

Announcing the Final Examination of Pavel Babenko for the degree of Doctor of Philosophy

Time & Location: November 2, 2009 at 1:00 PM in ENG-III 450

Title: VISUAL INSPECTION OF RAIL ROAD TRACKS

In this dissertation, we have developed computer vision methods for measurement of rail gauge, and reliable identification and localization of structural defects in railroad tracks. The rail gauge is the distance between the innermost sides of the two parallel steel rails. We have developed two methods for evaluation of rail gauge. These methods were designed for different hardware setups: the first method works with two pairs of unaligned video cameras while the second method works with depth maps generated by paired laser range scanners. We have also developed a method for detection of rail defects such as damaged or missed rail fasteners, tie clips, and bolts, based on correlation and MACH filters. Lastly, to make our algorithms perform in real-time, we have developed the GPU based library for parallel computation of the above algorithms. Rail gauge is the most important measurement for track maintenance, because deviations in gauge indicate where potential defects may exist. We have developed a vision-based method for rail gauge estimation from a pair of industrial laser range scanners. In this approach, we start with building a 3D panorama of the rail out of a stack of input scans. After the panorama is built, we apply FIR circular filtering and Gaussian smoothing to the panorama buffer to suppress the noise component. In the next step we attempt to detect railroad crossings or forks in the panorama buffer. If they are not present, we find the rail edge using robust line fit, otherwise we predict the rail edge positions using Kalman filters. We find the adjusted positions of rail edges using mean shift clustering. We approximate rail head surface by the third degree polynomial and then fit two plane surfaces to find the exact position of the rail edge. Lastly, using rail edge information, we calculate the rail gauge and smooth it with 1D Gaussian filter. We have also developed a vision-based method to estimate the rail gauge from a pair of unaligned high shutter speed calibrated cameras. In this approach, we detect the rail by building an edge map, fitting lines into the edge map using the Hough transform, and detecting persistent edge lines using a history buffer. After railroad track parts are detected, we segment rails out to find rail edges and calculate the rail gauge.

We have demonstrated how to apply Computer Vision methods (the correlation filters and MACH filters in particular) to find different types of rail road elements, like rail road clips, bolts, and rail plates, in real-time. The application of many correlation filters cannot be done in real-time. We have succeeded to overcome this difficulty by using the parallel computation technology which is widely available in the modern GPUs. We have developed a library, MinGPU, which facilitates the use of GPUs for Computer Vision, and have also developed a MinGPU-based library of several Computer Vision methods, which includes, among others, an implementation of correlation filters on the GPU. Besides correlation filters, MinGPU include implementations of Lucas-Kanade Optical Flow, image homographies, edge detectors and discrete filters, image pyramids, morphology operations, and some graphics primitives.

Major: Computer Science

Educational Career:

Bachelor's of Computer Science, 1998, Belarus State University of Informatics and RadioElectronics

Master's of Computer Science, 2006, University of Central Florida

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Approved for distribution by Dr. Mubarak Shah, Committee Chair, on April 23, 2009.

The public is welcome to attend.