In [1]:

```python
import random
import time
import tracemalloc
import matplotlib.pyplot as plt
from random import sample
```

In [2]:

```python
def countingSortForRadix(inputArray, placeValue):
    # We can assume that the number of digits used to represent
    # all numbers on the placeValue position is not grater than 10
    countArray = [0] * 10
    inputSize = len(inputArray)

    # placeElement is the value of the current place value
    # of the current element, e.g. if the current element is
    # 123, and the place value is 10, the placeElement is
    # equal to 2
    for i in range(inputSize):
        placeElement = (inputArray[i] // placeValue) % 10
        countArray[placeElement] += 1

    for i in range(1, 10):
        countArray[i] += countArray[i-1]

    # Reconstructing the output array
    outputArray = [0] * inputSize
    i = inputSize - 1
    while i >= 0:
        currentEl = inputArray[i]
        placeElement = (inputArray[i] // placeValue) % 10
        countArray[placeElement] -= 1
        newPosition = countArray[placeElement]
        outputArray[newPosition] = currentEl
        i -= 1

    return outputArray

def radixSort(inputArray):
    # Step 1 -> Find the maximum element in the input array
    maxEl = max(inputArray)
```

```python
    # Step 2 -> Find the number of digits in the `max` element
    D = 1
    while maxEl > 0:
        maxEl /= 10
        D += 1

    # Step 3 -> Initialize the place value to the least significant place
    placeVal = 1

    # Step 4
    outputArray = inputArray
    while D > 0:
        outputArray = countingSortForRadix(outputArray, placeVal)
        placeVal *= 10
        D -= 1

    return outputArray
```

In [5]:

```python
def complexity(data,num):
    subsequence = sample(data, num)
    start = time.time()
    tracemalloc.start()
    radixSort(subsequence)
    end = time.time()
    runtime = end - start
    current, peak = tracemalloc.get_traced_memory()
    usage = current / 10**6
    print(f"Best and average case usage is {usage}MB; Peak was {peak / 10**6}MB")
    tracemalloc.stop()
    print(f"Best and average case runtime is {runtime}")
    return runtime, usage

def complexityW(data,num):
    subsequence = sorted(sample(data, num),reverse=True)
    start = time.time()
    tracemalloc.start()
    radixSort(subsequence)
    end = time.time()
    runtime = end - start
    current, peak = tracemalloc.get_traced_memory()
    usage = current / 10**6
    print(f"Worst case usage is {usage}MB; Peak was {peak / 10**6}MB")
    tracemalloc.stop()
```

```python
    print(f"Worst and average case runtime is {runtime}")
    return runtime, usage
```

In [11]:

```python
random.seed(1)
sequence = [i for i in range(100000)]
random.shuffle(sequence)
seqRange = [50,100,200,500,1000,2000,5000,10000]
bestCase = []
worstCase = []
```

In [12]:

```python
for i in range(8):
     print(f"{i+1}: for {seqRange[i]} items\n --------------------")
     bestCase.append(complexity(sequence,seqRange[i]))
     worstCase.append(complexityW(sequence,seqRange[i]))
```

```
1: for 50 items
 --------------------
Best and average case usage is 0.0MB; Peak was 0.001064MB
Best and average case runtime is 0.008979320526123047
Worst case usage is 0.0MB; Peak was 0.001064MB
Worst and average case runtime is 0.007936477661132812
2: for 100 items
 --------------------
Best and average case usage is 0.0MB; Peak was 0.001864MB
Best and average case runtime is 0.009971141815185547
Worst case usage is 0.0MB; Peak was 0.001864MB
Worst and average case runtime is 0.011911153793334961
3: for 200 items
 --------------------
Best and average case usage is 0.000304MB; Peak was 0.003768MB
Best and average case runtime is 0.02521204948425293
Worst case usage is 0.0MB; Peak was 0.003464MB
Worst and average case runtime is 0.018942594528198242
4: for 500 items
 --------------------
Best and average case usage is 0.006018MB; Peak was 0.015538MB
Best and average case runtime is 0.2592785358428955
Worst case usage is 0.00528MB; Peak was 0.014044MB
Worst and average case runtime is 0.2538795471191406
5: for 1000 items
 --------------------
Best and average case usage is 0.005408MB; Peak was 0.024828MB
Best and average case runtime is 0.7176740169525146
Worst case usage is 0.005384MB; Peak was 0.024716MB
Worst and average case runtime is 0.7228741645812988
```

```
6: for 2000 items
 --------------------
Best and average case usage is 0.005384MB; Peak was 0.041409MB
Best and average case runtime is 1.5877869129180908
Worst case usage is 0.005384MB; Peak was 0.040628MB
Worst and average case runtime is 1.6328694820404053
7: for 5000 items
 --------------------
Best and average case usage is 0.005384MB; Peak was 0.089393MB
Best and average case runtime is 4.426867485046387
Worst case usage is 0.005586MB; Peak was 0.089357MB
Worst and average case runtime is 4.459205150604248
8: for 10000 items
 --------------------
Best and average case usage is 0.005328MB; Peak was 0.16875MB
Best and average case runtime is 8.949523687362671
Worst case usage is 0.005384MB; Peak was 0.169347MB
Worst and average case runtime is 9.131636142730713
```

In [13]:

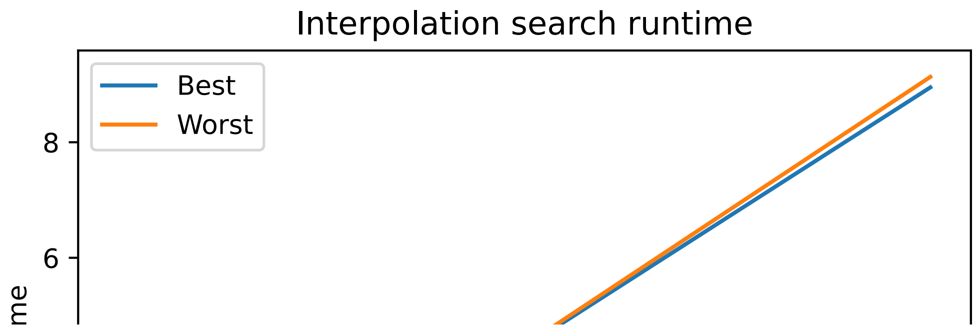
```
best_runtime, best_usage, = map(list, zip(*bestCase))
worst_runtime, worst_usage, = map(list, zip(*worstCase))
```

In [15]:

```
fig, ax = plt.subplots()
ax.plot(seqRange, best_runtime, label='Best')
ax.plot(seqRange, worst_runtime, label='Worst')
ax.set_xlabel('Items')
ax.set_ylabel('Runtime')
ax.set_title("Interpolation search runtime")
ax.legend()
```

Out[15]:

```
<matplotlib.legend.Legend at 0x2a320181f10>
```



In [16]:

```
fig, ax = plt.subplots()
ax.plot(seqRange, best_usage, label='Best')
ax.plot(seqRange, worst_usage, label='Worst')
ax.set_xlabel('Items')
ax.set_ylabel('Memory usage')
ax.set_title("Interpolation search runtime")
ax.legend()
```

Out[16]: <matplotlib.legend.Legend at 0x2a3201d5b80>

In [ ]: