

Automatic Segmentation of Microtubule Plus End Motion into Phases of Growth and Shortening.

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The plus ends of microtubules oscillate between phases of growth and shortening in a process called dynamic instability. Kinetic parameters used to describe microtubules' dynamic instability are the rates and duration of the two phases as well as the frequency of their interconversion (rescue and catastrophe). The parameters are extracted from live cell time-lapse imaging of fluorescently labeled tubulin. To date this is achieved with manual processing and hence is tedious and subjective. The goal of this work has been to automate the parameter extraction. Moreover, the accuracy of the estimate of the microtubule length is increased by computing it using multiple points along the microtubule axis. The automatic processing has been accomplished by first computing the image domain in which a microtubule is oscillating from a time-lapse fluorescent image stack. A Riemannian metric is computed over that region with a variation of fast marching. A geodesic in this metric gives the microtubule plus end trajectory. Subsequently, the variation of the length of each microtubule is used to subdivide the plus end polymerization into piecewise segments of linear polymerization rates. The discrete subdivision is performed efficiently using dynamic programming that determines the line segments of the microtubule length that give the best least squares fit in the time intervals. The line segments provide the kinetic statistics. The effectiveness of the algorithm is demonstrated with both phantom as well as real image sequences.