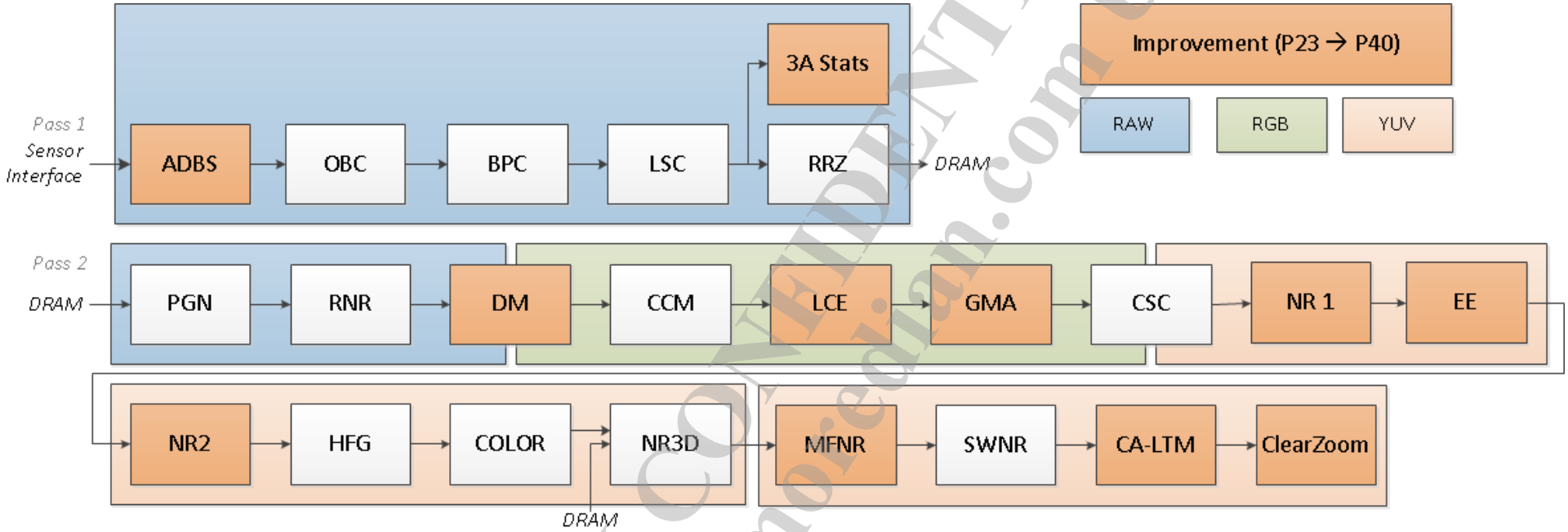
CONFIDENTIAL B

P40 Pipeline Introduction

P40 Block Diagram



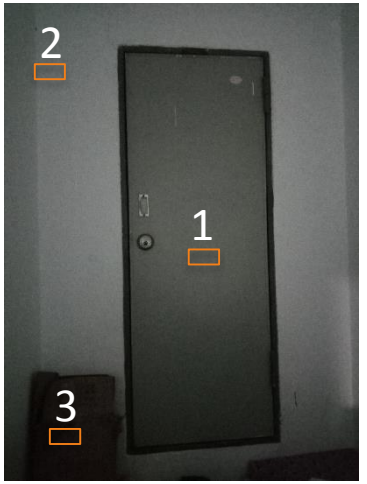
Noise		Tone		Color	
BPC	Bad Pixel Correction & G imbalance	ADBS	Advanced De-Bias	PGN	Pre-gain (WB gain)
NR 1	Noise Reduction 1	OBC	Optical Black Correction	CCM	Color Correction Matrix
NR 2	Noise Reduction 2	LSC	Lens Shading Correction	COLOR	Color Engine
NR2 - ABF	Anti-Blooming Filter	LCE	Local Contrast Enhancement	**Morphing**	
NR2 - CCR	Chroma Coring	GMA	Gamma Correction	RRZ	Raw Resizer
RNR	Raw Noise Reduction	CA-LTM	Content-Aware Local Tone Mapping	**Texture**	
HFG	High Frequency Generator	**Others**		DM	Demosaic
NR3D	Temporal Noise Reduction	3A Stats	3A Statistics	EE	Edge Enhancement
MFNR	Multi-Frame Noise Reduction	CSC	Color Space Conversion	ClearZoom	Clear Zoom
SWNR	SW-based Noise Reduction				

