b_tree

February 10, 2025

[28]:
```
import numpy as np
from matplotlib import pyplot as plt
import seaborn as sns
import json
import pandas as pd
from sklearn.preprocessing import MinMaxScaler
import  itertools

sns.set_theme(style='ticks', font_scale=2.0, rc={'text.usetex': True})

plt.rcParams['text.usetex'] = True
plt.rcParams['font.size'] = 20
plt.rcParams['text.latex.preamble'] = r'\usepackage{lmodern}'
```

[41]:
```
import json
import pandas as pd
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()

# Load JSON data
with open("../code/macOS/btree/bench_over_n.json") as f:
    data = json.load(f)

benchmarks = data['benchmarks']

# Convert to DataFrame
btree_d = pd.DataFrame(benchmarks)

# Drop rows where 'name' contains 'OrderedMap' and create an explicit copy
btree_df = btree_d.loc[~btree_d['name'].str.contains("OrderedMap", na=False)].
 ↪copy()

# Convert time to milliseconds using .loc
btree_df.loc[:, 'real_time_ms'] = btree_df['real_time'] / 1e6
btree_df.loc[:, 'cpu_time_ms'] = btree_df['cpu_time'] / 1e6
```

```python
# Convert RAM and Page to integers and sum them; store back into 'RAM'
btree_df.loc[:, 'RAM'] = btree_df['RAM'].astype(int) + btree_df['Page'].
 ↪astype(int)

# Extract 'b' value from the 'name' column using .loc
btree_df.loc[:, 'b'] = pd.to_numeric(btree_df['name'].str.
 ↪extract(r'<(\d+)>')[0])

# Normalize cpu_time_ms, RAM, and Page
btree_df[['cpu_time_ms_norm', 'RAM_norm', 'Page_norm']] = scaler.fit_transform(
    btree_df[['cpu_time_ms', 'RAM', 'Page']]
)

# Calculate operations per nanosecond correctly
btree_df.loc[:, 'ops/ns'] = 20 / btree_df['cpu_time']

# Display the DataFrame
print(btree_df)
```

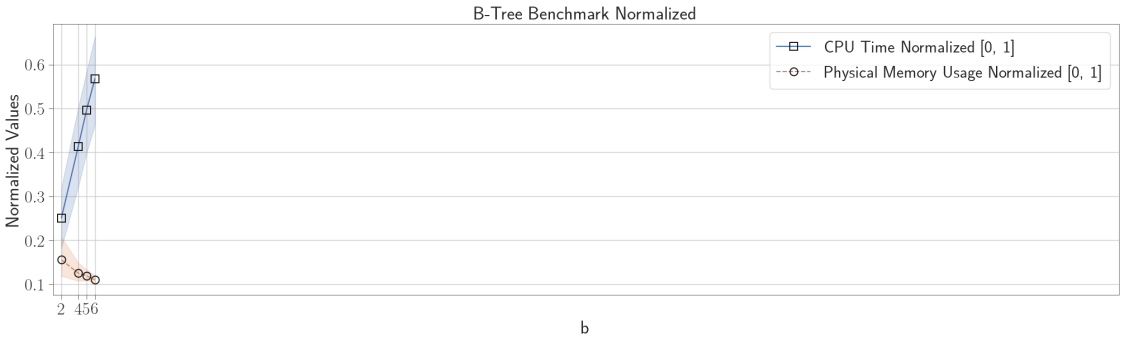
```
                          name  family_index  per_family_instance_index  \
23       BTreeMap_Insertion<2>/8             1                          0
24      BTreeMap_Insertion<2>/16             1                          1
25      BTreeMap_Insertion<2>/32             1                          2
26      BTreeMap_Insertion<2>/64             1                          3
27     BTreeMap_Insertion<2>/128             1                          4
..                           …           …                        …
225   BTreeMap_Search<6>/2097152             9                         18
226   BTreeMap_Search<6>/4194304             9                         19
227   BTreeMap_Search<6>/8388608             9                         20
228  BTreeMap_Search<6>/16777216             9                         21
229  BTreeMap_Search<6>/33554432             9                         22

                       run_name   run_type  repetitions  repetition_index  \
23       BTreeMap_Insertion<2>/8  iteration            1                 0
24      BTreeMap_Insertion<2>/16  iteration            1                 0
25      BTreeMap_Insertion<2>/32  iteration            1                 0
26      BTreeMap_Insertion<2>/64  iteration            1                 0
27     BTreeMap_Insertion<2>/128  iteration            1                 0
..                           …        …          …                …
225   BTreeMap_Search<6>/2097152  iteration            1                 0
226   BTreeMap_Search<6>/4194304  iteration            1                 0
227   BTreeMap_Search<6>/8388608  iteration            1                 0
228  BTreeMap_Search<6>/16777216  iteration            1                 0
229  BTreeMap_Search<6>/33554432  iteration            1                 0

     threads  iterations     real_time  …  time_unit      Page      RAM  \
23         1           1  2.837406e+14  …         ns       0.0      0.0
```

```
24         1           1  2.837406e+14  …         ns       0.0      0.0
25         1           1  2.837406e+14  …         ns       0.0      0.0
26         1           1  2.837406e+14  …         ns       0.0      0.0
27         1           1  2.837406e+14  …         ns       0.0      0.0
..       …           …           …  …        …       …      …
225        1           1  2.841936e+14  …         ns   30720.0  45984.0
226        1           1  2.841952e+14  …         ns   60416.0    800.0
227        1           1  2.841994e+14  …         ns  120832.0 -51872.0
228        1           1  2.842086e+14  …         ns  242688.0 -24352.0
229        1           1  2.842357e+14  …         ns  485376.0 -40480.0

     real_time_ms  cpu_time_ms  b  cpu_time_ms_norm  RAM_norm  Page_norm  \
23   2.837406e+08    61662.425  2      0.000000e+00  0.103174   0.000000
24   2.837406e+08    61662.467  2      8.489878e-08  0.103174   0.000000
25   2.837406e+08    61662.504  2      1.596906e-07  0.103174   0.000000
26   2.837406e+08    61662.534  2      2.203326e-07  0.103174   0.000000
27   2.837406e+08    61662.567  2      2.870387e-07  0.103174   0.000000
..            …           … ..               …       …        …
225  2.841936e+08   514369.491  6      9.151019e-01  0.117331   0.021095
226  2.841952e+08   515963.827  6      9.183246e-01  0.103420   0.041487
227  2.841994e+08   520070.890  6      9.266267e-01  0.087205   0.082974
228  2.842086e+08   529388.624  6      9.454615e-01  0.095677   0.166652
229  2.842357e+08   556369.176  6      1.000000e+00  0.090712   0.333304

           ops/ns
23   3.243466e-10
24   3.243464e-10
25   3.243462e-10
26   3.243461e-10
27   3.243459e-10
..            …
225  3.888255e-11
226  3.876241e-11
227  3.845630e-11
228  3.777943e-11
229  3.594735e-11

[184 rows x 21 columns]
```

