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	authors	• Radoslav Ivanov • James Weimer • Rajeev Alur • George J. Pappas • Insup Lee	**authors**	• Radoslav Ivanov • James Weimer • R. Alur • George J. Pappas • Insup Lee	DUPLICATES	316
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	abstract	This paper presents Verisig, a hybrid system approach to verifying safety properties of closed-loop systems using neural networks as controllers. Although techniques exist for verifying input/output properties of the neural network itself, these methods cannot be used to verify properties of the closed-loop system (since they work with piecewise-linear constraints that do not capture non-linear plant dynamics). To overcome this challenge, we focus on sigmoid-based networks and exploit the fact that the sigmoid is the solution to a quadratic differential equation, which allows us to transform the neural network into an equivalent hybrid system. By composing the network's hybrid system with the plant's, we transform the problem into a hybrid system verification problem which can be solved using state-of-the-art reachability tools. We show that reachability is decidable for networks with one hidden layer and decidable for general networks if Schanuel's conjecture is true. We evaluate the applicability and scalability of Verisig in two case studies, one from reinforcement learning and one in which the neural network is used to approximate a model predictive controller.	**abstract**	This paper presents Verisig, a hybrid system approach to verifying safety properties of closed-loop systems using neural networks as controllers. We focus on sigmoid-based networks and exploit the fact that the sigmoid is the solution to a quadratic differential equation, which allows us to transform the neural network into an equivalent hybrid system. By composing the network's hybrid system with the plant's, we transform the problem into a hybrid system verification problem which can be solved using state-of-the-art reachability tools. We show that reachability is decidable for networks with one hidden layer and decidable for general networks if Schanuel's conjecture is true. We evaluate the applicability and scalability of Verisig in two case studies, one from reinforcement learning and one in which the neural network is used to approximate a model predictive controller.		
	versions		**versions**			