CS404 - ASSIGNMENT 1

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Part 1 - Search Model

(a) States: All arrangements of the balls (1, 2, 3, 4) on the bottles (B1, B2, B3, B4, B5, B6)

(b) Successor State Function: Each of the successor states are obtained by legally moving any of the balls

(c) Initial State: State that is provided by the input, initially

(d) Goal Test: Each ball with the same color (1,2,3 or 4) are collected in one specific bottle -does not matter which bottle it is. There will be one full bottle with one specific color and 4 balls of that color.

(e) Step Cost: Each ball movement costs 1 unit

Part 3 - Heuristic Function

Heuristic Function: (where n is the number of balls to the bottom -height of the ball, bottom is 0)

$$h(x) = \begin{cases} 0, & \text{if all of the balls to the bottom is same color with x} \\ 4 - n, & \text{otherwise} \end{cases}$$

Proof:

Let $h^*(x)$ is optimal solution to make x satisfying the goal test.

In order to satisfy goal test, bottle should be full or empty (make of 4 balls). Furthermore, there are $3 - n$ balls stand over x, $4 - 1 - height$.

If all of the balls to the bottom is same color with x, $h(x) = 0$ and no need for a move: $h^*(x) = h(x) = 0$.

Otherwise, $3 - n$ moves must be made to free the above part of x and $h(x) = 4 - n$. Moreover, bottle that x initially belongs to will have $4 - n$ balls. In order to make that bottle free or full $min((4 - n), n)$ moves must be performed, as well.

$n \geq 1$, since there is at least 1 ball that has different color than x. Also $n \leq 3$, because there cannot be more than 4 balls in a bottle. Thus, n -height- has the following constraint: $1 \leq n \leq 3$

When $n \leq 4 - n$:
$h^*(x) = 7 - 2n$.

And according to constraint above, $3 \geq 4 - n \geq 1$.
Therefore, $3 \geq 4 - n$ and $h^*(x) \geq h(x)$

When $n > 4 - n$:

$h^*(x) = 3$.
Again according to constraint above, $7 - 2n \geq 4 - n$, since $3 \geq n$
Therefore, $7 - 2n \geq 4 - n$ and $h^*(x) \geq h(x)$

To sum up, in each scenario $h^*(x) \geq h(x)$. Hence, $h(x)$ is admissible.

Part 5 - Experimental Results

Table 1: Time Consumption (in seconds)

	test0	test1	test2	test3	test4	test5	test6	test7
A*	0.00699	0.00617	0.02422	0.02231	0.00000	0.00699	0.09272	0.07322
UCS	0.02954	0.22337	0.08682	0.09821	0.00000	0.02901	4.24340	22.90116

Table 2: Memory Consumption (in KB's)

	test0	test1	test2	test3	test4	test5	test6	test7
A*	36,726	30,935	125,838	121,966	700	18,616	370,187	258,488
UCS	46,250	25,6341	232,061	232,088	628	56,870	8,214,252	35,325,918

As expected A* performs much better than UCS, since it has an approximation of futher steps. Heuristic function allows A* to predict which choice would cost less time and memory in further step, and select the successor state accordingly. However, UCS expands the state with the less cost so far. Therefore, it has no prediction about the further cost of those steps, and it causes unnecessary expansions.

Because of those reasons, A* is expected to be faster and consume less memory, as it shows out to be. In test6 and test7, there are 6 different colors and initial state of those balls are distributed heterogeneously. Thus, a lot of unneccessary expansions are occurred in UCS, which makes running time and memory consumption much higher than the A* search.