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# VEGAS algorithm

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The **VEGAS algorithm**, due to G. P. Lepage,<sup>[1]</sup> is a method for **reducing error** in **Monte Carlo simulations** by using a known or approximate **probability distribution** function to concentrate the search in those areas of the **integrand** that make the greatest contribution to the final **integral**.

The VEGAS algorithm is based on **importance sampling**. It samples points from the probability distribution described by the function  $|f|$ , so that the points are concentrated in the regions that make the largest contribution to the integral.

In general, if the Monte Carlo integral of  $f$  is sampled with points distributed according to a probability distribution described by the function  $g$ , we obtain an estimate  $E_g(f; N)$ ,

$$E_g(f; N) = \frac{1}{N} \sum_i^N f(x_i)/g(x_i)$$

The **variance** of the new estimate is then

$$Var_g(f; N) = Var(f/g; N)$$

where  $Var(f; N)$  is the variance of the original estimate,  $Var(f; N) = E(f^2; N) - (E(f; N))^2$ .

If the probability distribution is chosen as  $g = |f|/I(|f|)$  then it can be shown that the variance  $Var_g(f; N)$  vanishes, and the error in the estimate will be zero. In practice it is not possible to sample from the exact distribution  $g$  for an arbitrary function, so importance sampling algorithms aim to produce efficient approximations to the desired distribution.

The VEGAS algorithm approximates the exact distribution by making a number of passes over the integration region while **histogramming** the function  $f$ . Each histogram is used to define a sampling distribution for the next pass. Asymptotically this procedure converges to the desired distribution. In order to avoid the number of histogram bins growing like  $K^d$  with dimension  $d$  the probability distribution is approximated by a separable function:  $g(x_1, x_2, \dots) = g_1(x_1)g_2(x_2) \dots$  so that the number of bins required is only  $Kd$ . This is equivalent to locating the peaks of the function from the **projections** of the integrand onto the coordinate axes. The efficiency of VEGAS depends on the validity of this assumption. It is most efficient when the peaks of the integrand are well-localized. If an integrand can be rewritten in a form which is approximately separable this will increase the efficiency of integration with VEGAS.

## See also [\[edit\]](#)

- [Las Vegas algorithm](#)
- [Monte Carlo integration](#)

## References [\[edit\]](#)

- ↑ Ohl, T. (July 1999). "Vegas revisited: Adaptive Monte Carlo integration beyond factorization". *Computer Physics Communications* **120** (1): 13–19. doi:10.1016/S0010-4655(99)00209-X .
- ↑ G.P. Lepage, A New Algorithm for Adaptive Multidimensional Integration, Journal of Computational Physics 27, 192-203, (1978)
- ↑ G.P. Lepage, VEGAS: An Adaptive Multi-dimensional Integration Program, Cornell preprint CLNS 80-447, March 1980
- ↑ The [GNU Scientific Library](#)  provides VEGAS routines

**Categories:** [Monte Carlo methods](#) | [Computational physics](#) | [Statistical algorithms](#) | [Variance reduction](#)

This page was last modified on 8 March 2014, at 23:43.

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