Use Intelligent Techniques in Detecting Straight Lines in Digital Images

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Abstract: *Knowledge about the lines in an image is useful in many applications, e.g. in Computer vision. If the equations of the same line in several 2D images are known, then it is possible to get the coordinates of the 3D object giving rise to the 2D images. To manually extract the line information from an image can be very tiring and time-consuming especially if there are many lines in the image. An automatic method is preferable, but is not as trivial as edge detection since one has to determine which edge point belongs to which line, if any. The Hough-transform makes this separation possible and is the method we have used in our program for automatic line detection.For better results we will Hybrid hough method with genetic algorithm will reach perfect results*

I.   I Gray – Scale Images

Gray – Scale Images are referred to as monochrome, They contain brightness information only, on color information. The number of bits used for each pixel determines the number of different brightness levels available. The typical image contains 8 bit/pixel data which allows us to have 256(0-255) different brightness (gray) levels. This representation provides more than adequate brightness resolution in terms of the human visual system's requirement and provide a "noise margin" by allowing for approximately twice as many gray levels as required. This noise margin is useful in real-word application because of the many different type of noise inherent in real systems [3][9].

II. Image Smoothing

The Gaussian smoothing operator is a 2-D convolution operator that is used to 'blur' images and remove detail and noise. In this sense it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian ('bell-shaped') hump. This kernel has some special properties which are detailed below. The Gaussian distribution in 1-D has the form

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

The Gaussian distribution in 2-D has the form [2].

$$G(x, y) = \frac{1}{\sqrt{2\pi}\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

III. Edge Detection

After smoothing the image and eliminating the noise, the next step is to find the edge strength by taking the gradient of the image. The Sobel operator performs a 2-D spatial gradient measurement on an image. The gradient magnitude is given by

$$|G| = \sqrt{GX^2 + GY^2}$$

Then the approximate absolute gradient magnitude (edge strength) at each point can be found by the formula below which is simple to calculate compared to the above exact gradient magnitude. Approximate gradient magnitude given below[8] :

$$|G| = |GX| + |GY| \qquad \begin{matrix} \cdots\cdots\cdots \;\; ⑥ \\ \cdots\cdots\cdots \;\; ⑦ \end{matrix}$$

The Sobel operator uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (Columns)   and   the   other   estimating   the   gradient   in   the y-direction (Row). SobelGx and Gy masks shown below each one estimate gradient x direction and y direction respectively . [1]

GX   GY

$$\begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \qquad \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

IV. Genetic Algorithm

Genetic algorithms search the solution space of a function through the use of simulated evolution, i.e., the survival of the fittest strategy. Genetic algorithms have been shown to solve linear and nonlinear problems by exploring all regions of the state space and exponentially exploiting promising areas through mutation, crossover, and selection operations applied to individuals in the population, which is individual solutions (analogous to chromosomes) of the state space [5]. These operators, which rely on probability rules, are applied to the population, and successive generations are produced. In general, the starting search for an optimal solution begins with a randomly generated population of chromosomes. Each generation will have a new set of chromosomes obtained from the application of the operators. A fitness, or objective function, is defined according to the problem. The parent selection process ensures that the fittest members of the population have highest probability of becoming parents, in the hope that their offspring will combine desirable features, and have superior fitness, to both. The algorithm terminates either when a set of generation number is reached, or the fitness has reached a "satisfactory" level. The use of a genetic algorithm requires the determination of six fundamental issues: (1) chromosome representation, (2) selection function, (3) creation of the initial population, (4) genetic 27 operators making up the reproduction function, (5) fitness function, and (6) termination criteria. The Genetic Algorithm consists of the following steps:
1. Generate the initial population.
2. Evaluate the fitness of the each individual according to a fitness function.
3. Select the fittest individual for mating.
4. Apply reproductive operators (e.g. crossover, mutation) to create offspring.
5. Evaluate the fitness of the offspring and select the fit individuals from the current generation and the offspring. They form the population of the next generation.
6. Stop if stopping criterion is met, else go to step 3.
A genetic algorithm is summarized in Figure 4.1, and each of the major components is discussed in detail below.[7]
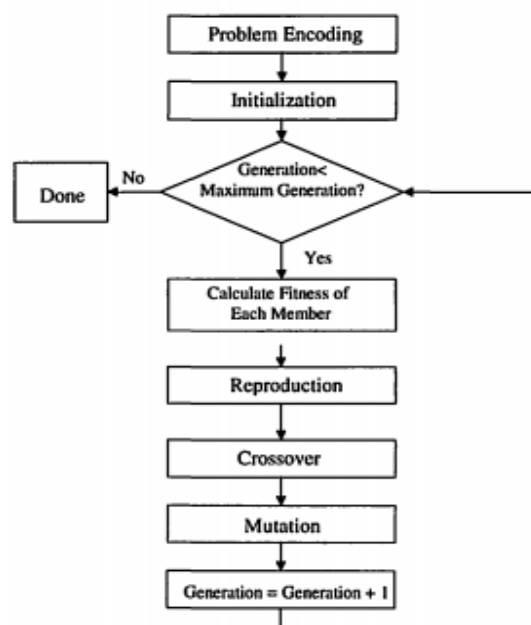

