Zero-Lag Synchronisation in a Small Opto-electronic Network

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Investigation

• Initially investigated:
  “Zero-Lag Synchronisation in a three-node Opto-electronic Network”

• Inspired by work by Ingo Fischer [1]

• Similar to synchronising neurons in brain
Our Opto-electronic network

- Network of four coupled opto-electronic oscillators [2]
- Applies self-feedback and coupling delays
- Flexible

Images taken from [2]
Conditions for Synchrony

• Synchrony only found for large values of coupling

• Nodes 1 and 3 in sync, 2 out of phase
Varying time delays

- Varied time-delays in node 1
- Changed coupling delay: induces lag
- Changed feedback delay: negligible effect
Driving vs Coupling

• Observed effects are not due to synchronisation
• Occur at such large values of coupling, that self-feedback is drowned out

$\varepsilon=0.85$:

85% coupling, 15% feedback
Comparison: Four-node chain

- No synchrony found
- Absence of “driving” node
Comparison: Four-node star

- Synchrony found
- Presence of “driving” node

(RMSD, $\varepsilon$) diagram for a four-node star network
Symmetries affect statistics

- Node symmetries implies:
  - Similar dynamics
  - Similar statistics

- Suggests finding symmetries by comparing statistics
Symmetries do show in statistics

\[ \text{Coupling strength } \varepsilon \rightarrow \]

\[ \text{RMS Synchronisation Error } \rightarrow \]

\[ (\text{RMSD, } \varepsilon) \text{ diagram for a four-node linear network} \]

\[ \begin{align*}
\text{(RMSD, } \varepsilon) \text{ diagram for a four-node star network} \\
\end{align*} \]
Conclusion

- Zero-lag synchrony demonstrated in three-node network
- Synchrony due to “driving”
- Zero-lag synchrony replicated in star network
- Absent in chain-network
- Network Statistics reveal network symmetries

References

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