HIGHLY EFFICIENT IMAGE FILE FORMAT: A REVIEW

Pratik Lahudkar [1], Sarita Sawale [2] , Krishna Bharambe [3], Vijay Deshmane [4]
Final year IT Student, Department of Information Technology,
[1, 3, 4]Anuradha Engineering College, Chikhli
[2]Assistant Professor, Department of Information Technology,
Anuradha Engineering College, Chikhli

Abstract

Nowadays, Digital Images are everywhere. An image refers to a two-dimensional art that represents the appearance of physical objects or artificial data. For saving the images in digital format , there are various file formats such as , BMP for paint graphics file , JPEG for regular image files , GIF for short animated files , PNG for adding transparent images , EXIF for professional photography purposes . Until now, JPEG was considered as the best format for clicking and storing images. As years passed, the resolution and size of images also changed. This resulted into the overflow of storage into smartphones and made the processing lagged to access the files. To resolve this problem HEIF was introduced with the qualities of JPEG, GIF, PNG and BMP in a combined way.

This paper covers the History of HEIF, Image Structure, Image Items, Sequences, Brands and MIME type definition. The future implementation and comparison of all image file formats is a part of this paper.

Keywords: image; file format; heif;

I.INTRODUCTION

An image is a digital art for storing data into the form of figures. Each image is considered as a file. When various images have their specific properties, they are categorised under their specific formats. There are various image formats implemented in the market. But they have their own consequences with respect to size, space, resolution, security. So to resolve these problems, a new image file format has been introduced by Apple known as HEIF. Which uses a specific compression technique for storage and security.HEIF is compatible with the ISO Base Media File Format only for iOS devices but soon, it will be implemented into android devices also. Use cases supported by HEIF include[1][2] :

- Clicking and Storage of burst photos.
- Support for simultaneous capture of video and still images, i.e. both image and video captured on the same time.
- Efficient presentation of images and animations.
- Store focal and exposure frames in the same file.
- Editing operations on pre-defined derived images.

II. DIGITAL IMAGES

An image commonly defines as a two-dimensional digital-art that can present the visual appearance of objects or show artificial data. Digital images use binary data, formed from 1's and 0's, to display the image content. The digital images were introduced in the 1920's when telegraph printers were used for transmitting images at long distances, but for computer use, they were used in the 1950's. Digital images can be categorized into two types i.e. vector and raster images [2].

A. Vector Images

Digital images can be displayed into pixel-based raster images and geometry-based vector images. The way image data is saved is slightly different, and in most cases it is hard to decide which type of digital image is the best choice. Since the 1960's vector graphics have used mathematical models for geometrical figures, for polygons, circles and lines, to represent images. This makes

it possible to measure an image independently onto the resolution of the display, meaning vector images don't have a fixed resolution to representing themselves. This is eligible for example in the computer-based design or producing applications, or with graphics which requires being measurable. An example is an icon in a graphical user interface which has to change in different sized monitors. Figure 1 shows a vector image of a line. The line is described by its parameters as follows:

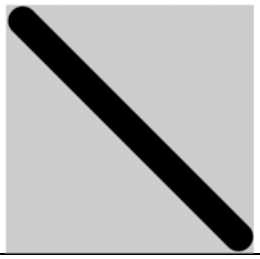

Fig 1. An example of a vector image. A way to store such an image could be "line width=1; line from 20,20 to 0,0;"

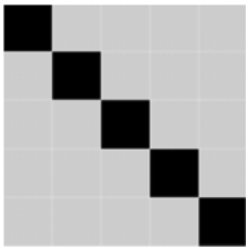

Fig 2. An example of a raster image. Storage could be a 2-dimensional 5x5 array of bits, where 0 represents a gray square and 1 as a black square: [1 0 0 0 0 ; 0 1 0 0 0 ; 0 0 1 0 0 ; 0 0 0 1 0 ;0 0 0 0 1].

