Noise Rejection Using Variable-Height Timing-Window Technique for Pulse Signals With Variable S/N Ratio

Zhaoqing Wang, Bo Chen, Harry H. Cheng, *Member, IEEE*,
Benjamin D. Shaw, Joe Palen, and Ping Feng

***Abstract*—This paper proposes a novel technique, known as the variable-height timing window (TW), for rejecting noise in an active source detection system. The basic principle of a TW and a methodology of using a microprocessor to dynamically adjust the height of the TW are presented. This variable-height TW technique has been applied to a laser-based detection system (LBDS) for detecting vehicle information on highways. Field-test results of the LBDS showed that the adaptive nature of the proposed TW approach can effectively reject various types of noise under different environmental conditions. This variable-height TW technique can also be used to remove out-of-window noise and suppress the effect of in-window noise in various field environments in which the signal/noise (S/N) ratio is variable.**

***Index Terms*—Laser-based detector, microprocessor control, noise rejection, pulse-signal detection, timing window (TW).**

I. Introduction

THE EMERGING applications in the detection of physical phenomena enable large-scale cognition and reconstruction of the real world. These applications include but are not limited to areas such as contamination and purification, climate prediction, building structures, transportation and traffic control, and even remote harsh environments. Active source detection systems are more reliable in obtaining signals of real phenomena when applied to unpredictable environments, since detection signals vary within different application environments such as indoor/outdoor, day/night, and even with different testing sites. Most systems utilize a repetitive pulse signal as a source to cut down on energy consumption and to be safer for people. Since these systems utilize a pulsed source, they have intrinsic special features for noise processing.

All detection systems are subject to several different types of noise, such as impulse noise [1], interference noise [2], and offset noise for capacitive systems [3]. Any of these types of noise may seriously affect the tolerance, precision, and accuracy of detection and can be classified broadly as either a systematic noise or a random noise [4]. Systematic noise arises from changes in the running conditions, e.g., temperature, humidity, or the aging of sensors. A random noise may include random external sources, random hardware noise, environmental effects, etc. The addition of noise rejection and/or cancellation into any detection system with an ability to change its sensitivity to the source signal would improve its performance and increase its reliability.

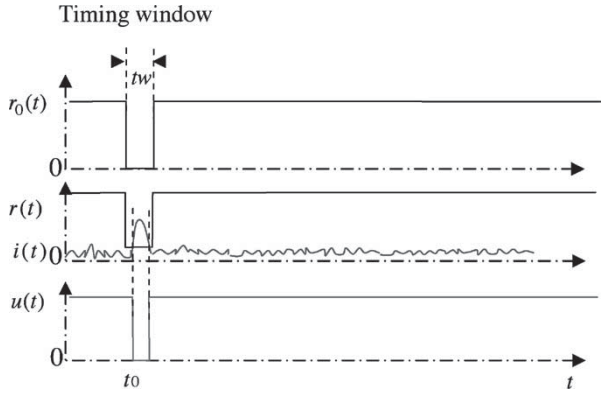

Fig. 1. Principle of a TW.

The example given in this paper is the integration of a variable-height timing window (TW) technique into a laser-based detection system (LBDS) [5] that is developed to detect the velocities and lengths of vehicles on the highway. The system is used outdoors and must adapt to changes in weather and climate, which affects the signal/noise (S/N) ratio of the detection system through the addition of noise, and changes in the magnitude of the reflected signal. This example shows that the use of a variable-height TW to reject noise makes the detection system not only more adaptive to its environment but also more reliable.

In this paper, the basic principle behind TWs is described first. Then, an adaptable noise-rejection method to handle variable S/N-ratio pulse signal using a variable-height TW is presented. Finally, this method is applied to the LBDS, and field-testing results from the highway are presented.

II. Working Principle of TWs

A TW is just a narrow pulse that is used to extract a small regime from an input source, as shown in Fig. 1. Signals outside

Manuscript received January 23, 2004; revised December 12, 2005. This work was supported by the California Department of Transportation through the Partners for Advanced Transit and Highways Program.

Z. Wang, B. Chen, H. H. Cheng, and P. Feng are with the Integration Engineering Laboratory, Department of Mechanical and Aeronautical Engineering, University of California, Davis, CA 95616 USA (e-mail: hhcheng@ucdavis.edu).

B. D. Shaw is with the Department of Mechanical and Aeronautical Engineering, University of California, Davis, CA 95616 USA.

J. Palen is with the Office of New Technology and Research, California Department of Transportation, Sacramento, CA 94273 USA.

Digital Object Identifier 10.1109/TIM.2006.870329