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An algorithm for tracking *C. elegans* body movement and muscular activity in Ca^{2+} dynamics video for tuning and validation of its locomotion simulation

A.Yu. Palyanov
A.P. Ershov Institute of Informatics Systems SB RAS, Novosibirsk, Russia
Novosibirsk State University, Novosibirsk, Russia
e-mail: palyanov@iis.nsk.su

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Motivation and Aim: Biologically reasonable computational simulation of the *C. elegans* nematode, including models of its sensory, nervous and muscular systems embedded into a body which is able to operate in a virtual physical environment, becomes closer each year, including the efforts of the OpenWorm project [1]. High-resolution explicit 3D simulation of *C. elegans* swimming and crawling, driven by artificial periodical signals activating its muscles, has been successfully performed using the Sibernetic environment [2]. Real or simulated worm's trajectory is determined by many factors, including neural activity, biomechanical properties of the body and muscles and properties of the physical environment as well. Overall neural activity and particularly the rhythmic patterns generation mechanism is still a challenge, so it seems rational to perform tuning and validation of virtual worm's nervous and muscular systems independently. Recently published experimental data of Ca^{2+} dynamics in body wall muscles of wild-type freely moving *C. elegans* [3], available as a video (https://www.youtube.com/watch?v=x861P1ijpR8), provided the capability to use it for validation of simulated muscles, body and environment.

Methods and Algorithms: In the present work the video mentioned above was split into a sequence of numbered frames (with the VirtualDub software) and an algorithm for tracking *C. elegans* body and obtaining muscular activity at each frame was designed and implemented in C++ with usage of FreeImage library. Image recognition includes raw detection of worm body outline, its further refinement, detection of head and tail points and calculation of worm body midline. The latter is further split into 100 equal length segments, and then every node is used to build the line orthogonal to body midline, which crosses left and right muscle bundles, which allows taking into account local body bending caused by current muscles stretching and contraction. and information about Ca^{2+} concentration is gathered.

Results: Muscular activity of real crawling C. elegans was extracted from 20 seconds long video with 100 ms interval between frames. Resulting post-processed video is available (https://www.youtube.com/watch?v=Bs72aNroKx0). Obtained data has been mapped onto *C. elegans* muscles layout and synchronized with Sibernetic simulation time scale. Resulting simulated movement trajectory has been studied and compared with the real one. Perspectives of their difference minimization via optimization of body, muscles and environment related parameters are discussed.

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