From the top-left corner towards right and down this can be expressed as a matrix:
[1 0 0 0 0 ; 0 1 0 0 0 ; 0 0 1 0 0 ; 0 0 0 1 0 ; 0 0 0 0 1]. A specific amount of dots with much enough color options close to each other can create an effective way of a continuous colored image. This suits very well to present content such as photographs and graphical images. Raster images are often considered as bitmap images. HEIF operate with raster image only. A raster image is defined by its dimensions i.e. width and height, that is performed in pixels. Information amount required to describe the properties of each pixel is called bit-depth. Each pixel has information about its intensity (for gray-scale images) or color, sometimes also transparency. Bit depth changes from 1 bit or two colored pixels, and most of the times black-and-white images at 64 bits, while a typical example of a 24-bit true color image where each of red, green and blue factor has 8 bits of data. This means 16,777,216 or 224 color combinations are possible.

width , and start and end points. the way to store such information could be a text file with content as " line width=1; line from 20,20 to 0,0;" [2].

B. Raster Images

On the other hand, a raster image consists of a grid of several squares, rounds or rectangular dots, also called as pixels, each of which represents a color. Figure 2 represents a simple black & white raster image. Storage can be a 2-dimensional 5x5 array of bits, where 0 represents a gray square and 1 as black square. [2]

C. Compression

The technique that data is generally stored in a raster image is simple: a two-dimensional array stores the specifications of regular sized dots. Therefore the size of raw image data file is purposely dependent on the resolution (i.e. width and height). High resolutions, combined with high bit depths, can easily result into data sizes handling of which imposes a challenge even for modern devices, not to mention transferring such images via mobile networks. Size of a raw image data can be calculated in the following way -
size = [width*height*bit-depth]/8 .Where size is image data size in bytes, height is image height in pixels, width as image width in pixels, and bit-depth is bits per pixel. To diminish issues related to extreme file sizes many raster image formats use some compression method to diminish file size. This result in funds with storage costs, faster data transmission times, and in less bandwidth needed to transfer images.

For modern computer systems, compression rarely performs a significant computational transparency. Low-power computational systems such as digital cameras

can relate to hardware implementation of encoding or decoding algorithms as needed. When a compression algorithm is lossless, it is possible to reconstruct original data perfectly. With a lossy compression algorithm some of the original data is lost permanently. Lossy compression often offers a better compression ratio by depending on the inability of human senses to notice the useless information. Even though image formats are often classified as lossy or lossless, nothing changes an usually lossless format encoder from manipulating the input image in a lossy manner to improve the compression rate. A utility named png-quant, for instance, declare to trim down normally losslessly compressed PNG (Portable Network Graphics) file sizes upto most 70%. As the additional processing is performed on the encoder side, this approach also provides permanent compatibility with present decoders. Lossless encodings implemented by image file formats include run length encoding (RLE), Huffman coding, and Lempel–Ziv–Welch (LZW) coding [2][3].

III. IMAGE FILE FORMATS

The requirement of storing digital images has immersed a wide array of image file formats to be developed. For a long time, application specific file formats were the only option, as hardware resources were inadequate and systems were not considerably inter-connected. In early times, digital paint system was used for storing images. Which for later use could have been done basically by storing frame buffer memory to device storage .Figure 3 represents this situation. Variety of image file formats made exchanging image files more difficult. Although this was not a problem when computer systems were capable for presenting graphics were rare, and used mostly for research functions. Pairing a file format strongly to hardware or software might make the implementation and execution quicker, but can severely impact the interchanging ability of the output files. Apple-PICT is an example of a badly interchangeable format, as it was mostly a binding format for operating system specific QuickDraw API drawing instructions[3].

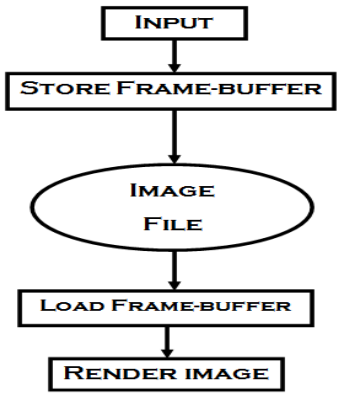

Fig 3. A simplified frame buffer saving diagram

A. Current vector image formats

Common vector format currently include PDF on a large scale which is most precisely used for storing documents as well as images for securely storing purposes. But, it has its own complications does not allow users to edit the images as well as document. Also, it is restricted for utilizing various files into the system.

B. Current raster image formats

General raster image formats presently include GIF, PNG, TIFF and JPEG. Latest formats indulge WebP and BPG (i.e. Better Portable Graphics), which may be considered as challenger of HEIF because they too, rely modern video encoding techniques to achieve good compression levels.

