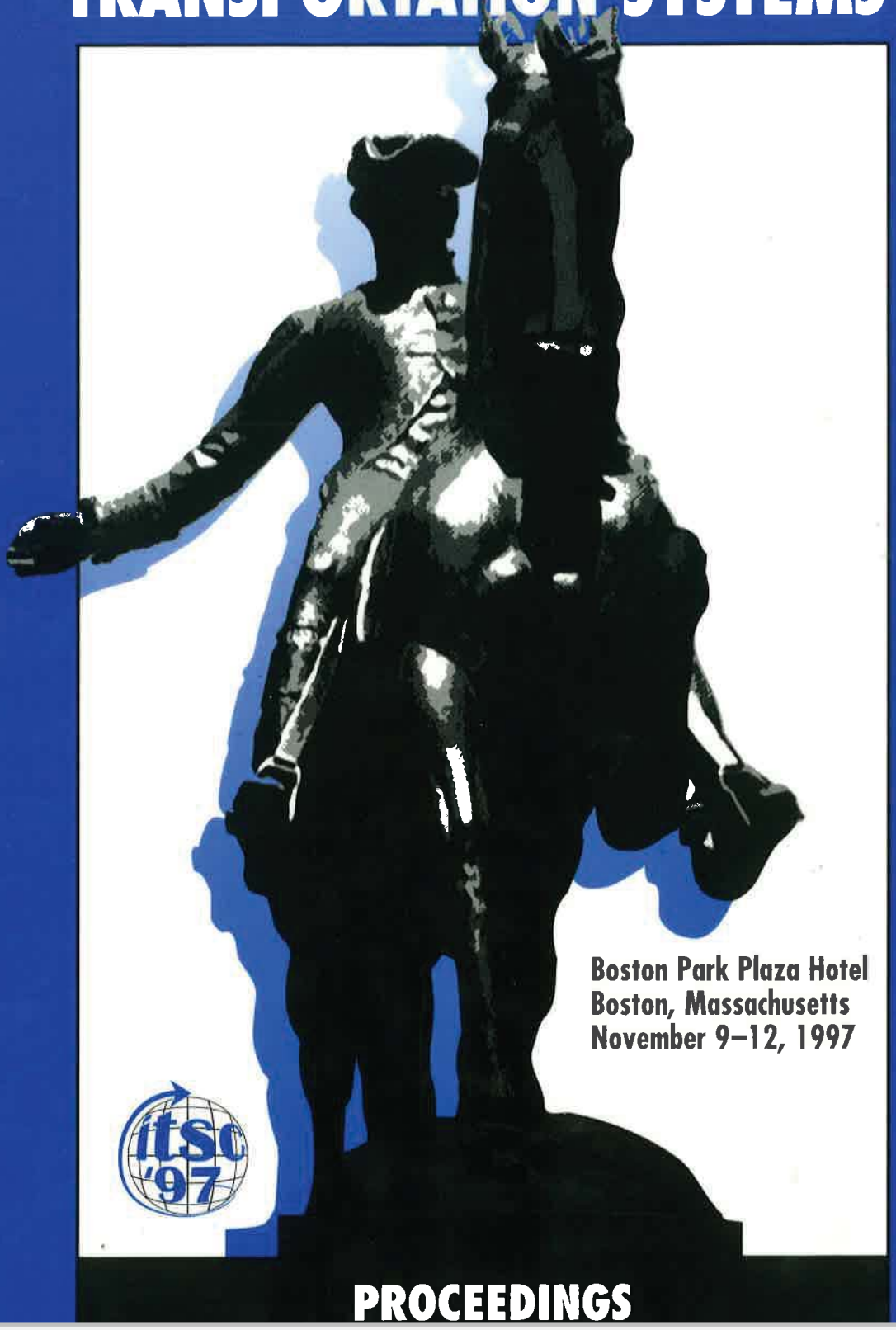
IEEE Conference on

INTELLIGENT TRANSPORTATION SYSTEMS



Boston Park Plaza Hotel
Boston, Massachusetts
November 9–12, 1997

itsc '97

PROCEEDINGS

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Welcome from the Conference General Chair

Welcome to the 1997 IEEE Conference on Intelligent Transportation Systems (ITSC'97).

