xkTuning Tool

v1.0

User Guide

VIP LAB @ Fudan University

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XK
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Revision History

The following table shows the revision history for this document.

Update	Author	Date
Version 1.0		
Added the XK-ISP C model to Manu Tuning Tool	Liu Jiaming (liujm22@m.fudan.edu.cn) Fan Yibo (fanyibo@fudan.edu.cn)	2022/12/4
Created the Main visualization Window for Manu Tuning		
Added the function of displaying output image of every model		
Added the function of download the image		

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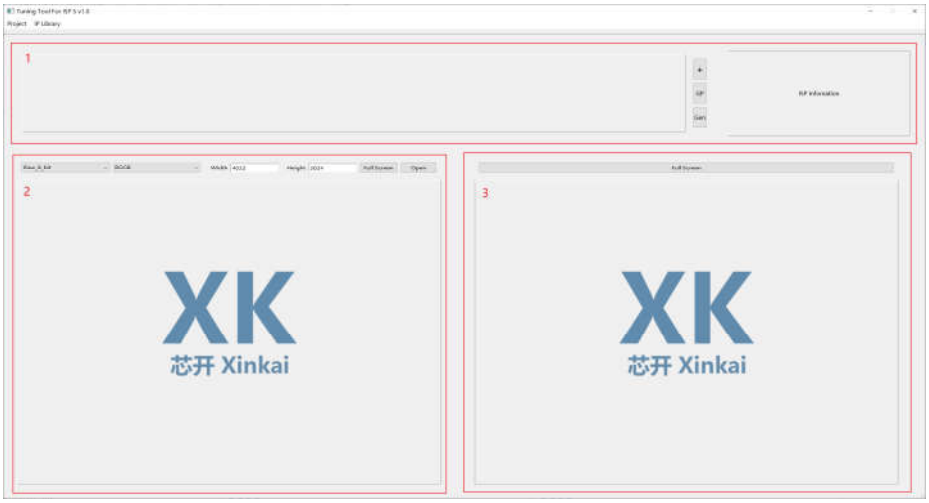
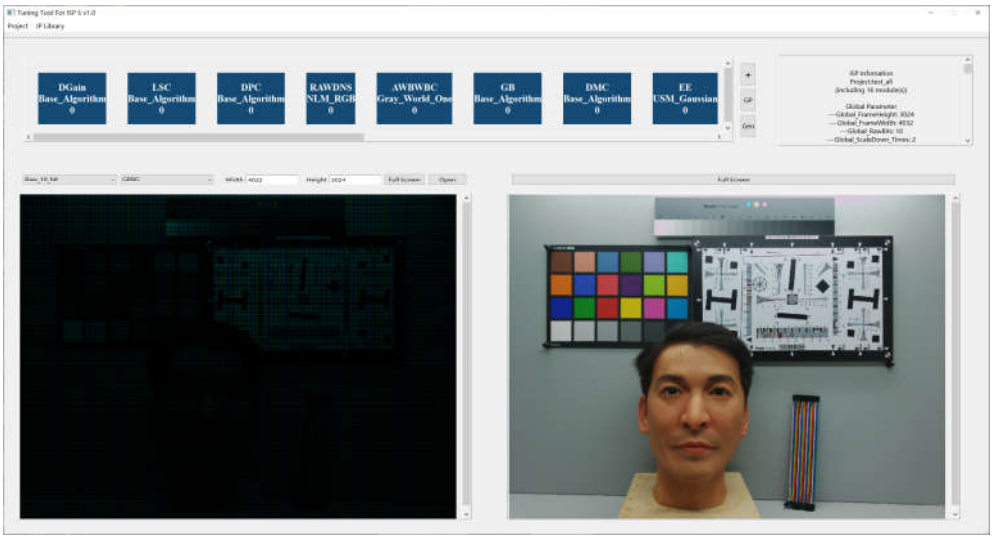
Introduction to XK-ISP Manu Soft Tuning Tool

XK-ISP Manu Soft Tuning Tool is based on the open-source XK-ISP C model developed by the Video & Image Processor laboratory of Fudan University. This tool contains some C-models of XK-ISP, with a total of 17 pipeline architectures at most, and has many configurable parameters for adjustment. The tool has a low code visual interface, and users can complete the corresponding configuration through simple interaction and manual input of parameters. With this tool, users have an efficient inspection method to speed up the process of parameter selection.