Graphics Interchange Format –

GIF was introduced by CompuServe in 1987 as the descendant of the RLE-based image format used in VIDTEX. In 1989, GIF was restructured to maintain animations and transparency. GIF works over lossless compression and image blocks with 256 colors commencing the 24-bit palette. These utilities made GIF a better opinion for the lossless storage of graphics for inadequate amount of colors. Lossless LZW compression enables serving sharp edges in images. Usually, GIF is not a good option for storing photographs because of the limited number of colors available for image blocks it consists of.

Portable Network Graphics –

In 1995 CompuServe proposed the PNG as a replacement for the GIF, with intent to create a patented-free alternative for it. The first PNG specification was released in 1996. Compared with GIF, PNG provided better compression, as

well as offers better true color support and an optional alpha channel transparency.

Tagged Image File Format -
TIFF files can be used for storing both photographs and graphics. It was originally created in mid-1980s to become a common image format for storing scanned images. Lossless compression support makes it possible to use TIFF files for image archiving and preservation purposes. Even though TIFF is currently public domain, its varied implementations can cause compatibility problems so that applications are able to access only files of a certain kind.
Joint Photographic Experts Group -
Abbreviation JPEG, Joint Photographic Experts Group, is often used to refer to several image formats which use a compression defined by the group. The JPEG issued the first JPEG standard in 1992 when it was also approved as ITU-T Recommendation T.81, and in 1994 as ISO/IEC 10918-1 standard. Common image formats using this compression are JPEG/JFIF (JPEG File Interchange Format) and JPEG/Exif It defined state-of-the-art compression techniques based on wavelet technology and a basic file format called JP2. JPEG XR (JPEG eXtended Range) was originally developed by Microsoft. Image coding specification standard ISO/IEC IS 29199-2 was published in 2009. The target was to keep high image quality while requiring low computational and storage resources.

WebP
WebP image format was introduced by Google in 2010. In the beginning it used lossy intra-frame coding of the VP8 video format. Later releases added lossless VP8L compression, transparency, color profile, animation support and metadata storage. Google claims WebP images using lossless compressed are 26% smaller in file size compared to PNGs, and files with lossy compression are 25-34% smaller in size compared to JPEG images at equivalent perceived quality. Google has released WebP format as open-source with a BSD-style license. In early 2016, some web browsers have a native WebP support (Google Chrome, Opera) [4].

High Efficiency Image File Format -
For video, Apple is using the High Efficiency Image Compression, or HEIC. This is the successor to the old image format. In fact, it's technically H.265. For still photos, Apple's actually using the same HEVC algorithm. A HEIF file can contain multiple images, so it's better designed for features such as Burst mode, and can also embed data like that generated by the two-camera system on iPhone Plus models or the front-facing camera of the iPhone X[4].

IV. HIGH EFFICIENCY IMAGE FILE FORMAT STANDARD

The High Efficiency Image File Format (HEIF) is a new image file format standard for storing raster images, image sequences and related metadata. The standardization effort started soon after the High Efficiency Video Coding (HEVC) standard was finalized, when it was realized that HEVC had good compression performance also with still pictures, and could be used e.g. with digital cameras if it was possible to save photographic metadata to the same file . However, HEIF is not restricted to storing HEVC encoded images only, but it can contain other encoded bit stream formats as well. As HEIF is built on existing ISO Base Media File Format (ISOBMFF) and HEVC standards, these are presented briefly before proceeding to HEIF structure and features in more detail [5].

A. History

The requirements and main use cases of HEIF were defined in 2013 by the technical team of Nokia Technologies. The technical development of the specification took about 1.5 years and was finalized in summer 2015 but until then , nokia was took over by Microsoft. So, then they sold all the rights and information to Apple.inc and developed it for further use. In June 2017, Apple announced support for HEIF in Mac High Sierra and iOS 11. Which will be used into iphone x and its further versions [5][4]

B. Standard Development

The first version of HEVC video compression standard was finalized in January 2013. MPEG requirements documents for storing HEVC compressed still images and image sequences were ready in August 2013. It presented an ISOBMFF based way to store HEVC compressed single images, image collections, image sequences, and related metadata using some specified algorithms for lossless compression [5][3] .

C. Image items

If one or several images are stored to an HEIF file, a single file root-level meta box will be present. It holds information about images, called image items, and possibly also the actual coded image data. In case several images are saved in an HEIF this way the result is called an image collection.