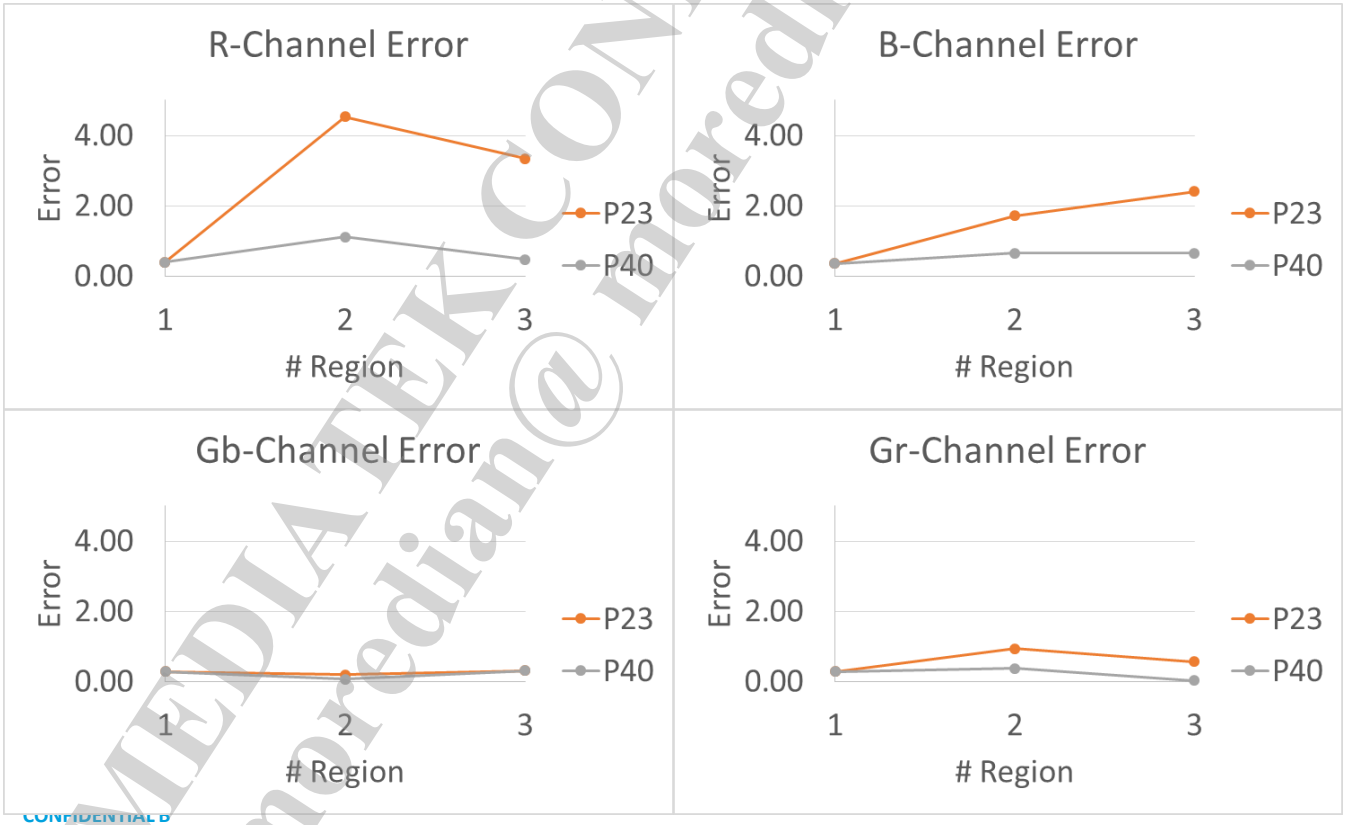
Major Module-Level Improvements

Module	Improvement Description
ADBS	Large-kernel local model to estimate precise optical black level
DM	Multi-scale interpolation to improve high-frequency content resolution
LCE	NR Link to reduce noise boosted after tone mapping
GGM	Support 192 control points (from 144)
NR1	Content-dependent multi-scale filtering with better frequency selectivity .Preserve more content/texture at same noise level .Preserve smooth gradation Direct 2D filter (instead of 1D+1D) to improve resolution and remove cross-line artifact Color-dependent NR Face IQ
