bitlet v11.0

高性能、低功耗的通用 MAC 计算引擎

用户手册

上海处理器技术创新中心 IP 产品

上海处理器技术创新中心
SHANGHAI INNOVATION CENTER FOR PROCESSOR TECHNOLOGIES

IP 特性

简介：本 IP 为上海处理器技术创新中心出品的高性能、低功耗、低面积开销的通用 MAC 计算引擎。可用于任何 AI 场景下的深度学习模型训练、推理过程，加速卷积、矩阵相乘等任何需要乘加、乘累加（MAC）操作的计算过程。通过高度可配的数据类型和位宽，达到性能、功耗的合理权衡，助力提高 AI 芯片产品的能效并降低流片成本，缩短 AI 芯片产品从研发到商用的周期。

IP 参数表

支持的 FPGA 类型	Xilinx 全系列
逻辑资源使用情况	见表 2.4、表 2.5
IP 形式	固核（网表文件）
设计实例	TBD
Test Bench	见附件 1
仿真模型	TBD
开发环境	Vivado Design Suite 2020.2
综合环境	Vivado Synthesis

技术支持：上海处理器技术创新中心

特性：

- **同一架构下，支持的浮点操作数类型：float 32/16，bfloat16**

- **支持的定点操作数类型：int8，fixed point 1~24 bit（本版本暂未支持）**

- **单次计算量：64 个 MAC（默认），可根据实际需要改变**

目　录

第一章 IP 总览

1 特性介绍

本 IP 将浮点类型 MAC、定点类型 MAC 以及整型 MAC 的计算集成于同一硬件架构中，用户不必针对每个 AI 场景选配不同的 MAC 计算 IP，只需通过本 IP 的接口参数进行配置即可适用于任何场景的模型推理，最大程度的方便用户开发自己的 AI 芯片产品，降低流片成本，缩短研发周期。

本 IP 支持浮点类型的高速 MAC 计算，因此搭载本 IP 的 AI 芯片可用于模型训练，助力高性能 AI 芯片产品的诞生。

本 IP 支持多种位宽（及其组合）。浮点类型支持 float 32/16，bfloat16 三种常用类型；定点类型支持 fixed point 1~24 bit 范围内的任意位宽，并单独支持(u)int8 整数类型。

多种数据类型的高度集成并未增加 IP 的面积。该特性有助于构建位于端侧的低功耗、低成本的 AI 芯片产品。

作为独特的深度学习加速 IP，本产品支持浮点 32 bit MAC 计算的"硬件剪枝"。详细请见第四章。

2 广泛、普适的应用场景

首先，本 IP 产品适用于任何 AI 场景下的模型训练和推理，包括云端的高性能计算场景和移动端的低功耗推理场景。

由于本 IP 的独有特性，还可支持以下特殊场景下的深度学习加速：

- **混合精度训练和推理**

混合精度（也称为超精度）计算是在单个操作中使用不同的精度级别，从而在不牺牲精度的情况下实现计算效率的提升。本 IP 支持混合精度训练和推理：

混合精度训练：支持 IEEE 754 float 32 与 float 16 以及 float 32 与 Google bfloat16 类型的混合精度训练，功能对标 NVIDIA GPU 产品的混合精度训练。该功能需要用户自行设定混合精度训练流程，本 IP 从底层 MAC 计算角度予以支持。

混合精度推理：本 IP 支持的定点类型位宽范围为 1~24 bit。用户可实现不同定点位宽下的混合精度推理。本功能在用户自行量化深度神经网络（DNN）每一层的数据位宽时尤为有用。例如，ResNet-50 的卷积层使用 8 bit 整型数，全连接层使用 10 bit 定点数。

- **近似计算——权衡性能与精度**

本 IP 自带业界首创的"硬件剪枝"功能，可将 float 32 模式下的推理速度提升 30%左右，模型精度基本无损（内部测试环境，0.1%~0.5%下降），反之，相当一部分模型的推理精度略有提升！

3 订购方式

本产品以 IP 授权方式供客户购买使用。

第二章   产品参数

1   端口描述

端口情况如图 2.1 所示。所有 信号均为高电平有效（active HIGH）。
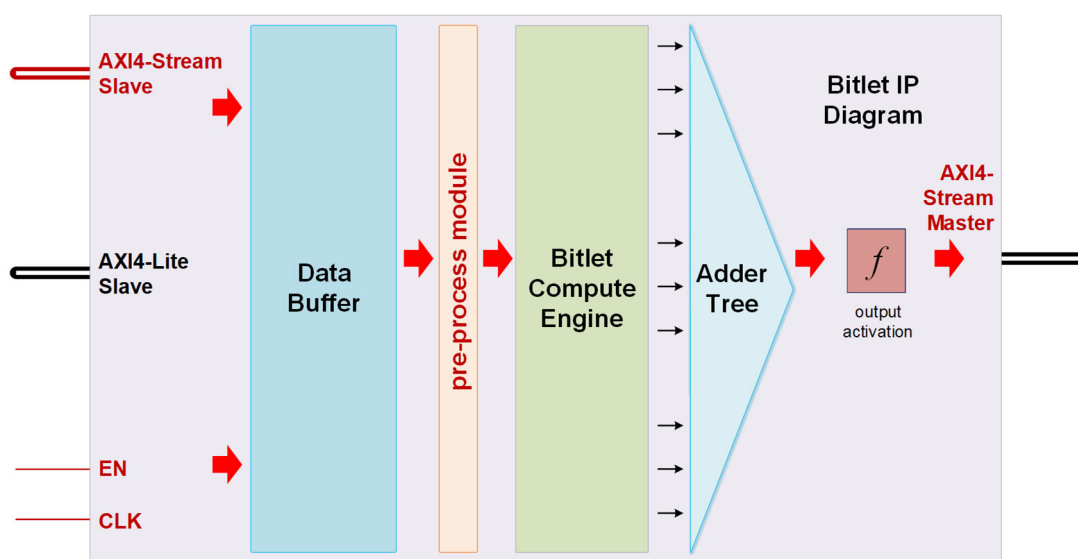
图 2.1 bitlet IP 端口及内部结构

表 2.1 端口功能描述

端口名称	输入/输出	功能
AXI4-Stream Slave [63:0]	Input	数据读入端口。本 IP 每次从 AXI 总线读入 64 组用于 MAC 计算的操作数（激活值和权重），不同数据类型（例如 fp32、bfloat16 等）的操作数均读入 64 组。对于不足 64 组操作数的情况下仍要计算 MAC（例如准备卷积计算的权重个数不能被 64 整除，同时为该卷积层的最后一次卷积），需要用户自行通过补零方式补足 64 组输入操作数。
AXI4-Stream Master [31:0]	Output	MAC 计算结果。对于本 IP 支持的所有数据类型，MAC 计算结果均使用 32 bit 表示：若输入配置为 int8 模式，结果为 int32 整型数；若为 fp32 模式，结果依旧为 fp32 型浮点数；若为 fp16 模式或者 bfloat16 模式，结果依旧为 16 bit 半精度浮点数，[0:15]为有效结果。

AXI4-Lite Slave	Input	寄存器读写端口，用于配置本 IP 输入数据类型和位宽。包含 IP Status Register 和 Control Register，其详情功能见表 2.2 寄存器配置和表 2.3 状态寄存器配置。
EN	Input	使能信号。高电平有效。
CLK	Input	时钟。

经过 AXI 总线传来的数据必须为 64 组（128 个数值）用于计算 MAC，不足 64 组需要用户自行补零。IP 的计算加速是基于对比特稀疏性的充分利用，相比速度的大幅提升，最后一次卷积计算不足 64 组操作数导致的补零并不会大幅增加该层卷积计算的整体延迟。

2 寄存器配置

本 IP 通过控制寄存器配置操作数的位宽、类型等；通过状态寄存器体现 IP 状态、错误信息等。寄存器的配置均服从 Little Endian 格式。控制寄存器的详细配置请见表 2.2，状态寄存器的详细配置请见表 2.3。

