CONSTITUTION AND SELECTION OF SCANNER FOR DIGITAL MAP

Tian Xiangchun
Xi'an Research Institute of Surveying and Mapping
Wang Hua
Northwestern Polytechnical University,

[Abstract]

This paper introduces conditions of scanner, and analyzes the constitution of the scanner, then put forward how to select a scanner for digital map.

Scanners for digital map have some strict index, for example size, resolution etc. The scanner for map digital must have big size; resolution above 300DPI, accuracy fit the requirement of map digital. The scanner have these feature then it constitution is different from those scanner for family and office usually.

This paper analyze these differ and these feature, then introduced the scanner how to performance it. For example, now scanners most are multi-CCD (Charge Coupled Device), That one CCD not settles for to scan maps, so use two or three even more CCD. But multi-CCD has some defect, that most be result from lens, like error from distortion.

Another unit to replace CCD is CIS (Contact Type Image Sensor), now it only uses to produce small size scanner, and have low price. CIS take light source and photoelectric transducer together, and leave out lens, but it's resolution and size is fixed, and few distance of imagery. This paper also analyzes advantages and defects respective of CCD and CIS.

In the end, put forward the development of scanner for digital maps in the future, and how to select a satisfactory scanner.

[Key words] digital map scanner CCD CIS

1 introduction

Scanner is a tool of reproducing graph by digit and used widely. With the rapid development of computers, scanners have entered into all trades and families. In general, the office automation doesn't need scanner with very high precision and very big size, but in digital trade, the exact project design and map, etc, need ones with higher precision in bigger size.

For the scanning of relative graphs, such as map, that peculiarity should be noted when selecting and using scanners. Therefore, it is very important and necessary to grasp scanners for acquiring qualified and high quality scanning graphs. This paper is for the requisition and peculiarity of scanning map and will introduce the principle and constitution of CCD scanner for map.

2 Generality of scanner

2.1 Referent parameter of scanner

To grasp scanner, we need to grasp the referents of measuring their performance firstly and pay attention to the follow referent parameters:

2.1.1 Resolution is a key parameter and decides general ranks of scanners. We can say that the rank is higher if resolution is higher. This is one of main difficulties in designing and producing scanners.

Resolution is usually divided into the follow several styles:

(1) Optical resolution: It is the highest resolution which optics and graphs can reach in scanners and decided by magnified multiple of optics and performance of sensors, such as size and number of graph element, etc.

(2) Actual resolution: It is the resolution of actual picking signals acquired by completely physical system.

(3) Inserted resolution: It can be named the highest resolution and is the resolution that the picking signals duplicated by circuit or software using some algorithms can reach. This resolution can't increase lucidity of scanning graphs.

2.1.2 Size: It is size of effective scanning range of scanners. In general, the difficulty of design is usually stronger and the price is usually higher if size of scanners is bigger. This is the main factor to affect mechanistic constitution of scanner. The bigger size with higher price relatively is used in scanning map.

2.1.3 tone range which can be called bit depth and color depth is the picking color described with how many bytes, such as 8 bits, 24 bits, 36 bits, 48 bits, etc. The layer will be abundant if number of bits is higher and division of colors is thinner.

2.1.4 dynamic range called density range represents capability of width scope of tone value reproduced by scanners, which is the range from nearby black. The scanners with good range of activity are able to project input

extent of brightness and darkness into output exactly. This makes graphs look brighter and detail lucidity. The described color layers are more and more abundant if scope of density is larger. In general, the range of activity is larger if scope of color is larger of scanners.

2.1.5 Speed is the time spent in scanning graphs with some parameters. The chief elements affected have picking speed, mechanical speed and transporting speed. Some scanners will present the time of one line picking which can be called linear picking-time.

2.1.6 Size precision: This is one point which should be pay attention to for scanning graphs, such as map, etc, but a few scanners will present the referent, because it is troubled very much and it is difficult to measure it exactly from designing to producing. Even if the same scanners produced in the same conditions will have different measure results which are crisp relatively and easy to be destroyed. The precision has a lot of deciding factors and is decide by optical lens and mechanical constitution mostly.

