

Automatic Extraction Of Pedestrian Path From Street Image

Field of invention

This invention relates to a method and a system that automatically extract a
5 pedestrian path from a digital image of a street. More particularly, this invention
relates to a method and a system that automatically extracts a pedestrian path and
determines a width of the pedestrian path from a street image.

Background

10 Going to a supermarket to buy grocery may be routine for most of us but for
the wheelchair users, a curb or a small step along the way can be a major obstacle
that prevent access to the supermarket. When we need to visit unfamiliar places, we
can always refer to a street map to help us navigate to our destinations. Such a map
may not be helpful to wheelchair users, as barrier-free access information is not
15 provided by most maps. Thus, for a wheelchair user to visit a new place, he is often
required to spend much effort searching and exploring possible barrier-free
pathways.

To increase accessibility for the disabled, those skilled in the art have been
20 building up a database to provide accessibility information about the commercial and
residential buildings in Singapore. However, the database mainly provides textual
information about availability of taxi stands, accessible parking lots, accessible lifts
and number of accessible entrances. Map information about barrier-free entrances is
only available for a few selected buildings. Pedestrian path and route information for
25 these areas are not available in this database.

A system that provides pedestrian path information and barrier-free routing
from point-to-point would be beneficial to the wheelchair users as this information
would reduce the travel time needed to explore accessible paths.

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Thus, those skilled in the art are constantly striving to provide a method and a system that collects pedestrian path in a more effective way.

Summary of Invention

5 The above and other problems are solved and an advance in the art is provided by a method and/or a system that extracts pedestrian path from a street image in accordance with this invention. A first advantage of a method and/or a system in accordance with embodiments of this invention is that it improves the efficiency of pedestrian path data collection. A second advantage of a method and/or
10 system in accordance with embodiments of this invention is that the method is fully automated without the need of any input from a user. A third advantage of a method and/or system in accordance with embodiments of this this invention is that the method and/or system is able to measure the relative width of the path as well as the distance of the path based on the camera location.

15 A system and a method for extracting pedestrian path from one a plurality of images captured from a side of a road in accordance with an embodiment of this invention is provided in the following manner. The system receives the image. The system then filters predetermined type of pixels in the image to form a first image and
20 filters edge lines in the image to form a second image. The system then combines the first image and the second image to form a third image. The third image comprises a first side, a second side, a top side, and a bottom side. A line is drawn for each of N sample points distributed on the first side of the third image. A number of white pixel counts for each of the line of the N sample points is determined and
25 stored in a register. A histogram is plotted based on the number of white pixel counts stored in the register against the N sample points. A position of a pedestrian path in the image is determined based upon a peak above a predetermined threshold line of the histogram.

30 In accordance with an embodiment of this invention, the system converts the received image from Red-Green-Blue (RGB) colour space to Hue-Saturation-Value

(HSV) colour space. The system then determines and converts the predetermined type of pixels to white colour. Preferably, the predetermined type of pixels is green in colour which has Hue values from 0.15 to 0.3.

5 In accordance with an embodiment of this invention, the system detects edge lines in the received image and extracts edge lines detected in the received image. The system then dilates the image and erodes the dilated image to form the second image. The method of detecting and extracting edge lines is Sobel edge detection and extraction algorithm.

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 In accordance with an embodiment of this invention, the system adds the first image to the second image to form an added image. Added image is inverted to form an inverted image. The system then detects each object in the inverted image and determines a pixel count of each object. Object in the inverted image which has a
15 pixel count that is less than a predetermined pixel count. Preferably, the predetermined pixel count is 5000.

 In accordance with an embodiment of this invention, the system selects a one of N sample points on the first side of the third image and draws a line from the
20 selected sample point to the second side. The line is parallel to the top side of the third image. The system then repeats the step of drawing a line drawing for each of the N sample points. In accordance with this embodiment, the system draws a subsequent line at a predetermined angle with respect to the line from the selected one of the N sample points. In accordance with this embodiment, the system obtains
25 a number of white pixel counts on the subsequent line and determines a highest number of white pixel counts among said subsequent line and said line. The system then stores the highest number of pixel counts in the register.