表 2.2 **控制寄存器**配置表

比特位分配	功能	默认值	配置模式 W（写）/R（读）	功能描述
0	R/S	0	W/R	Run / Stop，控制 IP 运行或者停止运行。
1	Reset	0	W	重置 IP。
2	Prune	0	W/R	是否开启硬件剪枝。此信号高电平有效，只适用于 fp32 模式的

比特位分配				MAC 计算加速。若配置该信号为有效，计算引擎只计算部分有效比特位，因此可进一步提升计算性能。不同 AI 任务下的精度损失请见表 4.11。
5:3	Prec. Config	000	W/R	数据类型配置。本 IP 目前支持 3 种数据类型的 MAC 计算：fp32（000）、fp16（001）、bfloat16（010）、int8（011）、1~24 bit fixed point（100，该版本暂未支持）。101、110、111 为预留配置，请不要使用。
10:6	Bit Width	1000	W/R	定点数位宽。IP 支持 1~24 bit 定点数位宽，该信号用于配置位宽的具体数值。
31：11	Reserved	1	W/R	预留比特位。该比特位读取后数值均为 1。

表 2.3 **状态寄存器**配置表

比特位分配	状态信息	默认值	配置模式 W(写)/R(读)	功能描述

0	HALT	0	W/R	0：IP 正常；1：异常停止（FlowErr、InputsizeErr）
1	DATA_IN	0	R	0：IP 当前无数据输入；1：IP 正在接收数据
2	DATA_IN_Valid	0	W/R	0：IP 不可接收数据；1：IP 可以接收数据
3	FlowErr	0	W/R	0：结果正常；1：MAC 结果溢出包含上溢下溢
4	InputsizeErr	0	W/R	0：输入操作数数量正确；1：输入操作数数量错误（非64个）
5	DONE	0	R	0：未完成计算或计算溢出；1：MAC 计算完成
6	COMPUTE	0	R	0：未进行 MAC 计算；1：MAC 计算未完成，处于计算过程中
7	IDLE	1	R	0：其他状态；1：IDLE 状态（初始化后默认进入此状态）
31：7	Reserved	1	W/R	预留比特位。该比特位读取后数值均为1

3 FPGA 资源使用

为进行对比，利用 Xilinx 现有 IP 搭建两个同功能的计算架构，**方案一**如图 2.2 所示，**方案二**如图 2.3 所示。
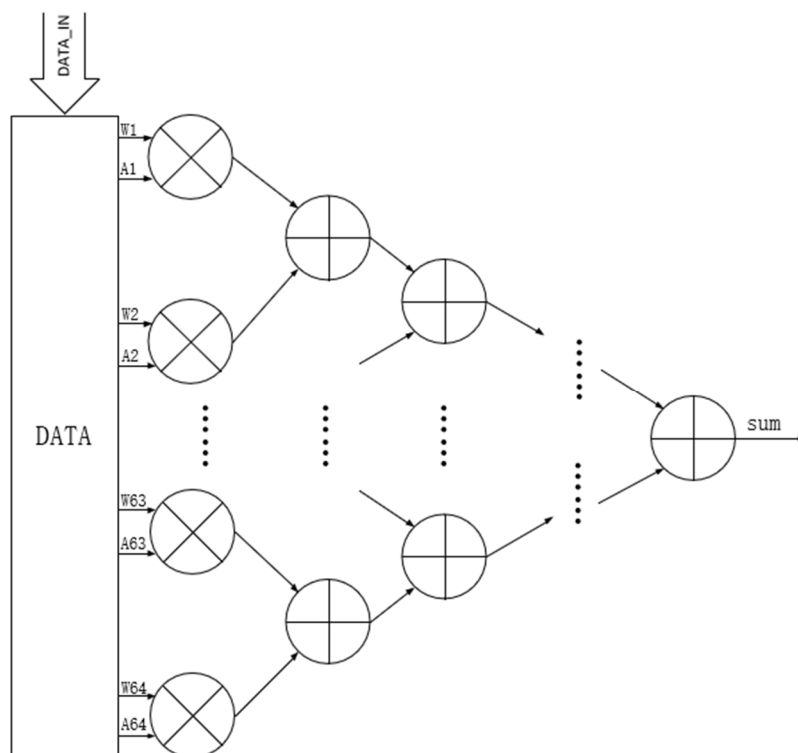
图 2.2 Xilinx 现有 IP 搭建 MAC 计算单元——方案一
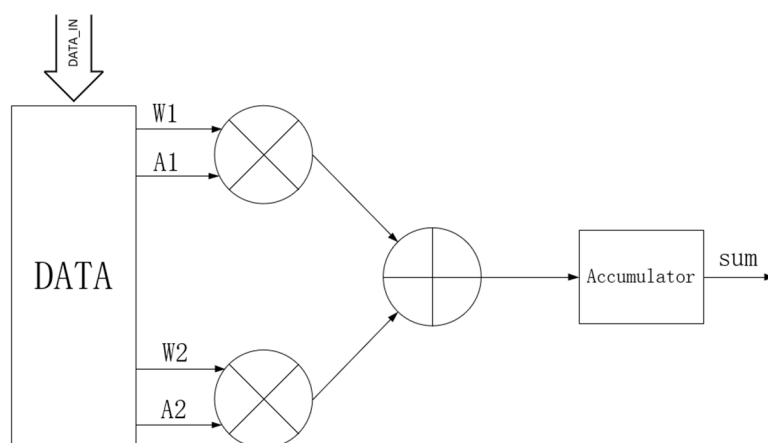
图 2.3 Xilinx 现有 IP 搭建 MAC 计算单元——方案二

FPGA 资源使用情况对比如表 2.4、表 2.5 所示

表 2.4 对标 Xilinx 方案一的资源使用情况

FPGA 型号	资源	本 IP	Xilinx 浮点 IP
ZU15EG	LUT	27K	33K
	FF	7K	32K
	BRAM	0	0
	DSP	0	0
	主频（MHz）	**200**	**200**

表 2.5 对标 Xilinx 方案二的资源使用情况

FPGA 型号	资源	本 IP	Xilinx 浮点 IP
ZU15EG	LUT	2.6K	2.7K
	FF	1.1K	1.5K
	BRAM	0	0
	DSP	0	0
	主频（MHz）	**200**	**200**

