Inference and learning
at the level of single synapses and spiking neurons

PART I

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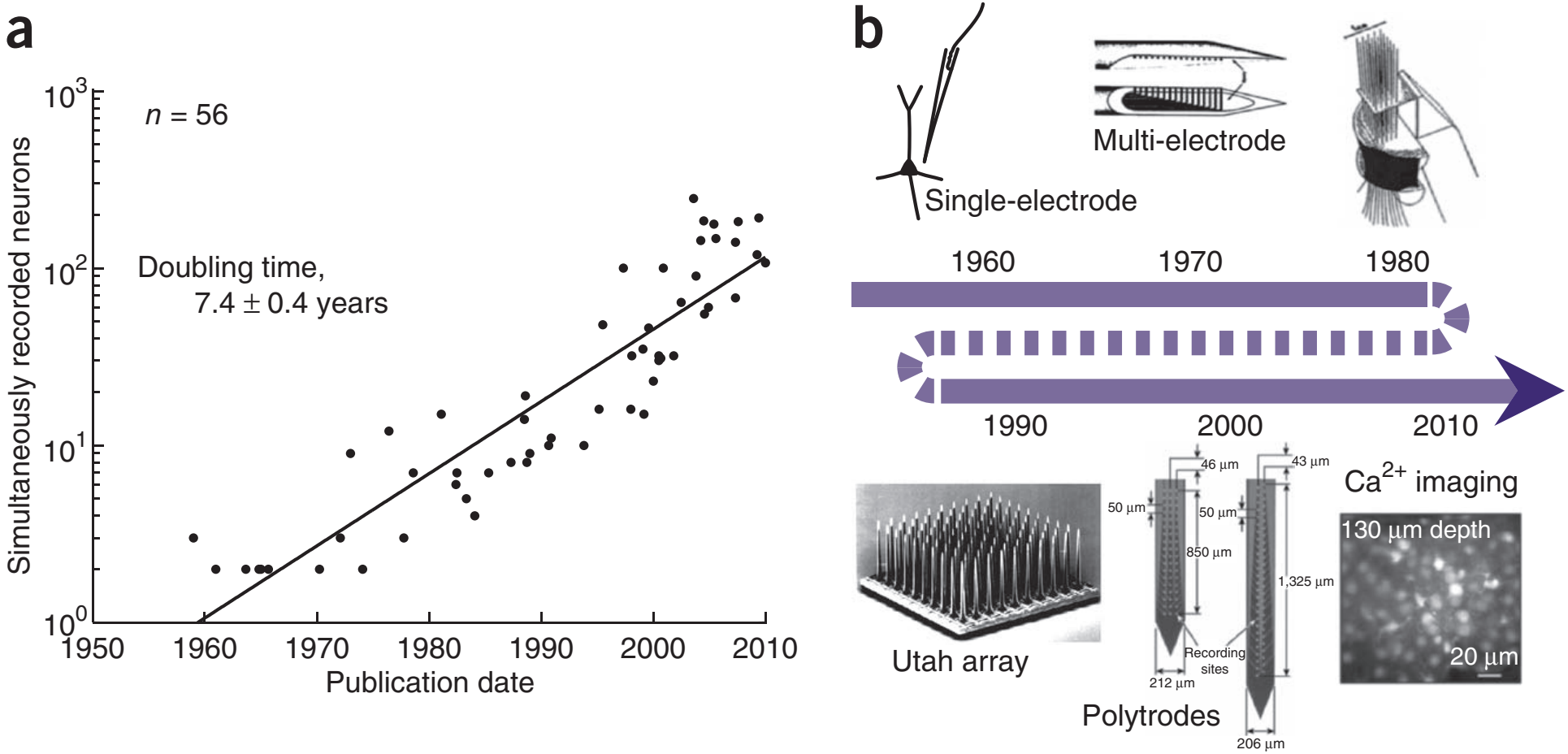
The data explosion



Need good questions and good methods

Stevenson and Körding, 2011

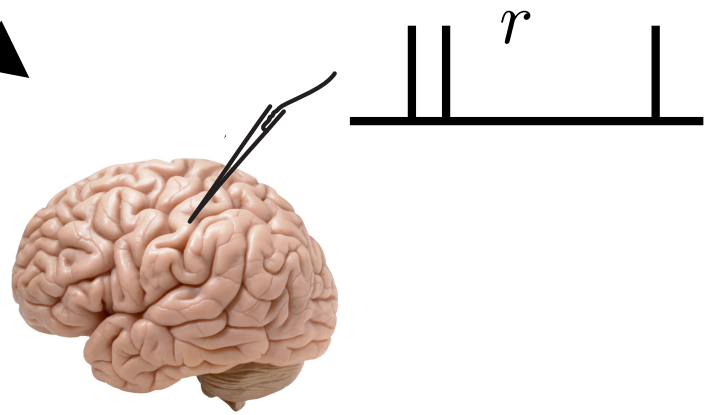
How to address the encoding/decoding problem?

