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1 Formeln

- CLIAF (Neftci 2011):

$$C_m \frac{\mathrm{d}}{\mathrm{d}x} V_m = I_{in}(t) - \beta + I_{fb} e^{\frac{\kappa}{U_T}(V_m - V_{th})}$$

- Axon-Hillock IAF (Mead 1989)

$$C_m \frac{\mathrm{d}}{\mathrm{d}x} V_m = I_{in}(t) - \beta, \quad V_m(t) \in (0, \Theta)$$

- Hodgkin-Huxley ()
- AdEx ()

2 Einheiten

- β - Konstanter Leckstrom
- $I_{in}(t)$ - Neuronaler Inputstrom

3 Abkürzungen

AER - Address Event Representation
CCN - Cooperative and Competitive Network
CLIAF - Constant Leaky Integrate And Fire neuron
DNC - Digital Network Chip
DPI - Differential Pair Integrator
FPGA - Field Programmable Gate Array
HH - Hodgkin Huxley neuron model
HICANN - High Input Count Analog Neural Network
IAF - Integrate-and-fire neuron model
ISI - InterSpike Intervall
LTD - Long Term Depression
LTP - Long Term Potention
LTU - Linear Threshold Unit
STDP - Spike Timing Dependent Plasticity
sWTA - Soft Winner-Take-All Network

4 Definitionen

- AER: Communication Protocoll which describes spikes from sources
- overconstrained: equations outnumber the unknowns

5 Notizen zu wichtigen Arbeiten

5.1 Neftci 2010: A Device Mismatch Compensation Method for VLSI Neural Networks

- transistor properties mismatch as major VLSI problem
- mismatch compensation algorithm through connectivity

- no layout disadvantage (no extra HW memory)
- exploits Address-Event Representation
- metaplasticity as homeostatic mechanism for homogeneous population response
- change connectivity profile (# or %) to normalize response strength
- test: sWTA as possible general purpose structure
- synaptic scaling method to normalize response of VLSI sWTA with HW respresentation and constraints (e.g. spiking output)
- synaptic circuits with linear filter (1st order) to summarize different sources
- 1 synapse emulates synapses with same time constant and weight → modulates coupling strength between populations
- test of theory with sWTA and an compensation matrix → up to 40% less variability and same mean in transfer function
- fig 1: bumps getting homogeneous after compensation (reduced mismatch)
- increased discrimination performance: generally better win rate of stronger input population

5.2 Neftci 2011: A Systematic Method for Configuring VLSI Networks of Spiking Neurons

- subthreshold transistor → small signal → prone to noise and mismatch
- automatic bidirectional parameter mapping technique (high-level NN simulation ←→ VLSI)
- algorithm is general and usable if LTU behaviour approximated in circuit (IAF for example)
- approx possible if a regime exists in which neurons have threshold-activation linear function
- algorithm: standart parameter translation + determining bias voltage
- LTU ←→ CLIAF model ←→ CLIAF VLSI
- Equations (2.5) and (2.6) as complete approximated description
- Equation (2.7) as bridge between LTUs and silicon neurons

5.3 Neftci 2013: Synthesizing cognition in neuromorphic electronic systems

5.4 Sheik 2011: Systematic configuration and automatic tuning of neuromorphic Systems

5.5 Gao 2012: Dynamical System Guided Mapping of Quantitative Neuronal Models Onto Neuromorphic Hardware

5.6 Grassia 2011: Tunable neuromimetic integrated system for emulating cortical neuron models

5.7 Brüderle Dissertation 2009: Neuroscientific Modeling with a Mixed-Signal VLSI Hardware System

5.8 Brüderle 2011: A Comprehensive Workflow for General-Purpose Neural Modeling with Highly Configurable Neuromorphic Hardware Systems

5.9 Schwartz Dissertation 2011: Reproducing Biologically Realistic Regimes on a Highly-Accelerated Neuromorphic Hardware System

6 Mögliche wichtige Arbeiten

- determining unknown parameters and state variables of physical systems by measurements of a limited number of observables (parameter estimation methods)
- Brillinger 2008
- Keat, Reinagel, Reid, Meister 2001
- Paninski, Pillow, Simoncelli 2004
- Okatan, Wilson, Brown 2005
- Huys, Ahrens, Paninski 2006
- Abarbanel, Creveling, Farsian, Kostuk 2009

7 Notizen

- iterative Parametersuche kann durch Heuristik verbessert werden
  (Russel, Orchard, Etienne-Cummings 2007)
- IAF sind strombasiert
- Das erste IAF Modell ist das Axon-Hillock Modell von Mead
- Das A-H-Modell nutzt einen konstanten Strom als leak statt Konduktanz
- LTUs sind simple Modelle, die keine Spikezeitinformation und nichtlineare Elemente beinhalten
- der positive Feedback von CLIAF kann vernachlässigt werden, wenn der Threshold so gesetzt ist, das der ISI gleich bleibt
- man kann τ_{refrac} und Pulsweite ignorieren falls beide $\ll T_{ISI}$
- falls $\overline{T_{ISI}} \ll \tau_{syn}$ fluktuiert der Synapsenstrom um konstanten Wert $\sim w, f_{ISI}$
- Synapsen werden oft als Tiefpässe realisiert
- viele Annahmen bei Berechnungen $\rightarrow$ verringerte Komplexität $\rightarrow$ analystisch lösbar

8 Kleine nützliche Wortsammlung

- parameter estimation/extraction/translation/mapping