第三章　前端设计开发

1　状态转换

本 IP 内部状态转换如图 3.1 所示。
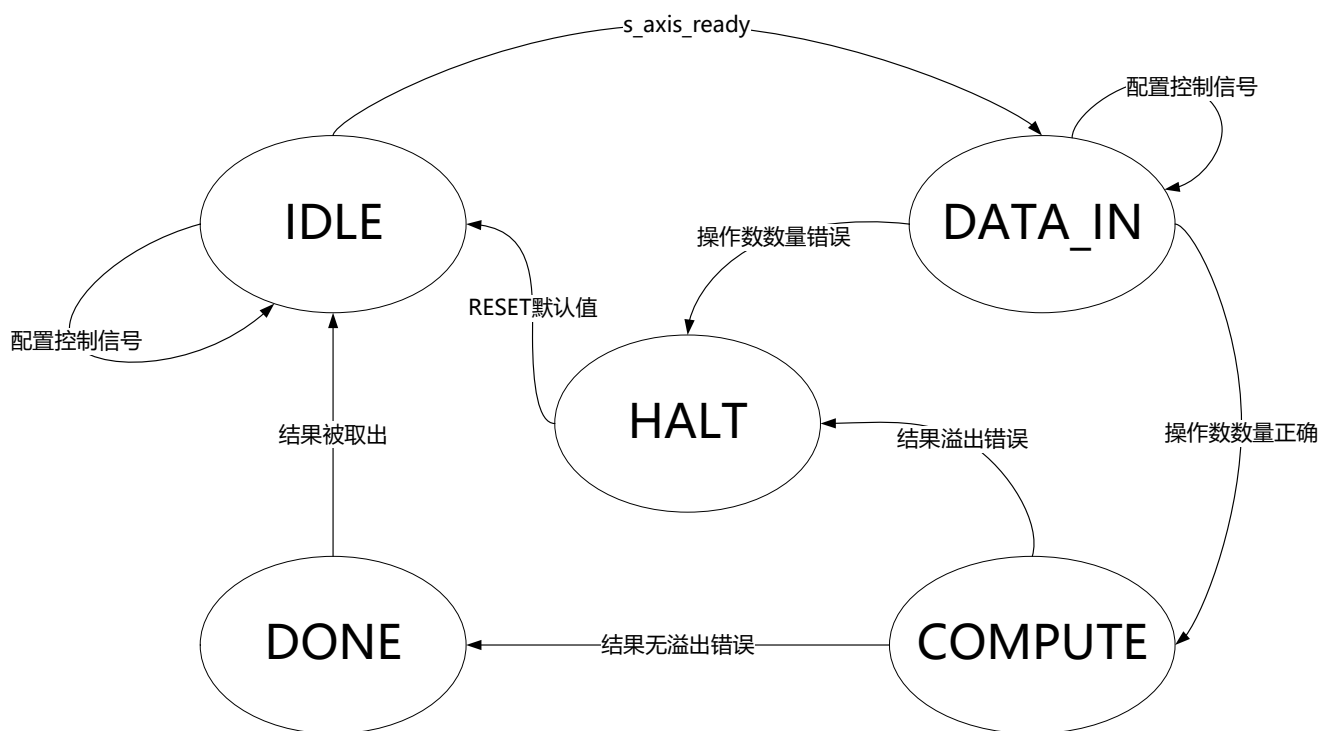
图 3.1 IP 状态转换图

图 3.1 中的所有状态名称、功能和表 2.3 一致。

在 IDLE 状态下（也即上电后），IP 使用默认配置（32 bit 浮点数类型、未开启硬件剪枝），用户可根据自身需求，对控制寄存器进行配置。

当总线信号 s_axis_ready 有效时，进入 DATA_IN 状态，此时可传入数据（注意：在此状态下，如果暂时不进行数据传输，也可在传输前对控制寄存器进行重新配置）。

若输入的操作数数量错误则进入 HALT 状态，需给本 IP 控制寄存器配置为 Reset（见表 2.2）复位至 IDLE 状态。

若输入操作数数量正确（64 组 A 和 W），IP 进入 COMPUTE 状态，进行 MAC 计算。在本状态下，如果 MAC 计算发生溢出则进入 HALT 状态。

反之，计算完成，进入 DONE 状态。计算得到的最终 MAC 结果被取走后，IP 重新恢复至 IDLE 状态。

第四章 前端测试验证

1 Testbench

测试激励请见附件 1。测试环境为 Xilinx Vivado 2020.2，FPGA 平台为 Xilinx ZU15EG。

2 功能验证

用于功能验证的测试数据全部来自于经过训练后的真实深度神经网络模型。 第一列序号 T0x 后面的括号代表 (N, W, H)，选取 C 从 1~64 共计 64 组 A 和 W。不同数据类型下的 MAC 分别用六组测试输入进行验证。

（1）fp32 浮点型

序号	FPGA 给出结果	Scoreboard 值（基准值）	误差
T01（3,3,2）	-3.666779041290283	-3.66677469646	0.00012%
T02（2,3,7）	0.385515958070755	0.385516006533	0.00001%
T03（4,10,12）	-1.4899413585662842	-1.48994276901	0.00009%
T04（6,8,10）	-0.09360458701848984	-0.0936038951979	0.00074%
T05（15,37,2）	-1.4142440557479858	-1.41424560438	0.00011%
T06（12,30,3）	-1.3206576108932495	-1.32065787215	0.00002%

（2）fp16 浮点型

序号	FPGA 给出结果	Scoreboard 值（基准值）	误差
T11（3,3,2）	-3.666015625	-3.66666048765	0.01758%

T12 （2,3,7）	0.385498046875	0.385508179665	0.0262%
T13 （4,10,12）	-1.4892578125	-1.49032366276	0.07151%
T14 （6,8,10）	-0.09368896484375	-0.0937158465385	0.02868%
T15 （15,37,2）	-1.4130859375	-1.41396450996	0.06213%
T16 （12,30,3）	-1.3203125	-1.32083457708	0.03952%

（3）bfloat16 浮点型

序号	FPGA 给出结果	Scoreboard 值（基准值）	误差
T21 （3,3,2）	-3.671875	-3.67367046245	0.00012%
T22 （2,3,7）	0.384765625	0.385251267347	0.00001%
T23 （4,10,12）	-1.484375	-1.4885820825	0.00009%
T24 （6,8,10）	-0.0927734375	-0.0932258497342	0.00074%
T25 （15,37,2）	-1.4140625	-1.41578620719	0.00011%
T26 （12,30,3）	-1.3203125	-1.320285439491272	0.00002%

（4）int8 整型

序号	FPGA 给出结果	Scoreboard 值（基准值）	误差
T31	-924	-924.0	0
T32	-2343	-2343.0	0
T33	-1170	-1170.0	0
T34	12019	12019.0	0
T35	3364	3364.0	0

| T36 | 5046 | 5046.0 | 0 |

3 状态寄存器验证

本节验证在 IP 不同状态下（如溢出、操作数数量错误），状态寄存器是否会按照表 2.3 给出对应的响应值。本节所有验证表中，**只观测状态寄存器的 0:7 比特位（其余比特位预留）。**

（1）正常工作情况

表 4.1 正常工作情况的状态寄存器对照表

初始化	11111111111111111111111110000100
数据输入	11111111111111111111111100000110
计算阶段（不可输入下一批数据）	11111111111111111111111101000000
计算阶段（可输入下一批数据）	11111111111111111111111101000100
计算完成	11111111111111111111111100100100

（2）输入操作数数量错误

表 4.2 操作数数量错误情况的状态寄存器对照表

初始化	11111111111111111111111110000100
数据输入	11111111111111111111111100000110
数据输入数量错误，需要复位	11111111111111111111111100010001

（3）MAC 计算结果溢出错误

表 4.3 计算结果溢出情况的状态寄存器对照表

| 初始化 | 11111111111111111111111110000100 |

数据输入	111111111111111111111100000110
计算阶段（不可输入下一批数据）	111111111111111111111101000000
计算阶段（可输入下一批数据）	111111111111111111111101000100
计算结果溢出，需要复位	111111111111111111111100001001

4 IP 性能验证

4.1 对标 Xilinx 现有 IP

方案一：

表 4.4 fp32 模式性能验证

序号	本 IP（fp32）方案一	Xilinx 浮点 IP（fp32）方案一
T01（3,3,2）	44	49

表 4.5 fp16 模式性能验证

序号	本 IP（fp16）方案一	Xilinx 浮点 IP（fp16）方案一
T01（3,3,2）	44	49

方案二：

表 4.6 fp32 模式性能验证

序号	本 IP（fp32）方案二	Xilinx 浮点 IP（fp32）方案二
T01（3,3,2）	38	53

表 4. 7 fp16 模式性能验证

序号	本 IP （fp16） 方案二	Xilinx 浮点 IP （fp16） 方案二
T01 （3,3,2)	38	53

表 4. 8 int8 模式性能验证

序号	本 IP （int8） 方案二	Xilinx 定点 IP （int8） 方案二
T01	38	35

4.2 硬件剪枝（精度+速度）

作为本 IP 的独特功能，本节验证硬件剪枝的性能，对开启硬件剪枝前后的精度和速度分别验证。

表 4. 9 本 IP 开启硬件剪枝后的精度验证

序号	未开启硬件剪枝	开启硬件剪枝	**误差 (绝对值)**
T01 （3,3,2)	-3.666779041290283	-3.700136184692383	0.0333571
T02 （2,3,7)	0.385515958070755	0.38472646474838257	0.0007895
T03 （4,10,12)	-1.4899413585662842	-1.4869602918624878	0.0029811
T04 （6,8,10)	-0.09360458701848984	-0.0987386628985405	0.0051341
T05 （15,37,2)	-1.4142440557479858	-1.4157835245132446	0.0015395
T06 （12,30,3)	-1.3206576108932495	-1.32065787215	0.0000003

表 4. 10 本 IP 开启硬件剪枝后的速度提升验证

序号	未开启硬件剪枝 (cycles)	**开启硬件剪枝（cycles)**	**速度提升**
T01 （3,3,2)	63	50	20.63492%

T02 (2,3,7)	67	54	19.40299%
T03 (4,10,12)	62	52	16.12903%
T04 (6,8,10)	63	57	9.52381%
T05 (15,37,2)	63	55	12.69841%
T06 (12,30,3)	62	54	12.90322%

