembles assembly-language programming.

In addition to unifying all previous language extensions, Postscript Level 2 introduced a number of new language features. These include functionality related to dictionaries, memory management, images, resources, filters, binary encoding, user paths, forms, colour spaces, CIE-based colour spaces and patterns.

The imaging model has later content totally replacing earlier content pixel-by-pixel, and so more sophisticated operations, such as image merge, cannot be expressed in standard PostScript alone. The NeXT extensions to PostScript address this, but are not widely implemented. Similar extensions are planned in PIM, and where the primary requirement is an interchange format, PIM should be considered.

Usage (Market segment and penetration)
Since its release in 1985 Postscript has found great market penetration as an interactive system for controlling raster output devices (particularly printers but also to a much lesser extent displays). In particular its use with printers in the office market is huge. It has been far less popular as a general-purpose programming language for end users in its own right. Environments such as the Sun Unix NeWS Server make use of it in this way but despite advantages have not become dominant.

Problems of lack of performance have prevented Postscript having a significant impact in the area of screen displays. Ever increasing processing power is likely to lead to increasing use of Postscript for this purpose, which in turn may support its use as a programming language. Until recently, the Postscript interpretation has tended to be a major bottleneck in the output chain involving high resolution output devices. Recent improvements in performance in software drivers for Postscript are bringing about a situation where this is no longer the case. These are likely to lead to increased market penetration by Postscript.

Quicktime

Area covered
Addition of time-based functionality to Apple operating system

Sponsoring body and standard details
Apple Computers - proprietary standard

Further details available from:
Apple Computer Europe
Le Wilson 2
Cedex 60
92058 Paris la Defense
France

Alternatively:
Apple Computer Inc
10201 North De Anza Boulevard
MS:23AQ Cupertino
California 95014
USA

Characteristics/description
Quicktime is an operating system extension for the Apple computer that retrofits low resolution video onto the desktop. Quicktime use requires three elements: an operating system extension (Quicktime Extension), a data object (in the MooV format), and a player or application program (eg Apple's Simple

Player). Quicktime is different from other recent moving picture formats, including MacroMind Director and HyperCard, in that it neither flips cards nor moves sprites. It involves not so much adding video as adding the notion of time into the operating system. The QuickTime clock determines the right video frame to display at the right time, and it can also orchestrate a sound mixer, a lighting board, or other real-world device that needs to be triggered by time cues.

Usage (Market segment and penetration)
Quicktime's market segment is largely that section of the Macintosh user community with a particular interest in multimedia. It is not clear that its penetration has yet become as large as might have been expected. There has been some user hesitation over certain areas of the functionality, for instance the video performance, quality and size of display window. The market appears to be waiting for these obstacles to be overcome.

SGML

Expanded name
Standard Generalized Markup Language

Area covered
Document structuring

Sponsoring body and standard details

- ISO
- IS 8879

Further details available from:
Local national standards organisations

Characteristics/description
This standard defines an object-oriented method for describing documents (and other information objects with appropriate characteristics).
The standard is essentially in two parts. The first defines a model for document description, a set of semantics, limited to what is

necessary for the model, and an abstract method of coding (syntax). The second part of the standard defines a specific (concrete) syntax, using a subset of the repertoire of ISO 646 for text and markup encoding.

Usage (Market segment and penetration)

SGML and images

Non-SGML Data

SGML recognises that users will want to include non-SGML data within SGML coded data and provides several mechanisms for doing this. Non-SGML data is data that is not parsable in accordance with the SGML standard. It is either data in an undefined character set, bit data, or some mix of the two. In undefined character set data, the bit combinations represent characters, but not in the document character set. In bit data, the bit combinations, although they can be managed as characters, do not represent a character repertoire in the usual way.

As non-SGML data cannot be scanned by the markup parser, and may contain bit combinations that could, for example, erroneously cause the operating system to terminate the file, it must be stored in an external entity. Its location is made known to the parser by an entity declaration.

Data Content Notations

Use of the data content notation is one method of attaching image data to SGML formatted data. The difference between one type of non-SGML data and another is indicated using the data content notation which the standard provides. SGML itself does nothing with notation declarations and does not understand the syntax; they are present just to register the fact that they are being used. However knowing the notation enables any SGML application processing the data, to pass the content of the element concerned to the correct parser for the data concerned. In other words, the actual meaning of what is in an element declared to have a data content notation, is entirely application dependent and not standardised at all within SGML itself.

Entity References

Another method is to include an image in an element declaration as an entity reference. The parser will look at the entity declaration as it processes the data. However it is not possible using this method, to include any information about the graphics in the SGML file, such as the size, where to position it on the page, what type of image it is. However, by defining an element and attaching attributes to it this sort of information can be included in the SGML file. Again there is no standard for interpreting the semantics of these attributes within SGML itself and any interpretation is application dependent.

