SUCCESS STORY

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Biologically-Inspired Long-Range Traffic Monitoring System with Basler ace USB 3.0 Camera

Customer

- Customer: Control and Simulation Research Group from National University of Singapore
- Location: Singapore
- Industry: Traffic ITS
- Implementation: 2015

Application

The number of automobiles around the world has increased tremendously during the past few decades, thanks to industrial revolution and advances in transport technology. As a result, the demand for an efficient traffic monitoring system has become inevitable for reliable traffic administration.

In Singapore, the currently-adopted Doppler effect-based LIDAR/RADAR speed detection systems have several drawbacks. One such challenge is that the movement of large vehicles may cause interference to the LIDAR/RADAR signal and lead to inaccuracy of speed readings. Moreover, the image taken by the camera, which is triggered by the speed detector, may contain multiple vehicles at the same time. This can cause incorrect issuance of speeding tickets, as there is no reliable way to pinpoint which vehicle was speeding. On the contrary, hand-held speed detection guns need manual operation, in addition to the above disadvantages.

Recent reports from the Singapore traffic authority show increasing numbers of speeding violations causing fatal accidents and injuries. Efforts to revolutionize traffic monitoring using computer-vision-based systems are limited by the fixed depth-of-field of the camera with short-range viewing ability. These systems perform vehicle tracking near the installed location, and hence they can only track and calculate vehicle speed within a small distance.

A reliable long-distance tracking vision-based traffic system is the real need-of-the-hour for the current situation.

Solution and Benefits

The Control and Simulation Research Group at National University of Singapore has developed a novel, affordable and yet reliable vision-based traffic monitoring system, which is known as 'Raptor Vision', to overcome the shortcomings of the current traffic monitoring systems. The system is inspired by the visual structure found in raptors, which have simultaneous near-field and far-field viewing capabilities. By making use of suitably designed Basler cameras with appropriate view-angle and focal lengths, the tracking range can be extended to 1km, which is a great improvement over single-cameras or current LIDAR/RADAR systems that can only track within 200 metres.

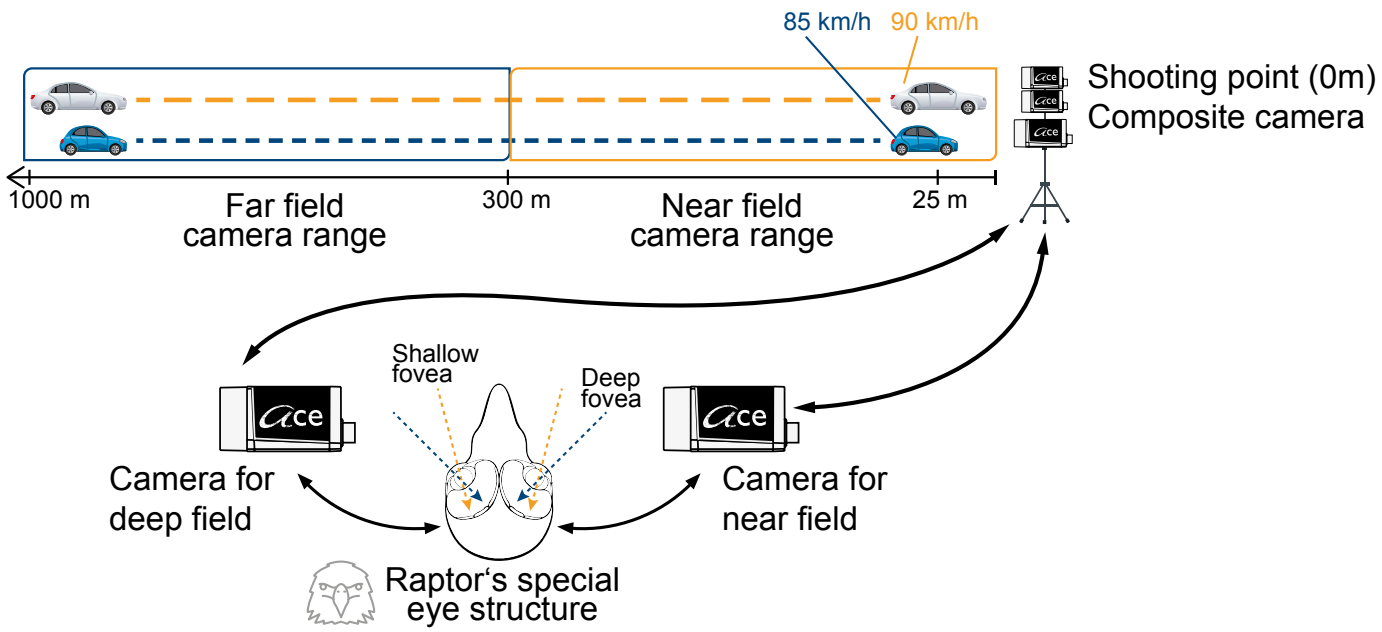

Figure 1. Overview of the Composite Vision System

In the initial phase, Basler distributor in Singapore, *Soda Vision*, provided the research group with sample cameras for proof of concept. The system consists of three Basler ace USB 3.0 cameras (two color cameras for tracking vehicles and one monochrome camera for capturing vehicle plates) and three programs (video shooting program, video stitching program and vehicle tracking program). Calculating the speed of the vehicles using the visual information allowed strong connections between identity and speed. The addition of a separate license plate detection camera to the composite vision system provides sufficient evidence for law enforcement. Through its deep-field object tracking ability, the composite vision system can handle high-speed vehicle tracking and can compensate for the drawbacks of existing speed monitoring systems. Moreover, the system has the potential to perform real-time tracking in complex road conditions and multiple lanes. Its simultaneous near and far-sensing capabilities can also be extended to other industries, such as faulty item inspection along a conveyor belt in manufacturing industries as well as employment in Unmanned Aerial Vehicles (UAV).

