National College of Ireland

Configuration Manual

MSc Research Project
MSc Cloud Computing

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Project Submission Sheet
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Configuration Manual

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1 Introduction

This Document explains how to set up the experimental setup and configurations required for this research project providing any user to perform the corresponding experimentation a step-by-step guideline of instructions to be followed, list of requirements and software packages or versions to be installed. This would enable the user to easily set up experimentation environment and reproduce the experiments with correct configuration applied.

2 System Configurations

All the experiment in research is performed on Windows 11 Operating System with i5 processor with 512 GB SSD and 12.7 GB System RAM.

2.1 List of software tool used

- VS code IDE for Code Execution [1]
- Python (3.12.3) with pandas(2.1.4)[2], numpy(1.26.4)[3] and Matplotlib (3.7.1)[4] for visualising the results.
- MealPy library[5](3.0.1)(Van Thieu et al.; 2023)(Van Thieu and Mirjalili; 2023)

[1]https://code.visualstudio.com/
[2]https://pypi.org/project/pandas/2.1.4/
[3]https://pypi.org/project/numpy/1.26.4/
[4]https://pypi.org/project/matplotlib/3.0.1/
[5]https://mealpy.readthedocs.io/en/latest/pages/general/introduction.html

3 Project Requirements

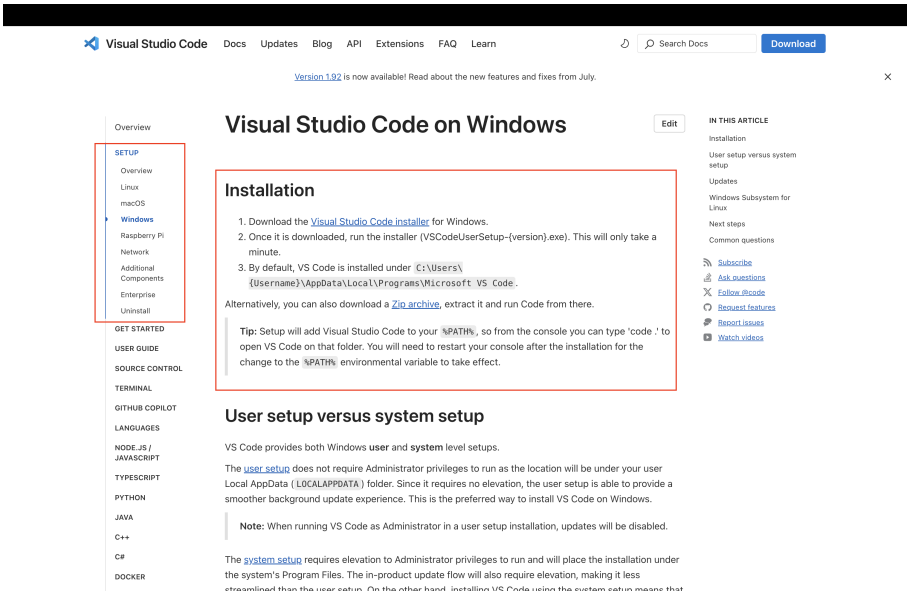


Figure 1: Installing VSCode

1. Install "python" version 3.12.3 and its packages from the official website of python [6]. Step by Step installation instruction can be followed as mentioned in the official documentation of VisualStudio[7] as mentioned in Figure 1.

2. Once VSCode is Installed make sure to add Jupyter extension to support .ipynb files as mentioned in Figure 2. This research uses Jupyter Notebook.

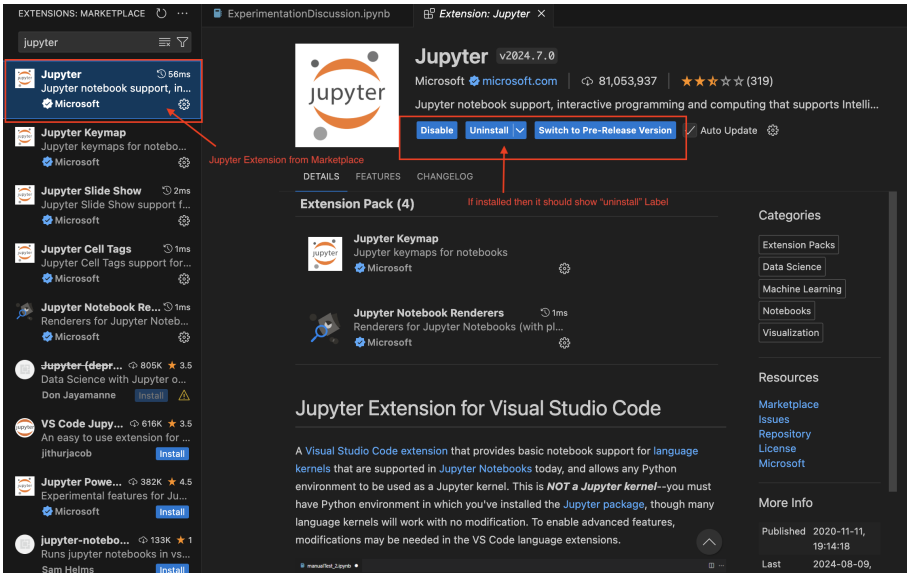


Figure 2: Installing Jupyter Extension on VSCode

[6]https://www.python.org/downloads/
[7]https://code.visualstudio.com/docs/setup/windows

