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

Emilio Altamira[1], Ivan Espino[1], Maximiliano Garibay[1], Santiago Lopez[1], Michael Schwarz[1], Michael Washington[1], Miroslav Svitek[2], Vladik Kreinovich[1]
[1]Department of Computer Science, University of Texas at El Paso, 500 W. University, El Paso, TX 79968, USA
egaltamira@miners.utep.edu, imespino@miners.utep.edu, mgaribay2@miners.utep.edu, slopez64@miners.utep.edu, mkschwarz@miners.utep.edu, mrwashington@miners.utep.edu, vladik@utep.edu
[2]Faculty of Transportation Sciences, Czech Technical University in Prague
svitek@fd.cvut.cz

1. 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?

2. 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 bit 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 small process during this time corresponds to what we observe in a fast process during a shorter period of time T/c.

3. Our explanation (cont-d)

- 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 that 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.

4. Examples

- When considering these examples, take into account that slow and fast are relative terms.
- They just means that some processes are much slower than others.
- However, 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 Moon is getting closer to the Earth.
- Since ancient times, we can reasonably well predict the planet motions.
- However, it is still difficult to predict the future slow changes.

5. Examples (cont-d)

- 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.
  - However, diseases that slowly degrade one's health – Alzheimer disease and other aged-related diseases – remain a challenge.
- Another example from medicine:
  - we understand immediate effect of medicines – and of different substances,
  - however, their slow long-term effects are very difficult to predict.

6. Examples (cont-d)

- For example:
  - we know that slow lead poisoning leads to an early death,
  - but in the Ancient Rome, lead from water pipes was the main reason why people's life span was shorter than expected.
- Closer to nowadays, a few decades ago people actively used asbestos not realizing its long-term negative effects.
- 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 come with huge uncertainty.

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