EE	Preserve smooth gradation Preserve saturation on color edge after sharpening Color-dependent enhancement
NR2-ABF	HW support anti-blooming filter natively
CA-LTM	Content-aware local tone mapping
ClearZoom	Achieve better zoom IQ
MFNR	Overall IQ Improvement

ADBS Improvement

- P40改善了區域bias的估計方式並加大window，消除色偏效果更佳





Comparison: P23

Comparison: P40

DM Improvement – P23

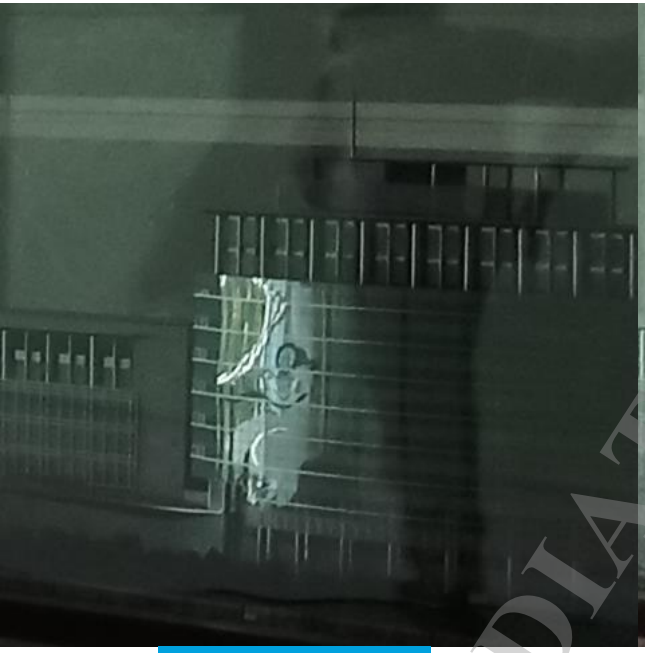
DM Improvement – P23

- Multi-scale interpolation

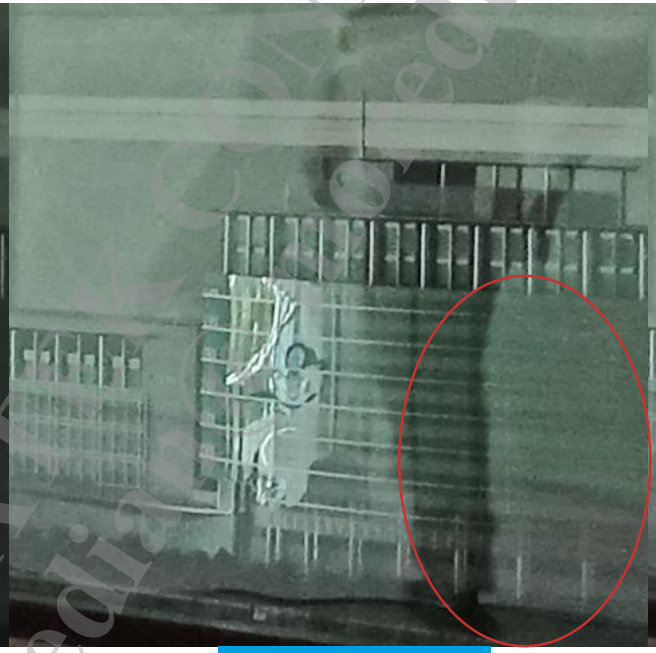
Improve high-frequency content resolution

