VLSI System Design HW2

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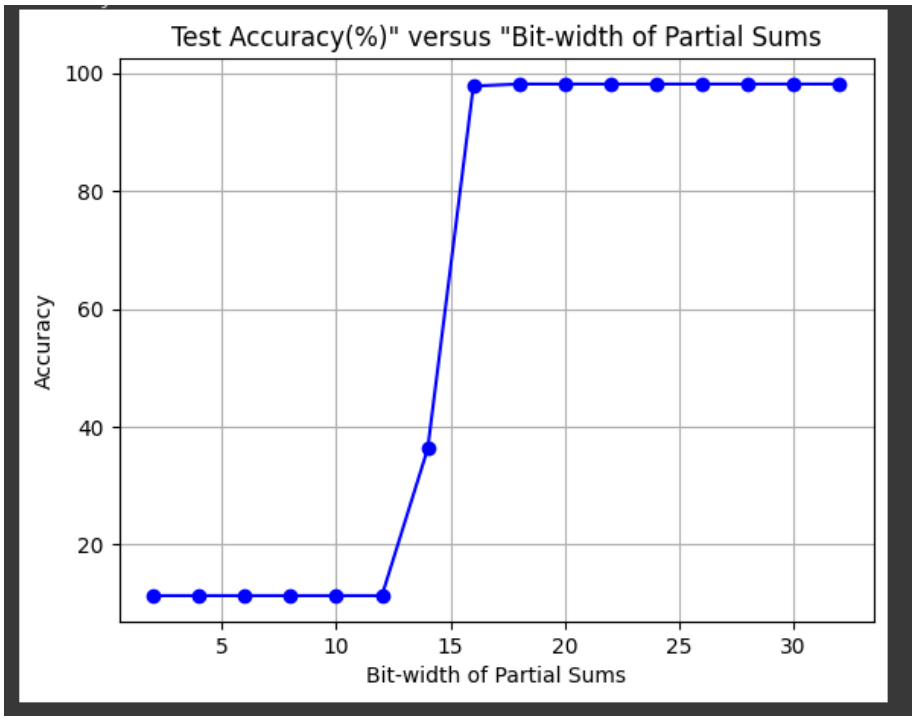
(1.1)

```
test_ACTQUANT (__main__.OpTestCase) ... ok
test_C1 (__main__.OpTestCase) ... ok
test_C3 (__main__.OpTestCase) ... ok
test_C5 (__main__.OpTestCase) ... ok
test_F6 (__main__.OpTestCase) ... ok
test_OUTPUT (__main__.OpTestCase) ... ok
test_S2 (__main__.OpTestCase) ... ok
test_S4 (__main__.OpTestCase) ... ok

----------------------------------------------------------------------
Ran 8 tests in 12.792s

OK
<unittest.runner.TextTestResult run=8 errors=0 failures=0>
```

(1.2)

```
bit: 32
bit-width range: (-2147483648, 2147483647)
Accuracy: 98.14%
98.14
```

(2.1.1)



(2.1.2)

the smallest bit-width of partial sums that maintains the same accuracy : 18

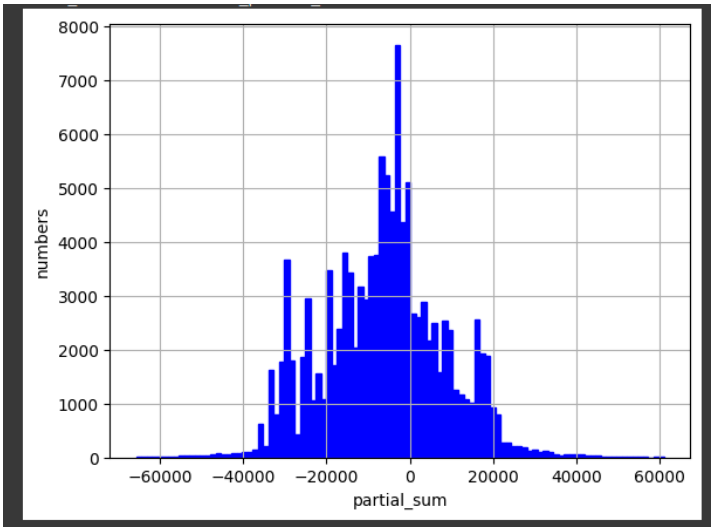
```
bit: 2
bit-width range: (-2, 1)
Accuracy: 11.35%
bit: 4
bit-width range: (-8, 7)
Accuracy: 11.35%
bit: 6
bit-width range: (-32, 31)
Accuracy: 11.35%
bit: 8
bit-width range: (-128, 127)
Accuracy: 11.35%
bit: 10
bit-width range: (-512, 511)
Accuracy: 11.35%
bit: 12
bit-width range: (-2048, 2047)
Accuracy: 11.35%
bit: 14
bit-width range: (-8192, 8191)
Accuracy: 36.26%
bit: 16
bit-width range: (-32768, 32767)
Accuracy: 97.81%
bit: 18
bit-width range: (-131072, 131071)
Accuracy: 98.14%
bit: 20
bit-width range: (-524288, 524287)
Accuracy: 98.14%
bit: 22
bit-width range: (-2097152, 2097151)
Accuracy: 98.14%
bit: 24
bit-width range: (-8388608, 8388607)
Accuracy: 98.14%
bit: 26
bit-width range: (-33554432, 33554431)
Accuracy: 98.14%
```