Internal coding

SGML is a language for coding hierarchical structures and so can in practise be used to code up any hierarchically structured data internally. For instance it would be possible to recode the grammar of CGM using the syntax of SGML. Then exactly the same information as is available in CGM would be available in SGML coded format. Equally the same could be done with other graphics languages that are based on a hierarchical structure.

Advantages to such an approach have been suggested. These include:

- full hypertext linking into and out of the graphics is enabled using exactly the markup methods and processing used for text elements.
- translation of text in graphics is enabled using the same tools and techniques used to translate text.
- the markup specifically enables re-use of graphic objects.
- independence of graphic specification from presentation systems.

Even a bitmap could in theory be coded as a cleartext encoding, by defining the number of scan lines, number of pixels per line etc. Such an encoding would be incredibly verbose and impractical. The question of efficiency regarding the encoding of formats at the level of CGM is also key. It is probably best to use an efficient coding for the graphic itself and include it as an entity in the SGML file.

Usage (Market segment and penetration)
SGML has made its principal impact in markets making use of structured texual (as opposed to graphical) information. This has particularly included those markets managing and producing technical documentation, although not exclusively so. SGML has been given significant impetus by its adoption within large initiatives such as the US Defense Department's CALS initiative and its adoption within the FORMEX standard of the Office of Official Publications of the European Community. Its take up elsewhere has been slow but steady. It is to be expected that the arrival of the Hytime and eventually DSSSL standards will increase SGML's market penetration.

SPDL

Expanded name
Standard Page Description Language

Area covered
Vector and Raster graphics

Sponsoring body and standard details

- ISO/IEC
- DIS

Further details available from:
Local national standards organisations

Characteristics/description
SPDL has its origins in the desire to provide a complete set of standard interchange languages for all stages of the traditional publishing process. SGML provides the language for use in interchange at the authoring and editorial stages. DSSSL provides the language for specifying to the typesetter (formatter) how the document is to be composed and presented. SPDL provides the

language that enables the style and layout decisions of the formatter to be realised on a variety of imaging surfaces (screen, paper, film, etc).

The issue of the establishment of conformance criteria is, of course, one of the reasons for the development of an agreed International Standard. One of the benefits of SPDL, which looks set to be an international reference version of the PostScript language, should be that it will set a standard against which conformance can be tested. As a result, interchange using the language will, at some defined level of functionality in the language, be reliable.

Usage (Market segment and penetration)
The new SPDL standard, being effectively an international reference version of Postscript is likely to benefit greatly from the already significant presence of Postscript across a large range of markets. In providing an ability to carry out conformance testing, this is likely to be welcomed and may lead to use as an interchange language on a scale that has not been seen with Postscript to date.

Miscellaneous

ACR-NEMA

Expanded name
The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) Standard for digital imaging and communications in medicine.

Area covered
Medical data processing.

Sponsoring body and standard details
American College of Radiology and the National Electrical
Manufacturers Association
Version 1 - 1985
Version 2 - 1988
Version 3 - DICOM .

Further details available from:
American College of Radiology
1891 Preston White Drive
Reston
VA 22091 Virginia
USA

Characteristics/description

Version 1 specified a hardware interface, a data dictionary and a set of commands. It supported only point-to-point message transmission.

Version 2, published three years after version 1, was developed as a result of practical trials, and devices which conform to the revision are widely available.

In version 3 - the DICOM Standard - the incorporation of an object oriented data model and the addition of support for ISO Standard communications substantially broadened the scope of the standard. The draft of the standard was composed of 9 parts.

Part 1: Introduction and Overview
Introduction, history and future directions; goals, rationale, and technical description of the parts of the standard.

Part 2: Conformance
Requirements for functional, messaging, encoding, and network conformance; structure of a conformance claim.

Part 3: Information Objects
The set of information objects referenced in service class specifications, attribute list, and semantics of definitions.

Part 4: Service Classes
Semantics of a command as applied to a data set in a given context. Definition of the object attributes required for a given transaction.

Part 5: Data Interchange Formats
Details of data structure and semantics, syntax, usage, compounding of data sets, and basic and advanced functions.

Part 6: Data Dictionary
Attributes of information objects classified by group and element number, name, and parameters; description of permitted values.

Part 7: Message Exchange Protocol
Examples of command exchanges in both point-to-point and ISO contexts, protocol for command encoding and status indication.

Part 8: Network Interface
Definition of a generic upper-layer service common to both OSI and TCP-IP environments, supporting standard networks.

Part 9: Point-to-Point Interface
Definition of 50-pin interface, physical protocol, data link frame protocol, virtual channels, and session layer services.

Usage (Market segment and penetration)
The ACR-NEMA (DICOM) standard is specific to the medical field and, it can be argued, limited to the US.

Source: *The ACR-NEMA DICOM Standard: W. Dean Bidgood, Jr. and Steven C Horil*

CGI

Expanded name
Computer Graphics Interface

Area covered

Vector graphics

Sponsoring body and standard details

- ISO/IEC
- DIS 1990

Further details available from:

Local national standards organisations

Characteristics/description

- Device interface (as opposed to programmer interface)
- Functionality defined in such a way that CGI can be used as a workstation within a graphical system such as GKS.