3. Research Artifacts are stored in zip folder that needs to be extracted. The Code Artifact directory structure looks as mentioned in Figure 3

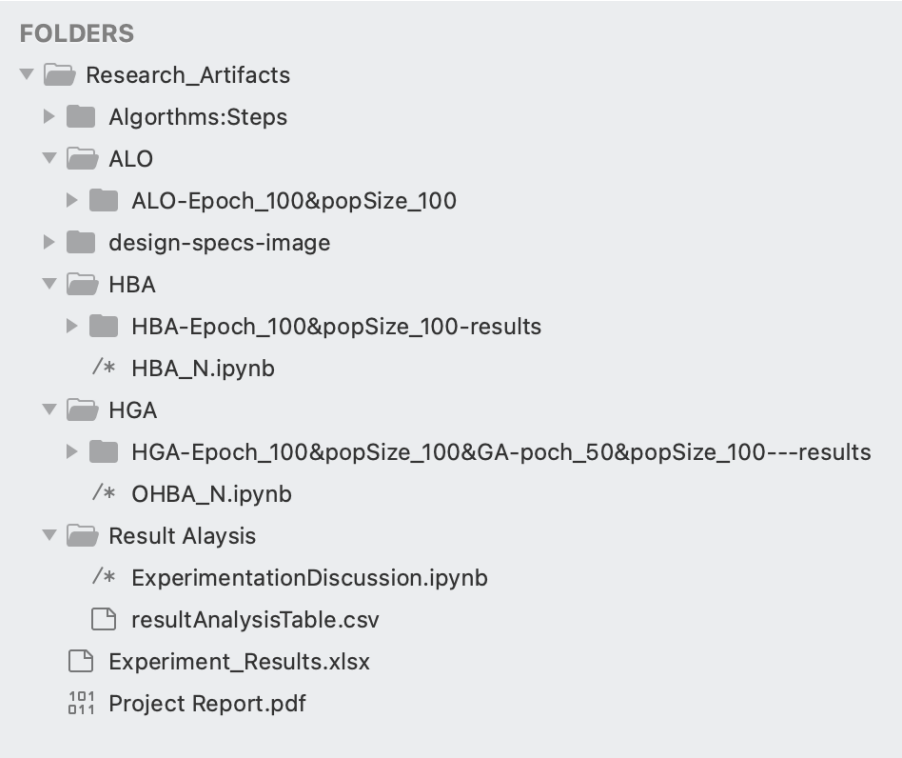


Figure 3: Code Artifact Directory Structure

4. The Experiment .ipynb File for each algorithm is present in the Algorithm respective directories and result output directories are systematically organised.

5. For the HGA algorithm, the main script is located at `/HGA/OHBA_N.ipynb`, and the results are saved in the directory `/HGA/HGA-Epoch_100&popSize_100&GApoch_50&popSize_100---results`.

6. For the HBA algorithm, the script can be found at `/HBA/HBA_N.ipynb`, and its results are stored in the directory `/HBA/HBA-Epoch_100&popSize_100-results`.

7. For the ALO algorithm its .ipynb is divided into three experiments. The directories are organized as follows: `/ALO/ALO-Epoch_100&popSize_100/Experiments1-70/ALO_N.ipynb` for the first set of experiments, `/ALO/ALO-Epoch_100&popSize_100/Experiments71-105/ALO_N.ipynb` for the second set, and `/ALO/ALO-Epoch_100&popSize_100/Experiments106-140/ALO_N.ipynb` for the third. The results for these experiments are stored in directories that match the experiment numbers: `/ALO/ALO-Epoch_100&popSize_100/Experiments1-70/ALOresults1-70`, `'/ALO/ALO-Epoch_100&popSize_100/Experiments71-105/results'`, and `'/ALO/ALO-Epoch_100&popSize_100/Experiments106-140/results'`.

Note

These .ipynb contains output content of the experimentation that were performed for this research project. These .ipynb files can be scrolled to observe the experimented results.

8. The above script contains the 'Problem Objective Function", Problem Dict that is provided to the algorithm and the Algorithm Implementation. These script are set to be executed to perform Experimentation in iterations which Varies VM count, Task Count, and one of the algorithms hyperparameter that is PR (Probability Rate). PR Value is varied in the range 0 to 1 and are labeled. Here pr=0 is labeled Baseline Experiment, pr=0.1 is Low pr, pr=0.25 is Moderate pr, pr=0.5 is Balanced pr, 0.75 is High pr, 0.9 is Extreme pr and pr=1 is labeled as max pr. This .ipynb files just needs to be executed top to down to generate the results.

