Example

Topic: scanners

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Abstract

This report investigates the current state of scanner technology and examines the predicted future advancements of scanners. A brief history of the scanner and its operation is initially outlined. The discussion then focuses on the advantages and limitations of the five main types of scanners in common use today: drum, flatbed, sheet-fed, slide, and hand held scanners. The performance of these scanners is examined in relation to four main criteria: resolution, bit-depth, dynamic range and software. It is concluded that further technological advances in these four areas as well as the deployment of new sensor technology will continue to improve the quality of scanned images. It is also suggested that specialised scanners will increasingly be incorporated into other types of technology such as digital cameras.

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1. Introduction

The purpose of this report is to survey the current state of scanner technology and to briefly discuss predicted advancements in the field.

By examining a range of recently published journal articles, magazine articles and internet sites on the topic of scanners this report describes the main types of scanners in common use today and examines their performance in relation to four criteria: resolution, bit-depth, dynamic range and software. The report then considers the effect of further technological advances in these four areas, as well as the deployment of new sensor technology on the future development of scanners.

The first scanner, initially referred to as a 'reading machine', was developed in 1960 by Jacob Rabinow, a Russian born engineer. The device could scan printed material and then compare each character to a set of standards in a matrix using, for the first time, the "best match principle" to determine the original message (Blatner, Fleishman and Roth 1998, p.3). This reading machine was to form the basis for the development of current scanning, sorting and processing machines.

An early improvement on the reading machine was the drum scanner. These scanners used a type of scanning technology called photomultiplier tubes (PMT). Drum scanners are still used in industry today because of the high quality images they produce. The development of smaller, more economical scanners such as desktop scanners and scanners for domestic use followed the drum scanner as the number of computer users increased and computer technology advanced.

Scanners can now capture images from a wide variety of two and three dimensional sources. These images are converted to digitised computer files that can be stored on a hard-drive or floppy disk. With the aid of specific software, these images can then be manipulated and enhanced by the user. It is now possible to deploy electronic acquisition to create an entire layout (including all graphic elements) from the same computer. This means manual stripping is no longer required (Scanners, digital cameras and photo CDs 2000). Scanners are considered an invaluable tool for adding graphics and text to documents and have been readily adopted by both business and domestic users.

2. How scanners work

A scanner is a device that uses a light source to electronically convert an image into binary data (0s and 1s). This binary data can then be used to store the scanned image on a computer. A scanner recreates an image by using small electronic components referred to as the scanner's 'eyes' (Scanner tips 2000). The type of 'eyes' used in today's scanners are charge-coupled devices (CCD) and photomultiplier tubes (PMT). These electronic eyes measure the amount of light reflected from individual points on the page and translate it to digital signals that correspond to the brightness of each point (Englander 2000).

To create a file on the computer that represents a colour image, the scanner divides the image into a grid with many individual points called pixels or picture elements (Scanner tips 2000). A scanning head, termed a row of 'eyes', reads over the grid and assigns a number to each pixel based on the main colour in that pixel, using green, blue and red. For example an aqua pixel would be saved as a number to represent the proportion of blue, green and red which represents the colour aqua (Scanners, digital cameras and photo CDs 2000).

3. Types of scanners

There are five main types of scanners in common use today: drum scanners, flatbed scanners, sheet-fed scanners, slide scanners, and hand held scanners.

3.1 Drum scanners

Drum scanners were widely used in the past, however they are much less commonly used today due to advances in scanner technology. As a result of their expense, these machines are primarily used by professionals in industry, where they are considered important due to the high-end quality image they produce and because they use PMT technology which is more sophisticated than charge-coupled devices (CCDs) and contact image sensor's (CISs). Drum scanners are difficult to operate and technicians operate these scanners by placing the item to be scanned on a glass cylinder rotating at high speeds around the sensor (Sullivan 1996).

3.2 Flatbed scanners

The most popular scanners for general use are flatbed scanners. This type of scanner is highly versatile because it is able to scan flat objects as well as small three dimensional objects. Flat-bed scanners operate by placing the item to be scanned on a glass window while scanning heads move underneath it. A transparency adapter is used to scan transparent originals such as slides or x-rays, and an automatic document feeder is available for scanning large numbers of documents (Scanner tips 2000).

3.3 Sheet-fed scanners

Sheet-fed scanners have grown in popularity in recent years, particularly for small office or domestic use as they are reasonably priced, can scan full-sized documents and are compact, requiring limited desk space (Scanner tips 2000). Most models of sheet-fed scanners have an inbuilt document feeder to overcome the problem of manually feeding one sheet of paper at a time. However the actual process or scanning with a sheet-fed scanner may result in distortion as the image to be scanned moves over the scanning heads (Scanner tips 2000). A further limitation of sheet-fed scanners is that they are unable to scan three dimensional objects.

3.4 Slide scanners

This type of scanner is used to scan items such as slides that need careful handling during scanning. Unlike other scanners, the scanning heads in slide scanners do not reflect light from the image, but rather pass light

through it. This enables these scanners to produce superior results without distortions caused by reflective light. To be able to scan small and detailed items, these scanners have a large number of eyes on the scanning head which produces a high quality result. Slide scanners tend to be more expensive and less versatile than flatbed and sheet-fed scanners as they are limited to only scanning slides and film. These scanners, however, are well suited to users requiring high quality scans of large numbers of slides (Scanner tips 2000).