Usage (Market segment and penetration)

The language bindings of CGI are still not yet formally standardised, though they are doubtless quite widely used.

Colour spaces

Expanded name

Colour spaces, calibrated colour, and IT8.7

Area covered

The IPI-CAI Common Architecture for Imaging Draft International Standard identifies the following colour spaces or parameterisations:

- standardised :	- CIE:	XYZ
		Yxy
		UVW
		Yuv
		L*a*b*
		L*u*v*
	- Linear RGB :	NTSC
		EBU
		SMPTE
		CCIR-709

- Gamma RGB:	NTCS EBU SMPTE CCIR-709
- Luminance-Chrominance	YIQ YUV SMPTE YCrCb CCIR-709 YCrCb EBU YCrCb

- non-standardised :	RGB CMY CMYK IHS

Ideally, not all of these would have to be supported, but most of them are well established in particular geographical and/or functional market segments.

The work of IT8 in preparing the four parts of IT8.7:

IT8.7-1 : Graphic arts colour transmission input target
IT8.7-2 : Graphic arts colour reflection input target
IT8.7-3 : Input data for characterisation of 4-colour process printing
IT8.7-4 : Reference RGB for graphic arts applications
brings the prospect of calibrated colour to the prepress world, so that for example CMYK data can be transformed between the "SWOP" and "Eurostandard" domains, and standard data is available from which to set up coefficients for transforms between RGB and CMYK domains.

Further details available from:
Local national standards organisations

Usage (Market segment and penetration)
IT8.7 parts 1, 2 and 3 are now in ANSI public review.

TWAIN

Expanded name
"Toolkit Without An Important Name"

Area covered
Interface between "plug-in" and DTP program, to connect image sources to applications.

Sponsoring body and standard details
Produced by consortium of Aldus, Caere, Hewlett-Packard, Logitech and Kodak, on behalf of a much wider community of "endorsers".

Further details available from:
Any of the participating organisations' information services.

Characteristics/description
Image applications have to implement a "TWAIN" interface in addition to (or instead of) their proprietary one (eg Quark Xtension, Aldus Addition etc.). Image source suppliers (eg scanner manufacturers) can then write one "plug-in", eg for the control of a "dumb" scanner, and this can be used from any application as a "pop-up" window, to load data straight into the application, instead of having to switch between the application and a scanner control program with data being held in a temporary file on disk.

Usage (Market segment and penetration)
Implementations are just beginning to be seen.

Pre-press vendor specific formats

Expanded name
Traditional Prepress Vendors' Open Interfaces

Area covered
Various raster image and page plan file formats

Sponsoring body and standard details

- Crosfield Electronics "Freeway"
- Dainippon Screen "Omega"
- Linotype-Hell "Chromalink"
- Scitex "Handshake"

Further details available from:

Crosfield Electronics Ltd
Three Cherry Trees Lane
Hemel Hempstead
Herts HP2 7RH
United Kingdom

Dainippon Screen Ltd
Colindeep Lane
London NW6 6HE
United Kingdom

Linotype-Hell AG
Postfach 56 60
Mergenthaler Allee 55-75
6236 Eschbom bei Frankfurt
Germany

Scitex Europe SA
Avenue Louise 120
1050 Brussels
Belgium

Characteristics/description

These products publish the "big four" pre-press vendors' preferred data interchange formats and protocols, allowing other vendors to interface to their products. They are included here only for reference.

Appendix 1

Summary of standards for image compression

This appendix, which is a summary of standards for image compression, has been assembled from 'Report on requirements for publishing tools and image handling, R2042/WMD/FUE/DS/P/003/b1, July 15 1992'

Summary of standards for image compression

Various standards bodies are developing algorithms for the compression and decompression of images. Beside these official or de-jure standards there are several common de-facto standards.

The principal industry standards under development or already completed today include:

B/W Images

- Fax Group 3/4 (CCITT)

  These standards define a compression method based on run length and Huffman coding for the transmission of facsimile images.

  Group 3 compression is included in the current generation of fax equipment. The more advanced Group 4 will gain acceptance in some fields with higher quality requirements in the near future.

- JBIG (CCITT)

  JBIG losslessly compresses binary (1 bit/pixel) images. Basically it models the redundancy in the image as the correlations of the pixel currently being coded with a set of nearby pixels called the "template". An example template might be the two pixels preceding this one on the same line, and the five pixels centred above this pixel on the previous line. The current pixel is then arithmetically coded based on the 8 bit (including the pixel being coded) state so formed. So there are (in this case) 256 contexts to be coded. The arithmetic coder and probability estimator for the contexts are IBM's patented Q-coder. The Q-coder uses low precision, rapidly adaptable (those two are related) probability estimation combined with a multiplyless arithmetic coder.