LCE Improvement

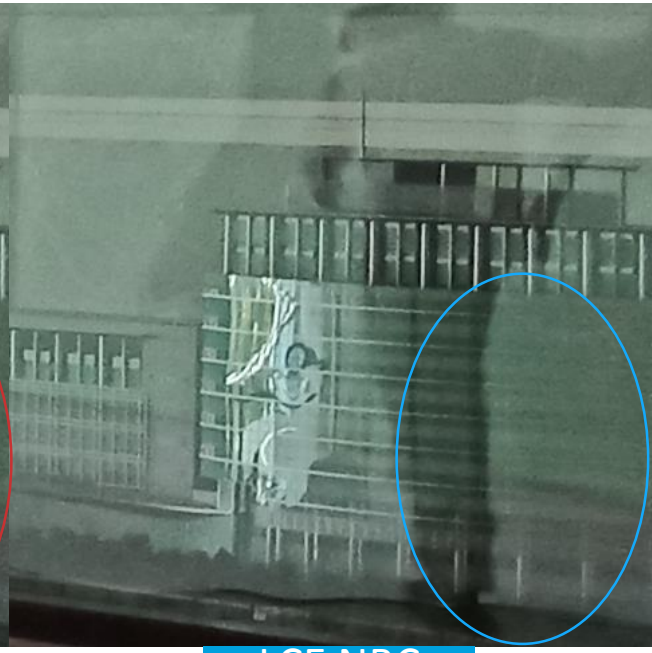
- LCE-NR Link
  - To suppress the noise which enhanced by LCE locally



LCE off



LCE on



LCE NBC Link on

Gamma Improvement

- Modify control points from 144 to **192** since P40

Input Range	Control Point Number	Step	Control Point
0~511	64	8	{0,8,16,… ,504}
512~1023	32	16	{512,528,… ,1008}
1024~2047	32	32	{1024,1056,… ,2016}
2048~4095	16 → 64	128 → 32	{2048,2064,… ,4064}

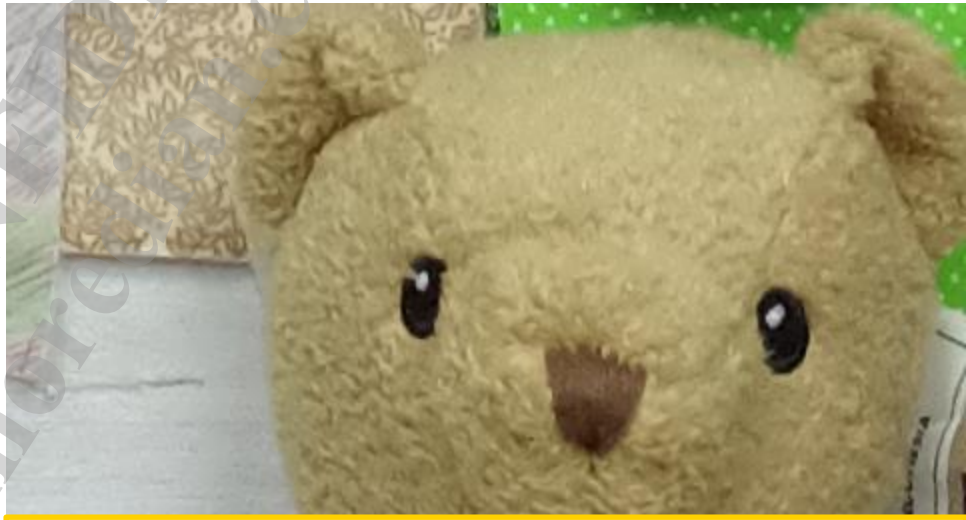
ISO400, 100%

NR1 Improvement – P23

ISO400, 100%

NR1 Improvement – P40

- NR Improvement
  - Content-dependent multi-scale filtering with better frequency selectivity
  - Direct 2D filter (instead of 1D+1D) to improve resolution and remove cross-line artifact

