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How To Efficiently Sample Data For Computation Of Statistics
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The mean of a sample is a random variable with a variance that is the variance of the measured variable divided by the number of samples, assuming the samples are independent. Ensuring independent samples requires that the sampling period is greater than twice the integral time scale T_u. This time scale is the integral over all time of the autocorrelation ρ of the signal. Three signals are analyzed to investigate the convergence of the mean and other statistics. One is the velocity in a turbulent jet measured using a hot-wire. The other two are pressure signals generated by flow through a confined array of cylinders. To determine T_u, 11 sets of 100,000 data points were acquired at high rate. The value of ρ for each record were averaged together. For the chaotic signal from the jet, ρ was generally positive or slightly negative. The pressure signals contain a coherent component that caused the autocorrelation to become a damped oscillation. In this case, the scheme of integrating ρ from 0 to the time where ρ became negative gives poor results. Instead, an exponential was fit to the envelope of ρ and integration was carried out to the point where this exponential function became small. Data were acquired in the jet and cylinder array at rates above and below those consistent with the $2T_u$ criterion. Even at 8 times the recommended rate the mean converged at the predicted rate [although the error magnitude was larger than the theory] and that at sampling period of $2T_u$ the error in the mean was well predicted by theory). Similar results were found for convergence of the variance.

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