  It is possible to use JBIG on greyscale or colour images by simply applying the algorithm one bit plane at a time. To get good results it is necessary to recode the grey or colour levels first though, so that adjacent levels differ in only one bit (Graycoding). This seems to work well up to about six bits per pixel, beyond which JPEG's lossless mode works better.

The intent of JBIG is to replace the current, less effective Group 3 and 4 fax algorithms.

True colour images

- JPEG (CCITT/ISO)

JPEG the most important still image compression mechanism. JPEG stands for 'Joint Photographic Expert Group', the original name of the committee that wrote the standard. JPEG is designed for compressing either full colour or greyscale digital images of "natural", real world scenes. It does not work as well on non-realistic images, such as cartoons or line drawings, and does not handle black & white (1 bit/pixel) images, nor does it handle motion picture compression.

JPEG is basically an implementation of the DCT codec. The JPEG baseline algorithm is "lossy" and achieves much of its compression by exploiting known limitations of the human eye, notably the fact that small colour details aren't perceived as well as small details of light and dark. Thus, JPEG is intended for compressing images that will be looked at by humans. There is a JPEG variation which provides lossless compression but the compression ratios are not competitive with the lossy algorithm.

The scope of JPEG encompasses several factors, which include multiple image components, varying sampling formats, multiple colour models, resolution independence, lossy (destructive), and lossless (nondestructive) algorithms variants. Following is a description of the processing steps involved in the JPEG compression/decompression of an image:
Initially the image is divided into 8x8 pixel squares and the DCT is applied to each square, resulting in 64 frequency coefficients. The coefficients are passed through the quantisation algorithm to eliminate unimportant frequencies. The remaining frequencies are

run through the variable length coding algorithm where the coefficients are encoded as a variable length string of bits (where the most frequently occurring values are represented by the fewest number of bits). Decompression inverts the process and passes the data.

The JPEG coding models include Lossless JPEG, in which dimensional differential pulse code modulation (DPCM) is utilised. In Lossy JPEG a two dimensional discrete cosine transform (DCT) is applied to convert blocks of an image from the spatial domain to the frequency domain. The transformed block is then scanned in a zig zag fashion to produce a frequency spectrum of the image segment.

The function of the DCT is to separate the image into its frequency components; the DCT includes the mapping of coherent blocks of the image into spectral band images. The DCT operation is reversible without loss, with the exception of rounding errors. Low frequency errors are more detectable than high frequency errors to the human eye.

Most image compression occurs during the quantisation phase of JPEG. Quantisation is not reversible without loss, is selective in precision among frequency components, and is responsible for controlling the compression level achieved by the algorithm. Quantisation resolution can be different for each frequency component; lower frequencies are generally coded with greater fidelity. The quantisation resolution in JPEG may be selected specifically for each image. All data is reduced in magnitude though not in the dynamic range represented; many high frequency coefficients are reduced to zero.

The data is further encoded using an entropy coder, which is lossless. In JPEG, the entropy coder is either a Huffman or an arithmetic coder. The choice has no impact on image quality, but arithmetic coding usually produces a smaller compressed file. On typical images, arithmetic coding produces a file 5 or 10 percent smaller than Huffman coding. Unfortunately, the particular variant of arithmetic coding specified by the JPEG standard is subject to patents owned by IBM, AT&T, and Mitsubishi. Baseline JPEG standard uses the Huffman encoder/decoder. Entropy coding exploits the probability of a particular code occurring to reduce the average number of bits transmitted. DCT causes small coefficient values to be more probable than large ones, so they are coded with the least number of bits. The zero valued coefficients occur most frequently. They are additionally run length coded in JPEG; the data is stored in run level pairs or events. JPEG events represented by frequency coefficients are joined together in a hierarchical manner to build up a complete image. Huffman code tables and quantisation tables are coded and pre-appended to the compressed image data. A complete bitstream contains all necessary information for decoding an image.

The JPEG decompressor applies the inverse operations to the bitstream to reconstruct the image. Data lost in the quantisation cannot be recovered.

A useful property of JPEG is that the degree of lossyness can be varied by adjusting compression parameters. This means that the image maker can trade off file size against output image quality.

Description of image compression techniques

An image, 1024 pixel x 1024 pixel x 24 bit, without compression, would require 3 MB of storage and 7 minutes for transmission, utilising 64 Kbit/s ISDN. If the image is compressed at a 10:1 compression ratio, the storage requirement is reduced to 300 KB and the transmission time drops to under 6 seconds. Seven 1 MB images can be compressed and transferred to a floppy disk in less time than it takes to send one of the original files, uncompressed, over an AppleTalk network.

In a distributed environment large image files remain a major bottleneck within systems. Compression is an important component of the solutions available for creating file sizes of manageable and transmittable dimensions. Increasing the bandwidth is another method, but the cost sometimes makes this a less attractive solution.