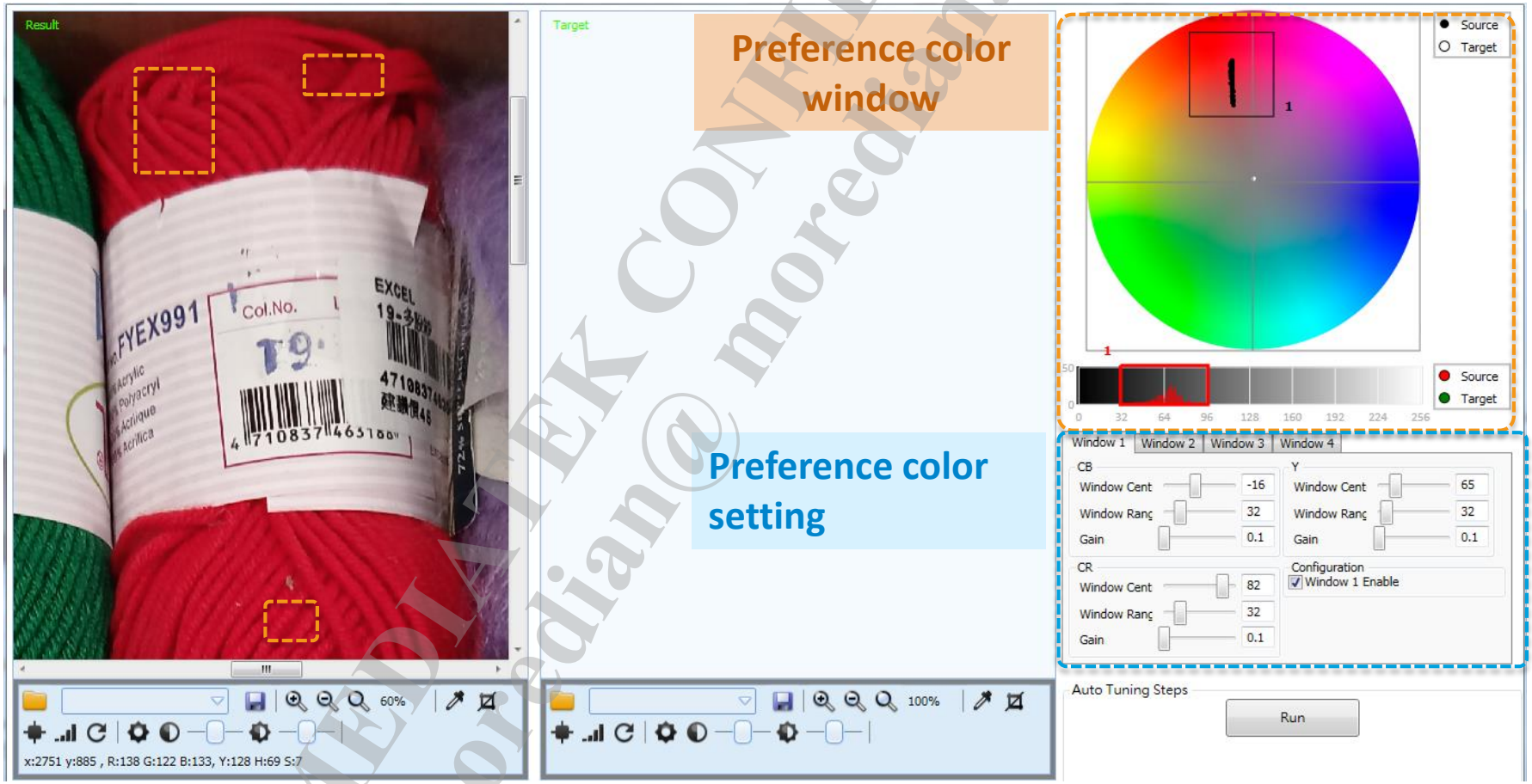


Preserve more content/texture with same noise level

Preserve smooth gradation