[42]:
```python
import os
import matplotlib.pyplot as plt
import seaborn as sns

# Create figure and axis with constrained layout enabled
fig, ax = plt.subplots(figsize=(20, 6), constrained_layout=True)

# Plot CPU time normalized
```

```
sns.lineplot(
    data=btree_df,
    x='b',
    y='cpu_time_ms_norm',
    marker='s',
    markerfacecolor='none',
    markeredgecolor='k',
    markeredgewidth=1.4,
    markersize=10,
    linestyle='-',  # Ensure line visibility
    linewidth=1.5,
    label='CPU Time Normalized [0, 1]',
    ax=ax
)

# Plot RAM usage normalized
sns.lineplot(
    data=btree_df,
    x='b',
    y='RAM_norm',
    marker='o',
    markerfacecolor='none',
    markeredgecolor='k',
    markeredgewidth=1.4,
    markersize=10,
    linestyle='--',
    linewidth=1.5,
    label='Physical Memory Usage Normalized [0, 1]',
    ax=ax
)

# Set labels and title
ax.set_title("B-Tree Benchmark Normalized")
ax.set_xlabel('b')
ax.set_ylabel('Normalized Values')

# Set grid and legend
ax.grid(True)
ax.legend()

# Adjust tick parameters
ax.tick_params(width=0.5)

# Adjust spines
for spine in ax.spines.values():
    spine.set_linewidth(0.5)
```

```
# Ensure unique and sorted xticks
plt.xticks(sorted(btree_df['b'].unique()))

# Set x-axis limits
plt.xlim([1, 128])

# Create the save directory if it doesn't exist
save_path = 'plot/' + ax.get_title().lower().replace(' ', '_') + '.pdf'
os.makedirs(os.path.dirname(save_path), exist_ok=True)

# If you don't use constrained_layout, you can try this alternative:
# plt.tight_layout(pad=3.0)

# Save figure with bbox_inches='tight'
plt.savefig(save_path, bbox_inches='tight')

# Show plot
plt.show()
```



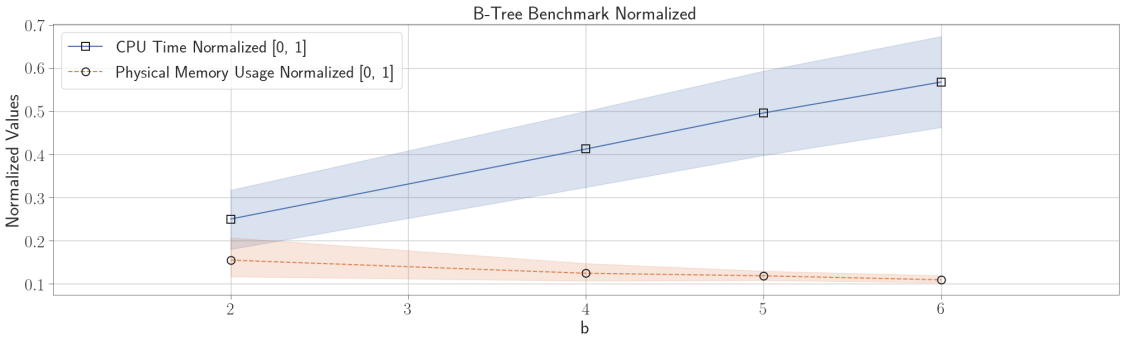
[49]:
```
"optimum b = " + str(btree_df.loc[np.argmin(np.abs(btree_df['RAM_norm'] -␣
↪btree_df['cpu_time_ms_norm'])), 'b'])
```

[49]:
```
'optimum b = 2'
```

[50]:
```
import os
import matplotlib.pyplot as plt
import seaborn as sns

# Create figure and axis with constrained layout enabled
fig, ax = plt.subplots(figsize=(20, 6), constrained_layout=True)

# Plot CPU time normalized
sns.lineplot(
    data=btree_df,
```

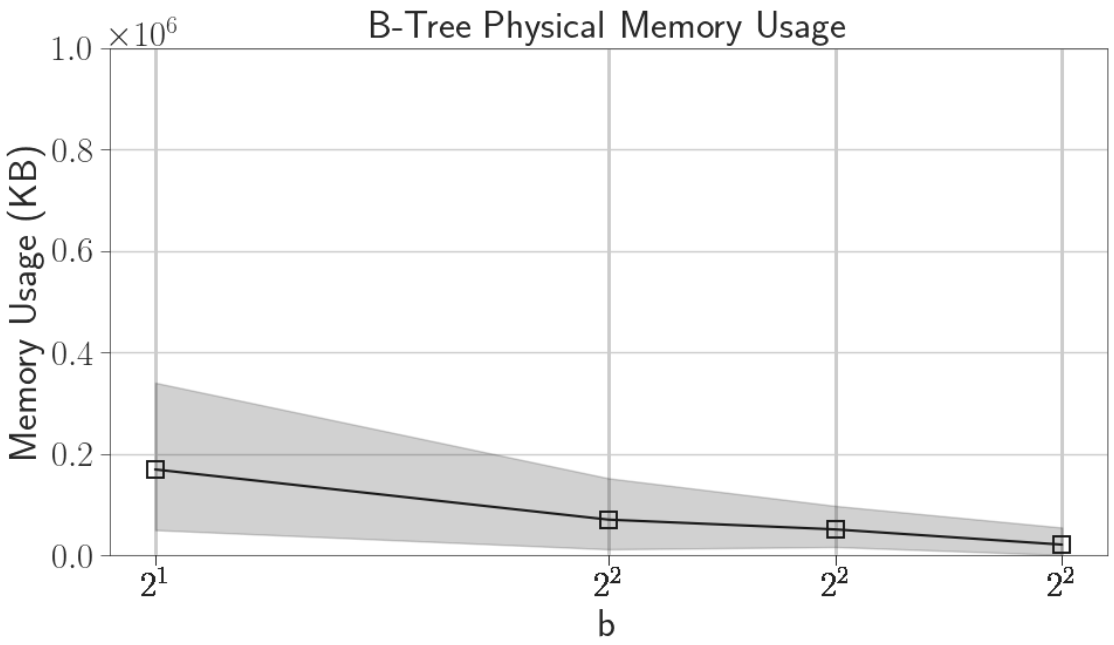
```
    x='b',
    y='cpu_time_ms_norm',
    marker='s',
    markerfacecolor='none',
    markeredgecolor='k',
    markeredgewidth=1.4,
    markersize=10,
    linestyle='-',  # Ensure line visibility
    linewidth=1.5,
    label='CPU Time Normalized [0, 1]',
    ax=ax
)

# Plot RAM usage normalized
sns.lineplot(
    data=btree_df,
    x='b',
    y='RAM_norm',
    marker='o',
    markerfacecolor='none',
    markeredgecolor='k',
    markeredgewidth=1.4,
    markersize=10,
    linestyle='--',
    linewidth=1.5,
    label='Physical Memory Usage Normalized [0, 1]',
    ax=ax
)

# Set labels and title
ax.set_title("B-Tree Benchmark Normalized")
ax.set_xlabel('b')
ax.set_ylabel('Normalized Values')

# Set grid and legend
ax.grid(True)
ax.legend()

# Adjust tick parameters and spines
ax.tick_params(width=0.5)
for spine in ax.spines.values():
    spine.set_linewidth(0.5)

# Set x-axis limits and ticks based on the actual data range
min_b, max_b = btree_df['b'].min(), btree_df['b'].max()
plt.xlim([min_b - 1, max_b + 1])
plt.xticks(range(min_b, max_b + 1))
```

```
# Create the save directory if it doesn't exist
save_path = 'plot/' + ax.get_title().lower().replace(' ', '_') + '.pdf'
os.makedirs(os.path.dirname(save_path), exist_ok=True)

# Save figure with bbox_inches='tight'
plt.savefig(save_path, bbox_inches='tight')

# Show plot
plt.show()
```