Various compression schemes take advantage of the human visual system process information. Platform portability and performance are important in the selection of the compression/decompression technique to be employed. Compression solutions today are more portable due to the change from proprietary high end solutions to accepted and implemented international standards. JPEG is evolving as the industry standard technique for the compression of continuous tone images.

Algorithms

Below is a brief overview of different algorithms for image compression. Some of the algorithms are general purpose, data independent and some are specific for the compression of images.

Two categories of algorithms can be distinguished:

- lossless and
- 'lossy'

The lossy techniques cause image quality degradation in each compression/ decompression step. Because of careful consideration of the human visual perception the degradation can be unrecognisable, depending on the selected compression ratio. In general, the lossy techniques provide a far superior compression ratio compared to the lossless techniques.

Lossless coding techniques

Lossless coding guaranties that the decompressed image is absolute identical to the original image before compression. This is an important requirement for some application domains, e.g. medial imaging, where not only high quality is in demand, but unaltered archiving is a legal requirement. Lossless techniques can as well be used for the compression of other data types where loss of information is not acceptable, e.g. text documents and program executables.

The following methods can be made more effective by adding a 1D or 2D delta coding to the process of compression. These deltas are more effectively codeable in run length, have (statistically) higher maxima in code tables (leading to better results in Huffman and general entropy codings), and build greater equal value areas usable for area coding.

Some of these methods can easily be modified to be lossy. Lossy element fits perfectly into 1D/2D run length search. Also, logarithmic quantisation may be inserted to provide better or more effective results.

Run length encoding

Run length encoding is a very simple method for compression of sequential data. It takes advantage of the fact, that in usual data streams consecutive single tokens are often identical. Run length encoding checks the stream for this fact and inserts a special token each time a chain of more than two equal input tokens are found. This special input advises the decoder to insert the following token *n* times into his output stream. Following is a short example of this method:

Clock	Input	Coder	Decoder
		Output	Output
1	A		
2	B	A	
3	C	B	A
4	C	Ø	B
5	C	Ø	Ø
6	C	Ø	Ø
7	C	Ø	Ø
8	D	%5C	Ø
9	E	D	CCCCC
10	Ø	E	D
11	Ø	Ø	E

In this example, there are 9 tokens going into the coder, but just 7 going out. The effectivity is a function of the amount of equal tokens in a row in relation to the amount of input tokens at all. This relation is very well in undithered two tone images, which is used i.e. for facsimile. Obviously, effectivity degrades when the input does not contain too many equal chains. With a rising density of information, the likelihood of two following tokens being the same does sink significantly, as there is always some noisy distortion on the input.

Run length coding is easily implemented, either in software or in hardware. It is fast and very well verifiable, but its compression ability is very limited.

Huffman encoding

This algorithm, developed by D.A. Huffman is based on the fact that in an input stream certain tokens occur more often than others. Based on this knowledge, the algorithm builds up a weighted binary tree according to their rate of occurrence. Each element of this tree is assigned a new code word, whereat the length of the code word is determined by its position in the tree. Therefore, the token which is most frequent and becomes the root of the tree is assigned the shortest code. Each more seldom element is assigned a longer code word. The least frequent element is assigned a code word which may have become twice as long as the input token.

The compression ratio achieved by Huffman encoding uncorrelated data becomes something like 1:2. On slightly correlated data, as on images, the compression rate may become much higher, the absolute maximum is defined by the size of a single input token and the size of the shortest possible output token (max. compression = token size[bits]/2[bits]). Standard palletised images with a limit of 256 colours may be compressed by 1:4 if they use only one colour, the practical results are in the range of 1:1.2 to 1:2.5.

Entropy coding (Lempel/Ziv)

The typical implementation of an entropy coder follows J. Ziv/A. Lempel's approach. Nowadays, there is a wide range of so called modified Lempel/Ziv codings. These algorithms all have a common way of working. The coder and the decoder both build up an equivalent dictionary of metasymbols, each of which represents a whole sequence of input tokens. If a sequence is repeated after a symbol was found for it, then only the symbol becomes part of the coded data and the sequence of tokens referenced by the symbol becomes part of the decoded data later. As the dictionary is build up based on the data, it is not necessary to put it into the coded data, as it is with the tables in a Huffman coder.

This method becomes very efficient even on virtually random data. The average compression on text and program data is about 1:2, the ratio on image data comes up to 1:8 on the average GIF image. Here again, a high level of input noise degrades the efficiency significantly.

Entropy coders are a little tricky to implement, as there are usually a few tables, all growing while the algorithm runs.

LZ coding is subject to patents owned by IBM and Unisys (formerly Sperry).

Area coding

Area coding is an enhanced form of run length coding, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, building up a two dimensional object. Therefore, as the two dimensions are independent and of same importance, it is obvious that a coding scheme aware of this has some advantages. The algorithms for area coding try to find rectangular regions with the same characteristics. These regions are coded in a descriptive form as an Element with two points and a certain structure. The whole input image has to be described in this form to allow lossless decoding afterwards.