表 4.11 本 IP 开启硬件剪枝后的**模型精度**验证（对开启剪枝后的精度提升**加粗标注**）

模型	精度评价指标	未开启硬件剪枝	**开启硬件剪枝**
ResNet-50	Top-1(%)	76.13	76.01
MobileNetV2	Top-1(%)	71.88	71.29
YoloV3	mAP 0.5:0.95	0.336	**0.338**
Multi-Pose	mAP 0.5:0.95	0.59	0.57
lapSRN	PSNR	31.65	31.44
	SSIM	0.90	0.89
DCPDNet	SSIM	0.78	**0.78**
DenseNet-161	Top-1(%)	77.14	**77.14**
FCOS	mAP 0.5:0.95	0.38	**0.38**
CartoonGAN	直接进行 visual 比较，请见后图		
Transformer	BLEU4	40.83	**40.92**
C3D	Top-1(%)	97.31	97.27
D3DNet	PSNR	36.05	36.04
	SSIM	0.94	**0.94**

| Original Image | 4x Super Resolution 未开启硬件剪枝 | 4x Super Resolution 开启硬件剪枝 |
| (195x195) | (780x780) | (780x780) |

图 4. 1 LapSRN 模型直接观感比较

Original Images w/o Cartoon Style Transfer

Cartoon Style Transfer 未开启硬件剪枝

Cartoon Style Transfer 开启硬件剪枝
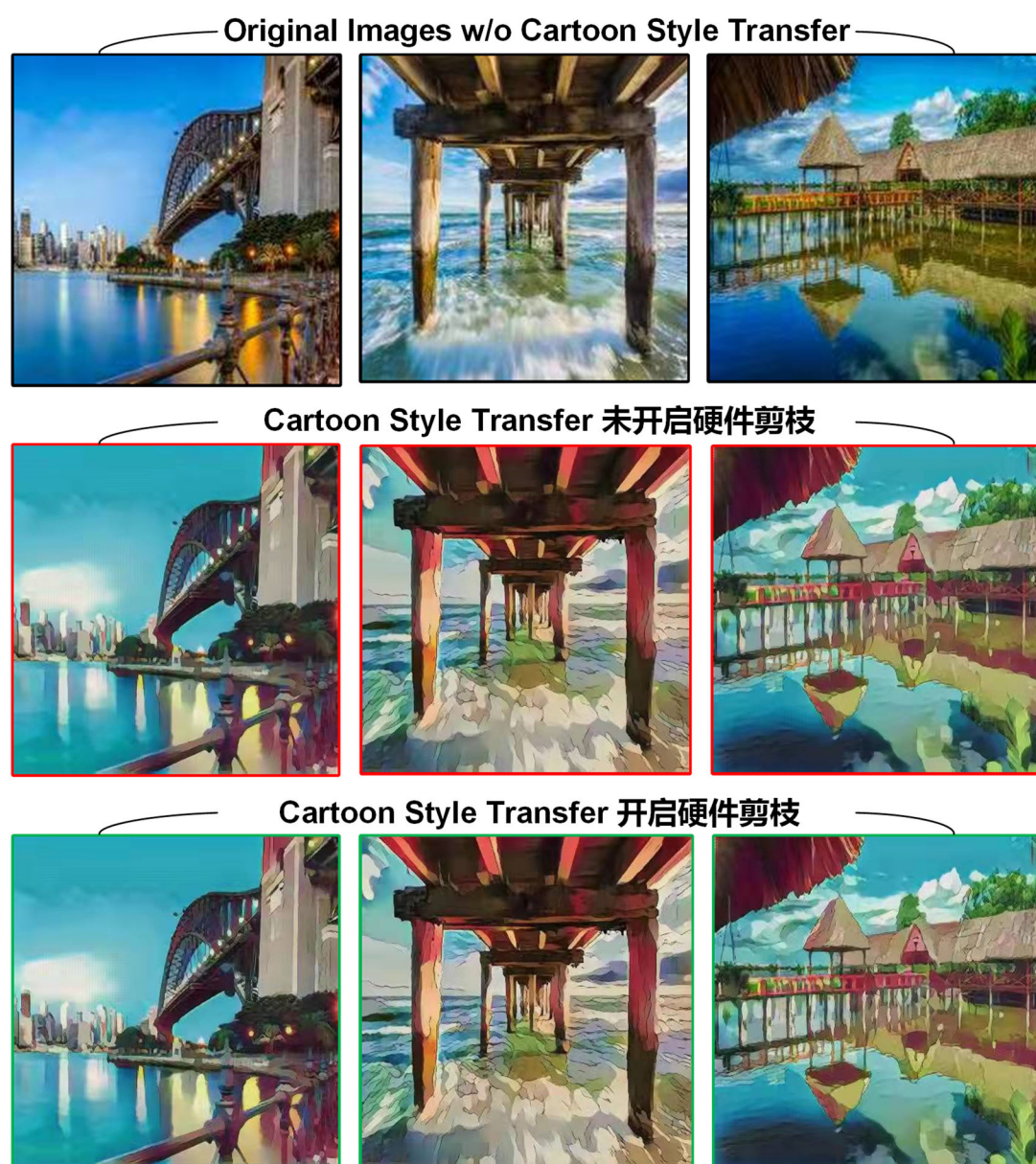
图 4. 2 CartoonGAN 模型直接观感比较

附件

1　测试输入

本附件给出第四章前端设计验证的全部输入数据。

1.1 fp32 浮点型

T01	
W	A
0.07999303936958313	-0.017914362251758575
0.0073795574717223364	-0.008810322731733322
-0.027198655530810356	-0.005805063992738724
0.18470199406147003	-0.0038078054785728455
-0.0473083294928073	-0.012084044516086578
0.058126479387283325	0.03730734810233116
-0.03383847326040268	0.00948055274784565
0.005617802496999502	-0.02785351127386093
0.1036030501127243	-0.02800063043832779
-0.029504185542464256	0.008610717952251434
-0.039597880095243454	-0.000760544091463089
-0.04190494120121002	0.008312761783599854
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-0.0333670973777771	-0.370769739151001
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-0.09563669562339783	-0.025776518508791924
-0.01761471852660179	0.04167773202061653
-0.16586332023143768	-0.056644707918167114
-0.19202621281147003	0.02026222087442875
0.5784693956375122	-0.42795971035957336
0.09622958302497864	0.013483718037605286
-0.08035562932491302	0.04994988441467285
-0.13144247233867645	-0.003632519394159317
0.0856546089053154	-0.06759897619485855
0.24424387514591217	0.0030192434787750244
-0.5546947717666626	-0.001679966226220131
-0.37751317024230957	-0.06897841393947601
0.15770356357097626	-0.11194035410881042
-0.018474601209163666	0.05591142177581787

0.20852874219417572	0.007335420697927475
0.0724683478474617	0.014240365475416183
-0.16170848906040192	-0.019562929868698123

1.2 fp16 浮点型

T11	
W	A
0.007381439208984375	-0.00881195068359375
0.08001708984375	-0.017913818359375
0.1846923828125	-0.00380706787109375
-0.027191162109375	-0.00580596923828125
0.058135986328125	0.03729248046875
-0.04730224609375	-0.0120849609375
0.005619049072265625	-0.0278472900390625
-0.033843994140625	0.00948333740234375
-0.029510498046875	0.00861358642578125
0.10357666015625	-0.0279998779296875
-0.041900634765625	0.0083160400390625
-0.03961181640625	-0.0007605552673339844
0.0036220550537109375	0.00531768798828125
-0.10284423828125	-0.10028076171875
0.01412200927734375	0.1634521484375
1.142578125	-1.2900390625
-0.042816162109375	-0.00997161865234375
-0.0809326171875	-0.00476837158203125
-0.1409912109375	-0.481201171875

