Neural Computation : Exercise Sheet 5

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The following questions are of the kind that may come up in the exam this year. They are designed to help you monitor your progress – try to answer the questions without your notes, and then use your notes to check whether your answers are correct. The percentages indicate the corresponding fraction of a 1.5 hour exam.

Question 1

(a) Dimensionality reduction is a form of data compression. What does this statement mean? Is it always true? **[4%]**

(b) Describe a practical example of when and why it would be useful to perform some form of compression on a set of data. **[4%]**

(c) Explain in detail how one can carry out dimensionality reduction using a simple *Multi-Layer Perceptron* (MLP). **[7%]**

(d) Describe in detail how one can carry out dimensionality reduction using a *Self Organizing Map* (e.g., a *Kohonen Network*). **[10%]**

Question 2

(a) Explain what is meant by the term *Topographic Map*. Give an example of where such a map can be found in the human brain, and outline why it might be useful there. **[7%]**

(b) Describe the key components of the architecture and self-organizing process that can be used to generate topographic maps in a *Kohonen Network*. **[10%]**

(c) Give intuitive explanations of why the size of the topological neighbourhood and the learning rate should both be decreased during a course of successful *Kohonen Network* training. **[8%]**

Question 3

(a) In general, what is meant by the term *Self Organising Map (SOM)*? **[4%]**

(b) Describe the particular form of Self Organising Map (SOM) that is generated by a *Kohonen Network*. **[5%]**

(c) Outline the main components of the self-organising process used to train a Kohonen Network, and comment on the possibility of a *Topological Defect* arising. **[8%]**

(d) In the context of Kohonen Networks, explain what is meant by the terms *Density Matching* and *Topological Ordering*, and why they are important features of the self organised mapping. **[8%]**

Question 4

(a) Describe the architecture of the *Self Organising Map (SOM)* known as a *Kohonen Network*. **[4%]**

(b) What kinds of applications can such networks be used for? Outline one concrete example application. **[5%]**

(c) The self organising process can be said to have four major components: Initialization, Competition, Cooperation, and Adaptation. Briefly describe the purpose of each of these components and how they can be implemented. **[8%]**

(d) Two equations used in the context of *Kohonen Networks* are:

$$T_{j,I(\mathbf{x})}(t) = \exp(-S^2_{j,I(\mathbf{x})} / 2\sigma^2(t))$$

$$\Delta w_{ji} = \eta(t) \; . \; T_{j,I(\mathbf{x})}(t) \; . \; (x_i - w_{ji})$$

What do each of the symbols in them mean, and how are these equations used in the self organising process? **[8%]**

Question 5

(a) By definition, there are no target output values in unsupervised learning. So, what exactly is learned by an unsupervised learning process? **[4%]**

(b) Explain the structure of the various layers of neurons in a standard *Kohonen Network*, and what each layer of neurons represents or computes. **[4%]**

(c) Describe the key steps in the standard unsupervised training algorithm that can be used to result in a *Kohonen Network* producing useful outputs. **[7%]**

(d) Explain the relation between a *Kohonen Network* and a *Noisy Encoder-Decoder Model*, and what that implies about the mapping performed by a *Kohoen Netowork*. **[10%]**

Question 6

(a) Describe the data compression properties of the mapping that is performed by an appropriately trained *Kohonen Network*. **[8%]**

(b) In this context, explain what is meant by the terms *Vector Quantization* and *Voronoi Tessellation*. **[7%]**

(c) Outline how *Learning Vector Quantization (LVQ)* can improve the performance of a Kohonen Network. **[10%]**