Why neural networks (and other techniques) predict fast processes more effectively than slow ones: explanation and examples

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Formulation of the problem. From the commonsense viewpoint, it seems easier to predict the future behavior of a slower process than of a fast process in which everything changes fast. However, for neural networks, the situation is opposite: neural networks predict fact processes much better than low ones. How can we explicit this empirical phenomenon?

Our explanation. Intuitively, a slow process $s(t)$ is a fast process $f(t)$ occurring at a slower rate – $c > 1$ times slower than the faster one. This is, in effect, how slow walk differs from fast walk, how slower heart beat differs from the faster one. So, what we see in a slow process at moment t, the fast process would show in time t/c: $s(t) = f(t/c)$.

Based on this observation, let us compare what a neural network – or any other technique – can predict after observing each of these two processes for some time T. What we observe for a slow process during this time corresponds to what we observe in a fast process during a shorter period of time T/c. Thus, when we observe a fast process, we have all the information that we have when observing a slow process – and we also have additional information corresponding to the time interval $[T/c, T]$.

So, by observing the fast process we get more information about the process than when we observe the slow process. And the more information we have, the more accurately we can predict the future behavior of the corresponding system. This explains why fast processes are easier to predict.

Examples. When considering these examples, take into account that slow and fast are relative terms, they just mean that some processes are much slower than others – but, e.g., a very slow chemical reaction is still much faster than a very fast planetary motion.

In *astronomy*: fast processes are movement of planets around the Sun and of satellites around their planets, slow processes are slow changes in the parameters of the orbits – e.g., that the Moon is getting closer to the Earth. Since ancient times, we can reasonably well predict the planets' motions, but it is still difficult to predict the future slow changes.

In *economics:* fast processes are yearly fluctuations of stock prices, unemployment, productivity – these can be predicted reasonably well, while slow processes, such as long-term effects of different economic policies, are very difficult to predict.

In *medicine:* we have learned to deal with many fast processes like viral and bacterial infections, but diseases that slowly degrade one's health – Alzheimer disease and other aged-related diseases – remain a challenge.

In *meterology:* fast processes are daily changes in weather, slow processes are climate changes. We can predict future weather reasonable accurately, but predicting climate change still comes with huge uncertainty.