-0.0010023117065429688	-0.258056640625
-0.06884765625	-0.0022411346435546875
0.0416259765625	-0.0122222900390625
-0.071044921875	0.06817626953125
0.09423828125	0.089111328125
-0.0275421142578125	-0.0155487060546875
-0.1265869140625	-0.2120361328125
0.141845703125	0.0589599609375
0.071533203125	-0.045928955078125
-0.419189453125	0.46728515625
-0.046539306640625	-0.0234375
-0.03997802734375	-0.007045745849609375
-0.1185302734375	0.048614501953125
0.041748046875	0.01165008544921875
0.0712890625	0.013580322265625
-1.2001953125	1.0908203125
0.002399444580078125	0.0176849365234375
0.06982421875	-0.1763916015625
0.08099365234375	0.06878662109375
-0.00670623779296875	-0.005077362060546875
0.057098388671875	0.0095977783203125
0.0985107421875	0.01482391357421875
-0.1043701171875	-0.056488037109375
0.04400634765625	-0.0012178421020507812
0.09649658203125	0.2393798828125
0.1259765625	-0.013046264648437
0.0933837890625	-0.01302337646484375

-0.188232421875	0.32861328125
-0.0295867919921875	0.02362060546875
0.4072265625	0.420654296875
0.136474609375	0.01263427734375
0.8583984375	-1.0986328125
-0.0218048095703125	0.019622802734375
-0.040374755859375	-0.0994873046875
0.01102447509765625	0.00036787986755371094
0.0024585723876953125	-0.053497314453125
-0.0716552734375	0.021331787109375
0.2384033203125	0.056121826171875
0.087890625	-2.276897430419922e-05
-0.068603515625	0.0021858215332031250
0.08343505859375	0.045074462890625
-0.075439453125	-0.0217742919921875
0.034210205078125	0.006587982177734375
0.124267578125	-0.065673828125
-0.027984619140625	0.003108978271484375

T12	
W	A
0.0183258056640625	0.00799560546875
-0.005611419677734375	0.0176849365234375
-0.0011119842529296875	0.040130615234375
0.0023040771484375	-0.08282470703125
0.0034637451171875	0.035980224609375
0.0009746551513671875	-0.042388916015625

-0.033843994140625	0.0024318695068359375
-0.0124969482421875	-0.0748291015625
0.036895751953125	-0.035614013671875
-0.0211334228515625	-0.00933074951171875
0.0062103271484375	0.004566192626953125
0.0041046142578125	0.0108642578125
-0.01270294189453125	-0.0156402587890625
0.03497314453125	-0.10906982421875
-0.036529541015625	0.08349609375
-0.058837890625	-1.1630859375
-0.0005741119384765625	-0.04254150390625
0.00659942626953125	-0.02325439453125
-0.033355712890625	-0.370849609375
-0.1400146484375	-0.31640625
0.0128326416015625	0.05877685546875
0.0166778564453125	-0.025787353515625
-0.047088623046875	0.096923828125
-0.0435791015625	0.1136474609375
0.0111923217773375	-0.0310821533203125
-0.050262451171875	-0.2021484375
0.033966064453125	0.12139892578125
-0.0196075439453125	-0.06781005859375
0.050323486328125	0.4306640625
0.00742340087890625	-0.2342529296875
0.00922393798828125	-0.030548095703125
0.0081634521484375	0.126953125
-0.00383758544921875	0.0087127685546875

-0.016754150390625	0.018798828125
0.05780029296875	0.8994140625
-0.002193450927734375	0.0175018310546875
-0.156982421875	-0.146240234375
0.058746337890625	0.09857177734375
-0.0031719207763671875	-0.048828125
0.005107879638671875	-0.02081298828125
-0.0068817138671875	0.010498046875
0.03143310546875	0.04730224609375
0.0010499954223632812	0.0052719116210937
0.2001953125	0.1693115234375
0.0908203125	-0.04632568359375
-0.01064300537109375	-0.0300445556640625
0.063720703125	0.301513671875
0.0244903564453125	0.08746337890625
0.139892578125	0.348388671875
0.01302337646484375	-0.0080413818359375
-0.057464599609375	-0.93115234375
-0.004718780517578125	0.0192718505859375
-0.00231170654296875	-0.10699462890625
0.0084075927734375	-0.0083694458007812
-0.09527587890625	-0.1171875
0.020965576171875	0.014862060546875
-0.011474609375	0.1832275390625
0.0126495361328125	-0.047637939453125
0.03216552734375	-0.0168304443359375
-0.09527587890625	0.0307159423828125

0.005847930908203125	-0.09112548828125
-0.0026569366455078125	0.0113677978515625
-0.035552978515625	-0.016876220703125
0.0007772445678710938	0.008544921875

T13	
W	A
-0.00988006591796875	-0.006603240966796875
-0.01061248779296875	-0.02734375
0.07733154296875	0.0423583984375
-0.046295166015625	0.0198822021484375
-0.1851806640625	0.0005412101745605469
-0.1553955078125	-0.0017795562744140625
-0.2998046875	-0.0098114013671875
0.019500732421875	-0.004199981689453125
-0.10101318359375	0.0138397216796875
-0.227783203125	-0.038238525390625
-0.11102294921875	-0.0097198486328125
0.0704345703125	-0.00946044921875
0.001491546630859375	-0.00826263427734375
0.069580078125	0.0655517578125
0.1583251953125	0.024688720703125
0.388671875	-1.2900390625
-0.0654296875	0.00588226318359375
0.0462646484375	0.0303802490234375
0.050994873046875	-0.232177734375
-0.00392913818359375	-0.220947265625

0.10687255859375	-0.005420684814453125
-0.1322021484375	0.023101806640625
-0.3466796875	0.047698974609375
0.0198974609375	-0.003574371337890625
0.020599365234375	0.0006031990051269531
-0.171875	-0.035186767578125
0.07489013671875	0.01477813720703125
-0.040130615234375	0.0022640228271484375
-0.2249755859375	0.3564453125
-0.17138671875	0.00971221923828125
0.10064697265625	0.01007843017578125
0.036865234375	0.0128173828125
-0.022125244140625	0.00029397010803222656
0.0007052421569824219	-0.0019397735595703125
-0.2578125	1.2119140625
-0.09600830078125	-0.0032520294189453125
-0.08868408203125	-0.166259765625
0.1339111328125	0.053436279296875
0.04107666015625	0.010398864746093375
-0.0162200927734375	0.004119873046875
0.041229248046875	-0.01422882080078125
-0.318603515625	0.0129547119140625
-0.0216827392578125	-0.01259613037109375
-0.4443359375	0.198974609375
0.1483154296875	-0.08160400390625
0.01177978515625	-0.009536743164625
-0.15283203125	0.13818359375

0.0273284912109375	-0.01363372802734375
-0.31201171875	0.38671875
0.0355224609375	0.021087646484375
0.33349609375	-1.12890625
0.08294677734375	0.0157318115234375
0.12841796875	-0.0018138885498046875
-0.037200927734375	0.00960540771484375
-0.017120361328125	-0.035491943359375
-0.1529541015625	-0.0042266845703125
0.1790771484375	0.0121917724609375
-0.048065185546875	0.0057792663574218750
0.00146484375	0.01171875
-0.2783203125	-0.0002186298370361328
-0.056732177734375	0.0070915222167968750
0.0897216796875	0.0258026123046875
0.03912353515625	-0.0049362182617187500
-0.006740570068359375	0.01019287109375

T14	
W	A
-0.09283447265625	-0.0102996826171875
0.275634765625	-0.0221405029296875
0.136962890625	0.036773681640625
-0.030471801757812 5	0.013336181640625
0.085205078125	0.009735107421875
-0.04449462890625	-0.00958251953125
-0.0609130859375	-0.06878662109375

