Inductive Programming: Tutorial 5
Induction of Efficient Programs

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The aim of this tutorial is to help you understand concepts in Lecture 5, involving Induction of Efficient Programs.

Question 1

Why is it an advantage to induce short programs? Give a reasoned argument.

Solution Assume all programs $H \in \mathcal{H}_n$ of size at most n are considered before programs $H' \in \mathcal{H}_{n+1}$ of size at most $n+1$. According to the Blumer bound for any ϵ, δ it is the case that $m_H < m_{H'}$ since $ln(|\mathcal{H}_n|) < ln(|\mathcal{H}_{n+1}|)$. So smaller programs can be learned using fewer examples.

Question 2

Why are shorter programs not always preferable?

Solution A shorter program H is not preferable to a long program H' in the case that H has higher time complexity than H'.

Question 3

Provide an example of when a longer program is preferable to a shorter one.

Solution The following is an example of when a longer program is preferable to a shorter one.

Program size

psort	s(L1,L2) :- permute(L1,L2), sorted(L2).
msort	s([],[]). s([H|T],L) :- sp(H,T,L1,L2), s(L1,L3), s(L2,L4), m(L3,L4,L).

Time complexity

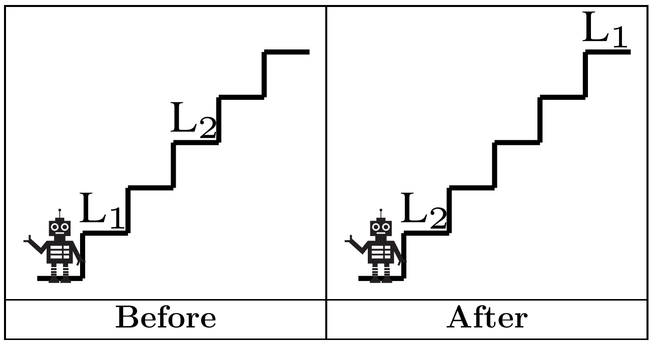
psort	O(n!)
msort	O(nlog(n))

Question 4

Provide 1) a labelled drawing of the Postman delivery problem for n letter and d places 2) a description of two strategies which can be induced by Metagol together with their time complexities.

Solution

1. Diagram of Postman delivery problem.



n letters and **d** places for delivery

2. In both strategies below the Postman starts at the base of the stairs.

   O(nd) strategy Until all letters are in their correct place the Postman repeately finds the next letter to be delivered, takes it to the place on the envelope and returns to the starting position.

   O(n+d) strategy The Postman first ascends the stairs collecting all letters in the postbag. The Postman then descends the stairs, delivering each letter from the postbag to the place indicated on the envelope.

Question 5

Give a table showing a) the cost function of Metagol$_O$, b) the cost function of Metaopt and c) the general cost ordering over the hypothesis space.

Solution

The table is as follows.

Metagol$_O$	$\sum_{e \in E} r(H, e)$
Metaopt	$\sum_{e \in E} \text{treecost}(H, e)$
General ordering	$\prec_\Phi$

Question 6

Give a table describing the following a) the Version space $\mathcal{V}_{B,E}$, b) the minimal cost hypothesis.

Solution

The table is as follows.

Version space $\mathcal{V}_{B,E}$	Hypothesis space consistent with B, E
Cost minimisation	$H \in \mathcal{V}_{B,E}$ and $\forall H' \in \mathcal{V}_{B,E} H \preceq_\Phi H'$

Question 7

Give a table showing the general form of the Metagol$_O$ and Metaopt algorithm for Cost Minimisation.

Solution The table is as follows.

Iteration	Hypothesis
1	$\lvert \mathrm{H}_1 \rvert$ minimal in $\mathcal{V}_{B,E}$
$i > 1$	$\lvert H_i \rvert$ minimal and $H_i \prec_\Phi H_{i-1}$
$i = \text{final}$	$\nexists H_i \; H_i \prec_\Phi H_{i-1}$
Return	$H_{\text{final}-1}$

Question 8

Give a simple statement of the convergence theorem for Metaopt.

Solution The statement of the convergence theorem for Metaopt is as follows.

Given sufficiently large $\lvert E \rvert$
Metaopt returns $\inf_{\preceq_\Phi} \mathcal{V}_{B,E}$