Operational verification of the existence of time and space

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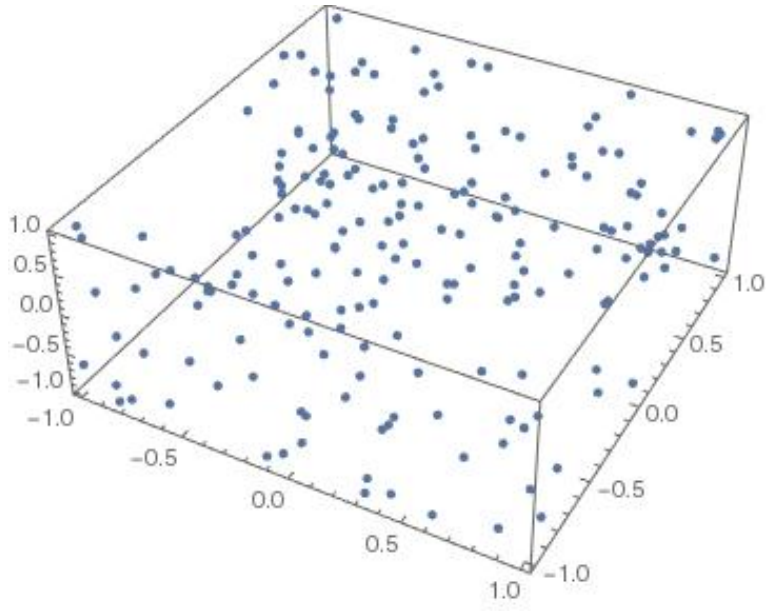
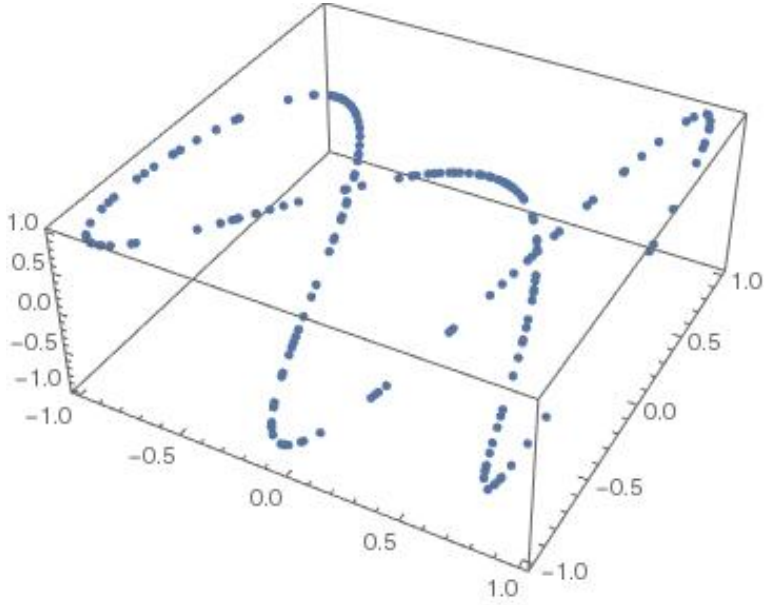
Gedanken-experiment



