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A COMPARISON OF THE ROBERTS, SOBEL, ROBINSON, CANNY, AND HOUGH IMAGE DETECTION ALGORITHMS

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ABSTRACT

In this paper, we present an evaluation of the Roberts, Sobel, Robinson, Canny, and Hough image detection algorithms based on their ability to detect outlines of red squares on a black and white background. Inspired by the Institute of Electrical and Electronics Engineers (IEEE) 1998 Southeastcon Student Hardware competition, the algorithms were tested on an image database comprised of gray scale images taken from a test platform constructed similar to the one specified in the competition rules. The success of each algorithm is based on its accuracy in detecting the edges of the red squares within the images from the database. We also provide an analysis of the algorithms in terms of their computational and storage requirements. Upon comparing and analyzing our results, we determined that the algorithms lack either the necessary speed or the efficiency to be a useful option for the Southeastcon competition.

SUMMARY

The work described in this paper was inspired by the 1998 Southeastcon Student Hardware Design competition, where an autonomous robot was to be designed that would seek and deactivate infrared lights located at the four corners of a square, black and white playing surface. As a deterrent, red "mines" were placed on the playing surface that penalized the robotic team if the robot moves over the center of the mine and activates a mine sensor.

A possible solution to the problem posed by the mines would be the design of an image detection system. The system would include some type of camera and image detection software. Images from the playing surface would be captured by the camera and then processed by the software. The software determines the presence, of any red mines within the image. This information would then allow the robot to adjust, if necessary, its direction on the playing surface so as to avoid stepping over the mines.

We have focused our research on the image detection software to investigate the feasibility and relative merits of using a standard image detection algorithm to implement with the design robot. Given the uniformity of the grid design on the

board, several conventional segmentation algorithms — such as Roberts, Sobel, Robinson, Canny, or Hough transform — can be effectively used to detect the borders of the red mines. These algorithms primarily differ in the image masks used to detect large changes in local pixel intensity.

We investigated four popular edge detection algorithms viz. Roberts, Sobel, Robinson, and Canny for this task, based on their different strengths and weaknesses. Images were first processed by the edge detection algorithms to determine points of discontinuities among the pixels. The processed images were then passed through a Hough transform line detection system to determine the lines within the images based on the discontinuities and their relative location.

A comprehensive image database was developed to effectively evaluate the success of each algorithm. The database consisted of two main classes of images — ten unique images taken under controlled lighting conditions and ten images taken in ambient lighting — for a total of 20 test images.

The performance of the edge detection algorithms was evaluated statistically. For each image, the location of each edge detected in the method described above was recorded. The detected edges were then compared to the actual edges in the image. The success of each algorithm was determined by the number of correctly detected edges, number of falsely detected edges, and the average speed of each algorithm. Table 1 indicates some initial results for edge detection performance.

Lighting Conditions	% Edge Detection Error			
	Roberts	Sobel	Robinson	Canny
Ambient	74.9%	65.9%	69.8%	34.8%
Controlled	84.6%	53.0%	68.0%	30.0%
Average	79.75%	59.45%	68.9%	32.4%

Table 1 : The percentage error of correctly detected edges

The results of our evaluations indicate that none of the algorithms tested in our research are suitable for the Southeastcon project of robot motion. The Canny algorithm provided adequate edge detection; but due to its complexity it was much too slow to be used in a realtime or near-realtime environment. The Roberts, Sobel, and Robinson were faster but provided relatively poor edge detection. In conclusion, due to time limitation in detecting and avoiding mines, image detection may not be a realistic method of mine avoidance.