 In accordance with an embodiment of this invention, the N sample points is
30 distributed from an intersection between the first side and the bottom side towards an intersection between the first side and the top side, and wherein N is more than 1.

In accordance with an embodiment of this invention, the position of the pedestrian path is determined based upon a peak closest to a sample point that is half of the N sample points. In accordance with an embodiment of this invention, the system determines a width of the pedestrian path based on intersections of the threshold line and the determined peak.

Brief description of drawings

The above and other features and advantages of a method and a system in accordance with this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a block diagram of a system for extracting pedestrian path from one of a plurality of images captured from a side of a road in accordance with this invention;

Figure 2 illustrating an image captured by an image capturing device that is mounted on a side of a vehicle;

Figure 3 illustrating an image that is readily available from the Internet;

Figure 4 illustrating a block diagram of a processing system of the various components for providing a system in accordance with an embodiment of this invention;

Figure 5 illustrating a flow diagram of a process for extracting pedestrian path from one of a plurality of images captured from a side of a road in accordance with this invention;

Figure 6 illustrating a flow diagram of a process to form a first image in accordance with this invention;

Figure 7 illustrating a flow diagram of a process to form a second image in accordance with this invention;

Figure 8 illustrating a flow diagram of a process for combining the first and second image to form a third image in accordance with this invention;

Figure 9 illustrating a flow diagram of a process for drawing lines on the third image in accordance with this invention;

Figure 10 illustrating a flow diagram of a process for determining a location of the pedestrian path and the width of the pedestrian path in accordance with this invention;

5 Figure 11 illustrating a diagram for translating the third image to a histogram in accordance with this invention;

Figure 12 illustrating an image of pedestrian path being detected in the street image in accordance with this invention;

Figure 13 illustrating an example of process 600 in accordance with this invention;

10 Figure 14 illustrating an example of process 700 in accordance with this invention;

Figure 15 illustrating an example of process 800 in accordance with this invention; and

15 Figure 16 illustrating an example of process 900 in accordance with this invention.

Detailed description

This invention relates to a method and a system that automatically extract a pedestrian path from a digital image of a street. More particularly, this invention
20 relates to a method and a system that automatically extracts a pedestrian path and determines a width of the pedestrian path from a street image.

A system that contains pedestrian path data needs to be collected. The conventional method of path data collection is through the use of a ground officer
25 using a GPS unit to collect location information as he moves along the pedestrian path. The method is very time consuming and is labor intensive. Other method of path collection involves the plotting of pedestrian path onto a satellite image but this method is not suitable for Singapore as the numerous trees along the road are natural obstacles to the visibility of the pedestrian path on the satellite image.
30 Moreover, the cost of satellite images is very high.

It is envisioned that a system and/or method in accordance with embodiments of this invention may be used to determine a pedestrian path from a street image. Figure 1 illustrates system 100 including computer system 105 and database 110. Database 110 is a repository for storing street images provided by image capturing device 120 or from the Internet 130. Computer system 105 is a typical processing system such as a desktop computer, laptop computer, or other computer terminal that is connected to database 110 or the Internet 130 via either a wired or wireless connection to access the street images. Computer system 105 executes applications that perform the required processes in accordance with this invention. One skilled in the art will recognize that although only one computer system 105 is shown, any number of computer systems may be connected and/or operating in parallel to perform the applications for providing embodiments of this invention without departing from this invention.

Figure 2 illustrates a typical street image captured by an image capturing device that is mounted on a side of a vehicle. Figure 3 illustrates a typical street image that is readily available from Google Street View. As observed from figures 2 and 3, the pedestrian paths are typically horizontal to the bottom or top of the street images. Hence, this invention assumes that all pedestrian paths in the street images are horizontal to the top or bottom of the street images.

Figure 4 illustrates an exemplary processing system 400 that represents the processing systems in computer system 105 that execute instructions to perform the processes described below in accordance with this invention. One skilled in the art will recognize that the instructions may be stored and/or performed as hardware, firmware, or software without departing from this invention. One skilled in the art will recognize that the exact configuration of each processing system may be different and the exact configuration executing processes in accordance with this invention may vary and processing system 400 shown in Figure 4 is provided by way of example only.

