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Exercise 7

Deadline: 06.07.2016

1 Sum-product algorithm (20 Points)

In this exercise we revisit the Boy Problem from exercise 06 and interpret it as a factor graph. We introduce the random variables A and B which indicate the sex of each of Alice's children with $P(A = 1 = \text{"}boy\text{"}) = P(B = 1 = \text{"}boy\text{"}) = 0.5$ and $C = A \vee B$ and $D = A \wedge B$.
Task: Given the Belief network in Figure 1 create the corresponding factor graph.

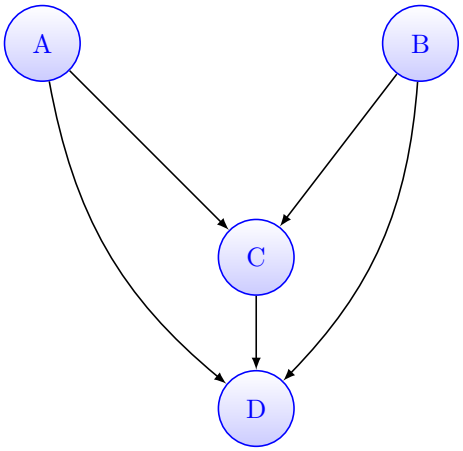


Abbildung 1: Belief Network of boy boy problem

Now consider that you meet Alice and she tells you that one of her children is a boy ($C = 1$).

Task:

- Create a new factor graph given that $C = 1$.
- Which graph property has changed such that we can apply belief propagation?
- In the new graph calculate $P(A|C = 1)$ and $P(D|C = 1)$:
  - For each factor in the factor graph: Create a table that displays the factor value for all state combinations of A, B, C, D (**Note**: You can drop the states from the tables that contradict the evidence).
  - Apply the sum-product algorithm on paper (4 rounds should be sufficient).

Hint: You do not need to compute the messages to node B since it will be identical to A due to symmetry.

2 Maze (20 Points)

2.1 Shortest Path

For this exercise we will look at a random walker inside a maze. The topology of the maze is described by the adjacency matrix M, where $M_{ij} = 1$ means that there is a door that leads from room number i to room number j (and no door if $M_{ij} = 0$). In our example M is symmetric.

Inside of the maze is a random walker who is initially in room 0. In each timestep the walker chooses go through one of the doors, with equal probability. We can describe this process as a Markov chain.

Task:

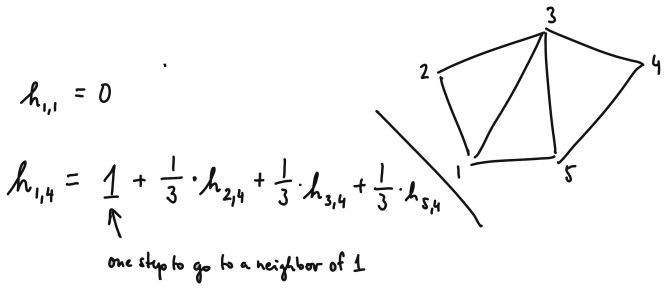
- How can the transition probability matrix be computed from M
- Derive a general formula for the most likely path to get from room 0 to room 99

Use the array in *maze.npy* from the lecture homepage as matrix M for the following:

- Compute the transition probability matrix from M
- Find the shortest Path between room 0 and room 99
- Find the most likely path between room 0 and room 99

2.2 Expected traversal time

We are also interested in the expected time it takes the random walker to traverse the maze. We define the traverse time h_{ij} that describes the time to reach room j for the first time, starting at i. In general you will find $h_{ij} \neq h_{ji}$. The easiest way to calculate $h_{0,99}$ is compute all traversing times simultaneously. You will have to find the equations yourself, but consider the following toy example:



Task:

- Derive a general formula for all h_{ij}.
- Calculate the expected time it takes the random walker to go from room 0 to room 99 using the derived equation and the values from M.
- Implement the random walker and measure the average of $h_{0,99}$ over 100000 walks.

3 Project Orientation (6 Points)

In order to give you an overview over the current state of machine learning algorithms we would like you to read some of the publications of recent conferences.

Task:

- Go to `http://www.cv-foundation.org/openaccess/CVPR2016.py` to find the current proceedings of CVPR 2016
- Go to `http://jmlr.org/proceedings/papers/v48/` to find the current proceedings of ICML 2016
- Go to `https://papers.nips.cc/book/advances-in-neural-information-processing-systems-28-2015` to find the current proceedings of last years NIPS 2015
- Select 3 papers that you find interesting. Focus on papers concerning neural networks or graphical models.
- For each selected paper write 2 (or a few) sentences why you choose them.

Regulations

Please hand in the python code, figures and explanations (describing clearly which belongs to which). Non-trivial sections of your code should be explained with short comments, and variables should have self-explanatory names. Plots should have informative axis labels, legends and captions. Please enclose all results into a single .pdf document and hand in the .py files that created the results. Please email the solutions to `mlhd1516@gmail.com` before the deadline. You may hand in the exercises in teams of maximally three people, which must be clearly named on the solution sheet (one email is sufficient). Discussions between different teams about the exercises are encouraged, but the code must not be copied verbatim (the same holds for any implementations which may be available on the WWW). Please respect particularly this rule, otherwise we cannot give you a passing grade.