Basic Visualization Window

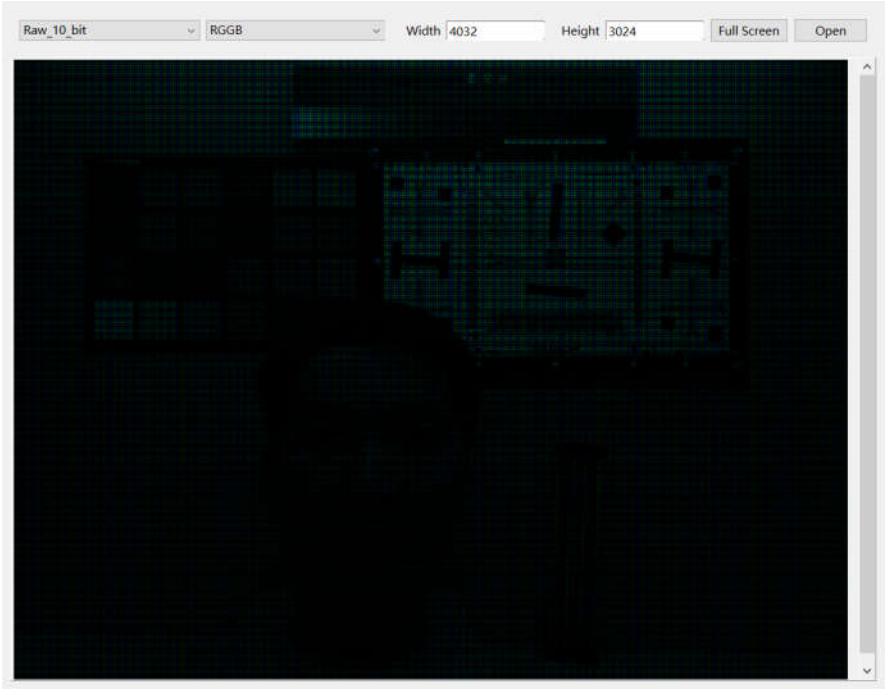
The main window consists of three parts. The first part is the ISP architecture diagram and ISP parameter information, the second part is the input Raw image information, and the third part is the output RAW/RGB/YUV (determined according to the ISP output).





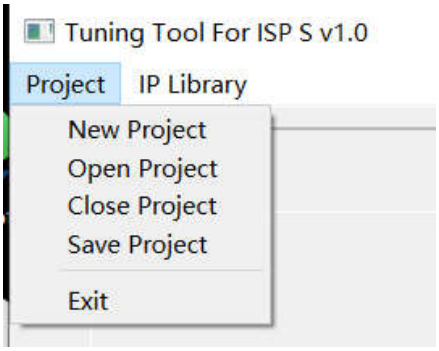
Raw Import

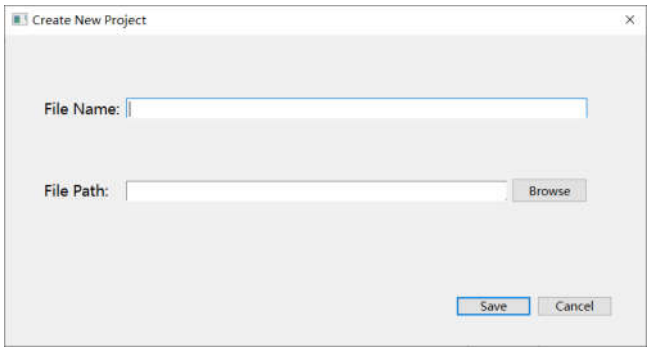
In this section, you can import different types of Raw images, such as ***8 bit, 10 bit, and 12 bit*** data widths. The format of the Bayer array is ***RGGB, GRBG, GBRG,*** and ***BGGR***. The width and height of the image are also necessary inputs. The user can display the 1:1 ratio result of the image through the pushbutton ***Full Screen***. When the previous information is confirmed to be correct, the pushbutton ***Open*** can be used to open the Raw image to be processed.