(2.2.1)

conv1_min_partial_sum = -65719

conv1_max_partial_sum = 61119

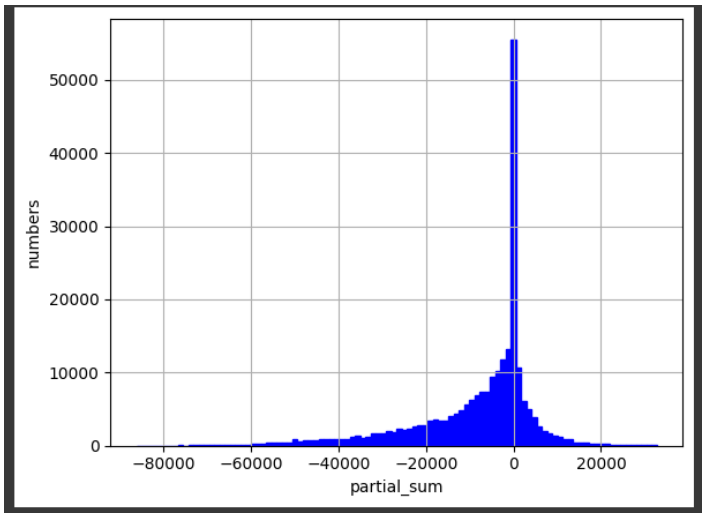
conv1_standard deviation_partial_sum = 14695.02059495775



conv3_min_partial_sum = -86196

conv3_max_partial_sum = 32701

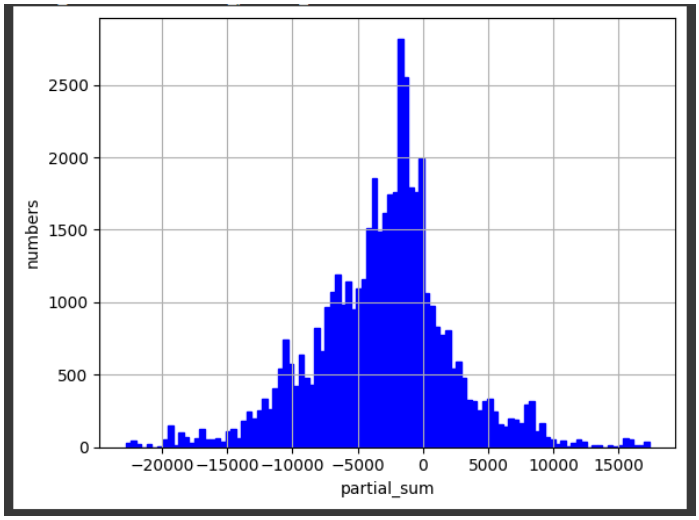
conv3_standard deviation_partial_sum = 13685.063595803571



conv5_min_partial_sum = -22761

conv5_max_partial_sum = 17345

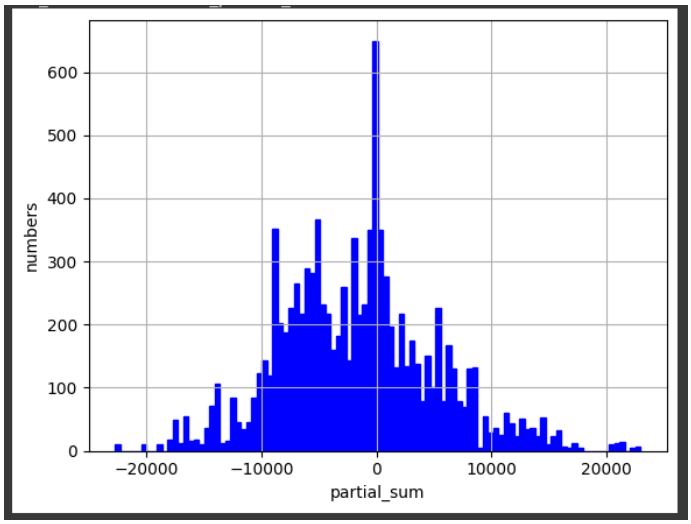
conv5_standard deviation_partial_sum = 5278.362709781564