[48]:
```
# Plot the data
fig, ax = plt.subplots(figsize=(10, 6))
min_value = btree_df['RAM'].min()


sns.lineplot(
    data=btree_df,
    x='b',
    y='RAM',
    marker='s',
    markerfacecolor='none',
    # linestyle='--',
    markeredgecolor='k',
    markeredgewidth=1.4,
    markersize=10,
    color='k',
    linewidth=1.5,
    label='KB',
    ax=ax
)

ax.set_title("B-Tree Physical Memory Usage")
ax.set_xlabel('b')
```

```
ax.set_ylabel('Memory Usage (KB)')
ax.grid(True)
ax.legend().remove()
ax.tick_params(width=0.5)
ax.spines['top'].set_linewidth(0.5)
ax.spines['right'].set_linewidth(0.5)
ax.spines['left'].set_linewidth(0.5)
ax.spines['bottom'].set_linewidth(0.5)

plt.xticks( [2**2] + list(btree_df['b'])[8:])
ax.xaxis.set_major_formatter(FuncFormatter(log_tick_formatter))

plt.ylim([0, 1E6])

plt.tight_layout()
plt.savefig('plot/' +ax.get_title().lower().replace(' ', '_') + '.pdf',␣
 ↪bbox_inches='tight')
plt.show()
```



Second part

[52]:
```
with open("../code/macOS/btree/bench_over_n.json") as f:
    data = json.load(f)

benchmarks = data['benchmarks']
```

```
btree_df = pd.DataFrame(benchmarks)

# btree_df['real_time_ms'] = btree_df['real_time'] / 1e6
btree_df['cpu_time_ms'] = btree_df['cpu_time'] / 1e6
btree_df['RAM'] = btree_df['RAM'].astype(int)
# btree_df['Page'] = btree_df['Page'].astype(int)

btree_df['n'] = btree_df['name'].apply(lambda x: pd.to_numeric(x.split('/')[1])␣
 ↪if len(x.split('/')) > 1 else None)
btree_df['b'] = pd.to_numeric(btree_df['name'].str.extract(r'<(\d+)>')[0])
btree_df['name'] = btree_df['name'].apply(lambda x: x.split('/')[0] if '/' in x␣
 ↪else x)
btree_df['operation'] = btree_df['name'].apply(lambda x: x.split('_')[1].
 ↪split('<')[0] if '_' in x else x)
btree_df['name'] = btree_df['name'].apply(lambda x: x.split('_')[0].
 ↪split('>')[0] if '_' in x else x)

# btree_df['cpu_time_ms_norm'] = (btree_df['cpu_time_ms'] -␣
 ↪btree_df['cpu_time_ms'].min()) / (btree_df['cpu_time_ms'].max() -␣
 ↪btree_df['cpu_time_ms'].min())
btree_df['RAM_norm'] = (btree_df['RAM'] - btree_df['RAM'].min()) /␣
 ↪(btree_df['RAM'].max() - btree_df['RAM'].min())
# btree_df['Page_norm'] = scaler.fit_transform(btree_df[['Page']])

btree_df
```

[52]:

	name	family_index	per_family_instance_index	\
0	OrderedMap	0	0	
1	OrderedMap	0	1	
2	OrderedMap	0	2	
3	OrderedMap	0	3	
4	OrderedMap	0	4	
..	…	…	…	
225	BTreeMap	9	18	
226	BTreeMap	9	19	
227	BTreeMap	9	20	
228	BTreeMap	9	21	
229	BTreeMap	9	22	

	run_name	run_type	repetitions	repetition_index	\
0	OrderedMap_Insertion/8	iteration	1	0	
1	OrderedMap_Insertion/16	iteration	1	0	
2	OrderedMap_Insertion/32	iteration	1	0	
3	OrderedMap_Insertion/64	iteration	1	0	
4	OrderedMap_Insertion/128	iteration	1	0	
..	…	…	…	…	
225	BTreeMap_Search<6>/2097152	iteration	1	0	

```
226   BTreeMap_Search<6>/4194304  iteration            1                 0
227   BTreeMap_Search<6>/8388608  iteration            1                 0
228  BTreeMap_Search<6>/16777216  iteration            1                 0
229  BTreeMap_Search<6>/33554432  iteration            1                 0

     threads  iterations     real_time      cpu_time time_unit      Page  \
0          1           1  2.836799e+14  1.005150e+09        ns       0.0
1          1           1  2.836799e+14  1.005194e+09        ns       0.0
2          1           1  2.836799e+14  1.005221e+09        ns       0.0
3          1           1  2.836799e+14  1.005248e+09        ns       0.0
4          1           1  2.836799e+14  1.005283e+09        ns       0.0
..       …          …           …            …       …       …
225        1           1  2.841936e+14  5.143695e+11        ns   30720.0
226        1           1  2.841952e+14  5.159638e+11        ns   60416.0
227        1           1  2.841994e+14  5.200709e+11        ns  120832.0
228        1           1  2.842086e+14  5.293886e+11        ns  242688.0
229        1           1  2.842357e+14  5.563692e+11        ns  485376.0

        RAM  cpu_time_ms         n    b  operation  RAM_norm
0        16     1005.150         8  NaN  Insertion  0.265228
1         0     1005.194        16  NaN  Insertion  0.265219
2         0     1005.221        32  NaN  Insertion  0.265219
3         0     1005.248        64  NaN  Insertion  0.265219
4         0     1005.283       128  NaN  Insertion  0.265219
..      …          …       …  …        …       …
225   15264   514369.491   2097152  6.0     Search  0.272918
226  -59616   515963.827   4194304  6.0     Search  0.235152
227 -172704   520070.890   8388608  6.0     Search  0.178115
228 -267040   529388.624  16777216  6.0     Search  0.130536
229 -525856   556369.176  33554432  6.0     Search  0.000000

[230 rows x 19 columns]
```

[53]:
```
btree_df.drop(columns=['real_time', 'cpu_time','iterations',␣
 ↪'repetition_index', 'run_name', 'repetitions', 'threads', 'run_type',␣
 ↪'family_index', 'per_family_instance_index', 'time_unit', 'Page',␣
 ↪'real_time'], inplace=True)

btree_df.rename(columns={
    'cpu_time_ms_norm': 'CPU Time Normalized [0, 1]',
    'cpu_time_ms': 'CPU Time (ms)',
    'RAM': 'Physical Memory Usage (KB)',
    'RAM_norm': 'Physical Memory Usage Normalized [0, 1]',
}, inplace=True)

btree_df
```