Stimulus s

Encoding

$p(r|s)$

brain response



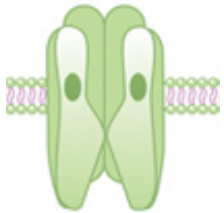
decoding

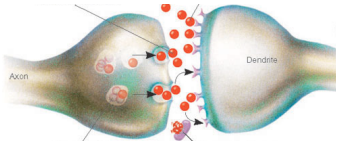
$$p(s|r) = \frac{p(r|s)p(s)}{p(r)}$$

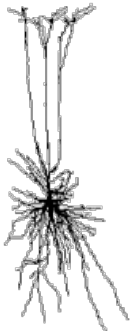
Need for a flexible and tractable model

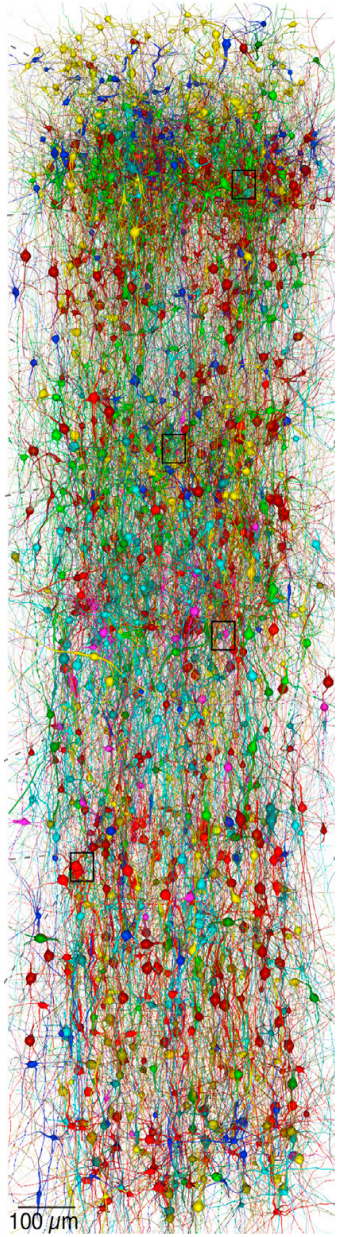
Flexible but NOT tractable approach

Full biophysical model









How can it be learned?

