Simulation experiments for hide-and-seek with different seeker distribution update strategies

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1 Experimental Settings

We perform some simulation experiments for Hide-and-Seek with three different **seeker distribution update strategies**:

(1) **No update:** no update of the seeker distribution (leads to hide-and-seek with replacement results)

(2) **Uniform update:** open a box, distribute its probability mass to every other unopened boxes, make its probability 0 (hide-and-seek without replacement)

(3) **Hot-cold update:** open a box, check if it is hot (based on some threshold criteria), if it is hot, distribute its mass to its unopened neighbors; otherwise distribute its mass to every other unopened boxes, and make its probability 0 (hide-and-seek without replacement)

Further, the **hider distribution** is varied across four different **forms**:

(1) **Easy hider:** The hider distribution is easy. It translate to a single spike (degenerate distribution) such that there is absolute certainty that the hider will always hide there.

(2) **Not-so-easy hider:** The hider distibution is less easy. It translates to a distribution where there are some boxes which have masses and majority of boxes have zero probability mass. We can call it semi-degenerate hider.

(3) **Not-so-hard hider:** Here the hider distribution is not-uniform. It is a random distribution. Each box have a non-zero probability mass such that it is not a uniform distribution.

(4) **Hard hider:** The hider distribution is adversarial. This translates to a uniform hider distribution in which randomness is very high.

Base setting The experiments are performed for three different settings of boxes $n = \{10, 100, 1000\}$. The maximum hiding trials is set at 1000. We call it a **failure**, if the hider is not found within n openings by using the seeker distribution. The threshold temperature for deciding whether a box is hot is varied as $\theta = \{0.10, 0.50, 0.80\}$. The neighborhood is fixed at 1 i.e. a box i has neighbors $i-1$ and $i-1$ except for the extreme cases like $i = 1$ and $i = n$ for which neighbors are $i+1$ and $i-1$ respectively.

For simulation with not-so-easy hider, we have fixed the degeneracy to 25% i.e. a hider distribution in which 25% boxes have non-zero probability. For further experiments, we vary this percentage. For all ther experiments here, we define performance of a box by: $\text{Perf}(i) = \frac{h_i}{\max(h_1,\ldots,h_n)}$, where $H = \{h_1, \ldots, h_n\}$ is the hider distribution.

2 Base Results

The mean and standard deviations of misses are calculated only for successful runs i.e. the hider was found by the seeker within n look-ups. Otherwise, it was treated as a failure and this result was not included for statistics.

Hider	**Update S**	n	**SuccessRate**	**mean(misses)**	**sd(misses)**
Easy	None	10	0.63	3.783	2.787
Easy	Uniform	10	1	4.631	2.8
Easy	Hot-cold	10	1	4.335	2.851
Not-so-easy	None	10	0.641	3.657	2.822
Not-so-easy	Uniform	10	1	4.579	2.847
Not-so-easy	Hot-cold	10	1	4.504	2.978
Not-so-hard	None	10	0.655	3.754	2.844
Not-so-hard	Uniform	10	1	4.485	2.834
Not-so-hard	Hot-cold	10	1	4.446	2.887
Hard	None	10	0.652	3.528	2.794
Hard	Uniform	10	1	4.39	2.854
Hard	Hot-cold	10	1	4.522	2.869
Easy	None	100	0.65	40.646	29.015
Easy	Uniform	100	1	50.65	29.21
Easy	Hot-cold	100	1	49.974	28.368
Not-so-easy	None	100	0.665	42.035	27.834
Not-so-easy	Uniform	100	1	50.522	28.115
Not-so-easy	Hot-cold	100	1	50.759	28.987
Not-so-hard	None	100	0.632	40.552	27.821
Not-so-hard	Uniform	100	1	47.59	28.564
Not-so-hard	Hot-cold	100	1	50.113	28.464
Hard	None	100	0.627	43.069	29.019
Hard	Uniform	100	1	49.82	28.578
Hard	Hot-cold	100	1	50.461	28.68
Easy	None	1000	0.631	416.185	276.21
Easy	Uniform	1000	1	512.223	287.658
Easy	Hot-cold	1000	1	500.191	290.517
Not-so-easy	None	1000	0.614	412.41	280.343
Not-so-easy	Uniform	1000	1	496.961	289.148
Not-so-easy	Hot-cold	1000	1	511.084	292.764
Not-so-hard	None	1000	0.627	416.137	279.347
Not-so-hard	Uniform	1000	1	486.806	284.766
Not-so-hard	Hot-cold	1000	1	491.265	291.296
Hard	None	1000	0.639	410.931	288.47
Hard	Uniform	1000	1	498.262	294.556
Hard	Hot-cold	1000	1	485.211	288.785