[53]:
```
            name  Physical Memory Usage (KB)  CPU Time (ms)         n    b  \
0    OrderedMap                           16       1005.150         8  NaN
1    OrderedMap                            0       1005.194        16  NaN
2    OrderedMap                            0       1005.221        32  NaN
3    OrderedMap                            0       1005.248        64  NaN
4    OrderedMap                            0       1005.283       128  NaN
..          …                            …            …       …  …
225    BTreeMap                        15264     514369.491   2097152  6.0
226    BTreeMap                       -59616     515963.827   4194304  6.0
227    BTreeMap                      -172704     520070.890   8388608  6.0
228    BTreeMap                      -267040     529388.624  16777216  6.0
229    BTreeMap                      -525856     556369.176  33554432  6.0

     operation  Physical Memory Usage Normalized [0, 1]
0    Insertion                                0.265228
1    Insertion                                0.265219
2    Insertion                                0.265219
3    Insertion                                0.265219
4    Insertion                                0.265219
..         …                                      …
225     Search                                0.272918
226     Search                                0.235152
227     Search                                0.178115
228     Search                                0.130536
229     Search                                0.000000

[230 rows x 7 columns]
```

[54]:
```
names = btree_df['name'].unique().tolist()
operations = btree_df['operation'].unique()


df_filtered_btree = btree_df[btree_df['name'] == 'BTreeMap']
df_filtered_map = btree_df[btree_df['name'] == 'OrderedMap']

exclude_columns = ['name', 'n', 'operation', 'b']

unique_names = btree_df['name'].unique().tolist()
print(unique_names)
print(operations)

btree_df
```

```
['OrderedMap', 'BTreeMap']
['Insertion' 'Search']
```

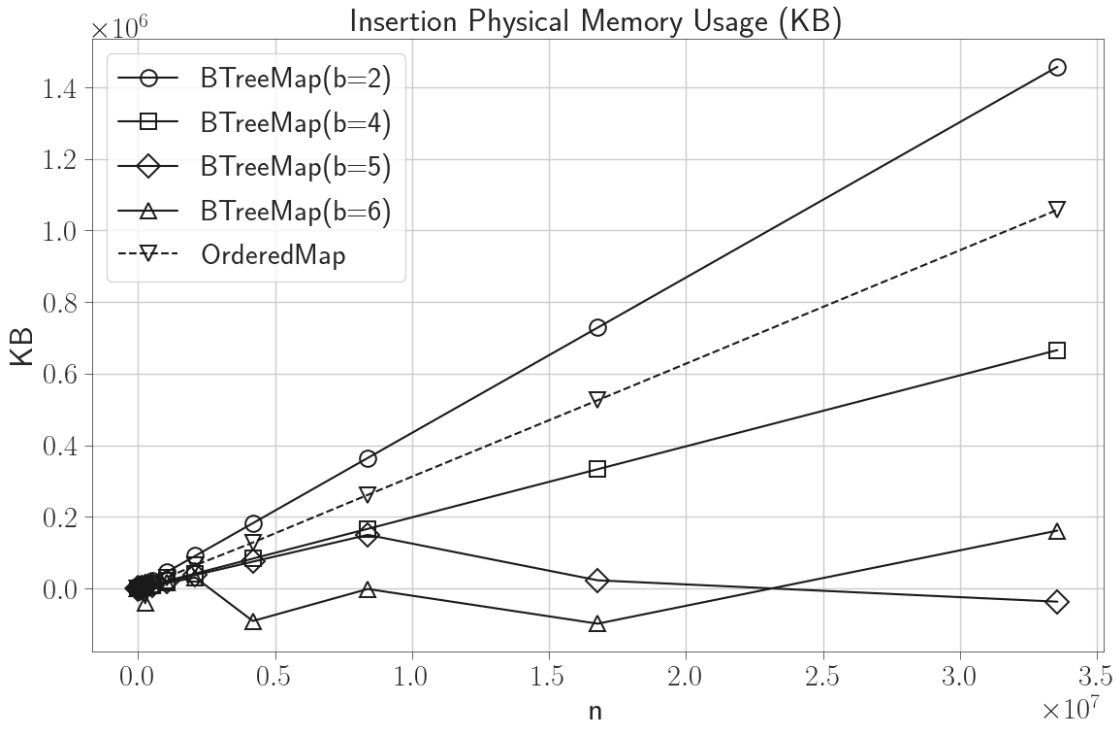
[54]:
```
           name  Physical Memory Usage (KB)  CPU Time (ms)         n    b  \
0    OrderedMap                          16       1005.150         8  NaN
1    OrderedMap                           0       1005.194        16  NaN
2    OrderedMap                           0       1005.221        32  NaN
3    OrderedMap                           0       1005.248        64  NaN
4    OrderedMap                           0       1005.283       128  NaN
..          …                           …            …       …  …
225    BTreeMap                       15264     514369.491   2097152  6.0
226    BTreeMap                      -59616     515963.827   4194304  6.0
227    BTreeMap                     -172704     520070.890   8388608  6.0
228    BTreeMap                     -267040     529388.624  16777216  6.0
229    BTreeMap                     -525856     556369.176  33554432  6.0

     operation  Physical Memory Usage Normalized [0, 1]
0    Insertion                                0.265228
1    Insertion                                0.265219
2    Insertion                                0.265219
3    Insertion                                0.265219
4    Insertion                                0.265219
..         …                                      …
225     Search                                0.272918
226     Search                                0.235152
227     Search                                0.178115
228     Search                                0.130536
229     Search                                0.000000

[230 rows x 7 columns]
```

[57]:
```
# Get unique names

# Columns to exclude from plotting

# Plot each unique name

markers = ['o', 's', 'D', '^', 'v', '<', '>', 'p', '*', 'h', 'H', 'x', 'X',␣
 ↪'d', '|', '_']

for op in operations:

    df_filtered_btree_op = df_filtered_btree[df_filtered_btree['operation'] ==␣
 ↪op]
    df_filtered_map_op = df_filtered_map[df_filtered_map['operation'] == op]

    for column in df_filtered_btree.columns:
        if column not in exclude_columns:
            fig, ax = plt.subplots(figsize=(12, 8))
```

```
            marker_cyc = itertools.cycle(markers)

            for b in df_filtered_btree_op['b'].unique():
                print(f'bt {column}')
                sns.lineplot(
                    data=df_filtered_btree_op[df_filtered_btree_op['b'] == b],
                    x='n',
                    y=column,
                    marker=next(marker_cyc),
                    markerfacecolor='none',
                    markeredgecolor='k',
                    markeredgewidth=1.4,
                    markersize=12,
                    color='k',
                    linewidth=1.5,
                    label= f'BTreeMap(b={int(b)})',
                    ax=ax
                )

            print(f'om {column}')
            sns.lineplot(
                data=df_filtered_map_op,
                x='n',
                y=column,
                marker=next(marker_cyc),
                markerfacecolor='none',
                linestyle='--',
                markeredgecolor='k',
                markeredgewidth=1.4,
                markersize=12,
                color='k',
                linewidth=1.5,
                label='OrderedMap',
                ax=ax
            )

            ax.set_title(f"{op.title()} {column}")
            ax.set_xlabel('n')

            if "Normalized" in column:
                ax.set_ylabel("Normalized Value")
            elif "(" in column:
                ax.set_ylabel(f"{column}".split('(')[1].split(')')[0])
            else:
                ax.set_ylabel(column)

            ax.grid(True)
```

```
            ax.legend()
            ax.tick_params(width=0.5)
            ax.spines['top'].set_linewidth(0.5)
            ax.spines['right'].set_linewidth(0.5)
            ax.spines['left'].set_linewidth(0.5)
            ax.spines['bottom'].set_linewidth(0.5)

            plt.tight_layout()
            plt.savefig('plot/' +ax.get_title().lower().replace(' ', '_') + '.
↪pdf', bbox_inches='tight')
            plt.show()
```

```
bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
om Physical Memory Usage (KB)
```