Hosted by 17 IEEE societies and supported by a number of international organizations, ITSC'97 is the first of a new series focusing on the broad technology aspects of Intelligent Transportation Systems (ITS). ITSC'97 incorporates the very successful Vehicle Navigation and Information System (VNIS) and Intelligent Vehicle Systems (IVS) conferences that have been held by individual IEEE societies in past years. In the technical program on the following pages, you will find that ITSC'97 includes a broad range of important and timely technical topics now active in various ITS projects.

The Conference Committee and the many additional individuals who have arranged ITSC'97 are excited about the technical papers that will be presented. All papers received in response to the 1996 Call for Papers have been peer-reviewed. We believe you will agree their quality is excellent. These papers, plus several sessions arranged around invited papers, have been organized into five parallel tracks of sessions running the full three days of the conference. One highlight is a series of sessions devoted to the rapidly evolving area of Applied Computer Vision.

The conference also features three plenary sessions—one each on the three days of the technical program. In the opening plenary on Monday, ***Mr. Richard Weiland*** *and* ***Mr. Peter Zuk****, well-recognized leaders in current ITS programs, provide some of their perspectives on progress in developing critically needed ITS standards. On the second day, four internationally known speakers will provide their perspectives on four key ITS technologies—navigation and position location, communication, automated vehicle control, and in-vehicle information systems. In the closing plenary on the third day, we invited* ***Dr. Kan Chen****, one of the early IVHS leaders to provide his views on the past, present and future of ITS. Our banquet speaker,* ***Mr. Hans-Georg Metzler****, Vice President of Research for Daimler-Benz, comes to us from Stuttgart, Germany and promises an informative presentation on evolving intelligent vehicle technology and related issues. We hope you won't miss any of these excellent presentations.*

Once again, welcome. We trust ITSC'97 will be a stimulating and technically rewarding conference for you.

Lyle Saxton
Conference General Chair

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IEEE Conference on Intelligent Transportation Systems

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EYE-TRACKING FOR DETECTION OF DRIVER FATIGUE

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Abstract

In this paper, we describe a system that locates and tracks the eyes of a driver. The purpose of such a system is to perform detection of driver fatigue. By mounting a small camera inside the car, we can monitor the face of the driver and look for eye-movements which indicate that the driver is no longer in condition to drive. In such a case, a warning signal should be issued. This paper describes how to find and track the eyes. We also describe a method that can determine if the eyes are open or closed. The primary criterion for the successful implementation of this system is that it must be highly non-intrusive. The system should start when the ignition is turned on without having the driver initiate the system. Nor should the driver be responsible for providing any feedback to the system. The system must also operate regardless of the texture and the color of the face. It must also be able to handle diverse conditions, such as changes in light, shadows, reflections, etc.

INTRODUCTION

Driver fatigue is an important factor in a large number of accidents. Lowering the number of fatigue-related accidents would not only save society a significant amount financially, but also reduce personal suffering. We believe that by monitoring the eyes, the symptoms of driver fatigue in our proposed system can be detected early enough to avoid several of these accidents. Detection of fatigue involves a sequence of images of a face, and observation of eye-movements and blink patterns.

The analysis of face images is a popular research area with applications such as face recognition, virtual tools and handicap aids [9,14], human identification and database retrieval [3]. There are also many real-time systems, being developed in order to track face features [15,13,17]. These kinds of real-time systems generally consist of three components:

a) Localization of the eyes (in the first frame),
b) Tracking the eyes in the subsequent frames,
c) Detection of failure in tracking.

Localization of the eyes involves looking at the entire image of the face and determining the eye-envelopes (the areas around the eyes). During tracking in subsequent frames, the search-space is reduced to the area corresponding to the eye-envelopes in the current frame. This tracking can be done at relatively low computational effort, since the search-space is significantly reduced. In order to detect failure in the tracking, general constraints such as distance between the eyes and horizontal alignment of the two eyes can be used.

This paper is organized as follows: In the next section, we describe some of the previous work in this area. Afterwards, we describe the experimental setup, and how the system operates. Then, we proceed to the description of the algorithm for the detection of fatigue. Finally, we present results and future work.

PREVIOUS WORK

Many methods have been proposed for localizing facial features in images [2,4,5,6,8,10,11,12,19]. These methods can roughly be divided into two categories: *Template-based matching* and *Feature-based matching*. These techniques are compared by Poggio and Brunelli [1]. One popular template-matching technique for extraction of face features is to use *deformable templates* [5,16], which are similar to the active snakes introduced by Kass [7], in the sense that they apply energy

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