Ruled Line Projection System for Paper Layout Assistance

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Abstract

This paper reports an evaluation experiment using our prototype system which dynamically projects ruled lines on a sheet of paper to support a user in layout design. The system projects lines at proper positions depending on shape and state of the sheet detected from camera images. In the experiment, we compared two sets of lines drawn by a subject with and without ruled lines. It was observed that the difference between these two conditions was significantly large, suggesting the feasibility of the proposed system.

1. Prototype system for evaluation

Our proposed system [1] assumes that computers and other people do not know what task a user is drawing or writing for. This is an absolutely different point from typical augmented reality (AR) system such as a remote assistance system [2] and AR modelling system [3]. Displaying ruled lines on paper has large potential to support for various tasks. This section describes hardware and software configurations of the prototype system.

The prototype system consists of a table with a transparent top board (50cm in diameter), a USB camera (Buffelo Kokuyo Supply Inc. BSW13K05HBK, 640x480 px. 30fps), a LCD projector (3M MP160, 640x480) and a standard PC (CPU: Intel Core2 2.66GHz, RAM: 2.94GB) shown in Fig. 1. The projector is fixed under the table for avoiding occlusions of user's hands.

This system projects ruled lines parallel to each edge of a sheet. To detect four edges, it computes binarization, labelling, edge detection, Hough transformation and rectangle determination, in order. In the rectangle determination, the optimal combination of four lines is selected from more than ten lines by minimizing an error. The error is a ratio of the number of points in two false regions to the number of all the points randomly sampled in the whole frame. The two regions are false positive and false negative regions between the detected sheet region and a hypothesized rectangle. The optimal combination having minimum error is found by a round robin.

Figure 1. Appearance of the prototype system.

Figure 2. Notepads with (left) and without (right) ruled line projection

2. Effectiveness of assistance

This experiment shows effectivity of assistance with projected lines shown in Fig. 2. We compared two sets of lines drawn by a subject with and without projection, as two conditions. For each condition, the subject was instructed to draw ten horizontal lines around the projected lines as straight as possible.

The acquired twelve drawn lines were compared with two measures computed in linear regression. The first measure (1) is average R-squared value, which represents linearity of each line. The second (2) is variance of gradients which represents uniformity among multiple lines.

In the case with ruled line projection, the variance of gradients was 2.77×10^{-4} and the average R-squared value 0.82. In the case without ruled line projection, the variance of gradients was 2.84×10^{-4} and the average R-squared value 0.44. We found that the differences of the measure (1) and (2) are significant large by unpaired t-test ($p<0.05$) and F-test ($p<0.1$), respectively. These results suggest the feasibility of the projected ruled lines.

References

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