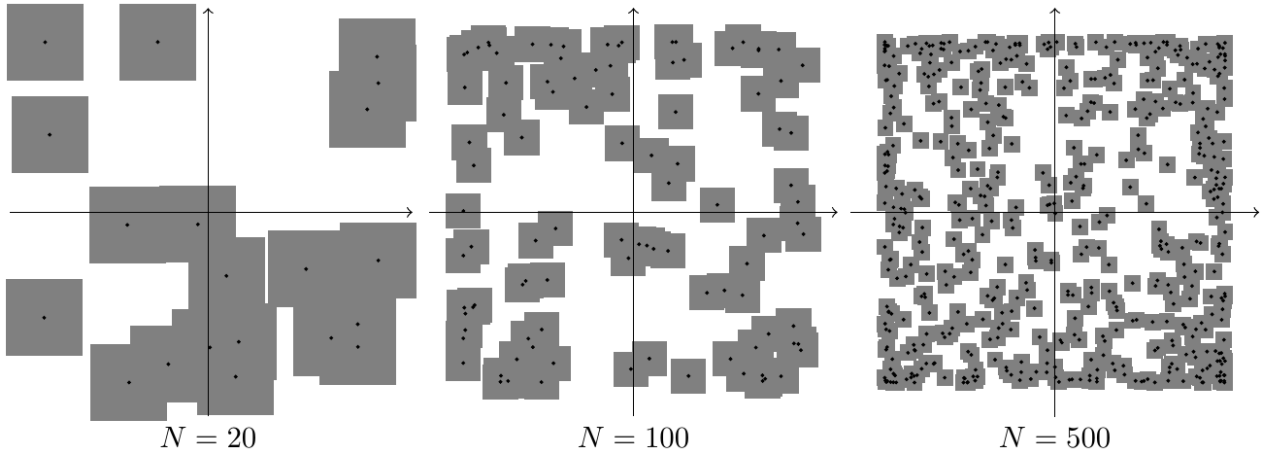
- Perform N measurements of K observables without keeping track of their order.
- Arrange results into randomized K-tuples $(a_3, b_7, c_4, \ldots)$.
- Plot these K-tuples as points in a K-dimensional space.
- Observe that they are randomly distributed!

Experimental signal of the time manifold



- Real-world dataset is *special* and non-random: *one special permutation* reveals the 1-dimensional manifold in a K-dimensional space.
- *Time manifold!*

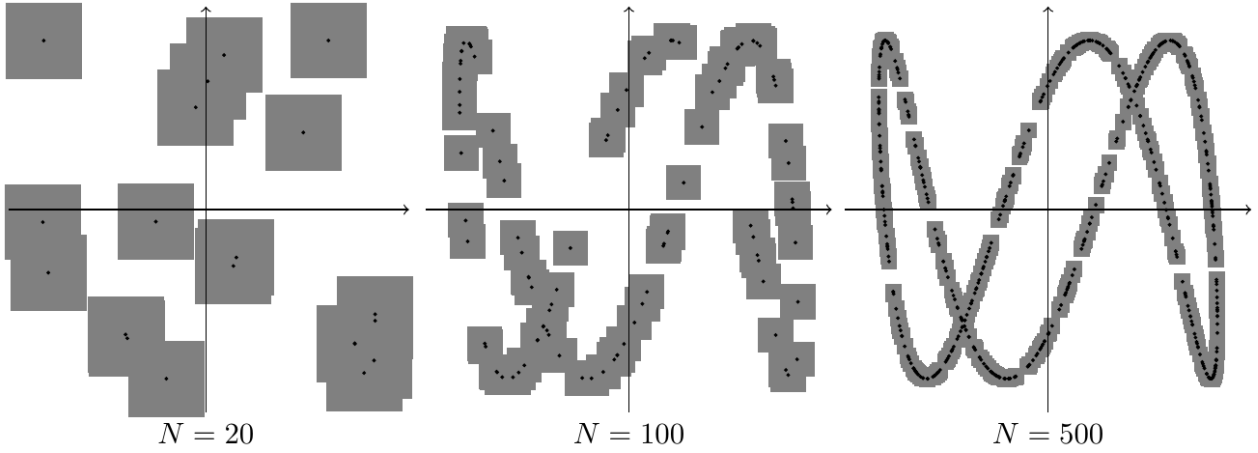
Generic permutation signature



- Construct a small cube around each datapoint.
- Choose its size so that sum of all cube volumes equals the total volume of K-space.
- Due to overlaps, the total grey volume is smaller than the sum, but remains finite:

$$\alpha(N) \equiv \frac{V_{\text{grey}}}{V_K} \approx const, \qquad \text{even when } N \gg 1\,.$$

Special permutation signature



- Ratio of grey volume over the K-space volume drops asymptotically to zero.
- Datapoints lie on a subset of measure zero!
- The formula for the dimension of the corresponding submanifold:

$$\alpha(N) \equiv \frac{V_{\text{grey}}}{V_K} = const \cdot N^{\frac{D}{K}-1} \to 0 \quad (N \gg 1)\,, \qquad D = K\left[1 + \lim_{N\to\infty} \frac{\log \alpha(N)}{\log N}\right]\,.$$

Bibliography

[1] N. Paunković and M. Vojinović, `arXiv:2209.04783`.

THANK YOU!