For the differences of requisition for scanning map, we can say that scanners for scanning map should be paid attention to in the follow parts particularly: size; resolution; size precision; software functions.

Because the most maps have bigger size, and more strict precision requisition for map, the size precision should be noted particularly. On map, many factors are very small, such as linear factor less than 0.1mm usually, and for reproducing map, resolution is not too low and above 300DPI usually. On the other hand, because maps except for image graphs have less color but more lines, many scanners for projects supply processing software with enough functions, such as enhancing and flatting lines and color management easy to restore color of map, etc. This is helpful for acquiring satisfactory scanning graphs directly and conveniently.

2.2 Sensor

The core component of scanner is sensors (optical components), and mainly has three kinds now: Photo multiplier, Charge Coupled Device (CCD) and Contact type Image Sensor (CIS).

Photo multiplier is a kind of electron tube actually. The optical material mainly is mixture of oxidation of metal Se and other active metal oxidations. Photoelectric cathode is made with that material and able to launch electrons, which impinge anode through the acceleration and enhancement of grid and become current under the sunshine. In all kinds of photosensitive components, photo multiplier is one with the best performance, and no matter sensitivity, noise coefficient and active range are all ahead of other ones largely. It should be praised that its output signals almost not need to do any adjustment then acquire exact color restore. At the same time, the temperature coefficient of photo multiplier is very low to be able to ignore. So, it isn't almost affected by temperature of around circumstance. However, photo multiplier has the highest price in all kinds of photosensitive components, and because it only can scan a pixel one time, scanning speed is very low. It will need tens of minutes to scan a graph, so it is used in expensive and special drum scanner now.

The follow pat of this paper mainly introduces and analyses CCD scanner used widely. CCD is like semi conductivity integrated circuit used usually by us and integrates from thousands to ten thousands of photoelectric triodes on a silicon which are divided into three ranks that are covered by fillers of red, green and blue colors respectively so as to realize color scanning. Photoelectric triodes may produce current under the sunshine and the current is output after being magnified. The technology of using CCD scanner has been ripened through the development of many years. Photoelectric triodes are photosensitive components used mainly in mainstream scanners on the market. The advantages of CCD mainly are the follow points. Firstly, performance of quality of making graph is increased greatly in recent years and the performance of its high end's products have approached low level's products of photo multiplier. Secondly, making graphs on the surface of objects has depth of field and can scan sags and crests objects. Lastly, the coefficient of temperature is lower so that the charge of temperature in around circumstance may be ignored. The defects of CCD mainly are the follow points. Firstly, because the distance of thousands of photoelectric triodes is very near (micrometer level), the phenomenon of obvious discharge exists among photoelectric triodes and signals of every photosensitive element disturb each other to decrease actual lucidity of scanners. Secondly, because speculum and lens are adopted, divergence and graph divergence of graph color will occur so that it needs to be adjusted by software. Thirdly, capability of resisting smite is weaker. Lastly, scanner can't be made very small in volume.

At present, the scanners using another component have come into market. Contact type image sensor is called technology of CIS. This kind of scanners appears in recent one or two years. Actually, the technology appears with technology of CCD at the same time nearly. The technology is propagated very quickly at that moment so that nearly every plant of producing scanners presents several types of scanner with CIS. Because size is too big, making graphs can't be used in lens and only depend on attached objects to discern it. So optical resolution can only reach the biggest 200dpi. It was ever used on low-level handed style of no color scanners. However, with the coloration and high sensitivity of scanners, CIS disappeared in market of scanner rapidly. In 1998 later, CIS technology has great breakthrough and the limited resolution is increased to 600DPI. And its cost is only are third of CCD, so it is used widely. Above the performance, contact type image sensor has original

defects. Firstly, because lens can't be used, it only can be attached manuscripts for scanning. Actual lucidity can't reach referent greatly, and if it hasn't depth of field and can't scan solid object. On the other hand, every photosensitive element disturbs seriously each other so as to further decrease lucidity. But because we have no ways to make three parallel photosensitive elements at the same time and realize three colors scanning at the same time. Contact type image sensor uses super-digits array as light source, which is worse no matter light color than equality of light. And because LED array is constituted of hundreds of super-digits, and it means destruct of whole array once there is one destroyed, the lifetime of this product is shorter.

