

# Attractor Dynamics with Synaptic Depression

C. C. Alan Fung, K. Y. Michael Wong, He Wang, Si Wu

What is “Synaptic Depression” ?

→ The synaptic efficiency is depressed due to the shortage of neural transmitters after a spike

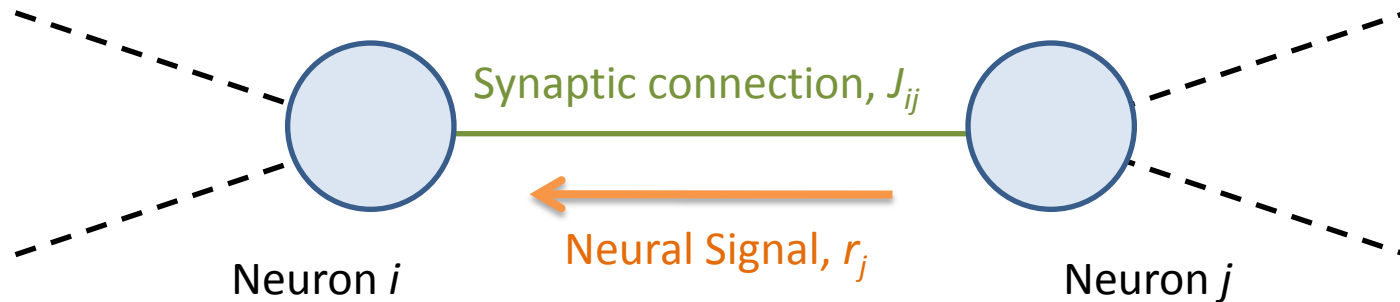
## The Motivation

In this paper, we investigate:

- ✓ How synaptic depression affects the **intrinsic dynamics of continuous attractor neural networks** (CANNs)
- ✓ How synaptic depression affects the performance of CANNs in tracking external stimuli
- ✓ How a neural network enables a **short-term memory** by holding a family of slow-decaying states

# Attractor Dynamics with Synaptic Depression

## Model

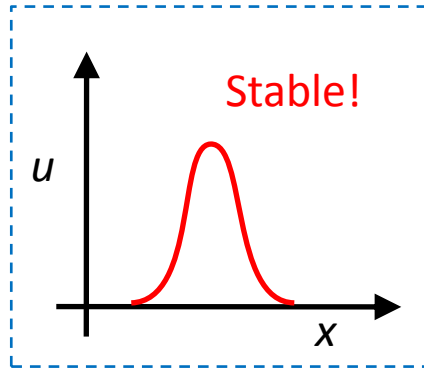


1. Synaptic connection strength,  $J_{ij}$ , is pre-defined
2. If a signal is sent from neuron  $j$  to neuron  $i$ , **the connection strength from  $j$  to  $i$  will be weakened**, due to synaptic depression
3. This effect is denoted by  $p_j$ ,  $0 < p_j < 1$
4. The effective connection from neuron  $j$  to neuron  $i$  is then  $J_{ij}p_j$
5. **The time needed for recovery of  $p_j$  to 1 is about several ten times of the time scale of synaptic response**

# Attractor Dynamics with Synaptic Depression

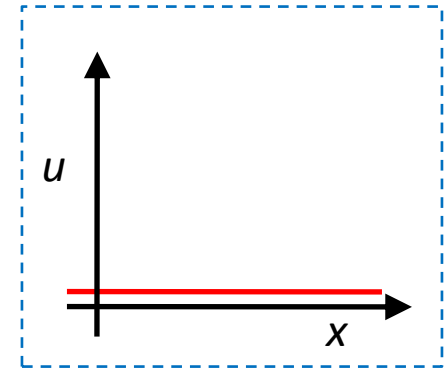
## Intrinsic Phase

CANN Without  
Synaptic  
Depression:



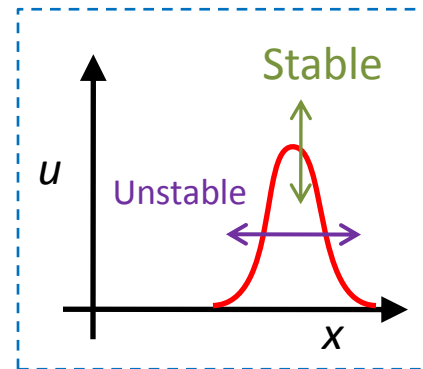
← Static bump

Silent state →

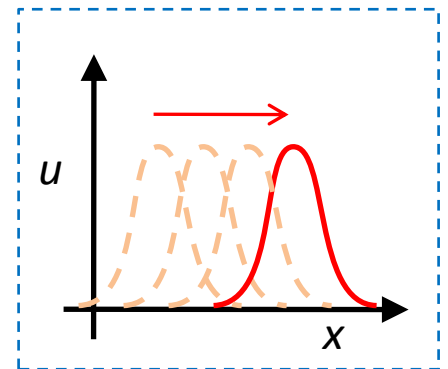


CANN With  
Synaptic  
Depression:

- Besides Static bumps and silent states, **two additional phases** can be found
- How do these phases depend on **inhibition** and **synaptic depression** ?



Metastatic

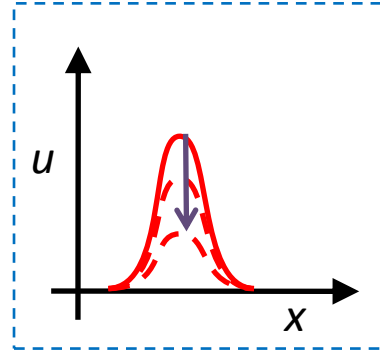


Moving

# Attractor Dynamics with Synaptic Depression

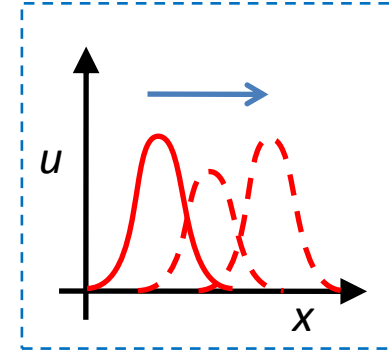
## Slow Decaying

- After the removal of stimulus, how does the neural activity decay in a **non-exponential** manner ?
- This slow-decaying behavior functions as a mechanism of short-term memory



## Tracking

- How is the tracking of changing stimuli affected ?
- Synapses are dynamical. Don't forget synaptic depression in the tracking process !



## Impact

- Unlike CANNs with static coupling, CANNs with synaptic depression have richer dynamics
- Provides a mechanism of working memory

Our poster is poster No. 6. All are welcome.  
Please feel free to give us comments. Thank You!