Letter to the Editor

Comments on Adjoint Monte Carlo Sampling Techniques

This letter is intended to correct a possible misunderstanding concerning the results of our paper.[1] Our action is prompted by certain statements made in Ref. 2 which lead us to believe that we may not have been emphatic enough in Ref. 1 in delineating the range of problems to which our adjoint sampling technique applies.

Specifically, Ref. 2 states that the technique of Ref. 1 is not applicable to problems involving inelastic scattering. This is not the case, although it is undoubtedly the case that some of the advantage of our method is lost in the presence of inelastic scattering. To place our paper and Ref. 2 in the proper perspective we shall restate what each accomplishes in our view.

Both Refs. 1 and 2 investigate the possibility that the variance in estimating some functional of the neutron flux through a simulation of the adjoint transport equation may be reduced through an alteration of the underlying sampling laws and a corresponding adjustment of the pseudo-particle[a] weight. Furthermore, both Refs. 1 and 2 are based on an alteration of the scattering mechanism for pseudo-particles, rather than on an alteration of the transport mechanism. The major differences between the techniques of Refs. 1 and 2 is that in Ref. 1 the attempt is to increase the efficiency with little or no increase in computing cost, while in Ref. 2 the attempt is to minimize the time spent in an adjoint simulation by using information from the direct simulation.

To be more specific, Ref. 1 points out that for a certain class of transport problems, namely problems in which only a single elastic moderator is present in each region, substantial variance reduction in adjoint Monte Carlo estimation may be obtained *without* incurring any additional computing costs. The variance reduction is achieved by transforming the adjoint transport equation by means of a discontinuous importance function which, in each region, is the flux in an infinite medium of scattering appropriate for that region. The motivation for this particular transformation was to achieve unit weights upon collision of a pseudo-particle; in other words, to achieve balance upon scattering in the adjoint simulation. However, the derivation of Eq. (27) of Ref. 1, which gives the condition needed for unit weights, is perfectly general and the transforming function $\psi^{\infty}(\boldsymbol{x},E,\boldsymbol{\omega})$ which appears in Eq. (27) is the flux which would result in the absence of any source or absorption in each region. While the flux $\psi^{\infty}(\boldsymbol{x},E,\boldsymbol{\omega})$ takes a particularly simple form if only a single elastic moderator is present in each region, Eq. (27) shows that if $\psi^{\infty}(\boldsymbol{x},E,\boldsymbol{\omega})$ can be calculated, then unit weights can be achieved, no matter what the scattering law in each region may be.

As we view it, Ref. 2 examines the usefulness of obtaining auxiliary information about an approximate importance function through Monte Carlo simulation of the direct transport equation and then using this information to transform the adjoint equation in order to reduce the variance. Instead of being guided by a desire to achieve unit weights upon scattering of each pseudo-particle, Carter and McCormick are guided by a desire to approximate the scattering law which would be needed to implement a zero variance importance sampling procedure.

Thus, when the two techniques are compared within an importance sampling framework, one can say that Ref. 2 seeks to obtain scattering laws for pseudo-particles based on approximations to the zero variance prescription, while Ref. 1 makes use of scattering laws which are, in some sense, "natural," and which involve little or no additional computation. The importance function appropriate for use in Ref. 2 is the actual neutron flux for the problem, while the importance function used in Ref. 1 is the flux in a problem which is related to the original problem in a definite way, namely through deletion of the source and absorption in each region.

Leo B. Levitt

Atomics International
P. O. Box 309
Canoga Park, California 91304

Jerome Spanier

Science Center/North American Rockwell Corp.
1049 Camino Dos Rios
Thousand Oaks, California 91360

May 4, 1970

[a]This term was introduced by Carter and McCormick in Ref. 2 to denote a particle arising from a simulation of the adjoint transport equation.

[1]LEO B. LEVITT and JEROME SPANIER, *Nucl. Sci. Eng.*, **37**, 278 (1969).

[2]L. L. CARTER and N. J. McCORMICK, *Nucl. Sci. Eng.*, **39**, 296 (1970).