Figure 1: Results for $\theta = 0.10$ with base setting

Hider	Update S	n	SuccessRate	mean(misses)	sd(misses)
Easy	None	10	0.63	3.783	2.787
Easy	Uniform	10	1	4.631	2.8
Easy	Hot-cold	10	1	4.335	2.851
Not-so-easy	None	10	0.641	3.657	2.822
Not-so-easy	Uniform	10	1	4.579	2.847
Not-so-easy	Hot-cold	10	1	4.504	2.978
Not-so-hard	None	10	0.655	3.754	2.844
Not-so-hard	Uniform	10	1	4.485	2.834
Not-so-hard	Hot-cold	10	1	4.335	2.812
Hard	None	10	0.656	3.534	2.791
Hard	Uniform	10	1	4.395	2.855
Hard	Hot-cold	10	1	4.54	2.878
Easy	None	100	0.639	41.765	28.103
Easy	Uniform	100	1	49.856	28.525
Easy	Hot-cold	100	1	47.915	28.729
Not-so-easy	None	100	0.643	41.258	28.339
Not-so-easy	Uniform	100	1	50.054	28.845
Not-so-easy	Hot-cold	100	1	48.093	28.668
Not-so-hard	None	100	0.62	41.442	27.754
Not-so-hard	Uniform	100	1	50.739	28.991
Not-so-hard	Hot-cold	100	1	50.957	28.689
Hard	None	100	0.665	41.062	27.899
Hard	Uniform	100	1	50.324	28.469
Hard	Hot-cold	100	1	50.468	28.803
Easy	None	1000	0.614	402.634	274.811
Easy	Uniform	1000	1	492.868	285.436
Easy	Hot-cold	1000	1	496.751	287.265
Not-so-easy	None	1000	0.66	419.939	285.935
Not-so-easy	Uniform	1000	1	499.622	284.84
Not-so-easy	Hot-cold	1000	1	489.937	288.627
Not-so-hard	None	1000	0.655	417.09	276.514
Not-so-hard	Uniform	1000	1	510.347	291.584
Not-so-hard	Hot-cold	1000	1	490.899	289.477
Hard	None	1000	0.635	399.254	277.453
Hard	Uniform	1000	1	500.742	299.355
Hard	Hot-cold	1000	1	494.067	287.592

Figure 2: Results for $\theta = 0.50$ with base setting

2.1 Interpretations

- For all the cases, search fails approximately 40% of times when there is no update (with replacement).
- In all the three θ settings, we see that most of the time, the hot-cold update strategy is better than the uniform update when the hider distribution is not-so-hard or not-so-easy. It does hold sometimes when the hidistribution is a degenerate one or uniform (hard).
- From the tables, it is not very clear whether neighborhood size has any effect on the performance.

