Numerical modeling of single-molecule detection and trapping in a nanochannel WILLIAM ROBINSON, ZBIGNIEW SIKORSKI, LLOYD M. DAVIS, UTSI — Confocal fluorescence microscopy with single-photon counting enables detection of individual fluorescent molecules as they randomly diffuse through a tightly focused laser beam. However, for many biophysical studies, there is a need to observe the same molecule for an extended duration, without immobilizing it to a surface. The problem of trapping a single fluorescent molecule in solution is examined here via numerical simulation. Optical trapping provides insufficient force for trapping small biomolecules. Instead, a means for sensing the molecule’s position and applying real-time feedback of motion to compensate diffusional displacement is used for trapping. The use of a nanochannel to confine the molecule reduces the problem to one dimension. The position of the molecule along the nanochannel is measured from its fluorescence induced by a pulse-interleaved two-beam laser-irradiance pattern. The time-gated photons are analyzed via maximum-likelihood methods and an electrophoretic motion provides the trapping mechanism. Flexible parameters allow a multi-variable analysis of the trapping efficiency and effectiveness. The reaction of the flow is set to the time-delayed response of a realistic field-programmable gate array (FPGA) controller. Trapping algorithms developed in the simulation are to be experimentally implemented in the FPGA.

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