2.3 Constitution of scanner

About constitution of scanner now, there are usually flat-bed ones, paper-returned, roller (drum style) and hand-taken. The ones used usually in scanning map mainly are flat-bed ones, paper-returned and roller (drum style). Their advantages and defects each other are decided by their constitution. We will state these in the follow.

Because flat-bed scanner is limited by material and volume, it is more difficult to design big size and produce, and a lot of size of map is above A3, many project scanners use roller and paper-returned style.

2.4 Interface of scanner

Interface of scanner means the style of connection with computers and is divided into SCSI, EPP, USB and 1394 (fire-wire), the last three of which are new interface used in recent years, Traditional scanners all use SCSI cards as interface which is fast in speed, more in connective devices and low in using system resource. But scanner plants will develop simplified special SCSI cards for scanner to decrease cost. These SCSI interface has no advantages in transporting speed compared of EPP, USB 1.0 nearly, and because we will take apart bin to setup, it is more troubled. Of course, there are many plants using standard SCSI cards to connect scanners. This will make scanning speed faster and effect is obvious. It is suggested that you should try to buy scanner with standard SCSI if you buy scanner with SCSI. The scanner with EPP parallel interface uses common parallel lines to be able to connect with computer. In general, such scanner has a conversion used to connect printer, but there is only a device using parallel interface in the same time. If printing and scanning are dome at the same time, we can't bear the low speed. The advantages of EEP are simple setting up, low price, not needing to set interruption and address and no conflicting with other hardware. The defect is the transporting speed is lower than one of SCSI. Of course, the speed is faster than one of common parallel interface, and it's enough to personal user. USB is the newest interface. Its advantages are the same as EPP, and just speed is faster (the highest speed is2Mbps/s for USB 1.0, 500Mbps/s for USB 2.0), using is more convenient (supporting hot plugging). Its defects are the same as other USB device. Because there are not drivers of USB used in DOS, it doesn't support DOS. But now there are less software supporting only DOS. Added scanning and graph-editing software are less very much. This isn't a serious problem. The interface of 1394 is new one on market whose transporting speed is the highest 480Mbps/s. And there are some scanners using this interface.

3. Analysis of CCD scanner for map

By the example if CCD scanner, we will introduce and analysis it emphatically.

3.1 Constitution and working principle

Now common scanner with big size mainly is used CCD (charge couple device) as main component. By the example of CCD scanner, it uses linear array CCD to receive messages from optics (include of lens and speculum, etc), and form needed digital graph signals through A/D conversion, etc. The principle figure is figure 1:

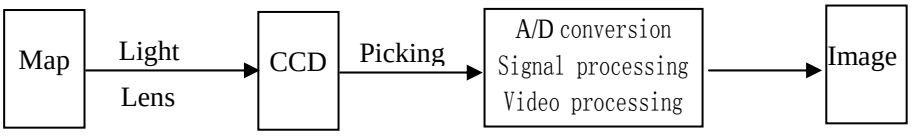

Figure 1 principle figure of CCD scanner

Now about constitution of scanners, usually in scanning map mainly are flatbed ones, paper-returned and roller (drum style). The ones mainly used for scanning map have two kinds of flatbed ones, paper-returned and roller. The follow figure 2 is by the example of flatbed constitution.

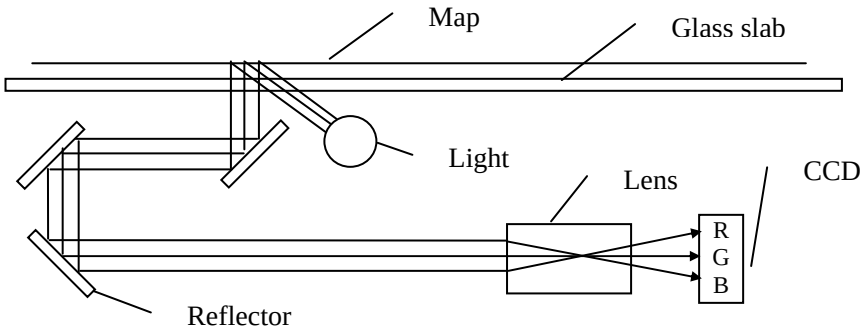

Figure 2 figure of constitution of flat-bed CCD scanner

Every kind of scanners has same optical constitution and working principle generally. Because it is linear array CCD, it needs to move lens, speculum or original manuscript. Because the adopted moving methods are different, constitution is different. Optical resolution will be settled after constitution is settled. But resolution may be greater in moving direction, and moving is calm and slow. Then resolution will be increased. So the resolution of scanner we usually see will be 600*1200, and plotter has the same resolution referent.

