

## OPTIMAL CONTROL AND SEMICONTINUOUS VISCOSITY SOLUTIONS

E. N. BARRON AND R. JENSEN

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**ABSTRACT.** We study the value function for an optimal control problem with upper semicontinuous terminal data. We prove that the upper semicontinuous envelope of the value function is the unique semicontinuous viscosity solution of the Bellman equation and that it coincides with the value function obtained when using relaxed controls.

### 0. INTRODUCTION AND SUMMARY

In [2] we introduced an extension of the theory of viscosity solutions for Hamilton–Jacobi equations of the form  $\Lambda(u) \equiv u_t + H(t, x, D_x u) = 0$  if  $(t, x) \in (0, T) \times \mathbb{R}^n$  and  $u(T, x) = g(x)$ . The classical theory in which  $g$  is assumed to be continuous was initiated in the pioneering paper of Crandall and Lions [4]. Our extension is to allow semicontinuous terminal data  $g$  but we require the Hamiltonian  $H(t, x, p)$  to be convex (for upper semicontinuous  $g$ ) in  $p$ . For lower semicontinuous terminal data we require concavity. This convexity assumption is satisfied in problems of optimal control of ordinary differential equations, where we are dealing with the Bellman equation.

From now on we discuss only the upper semicontinuous (u.s.c) case with the lower semicontinuous case being entirely analogous.

The problem with u.s.c data, of course, is that we can only deal with u.s.c candidate functions as solutions to the Bellman equation since it is known that discontinuities propagate in first order problems. This leads to the difficulty that the definition of viscosity supersolution is vacuous in general because it requires the existence of a smooth function, say  $\phi$  for which  $u - \phi$  achieves a minimum at some point and  $\Lambda(\phi) \leq 0$  at this point. There is no problem with the definition of viscosity subsolution, which requires that  $u - \phi$  achieve a maximum and then  $\Lambda(\phi) \geq 0$  at the max point. In [2] we defined  $u$  to be

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# Pitman Research Notes In Mathematics Series Viscosity Solutions And Optimal Control

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