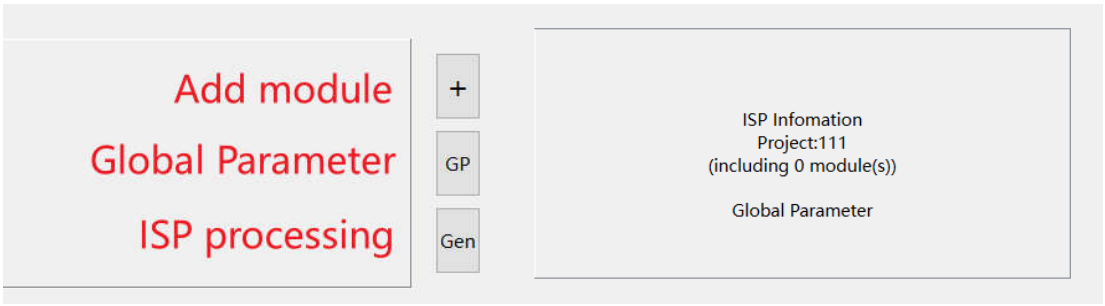


Project Management

In the menu bar ***Project***, we can choose to create a ***New Project***, ***Open Project***, ***Close Project***, and ***Save Project***. After a project is created, there is no module in the ISP architecture, but the ISP project information has been displayed in the ISP information, which means that the project has been successfully created.