Processing system 400 includes Central Processing Unit (CPU) 405. CPU 405 is a processor, microprocessor, or any combination of processors and microprocessors that execute instructions to perform the processes in accordance with the present invention. CPU 405 connects to memory bus 410 and Input/Output (I/O) bus 415. Memory bus 410 connects CPU 405 to memories 420 and 425 to transmit data and instructions between the memories and CPU 405. I/O bus 415 connects CPU 405 to peripheral devices to transmit and receive data between CPU 405 and the peripheral devices. One skilled in the art will recognize that I/O bus 415 and memory bus 410 may be combined into one bus or subdivided into many other busses and the exact configuration is left to those skilled in the art.

A non-volatile memory 420, such as a Read Only Memory (ROM), is connected to memory bus 410. Non-volatile memory 420 stores instructions and data needed to operate various sub-systems of processing system 400 and to boot the system at start-up. One skilled in the art will recognize that any number of types of memory may be used to perform this function.

A volatile memory 425, such as Random Access Memory (RAM), is also connected to memory bus 410. Volatile memory 425 stores the instructions and data needed by CPU 405 to perform software instructions for processes such as the processes for providing a system in accordance with this invention. One skilled in the art will recognize that any number of types of memory may be used to provide volatile memory and the exact type used is left as a design choice to those skilled in the art.

I/O device 430, keyboard 435, display 440, memory 445, network device 450 and any number of other peripheral devices connect to I/O bus 415 to exchange data with CPU 405 for use in applications being executed by CPU 405. I/O device 430 is any device that transmits and/or receives data from CPU 405. Keyboard 435 is a specific type of I/O that receives user input and transmits the input to CPU 405. Display 440 receives display data from CPU 405 and display images on a screen for a user to see. Memory 445 is a device that transmits and receives data to and from

CPU 405 for storing data to a media. Network device 450 connects CPU 405 to a network for transmission of data to and from other processing systems.

Figure 5 illustrates a flow diagram of process 500 performed by a system in computer system 105 in accordance with an embodiment of this invention. The system is provided by processes stored in software, firmware, or hardware that performs the processes described. Process 500 begins in step 505 by receiving a street image from database 110. Process 500 then proceeds to step 510 where a predetermined type of pixels is filtered to form a first image. An embodiment of a process for performing the step of filtering of the predetermined type of pixels will be described further with reference to Figure 6 below.

Process 500 then proceeds to step 515 where edge lines are filtered to form a second image. An embodiment of a process for performing the step of filtering of edge lines will be described further with reference to Figure 7 below.

The first and second images are then combined in step 520 to form a third image. The steps of forming a third image will be described further with reference to figure 8 below. In step 525, lines are super-imposed onto the third image. A number of white pixel counts on or within a certain proximity of each of the lines are determined in step 530. An embodiment of a process for performing the steps of drawing lines and determining number of white pixel counts will be described further with reference to Figure 9 below.

In step 535, a histogram is plotted based on the white pixel counts as shown in Figure 11. Third image 1110 in Figure 11 illustrates a processed image of Figure 2 in accordance with the described embodiment of this invention. Third image 1110 has a top side 1120, a bottom side 1130, a first side 1140 and a second side 1150. Histogram 1160 is plotted based on white pixel counts against a row number which corresponds to the length of either the first side 1140 or the second side 1150. In histogram 1160 shown in figure 11, row number 0 refers to the intersection between

first side 1140 and top side 1120 while row number 1024 refers to the intersection between first side 1140 and bottom side 1130.

The pedestrian path is then determined in step 540 based on the peak in the histogram that is above a predetermined threshold. In particular, a threshold line 1170 based on the predetermined threshold is drawn across the histogram 1160 as shown in figure 11. In cases where it is determined to contain more than one peak, the peak closest to the row number at the middle of the image is determined to be the pedestrian path. However, other methods for determining the likely pedestrian path may be used without departing from this invention. Furthermore, street images are typically obtained using an image capturing device mounted on a side of a vehicle. Hence, such street images may contain a portion of a road at the bottom of street images. Figure 12 shows an example of street image with pedestrian path 1210 being identified. Process 500 ends after step 540.

