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## **Ensembles of Compact, Region-specific & Regularized Spiking Neural Networks for Scalable Place Recognition**

### **Motivation**

Learning from animal navigation and brain function in nature to develop intelligent robotic navigation systems.

### **Deep Neural Networks**



- Use continuous activation values
- · State-of-the-art in many tasks

### Visual Place Recognition

Given a query image, can we find the most similar reference image? Reference



### Goal:

Our goal is to develop a massively parallelized ensemble of spiking neural networks for visual place recognition, scaling up prior work [2].



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This work: 2700 places

### References

[1] Microsoft Stock Images, 2022: Brain and Maze [2] Hussaini, Milford & Fischer R-AL + ICRA2022: Spiking Neural Networks for Visual Place Recognition via Weighted Neuronal Assignments

### **Method**



Left: We train compact, localized spiking neural networks that solely recognize places in a local region of the environment.

Middle: Independent training lacks global regularization, resulting in some neurons erroneously responding to places outside their area of expertise (we refer to these neurons as hyperactive). We detect and remove these neurons. Right: At deployment time, a query image is fed to all networks in parallel. As hyperactive neurons were removed, the strongest response of the remaining neurons in all networks is used for the place-matching decision.

### Results

We largely outperform prior SNN [2], and Ensemble SNN with hyperactive neurons, and the performance of our method is comparable to NetVLAD, DenseVLAD, and Sum-

### of-Absolute Differences (SAD).



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An example of a summer query image correctly matched to its corresponding spring reference place.



### **Future Directions**

- High tolerance to significant viewpoint changes
- Use of event streams from an event camera as input data
- Deployment on neuromorphic hardware (Intel's Loihi 2)
- Integration to a full SNN-based SLAM pipeline



Spiking Neural Networks

- Use binary spikes
- Energy-efficient with low latencies