9. Problem Objective Function of the Research is mentioned in all the scripts and is defined as mentioned in Figure 4

```
# Define the Problem objective function to evaluate the solution
def Fun(solution):
    list1 = [0] * vmcount  # Initialize a list to store load distribution across VMs
    val = 0.0
    for i in range(solution.size):
        solution[i] = round(solution[i])  # Round the solution values to nearest integers

        # If the solution element is non-zero, calculate its VM index
        if solution[i] != 0:
            index = min(max(int(solution[i]) - 1, 0), len(list1) - 1)
            list1[index] += taskcount / VM[index]  # Add the load to the corresponding VM based on the task distribution
        else:
            index = min(max(int(solution[i]), 0), len(list1) - 1)
            list1[index] += taskcount / VM[index]  # Add the load to the corresponding VM based on the task distribution

    # Return the minimum load among all VMs as the objective value
    return min(list1)
```

Figure 4: Defined Problem Objective

10. In the Script the Experiment parameters are defined as mentioned in Figure 5. The list [100, 375, 750, 1000], The list [30, 45, 60, 75, 90]for VM Count, the list [0.0, 0.1, 0.25, 0.5, 0.75, 0.9, 1.0] for 'pr' represents the different task counts, vm counts and pr value that the experiment will be executed. Each value in this list maps to a separate experiment where the problem objective is solved for that specific task count.

```
# Experiment Parameters
task_counts = [100, 375, 750, 1000]
vm_counts = [30, 45, 60, 75, 90]
pr_values = [0.0, 0.1, 0.25, 0.5, 0.75, 0.9, 1.0]
```

Figure 5: Experiment Parameter Defination

11. Problem Dict that is fed into the Algorithm are defined where upper bound , lower bound, and the defined obj_function (Fun) is passed to the algorithms as shown in Figure 6.

```python
problem_dict1 = {
    "bounds": FloatVar(lb=[0 for i in range(size)], ub=[vmcount - 1 for i in range(size)], name="delta"),
    "minmax": "min",
    "obj_func": Fun,
}
```

Figure 6: Problem Dictionary for the Algorithm to solve

12. The .ipynb file needs to be execute from top to bottom to generate the results. The experiment runs for every combination of task_count, vm_count, and pr, which means it executes 4 (task counts) x 5 (VM counts) x 7 (pr values) = 140 separate experiments for a single algorithm. This research conducts similar experimentation for HBA, HGA and ALO that are total 3 x 140 separate experiments which is equal to total 420 seperate experiments for this research that are in combination as mentioned in point 10.

13. The output result is shown as mentioned in Figure 7 saved to the specific directories as mentioned in point 7 in json format.

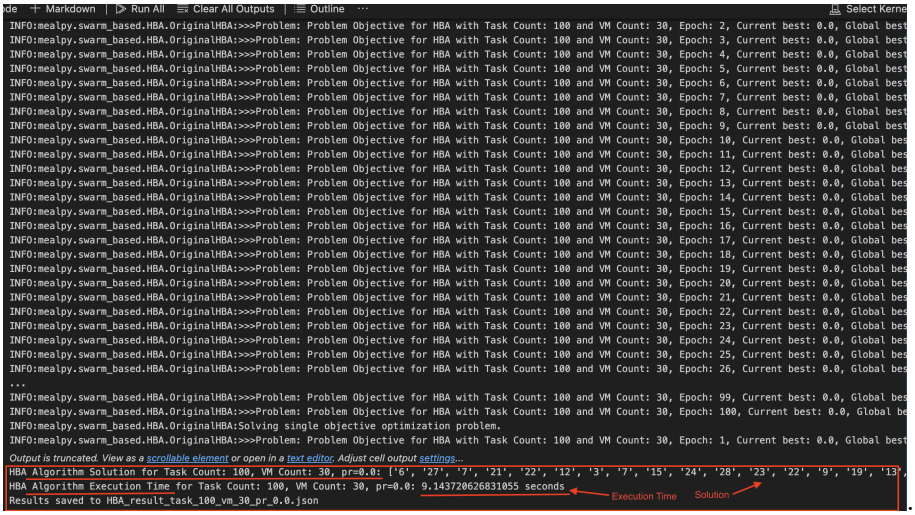
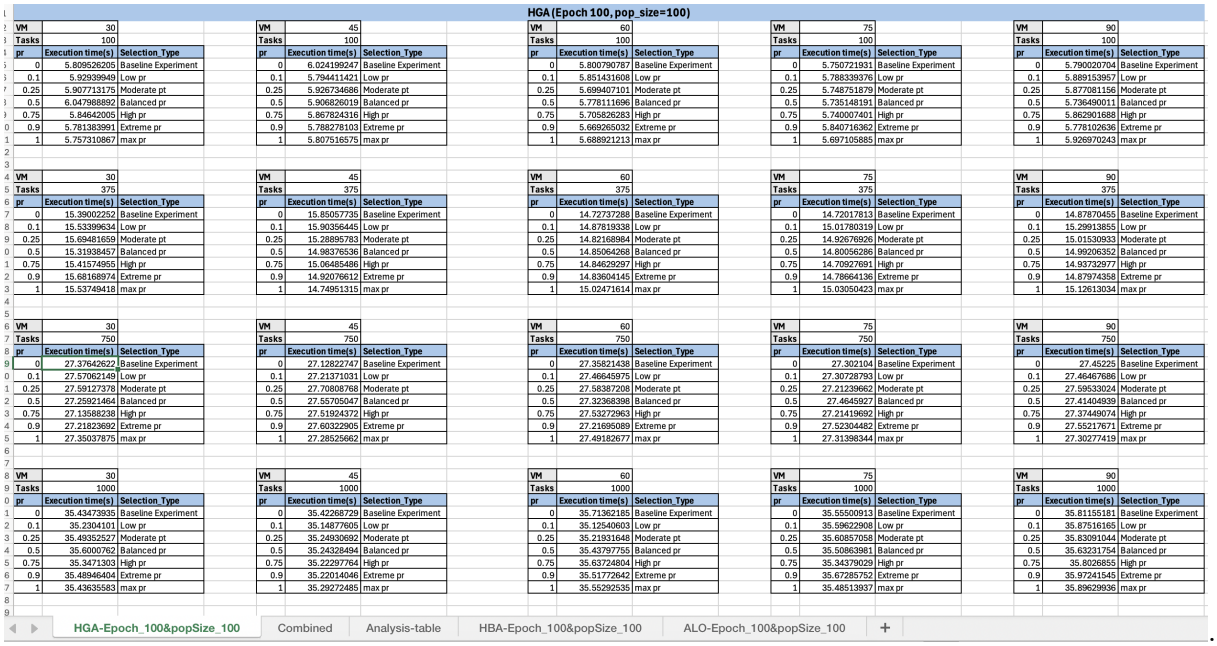


