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Anti-aliased Pixel and Intensity Slope Detector

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Abstract

A method to detect anti-aliased pixel and pixel that render a slope of intensity gradient is described here. Anti-aliased pixels make lines smoothed and image looks better. Therefore, many computer text and image rendering applications processing text and computer created images to do them viewable like taken with a camera.

Anti-aliased pixels are a big problem for image magnification. Image magnification methods use neighbor pixels to interpolate lacking pixels values. Because the same algorithm is applied to all pixels without analyzing what every pixel represent, this generates magnification blur. This phenomenon decreases object's edge sharpness like blurring or low pass filter.

However, anti-aliased pixel can be used to estimate line position with subpixel accuracy [1], aliasing blur can be decreased and image magnification quality will increase. An anti-aliased pixel looks like intensity gradient slope and is necessary to detect what pixel is slope and what pixel is anti-aliased. There is a fast algorithm to magnify image [2] where different algorithms are used on four pixel groups to estimate better region magnification quality. This method is very quick, simple to implement and draws a very good result in relation with well-known interpolation algorithms.

Aliasing phenomenon occurs because objects in real world have continues, smooth curves and straight lines in various directions, where digital pictures have discrete points called pixels which are arranged rectangular [3-5]. Actually, an image sensor or monitor pixel has some small physical size, so it have finite resolution, where real world have infinite resolution. When high or infinite resolution object is projected to finite low-resolution discrete mesh, like image sensor, lines and curves become jagged. As soon as we deviate from rectangular shapes, we begin to see some unwanted artifacts. These unwanted artifacts, often-called *stairsteps* or *jaggies*, are a form of aliasing. They will appear whenever we attempt to represent a shape that deviates from a rectangle. This is because the image sensors and screens are rectangular as the pixels. This problem can be partly solved by increasing grey level or color level number, but this is only the deception of the eye, the result is still the same, some stairs become only lower intensity. This minimizes visible distortion artifacts.

Anti-aliasing phenomenon occurs when pixel is partially covered with light and dark area. That pixel intensity is proportional to light and dark area ratio. Anti-aliasing obtains naturally when picture is taken on digital camera. Anti-aliased image looks better, curves and lines looks smooth.

In digital signal and image processing, anti-aliasing is the technique of minimizing the distortion artifacts known as aliasing when representing a high-resolution signal at a lower resolution. Anti-aliasing is used in digital photography and computer graphics [3-5]. Text and digitally created image rendering on digital screen like LCD or digital projector have problem with pixel aliasing – image is jagged. Therefore, there are many methods to make image anti-aliased.

Theoretically, anti-aliased pixels are on the image edges, but not every edge pixel is anti-aliased. After some experiments with the most popular edge filters, it was found that some edge filters shift the edge at least by one pixel position. Other edge filters generate edge more than one pixel thickness and that is not usable for anti-aliased pixel detection. Moreover, the main weakness of various edge filters is threshold, which value mostly defined manually. Additionally, threshold value depends not only on whole image illumination, but also on image part illumination, for example, shadow of object has less light than common image. To get well-formed edge on shadowed image it is necessary to define different threshold values in shadow zone and in light zone. Unfortunately, automated edge detection methods are currently unformed.

Edge and anti-aliased pixels relation cannot be superposed. Moreover, edge detection commonly require manual turning, which is unsuitable for image magnification that will be automatic, without any turning or any interposition with human.

Image anti-aliasing technique

Image anti-aliasing filter use convolution as the most of image-processing methods use. The simplest convolution kernel

$$K_{AA} = \frac{1}{5}\begin{vmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{vmatrix}. \quad (1)$$

The C code implementation of this convolution algorithm is very simple and shows how it works.

```
int smooth_mpixel(int x, int y)
{
  int sum;

  sum = get_mpixel(source, x, y);
  if (sum == 255)
  {
    // pixel is transparent, do not filter
    return sum;
  }
  else
  {
    sum += get_mpixel(source,x - 1,y);
    sum += get_mpixel(source,x + 1,y);
    sum += get_mpixel(source,x,    y - 1);
    sum += get_mpixel(source,x,    y + 1);
    return sum / 5;
  }
}

void simple_smooth(int width, int height)
{
  int x, y;

  for(y=1; y<height-1; y++)
  {
    for(x=1; x<width-1; x++)
    {
      set_mpixel(target,x,y,smooth_mpixel(x,y));
    }
  }
}
```

