Machine Learning - Assignment 1

Eden Dupont 204808596 - Afeka College of Engineering
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Theoretical Part

1. Describe the instance domain (X) and the label set (Y).
   Answer:
   The instance domain would be inputs in the form of [0, 1]^d
   Where d is the number of inputs which corresponds to a label
   from the label set.

   For example: ([0,1,1],1)
   In this example [0, 1, 1] is the input of domain X
   And 1 is the label from the label set which corresponds to that input

   Each input is labelled according to an unknown function, for which we want to find and hypothesis that fits into as much as possible.

2. Present the entire hypothesis class for d=2.
   Answer:
   {∅, x1, ¬x1 ,x2 ,¬x2, ¬x1∧¬x2 ,x1∧¬x2 ,¬x1∧x2 ,x1∧x2 ,x1∧¬x1∧x2∧¬x2}
3. Suggest an equation that describes the size of the hypothesis class for any given d.
   Answer: for each input, we shall create 3 states in the conjunction statement: atomic, negation, non-existent (X,¬X,None)
   For d inputs there would then be 3^d statements, and we should also add an all-negative statement (for example x1∧¬x1∧x2∧¬x2)
   In short: $3^d + 1$ is the size of the hypothesis class for any given d.

4. Suppose that the true conjunction is $\neg x1 \land x2 \land x3$:
   a. Can the following example exist in the training set: ((1,0,1,1),0)?
      If not, suggest a correction.

Answer:

The example **can** exist in the training set because when the data is put in the conjunction we would get the same output as expected:

$\neg x1 \land x2 \land x3 = 0 \land 0 \land 1 = 0$ -> (same as labelled 0)

   b. Can the following examples co-exist in the training set:
      ((0,1,1,0),1),
      ((0,1,1,1),1)
      If not, suggest a correction.

Answer: The example **can co-exist** in the training set.

$\neg x1 \land x2 \land x3 = 1 \land 1 \land 1 = 1$ -> (same as labelled 1 for both training sets)

Input x4 is in a 'don't care' state because it is not part of the conjunction.

2. The Consistency Algorithm

1. **Explain in your own words, what the Consistency Algorithm do?**
   Answer: The Consistency Algorithm assumes an initial all negative hypothesis which includes all possible literals, for each example from the dataset, it will remove the literals that don't conform to their predicted label, and repeats until all of the data is checked.
   The algorithm finishes with a hypothesis which fits all data points or finishes with an empty set hypothesis in which case there are examples which negate each other in the dataset.
2. Does this algorithm try to reduce the error on the training examples to zero? Explain.
   Answer: yes, for each example from the dataset, the hypothesis fixes itself so that there would be no error, and then using the fixed hypothesis for the following examples - in the end there would be no error on the dataset (or no solution found)
3. What is the run-time per iteration?
   Answer: The run-time iteration is $O(d)$
   2*d for calculating value on the hypothesis (worst case, an all negative hypothesis with 2*d literals)
   And another 2*d for removing literals from the hypothesis
   $O(2d + 2d) = O(4d) = O(d)$ for each iteration

The Consistency Algorithm - Practical Part

The code is included in ex1_main.py