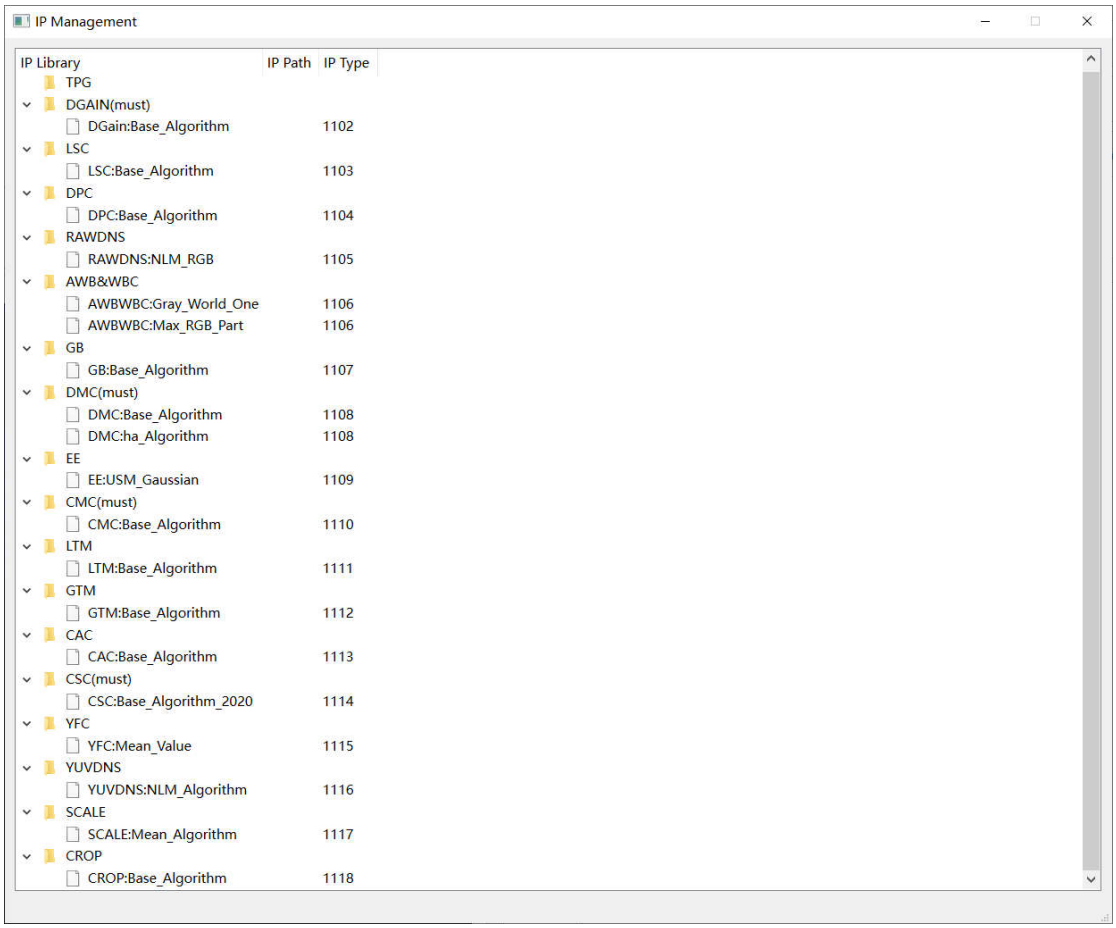






After creating a project, the project has been opened. Then we can add modules by clicking the pushbutton ***ADD Module.*** We can view the global parameter of the current module through the pushbutton ***Global Parameter.*** If we import pictures and XKISP module, we can get the processed pictures through the pushbutton ***ISP Processing***. On the right side of the button is the current architecture information of the ISP. Without importing any modules, Project 111 contains 0 modules.

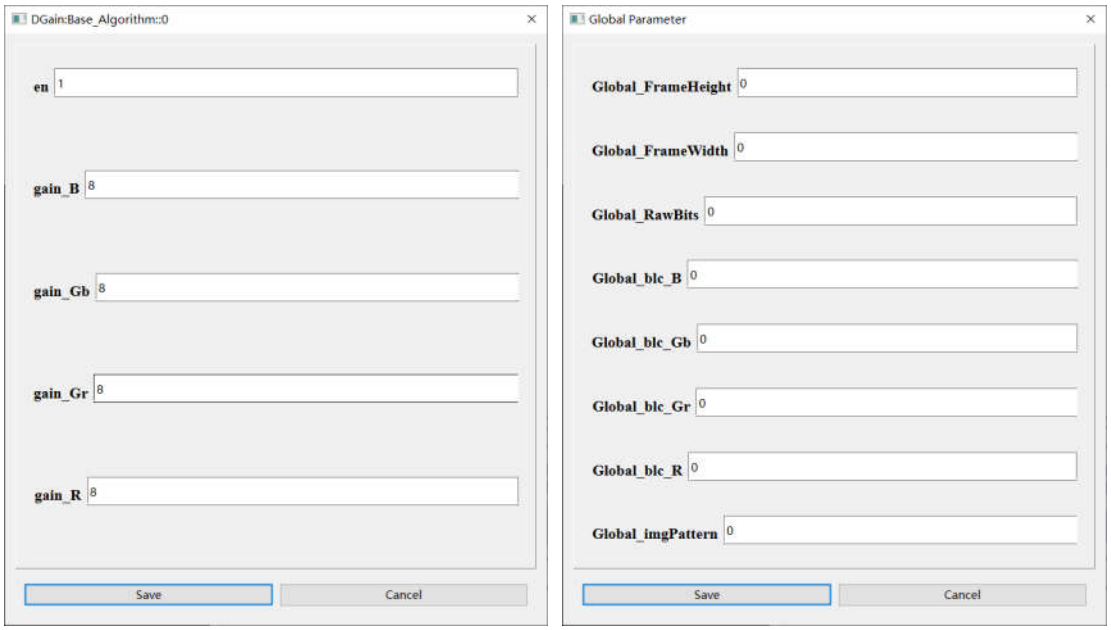
XK-ISP IP management



In XK-ISP IP management, you can freely add the required algorithm modules through the pushbutton ***ADD Module***. In this version, we include 17 types of algorithm modules, 19 different algorithms in total. The order of algorithm types follows the XK-ISP standard pipeline, which involves RAW ->RGB 4 ->RGB4 ->YUV format processing. It should be noted that the type of mark ***(must)*** must exist if you want to complete the conversion of image format.

