Abstract

In the context of increasing automation of modern vehicles, driving simulators with real steering and monitor-based displays are widely used. Head mounted displays (HMD), such as virtual reality (VR) glasses and augmented reality (AR) glasses offer the possibility of using real vehicles and project simulated environments. This new simulation setup will contribute to more efficient and more realistic testing of driver assistance systems, as the tests will be conducted in real cars with real drivers in a simulated environment. Projecting scenes into the HMD, is a challenge, as the moving HMD must be tracked within a car in motion. The present work is embedded in a project at the Institute for Automotive Engineering (IKA), RWTH Aachen, which aims at solving this dynamic tracking challenge.

This master thesis transfers 2D tracker recognition into 3D tracking based on active markers, to solve the dynamic tracking challenge. The tracking system is based on two stereo-calibrated, $659x494\ [px]$ cameras, providing $120\ fps$ in a frontoparallel setup. The computer vision toolbox of OpenCV is utilized to calibrate the camera pair, detect the active markers on the camera frames and calculate the 3D position of the tracked markers. The camera-based tracking system displays a high reliability in detection of the markers and position calculation.

The active marker detection has shown eight-fold lower latency, and higher reliability in favor of a contour detection algorithm in combination with a minimum enclosing circle algorithm, compared to a Hough Circle detection algorithm.

The accuracy of position detection is evaluated against the HTC Vive Lighthouse sensors displaying the position in the Unity Game Engine, which is used as ground truth. Position tracking of the camera-based system was shown to be comparable to the ground truth and displays minor errors. Furthermore, the camera-system inherent latency, averaging to $17.12\ ms$, is promising. However, a latency averaging to $68.5\ ms$ in detecting the same 3D position by the camera-based and Unity-based tracking system has been measured. This high latency value requires further investigation.

Keywords: Camera-based 3D tracking, head-mounted displays, active marker detection, Hough Circles, stereo camera calibration