-> Perfect recipe for overfitting

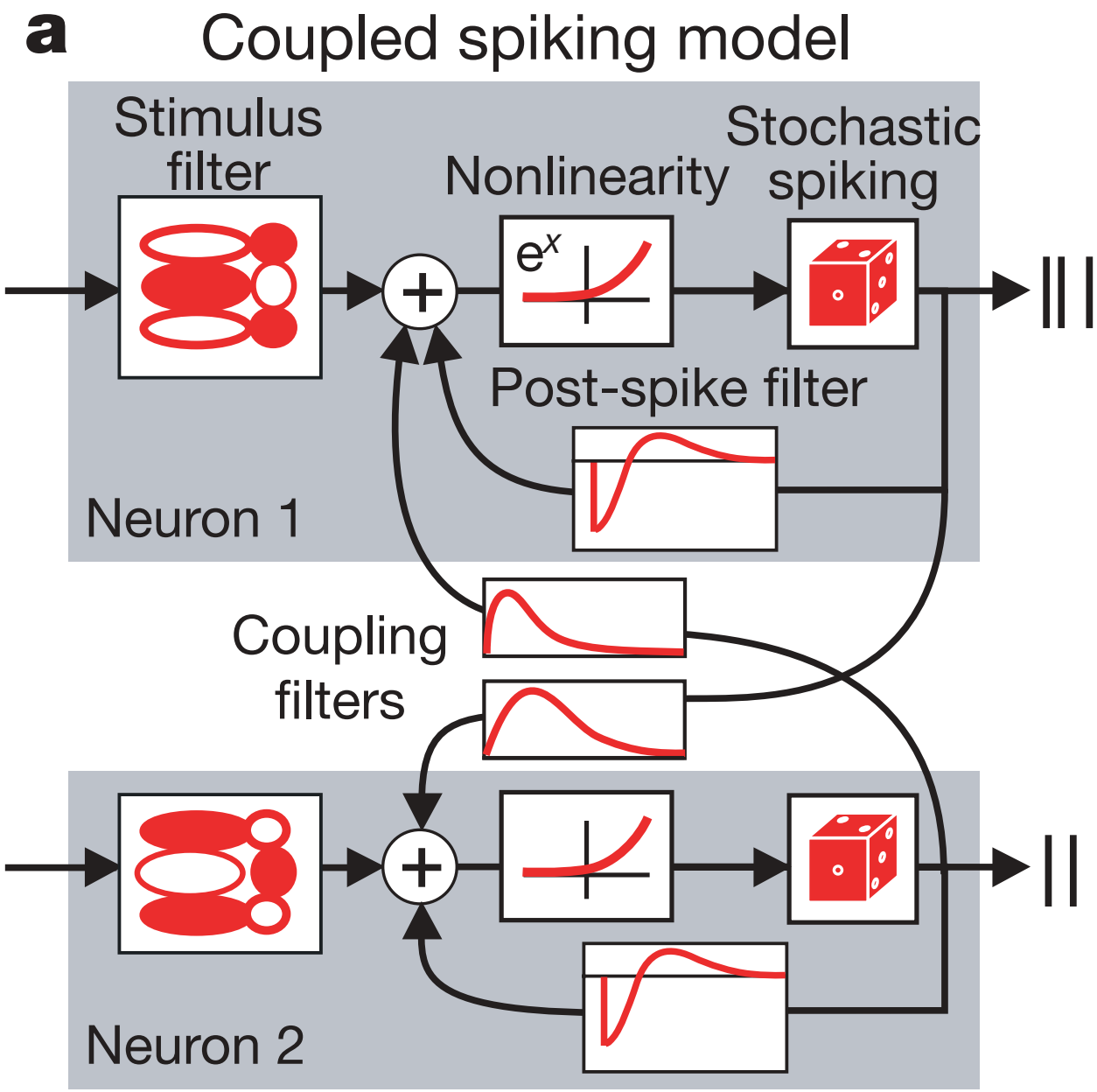
Tractable but NOT flexible model

Boring model:

Each neuron is described by a constant firing rate

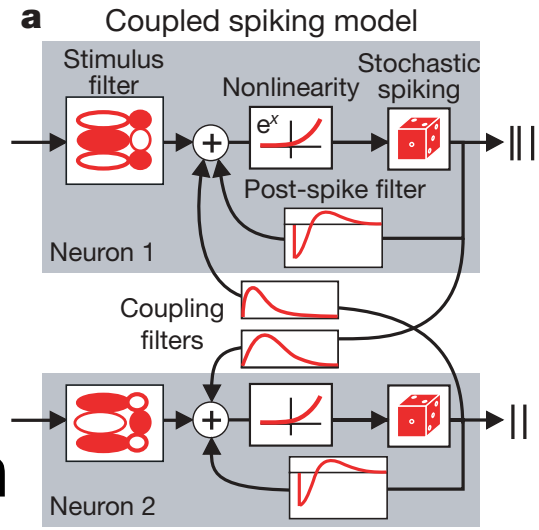
Easy to fit
no overfitting
…. but terribly boring!

Generalised linear model: a sweet spot



Why GLM ?

- Flexibility
  - includes neuron couplings + refractoriness
  - stochastic -> convenient for Bayes rule
  - additional features such as short-term plasticity
- Tractable
  - PDF analytically tractable
  - convex under some conditions
- won spike prediction competition
- … I just like it



Outlook of part I

Generalised linear model (GLM)

- Motivation for the GLM
- Math primer
- Definition of the GLM
- Properties of the GLM
- Learning with the GLM

Bibliography

- Wulfram Gerstner, Werner M. Kistler, Richard Naud and Liam Paninski. *Neuronal Dynamics: From Single Neurons to Networks and Models of Cognition*. 2014
- Paninski, L. (2004). *Maximum likelihood estimation of cascade point-process neural encoding models*. Network: Computation in Neural Systems, 15(4), 243–262.