

# Principle of Uniform Nonlocality and the Halting Sequence

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**Theorem 1** *Let  $(\mathcal{X}, \mu)$  and  $(\mathcal{Y}, \nu)$  be non-atomic computable measure spaces with  $U = \log \mu(\mathcal{X}) = \log \nu(\mathcal{Y})$ . Let  $(\mathcal{Z}, \rho)$  be a non-atomic computable probability space. Let  $A : \mathcal{Z} \rightarrow \mathcal{X}$  and  $B : \mathcal{Z} \rightarrow \mathcal{Y}$  be continuous. Let  $\mathbf{I}(\langle A, B \rangle : \mathcal{H}) < \infty$ . There is a constant  $c$  with  $\rho\{\alpha : \max\{\mathbf{G}_\mu(A(\alpha)), \mathbf{G}_\nu(B(\alpha))\} < U - n\} > 2^{-n - \mathbf{K}(n) - c}$ .*

## Principle of Uniform Nonlocality and the Halting Sequence

*If one has access to the halting sequence, then non-trivial information can be inferred between spacelike events.*

### Example

Let  $(\mathcal{X}, \mu)$  and  $(\mathcal{Y}, \nu)$  be computable measure spaces and  $(\mathcal{Z}, \rho)$  be a computable probability space. Let  $A : \mathcal{Z} \rightarrow \mathcal{X}$  and  $\mathcal{Z} \rightarrow \mathcal{Y}$  be computable functions. Let  $\{X_n, Y_n\}_{n=1}^\infty$  be random subsets of  $\mathcal{X}$  and  $\mathcal{Y}$  of size  $n$  that created from independently sampling  $\mathcal{Z}$  with  $\rho$  and then applying  $A$  and  $B$  respectively. Let  $X_n^m = \{\alpha \in X_n : \mathbf{G}_\mu(\alpha) < -m\}$  and  $Y_n^m = \{\alpha \in Y_n : \mathbf{G}_\nu(\alpha) < -m\}$ . Using Theorem 1, there exists a  $c$  where

$$\lim_{n \rightarrow \infty} |\{t : X_n(t) \in X_n^m \cap Y_n(t) \in Y_n^m\}| / n > 2^{-m - \mathbf{K}(m) - c}.$$

Assume  $\mathbf{G}$  is computable, let  $m \in \mathbb{N}$ , and let  $n \rightarrow \infty$ . For each  $n$ , one can compute  $X_n^m$  and using Theorem 1, one can infer that  $|\{t : X_n(t) \in X_n^m \cap Y_n(t) \in Y_n^m\}| / n > 2^{-m - \mathbf{K}(m) - c}$ . Thus with access to the halting sequence, one can learn information across spacelike events.

Using a slight modification of the max entropy theorem, one gets another interesting example. Given a source of energy which propagates at the speed of light to a set of distant systems that all have spacelike separations. Each pulse is sent according to a distribution that is conditional to the previous pulse. Each system changes according to a random function of a pulse and the previous state. There is an algorithm that on input of the halting sequence and a large enough amount of pulses can output, with high probability, information about the algorithmic entropies of all other systems. As the number of pulses approaches infinity, the probability of learning information approaches unity. The rate of convergence is solely a functions of the systems and not the pulse distribution and update functions. The systems can be in distant galaxies.