V Hough Transform

The Hough transform (HT), named after Paul Hough who patented themethod in 1962, is a powerful global method for detecting edges. Ittransforms between the Cartesian space and a parameter space in which astraight line (or other boundary formulation) can be defined.[6]

Let's consider the case where we have straight lines in an image. We firstnote that for every point (,) ii x y in that image, all the straight linespassing through that point satisfy Equation 1 for varying values of lineslope and intercept (m,c) , [$y = mx + c$] …. Equation 1, see Figure 1.
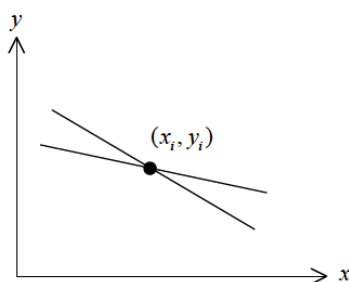
Figure 1: Lines through a point in the Cartesian domain.

Now if we reverse our variables and look instead at the values of (m,c) as afunction of the image point coordinates (,) ii x y , then Equation 1 becomes:c = y - mx Equation 2Equation 2 describes a straight line on a graph of c against m as shown inFigure 2.
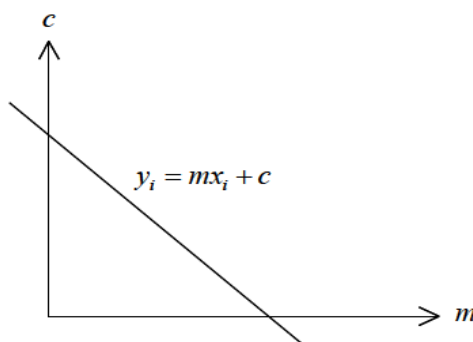
Figure 2: The (m,c) domain.

At this point, it is easy to see that each different line through the point(xi ,yi) corresponds to one of the points on the line in the (m,c) space.Now, consider two pixels P1 and P2, which lie on the same line in the(x, y) space. For each pixel, we can represent all the possible lines throughit by a single line in the (m,c) space. Thus a line in the (x, y) space thatpasses through both pixels must lie on the intersection of the two lines inthe (m,c) space, which represent the two pixels. This means that all pixelswhich lie on the same line in the (x, y) space are represented by lineswhich all pass through a single point in the (m,c) space, see Figure 3 andFigure 4.[6]
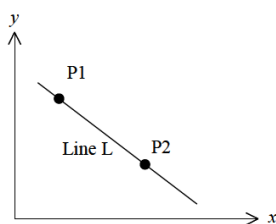
Figure 3: Points on the same line.
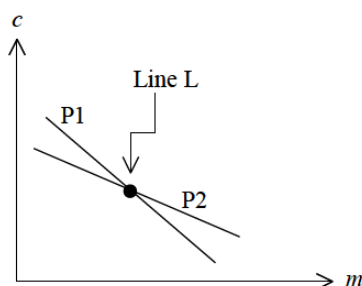
Figure 4: The mapping of P1 and P2 from Cartesian space to the(m,c) space.