Figure 7: Algorithm Solution output

14. The results and execution time from these algorthms are recorded in a .csv file that records the execution time for all the 420 experiment test cases. The CSV file and combined experiment result tables are available in '`Experiment_Results.xlsx`' file in root folder & '`/ResultAlaysis/resultAnalysisTable.csv`' directory in artifact folder. The Figures 8 9 10 shows the recorded results for all the experiments performed in the research.



HGA (Epoch 100, pop_size=100)

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	100		Tasks	100		Tasks	100		Tasks	100		Tasks	100	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	5.809526205	Baseline Experiment	0	6.024199247	Baseline Experiment	0	5.800790787	Baseline Experiment	0	5.750721931	Baseline Experiment	0	5.790020704	Baseline Experiment
0.1	5.92939949	Low pr	0.1	5.794411421	Low pr	0.1	5.851431608	Low pr	0.1	5.78833976	Low pr	0.1	5.889153957	Low pr
0.25	5.907713175	Moderate pt	0.25	5.926734686	Moderate pt	0.25	5.699407101	Moderate pt	0.25	5.748751879	Moderate pt	0.25	5.877081156	Moderate pt
0.5	6.047988892	Balanced pr	0.5	5.906826019	Balanced pr	0.5	5.778111696	Balanced pr	0.5	5.735148191	Balanced pr	0.5	5.736490011	Balanced pr
0.75	5.84642005	High pr	0.75	5.867824316	High pr	0.75	5.705826283	High pr	0.75	5.740007401	High pr	0.75	5.862901688	High pr
0.9	5.781383991	Extreme pr	0.9	5.788278103	Extreme pr	0.9	5.669265032	Extreme pr	0.9	5.840716362	Extreme pr	0.9	5.778102636	Extreme pr
1	5.757310867	max pr	1	5.807516575	max pr	1	5.688921213	max pr	1	5.697105885	max pr	1	5.926970243	max pr