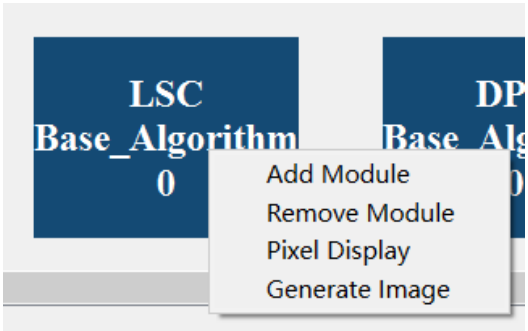
When you **double-click** an algorithm, the algorithm module will appear in the ISP architecture. **Double click** the module to pop up the parameter configuration window. You can modify any parameter to achieve the required functions. The function of parameters will be shown in the following sections. Different modules have different

parameters, which also contain some global parameters. We can modify the global parameters in the existing modules by the pushbutton ***Global Parameter***. It is worth noting that these parameters should be consistent with the Image input parameters (width and height).



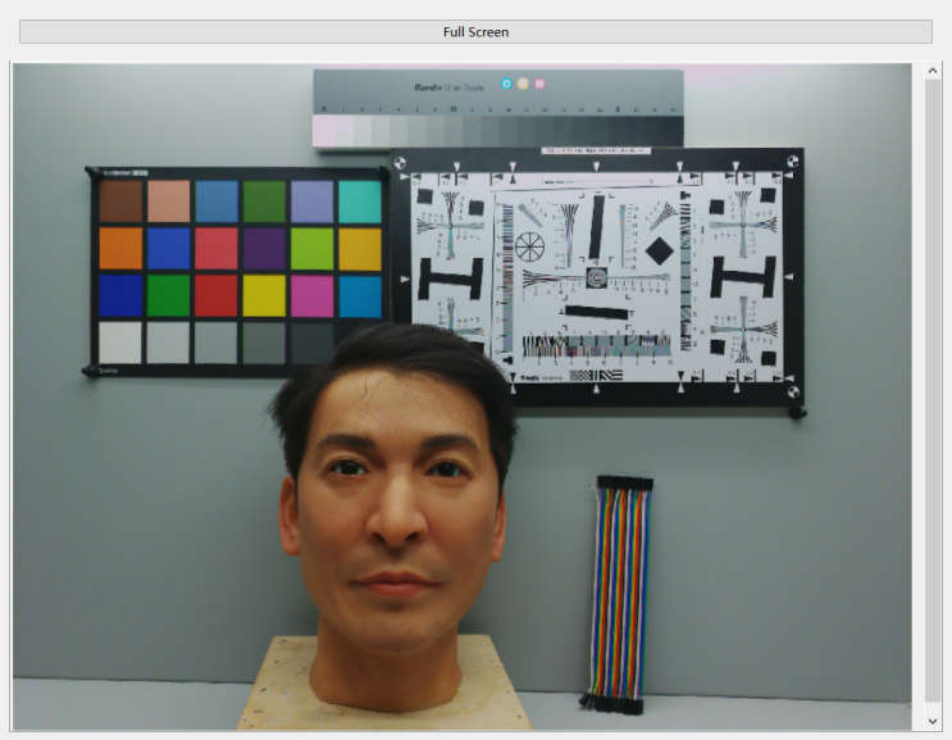
In addition, we can **right-click** a single algorithm module to complete other functions, including:

- ✧ Add a new module before the module
- ✧ Delete the module
- ✧ Display the processing result (image) of this module
- ✧ Download the processing results (image) of this module



Output Display

The image processed by the ISP will be shown in the output display section in the form of scaling, regardless of the final output of ISP in any format (***RAW, RGB (4), YUV***). The user can display the 1:1 ratio result of the image through the pushbutton ***Full Screen***.



XK-ISP IP Introduce

In this section, we will briefly introduce the purpose of each IP, the meaning of the parameters, and the configurable range of the parameters to help users better tune their own ISPs.

Dgain—RAW

✧ Base_Algorithm

In case of no sensor, the gain value only completes the adjustment of the bit width.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_RawBits	Bit width of Raw	Non	10
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1
Global_blc_R	Black level value of R	Non	0
Global_blc_Gr	Black level value of Gr	Non	0
Global_blc_Gb	Black level value of Gb	Non	0
Global_blc_B	Black level value of B	Non	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
gain_R	Gain value of R	8bit-32 10bit-8 12bit-2	8
gain_Gr	Gain value of Gr	8bit-32 10bit-8 12bit-2	8
gain_Gb	Gain value of Gb	8bit-32 10bit-8 12bit-2	8
gain_B	Gain value of B	8bit-32 10bit-8 12bit-2	8