The possible performance of this coding method is limited mostly by the very high complexity of the task of finding largest areas with the same characteristics. Practical implementations use recursive algorithms for reducing the whole area to equal sized subrectangles until a rectangle does fulfil the criteria defined as having the same characteristic for every pixel.

This type of coding can be highly effective but it bears the problem of a nonlinear method, which can not be implemented in hardware. Therefore, the performance in terms of compression time is not competitive, although the compression ratio is.

Lossy coding techniques

Lossy image coding techniques are all based on a common general structure. In the following scheme [Fig. 1], the basic steps of a coding process are shown. The first block is the most characterising the coding method, since it contains the model by which the data are represented (for instance, the transformation to be applied to the image); in the next step, the new data generated by the transformation, are quantised to reduce the amount of information; finally, a code is generated by associating appropriate codewords to the raw data produced by the quantiser.

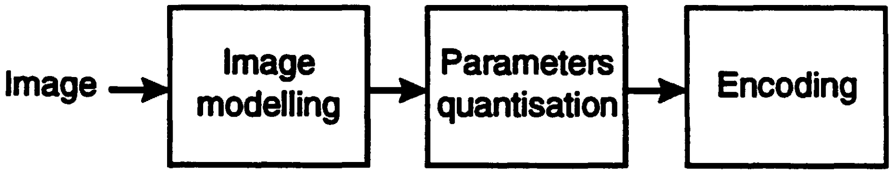


Fig. 1: General Coding Scheme

Each one of the three operations described (modelling, quantisation and coding) are in some part responsible of the compression. The first step is, in general, aimed at the exploitation of statistical characteristics of the image (i.e., high correlation, redundancy, etc.): typical examples are transform coding methods, in which the data are represented in a different domain (e.g., frequency in the case of the Fourier Transform [FT], the Discrete

Cosine Transform [DCT], the Kahrunen-Loewe Transform [KLT], and so on), where a reduced number of coefficients contains most part of the original information. It is to be pointed out that this first phase does not produce necessarily a loss of information.

The aim of the quantisation, realised in the second step, is to reduce the amount of data used to represent the information into the new domain. Quantisation is in most cases not a reversible operation: therefore, it belongs to the so called 'lossy' methods.

The last operation is usually error free and used to optimise the representation of the information (then, possibly, to further reduce the bit rate), and to introduce some error detection code if needed.

In the following sections, a review of the most important coding schemes for lossy compression is given; in particular, some methods are described in their canonical form (transform coding, region based approximations, fractal coding, wavelets, hybrid methods) and some variations and improvements presented in the scientific literature are reported and discussed.

Transform coding (DCT/Wavelets/Gabor)

A general transform coding scheme involves subdividing an *N* _ *N* image into smaller *n* _ *n* blocks and performing a unitary transform on each subimage. A unitary transform is a reversible linear transform whose kernel describes a set of complete, orthonormal discrete basis functions. The goal of the transform is to decorrelate the original signal, and this decorrelation generally results in the signal energy being redistributed among only a small set of transform coefficients. In this way, many coefficients may be discarded after quantisation and prior to encoding. Also, visually lossless compression can often be achieved by incorporating the HVS contrast sensitivity function in the quantisation of the coefficients.

As to the block diagram of Fig. 2, for a transform coding scheme, the first block is made up of two steps: a segmentation one, in which the image is subdivided in bidimensional vectors (possibly different sized); a transformation step, in which the chosen transform (e.g., KLT, DCT, Hadamard, _) is applied.

Second block can be performed in several ways: most classical approaches are 'zonal coding', consisting in the scalar quantisation of the coefficients belonging to a predefined area (with a fixed bit allocation), and 'threshold coding', consisting in the choice of the coefficients of each block characterised by an absolute value exceeding a predefined threshold. Another possibility, that leads to higher compression factors, is to apply a vector quantisation scheme to the transformed coefficients.

The last step, which is almost the same for each coding method, consists of the encoding of quantised coefficients; in the cases of scalar approaches a classical Huffman code can be in general successful.

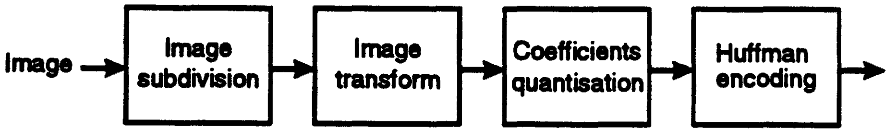


Fig. 2 : General Transform Coding Scheme

The JPEG standard ("Standards for Image Compression: JPEG" , "Product Overview: JPEG") is an example of an implementation based on transform coding.

Vector quantisation

In this section, the main characteristics of vector quantizers will be briefly discussed, and some improvements presented that can be adopted in order to reach higher performances.

