VPRTempo: A Fast Temporally Encoded Spiking Neural Network for Visual Place Recognition

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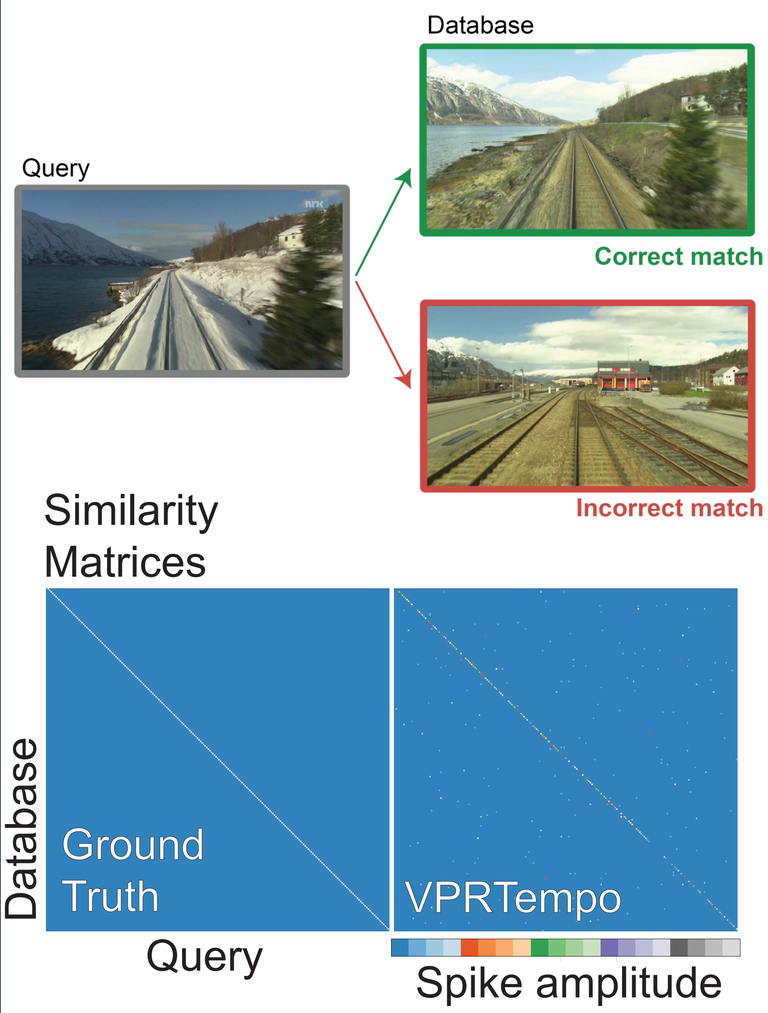
Acknowledgements

Introduction



The Challenge

How do robots localize based on previously visited places in real time?

Question

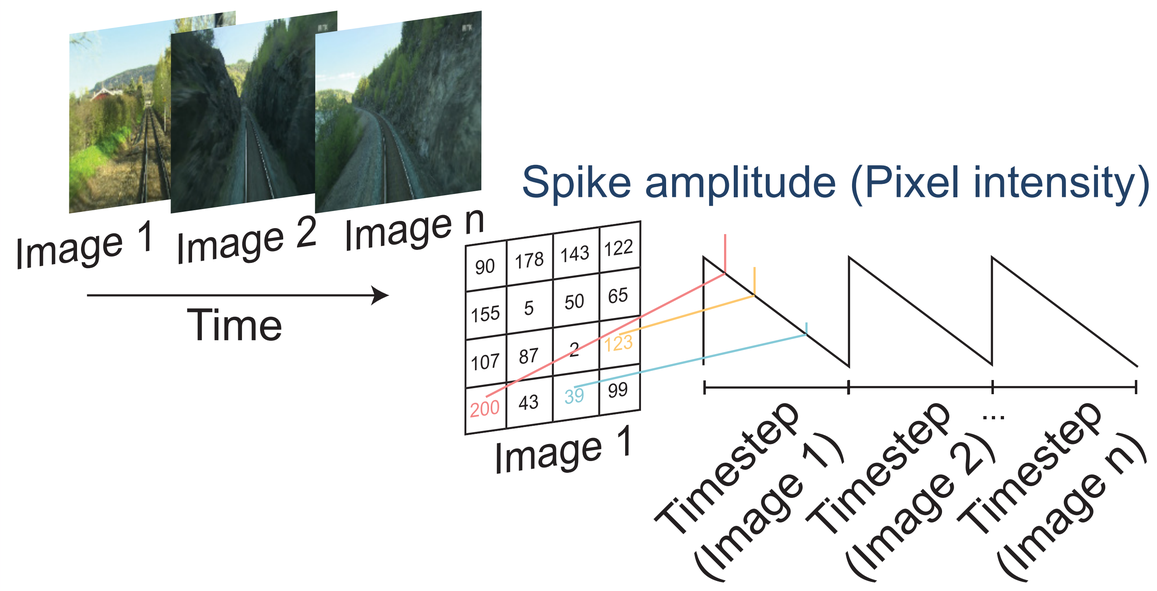
Can we find the most similar reference image given a query image using low latency spiking neural networks?

