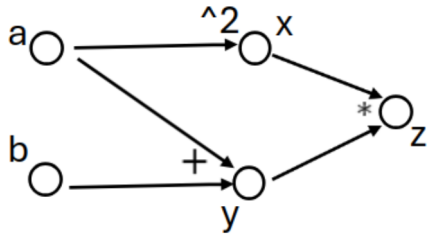
Exercise Sheet 3

Neural Computation
University of Birmingham

Week 3 2025

Exercise 1.

1. Consider the computation graph below. The + and * symbol correspond to addition and multiplication respectively. The symbol '^2' indicates that the variable is squared.



   (a) Write down the equation corresponding to the computation graph, describing the calculation of the output variable z from the inputs a,b. Which part of the equation corresponds to the intermediate variables x and y?

   (b) Consider the graph from above and $a = 1$ and $b = -2$. Use the forward pass of the backpropagation algorithm to compute x, y, and z.

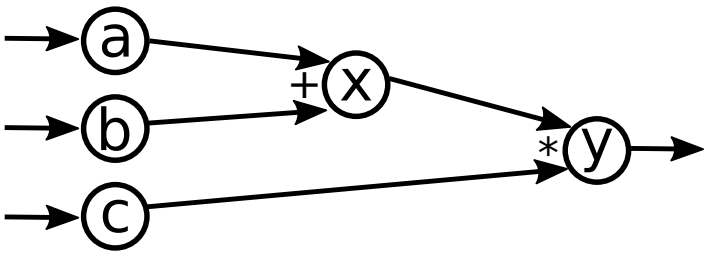
   (c) Use the backward pass to compute the partial derivatives of z in the direction of x, y, a, and b.

2. (a) Consider the following linear regression problem: Given a set of training data, you want to predict the price of a real estate property from the number of bedrooms in a home using a squared error loss function. Sketch the computation graph for the prediction and the resulting loss.

   (b) Mark which nodes in your graph from (b)(i) correspond to the number of bedrooms x, the predicted price $\hat{y}$, the true price y, the loss L and the learnable parameters w and b.

Exercise 2.

1. Consider the computation graph below. The + and $*$ symbol corrspond to addition and multiplication respectively. Write down the equation corresponding to the computation graph, describing the calculation of the output variable y from the inputs a, b, c. Which part of the equation corresponds to the intermediate variable x?



2. Consider $a = 2$, $b = 3$, and $c = 2$. Use the forward pass of the backpropagation algorithm to compute x and y.

3. Based on the results from (b), use the backward pass of the backpropagation algorithm to compute the derivatives $\frac{\partial y}{\partial x}$, $\frac{\partial y}{\partial a}$, $\frac{\partial y}{\partial b}$, and $\frac{\partial y}{\partial c}$.

4. Sketch a computation graph for the equation $g = \big((a*b+c*d+e)-f\big)^2$. You do not have to name the intermediate variables. Write '2' next to an arrow to indicate the squaring operation. You can interpret the equation from (d) as computing the loss function for a linear regression problem. Which variables correspond to the inputs and which to the learned parameters of the model? Which variable corresponds to the ground truth label. Note that there are multiple solutions, providing one is sufficient.