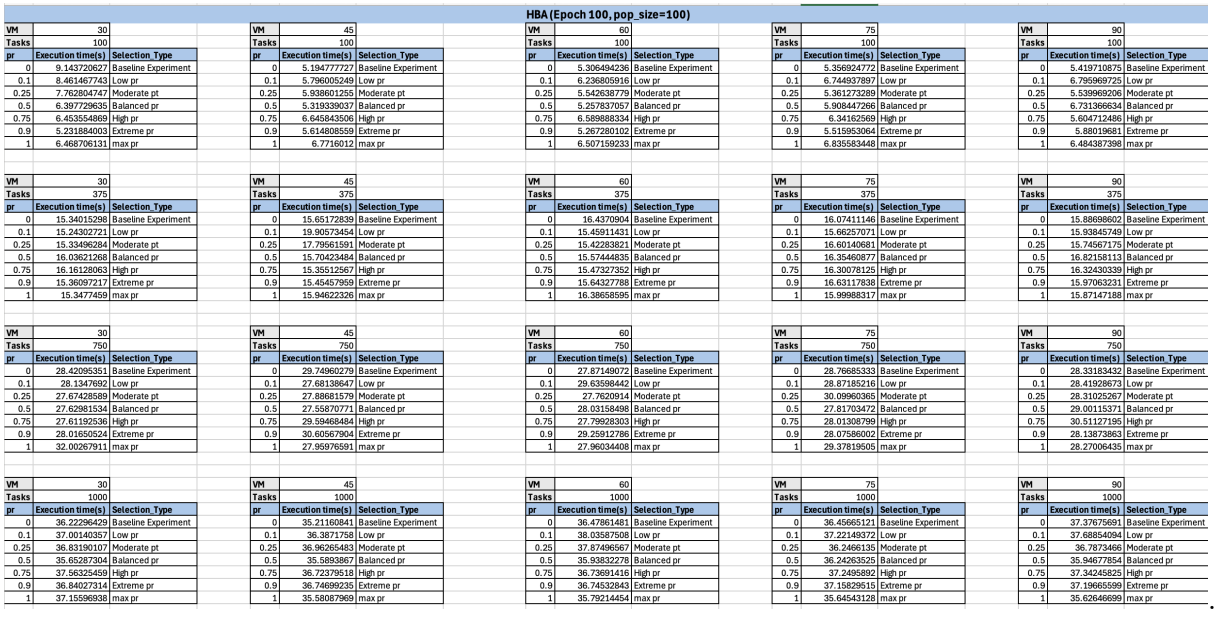
VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	375		Tasks	375		Tasks	375		Tasks	375		Tasks	375	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	15.39002252	Baseline Experiment	0	15.85057735	Baseline Experiment	0	14.72737288	Baseline Experiment	0	14.72017813	Baseline Experiment	0	14.87870455	Baseline Experiment
0.1	15.53399634	Low pr	0.1	15.90356445	Low pr	0.1	14.87819338	Low pr	0.1	15.01780319	Low pr	0.1	15.29913855	Low pr
0.25	15.69481659	Moderate pt	0.25	15.28895783	Moderate pt	0.25	14.82168984	Moderate pt	0.25	14.92676926	Moderate pt	0.25	15.01530933	Moderate pt
0.5	15.31938457	Balanced pr	0.5	14.98376536	Balanced pr	0.5	14.85064268	Balanced pr	0.5	14.80056286	Balanced pr	0.5	14.99206352	Balanced pr
0.75	15.41574955	High pr	0.75	15.06485486	High pr	0.75	14.84629297	High pr	0.75	14.70827691	High pr	0.75	14.93732977	High pr
0.9	15.68168974	Extreme pr	0.9	14.92076612	Extreme pr	0.9	14.83604145	Extreme pr	0.9	14.78664136	Extreme pr	0.9	14.87974358	Extreme pr
1	15.53749418	max pr	1	14.74951315	max pr	1	15.02471614	max pr	1	15.03050423	max pr	1	15.12613034	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	750		Tasks	750		Tasks	750		Tasks	750		Tasks	750	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	27.37642622	Baseline Experiment	0	27.12822747	Baseline Experiment	0	27.35821438	Baseline Experiment	0	27.302104	Baseline Experiment	0	27.45225	Baseline Experiment
0.1	27.57062149	Low pr	0.1	27.21371031	Low pr	0.1	27.46645975	Low pr	0.1	27.30728793	Low pr	0.1	27.46467686	Low pr
0.25	27.59127378	Moderate pt	0.25	27.70808768	Moderate pt	0.25	27.58387208	Moderate pt	0.25	27.21239662	Moderate pt	0.25	27.59533024	Moderate pt
0.5	27.25921464	Balanced pr	0.5	27.55705047	Balanced pr	0.5	27.32368398	Balanced pr	0.5	27.4645927	Balanced pr	0.5	27.41404939	Balanced pr
0.75	27.13588238	High pr	0.75	27.51924372	High pr	0.75	27.53272963	High pr	0.75	27.21419892	High pr	0.75	27.37449074	High pr
0.9	27.21823692	Extreme pr	0.9	27.60322905	Extreme pr	0.9	27.21695089	Extreme pr	0.9	27.52304482	Extreme pr	0.9	27.55217671	Extreme pr
1	27.35037875	max pr	1	27.28525662	max pr	1	27.49182677	max pr	1	27.31398344	max pr	1	27.30277419	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	35.43473935	Baseline Experiment	0	35.42268729	Baseline Experiment	0	35.71362185	Baseline Experiment	0	35.55500913	Baseline Experiment	0	35.81155181	Baseline Experiment
0.1	35.2304101	Low pr	0.1	35.14877605	Low pr	0.1	35.12540603	Low pr	0.1	35.59622908	Low pr	0.1	35.87516165	Low pr
0.25	35.49352527	Moderate pt	0.25	35.24930692	Moderate pt	0.25	35.21931648	Moderate pt	0.25	35.60857058	Moderate pt	0.25	35.83091044	Moderate pt
0.5	35.6000762	Balanced pr	0.5	35.24328494	Balanced pr	0.5	35.43797755	Balanced pr	0.5	35.50863981	Balanced pr	0.5	35.63231754	Balanced pr
0.75	35.3471303	High pr	0.75	35.22297764	High pr	0.75	35.63724804	High pr	0.75	35.34379029	High pr	0.75	35.8026855	High pr
0.9	35.48946404	Extreme pr	0.9	35.22014046	Extreme pr	0.9	35.51772642	Extreme pr	0.9	35.67285752	Extreme pr	0.9	35.97241545	Extreme pr
1	35.43635583	max pr	1	35.29272485	max pr	1	35.55292535	max pr	1	35.48513937	max pr	1	35.89629936	max pr

