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Gaussian Mixture Models (GMM) are among the most statistically mature methods for clustering and density estimation with numerous successful applications in science and engineering. In this study, we investigate an approach based on numerical algebraic geometry (NAG) and multicomplex Taylor series expansion (MCTSE) to enhance the Method of Moments (MM) for estimating parameters of large-scale GMMs. The proposed methodology uses MCTSE as a numerical method for calculating higher-order partial derivatives of the moment generating function of GMM. Next, it employs NAG for solving the resulting system of polynomial equations to estimate the parameters of GMM. We compare the performance of the proposed approach against popular Expectation Maximization (EM) method using extensive simulation. (Received September 15, 2017)