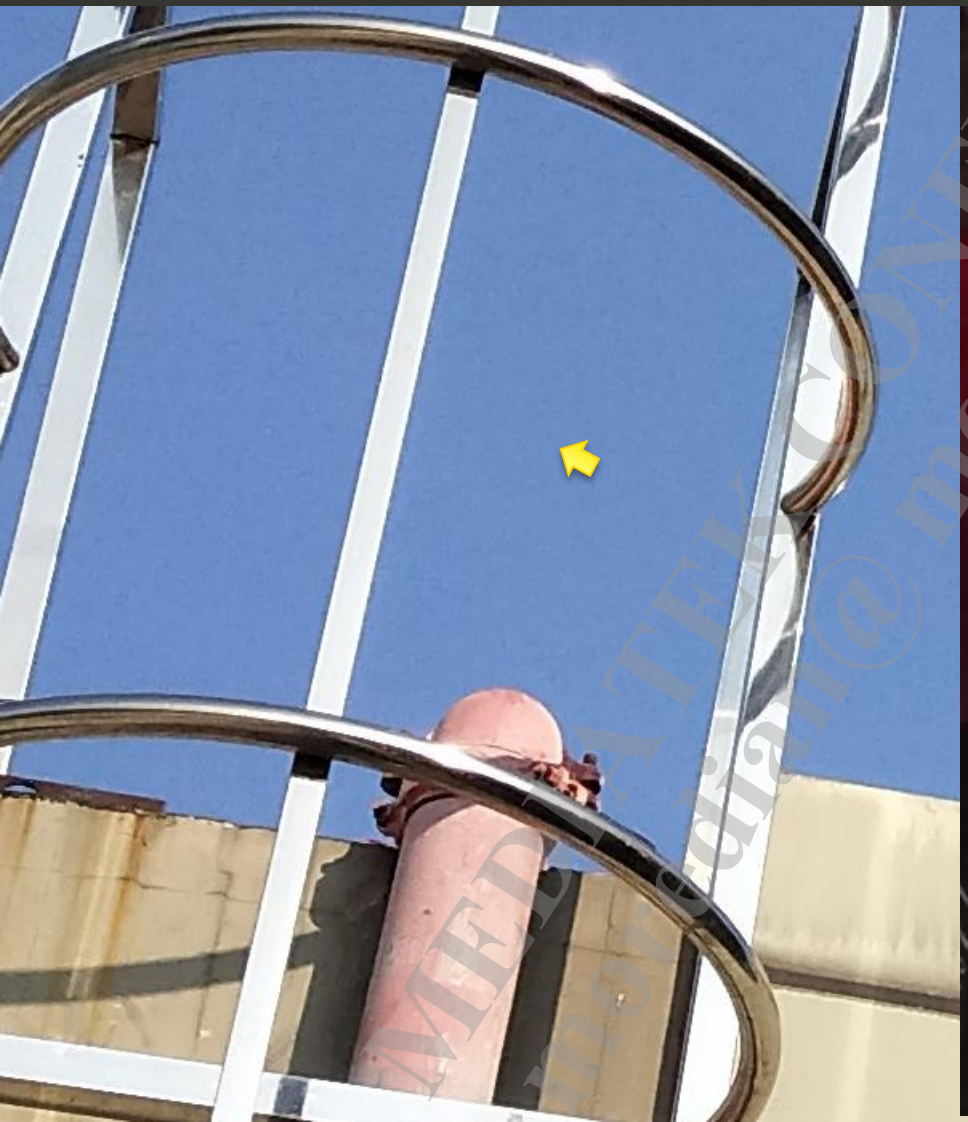
NR1 Improvement – Color-Dependent NR

- Adjust NR strength by luma & color