HGA-Epoch_100&popSize_100 | Combined | Analysis-table | HBA-Epoch_100&popSize_100 | ALO-Epoch_100&popSize_100 | +

Figure 8: HGA Experiment execution time records



HBA (Epoch 100, pop_size=100)

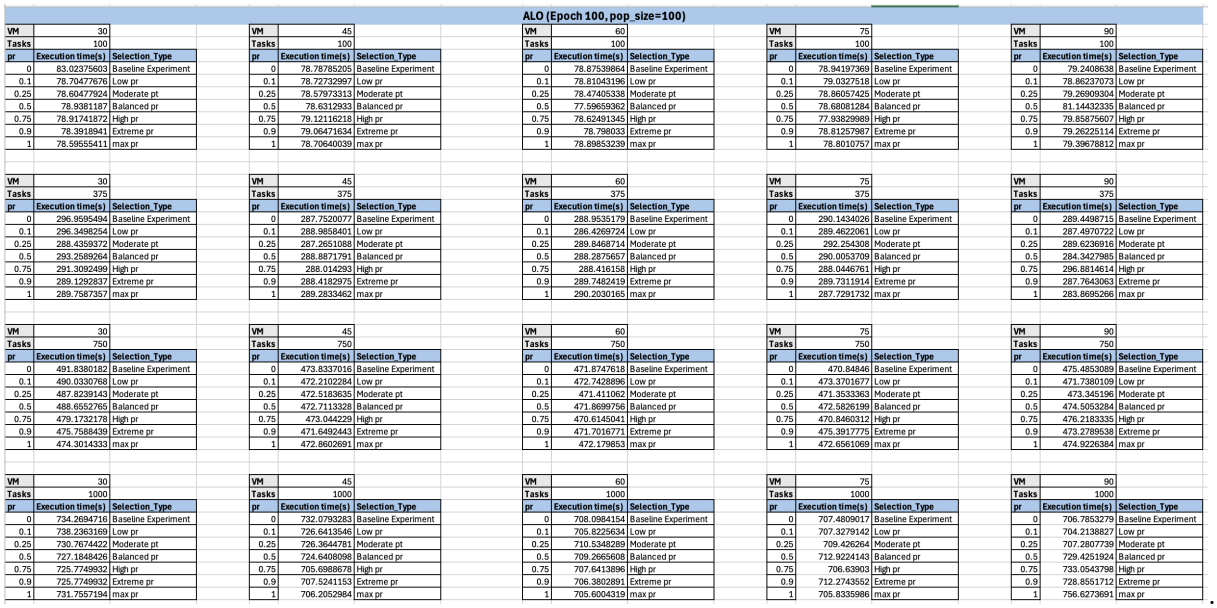
VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	100		Tasks	100		Tasks	100		Tasks	100		Tasks	100	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	9.143720627	Baseline Experiment	0	5.194777727	Baseline Experiment	0	5.306494236	Baseline Experiment	0	5.356924772	Baseline Experiment	0	5.419710875	Baseline Experiment
0.1	8.461467743	Low pr	0.1	5.796005249	Low pr	0.1	6.236805916	Low pr	0.1	6.744937897	Low pr	0.1	6.795969725	Low pr
0.25	7.762804747	Moderate pt	0.25	5.938601255	Moderate pt	0.25	5.542638779	Moderate pt	0.25	5.361273289	Moderate pt	0.25	5.539969206	Moderate pt
0.5	6.397729635	Balanced pr	0.5	5.319339037	Balanced pr	0.5	5.257837057	Balanced pr	0.5	5.908447266	Balanced pr	0.5	6.731366634	Balanced pr
0.75	6.453554869	High pr	0.75	6.645843506	High pr	0.75	6.589888334	High pr	0.75	6.34162569	High pr	0.75	5.604712486	High pr
0.9	5.231884003	Extreme pr	0.9	5.614808559	Extreme pr	0.9	5.267280102	Extreme pr	0.9	5.515953064	Extreme pr	0.9	5.88019681	Extreme pr
1	6.468706131	max pr	1	6.7716012	max pr	1	6.507159233	max pr	1	6.835583448	max pr	1	6.484387398	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	375		Tasks	375		Tasks	375		Tasks	375		Tasks	375	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	15.34015298	Baseline Experiment	0	15.65172839	Baseline Experiment	0	16.4370904	Baseline Experiment	0	16.07411146	Baseline Experiment	0	15.88698602	Baseline Experiment
0.1	15.24302721	Low pr	0.1	19.90573454	Low pr	0.1	15.45911431	Low pr	0.1	15.66257071	Low pr	0.1	15.93845749	Low pr
0.25	15.33496284	Moderate pt	0.25	17.79561591	Moderate pt	0.25	15.42283821	Moderate pt	0.25	16.60140681	Moderate pt	0.25	15.74567175	Moderate pt
0.5	16.03621268	Balanced pr	0.5	15.70423484	Balanced pr	0.5	15.57444835	Balanced pr	0.5	16.35460877	Balanced pr	0.5	16.82158113	Balanced pr
0.75	16.16128063	High pr	0.75	15.35512567	High pr	0.75	15.4732352	High pr	0.75	16.30078125	High pr	0.75	16.32430339	High pr