0.066650390625	-0.00809478759765625
-0.12420654296875	-0.0209808349609375
0.010551452636671875	-0.026092529296875
-0.10003662109375	-0.01043701171875
-0.045166015625	-0.01318359375
0.0650634765625	-0.0088653564453125
0.039031982421875	0.12744140625
-0.221923828125	-0.09136962890625
0.076416015625	-1.296875
0.08038330078125	-0.0080718994140625
0.011871337890625	0.03363037109375
0.11004638671875	-0.00693511962890625
-0.267822265625	-0.263427734375
0.036529541015625	-0.00470733642578125
0.11785888671875	0.0231170654296875
-0.11004638671875	-0.01922607421875
0.07940673828125	-0.050628662109375
-0.01212310791015625	-0.0142822265625
-0.1295166015625	-0.00919342041015625
0.08935546875	0.039276123046875
-0.031463623046875	0.025238037109375
0.265380859375	0.294189453125
0.214111328125	0.006580352783203125
0.005123138427734375	-0.01617431640625
0.4248046875	0.03375244140625
-0.0675048828125	0.004566192626953125
0.0248565673828125	0.0021209716796875

-0.12274169921875	1.2236328125
-0.034942626953125	0.00460052490234375
0.01087188720703125	-0.21484375
0.0897216796875	0.0894775390625
-0.149169921875	-0.008880615234375
0.0229949951171875	0.007198333740234375
0.12030029296875	0.00022041797637939453
0.1212158203125	0.1234130859375
-0.10595703125	-0.015045166015625
0.2113037109375	0.181884765625
-0.03240966796875	-0.05926513671875
0.0035877227783203125	0.001598358154296875
-0.15625	-0.003211975097656250
-0.054107666015625	0.00684356689453125
0.02593994140625	0.267333984375
-0.1756591796875	0.0203399658203125
0.0916748046875	-1.095703125
0.137939453125	0.0142593383789062
0.121337890625	0.0489501953125
0.00899505615234375	0.0088882446289062
0.1875	-0.07977294921875
0.1229248046875	-0.006252288818359375
-0.11865234375	0.03179931640625
0.004230499267578125	0.0004603862762451172
0.0233612060546875	0.0516357421875
0.26416015625	-0.0128173828125
0.03399658203125	-0.011634826660156250

-0.1827392578125	-0.00998687744140625
-0.0156402587890625	-0.00832366943359375
-0.0198211669921875	0.0037403106689453125

T15	
W	A
0.007381439208984375	-0.00653839111328125
0.08001708984375	-0.035888671875
0.1846923828125	0.186279296875
-0.027191162109375	0.03045654296875
0.058135986328125	0.03497314453125
-0.04730224609375	-0.0296173095703125
0.005619049072265625	0.1368408203125
-0.033843994140625	0.01076507568359375
-0.029510498046875	0.00848388671875
0.10357666015625	-0.002239227294921875
-0.041900634765625	-0.045318603515625
-0.03961181640625	-0.04998779296875
0.0036220550537109375	0.002376556396484375
-0.10284423828125	0.0709228515625
0.01412200927734375	-0.002735137939453125
1.142578125	-0.4462890625
-0.042816162109375	0.0256805419921875
-0.0809326171875	0.0052642822265625
-0.1409912109375	-0.0279083251953125
-0.0010023117065429688	-0.347412109375
-0.06884765625	-0.01491546630859375

0.0416259765625	-0.0001685619354248047
-0.071044921875	0.039093017578125
0.09423828125	0.027069091796875
-0.0275421142578125	0.01399993896484375
-0.1265869140625	0.02935791015625
0.141845703125	0.0308990478515625
0.071533203125	0.037567138671875
-0.419189453125	0.11224365234375
-0.046539306640625	-0.0184783935546875
-0.03997802734375	-0.01824951171875
-0.1185302734375	0.06378173828125
0.041748046875	0.0074615478515625
0.0712890625	0.025634765625
-1.2001953125	0.404541015625
0.002399444580078125	-0.009765625
0.06982421875	-0.155029296875
0.08099365234375	0.07135009765625
-0.00670623779296875	0.0249176025390625
0.057098388671875	0.038665771484375
0.0985107421875	0.0204925537109375
-0.1043701171875	-0.022308349609375
0.04400634765625	-0.035858154296875
0.09649658203125	-0.09619140625
0.1259765625	-0.2220458984375
0.0933837890625	-0.01526641845703125
-0.188232421875	0.036865234375
-0.0295867919921875	0.0193023681640625

0.4072265625	-0.0970458984375
0.136474609375	-0.005558013916015625
0.8583984375	-0.3828125
-0.0218048095703125	0.036346435546875
-0.040374755859375	0.0219268798828125
0.01102447509765625	0.02215576171875
0.0024585723876953125	-0.0347900390625
-0.0716552734375	0.0134735107421875
0.2384033203125	0.0357666015625
0.087890625	-0.0201263427734375
-0.068603515625	-0.1591796875
0.08343505859375	-0.06207275390625
-0.075439453125	-0.051025390625
0.034210205078125	0.00940704345703125
0.124267578125	-0.02276611328125
-0.027984619140625	0.0284881591796875

T16	
W	A
0.00567626953125	-0.01424407958984375
0.061737060546875	-0.0247650146484375
-0.10455322265625	0.113037109375
0.130126953125	0.00858306884765625
-0.041778564453125	-0.01800537109375
-0.11749267578125	-0.011962890625
0.042816162109375	0.10491943359375
0.21630859375	0.0038967132568359375

-0.0936279296875	0.052947998046875
-0.07940673828125	-0.0452880859375
-0.11181640625	-0.01342010498046875
-0.040130615234375	-0.0095977783203125
-0.12188720703125	0.0020275115966796875
-0.0338134765625	0.05804443359375
0.61572265625	-0.02020263671875
1.2333984375	-0.486572265625
0.0528564453125	0.0070762634277734375
0.1324462890625	0.01386260986328125
-0.319580078125	0.039642333984375
0.10003662109375	-0.306640625
-0.2042236328125	0.002597808837890625
0.0977783203125	0.01470947265625
-0.365966796875	0.056976318359375
-0.09857177734375	-0.0295562744140625
-0.09075927734375	0.008331298828125
0.2110595703125	0.05462646484375
-0.174560546875	0.01059722900390625
0.0209503173828125	-0.0110321044921875
-0.46728515625	0.0894775390625
0.48388671875	0.0188751220703125
0.004486083984375	0.0250396728515625
-0.0064849853515625	-3.349781036376953e-05
-0.033782958984375	-0.00904083251953125
-0.09234619140625	-0.00804901123046875
-0.72265625	0.50390625

-0.12176513671875	-0.01763916015625
-0.00196075439453125	-0.155029296875
-0.01183319091796875	0.0643310546875
0.09240722265625	-0.0013408660888671875
0.10015869140625	0.007106781005859375
-0.0784912109375	-0.00227546691894531250
-0.95751953125	0.0056915283203125
-0.1600341796875	-0.002513885498046875
0.0823974609375	-0.07647705078125
0.08642578125	-0.242431640625
0.177978515625	-0.0036602020263671875
-0.09564208984375	-0.0257720947265625
-0.1800537109375	-0.042694091796875
-0.1658935546875	-0.056640625
-0.017608642578125	0.04168701171875
0.57861328125	-0.427978515625
-0.1920166015625	0.020263671875
-0.08038330078125	0.049957275390625
0.09625244140625	0.01348114013671875
0.08563232421875	-0.067626953125
-0.1314697265625	-0.003631591796875
-0.5546875	-0.0016803741455078125
0.2442626953125	0.0030193328857421875
0.15771484375	-0.1119384765625
-0.37744140625	-0.0689697265625
0.20849609375	0.007335662841796875
-0.0184783935546875	0.055908203125

-0.1617431640625	-0.019561767578125
0.07244873046875	0.01424407958984375

1.3 bfloat16 浮点型

T21	
W	A
0.00738525390625	-0.0087890625
0.080078125	-0.0179443359375
0.1845703125	-0.0038146972656
-0.0272216796875	-0.0057983398437
0.05810546875	0.037353515625
-0.04736328125	-0.0120849609375
0.005615234375	-0.02783203125
-0.033935546875	0.00946044921875
-0.029541015625	0.00860595703125
0.103515625	-0.0279541015625
-0.0419921875	0.00830078125
-0.03955078125	-0.0007591247558
0.00361633300781	0.00531005859375
-0.10302734375	-0.10009765625
0.01409912109375	0.1630859375
1.140625	-1.2890625
-0.042724609375	-0.0099487304687
-0.0810546875	-0.0047607421875
-0.140625	-0.48046875
-0.0009994506835	-0.2578125
-0.06884765625	-0.0022430419921