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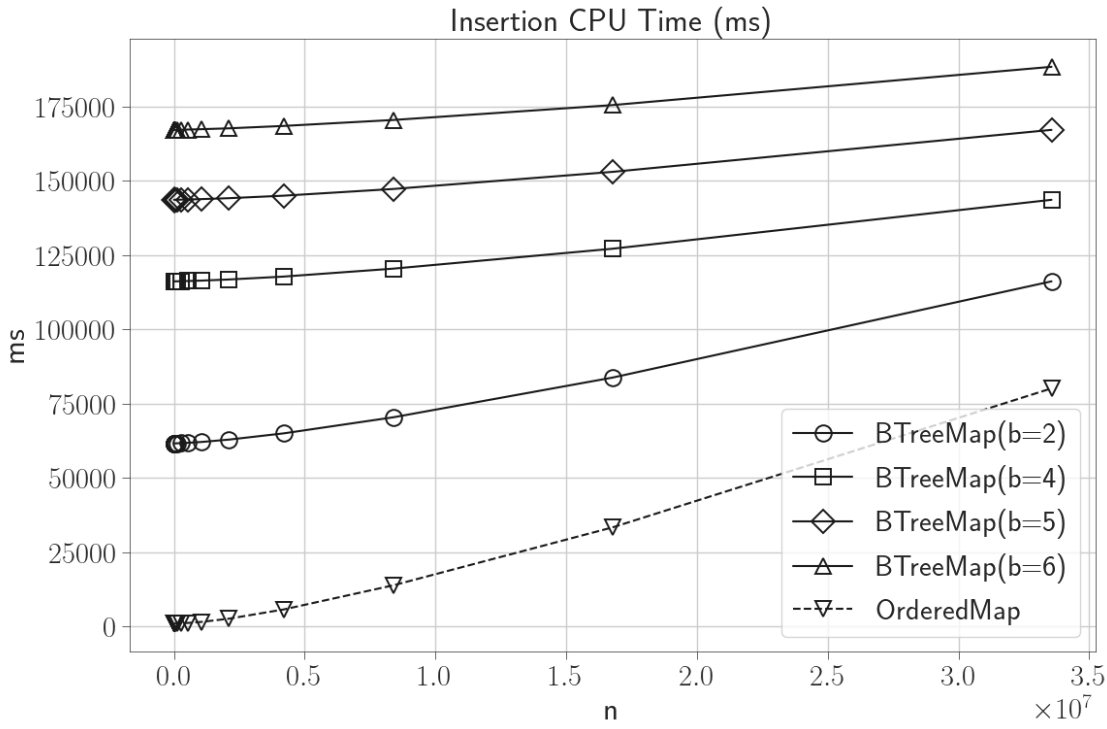


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bt Physical Memory Usage Normalized [0, 1]
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bt Physical Memory Usage Normalized [0, 1]
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om Physical Memory Usage Normalized [0, 1]
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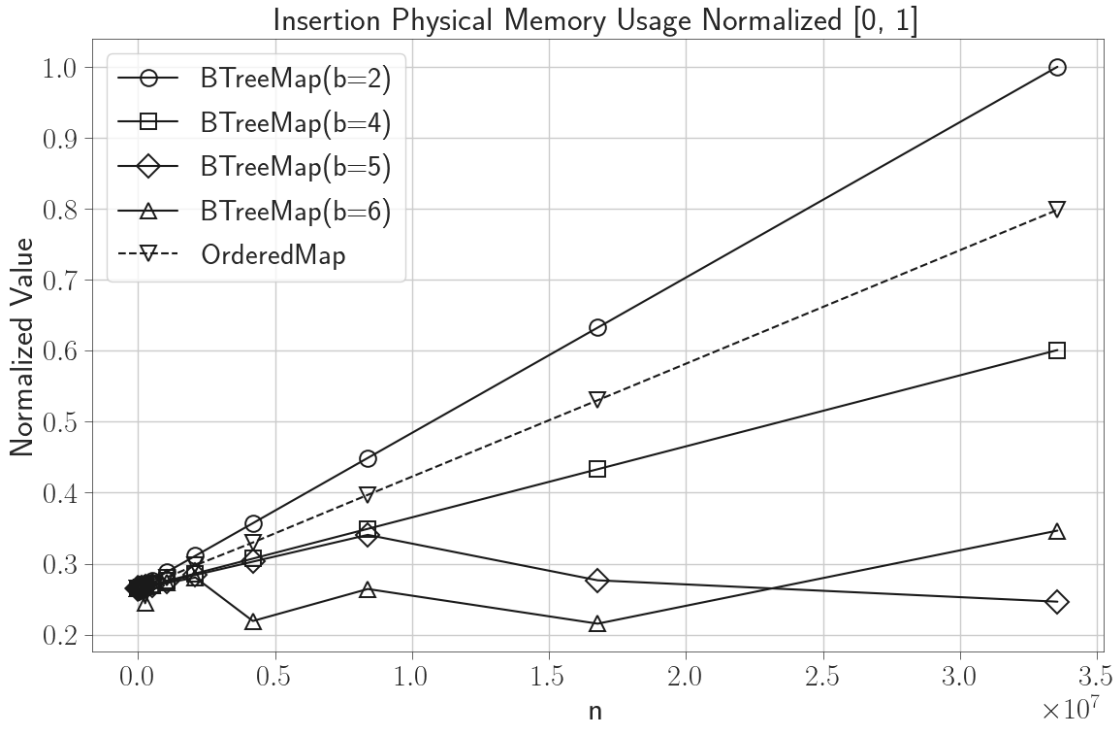