3.2 Character of CCD connection scanner

3.2.1 connection object and principle

CCD scanners adopt above 8000pixels linear array CCD greatly. By the example of 8000 pixels, scanning size is A1, and resolution is 600DPI so that we can computer needing how many pixels and CCD components. Computing as follows by approximation:

600mm * 600DPI / 25.4mm/inch = 14173pixels

From above, we can see that we need two CCD to satisfy the requirement of size.

Another reason for connection is distortion if optics will lead to unbalance magnified coefficient in the field of lens. The solution is to increase quality of hardware, use less distortion lens or decrease angle of aperture. There are two ways to decrease angle of aperture. One is to increase the distance between objects. The method will make volume larger. To decrease volume, speculum is needed. Now this brings new error. The other is to increase number of connection lens such that cost and difficulty is lower relatively.

Main difficulty and weakness of large size scanner appear because of this connection. The connection figure is the follow:

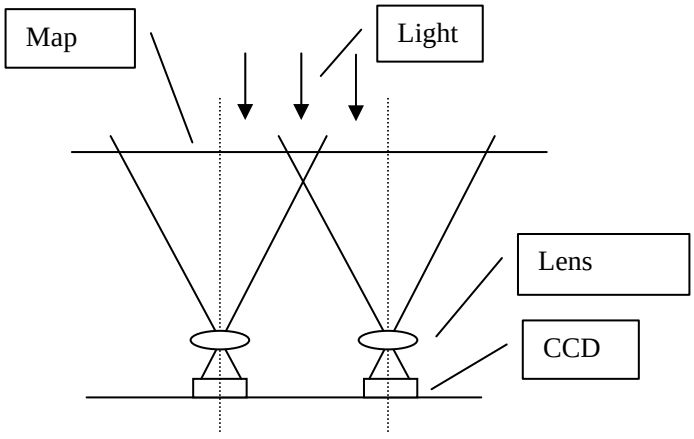

Figure 3 the connection figure of CCD scanner

Connection demands that two group of lens and CCD have agreeable performance, firstly, especially optical performance, such as magnified multiple, lucidity and color, etc, can’t be to have great difference lest making image produces differences. Secondly, space position is parallel, such as CCD must link to a line on the same plane in figure 3, or keep parallel and lens should be response with CCD position.

3.2.2 Weakness of multi-CCD scanner

Connection not only increases size effectively, but also inherits and increases some defects. As users, we need to know defects of scanners so that it is not only helpful to select proper scanners, but also to use rightly.

As the device for scanning map, its color usually satisfies requirements. The more we require is resolution and precision. We will analyze from that easy to be ignored in optics system and constitution.

3.2.2.1 error of optics

Resolution mainly is constituted of CCD components and optical making graphs system. The size of pixel on CCD decides the top limitation of actual resolution basically. Size of pixel of some CCD is very small. There are ten or twenty thousand of ones in a CCD component. But the scanners don't use them. This is relative with optics. The reason is as description of above another one of connection, and it is the result of distortion of optical lens.

We scan using standard grid as original manuscript and read acquired number of pixels every l0mm, then will get the result as figure 4.