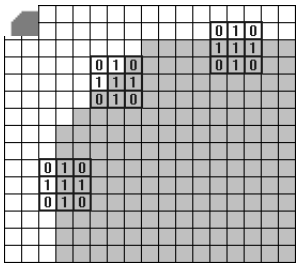

Fig. 1. Anti-aliased filter

Fig. 2. Anti-aliased image

Each anti-aliased image (Fig. 2) pixel is calculated as mean of five pixels (Fig. 1). This routine has an asymmetry, which can be both an advantage and a disadvantage: diagonal edges are blurred more than horizontal or vertical edges. To show why, the filter matrix was put in the following figure (Fig. 1) on a horizontal edge, a vertical edge and an edge at 45 degrees. Assume that in this figure, a white pixel has value one (1.0) and a gray pixel has value zero (0.0). Anti-aliasing filter blur an image and it looks slightly like an image from a digital camera. However, in real camera anti-aliased pixel is only one pixel that is between light and dark area. When there is more than one pixel, they represent a ramp of image intensity. In this situation, there are two anti-aliased pixels, one on the top of ramp and other on the bottom of the ramp.

Anti-aliased and intensity slope pixel detection

Most of mathematic methods are reciprocal, and anti-aliased pixel can be detected with inverting previous method. Coefficients for surround pixel values are calculated from image A pixels as matrix:

$$\begin{matrix} A_4 & A_3 & A_2 \\ A_5 & A_0 & A_1 \\ A_6 & A_7 & A_8 \end{matrix}, \quad (2)$$

$$\begin{aligned} A_0 &= A(x,y), \\ A_1 &= A(x+1,y) - A(x,y), \\ A_2 &= A(x+1,y-1) - A(x,y), \\ A_3 &= A(x,y-1) - A(x,y), \\ A_4 &= A(x-1,y-1) - A(x,y), \\ A_5 &= A(x-1,y) - A(x,y), \\ A_6 &= A(x-1,y+1) - A(x,y), \\ A_7 &= A(x,y+1) - A(x,y), \\ A_8 &= A(x+1,y+1) - A(x,y). \end{aligned} \quad (3)$$

After number of tests it was found, that anti-aliased and slope pixels has some positive and negative and no coefficients with zero value. Zero values means that pixel is on the top or the bottom of intensity hop or on the straight line.

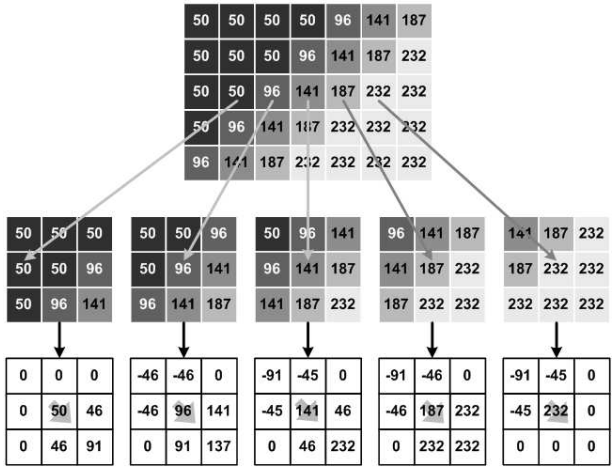

Fig. 3. Scanning anti-aliased image line

Very simple situation (Fig. 3) shows how slope and anti-aliased pixel detector works. When pixel lies on slope or is anti-aliased, surround coefficients have positive and negative values and when line intensity unvarying no more than two zero values which direction is the same as line.

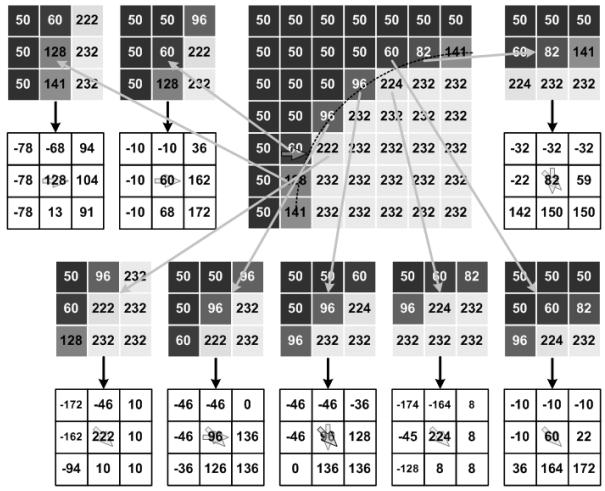

Fig. 4. Scanning anti-aliased image curve

The same algorithm can be applied for curves (Fig. 4) with the same results. Curve shape lines sometimes have more than one direction. Therefore, algorithm will be supplemented with direction evaluation function.