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om Physical Memory Usage (KB)
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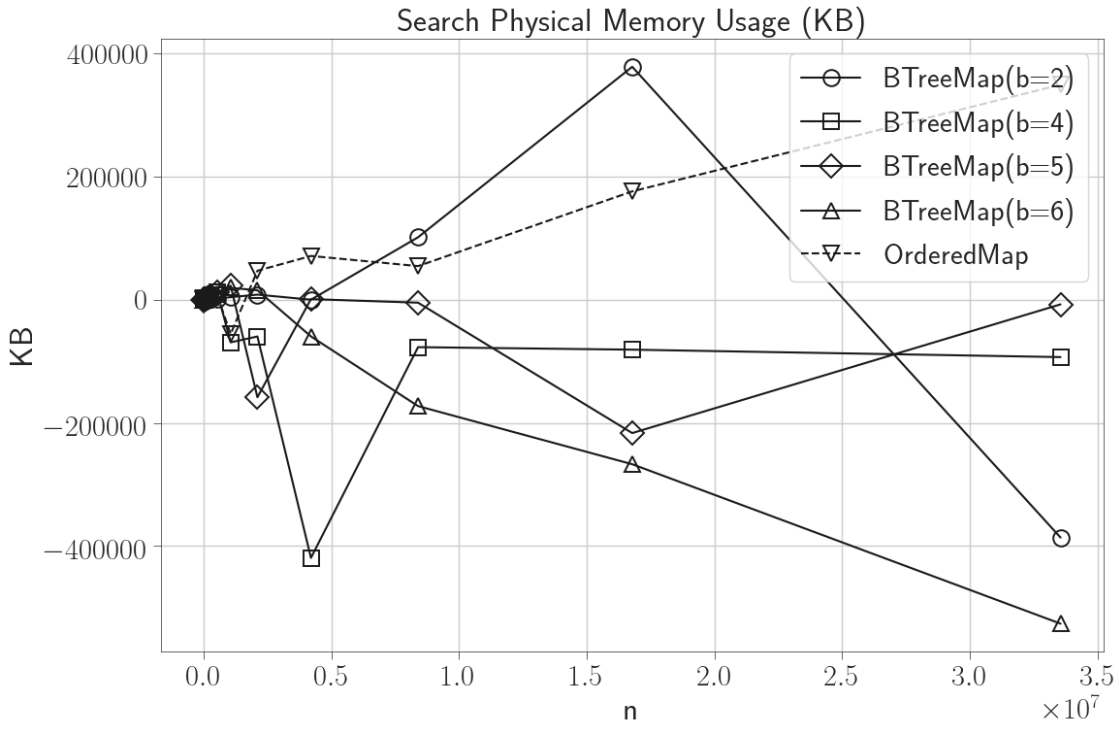


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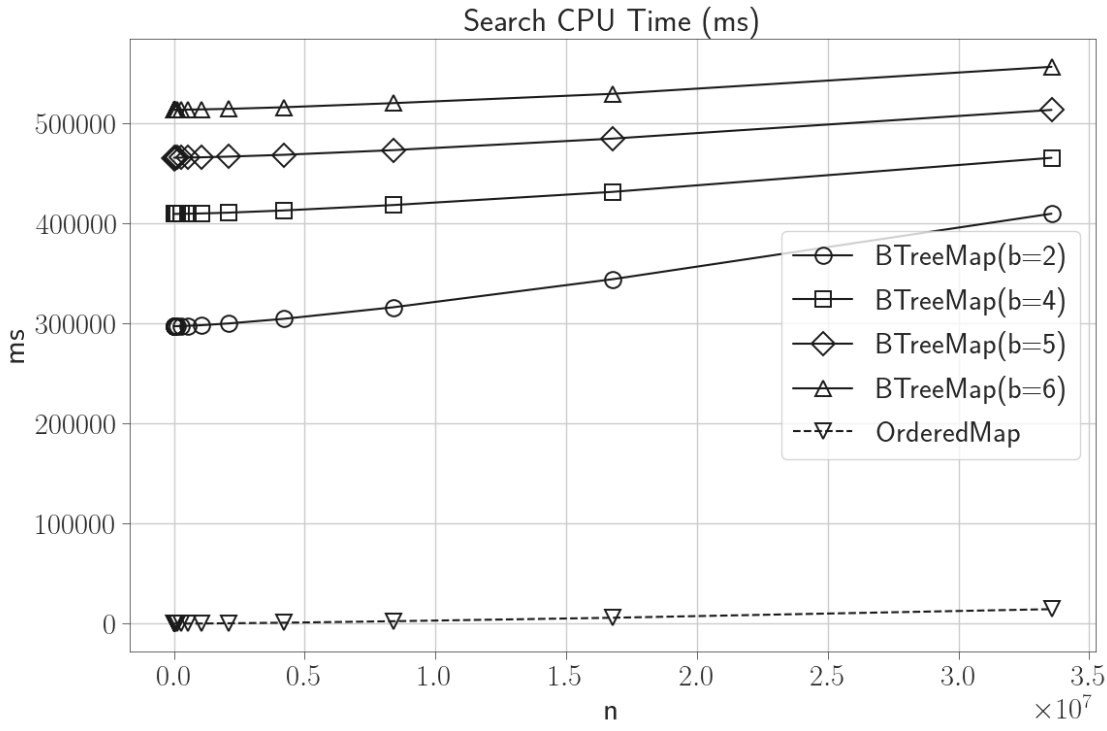


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bt Physical Memory Usage Normalized [0, 1]
bt Physical Memory Usage Normalized [0, 1]
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om Physical Memory Usage Normalized [0, 1]
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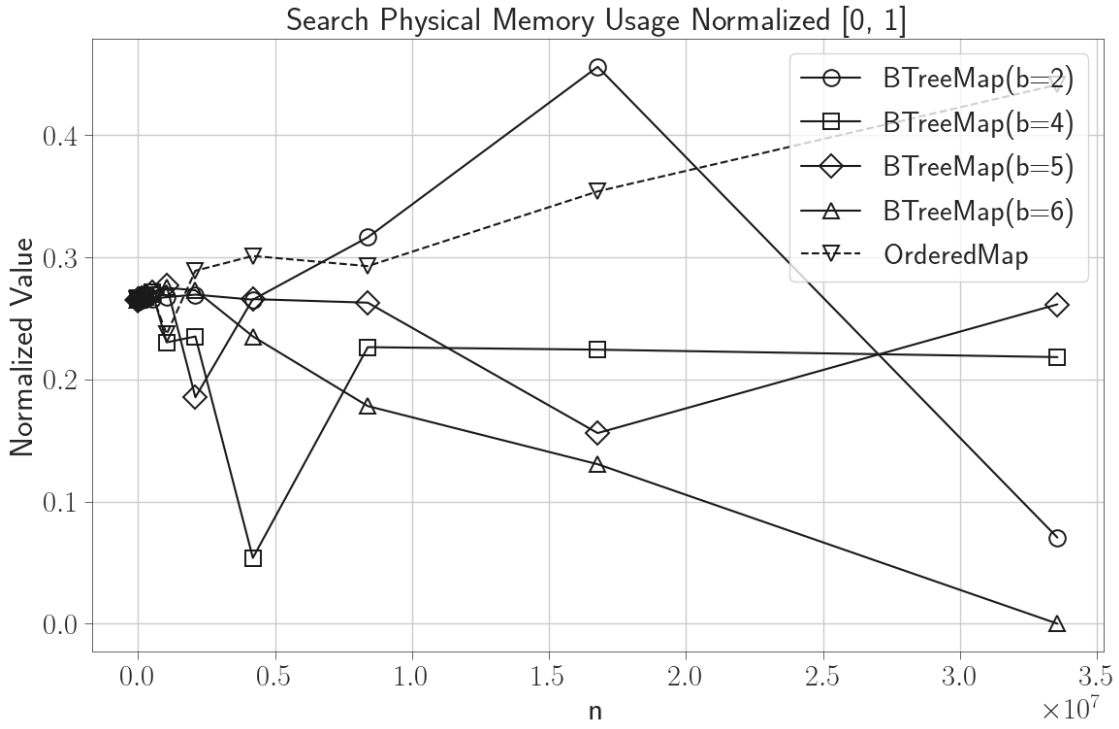