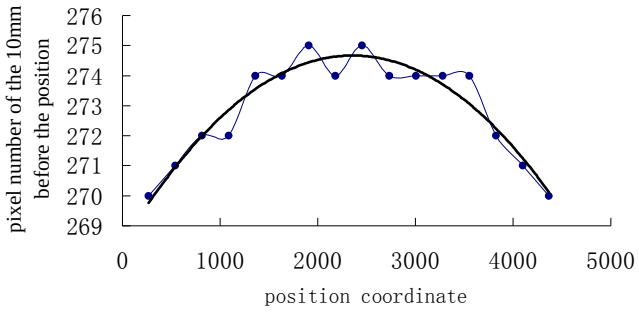

Figure 4 the result of distortion error

From above figure, we can see that values of center and two ends of lens are not the same. It is distortion that causes magnified multiple unbalance. Pixels on the center are more, but two ends less. From graph, center graph of lens is wider, but two ends narrower. This doesn't need to be thought over far scanning common graphs, but it its over than permitted error range for graphs with higher requirement for precision, such as map.

To solve this error, one way is to increase distance between objects and decrease angle of making graph of lens. The other way is to add CCD connection with lens. The last way is to do interpolation procession with software. The ways of interpolation is to divide error fairly, but can't solve it originally.

In optics speculum is easy to fix relatively and error isn't obvious. So, this paper isn't going to state it.

3.2.2.2 Error caused by constitution

The same as distortion error of lens, there are much error caused by constitution original. For example, the distance of object and graph of flat-bed and paper-returned scanners is fixed, but one of roller (drum style) will be decreased because of the thickness of attached original manuscript, and graph will be magnified relatively, that is resolution is added a few. The change is figure 5.

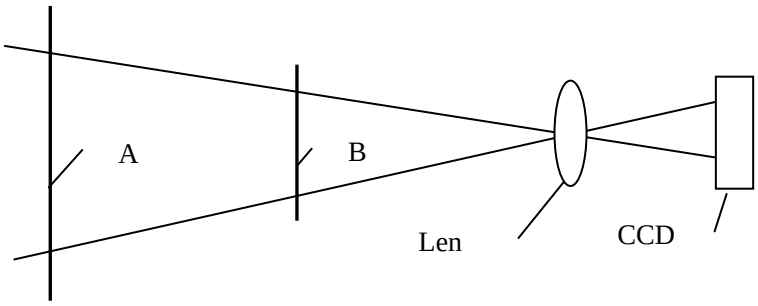

Figure 5 the change of distance between object and graph

From figure, we can see that scanning range of original manuscript of A and B position is different, but number of pixels got by scanning is the same.

We can see that scanners have requirement for thickness of original manuscript, except for flatbed ones.

On the other condition, an important error source is connection. Current scanners almost have no problems in color and lucidity. Many problems appear in size error, and mainly are worse parallel of every camera and CCD. As figure 6.

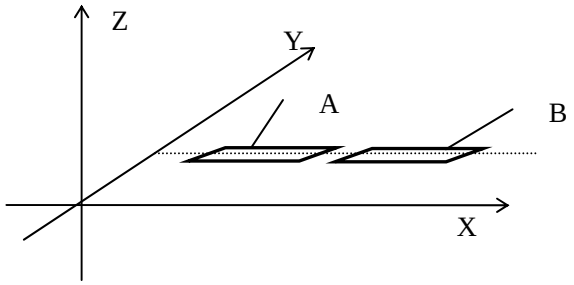

Figure 6 the connection CCD and lens position

It is easy to put two groups of CCD and lens on one plane, but it's hard to put CCD on one line or parallel in space, and stable relatively. Because optics is easy to be destroyed, especially vibration is make connection error position. The graphs scanned will produce error for that. It's easy to measure if it's sloped by scanning with a line. The result as figure 7:

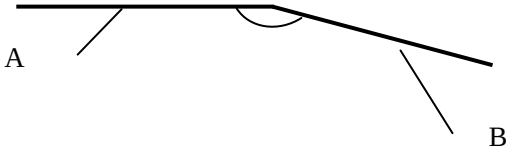

Figure 7 the result figure of setting line scanning

The image made from two CCD forms an angle, not a line. The whole image will distort relatively, and error is usually over than we requirement for map digital.

3.3 Comparison of CCD scanner and CIS scanner

We have stated photosensitive components themselves above, now we will compose scanners using the two components in follows.