Figure 6 illustrates a flow diagram of process 600 performed by the system in computer system 105 in accordance with an embodiment of this invention to perform step 510 in process 500. Process 600 begins in step 605 by converting street image from Red-Green-Blue (RGB) colour space to Hue-Saturation-Value (HSV) colour space. All pixels that are green in colour are determined and converted to white colour in step 610. Due to the large amount of greeneries in Singapore, green pixels are determined and converted to white pixels from the street image. One skilled in the art will recognize that each colour may have different shades due to higher resolution images taken from image capturing device. Hence, when determining green pixels in a street image, a range of values may be used for determining a particular colour. One skilled in the art will also recognize that the types of pixels selected for extraction is due to the environment and the exact choice of pixel type selected is left as a design choice to those skilled in the art.

An example of process 600 is illustrated in the following MatLab code wherein a street image is converted from Red-Green-Blue (RGB) colour space to Hue-

Saturation-Value (HSV) colour space. In this example, the pixels that have Hue values from 0.15 to 0.3 (different shades of green pixels) are converted to white pixels. Figure 13 illustrates process 600. Image 1310 shows the original street image. Image 1320 shows the original street image converted to HSV colour space.

- 5 Image 1330 shows that greeneries are converted to white colour. Image 1330 is also an example of the first image in step 510 of process 500.

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%remove Greeneries from the Street image
10  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    C=rgb2hsv(B);
    G = zeros(rmax,cmax/3,3); %G is for grass array

    for i=1:rmax,
15      for j=1:cmax/3;
        if(C(i,j,1)>0.15 && C(i,j,1)<0.3)
            G(i,j,1)=1;
            G(i,j,2)=1;
            G(i,j,3)=1;
20      end
        end
    end
end

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- 25 Figure 7 illustrates a flow diagram of process 700 performed by the system in computer system 105 in accordance with an embodiment of this invention to perform step 515 in process 500. Process 700 begins in step 705 to detect edge lines in street image. Edge lines detected in street images are then extracted in step 710. One skilled in the art will recognize that any type of edge/line detection and/or extraction method such as the Sobel edge detection method may be used without departing from the invention and the exact choice of edge/line detection method
- 30 selected is left as a design choice to those skilled in the art.

The image is dilated in step 715 to expand the shapes or objects in the image. After step 715, process 700 erodes the image in step 720. The image is eroded to contract the image to better define the shapes or objects in the image.

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An example of process 700 is illustrated in the following MatLab code on a street image shown as image 1310 in Figure 14. In this example, the Sobel edge detection algorithm is used to detect edge lines in the street image. Figure 14 illustrates an image being processed by the following MatLab code. Image 1310 shows the original street image. Image 1420 shows a processed image after Sobel edge extraction. Image 1430 shows the image after expansion while image 1440 shows the image after contraction. Image 1440 is also an example of the second image in step 515 of process 500.

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15      %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
      %Use sobel edge detector to find Edge line image
      %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
      D=rgb2gray(B);
      D1 = edge(D,'sobel');

20      %Expansion and contraction of image
      se = strel('square',4);
      D1 = imdilate(D1,se);
      D1 = imdilate(D1,se);
25      E1 = imerode(D1,se);
      E1 = imerode(E1,se);
      N=E1;

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Figure 8 illustrates a flow diagram of process 800 performed by the system in computer system 105 in accordance with an embodiment of this invention. Process 800 is an embodiment of a process for performing step 520 in process 500. Process

800 begins in step 805 to combine both first and second images to form an added image. In particular, first image is added to second image to form an added image. In step 810, the added image is inverted. Small objects in inverted image are then removed in step 815 to form the third image in step 520 in process 500. In particular,
5 process 500 detect each object in the inverted image and determine a pixel count of each object. Process 500 then removes each said object from the inverted image which has a pixel count that is less than a predetermined pixel count.