Following the discussion above, we now can describe an algorithm fordetecting lines in images. The steps are as follows:
1. Find all the edge points in the image using any suitable edgedetection scheme.
2. Quantize the (m,c) space into a two-dimensional matrix H withappropriate quantization levels.

3. Initialize the matrix H to zero.

4. Each element of H matrix, (,) ii H m c , which is found to correspond toan edge point is incremented by 1. The result is a histogram or avote matrix showing the frequency of edge points corresponding tocertain (m,c) values (i.e. points lying on a common line).

5. The histogram H is thresholded where only the large valued elements are taken. These elements correspond to lines in the original image.
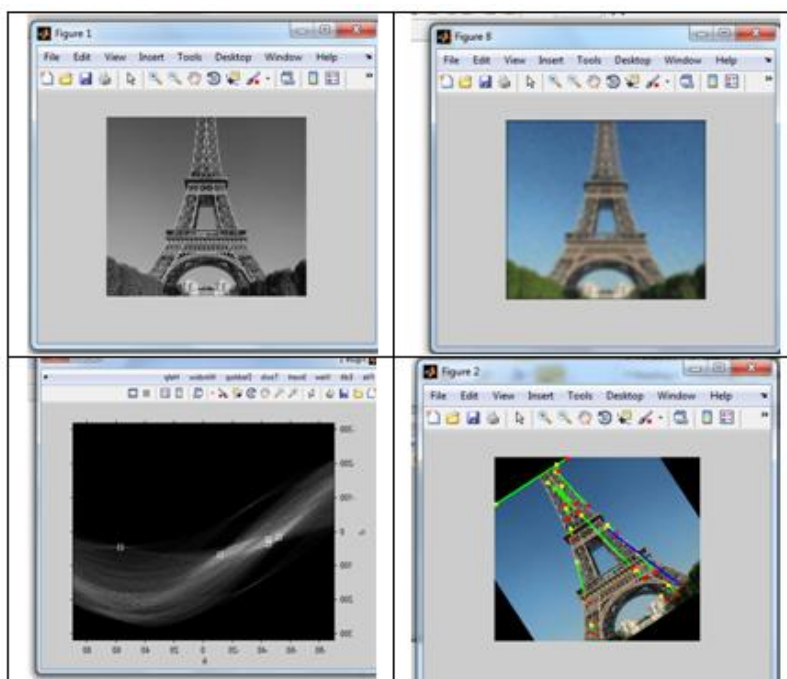
V. Flowchart Suggested Hybrid Method
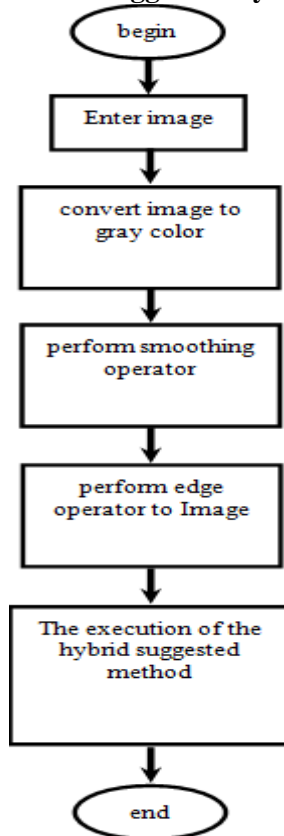
VI. Applied Algorithm
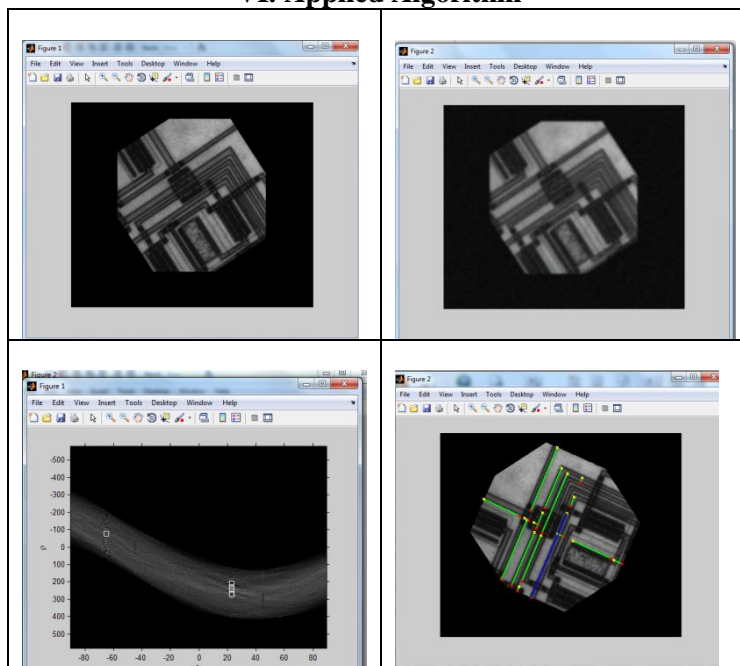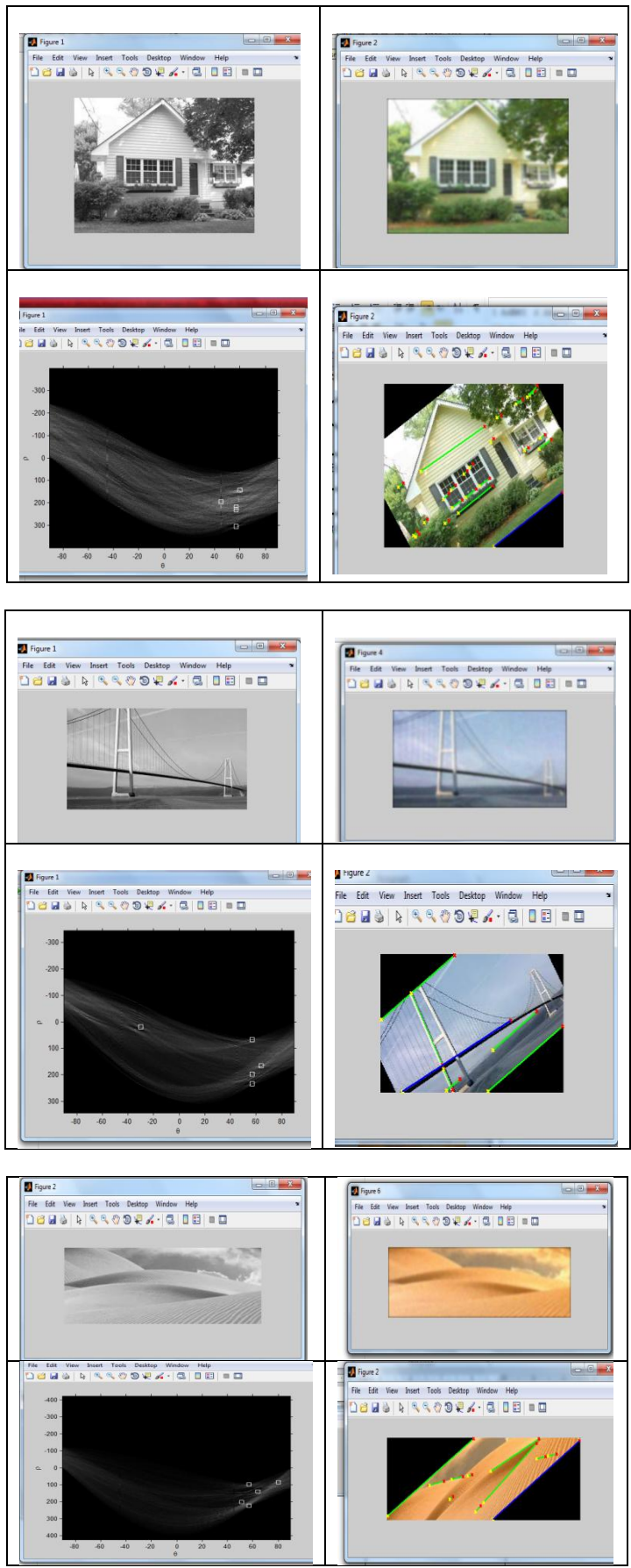
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