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SVMT: A MATLAB toolbox for stereo-vision motion tracking of motor reactivity

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ABSTRACT

This article presents a Matlab-based stereo-vision motion tracking system (SVMT) for the detection of human motor reactivity elicited by sensory stimulation. It is a low-cost, non-intrusive system supported by Graphical User Interface (GUI) software, and has been successfully tested and integrated in a broad array of physiological recording devices at the Human Physiology Laboratory in the University of Granada. The SVMT GUI software handles data in Matlab and ASCII formats. Internal functions perform lens distortion correction, camera geometry definition, feature matching, as well as data clustering and filtering to extract 3D motion paths of specific body areas. System validation showed geo-rectification errors below 0.5 mm, while feature matching and motion paths extraction procedures were successfully validated with manual tracking and RMS errors were typically below 2% of the movement range. The application of the system in a psychophysiological experiment designed to elicit a startle motor response by the presentation of intense and unexpected acoustic stimuli, provided reliable data probing dynamical features of motor responses and habituation to repeated stimulus presentations. The stereo-geolocation and motion tracking performance of the SVMT system were successfully validated through comparisons with surface EMG measurements of eyeblink startle, which clearly demonstrate the ability of SVMT to track subtle body movement, such as those induced by the presentation of intense acoustic stimuli. Finally, SVMT provides an efficient solution for the assessment of motor reactivity not only in controlled laboratory settings, but also in more open, ecological environments.

1. Introduction

In experimental psychophysiology, human motor reactivity to sensory stimulation is usually indexed by surface electromyography (EMG), which requires the placement of several electrodes on the skin surface [1]. This limits the mobility of the subject and reduces the possible contexts in which motor responses can be recorded and evaluated. In addition, EMG captures only the activity of specific muscle groups, whereas certain motor reflexes to sensory stimuli, such as the startle reflex, involve a global motor response characterized by complex muscle contraction patterns at different body areas [2]. A detailed investigation of these global motor reactivity patterns, in relation to underlying physiological control mechanisms, could result in a more systematic mapping of psychophysiological processes under sensory stimulation.

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Appendix II. Basic input/output variables

The *params* structure

params.asects – sets the approach to define the preferred body area: 1 for manual definition
params.fps – the video acquisition frequency in frames per second
params.kplot – if set to 1, the frames with all identified keypoints are plotted at the */SVMT/Exports/Keypoints* directory (recommended value: 0)
params.tdplot – if set to 1, a 3D scatter plot is generated for each frame showing the keypoints cloud. The plots are stored at the */SVMT/Exports/Keypoints* directory (recommended value: 0)
params.trajeplot – if set to 1, the trajectory extraction validation plot is generated at */SVMT/Workspace/ Trajectory_extraction* (recommended value: 1)
params.mvideo – option to generate the event summary video file at */SVMT/Workspace/Videos* (recommended value: 0; 1 to make video without compression, for compression input the compression string instead)
params.sc – a cell containing the names of the desired body areas as strings (e.g. 'Head'; 'Left shoulder'; 'Right shoulder'; 'Core')

The *paths* structure

paths.repos – the path of the toolbox directory SVMT_Repository
paths.raw – the path of the Raw image directory
paths.exports – the Exports path location
paths.calibration – the Calibration export files path

The *patterns* structure

A $n \times 1$ structure, where n is the number of preferred body areas.
patterns.im – the pattern image as imported in MATLAB with the imread function
patterns.name – the name of the preferred body areas (equivalent to params.sc)

The *event* structure

event.keypoints – all the information related to the identified keypoints
event.geops – stereo-triangulation results of all the identified keypoints, also separated in body areas
event.sections – perimetry of the areas containing each body area in the first frame of the left camera (L-1)
event.ntraj – trajectories of all the identified keypoints, as well as their corresponding image coordinates (not to be confused with event.traj, which is an intermediate result)
event.strajs – trajectories of the identified keypoints grouped per body areas, as well as their corresponding image coordinates
event.trajectories – the final estimated trajectories of the body areas of interest
event.velocities – the final estimated velocities of the body areas of interest
event.time – the time vector (in seconds) of the processed event
event.nlims – provides the range of the *x*, *y*, *z* coordinates of the identified keypoints for better visualization of the outputs

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