As is well known, a vector quantiser can be defined as a transform operator *T* from a *K*-dimensional Euclidean space R^K to a finite subset *X* in R^K made up of *N* vectors.

In other words, the subset *X* is the vector codebook, or, more generally, the code book. Clearly, the choice of the set of vectors $\{x_i\}$ is of major importance. The level of distortion due to the transformation *T* is generally computed as the MSE between the "real" vector *x* in R^K and the corresponding vector $x'=T(x)$ in *X*.

This error is such as to minimise the Euclidean distance *d*.

The optimum scalar quantiser was proposed by Lloyd and Max. Later on, Linde, Buzo and Gray resumed and generalized this method, extending it to the case of a vector quantiser. The algorithm that they proposed is derived from the KNN clusterisation method, and is performed by iterating the following basic operations:

- subdivide the training set into *N* groups (called 'partitions' or 'Voronoi regions'), which are associated with the *N* codebook letters, according to a minimum distance criterion;
- the centroids of the Voronoi regions become the updated codebook vectors;
- compute the average distortion: if the percent reduction in the distortion (as compared with the previous step) is below a certain threshold, then STOP.

Once the codebook has been designed, the coding process simply consists in the application of the *T* operator (as defined above) to the vectors of the original image. In practice, each group of *n* pixels will be coded as an address in the vector codebook, that is, as a number from 1 to *N*. The compression ratio *C* is therefore given by:

$$C = \frac{\log_2 N}{k.n}$$

where *n* represents the number of bits associated with each pixel in the original image.

The LBG algorithm for the design of a vector codebook always reaches a local minimum for the distortion function, but often this solution is not the optimal one. A careful analysis of the LBG algorithm's behaviour allows one to detect two critical points: the choice of the starting codebook and the uniformity of the Voronoi regions' dimensions. For this reason some algorithms have been studied and implemented to reach better performances: as regard to the initialisation of the LBG algorithm, for instance, one can observe that a random choice of the starting codebook requires a large number of iterations before reaching an acceptable amount of distortion. Moreover, if the starting point leads to a local minimum solution, the relative stopping criterion prevents further optimisation steps.

Segmentation and approximation methods
In segmentation and approximation methods, the image is modelled as a mosaic of regions, each one characterised by a sufficient degree of uniformity of its pixels with respect to a certain feature (e.g., grey level, texture); to each region, some parameters related to the characterising feature are then associated.

The operations of finding a suitable segmentation and an optimum set of approximating parameters are highly correlated, since the segmentation algorithm must take into account the error produced by the region reconstruction (in order to limit this value within determined bounds). These two operations constitute the first block for this class of coding schemes; second and third steps are strongly dependent on the statistical characteristics of the parameters of the approximation (and therefore on the approximation itself).

Classical examples are 'polynomial approximation' and 'texture approximation': in the former, the regions are reconstructed by means of polynomial functions in *(x, y)*; the task of the encoder is to find the optimum coefficients a_i for the basis functions a_0, a_1x, a_2y, a_3xy, a_4x^2, a_5y^2, _ In the latter method, the regions are filled by synthesising a parametrised texture based on some model (e.g., fractals, statistical methods, Markov Random Fields [MRF], _). It is to be pointed out that, while in the polynomial approximation the problem of finding optimum coefficients is quite simple (it is possible to use least squares approximation or similar exact formulations), for texture based techniques the problem can be very complex.

Spline approximation methods (Bilinear Interpolation/Regularisation)

These methods fall in the more general problem of image reconstruction or sparse data interpolation. The basic concept is to interpolate data from a set of points coming from original pixel data or calculated in order to match some error criteria. The problem of interpolating a set of sparse data is generally ill posed, so some regularization algorithm must be adopted in order to obtain a unique solution. The problem is well known in literature, and many interpolation algorithms can be used. In order to apply this kind of techniques to image coding, a good interpolant must be used to match visual criteria. Spline interpolation is a good visual interpolant notwithstanding it requires a great computational effort. Bilinear interpolation is more easy to implement, while maintaining a very good visual quality. Regularization involves the minimisation of an energy function in order to obtain an interpolant which presents some smoothness constraints; it can be combined with non continuities along edges in order to preserve contours quality in reconstruction. Generally all interpolants computations require the solution of very large linear systems even if related to very sparse matrices. This leads to the use of recursive solution such as relaxation (suitable for a large parallel implementation), or to the use of gradient descent algorithm.

The use of an interpolation algorithm for image coding is more interesting when related to techniques such as two source decomposition, where the image is modelled as the sum of two sources; one is the stationary part (it can be considered related to the low frequency content), the second is the residual content coming from non-stationarities such as edges. The first of the two sources is coded by means of a prediction scheme that can be one of the previous described interpolants. The second source (the residual) can be coded trough the use of a classical coding method (transform coding, vector or scalar quantisation etc.). Moreover two source decomposition is a very effective coding scheme as far as it shows a low tile effect that affects all block coding techniques when compression factors become higher.