An example of process 800 is illustrated in the following MatLab code with
10 reference to figure 15. In this example, the first image 1330 is added to the second image 1440 to form noise image 1510. Noise image is then inverted to form inverted noise image 1520. Small objects are removed to form third image 1530. In particular, any objects that is smaller than 5000 pixels are removed.

```

15      %%%%%%%%%%%%%%
      %Add the Green Pixel image & the Edge Line image to form the noise image
      %%%%%%%%%%%%%%
      for i=1:rmax,
          for j=1:cmax/3;
20          Z(i,j,1)=G(i,j,1)+N(i,j,1);

          if(Z(i,j,1)>0)
              Z(i,j,1)=1;
          end
25      end
      end

      invZ = ~Z; %inverse Z image
      K = bwareaopen(invZ,1000); %remove objects smaller than 5000 pixels
30

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Figure 9 illustrates a flow diagram of process 900 performed by the system in computer system 105 in accordance with an embodiment of this invention. Process 900 is an embodiment of a process for performing step 525 in process 500. Process 900 is further illustrated with reference to figure 16. Figure 16 shows third image 1530 having a top side 1620, a bottom side 1630, a first side 1640 and a second side 1650. Sample points 1680-1689 are distributed along either the first side 1640 or second side 1650.

Process 900 beings in step 905 to select a sample point on the first side 1640. As an illustration, sample point 1685 is selected and a horizontal line that is parallel to the top and bottom sides 1620 and 1630 is drawn from sample point 1685 on the first side 1640 to the second side 1650 shown as line 1690 in step 910. The number of white pixels on or within a predetermined distance from the horizontal line is determined and stored in a register in step 930. In step 935, process 900 determines whether horizontal lines have been drawn on all sample points. Process 900 ends if all horizontal lines have been drawn on all sample points. Otherwise, process 900 proceeds to step 940 to select the next sample point and repeat from step 910. One skilled in the art will recognize that although only 10 sample points are illustrated in figure 16, any other number of sample points may be use without departing from the invention. Further, the more sample points selected would equate to more accurate scanning of a street image to locate the pedestrian path and the exact number of sample points selected is left as a design choice for those skilled in the art.

It is observed that pedestrian path in street images may not be parallel to top and bottom sides of the street image due to positioning of image capturing device. Hence, to compensate such imperfect capturing of street images, process 900 may optionally provide step 915 to draw lines 1691 and 1692 which is at a predetermined angle 1693 with respect to the horizontal line. In step 920, process 900 obtains the number of white pixels on or within a predetermined distance from each of the lines drawn. The highest number of white pixels count among the three lines is determined and store in the register. One skilled in the art will recognize that the

angle 1693 may vary and the choice is left to those skilled in the art. Further, more lines may be drawn for each sample point without departing from the invention.

An example of process 900 is illustrated in the following MatLab code. In this example, the Bresenham lines are drawn to determine the number of white pixels for each of the 1024 sample points.

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Determine number of white pixels for each sample point
10  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    Max = zeros(1024,3);
    for r0 = 1:1024
        for r1 = (r0-200):(r0+200) %1024
            if (r1>0 && r1<1024)
15         counter=0
            [x y] = bresenham_line(r0,1,r1,1280);
                for n = 1:1280-1
                    i=x(n);
                    j=y(n);
20                 if (B(i,j,1)>0)
                        counter=counter+1;
                    end
                end
                if (counter>max(r0))max(r0,1)=counter;max(r0,2)=r1;
25             end
            end
        end
    end
end

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Figure 10 illustrates a flow diagram of process 1000 performed by the system in computer system 105 in accordance with this invention. Process 1000 is an

embodiment of a process for performing step 535 in process 500. Process 1000 begins in step 1005 to retrieve pixel counts for each of the lines drawn from the register. In step 1010, a histogram 1140 is plotted as shown in figure 11. Histogram 1160 is plotted based on white pixel counts against a row number. The row number corresponds to the location of sample points on the first side of third image. For the example shown in figure 11, 1024 sample points are used. This means that row 0 refers to a location of the sample point that is proximate or at the top side of image while row 1024 refers to a location of the sample point that is proximate of at the bottom side of image. A threshold line 1170 based on a predetermined threshold is drawn across the histogram 1160 in step 1015. The location of pedestrian path is then determined at step 1020. Particularly, the peak above the threshold line is determined to be the pedestrian path. In cases where it is determined to contain more than one peak, the first peak which is closest to the row number at the middle of the image is determined to be the pedestrian path. In the example shown in figure 11, the row number at the middle of the image is row number 512 (i.e. $1024/2$). It is observed that street images are typically obtained using an image capturing device mounted on a side of a vehicle. Hence, such street images may contain a portion of a road at the bottom side of street images.

