The Alan Turing Institute

Chinese character recognition

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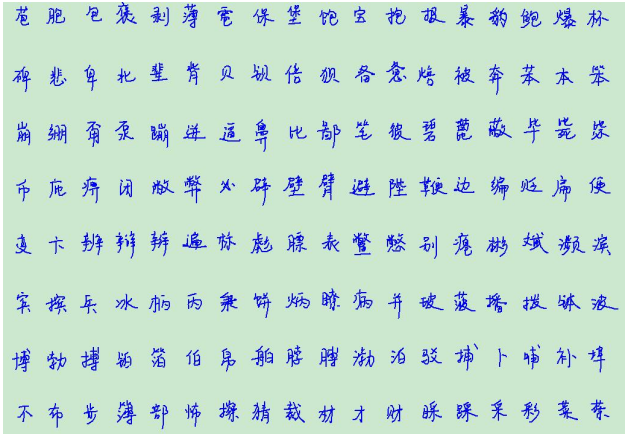
Handwriting

Online handwriting

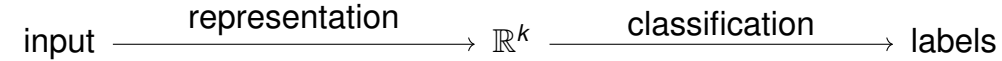
Chinese - the Casia online dataset



http://www.nlpr.ia.ac.cn/databases/handwriting/Home.html

Signatures

Typical approaches



Signatures

The signature of a path is a set of iterated integrals.
Consider a path in $\mathbb{R}^3$ parameterised by the variable t ranging from 0 to 1, given by

$$t \mapsto (f_1(t), f_2(t), f_3(t))$$

Then, for example, the element 2,3 of the signature is

$$\int_0^1 \left[\int_0^t f_2'(s)\, ds \right] f_3'(t)\, dt = \int_0^1 \int_0^t df_2(s)\, df_3(t)$$

and element 2,1,2 of the signature is

$$\int_0^1 \int_0^t \int_0^s df_2(r)\, df_1(s)\, df_2(t).$$

Signatures

The mth level of the signature of a path in $\mathbb{R}^d$ is the d^m values of the elements with m integrated integrals. It takes values in $(\mathbb{R}^d)^{\otimes m}$. Given a piecewise linear path, it is easy to compute the first m levels of its signature using a theorem called Chen's identity.

Log-Signature demonstration

There is redundancy in the signature. The log signature is a transformation of the same information as the signature which is not redundant. For example, in $\mathbb{R}^2$, the first four levels of the signature look like this

$$(\cdot\,\cdot) + \begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix} + \begin{pmatrix}\begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix} & \begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix}\end{pmatrix} + \begin{pmatrix}\begin{pmatrix}\begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix} & \begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix}\end{pmatrix} & \begin{pmatrix}\begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix} & \begin{pmatrix}(\cdot\,\cdot)\\(\cdot\,\cdot)\end{pmatrix}\end{pmatrix}\end{pmatrix}$$

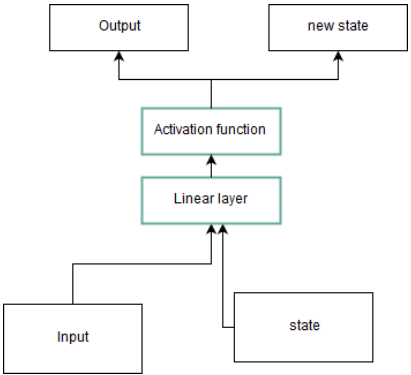
- that is $2 + 4 + 8 + 16 = 30$ numbers while the log signature is only $2 + 1 + 2 + 3 = 8$ numbers.

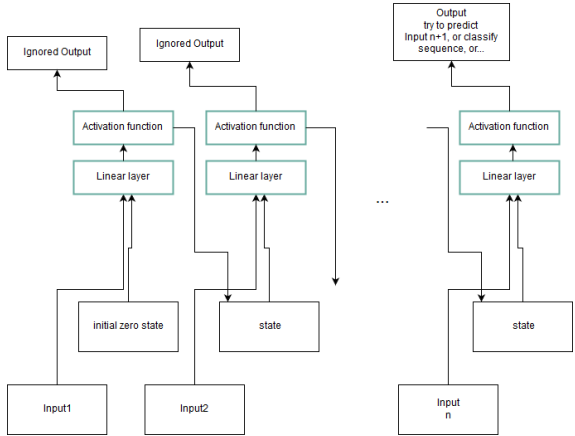
Questions

A signature is a nice representation of a path of arbitrary length. When is it good enough? What properties of a complicated path can be derived from some levels of its signature? How to balance a representation using more levels of the signature versus chopping the path up and looking at signatures of the chunks?

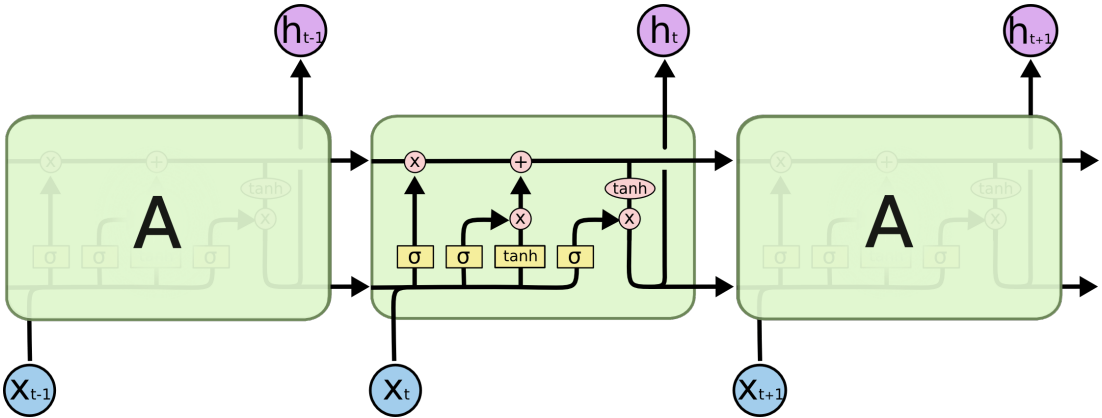
Recurrent Neural Networks

Recurrent Neural Networks





Long short term memory



colah.github.io/posts/2015-08-Understanding-LSTMs/

Thanks!

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