IBM Team

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SCOPE

Project Summary

The goal of this project was to design a system to make possible near real-time reporting of inventory levels of products in retail grocery stores. The work encompassed integration of commercially-available vision, navigation, and networking technologies on a shopping cart and the development of custom image processing software to perform inventory sensing and reporting.

Refining the Problem

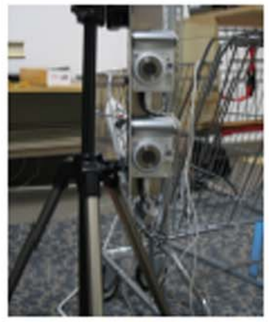
After some initial research, we determined that a robotic platform would not optimally fulfill the needs of our user group. Therefore we chose to mount a distributed sensor system on shopping carts, since this would provide sufficient coverage of the store, minimize the potential for interfering with customers and keep costs down. We chose to mount cameras on the carts as our only method of data collection, since they provide us with the ability to identify items, determine rough stock levels, and even give us convenient pictures that can be manually checked by employees if necessary.

Hardware

Testing Environment

Test Environment: The testing environment was constructed to mimic an actual grocery store and allows us to perform system tests without the need to interfere with the day to day activities of our user group.

Camera Mount

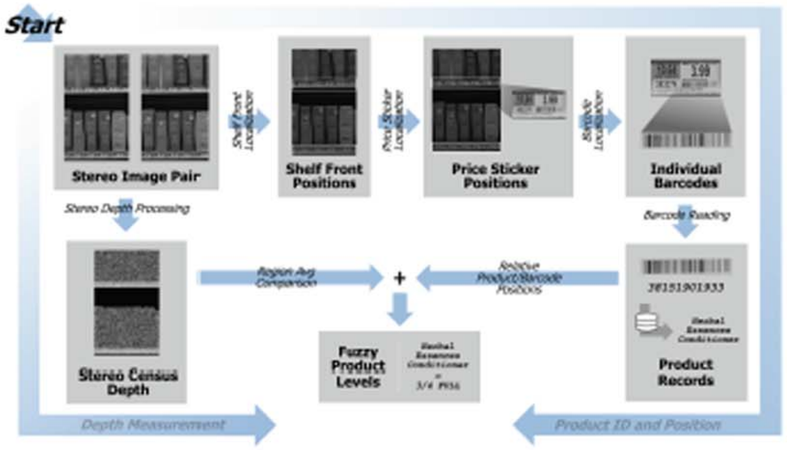


Final camera mounts: (top) Final design of stereo vision camera mount. (bottom) Camera mounted on linear slide for acquisition of test images.

Shopping Cart

Hardware system: The initial modifications made to our shopping cart provide a stable laptop work surface and mounting points for stereo vision cameras.

Software



Edge of Shelf Finding

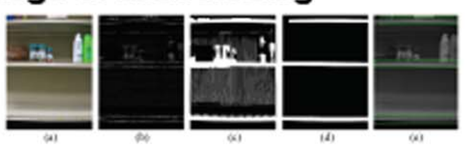
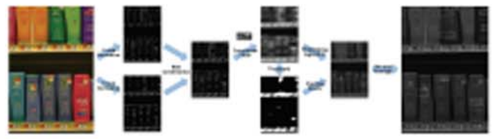


Image (a) is the original image. In image (b), the vertical derivative has been calculated and the threshold of the absolute values taken. In image (c), vertically-adjacent horizontal lines have been joined and the rest eliminated. In image (d), areas that do not extend across at least a third of the frame have been eliminated. Image (e) shows the final bounding boxes overlaid on the original image.

Price Sticker Localization



Price sticker localization algorithm: A visual overview of the steps in our price sticker localization algorithm. The input image is on the left and the output price sticker positions are overlaid on the right.

Barcode Identification

Barcode reading algorithm: The step by step conceptualization of our homemade barcode reading algorithm

Barcode Finding

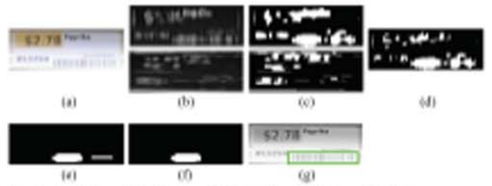
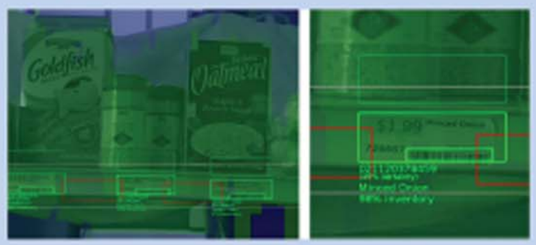


Image (a) is the original price sticker region to be searched. Images (b) are the results of vertical and horizontal Gabor filtering, and (c) are the results with morphological filtering applied. Image (d) is the combination of vertical and horizontal filtered images. Image (e) shows the results of binary opening to locate barcode-proportioned regions. Image (f) shows elimination of all but the largest connected region. Image (g) shows the identified barcode region after left and right boundary expansion.

Results



An example of the results from our final prototype implementation, illustrating all of the data collected. The light gray box is the identified shelf front. The product barcodes, names, and inventory levels are shown in green. The stereo data is overlaid as a blue/green gradient. The thin green boxes above the price stickers show the region used for inventory measurement. The red boxes represent possible price sticker regions that were identified and then discarded when no barcode was found within them. The entire process of