From Traditional Neural Networks to Deep Learning: Towards Mathematical Foundations of Empirical Successes

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Abstract. How do we make computers think? To make machines that fly, it is reasonable to look at the creatures that know how to fly: the birds. To make computers think, it is reasonable to analyze how we think – this is the main origin of neural networks. At first, one of the main motivations was speed – since even with slow biological neurons, we often process information fast. The need for speed motivated traditional 3-layer neural networks. At present, computer speed is rarely a problem, but accuracy is – this motivated deep learning. In this paper, we concentrate on the need to provide mathematical foundations for the empirical success of deep learning.

Vladik Kreinovich received his MS in Mathematics and Computer Science from St. Petersburg University, Russia, in 1974, and PhD from the Institute of Mathematics, Soviet Academy of Sciences, Novosibirsk, in 1979. From 1975 to 1980, he worked with the Soviet Academy of Sciences; during this time, he worked with the Special Astrophysical Observatory (focusing on the representation and processing of uncertainty in radio astronomy). For most of the 1980s, he worked on error estimation and intelligent information processing for the National Institute for Electrical Measuring Instruments, Russia. In 1989, he was a visiting scholar at Stanford University. Since 1990, he has worked in the Department of Computer Science at the University of Texas at El Paso. In addition, he has served as an invited professor in Paris (University of Paris VI), France; Hannover, Germany; Hong Kong; St. Petersburg, Russia; and Brazil. His main interests are the representation and processing of uncertainty, especially interval computations and intelligent control. He has published six books, eighteen edited books, and more than 1,300

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