Hider	Update S	n	SuccessRate	mean(misses)	sd(misses)
asy	None	10	0.63	3.783	2.787
Easy	Uniform	10	1	4.631	2.8
Easy	Hot-cold	10	1	4.335	2.851
Not-so-easy	None	10	0.641	3.657	2.822
Not-so-easy	Uniform	10	1	4.579	2.847
Not-so-easy	Hot-cold	10	1	4.504	2.978
Not-so-hard	None	10	0.655	3.754	2.844
Not-so-hard	Uniform	10	1	4.485	2.834
Not-so-hard	Hot-cold	10	1	4.483	2.766
Hard	None	10	0.652	3.541	2.798
Hard	Uniform	10	1	4.386	2.863
Hard	Hot-cold	10	1	4.519	2.865
Easy	None	100	0.646	40.655	28.211
Easy	Uniform	100	1	50.108	29.392
Easy	Hot-cold	100	1	48.619	28.875
Not-so-easy	None	100	0.624	40.921	28.459
Not-so-easy	Uniform	100	1	49.73	29.059
Not-so-easy	Hot-cold	100	1	48.466	28.245
Not-so-hard	None	100	0.631	41.507	28.263
Not-so-hard	Uniform	100	1	47.593	28.903
Not-so-hard	Hot-cold	100	1	50.019	29.309
Hard	None	100	0.67	41.619	28.437
Hard	Uniform	100	1	49.599	28.607
Hard	Hot-cold	100	1	51.066	28.57
Easy	None	1000	0.629	403.057	278.106
Easy	Uniform	1000	1	497.534	291.436
Easy	Hot-cold	1000	1	507.671	283.002
Not-so-easy	None	1000	0.641	405.512	280.423
Not-so-easy	Uniform	1000	1	505.259	289.631
Not-so-easy	Hot-cold	1000	1	501.384	292.487
Not-so-hard	None	1000	0.63	415.927	277.352
Not-so-hard	Uniform	1000	1	511.699	292.094
Not-so-hard	Hot-cold	1000	1	492.659	288.286
Hard	None	1000	0.64	404.306	278.995
Hard	Uniform	1000	1	499.725	298.313
Hard	Hot-cold	1000	1	485.958	282.813

Figure 3: Results for $\theta = 0.80$ with base setting

- Further, in the second type of hiders (i.e. not-so-easy hiders), does reducing the degeneracy help.

In the next sections, we perform two sets of experiments: (1) varying the degenracy for the not-so-easy hiders, and (2) increasing the neighborhood size from 1 to {2,3}.

3 Degeneracy variation Results

This section contains results for new settings (1) described above. The degeneracy was set at 25% of n in the base setting in the section 1. The new settings for degeneracy is varied as: $\{0.10n, 0.20n, 0.30n, \ldots, 0.90n\}$ for the not-so-easy hider. It should be noted that when the degeneracy is reduced so much (viz. more boxes with probability mass greather than 0), the not-so-easy hider may not remain as it is. It could approach to be an pure non-uniform distribution (not-so-hard hider). We perform these experiments just with a fixed[1] $n = 1000$.

—-to be done—-

4 Experiments with Hot-and-Cold thresholds θ_h and θ_c

1. Open a box i
2. If performance of box $i \geq \theta_h$: distribute its probability mass to all the unopened boxes in its neighborhood.
3. If performance of box $i \leq \theta_c$: distribute its probability mass to all the unopened boxes except its neighborhood.
4. Otherwise (i.e. none of the above conditions are true): distribute its probability mass to all the unopened boxes.
5. Repeat 1–4 until the hider is found.

[1] Can be studied for any n. Just to avoid confusions, we fix n.

choiceH	choiceUpdS	SuccessRate	mean(misses)	sd(misses)
		$n = 1000$		
1	1	0.647	415.765	279.076
1	2	1.000	485.743	291.479
1	3	1.000	483.394	280.817
2	1	0.622	424.259	295.290
2	2	1.000	505.753	288.841
2	3	1.000	497.388	285.391
3	1	0.614	425.721	268.688
3	2	1.000	501.925	291.147
3	3	1.000	498.737	285.369
4	1	0.629	398.860	277.083
4	2	1.000	497.892	296.853
4	3	1.000	511.561	286.341
		$n = 2000$		
1	1	0.645	854.050	568.091
1	2	1.000	1006.014	562.589
1	3	1.000	997.183	570.448
2	1	0.612	855.533	570.626
2	2	1.000	1041.809	592.339
2	3	1.000	1024.389	593.691
3	1	0.612	847.077	569.229
3	2	1.000	998.326	565.699
3	3	1.000	1016.857	574.992
4	1	0.627	820.746	542.065
4	2	1.000	1013.802	583.904
4	3	1.000	1018.995	584.717
		$n = 3000$		
1	1	0.627	1249.045	816.693
1	2	1.000	1509.410	852.052
1	3	1.000	1430.123	860.659
2	1	0.617	1255.799	812.271
2	2	1.000	1451.379	881.715
2	3	1.000	1500.294	867.022
3	1	0.617	1259.626	852.565
3	2	1.000	1513.932	873.289
3	3	1.000	1541.243	855.966
4	1	0.643	1249.299	844.649
4	2	1.000	1506.715	853.001
4	3	1.000	1501.686	880.258