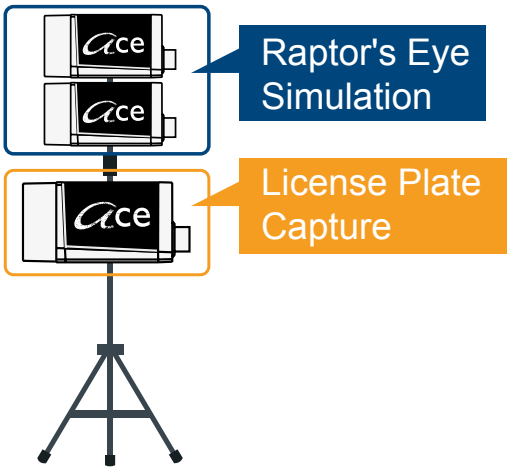

Figure 2 Implementation Using Basler Cameras

Basler ace with USB 3.0 offers low CPU load and highly reliable data transfer between host and device, and integrated (buffer) memory for top stability in industrial applications. Dr. Bharath Ramesh, the Research Fellow leading the team that developed this system comments: "This composite vision system with multiple depth-of-field viewing ability has largely extended the tracking range of traditional traffic monitoring systems. Basler ace cameras with the USB 3.0 standard were chosen for implementation due to their plug-and-play usability (no extra power supply needed) and high bandwidth capability."

For the above composite camera implementation with a license plate camera, synchronous capturing of videos from all three cameras is required, using a stable software that avoids frame rate drops. Random frame rate drops by either or both cameras in the composite setup will cause the two videos to be out of synchronization. Consequently, the composite video will have various tracking issues such as cars suddenly vanishing or double images of them at the stitch line. To prevent frame rate dropping issues, all frames acquired by the cameras are first stored in a buffer before being written to a single video file. To make sure that the buffer operation is fast enough, it is performed in the system RAM, since read/write operation in RAM is generally faster than that of in a hard disk. However, the buffer can become saturated with the image data and cause an abrupt crash of the program. Hence, a multi-threading program was implemented to split the individual operations and carry them out concurrently to save memory and processing time.

The initial experiments to synchronously capture videos using MATLAB was unsuccessful, because it could not differentiate the identical cameras with different lenses. Hence, a program was written in C++ making use of the Application Programming Interface (API) provided by Basler. Thus, camera settings, such as frame rate, shutter speed, and exposure time, were configured to be used by the video acquisition program. This program can accommodate multiple cameras for synchronous recording provided that they are all connected to USB 3.0 ports.

After locating the speeding vehicle, we extract the number plate information by making use of common techniques in computer vision for reading number plate information. These techniques analyze horizontal and vertical edges of an input image to locate the license plate.

Efforts were made to borrow a speed gun or a similar device from the Land Transport Authority of Singapore (LTA) and the Singapore Traffic Police, but both authorities informed us that the use of such device by the public, even for research purposes, is not allowed. Hence, we made use of publicly-installed RADAR speed notification boards to calibrate a smartphone app, and then used it for verifying the estimated speed of the proposed system. The speed board provides reference speed data for comparing the output of mobile applications, several of which were tested for suitability and accuracy. Ultimately, an app called Speed Radar Cam was found to be the most accurate and reliable mobile application to aid in verifying the speed calculation algorithm.

The mobile application was used during the on-site experiments to verify the accuracy of the tracking software. The errors between the calculated speed and the output from Speed Radar Cam usually deviated between ±3km/h. Hence, the accuracy of the proposed speed calculation algorithm falls within a reasonable range and is a reliable vision-based traffic monitoring solution. As pointed out earlier, the main drawback of RADAR-based traffic monitoring systems is the lack of vehicle identity information while estimating the speed. The composite vision system solves this problem by providing a snapshot of the speeding vehicle.

Technologies Used

- *Basler acA1300-30um*, *Basler acA1300-30uc* (1.3 MP USB 3.0 color and monochrome cameras)
- Software: *Basler pylon Camera Software Suite*, Visual Studio2013, Matlab2015a

Basler acA1300-30um, Basler acA1300-30uc

More Information

http://driving-in-singapore.spf.gov.sg/services/driving_in_singapore/documents/Annual_Road_Traffic_Stats.pdf

"Biologically Inspired Composite Vision System for Multiple Depth-of-field Vehicle Tracking and Speed Detection", Lin Lin, Bharath Ramesh, and Cheng Xiang, The 12th Asian Conference on Computer Vision, Singapore, November 1-5, 2014.

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