Fractal coding (texture synthesis, iterated functions system [IFS], recursive IFS [RIFS])

Fractal parameters, including fractal dimension, lacunarity, as well as others described below, have the potential to provide efficient methods of describing imagery in a highly compact fashion for both intra- and interframe applications. Fractal methods have been developed for both noisy and noise free coding methods.

Images of natural scenes are likely candidates because of the fractal structure of the scene content, but results are reported to be applicable to a variety of binary, monochrome, and colour scenes.

In the mid-eighties Dr Michael Barnsley reported the use of "Iterated Function System" for image compression and synthesis. Using sets of affine transformations developed for a given image, and a principal result known as the "collage theorem", intraframe compressions in excess of 10,000:1 and interframe compression in excess of 1,000,000:1 were reported. The collage theorem states that if an image can be covered (approximately) with compressed affine transformations of itself, then the image can be (approximately) reconstructed by computing the attractor (in the sense of non linear dynamic systems) of this set of affine transformations.

This convergence was extremely slow, about 100 hours on a Cray, unless assisted by a person and was presented as an illustration of a scientific possibility, not as a commercial reality. In 1987 Barnsley and Sloan formed Iterated Systems Inc to develop a product that would function in a commercial environment. By the end of 1988 Iterated Systems had developed the patented technique called the 'Fractal Transform' which has become the basis of their current product range. The development allowed a real world image to be reduced to a set of fractal equations based on the image being processed, rather than a huge library of pre-calculated, reference, fractal patterns. Image compression algorithms which are noise free have been reported to be developed from this transform for real time automatic image compression at ratios between 10:1 and 100:1

Barnsley has not divulged any technical information about the Fractal Transform beyond that in his book "Fractals Everywhere". The book explains the idea of IFS codes at length but is vague about the application of the collage theorem to specific compression problems.

Researchers at BellCore have developed a compression method that incorporates a Peano Scan (the Peano curve is a "space filling" fractal curve) with a fractal based coding schema for intraframe compression, so making it possible to archive high picture quality with bit rates of less than one bit per pixel. A fractal based method was reported earlier by Walach while the concepts of using a Peano Scan has been used for storage, compression and display. The BellCore researchers have combined these two fractal concepts into an efficient implementation which is now being incorporated into a VLSI chip. Compression results show good quality imagery at a rate of 0.8-1 bit per pixel. The technique may be implemented in an adaptive fashion since a local estimate of fractal dimension provides an objective measure of image complexity.

An alternative approach to image compression, also incorporating some features of fractal geometry, is based on orthogonal pyramid transforms. These transforms decompose the image as a weighted sum of basis functions. The basis functions have several attractive features including localisation in space and spatial frequency as well as self similarity. This latter feature reflects the notion that basis functions are scaled version of one another, and thus are able to capture image information at all scales in a uniform way. The pyramid transform techniques are based, in part, on an earlier concept of quadrature mirror filters. The pyramid structure results from dealing with the image at multiple resolutions. Results reported show high quality imagery at rates of 0.65 bits per pixel. The MSE is comparable to 16 X 16 block DCT transform coding algorithms but superior in visual image quality.

Efficiency and quality of different lossy compression techniques

The performances of lossy picture coding algorithms is usually evaluated on the basis of two parameters:

1. the compression factor (or analogously the bit rate) and
2. the distortion produced on the reconstruction.

The first is an objective parameter, while the second strongly depends on the usage of the coded image. Nevertheless, a rough evaluation of the performances of a method can be made by considering an objective measure of the error, like MSE or SNR.

As to the methods described in the previous pages, average compression ratios and SNR values obtainable are presented in the following table:

Method	VQ	DCT -SQ	DCT-VQ	AP	SplineTSD	Fractals
Bit Rate (bpp)	0.8-0.4	0.8-0.3	0.3-0.08	0.3-0.1	0.4-0.1	0.8-0.0_
SNR (dB)	36-30	36-31	30-25	image dependent	36-32	image dependent

Tab Comparison of Different Compression Methods

During the last years, some standardisation processes based on transform coding, such as JPEG, have been started. Performances of such a standard are quite good if compression factors are maintained under a given threshold (about 20 times). Over this threshold, artifacts become visible in the reconstruction and the effect affects seriously the images decoded, due to quantisation effects of the DCT coefficients.

On the other hand, there are two advantages: first, it is a standard, and second, dedicated hardware implementations exist. For applications which require higher compression factors with a minor loss of accuracy than JPEG, different techniques should be selected such as wavelets coding or spline interpolation, followed by an efficient entropy encoder such as Huffman, arithmetic coding or vector quantisation. Some of this coding schemes, are suitable for progressive reconstruction (Pyramidal Wavelet Coding, Two Source Decomposition, etc.). This property can be exploited by applications such as coding of images in a database, for previewing purposes or for transmission on a limited bandwidth channel.

Appendix 2

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