0.9	15.36097217	Extreme pr	0.9	15.45457959	Extreme pr	0.9	15.64327788	Extreme pr	0.9	16.63117838	Extreme pr	0.9	15.97063231	Extreme pr
1	15.3477459	max pr	1	15.94622326	max pr	1	16.38658595	max pr	1	15.99988317	max pr	1	15.87147188	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	750		Tasks	750		Tasks	750		Tasks	750		Tasks	750	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	28.42095351	Baseline Experiment	0	29.74960279	Baseline Experiment	0	27.87149072	Baseline Experiment	0	28.76685333	Baseline Experiment	0	28.33183432	Baseline Experiment
0.1	28.1347692	Low pr	0.1	27.68138647	Low pr	0.1	29.63598442	Low pr	0.1	28.87185216	Low pr	0.1	28.41928673	Low pr
0.25	27.67428588	Moderate pt	0.25	27.88681579	Moderate pt	0.25	27.7620914	Moderate pt	0.25	30.09960365	Moderate pt	0.25	28.31025267	Moderate pt
0.5	27.62981534	Balanced pr	0.5	27.55870771	Balanced pr	0.5	28.03158498	Balanced pr	0.5	27.81703472	Balanced pr	0.5	29.00115371	Balanced pr
0.75	27.61192536	High pr	0.75	29.59468484	High pr	0.75	27.79928303	High pr	0.75	28.01308799	High pr	0.75	30.51127195	High pr
0.9	28.01650524	Extreme pr	0.9	30.60567904	Extreme pr	0.9	29.25912786	Extreme pr	0.9	28.07586002	Extreme pr	0.9	28.13873863	Extreme pr
1	32.00267911	max pr	1	27.95976591	max pr	1	27.96034408	max pr	1	29.37819505	max pr	1	28.27006435	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	36.22296429	Baseline Experiment	0	35.21160841	Baseline Experiment	0	36.47861481	Baseline Experiment	0	36.45665121	Baseline Experiment	0	37.37675691	Baseline Experiment
0.1	37.00140357	Low pr	0.1	36.3871758	Low pr	0.1	38.03587508	Low pr	0.1	37.22148372	Low pr	0.1	37.68854094	Low pr
0.25	36.83190107	Moderate pt	0.25	36.96265483	Moderate pt	0.25	37.87496567	Moderate pt	0.25	36.2466135	Moderate pt	0.25	36.7873466	Moderate pt
0.5	35.65287304	Balanced pr	0.5	35.5893867	Balanced pr	0.5	35.93832278	Balanced pr	0.5	36.24263525	Balanced pr	0.5	35.94677854	Balanced pr
0.75	37.56325459	High pr	0.75	36.72379518	High pr	0.75	36.73691416	High pr	0.75	37.2495892	High pr	0.75	37.34245825	High pr
0.9	36.84027314	Extreme pr	0.9	36.74699235	Extreme pr	0.9	36.74532843	Extreme pr	0.9	37.15829515	Extreme pr	0.9	37.19665599	Extreme pr
1	37.15596938	max pr	1	35.58087969	max pr	1	35.79214454	max pr	1	35.64543128	max pr	1	35.62646699	max pr