[56]:
```
# Get unique names
# Columns to exclude from plotting
# Plot each unique name

markers = ['o', 's', 'D', '^', 'v', '<', '>', 'p', '*', 'h', 'H', 'x', 'X',␣
 ↪'d', '|', '_']

for op in operations:

    df_filtered_btree_op = df_filtered_btree[df_filtered_btree['operation'] ==␣
 ↪op]
    df_filtered_map_op = df_filtered_map[df_filtered_map['operation'] == op]

    for column in df_filtered_btree.columns:
        if column not in exclude_columns:
            fig, ax = plt.subplots(figsize=(12, 6))

            marker_cyc = itertools.cycle(markers)

            for b in df_filtered_btree_op['b'].unique():
                print(f'bt {column}')
                sns.lineplot(
                    data=df_filtered_btree_op[df_filtered_btree_op['b'] == b],
```

```
                    x='n',
                    y=column,
                    marker=next(marker_cyc),
                    markerfacecolor='none',
                    markeredgecolor='k',
                    markeredgewidth=1.4,
                    markersize=12,
                    color='k',
                    linewidth=1.5,
                    label= f'b={int(b)}',
                    ax=ax
                )

            ax.set_title(f"BTree {op.title()} {column}")
            ax.set_xlabel('n')
            ax.set_ylabel(column)
            ax.grid(True)
            ax.legend()
            ax.tick_params(width=0.5)
            ax.spines['top'].set_linewidth(0.5)
            ax.spines['right'].set_linewidth(0.5)
            ax.spines['left'].set_linewidth(0.5)
            ax.spines['bottom'].set_linewidth(0.5)

            # plt.xticks(np.logspace(0, 2^20, num=12, base=2, dtype=int) )
            # ax.xaxis.set_major_formatter(FuncFormatter(log_tick_formatter))

            plt.tight_layout()
            plt.savefig('plot/' +ax.get_title().lower().replace(' ', '_') + '.
↪pdf', bbox_inches='tight')
            plt.show()
```

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bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
bt Physical Memory Usage (KB)
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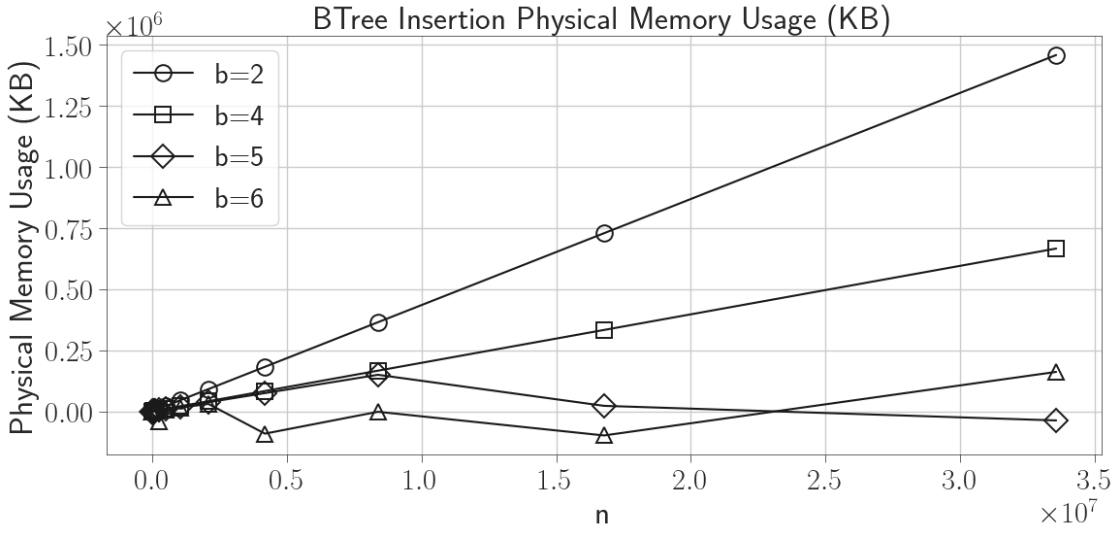


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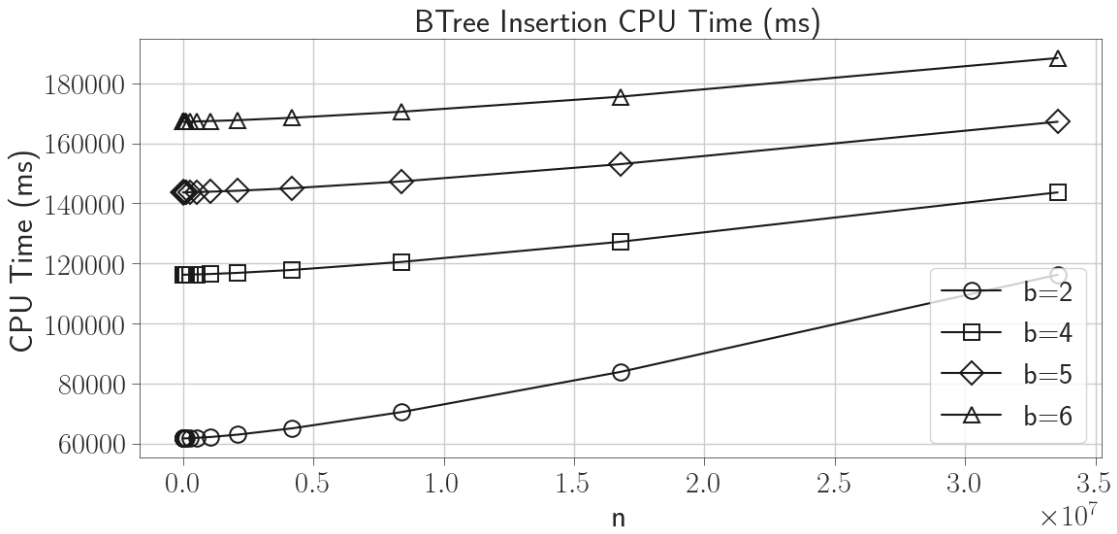