3.5 Hand held scanners

Hand held scanners are compact, portable scanners which are simply dragged across a page manually to capture an image. These scanners are easy to use and economical to purchase; however, their use is limited to text of up to four inches in diameter that does not require a high resolution. For this reason, hand held scanners are unsuitable for colour images. A further disadvantage of hand held scanners is that the user must have a steady hand when scanning or the resulting image will be distorted (Scanner tips 2000).

4. Scanner specifications

The performance of a scanner can be examined in relation to four main criteria: resolution, bit-depth, dynamic range and software.

4.1 Resolution

Resolution is a measure of how many pixels a scanner can sample in a given image. It is used to describe the amount of detail in an image (Figeiredo, McIllree and Thomas 1996). Higher resolution scanners are generally more expensive and produce superior results as they have a greater capacity to capture detail. Scanners have two types of resolutions: optical resolution and interpolated resolution.

Optical resolution, or hardware resolution, is a measure of how many pixels a scanner can actually read. A current model desktop scanner typically has a resolution of 300 x 300 dots per inch (dpi) (Anderson 1999). This means that this scanner has a scanning head with 300 sensors per inch, so it can sample 300 dpi in one direction and 300 dpi in the other direction by stopping the scanning head 300 times per inch in both directions. Some scanners stop the scanning head more frequently as it moves down the page, giving an optical resolution of 300 x 600 dpi; however, scanning more frequently in one direction does not improve the result of the scan. The basic requirement for scanning detailed images and line art from photos or other printed originals is an optical resolution of 600 dpi. When scanning slides and negatives the minimum optical resolution is 1200 dpi.

Interpolated resolution measures the number of pixels a scanner is able to predict. A scanner can turn a 300 x 300 dpi scan into a 600 x 600 dpi scan by looking in-between scanned pixels and guessing what that spot would have looked like if it had been scanned. This prediction is then used to insert new pixels in between the actual ones scanned. This technique is less precise than optical resolution; however it assists in improving the enlargement of scanned images.

4.2 Bit depth

Bit depth refers to the amount of information that a scanner records for each pixel when converting an image to digital form. Scanners differ in the amount of data they record for each pixel within an image. The simplest kinds of scanners only record data related to black and white details and have a bit depth of 1 (Anderson 1999). The minimum bit depth required for scanning photographs and documents is 24-bits, while slides, negatives or transparencies need a scanner with at least 30-bits.

Thus for a scanner to produce a high quality scan with colour, a higher bit depth is required. In general, current scanners have a bit depth of 24, which means that 8 bits of information can be collected for the three primary colours used in scanning; blue, red and green (Anderson 1999). This high resolution allows scanners to produce images close to photographic quality.

4.3 Dynamic range

Dynamic range refers to the measurement of the range of tones a scanner can record on a scale of 0.0 to 4.0, with 0.0 being perfect white and 4.0 being perfect black. Colour flat-bed scanners usually have a dynamic range of 2.4. A range of this measurement is unable to provide high quality colour scans. A dynamic range of 2.8 and 3.2 is suited to professional purposes and can be found in high-end scanners. An even higher dynamic range of 3.0 to 3.8 can be provided by drum scanners.

4.4 Software

A scanner, like any type of hardware, requires software. Typically the two most common pieces of software provided with scanners include optical character recognition (OCR) and image editing software. Optical character recognition software translates the information recorded in a scan, tiny dots, into a text file which can be edited. Image editing software allows the tones and colours of an image to be manipulated for better printing and display. Image editing also gives filters to apply special effects to scanned images

5. Future developments

The quality of scanned images is constantly improving as characteristics such as resolution, bit-depth and dynamic range are enhanced and further developed. More sophisticated image editing and optical character recognition software development is also resulting in superior quality scans. Future advances are expected to result in the incorporation of specialized scanners into other types of technology such as the recently developed digital camera. This device allows the user to take pictures of three-dimensional objects much like a regular camera, except that instead of using film, the objects are scanned by the camera in a similar process to the functioning of a flatbed scanner.

The relatively new area of sensor technology in the form of a contact image sensor (CIS) (see Appendix 1) is expected to improve the functionality of scanners and the quality of images as it "replaces the cumbersome optical reduction technique with a single row of sensors" (Grotta and Wiener 1998, p. 1). Developers have already been able to produce a CIS scanner which is thinner, lighter, more energy efficient and cheaper to manufacture than a traditional CCD base device. However, the quality of the scan is not as good as its counterparts. Further development of CIS technology is needed to improve image quality and colour, and to address the problem of a limited 300 or 600 dpi.

6. Conclusion

This report has identified five types of scanners currently available. Some are primarily used for professional purposes such as the drum scanner; others are used more broadly in the workplace and home such as flatbed scanners and to a lesser extent sheetfed scanners. Scanners for specialized purposes have also been identified such as slide and handheld scanners. The performance of these scanners is dependent upon their resolution, bit-depth, dynamic range and software. Scanners have improved significantly in recent years in terms of weight, size, price and speed, and the replacement of CCD technology with CIS technology is anticipated to produce further benefits to these areas as well as to scan quality. The impact of these improvements is expected to increase the accessibility of scanner technology to a wider range of users and its suitability for a wider range of purposes. In relation to this, the future of scanner technology seems to point to the convergence of different technologies. Specialized scanners are currently being incorporated into other types of technologies such as digital cameras, printers, and photocopiers. This can be expected to continue with other forms of technology in conjunction with further improvements to image quality, speed, price, size and weight.

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