Fig. 5. Real image with lines, curves and noise

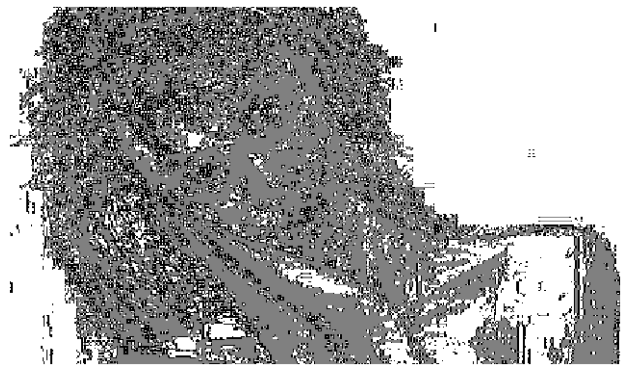

Fig. 6. Anti-aliased and slope map (anti-aliased – black, slope – gray, any –white)

Real pictures (Fig. 5) have flashes, shadows, noise and digitization artifacts, which disturb simple algorithm and it must be enhanced. Image (Fig. 6) shows anti-aliased (black) ant slope (gray) pixels to show how this algorithm works. The main feature, that matrix coefficients must have with different signs have been supplemented with direction evaluation. Image and digitization noise can be recognized as anti-aliased or slope pixel. Some kind of noise as "salt and pepper" noise commonly is only one pixel noise, and this algorithm is insensitive for that kind of noise, because all surrounded pixels intensity are lower for "salt" pixels or higher for "pepper" pixels, than difference of pixel intensity always have the same sign.

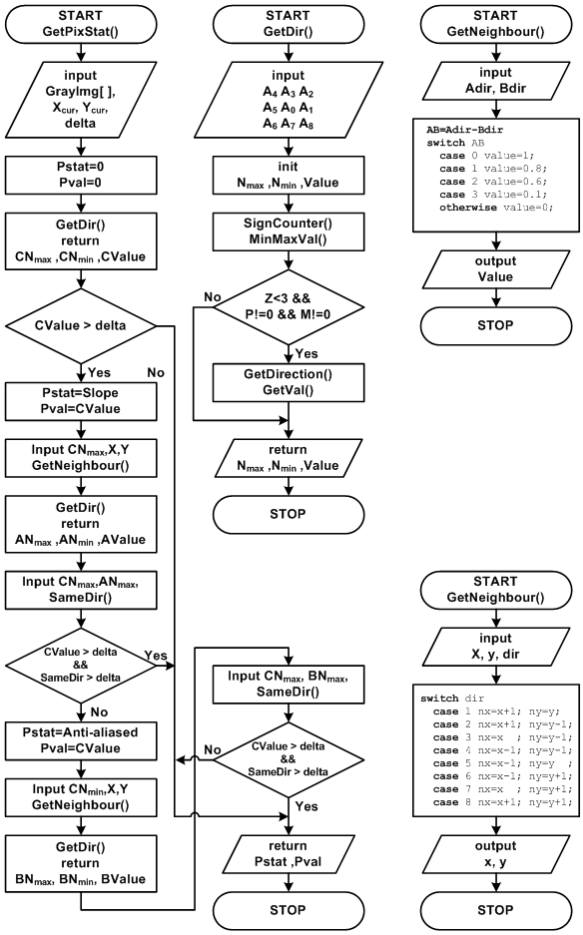

Fig. 7. Anti-aliased and slope pixel detection algorithm

For each pixel is checking surrounded pixels difference with center pixel if it has positive and negative values and no more than two zero values. Therefore, this pixel is at least slope pixel. Then check if the pixel is anti-aliased. Previously, pixel numbers were obtained with maximal and minimal values. Later try these pixels as center and check if these pixels are on top or bottom of brightness landscape. A top or bottom pixel has more than two zero values in difference matrix.

