Sum Product Network with VAE Leaves

P. L. Tan*, R. Peharz*, T. Adel*
* Department of Engineering, University of Cambridge

**What are Sum Product Networks?**

SPNs use **sum nodes** and **product nodes** to compose many simple univariate distributions into a large complicated multivariate distribution.

- **Sum nodes** over disjoint sets of random variables can be composed into a **product node**.
- **Product nodes** over identical sets of random variables can be composed into a **sum node**.

By recursively applying these two simple rules, we can build deep, complicated yet compact representations of multivariate distributions.

**How to compose:**
- **Sum nodes** over disjoint sets of random variables can be composed into a **product node**.
- **Product nodes** over identical sets of random variables can be composed into a **sum node**.

**Properties of SPN**

<table>
<thead>
<tr>
<th>Easy</th>
<th>Hard</th>
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<tbody>
<tr>
<td>Sample</td>
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<tr>
<td>Learn parameters</td>
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<tr>
<td>Marginalise missing R.V.</td>
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<tr>
<td>Infer missing R.V.</td>
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<tr>
<td>Compute likelihood</td>
<td>Learn structure</td>
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**Proposed Solution:**
- Keep dense SPN small by decomposing image down to superpixel only.
- Neural generative model (like VAEs) handles distribution of superpixel.

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**Typical Training Curves on MNIST:**
- Compare SPN-VAE against vanilla SPN and vanilla VAE.
- Vanilla VAE has same size as all VAE leaves combined.
- Same learning rate (0.01) and algorithm (Adam).

**Further Work:**
1. Investigate SPN’s regularization effect.
2. Evaluate model on more datasets.
3. Try other neural generative models like PixelRNN.
4. Show that theoretical benefits of SPN are preserved when using VAE leaves.
5. Propose and validate a convolutional architecture of SPN with mix of Gaussian and VAE leaves.

**Contact**
plt28@cam.ac.uk