Figure 9: HBA Experiment execution time records



ALO (Epoch 100, pop_size=100)

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	100		Tasks	100		Tasks	100		Tasks	100		Tasks	100	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	83.02375603	Baseline Experiment	0	78.78785205	Baseline Experiment	0	78.87539864	Baseline Experiment	0	78.94197369	Baseline Experiment	0	79.2408638	Baseline Experiment
0.1	78.70477676	Low pr	0.1	78.72732997	Low pr	0.1	78.81043196	Low pr	0.1	79.0327518	Low pr	0.1	78.86237073	Low pr
0.25	78.60477924	Moderate pt	0.25	78.57973313	Moderate pt	0.25	78.47405338	Moderate pt	0.25	78.86057425	Moderate pt	0.25	79.26909304	Moderate pt
0.5	78.9381187	Balanced pr	0.5	78.6312933	Balanced pr	0.5	77.59659362	Balanced pr	0.5	78.68081284	Balanced pr	0.5	81.14432335	Balanced pr
0.75	78.91741872	High pr	0.75	79.12116218	High pr	0.75	78.62491345	High pr	0.75	77.93829989	High pr	0.75	79.85875607	High pr
0.9	78.3918941	Extreme pr	0.9	79.06471634	Extreme pr	0.9	78.798033	Extreme pr	0.9	78.81257987	Extreme pr	0.9	79.26225114	Extreme pr
1	78.59555411	max pr	1	78.70640039	max pr	1	78.89853239	max pr	1	78.8010757	max pr	1	79.39678812	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	375		Tasks	375		Tasks	375		Tasks	375		Tasks	375	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	296.9595494	Baseline Experiment	0	287.7520077	Baseline Experiment	0	288.9535179	Baseline Experiment	0	290.1434026	Baseline Experiment	0	289.4498715	Baseline Experiment
0.1	296.3498254	Low pr	0.1	288.9858401	Low pr	0.1	286.4269724	Low pr	0.1	289.4622061	Low pr	0.1	287.4970722	Low pr
0.25	288.4359372	Moderate pt	0.25	287.2651088	Moderate pt	0.25	289.8468714	Moderate pt	0.25	292.254308	Moderate pt	0.25	289.6236916	Moderate pt
0.5	293.2589264	Balanced pr	0.5	288.8871791	Balanced pr	0.5	288.2875657	Balanced pr	0.5	290.0053709	Balanced pr	0.5	284.3427985	Balanced pr
0.75	291.3092499	High pr	0.75	288.014293	High pr	0.75	288.416158	High pr	0.75	288.0446761	High pr	0.75	296.8814614	High pr
0.9	289.1292837	Extreme pr	0.9	288.4182975	Extreme pr	0.9	289.7482419	Extreme pr	0.9	289.7311914	Extreme pr	0.9	287.7643063	Extreme pr
1	289.7587357	max pr	1	289.2833462	max pr	1	290.2030165	max pr	1	287.7291732	max pr	1	283.8695266	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	750		Tasks	750		Tasks	750		Tasks	750		Tasks	750	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	491.8380182	Baseline Experiment	0	473.8337016	Baseline Experiment	0	471.8747618	Baseline Experiment	0	470.84846	Baseline Experiment	0	475.4853089	Baseline Experiment
0.1	490.0330768	Low pr	0.1	472.2102284	Low pr	0.1	472.7428896	Low pr	0.1	473.3701677	Low pr	0.1	471.7380109	Low pr
0.25	487.8239143	Moderate pt	0.25	472.5183635	Moderate pt	0.25	471.411062	Moderate pt	0.25	471.3533363	Moderate pt	0.25	473.345196	Moderate pt
0.5	488.6552765	Balanced pr	0.5	472.7113328	Balanced pr	0.5	471.8699756	Balanced pr	0.5	472.5826199	Balanced pr	0.5	474.5053284	Balanced pr
0.75	479.1732178	High pr	0.75	473.044229	High pr	0.75	470.6145041	High pr	0.75	470.8460312	High pr	0.75	476.2183335	High pr
0.9	475.7588439	Extreme pr	0.9	471.6492443	Extreme pr	0.9	471.7016771	Extreme pr	0.9	475.3917775	Extreme pr	0.9	473.2789538	Extreme pr
1	474.3014333	max pr	1	472.8602691	max pr	1	472.179853	max pr	1	472.6561069	max pr	1	474.9226384	max pr

VM	30		VM	45		VM	60		VM	75		VM	90	
Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000		Tasks	1000	
pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type	pr	Execution time(s)	Selection_Type
0	734.2694716	Baseline Experiment	0	732.0793283	Baseline Experiment	0	708.0984154	Baseline Experiment	0	707.4809017	Baseline Experiment	0	706.7853279	Baseline Experiment
0.1	738.2363169	Low pr	0.1	726.6413546	Low pr	0.1	705.8225634	Low pr	0.1	707.3279142	Low pr	0.1	704.2138827	Low pr
0.25	730.7674422	Moderate pt	0.25	726.3644781	Moderate pt	0.25	710.5348289	Moderate pt	0.25	709.426264	Moderate pt	0.25	707.2807739	Moderate pt
0.5	727.1848426	Balanced pr	0.5	724.6408098	Balanced pr	0.5	709.2665608	Balanced pr	0.5	712.9224143	Balanced pr	0.5	729.4251924	Balanced pr
0.75	725.7749932	High pr	0.75	705.6988678	High pr	0.75	707.6413896	High pr	0.75	706.63903	High pr	0.75	733.0543798	High pr
0.9	725.7749932	Extreme pr	0.9	707.5241153	Extreme pr	0.9	706.3802891	Extreme pr	0.9	712.2743552	Extreme pr	0.9	728.8551712	Extreme pr
1	731.7557194	max pr	1	706.2052984	max pr	1	705.6004319	max pr	1	705.8335986	max pr	1	756.6273691	max pr

Figure 10: ALO Experiment execution time records

15. The Scenarios mentioned in the evaluation table and the graph visualisation is performed in the file that is available in the `/ResultAlaysis/ExperimentationDiscussion.ipynb` directory. This file input is the combined results recorded and in the above Figures 8 9 10. This .ipynb file will generate the evaluation graph that is discussed in the Research Project Evaluation section. This `/ResultAlaysis/ExperimentationDiscussion.ipynb` file needs to be executed top to down for similar results.

References

Van Thieu, N., Barma, S. D., Van Lam, T., Kisi, O. and Mahesha, A. (2023). Groundwater level modeling using augmented artificial ecosystem optimization, *Journal of Hydrology* **617**: 129034.

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