Comments on "Dynamic Optimization of Batch Reactors Using Adaptive Stochastic Algorithms"

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Sir: In a recent paper, "Dynamic Optimization of Batch Reactors Using Adaptive Stochastic Algorithms" by Eugenio Carrasco and Julio Banga, the authors consider four sample problems and conclude that in several cases they have been able to significantly improve the solutions obtained by other methods. Such a claim is unsubstantiated, and I wish to clarify some of the misconceptions.

In their first example, their results with one method were 0.09% below the optimum yield reported by Luus (1994) and 0.2% below the optimum yield with the other method. Therefore, the solutions they obtained were inferior to the published result. In their second example they were able to come to within 0.004% of the global optimum reported by Luus (1994) by using the ICRS/DS method, but their ARDS/DS method did not give a control policy that is in the immediate vicinity of the optimal control policy, as can be seen in their Figure 3. Certainly both of the profiles cannot represent the optimal control policy, since they are quite different. When compared to the result obtained by Bojkov and Luus (1996) in a preliminary run in a computation time of 40 s on a Pentium/66, their computational procedure is about 8 times slower in giving an inferior result.

The most bothersome part of their paper is the treatment of the last example involving chemotherapy, where the problem is actually changed to yield a better result. By leaving out three state constraints, they reported the maximum value of the performance index of 17.742 and claimed that the result is "an improvement of 23% over the results of Luus et al. (1995)". In their Figure 7 they give an incorrect optimal control policy for this "simplified" problem. When the three constraints in their eqs 42−44 are omitted, the optimal drug scheduling problem becomes much simpler and can be readily solved with iterative dynamic programming (IDP) as outlined by Luus (1989). In fact, I solved this simplified problem with IDP, using a multipass procedure with a single grid point and 15 allowable values for control. To handle the state constraints, I used a quadratic penalty function with a shifting term for the constraint on x_3 and the method suggested by Mekarapiruk and Luus (1997) to handle the inequality constraint on x_2. The total computation time for 50 passes, each consisting of 30 iterations, took about 13 min on a Pentium/120. The optimum value for J is 17.993, which is substantially better than the value 17.742 reported in their paper. The optimal control policy for this simplified problem is given in Figure 1. As can be seen, the control policy is totally different from the control policies given in Figure 7 of Carrasco and Banga (1997). The optimal control policy is zero until the 42nd day when it switches to 28.19 and then switches to 35.31 on the 43rd day before leveling off at 13.5. Since they had difficulty obtaining the optimal control policy for this simplified problem, their solution obtained to the original problem with three additional state constraints is open to question. This may explain why they were having difficulties obtaining the optimum value of J = 17.476 obtained by Luus et al. (1995) by using the LJ optimization procedure (Luus and Jaakola, 1973) for the original problem as formulated by Martin (1992). It should be further noted that the differential equations are well-behaved, and no special consideration is required for numerical integration. Therefore, there exist serious limitations in the optimization procedures recommended by Carrasco and Banga for solving nonlinear optimal control problems.

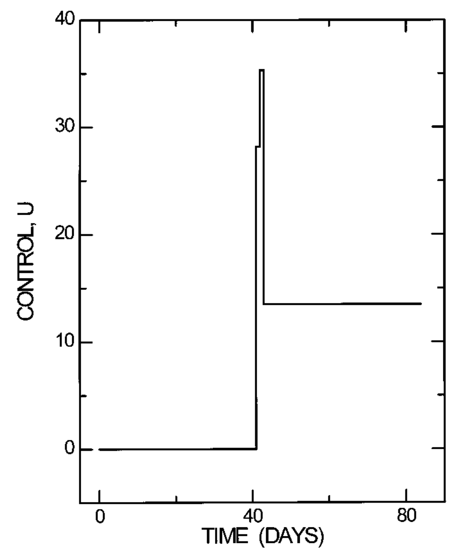

Figure 1. Optimal control policy for the simplified cancer chemotherapy problem where three state constraints have been removed.

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