In step 1025, process 1000 determines an estimation of the width of the pedestrian path on the image based on the distance between the intersections 1180 and 1190. In order to obtain a more accurate estimation of the width of pedestrian path, the width determined in step 1025 may be multiplied by a constant. This constant is derived based on the average of a few known width of pedestrian path in relation to width of pedestrian path determined on the street image. Figure 12 shows an example of street image with pedestrian path 1210 and the width of pedestrian path (between 1220 and 1230) being identified.

The above is a description of embodiments of a system in accordance with the invention as set forth below. It is envisioned that those skilled in the art can and

will design alternative embodiments of this invention based upon this invention that infringe on this invention as set forth in the following claims.

Claims

1. A method of extracting pedestrian path from one of a plurality of images captured from a side of a road comprising:

receiving said image;

5 filtering predetermined type of pixels in said image to form a first image;

filtering edge lines in said image to form a second image;

combining said first image and said second image to form a third image, said

third image having a first side, a second side, a top side, and a bottom side;

10 drawing a line for each of N sample points distributed on said first side of said third image;

determining a number of white pixel counts for each of said line of said N sample points;

storing said number of white pixel counts for each of said lines of said N

15 sample points in a register;

plotting a histogram based on said number of white pixel counts stored in said register against said N sample points; and

determining a position of a pedestrian path in said image based upon a peak above a predetermined threshold line of said histogram.

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2. The method according to claim 1 wherein said step of filtering predetermined type of pixels comprises:

converting said received image from Red-Green-Blue (RGB) colour space to Hue-Saturation-Value (HSV) colour space; and

25 determining and converting said predetermined type of pixels to white colour.

3. The method according to claim 2 wherein said predetermined type of pixels are green in colour.

30 4. The method according to claim 2 wherein said predetermined type of pixels is pixel that has Hue values from 0.15 to 0.3.

5. The method according to claim 1 wherein said step of filtering edge lines from said received image to form said second image comprises:

detecting edge lines in said received image; and
5 extracting determined edge lines in said received image.

6. The method according to claim 5 wherein said step of filtering edge lines from said received image to form said second image further comprises:

dilating said image after extracting determined edge lines; and
10 eroding said dilated image to form said second image.

7. The method according to claim 5 wherein said steps of detecting and extracting edge lines is Sobel edge detection and extraction algorithm.

15 8. The method according to claim 1 wherein said step of combining said first image and said second image to form a third image comprises:

adding said first image to said second image to form an added image;
inverting said added image to form an inverted image;
detecting each object in said inverted image;
20 determining a pixel count of each said object; and
removing each said object from said inverted image which has a pixel count that is less than a predetermined pixel count.

9. The method according to claim 8 wherein said predetermined pixel count is
25 5000.

10. The method according to claim 1 wherein said step of drawing said line for each of said N sample points distributed on said first side of said third image comprises:

30 selecting a one of N sample points on said first side of said third image;

drawing a line from said selected sample point to said second side, said line being parallel to said top side of said third image; and
repeating said step of selecting and drawing for each of said N sample points.

5 11. The method according to claim 10 said step of drawing a line from said selected sample point to said second side further comprising:
drawing a subsequent line at a predetermined angle with respect to said line from said selected one of said N sample points.

10 12. The method according to claim 11 wherein said step of determining said number of white pixel counts for each of said line of said N sample points comprises:
obtaining a number of white pixel counts on said subsequent line; and
determining a highest number of white pixel counts among said subsequent line and said line.

15 13. The method according to claim 12 wherein said step of storing said number of white pixel counts comprises storing said highest number of pixel counts.

14. The method according to claim 1 wherein said N sample points is distributed
20 from an intersection between said first side and said bottom side towards an intersection between said first side and said top side, and wherein N is more than 1.

15. The method according to claim 14 wherein said step of determining said position of said pedestrian path comprises:
25 determining a peak closest to a sample point that is half of said N sample points.

16. The method according to claim 15 further comprising:
determining a width of said pedestrian path based on intersections of said
30 threshold line by said determined peak.

17. A system for extracting pedestrian path from one of a plurality of images captured from a side of a road comprising:

instructions for directing a processing unit in a computer system to:

receive said image;

5 filter predetermined type of pixels in said image to form a first image;

filter edge lines in said image to form a second image;