LSC—RAW

✧ Base_Algorithm

Lens shadow correction, gain obtained through sensor lens data.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_RawBits	Bit width of Raw	Non	10
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1
Global_blc_R	Black level value of R	Non	0
Global_blc_Gr	Black level value of Gr	Non	0
Global_blc_Gb	Black level value of Gb	Non	0
Global_blc_B	Black level value of B	Non	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
LSCConfig	Lens parameter selection	0~7 correspond to different lens gain parameters	4

DPC—RAW

✧ Base_Algorithm

defect point correction, detect defect points in the image and correct them by surrounding values.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Threshold_White	Threshold value recognized as white point (threshold value of the difference between the center point and surrounding points)	0~4095	300
Threshold_Black	Threshold value recognized as black point (threshold value of the difference between the center point and surrounding points)	0~4095	300

RAWDNS—RAW

✧ NLM_RGB

Non Local Mean filtering for RGB in RAW domain.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1
Global_blc_R	Black level value of R	Non	0
Global_blc_Gr	Black level value of Gr	Non	0
Global_blc_Gb	Black level value of Gb	Non	0
Global_blc_B	Black level value of B	Non	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Window_Radius	Match block radius, length is 2* Window_Radius+1	1~20 (Experience value)	2
Block_Radius	Search block radius, length is 2* Block_Radius+1	1~20 (Experience value)	5
Filter_Parameter	Filter coefficient k	10~1000 (Experience value)	100
Sigma	Gaussian sigma	1~400 (Experience value)	20

AWBWBG—RAW

✧ Gray_World_One

Gray world method completes white balance, calculates green mean value, and normalizes green components.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1
Global_blc_R	Black level value of R	Non	0
Global_blc_Gr	Black level value of Gr	Non	0
Global_blc_Gb	Black level value of Gb	Non	0
Global_blc_B	Black level value of B	Non	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
WBGain	Gain after white balance	1-4095	3700

AWBWBG—RAW

✧ Max_RGB_Part

This module collect the pixel of x% maximum value of the whole image as the white reference point for white balance.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1
Global_blc_R	Black level value of R	Non	0
Global_blc_Gr	Black level value of Gr	Non	0
Global_blc_Gb	Black level value of Gb	Non	0
Global_blc_B	Black level value of B	Non	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
WBGain	Gain after white balance	1~4095	3700
remove_Max_Proportion	Remove the top x% highlights (possibly the bad ones)	0~99	5
cal_Max_Proportion	Calculate the maximum point of the remaining x%	1~100	5

GB—RAW

✧ Base_Algorithm

The module Count the difference value of the green component in the search block, and correct the color difference of Gr and Gb.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
LowNumThreshold	Number threshold of pixels exceeding the color difference threshold in the block	Generally not greater than 1/4 of the number of pixels in the block	4
GreenBalanceThreshold	Threshold of adjacent green difference	1~2000 (Experience value)	683
WindowRadius	Match Block Radius	1~20 (Experience value)	3

DMC—RGB

✧ Base_Algorithm

The module remove the mosaic, convert the RAW image to RGB image, and average the surrounding color components.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1

DMC—RGB

✧ ha_Algorithm

The module remove the mosaic, convert the RAW image to RGB image, and average the surrounding color components.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_imgPattern	Bayer array format	0-R 1-Gr 2-Gb 3-B	1

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1

EE—RGB

✧ USM_Gaussian

Wavelet decomposition through hardware friendly Gaussian template and edge enhancement (sharpening) through frequency processing.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Sigma_X	Horizontal Gaussian sigma	10~150 (Experience value)	77
Sigma_Y	Vertical Gaussian sigma	10~150 (Experience value)	77
ScalingFactor	The threshold of signals with different frequencies is related to the result of Gaussian convolution, and this value is the scaling coefficient of the result	5~15 (Experience value)	10
WindowRadius	Gaussian filtering window radius	1~3 (Experience value)	2
HighFeqGain	Gain coefficient of high-frequency boundary	<16: Down > 16: Up	42