0.04150390625	-0.01220703125
-0.07080078125	0.068359375
0.09423828125	0.08935546875
-0.027587890625	-0.0155639648437
-0.126953125	-0.2119140625
0.1416015625	0.058837890625
0.0712890625	-0.0458984375
-0.419921875	0.466796875
-0.046630859375	-0.0234375
-0.0400390625	-0.0070495605468
-0.11865234375	0.048583984375
0.041748046875	0.01165771484375
0.0712890625	0.0135498046875
-1.203125	1.09375
0.00239562988281	0.0177001953125
0.06982421875	-0.1767578125
0.0810546875	0.06884765625
-0.0067138671875	-0.0050659179687
0.05712890625	0.00958251953125
0.0986328125	0.01483154296875
-0.1044921875	-0.056396484375
0.0439453125	-0.001220703125
0.0966796875	0.2392578125
0.1259765625	-0.0130615234375
0.09326171875	-0.0130004882812
-0.1884765625	0.328125
-0.029541015625	0.0235595703125

0.408203125	0.419921875
0.13671875	0.01263427734375
0.859375	-1.1015625
-0.0218505859375	0.0196533203125
-0.040283203125	-0.099609375
0.01104736328125	0.00036811828613
0.00245666503906	-0.053466796875
-0.07177734375	0.0213623046875
0.23828125	0.05615234375
0.087890625	-2.2768974304199
-0.06884765625	0.00218200683593
0.08349609375	0.045166015625
-0.0751953125	-0.021728515625
0.0341796875	0.006591796875
0.1240234375	-0.06591796875
-0.0279541015625	0.00311279296875

T22	
W	A
0.018310546875	0.00799560546875
-0.005615234375	0.0177001953125
-0.0011138916015	0.0400390625
0.00230407714843	-0.0830078125
0.00346374511718	0.035888671875
0.00097274780273	-0.04248046875
-0.033935546875	0.00242614746093
-0.0125122070312	-0.07470703125

0.036865234375	-0.03564453125
-0.0211181640625	-0.0093383789062
0.00619506835937	0.00457763671875
0.00411987304687	0.0108642578125
-0.0126953125	-0.015625
0.034912109375	-0.10888671875
-0.03662109375	0.08349609375
-0.058837890625	-1.1640625
-0.0005760192871	-0.04248046875
0.006591796875	-0.023193359375
-0.033447265625	-0.37109375
-0.1396484375	-0.31640625
0.0128173828125	0.058837890625
0.0167236328125	-0.0257568359375
-0.047119140625	0.0966796875
-0.04345703125	0.11376953125
0.01116943359375	-0.0311279296875
-0.05029296875	-0.2021484375
0.033935546875	0.12158203125
-0.0196533203125	-0.06787109375
0.05029296875	0.431640625
0.00741577148437	-0.234375
0.009216308593 75	-0.030517578125
0.0081787109375	0.126953125
-0.0038452148437	0.00872802734375
-0.0167236328125	0.018798828125
0.057861328125	0.8984375

-0.002197265625	0.0174560546875
-0.1572265625	-0.146484375
0.058837890625	0.0986328125
-0.003173828125	-0.048828125
0.00509643554687	-0.0208740234375
-0.0068664550781	0.010498046875
0.031494140625	0.04736328125
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0.2001953125	0.1689453125
0.0908203125	-0.04638671875
-0.0106201171875	-0.030029296875
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0.0245361328125	0.08740234375
0.1396484375	0.34765625
0.01300048828125	-0.008056640625
-0.057373046875	-0.9296875
-0.0047302246093	0.019287109375
-0.0023040771484	-0.10693359375
0.0084228515625	-0.0083618164062
-0.09521484375	-0.1171875
0.02099609375	0.01483154296875
-0.011474609375	0.18359375
0.01263427734375	-0.047607421875
0.0322265625	-0.016845703125
-0.09521484375	0.03076171875
0.005859375	-0.09130859375
-0.0026550292968	0.0113525390625

-0.03564453125	-0.016845703125
0.00077819824218	0.008544921875

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-0.04638671875	0.0198974609375
-0.185546875	0.00054168701171
-0.1552734375	-0.0017776489257
-0.30078125	-0.0098266601562
0.01953125	-0.0042114257812
-0.10107421875	0.01385498046875
-0.2275390625	-0.038330078125
-0.11083984375	-0.0097045898437
0.0703125	-0.0094604492187
0.00148773193359	-0.0082397460937
0.0693359375	0.0654296875
0.158203125	0.024658203125
0.388671875	-1.2890625
-0.0654296875	0.00588989257812
0.04638671875	0.0303955078125
0.051025390625	-0.232421875
-0.0039367675781	-0.220703125
0.10693359375	-0.0054321289062
-0.1318359375	0.0230712890625

-0.34765625	0.047607421875
0.0198974609375	-0.0035705566406
0.0206298828125	0.00060272216796
-0.171875	-0.03515625
0.07470703125	0.0147705078125
-0.0400390625	0.00225830078125
-0.224609375	0.35546875
-0.171875	0.00970458984375
0.1005859375	0.01007080078125
0.036865234375	0.0128173828125
-0.0220947265625	0.00029373168945
0.00070571899414	-0.0019378662109
-0.2578125	1.2109375
-0.09619140625	-0.0032501220703
-0.0888671875	-0.166015625
0.1337890625	0.053466796875
0.041015625	0.0103759765625
-0.0162353515625	0.00411987304687
0.041259765625	-0.0142211914062
-0.318359375	0.012939453125
-0.021728515625	-0.0125732421875
-0.443359375	0.19921875
0.1484375	-0.08154296875
0.01177978515625	-0.009521484375
-0.1533203125	0.1376953125
0.02734375	-0.0136108398437
-0.3125	0.38671875

0.03564453125	0.0211181640625
0.333984375	-1.125
0.0830078125	0.0157470703125
0.1279296875	-0.0018157958984
-0.037109375	0.00958251953125
-0.01708984375	-0.035400390625
-0.1533203125	-0.0042114257812
0.1787109375	0.01220703125
-0.048095703125	0.00576782226562
0.00146484375	0.01171875
-0.279296875	-0.0002183914184
-0.056640625	0.007080078125
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0.0390625	-0.0049438476562
-0.0067443847656	0.01019287109375

T24	
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0.275390625	-0.0220947265625
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-0.030517578125	0.0133056640625
0.08544921875	0.00970458984375
-0.04443359375	-0.0095825195312
-0.060791015625	-0.06884765625
0.06689453125	-0.0081176757812
-0.1240234375	-0.02099609375

0.01055908203125	-0.026123046875
-0.10009765625	-0.0104370117187
-0.045166015625	-0.01318359375
0.06494140625	-0.0088500976562
0.0390625	0.1279296875
-0.2216796875	-0.09130859375
0.076171875	-1.296875
0.08056640625	-0.008056640625
0.0118408203125	0.03369140625
0.10986328125	-0.0069274902343
-0.267578125	-0.263671875
0.03662109375	-0.0046997070312
0.11767578125	0.0230712890625
-0.10986328125	-0.019287109375
0.07958984375	-0.050537109375
-0.0121459960937	-0.0142822265625
-0.1298828125	-0.0092163085937
0.08935546875	0.039306640625
-0.031494140625	0.0252685546875
0.265625	0.294921875
0.2138671875	0.006591796875
0.005126953125	-0.0162353515625
0.42578125	0.03369140625
-0.0673828125	0.00457763671875
0.02490234375	0.00212097167968
-0.12255859375	1.2265625
-0.034912109375	0.00460815429687