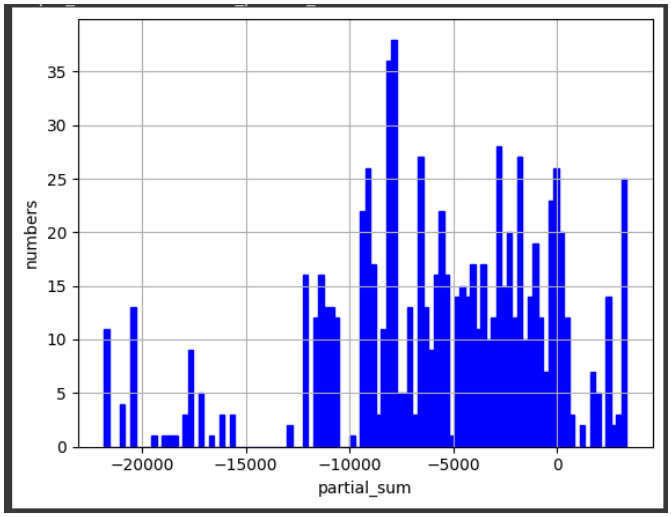
fc6_min_partial_sum = -22726

fc6_max_partial_sum = 22931

fc6_standard deviation_partial_sum = 6814.782848677579



output_min_partial_sum = -21818
output_max_partial_sum = 3370
output_standard deviation_partial_sum = 5364.636346566406



(2.2.2)

在尋找最小 bit-width 的過程中，可以根據先前所得到的 partial_sum 得知大概的 bit-width 並且去調整它，在挑選過程中，我得到了兩個結果，其中一個是保持準確率不變的最小 bit-width，一個是提高準確率的最小 bit-width。

準確率不變:

Conv1_minimum bit-width of partial sums : 17
Conv3_minimum bit-width of partial sums:17
Conv5_minimum bit-width of partial sums:15
Fc6_minimum bit-width of partial sums:15
Output_minimum bit-width of partial sums:13
Accuracy: 98.14%

準確率提高:

Conv1_minimum bit-width of partial sums : 17
Conv3_minimum bit-width of partial sums:16
Conv5_minimum bit-width of partial sums:15
Fc6_minimum bit-width of partial sums:14
Output_minimum bit-width of partial sums:13
Accuracy: 98.24000000000001%

(3.1.1)

Conv1:

$$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$$

$$Sadd = 18$$

$$Nmul = 1 * 6 * 28 * 28 * 5 * 5 * 1 = 117600$$

$$Nadd = 117600$$

$$Ew = 9643200$$

Conv3:

$$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$$

$$Sadd = 18$$

$$Nmul = 1 * 16 * 10 * 10 * 5 * 5 * 6 = 240000$$

$$Nadd = 240000$$

$$Ew = 19680000$$

Conv5:

$$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$$

$$Sadd = 18$$

$$Nmul = 1 * 120 * 1 * 1 * 5 * 5 * 16 = 48000$$

$$Nadd = 48000$$

$$Ew = 3936000$$

Fc6:

$$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$$

$$Sadd = 18$$

$Nmul = 1 * 84 * 120 = 10080$
$Nadd = 10080$
$Ew = 826560$

Output:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 18$
$Nmul = 1 * 10 * 84 = 840$
$Nadd = 840 + 10 = 850$
$Ew = 69060$

Total

$Ew = 34154820$

Layer	Smul	Nmul	Sadd	Nadd	Ew
Conv1	64	117600	18	117600	9643200
Conv3	64	240000	18	240000	19680000
Conv5	64	48000	18	48000	3936000
Fc6	64	10080	18	10080	826560
Output	64	840	18	850	69060
Total					34154820

(3.1.2)

Conv1:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 17$
$Nmul = 1 * 6 * 28 * 28 * 5 * 5 * 1 = 117600$
$Nadd = 117600$
$Ew = 9525600$

Conv3:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 17$
$Nmul = 1 * 16 * 10 * 10 * 5 * 5 * 6 = 240000$
$Nadd = 240000$

$Ew = 19440000$

Conv5:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 15$

$Nmul = 1 * 120 * 1 * 1 * 5 * 5 * 16 = 48000$

$Nadd = 48000$

$Ew = 3792000$

Fc6:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 15$

$Nmul = 1 * 84 * 120 = 10080$

$Nadd = 10080$

$Ew = 796320$

Output:

$Smul = 64 * \left(\frac{8}{8}\right)^2 = 64$

$Sadd = 13$

$Nmul = 1 * 10 * 84 = 840$

$Nadd = 840 + 10 = 850$

$Ew = 64810$

Total

準確率不變:

$Ew = 33618730$

Layer	Smul	Nmul	Sadd	Nadd	Ew
Conv1	64	117600	17	117600	9525600
Conv3	64	240000	17	240000	19440000
Conv5	64	48000	15	48000	3792000
Fc6	64	10080	15	10080	796320
Output	64	840	13	850	64810
Total					33618730

準確率提高: (其詳細算法可從準確率不變類推)

$Ew = 33368650$

Layer	Smul	Nmul	Sadd	Nadd	Ew
Conv1	64	117600	17	117600	9525600
Conv3	64	240000	16	240000	19200000
Conv5	64	48000	15	48000	3792000
Fc6	64	10080	14	10080	786240
Output	64	840	13	850	64810
Total					33368650