CMC—RGB

✧ Base_Algorithm

Correction of color space through color ring and CCM lens file.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
gain[3][4]	Color gain matrix	According to the information configuration of the lens, one is adopted here (high-frequency information is 0)	$\begin{matrix} 6552 & -2530 & -216 & 0 \\ -618 & 5211 & -593 & 0 \\ 153 & -2902 & 6750 & 0 \end{matrix}$
CFC_enable		0-off 1-on	0
CFCStrength		<32：Down ＞32：Up	32
DiscardH		0-off 1-on	0
HueRange0	Color ring demarcation	0~359（related to color ring attribute）	240
HueRange1	Color ring demarcation	0~359（related to color ring attribute）	270
HueBandShift	Color ring shift（1 << HueBandShift）	0~8	3
EdgeThreshold	High frequency information threshold	0~4096	16
EdgeBandShift	High frequency shift（1 << EdgeBandShift）	0~10	3

LTM—RGB

✧ Base_Algorithm

The method of bilateral filtering and the completion of local tone mapping.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
contrast	contrast ratio	<4096： Low frequency Down ＞4096: Low frequency Up	3200
ratio	Output gain rate	<8： Down ＞8： Up	38

GTM—RGB

✧ Base_Algorithm

Tone mapping with gamma curve (stored in LUT).

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Dithering_en	Add a small amount of noise to improve subjective quality	0-off 1-on	1

CAC—RGB

✧ Base_Algorithm

The module remove abnormal boundaries such as purple edges from the edges.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Block_Radius	The radius of boundary search of sobel filter	1~20	3
Transient	Threshold of boundary	Depending on the size of the Block, 1000+	7000
Edge_for_Transient	Threshold of detail boundary	Depending on the size of the Block, 1000+	4000

CSC—YUV

✧ Base_Algorithm_2020

The module use BT2020 standard to obtain YCrCb values.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_YUV_Bits	Bit width of YUV	8,9,10,12,14	10

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1

YFC—YUV

✧ Mean_Value

The module calculate the average value of YUV4XX.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_YUV_Pattern	Pattern of YUV	0-YUV444 1-YUV422 2-YUV420	0

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1

YUVDNS—YUV

✧ NLM_Algorithm

Non Local Mean filtering for YUV values in YUV domain.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_YUV_Pattern	Pattern of YUV	0-YUV444 1-YUV422 2-YUV420	0
Global_YUV_Bits	Bit width of YUV	8,9,10,12,14	10

- Local parameters

parameters	function	detail	default
en	Enable signal	0-off 1-on	1
Y_Window_Radius	Radius of matching block of Y component	1~20 (Experience value)	1
Y_Block_Radius	Radius of search block of Y component	1~20 (Experience value)	2
Y_Filter_Parameter	Filtering coefficient of Y component	10~1000 (Experience value)	100
Y_Sigma	Gaussian Sigma of Y component	1~400 (Experience value)	5
UV_Window_Radius	Radius of matching block of UV component	1~20 (Experience value)	1
UV _Block_Radius	Radius of search block of UV component	1~20 (Experience value)	2
UV _Filter_Parameter	Filtering coefficient of UV component	10~1000 (Experience value)	100
UV _Sigma	Gaussian Sigma of UV component	1~400 (Experience value)	5

SCALE—YUV

✧ Mean

This module can scale pictures.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_YUV_Pattern	Pattern of YUV	0-YUV444 1-YUV422 2-YUV420	0
Global_ScaleDown_Times	Zoom multiple	Multiple of 2	2

CROP—YUV

✧ Base_Algorithm

Clipping, through coordinates of two points.

- Global parameters

parameters	function	detail	default
Global_FrameWidth	Frame width	Non	4032
Global_FrameHeight	Frame height	Non	3024
Global_YUV_Pattern	Pattern of YUV	0-YUV444 1-YUV422 2-YUV420	0
Global_ScaleDown_Times	Zoom multiple	Multiple of 2	2
Global_Upper_Left_X	Horizontal coordinate of upper left corner	According to the image size of the previous module	200
Global_Upper_Left_Y	Vertical coordinate of the upper left corner	According to the image size of the previous module	200
Global_Lower_Right_X	Horizontal coordinate of the lower right corner	According to the image size of the previous module	1000
Global_Lower_Right_Y	Vertical coordinate of the lower right corner	According to the image size of the previous module	1000