Multiple particle tracking in 3-D+t microscopy: method and application to the tracking of endocytosed quantum dots

We propose a method to detect and track multiple moving biological spot-like particles showing different kinds of dynamics in image sequences acquired through multidimensional fluorescence microscopy. It enables the extraction and analysis of information such as number, position, speed, movement, and diffusion phases of, e.g., endosomal particles. The method consists of several stages. After a detection stage performed by a three-dimensional (3-D) undecimated wavelet transform, we compute, for each detected spot, several predictions of its future state in the next frame. This is accomplished thanks to an interacting multiple model (IMM) algorithm which includes several models corresponding to different biologically realistic movement types. Tracks are constructed, thereafter, by a data association algorithm based on the maximization of the likelihood of each IMM. The last stage consists of updating the IMM filters in order to compute final estimations for the present image and to improve predictions for the next image. The performances of the method are validated on synthetic image data and used to characterize the 3-D movement of endocytic vesicles containing quantum dots.

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