At first, CIS is mainly used in low level no color hand-taken scanners and faxes. Because its performance referent is lower than CCD at that time. In general, the used lens group is light fibre pillar lens array, and light source is LED array. Because pillar lens makes scanning original manuscript to do 1:1 imaging on sensors, the distance between scanning original manuscript and sensor can be decreased. Such it doesn't need to design optics and add light source additionally so that the whole volume and weight are decreased greatly. In a color CIS model, there is only one sensor array to be integrated, but three LED light component array. They can launch RGB three kinds of different lights respectively. As figure 8:

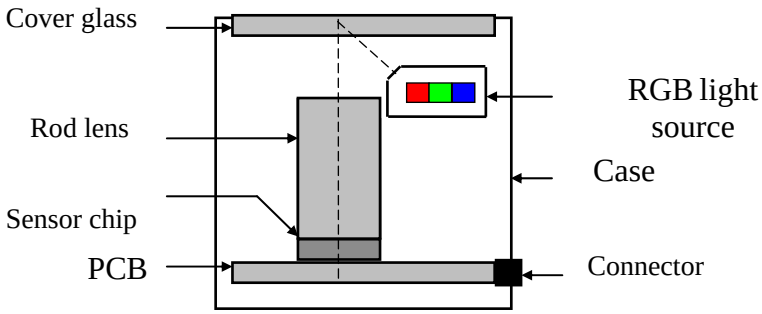

Figure 8 the cutting figure of CIS component

The procedure picking for manuscript is that the three LED light component launch RGB three colors lights according to the time sequence respectively. After every light is launched, sensor array will receive photo once

and send signal out to model once, Until receiving photo three times and transporting signals three times, then transporting RGB color graph signals of the line of paper to finish, and moving to next line of paper. As above, the whole paper is scanned for graph until end.

Character of CIS compared with CCD as table 1:

	CCD scanner	CIS scanner
Constitution	Complicated	Simple, suitable to design
Optics	Extra optics	No complicated optics
Light	Extra light, result is good	No extra light, result is worse.
Size	Wide	No product (now)
Solution	High	Low
Lucidity	(In fact) high	(In fact) low
Precision	Good, exist distortion	good，distortion is small
Color	Better	Good
Depth of field	Have some depth of field, Photo is good	Small
Stability	Good	Better, no vibration
Volume and weigh	Large and heavy	Small and light
Price	A litter expensive	Cheap

Table 1 comparison of CCD and CIS

From above table, we know that CIS scanner have better performance when scanning graphs required for color lower, such as map. With the development of technology continuously, there will be better products to compete with CCD.

4.concludsion

The usual user only pays attention the technique quota that the companies provide when use the scanner, and do not understand its implement and working principle. But to scanning map, the requirement is more special .For example precision, user always consider the error on whole image. This paper describes the structure and principle on usual mutil-CCD scanner, presents several aspects that should be noticed relating to the characteristic of map scanning, analyses phenomenon and reasons that are produced by corresponding problems. Pay attention this several aspects will contribute very much to get the qualified image when selection and the use scanners.

With rapid developing on sensor, optics and computer technology, the form of scanner will become more and more various, its function more and more strong. Because the rate, precision and image process on map scanning will make progress, we will get even more selection chance. With the precision demand of map improving, the space that we live will get more and more accurate description.

Reference:

1：Tang Huijun Zhou Renkui, Zhou Sizhong The calculation and compensation on the illuminance of CCD assembly camera , acta photonica sinica Vol.27 No.7 July 1998 660-663

2：Guo Fanxia The principle and development application on scanner , Tsinghua University Press 1996 5-21

3：Zhang Yimo The application of optic Mechanism Press 1982：Chap Sixth

4: [U.S.A] Ihrig S, Ihrig E. , Using the technology scanning map , Beijing： Electronic Industrial Press 1996：112~1185：

5: Wang Erqi etc. The precision analysis of optic apparatus , Measurement Press 1989

6： Zhao Congzhong The researching of CCD optic, the second nation CCD's application technique academy

seminar 1992.8

7： He Zaixin The researching of the size equivalent for CCD testing tech，the second nation CCD's application technique academy seminar 1992.8

8：Wang Qingyou Sun Xuezhu CCD Application technology, Tianjin University Press 1990