Roles or Sequences of images

As multiple images can be stored in the file, it can be useful to differentiate between them by assigning certain roles. The roles specified in HEIF are listed and described in Table. Note that a single image can be associated with more than one role

Table 1. Roles or Sequences of images.

Role	Description
Coded-image	A coded representation of image.
Derived-image	The image that is derived after extraction from its original source
Cover-image	This image is used to define a batch of photos into the form of a cover photo
Thumbnail-image	A smaller-resolution representation of the original image that is generally into a square resolution
Auxiliary-image	An image that supports as a backup image for the main or master image
Master-image	It is the main image file that is used to provide image data to the user
Hidden-image	An image that is never expected be displayed to the user.

V. IMPLEMENTATION

Up until now, iOS devices have captured video in the MPEG-4/H.264 format, and still photos in JPEG. But with iOS 11 (on recent hardware), Apple is breaking with tradition and switching to a new set of formats that promise dramatic decreases in file size— at the cost of some added complexity in terms of file compatibility [6][5]

To force modern iOS device models to shoot in the old formats, tap on the Camera item in Settings, tap Formats and choose Most Compatible. If you choose this setting, your device will capture in the old formats—costing you space but gaining you the ultimate in compatibility.

If you connect your iPhone or iPad to a Mac, you'll need to upgrade that Mac to macOS High Sierra in order to read the HEIF or HEVC files. This works entirely transparently. When we connected our iPhone 7 running iOS 11 to my Mac running macOS Sierra, and opened the Image Capture app, every image we have captured on my iPhone was listed as a JPEG - despite the fact that they had been captured as HEIF files. If you want to force an iOS device to transfer the original file formats, regardless of compatibility, you can do that. Just change the Transfer to Mac or PC setting in the Photos area of the Settings app to Keep Originals [7][6].

VI. COMPARISON OF IMAGE FORMATS

It can be observed that HEIF is more extensible and comprehensive than the other compared file formats. Particularly the possibility to include other media types, the advanced multi-picture features, and the support for non-destructive editing make HEIF more advanced than the other formats. The rich set of features make HEIF suitable for a broad range of devices and applications, including for example burst photography [7].

The following table compares all of the image file formats under various aspects of compression, picture functions, derivation, and auxiliary information.

Also specifies the various forms and extensibility of these image formats [8][7]

Table 3 : comparison of all image formats

	.heic	Exif	PNG	GIF	WebP	TIFF	JPEG
Forms and extensibility							
Base container file format	ISOBMFF	TIFF	-	-	RIFF	TIFF	-
Lossy compression	Yes (HEVC)	Yes (JPEG)	No	No	Yes (VP8)	Yes	Yes
Lossless compression	Yes (HEVC)	Yes (TIFF REV 6.0)	Yes (PNG)	Yes (GIF)	Yes (VP8L)	Yes	Yes
Extensible to other metadata formats	Yes	No	No	No	No	No	Yes (XML-based)
Multi picture functions							
Multiple images in the same file	Yes	No	No	Yes	Yes	No	Yes
Image sequences or animations	Yes	No	No	Yes	Yes	No	Yes
Derived images							
Multiple of 90 degree rotation	Yes	Yes	No	No	No	Yes	Yes
Cropping	Yes	No	No	No	No	No	Yes
Tiling / overlaying	Yes	No	No	No	Yes	No	Yes
Extensible to other editing operations	Yes	No	No	No	No	No	No
Auxiliary picture information							
Transparency (alpha plane)	Yes	No	Yes	No	Yes	Yes	Yes
Thumbnail image	Yes	Yes	No	No	No	Yes	Yes

VII. FUTURE SCOPE

As this file format is at present used for iOS which are costly in price aspects for most of the users. But within some years, this format will also be implemented into android phones starting from Nokia. This will allow mid range smartphones to utilize this feature within costing range .So, HEIF will act as a boon for image storage into smartphone industry.

VIII. CONCLUSION

There are number of file formats such as JPEG,GIF, BMP, PNG, TIFF, EXIF, for storing images at higher size but at lossy and secureless compression , HEIF is a substitute that stores

images at a higher resolution and lesser size using lossless CP8L compression which is more secure than other image formats . So, the use of HEIF for digital images could be considered as a boon for the future.

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