cases	doc_1		doc_2		decision	id
	authors	V. I. Avrutskiy	authors	V.I. Avrutskiy	DUPLICATES	320
	title	Neural networks catching up with finite differences in solving partial differential equations in higher dimensions	title	Neural networks catching up with finite differences in solving partial differential equations in higher dimensions		
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	id	id5975305121987257855	id	id1340507698461480686		
	abstract	Fully connected multilayer perceptrons are used for obtaining numerical solutions of partial differential equations in various dimensions. Independent variables are fed into the input layer, and the output is considered as solution's value. To train such a network one can use square of equation's residual as a cost function and minimize it with respect to weights by gradient descent. Following previously developed method, derivatives of the equation's residual along random directions in space of independent variables are also added to cost function. Similar procedure is known to produce nearly machine precision results using less than 8 grid points per dimension for 2D case. The same effect is observed here for higher dimensions: solutions are obtained on low density grids, but maintain their precision in the entire region. Boundary value problems for linear and nonlinear Poisson equations are solved inside 2, 3, 4, and 5 dimensional balls. Grids for linear cases have 40, 159, 512 and 1536 points and for nonlinear 64, 350, 1536 and 6528 points respectively. In all cases maximum error is less than $8.8\cdot10^{-6}$, and median error is less than $2.4\cdot10^{-6}$. Very weak grid requirements enable neural networks to obtain solution of 5D linear problem within 22 minutes, whereas projected solving time for finite differences on the same hardware is 50 minutes. Method is applied to second order equation, but requires little to none modifications to solve systems or higher order PDEs.	abstract	Fully connected multilayer perceptrons are used for obtaining numerical solutions of partial differential equations in various dimensions. Independent variables are fed into the input layer, and the output is considered as solution's value. To train such a network one can use square of equation's residual as a cost function and minimize it with respect to weights by gradient descent. Following previously developed method, derivatives of the equation's residual along random directions in space of independent variables are also added to cost function. Similar procedure is known to produce nearly machine precision results using less than 8 grid points per dimension for 2D case. The same effect is observed here for higher dimensions: solutions are obtained on low density grids, but maintain their precision in the entire region. Boundary value problems for linear and nonlinear Poisson equations are solved inside 2, 3, 4, and 5 dimensional balls. Grids for linear cases have 40, 159, 512 and 1536 points and for nonlinear 64, 350, 1536 and 6528 points respectively. In all cases maximum error is less than 8.8Â·10^-6, and median error is less than 2.4Â·10^-6. Very weak grid requirements enable neural networks to obtain solution of 5D linear problem within 22 minutes, whereas projected solving time for finite differences on the same hardware is 50 minutes. Method is applied to second order equation, but requires little to none modifications to solve systems or higher order PDEs.		
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