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Lyapunov-Razumikhin techniques for state-dependent delay differential equations

We present theorems for the Lyapunov and asymptotic stability of the steady state solutions to general state-dependent delay differential equations (DDEs) using Lyapunov-Razumikhin methods. These theorems build upon the previous work of Hale and Verduyn Lunel (1993), and Barnea (1969) which were mainly aimed at equations with simpler delay terms (e.g. constant and time-dependent delays), and are less applicable to state-dependent DDEs such as the following model equation,

$$\dot{u}(t) = \mu u(t) + \sigma u(t - a - cu(t)).$$

The stability region $\Sigma_\star$ of the zero solution to this model problem is known, and it is the same for both the constant delay ($c = 0$) and state-dependent delay ($c \neq 0$) cases. Using our results we can prove the asymptotic stability of the zero solution to this model problem in parts of $\Sigma_\star$, considerably expanding upon the work of Barnea who proved Lyapunov stability for the simpler $\mu = c = 0$ constant delay case. Similar techniques are used to derive a condition for global asymptotic stability of the zero solution to the model problem, and bounds on periodic solutions when the zero solution is unstable. This is joint work with A.R. Humphries