0.0108642578125	-0.21484375
0.08984375	0.08935546875
-0.1494140625	-0.0089111328125
0.02294921875	0.0072021484375
0.1201171875	0.00022029876708
0.12109375	0.12353515625
-0.10595703125	-0.0150756835937
0.2109375	0.181640625
-0.032470703125	-0.059326171875
0.00358581542968	0.00159454345703
-0.15625	-0.0032043457031
-0.05419921875	0.0068359375
0.0260009765625	0.267578125
-0.17578125	0.0203857421875
0.091796875	-1.09375
0.1376953125	0.0142822265625
0.12158203125	0.049072265625
0.00897216796875	0.0089111328125
0.1875	-0.07958984375
0.123046875	-0.0062561035156
-0.11865234375	0.03173828125
0.00424194335937	0.00045967102050
0.0233154296875	0.051513671875
0.263671875	-0.0128173828125
0.033935546875	-0.0116577148437
-0.1826171875	-0.010009765625
-0.015625	-0.00830078125

-0.019775390625	0.00373840332031

T25	
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0.00738525390625	-0.0065307617187
0.080078125	-0.035888671875
0.1845703125	0.1865234375
-0.0272216796875	0.0303955078125
0.05810546875	0.034912109375
-0.04736328125	-0.0296630859375
0.005615234375	0.13671875
-0.033935546875	0.0107421875
-0.029541015625	0.00848388671875
0.103515625	-0.0022430419921
-0.0419921875	-0.04541015625
-0.03955078125	-0.050048828125
0.00361633300781	0.00238037109375
-0.10302734375	0.07080078125
0.01409912109375	-0.0027313232421
1.140625	-0.447265625
-0.042724609375	0.025634765625
-0.0810546875	0.0052490234375
-0.140625	-0.0279541015625
-0.0009994506835	-0.34765625
-0.06884765625	-0.014892578125
0.04150390625	-0.0001688003540

-0.07080078125	0.0390625
0.09423828125	0.027099609375
-0.027587890625	0.01397705078125
-0.126953125	0.029296875
0.1416015625	0.0308837890625
0.0712890625	0.03759765625
-0.419921875	0.1123046875
-0.046630859375	-0.0184326171875
-0.0400390625	-0.018310546875
-0.11865234375	0.06396484375
0.041748046875	0.0074462890625
0.0712890625	0.025634765625
-1.203125	0.404296875
0.00239562988281	-0.009765625
0.06982421875	-0.1552734375
0.0810546875	0.0712890625
-0.0067138671875	0.02490234375
0.05712890625	0.03857421875
0.0986328125	0.0205078125
-0.1044921875	-0.0223388671875
0.0439453125	-0.035888671875
0.0966796875	-0.09619140625
0.1259765625	-0.2216796875
0.09326171875	-0.0152587890625
-0.1884765625	0.036865234375
-0.029541015625	0.019287109375
0.408203125	-0.09716796875

0.13671875	-0.0055541992187
0.859375	-0.3828125
-0.0218505859375	0.036376953125
-0.040283203125	0.02197265625
0.01104736328125	0.022216796875
0.00245666503906	-0.03466796875
-0.07177734375	0.01348876953125
0.23828125	0.03564453125
0.087890625	-0.0201416015625
-0.06884765625	-0.1591796875
0.08349609375	-0.06201171875
-0.0751953125	-0.051025390625
0.0341796875	0.0093994140625
0.1240234375	-0.0228271484375
-0.0279541015625	0.0284423828125

T26	
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-0.041748046875	-0.01806640625
-0.11767578125	-0.011962890625
0.042724609375	0.10498046875
0.2158203125	0.00389099121093
-0.09375	0.052978515625

-0.07958984375	-0.04541015625
-0.11181640625	-0.013427734375
-0.0400390625	-0.0095825195312
-0.1220703125	0.00202941894531
-0.033935546875	0.05810546875
0.6171875	-0.020263671875
1.234375	-0.486328125
0.052978515625	0.007080078125
0.1328125	0.01385498046875
-0.3203125	0.03955078125
0.10009765625	-0.306640625
-0.2041015625	0.00259399414062
0.09765625	0.01470947265625
-0.365234375	0.056884765625
-0.0986328125	-0.029541015625
-0.0908203125	0.00836181640625
0.2109375	0.0546875
-0.1748046875	0.0106201171875
0.02099609375	-0.0110473632812
-0.466796875	0.08935546875
0.484375	0.0189208984375
0.00448608398437	0.0250244140625
-0.0064697265625	-3.3617019653320
-0.03369140625	-0.009033203125
-0.09228515625	-0.008056640625
-0.72265625	0.50390625
-0.12158203125	-0.017578125

-0.0019683837890	-0.1552734375
-0.0118408203125	0.064453125
0.09228515625	-0.0013427734375
0.10009765625	0.00711059570312
-0.07861328125	-0.0022735595703
-0.95703125	0.00570678710937
-0.16015625	-0.0025177001953
0.08251953125	-0.07666015625
0.08642578125	-0.2421875
0.177734375	-0.003662109375
-0.095703125	-0.0257568359375
-0.1796875	-0.042724609375
-0.166015625	-0.056640625
-0.017578125	0.041748046875
0.578125	-0.427734375
-0.1923828125	0.020263671875
-0.08056640625	0.050048828125
0.09619140625	0.01348876953125
0.08544921875	-0.0673828125
-0.1318359375	-0.0036315917968
-0.5546875	-0.0016784667968
0.244140625	0.00302124023437
0.1572265625	-0.11181640625
-0.376953125	-0.06884765625
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-0.0184326171875	0.055908203125
-0.162109375	-0.01953125

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1.4 int8 整型

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44	-41
4	7
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-47	-30
3	-2
-33	-32
-35	-5
-34	43
-27	-43
-41	42
29	33
33	31
-28	6
48	-8

-19	-15
-46	5
-27	0
18	19
30	18
-6	25
-1	-37
-9	-12
41	1
-25	-5
-22	-29
26	45
9	15
-47	-8
-50	11
-36	26
33	-15
33	26
-32	-8
45	31
21	36
26	-42
-16	-27
-38	26
1	26
44	18
37	-12

15	-50
24	13
-39	-38
-36	42
44	31
13	1
-8	-9
21	-27
34	25
-32	9
-19	35
42	-31
-21	3
-24	31
-15	-27
8	-9

T32	
W	A
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13	39
34	1
26	46
18	8
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-43	46

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-35	-29
31	21
48	-19
35	-16
-7	-36
9	40
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-39	-14
6	-20
-40	-36
38	-13
42	-11
47	-11
5	38
42	21
-45	39
-43	12
-44	-46
-42	41
4	46
-47	22
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-9	-41
3	10
34	-39

6	18
22	-26
-5	-35
1	14
-2	-10
-15	30
3	46
33	18
10	-2
29	39
-29	-20
-45	-36
-15	-8
-3	-43
-44	0
9	34
28	-7
0	45
-1	49
-19	-4
-50	-9
36	-12
-33	27
5	-50
16	19
1	-5
34	-41

-21	39
0	47

T33	
W	A
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40	38
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-36	6
15	-37
41	41
-29	-13
5	3
-44	27
24	-38
-43	21
7	9
42	25
-42	33
-50	23
-16	5
23	-15
13	45
43	-49

-32	-29
3	47
40	15
-22	-40
25	17
13	-5
13	-31
-25	39
45	-44
46	38
32	-23
38	-24
47	33
-26	15
23	6
-41	-15
39	2
22	1
-9	20
19	-8
-15	10
17	43
0	31
21	49
-40	0
-37	21
26	23

-6	-28
-30	-40
10	-14
42	20
15	-4
33	5
9	-49
-27	26
-17	26
-28	32
-22	-36
-43	23
-40	46
-30	-4
-25	-20

T34	
W	A
-47	-23
47	21
-34	-5
11	41
30	28
-36	-3
-33	-32
37	-26
50	-11

35	33
42	49
-17	-38
-2	28
-1	-6
38	19
32	-46
39	41
-44	8
-7	7
-23	9
44	28
43	2
16	42
19	-16
-45	41
-28	-25
-37	11
38	5
34	-24
-18	20
38	-24
36	-19
-1	-23
22	46
49	50
-45	-28

-22	-35
11	-49
-10	21
43	-23
-35	5
-34	-26
-16	-16
34	34
-46	-8
31	-47
-14	27
33	5
-48	-14
-11	-7
-30	-13
30	20
50	-40
-40	-27
17	-39
-18	-21
17	24
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版本更新历史

日期	版本	说明
2022.01.01	1.0	用户手册始发版本。