Goal

Develop a real-time capable spiking neural network to perform visual place recognition, using biologically inspired learning.

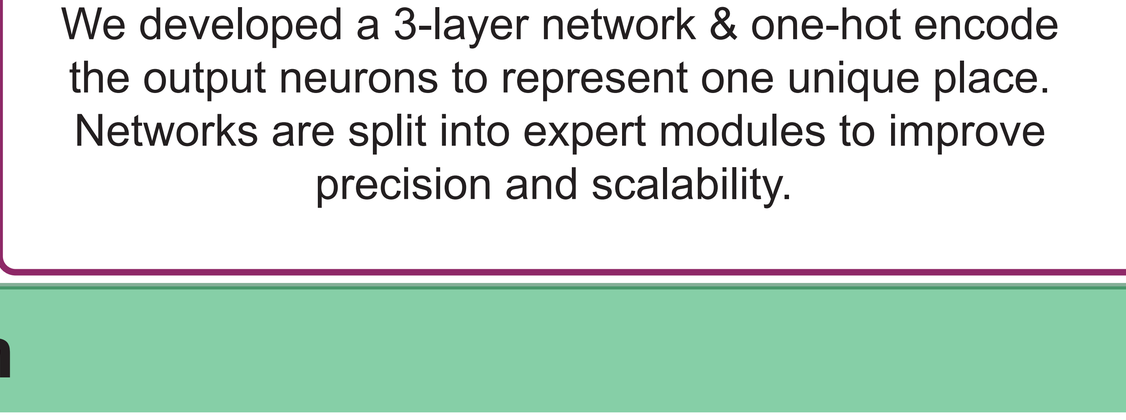
Methodology

Temporal Coding Scheme



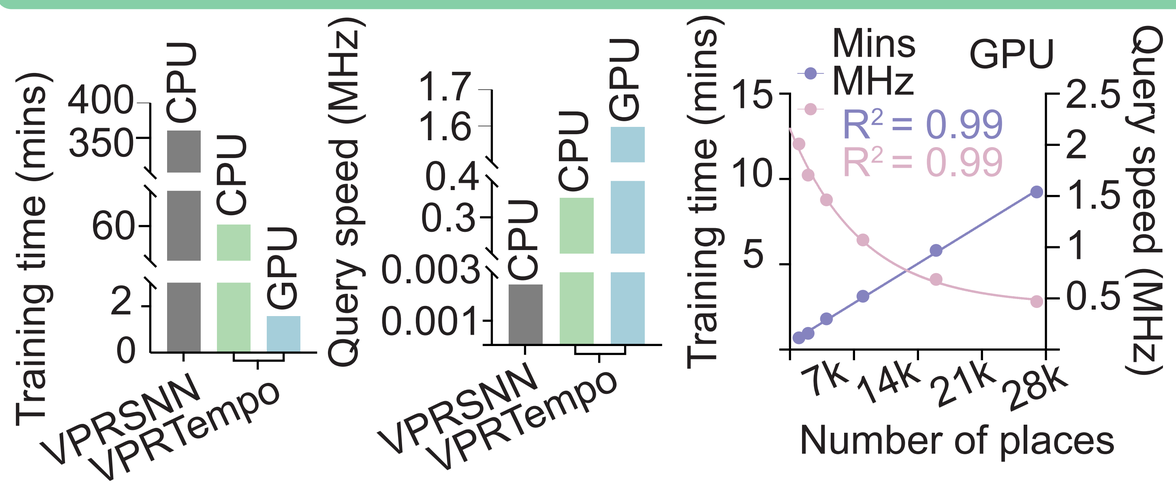
Spike efficiency was improved over 100%, when compared to rate encoded systems, by encoding pixel intensities as spike timings within a timestep.