combine said first image and said second image to form a third image,
said third image having a first side, a second side, a top side, and a bottom
side;

10 draw a line for each of N sample points distributed on said first side of
said third image;

determine a number of white pixel counts for each of said line of said N
sample points;

15 store said number of white pixel counts for each of said lines of said N
sample points in a register;

plot a histogram based on said number of white pixel counts stored in
said register against said N sample points;

determine a position of a pedestrian path in said image based upon a
peak above a predetermined threshold line of said histogram; and

20 a media readable by said processing unit in said computer system that stores
said instructions for directing said processing unit in said computer system.

18. The system according to claim 17 wherein said instructions to filter
predetermined type of pixels comprises instructions for directing said processing unit

25 in said computer system to:

convert said received image from Red-Green-Blue (RGB) colour space to

Hue-Saturation-Value (HSV) colour space; and

determine and convert said predetermined type of pixels to white colour.

30 19. The system according to claim 18 wherein said predetermined type of pixels
are green in colour.

20. The system according to claim 18 wherein said predetermined type of pixel is pixel that has Hue values from 0.15 to 0.3.

5 21. The system according to claim 17 wherein said instructions to filter edge lines from said received image to form said second image comprises instructions for directing said processing unit in said computer system to:

detect edge lines in said received image; and
extract determined edge lines in said received image.

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22. The system according to claim 21 wherein said instructions to filter edge lines from said received image to form said second image further comprises instructions for directing said processing unit in said computer system to:

dilate said image after extracting determined edge lines; and
15 erode said dilated image to form said second image.

23. The system according to claim 21 wherein said instructions to detect and extract edge lines is Sobel edge detection and extraction algorithm.

20 24. The system according to claim 17 wherein said instructions to combine said first image and said second image to form a third image comprises instructions for directing said processing unit in said computer system to:

add said first image to said second image to form an added image;
invert said added image to form an inverted image;
25 detect each object in said inverted image;
determine a pixel count of each said object; and
remove each said object from said inverted image which has a pixel count that is less than a predetermined pixel count.

30 25. The system according to claim 24 wherein said predetermined pixel count is 5000.

26. The system according to claim 17 wherein said instructions to draw said line for each of said N sample points distributed on said first side of said third image comprises instructions for directing said processing unit in said computer system to:

- 5 select a one of N sample points on said first side of said third image;
 draw a line from said selected sample point to said second side, said line being parallel to said top side of said third image; and
 repeat said instructions to select and draw for each of said N sample points.

10 27. The system according to claim 26 said instructions to draw a line from said selected sample point to said second side further comprises instructions for directing said processing unit in said computer system to:

 draw a subsequent line at a predetermined angle with respect to said line from said selected one of said N sample points.

15

28. The system according to claim 27 wherein said instructions to determine said number of white pixel counts for each of said line of said N sample points comprises instructions for directing said processing unit in said computer system to:

- obtain a number of white pixel counts on said subsequent line; and
20 determine a highest number of white pixel counts among said subsequent line and said line.

29. The system according to claim 28 wherein said instructions to store said number of white pixel counts comprises instructions for directing said processing unit
25 in said computer system to storing said highest number of pixel counts.

30. The system according to claim 17 wherein said N sample points is distributed from an intersection between said first side and said bottom side towards an intersection between said first side and said top side, and wherein N is more than 1.

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31. The system according to claim 30 wherein said instructions to determine said position of said pedestrian path comprises instructions for directing said processing unit in said computer system to:

5 determine a peak closest to a sample point that is half of said N sample points.

32. The system according to claim 31 further comprising instructions for directing said processing unit in said computer system to:

10 determine a width of said pedestrian path based on intersections of said threshold line by said determined peak.

33. A system for extracting pedestrian path from one of a plurality of images captured from a side of a road comprising:

15 circuitry in a computer system configured to receive said image;
 circuitry in a computer system configured to filter predetermined type of pixels in said image to form a first image;

 circuitry in a computer system configured to filter edge lines in said image to form a second image;

20 circuitry in a computer system configured to combine said first image and said second image to form a third image, said third image having a first side, a second side, a top side, and a bottom side;