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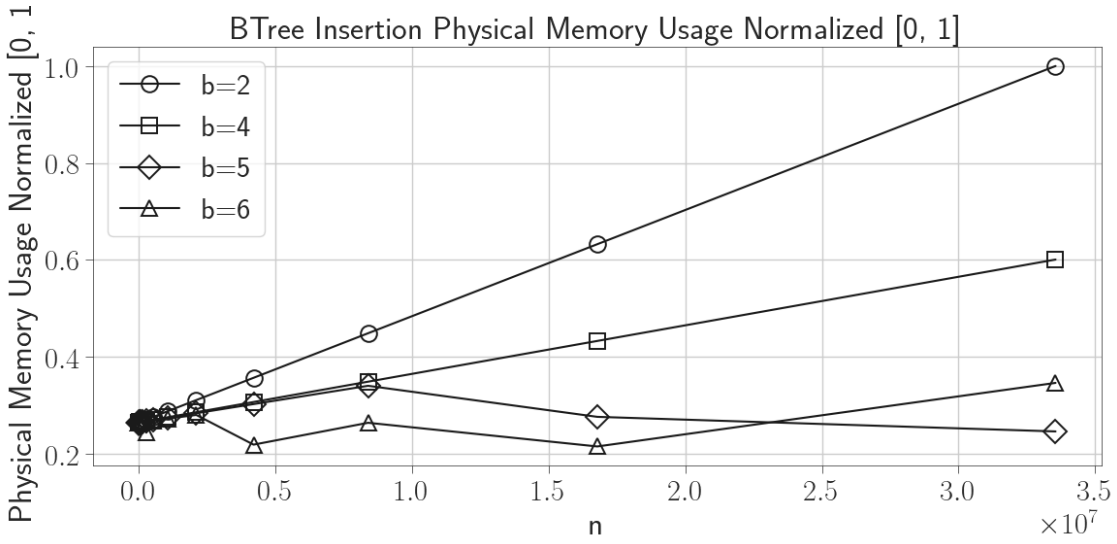


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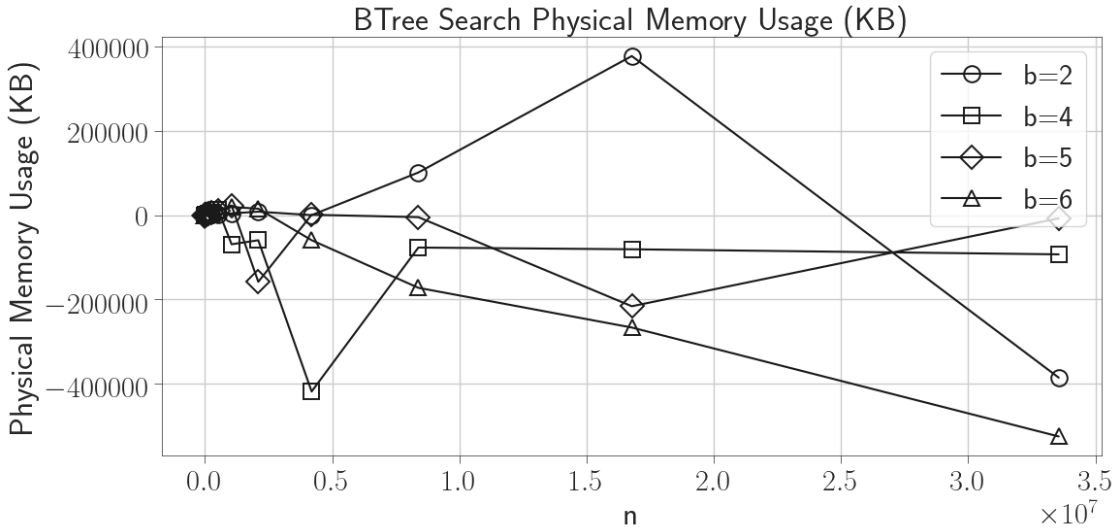


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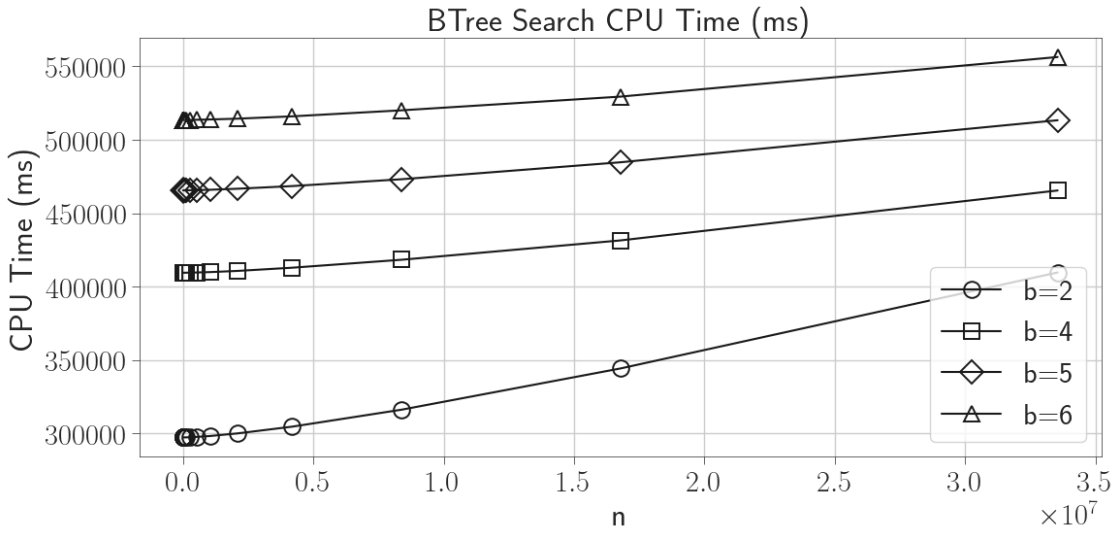


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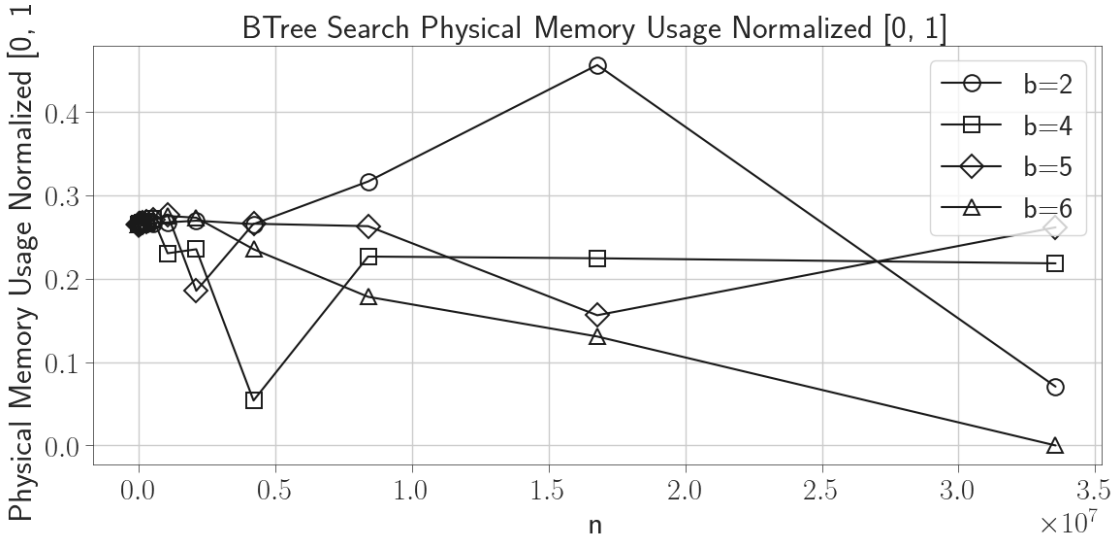

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