Network Architecture



We developed a 3-layer network & one-hot encode the output neurons to represent one unique place. Networks are split into expert modules to improve precision and scalability.

Results: Network speeds

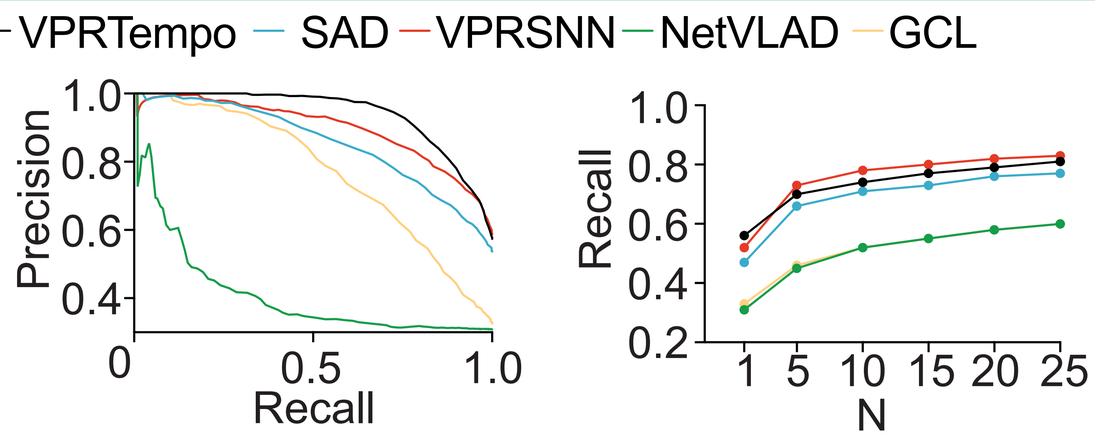


Highly efficient learning & deployment

Combining our unique temporal coding scheme [1] with efficient learning rules, VPRTempo is capable of learning large reference databases with real-time capability, achieving significantly faster deployment than other spiking neural networks [2].

Results: Performance and precision

Method	Nordland (3300 places) R@1 (%)	Train CPU (min)	Query CPU (Hz)	Train GPU (min)	Query GPU (Hz)
SAD [33]	48	-	10	-	17
NetVLAD [11]	31	15120	0.5	1512	31
GCL [14]	32	360	2	360	77
VPRSNN [8]	53	360	2	-	-
VPRTempo (ours)	**56**	**60**	**353**	**1**	**1634**



Compared to conventional and state-of-the-art place recognition systems, VPRTempo was trained and deployed orders of magnitude faster. We did not trade-off precision, as we perform comparably to these methods.

Conclusions

- We present the first temporally encoded spiking neural network for visual place recognition.
- A real-time capable place recognition system, suitable for resource contrained platforms.
- Developed an accurate network with modular capabilities for large scale place recognition.

References

[1] Stratton, Wabnitz, Essam, Cheung, & Hamilton: arXiv 2022, Making a Spiking Net Work: Robust brain-like unsupervised machine learning

[2] Hussaini, Milford, & Fischer: ICRA2023, Ensembles of Compact, Region-specific & Regularized Spiking Neural Networks for Scalable Place Recgnoition

vprtempo.github.io