 circuitry in a computer system configured to draw a line for each of N sample points distributed on said first side of said third image;

25 circuitry in a computer system configured to determine a number of white pixel counts for each of said line of said N sample points;

 circuitry in a computer system configured to store said number of white pixel counts for each of said lines of said N sample points in a register;

 circuitry in a computer system configured to plot a histogram based on said number of white pixel counts stored in said register against said N sample points; and

circuitry in a computer system configured to determine a position of a pedestrian path in said image based upon a peak above a predetermined threshold line of said histogram.

34. The system according to claim 33 wherein said circuitry in a computer system
5 configured to filter predetermined type of pixels comprises:

circuitry in a computer system configured to convert said received image from Red-Green-Blue (RGB) colour space to Hue-Saturation-Value (HSV) colour space; and

circuitry in a computer system configured to determine and converting said
10 predetermined type of pixels to white colour.

35. The system according to claim 34 wherein said predetermined type of pixels are green in colour.

15 36. The system according to claim 34 wherein said predetermined type of pixels is pixel that has Hue values from 0.15 to 0.3.

37. The system according to claim 33 wherein said circuitry in a computer system configured to filter edge lines from said received image to form said second image
20 comprises:

circuitry in a computer system configured to detect edge lines in said received image; and

circuitry in a computer system configured to extract determined edge lines in said received image.

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38. The system according to claim 37 wherein said circuitry in a computer system configured to filter edge lines from said received image to form said second image further comprises:

circuitry in a computer system configured to dilate said image after extracting
30 determined edge lines; and

circuitry in a computer system configured to erode said dilated image to form said second image.

39. The system according to claim 37 wherein said circuitry in a computer system
5 configured to detect and said circuitry in a computer system configured to extract edge lines is Sobel edge detection and extraction algorithm.

40. The system according to claim 33 wherein said circuitry in a computer system
configured to combine said first image and said second image to form a third image
10 comprises:

circuitry in a computer system configured to add said first image to said
second image to form an added image;

circuitry in a computer system configured to invert said added image to form
an inverted image;

15 circuitry in a computer system configured to detect each object in said
inverted image;

circuitry in a computer system configured to determine a pixel count of each
said object; and

removing each said object from said inverted image which has a pixel count
20 that is less than a predetermined pixel count.

41. The system according to claim 40 wherein said predetermined pixel count is
5000.

25 42. The system according to claim 33 wherein said circuitry in a computer system
configured to draw said line for each of said N sample points distributed on said first
side of said third image comprises:

circuitry in a computer system configured to select a one of N sample points
on said first side of said third image;

circuitry in a computer system configured to draw a line from said selected sample point to said second side, said line being parallel to said top side of said third image; and

5 circuitry in a computer system configured to repeat said circuitry in a computer system configured to select and said circuitry in a computer system configured to draw for each of said N sample points.

43. The system according to claim 42 wherein said circuitry in a computer system configured to draw a line from said selected sample point to said second side further comprising:

10 circuitry in a computer system configured to draw a subsequent line at a predetermined angle with respect to said line from said selected one of said N sample points.

15 44. The system according to claim 43 wherein said circuitry in a computer system configured to determine said number of white pixel counts for each of said line of said N sample points comprises:

circuitry in a computer system configured to obtain a number of white pixel counts on said subsequent line; and

20 circuitry in a computer system configured to determine a highest number of white pixel counts among said subsequent line and said line.

45. The system according to claim 44 wherein said circuitry in a computer system configured to store said number of white pixel counts comprises storing said highest number of pixel counts.

46. The system according to claim 33 wherein said N sample points is distributed from an intersection between said first side and said bottom side towards an intersection between said first side and said top side, and wherein N is more than 1.

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47. The system according to claim 46 wherein said circuitry in a computer system configured to determine said position of said pedestrian path comprises:

circuitry in a computer system configured to determine a peak closest to a sample point that is half of said N sample points.

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48. The system according to claim 47 further comprising:

circuitry in a computer system configured to determine a width of said pedestrian path based on intersections of said threshold line by said determined peak.

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