Development of Optical Computer Recognition (OCR) for Monitoring Fatigue in Space

F. Yang,1 N. Michael,1 D. Metaxas,1 and D.F. Dinges2

1Center for Computational Biomedicine Imaging and Modeling Center, Rutgers University, New Brunswick, NJ, USA, 2Division of Sleep and Chronobiology, Department of Psychiatry, University of Pennsylvania School of Medicine, Philadelphia, PA, USA

INTRODUCTION. Fatigue from chronic partial sleep deprivation, circadian misalignment (e.g., slam-shifts), and work overload (e.g., EVAs) is a risk factor for astronaut cognitive performance in space flight. There is a need for techniques that objectively and unobtrusively identify the presence of fatigue on-line, when astronauts are performing critical tasks in space. Double-blind controlled trials of various technologies have found that tracking slow eyelid closures (referred to as PERCLOS) is one of the most reliable ways to detect lapses of attention—the hallmark feature of fatigue—during critical performance tasks [1]. This study is using video of the human face during performance to validate an objective, unobtrusive, computational model-based tracker of slow eyelid closures using Optical Computer Recognition (OCR) that reliably identifies the percentage of slow eyelid closures (PERCLOS) as a behavioral marker of astronaut fatigue. The experimental validation of the OCR tracker for fatigue is being done by Dr. David F. Dinges and colleagues (see separate abstract by Jones et al.). The OCR system being developed can monitor alertness in real time providing an early detection of fatigue. Computerized approaches involving inexpensive camera equipment offer a completely unobtrusive way to achieve this requirement. By tracking human faces and measuring (PERCLOS), a measure of subjects’ alertness can be obtained since longer duration blinking directly correlates to increased levels of fatigue [1]. Such systems can have applications beyond space flight (e.g., in consumer cars to alert fatigued drivers and prevent accidents).

TECHNOLOGY DEVELOPMENT. We present a method for real-time face tracking, eye-blink detection and PERCLOS estimation. Our face tracker uses a group of deformable statistical models of facial shape variation and local texture distribution to robustly track facial landmarks (e.g., eyes, eyebrows, nose, and mouth). The model tolerates partial occlusions, it automatically detects and recovers from lost track, and it handles head rotations up to full profile view. Detected facial landmarks are filtered online, both in terms of shape and motion, using eigenspace analysis and temporal dynamical models to prune false detections. We use the tracked position of the eyes as a basis for our eye segmentation algorithm, which further refines this result. This algorithm is based on skin color modeling of the color distribution of pixels in the eye regions as a mixture model. An expectation-maximization (EM) algorithm is used to cluster the pixels into three groups in HSV color space: skin, white and black, and the statistics of these parameters. The first few tracked frames are used to calculate the model of opened eye color appearance. In subsequent frames, this model is used to classify pixels as skin and non-skin, and then morphological operators refine the final eye region. Based on its area, the eyes are classified as opened or closed. Once a blink is detected, our algorithm measures its duration, hence obtaining a measure of PERCLOS by averaging blink durations over a sliding temporal window. As an additional cue, we use kernel density estimation techniques to obtain the model of opened eye appearance. We are also developing a method for dynamic model updates to better tolerate illumination changes and head movement, and super-resolution [2-4] techniques for image enhancement to improve tracking and detection accuracy.


FUNDING. Supported by the National Space Biomedical Research Institute through NASA NCC 9-58.