Testing and results

Other method to detect anti-aliased and slope pixels was not found, therefore this method cannot be compared with another method. Therefore, there was only optical method to check how it works.

For artificial images, created with drawing tools, this method works excellent. However, with real pictures, taken with photo camera or unknown source, accuracy is about 65 – 95 percent. One problem that decreases accuracy is noise that come from image sensor. Image with good lightning draw better results when pour lighted images have more random noise and shows worse results.

The other source of errors is image compression artifacts that are visible as intensity waves near edges – these artificial waves are recognized by detector.

After number of tests it was defined, that pixel that was unrecognized as anti-aliased was impacted with noise, accordingly method, as it is designed work perfect.

Conclusion

After revising, a lot of literature another method to detect anti-aliased pixel was not found. There are many methods to make anti-aliased image from aliased. In many application anti-aliased image is exactly what expected, and feature for anti-aliased pixel detection is unnecessary.

Anti-aliased and slope pixel detector works perfect as it was designed, but for better results for image magnification purposes it must be improved. Small kernel 3x3 guarantee high processing speed, but cannot detect continuous lines in noisy images.

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V. Vyšniauskas. Anti-aliased Pixel and Intensity Slope Detector // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 7(95). – P. 107–110.

Each image dot can be associated with some image part, for example line, area where intensity changes or area with constant intensity. Image processing use these image parts. Image transferring into the digital domain in any words image digitizing, because of finite dot (pixel) size some pixels are partly closed with light and dark area. These pixels are called anti-aliased. Frequently these pixels are unwanted or impede to extract edge or blur magnified image or ripple edge in shrink image. When it is possible to detect that pixel, different algorithm can be applied for processing and image quality can be increased. A method to detect anti-aliased pixels and pixels which intensity change continuous (slope) is presented. Ill. 7, bibl. 5 (in English; summaries in English, Russian and Lithuanian).

В. Вишняускас. Детектор пересечённых точек и точек на склоне яркости // Электроника и электротехника. – Каунас: Технология, 2009. – № 7(95). – P. 107–110.

Каждая точка изображения может быть отнесена к какому нибуть объекту в нем, например, к линии, к зоне с изменяющейся яркостью, или к зоне с постоянной яркостью. Эти части изображения используются при обработке. При переводе изображения в дискретное пространство, или оцифровке из-за конечной величины точки появляются такие точки, которые частично накрывают светлую и тёмную части изображения. Такие точки называются пересечёнными. Чаще всего они мешают выделить контур, способствуют размыванию контуров при увеличении, или делают рябь на контурах при уменьшении. Если определить такие точки, то к ним можно применить другой метод обработки и тем самым улучшить качество изображения. Представлен метод обнаружения пересечённых точек и точек на склоне яркости. Ил. 7, библ. 5 (на английском языке; рефераты на английском, русском и литовском яз.).

V. Vyšniauskas. Susiliejančių ir ryškumo šlaito taškų nustatymas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 7(95). – P. 107–110.

Kiekvieną vaizdo tašką galima priskirti kuriai nors vaizdo daliai, pavyzdžiui, linijai, ryškumo pokyčio sričiai ar sričiai, kurios ryškumas nesikeičia. Šios vaizdo dalys naudojamos apdorojant vaizdus. Perkeliant vaizdus į diskretinę erdvę arba, kitaip sakant, juos skaitmeninant, dėl baigtinio taško dydžio atsiranda taškų, kuriuos iš dalies uždengia šviesi ir tamsi vaizdo sritys. Tokie taškai vadinami susiliejančiais. Dažnai, apdorojant vaizdus, jie ne tik nereikalingi, bet ir trukdo, pavyzdžiui, jie trukdo išskirti kontūrus arba kontūras išskysta didinant vaizdą bei raibuliuoja jį mažinant. Nustačius tokius taškus ir apdorojant vaizdą pagal kitokius algoritmus, galima labai pagerinti apdoroto vaizdo kokybę. Pateikiamas metodas, kuris leidžia aptikti susiliejančius taškus ir taškus, kuriuose kinta vaizdo ryškumo intensyvumas. Il. 7, bibl. 5 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).