Memory Efficient Algorithm for Rotating Image

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Storage devices of a computer are structured hierarchically. In general, a magnetic disk is used as an external strage to compensating the capacity of main memory. In order to reduce the performance difference between CPU and main memory, CPU has smaller, faster memory. Such memory is called *cache memory* (or simply, *cache*).

A typical CPU has 2 or 3 levels of cache memory. Generally, cache in the first level is size from 16KByte to 32KByte, and its access time is 1 nano second. The one in the second level uses 512KByte to several time and its acces time is 10 nano second. Forthermore, there is a big difference by performance of hardware, the cache in the first level is 100 times faster than the main memory, but the magnetic disk is 100,000 times slower. Memory capacity increases as it leaves from the arithmetic device, but speed decreases. In this way there is hierarchical structure in memory, and access time differs greatly.

When a large quantity of data cannot store in main memory, data transfer is repeated between external storage and main memory. However, as already stated, gret time is required for the data transfer. In order to reduce the whole processing time, it is important to reduce the number of times of data transfer. To perform meaningful calculation for a large amount of data, efficient becomes very bad unless the layered structure of memory storage is considered.

A number of studies have been done in the direction addressed above mainly in a field of network system which is related to database or a web server accessed by hundreds of thousands of people for example. However, it is not so popular in the field related to embedded systems on image proccessing for hight speed. Therefore, there are many examples which are too bad in respect of input and output, and it is required to improve those algorithms. The purpose of this research is realization of an image processing method to use memory for efficiently. In this resurch we mainly focus ourselves on scanners.

Recent scanners are gaining more precisions year by year and there is increasing demand for clear digital images of high resolution. For the purpose a large size of memory is necessary for scanners. To scan a sheet of paper of A4 size in 2400dpi with 24-bit full colors, required memory amounts to approximately 1.6 GByte. Angle compensation of the scanned image can be easily performed if memory for two pictures is available. However, increasing memory size causes increase of cost. Therefore, memory efficient processing is required without using a large amount of memory.

An sutomatic angle compensation is effective especially when a number of sheets of documents are scanned since it greatly reduces human operations. When a sheet of document is scanned with a scanner, a rotation angle is first detected and then angle compensation of the image is performed if necessary. A rotation angle can be efficiently detected using the existing research result. Therefore, in this research we propose an algorithm for angle compensation with sufficient memory efficiency.

First, given a scanned image and a rotation angle, we find a rectangle of largest possible area contained in the image. Namely we find a rectangle of largest possible area rotated by an angle θ that is inscribed in a given axis-parallel rectangle. Actually, we do not know where in the image necessary information is located. This is why we try to find a largest possible rectangle. We assume that necessary information is included in the rectangle obtained. In addition, we want to know which part of the image is available for interpolation process. We assume a regular size for input images. In other words, we assume images of aspect ratio $\sqrt{2} : 1$. Under the assumption we examine what is a largest possible rectangle in an axis-parallel rectangle. We claim that such a rectangle has the largest

area when all of its four corners touch the four sides of the original image. It is the case for rotation angles between 0 and 22.5 degrees. Rotation angles rarely exceeds 22.5 degrees.

Given a rotation angle of an image, we need to calculate a rotated image using interpolation. Interpolation is done pixel by pixle. Among a number of methods, we use a simple linear interpolation. In this interpolation method, for each pixel in the rotated image we find four pixels nearest to it in the original image and determine brightness of the pixel based on a linear interpolation formula. In order to save memory we write a pixel value over the original image. So we must guarantee that every interpolation is carried only using pixle values of the original image. In this thesis we implement memory-efficient algorithm by detecting all dangerous pixels in advance.