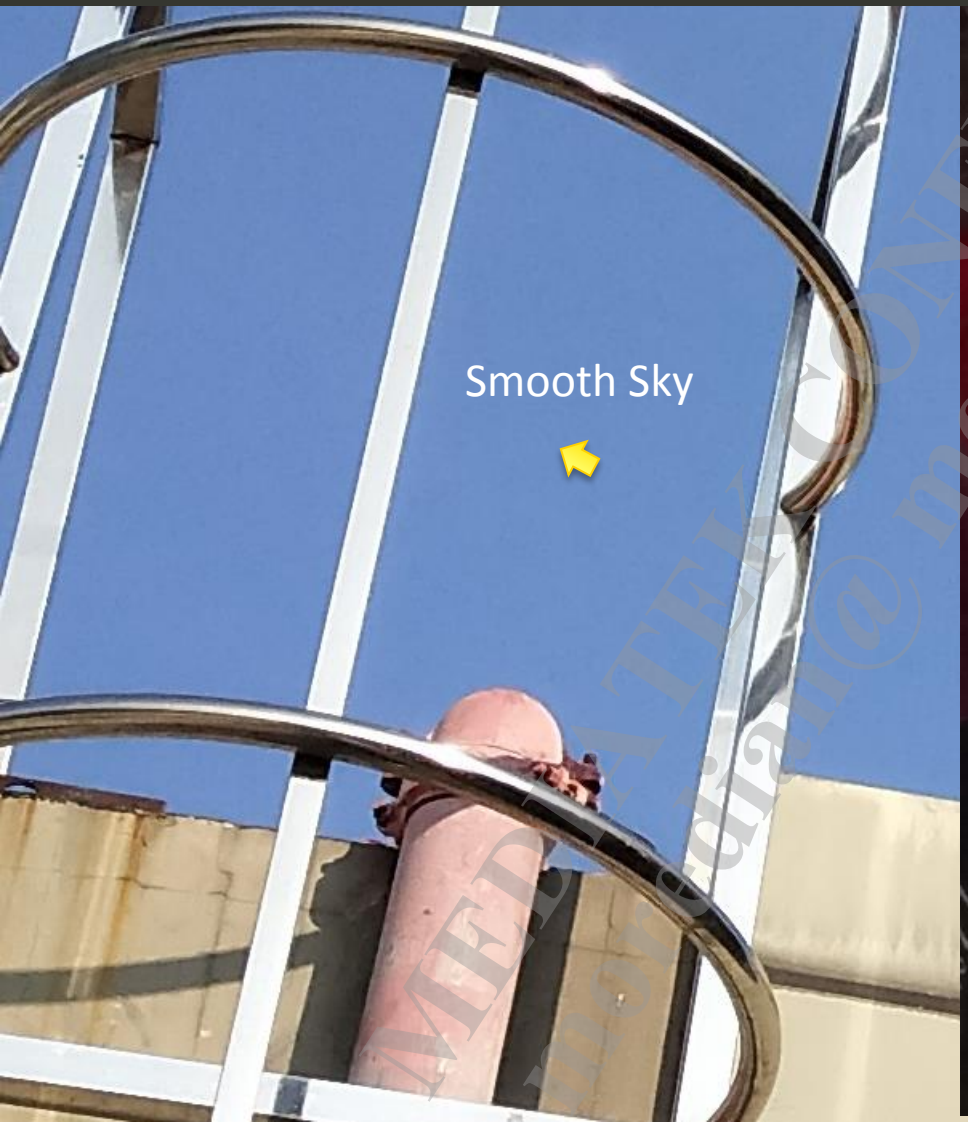
Color-Dependent NR OFF

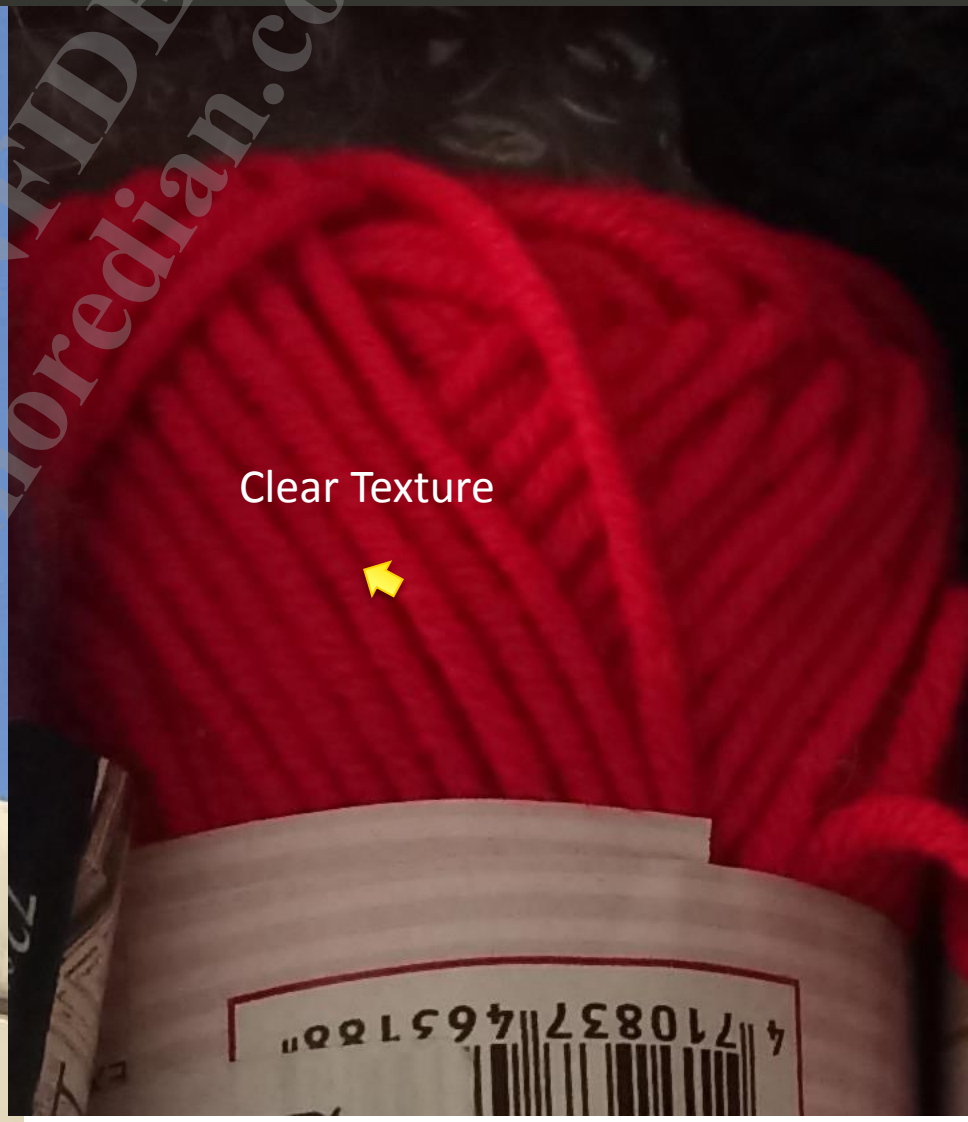
ISO 100 100% ISO 1600



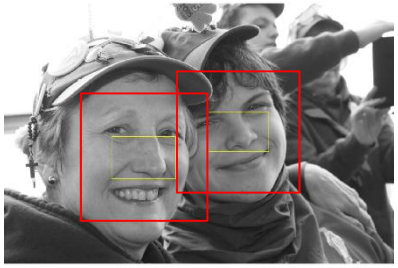
Color-Dependent NR ON

ISO 100 100% ISO 1600





NR1 Improvement – Face IQ



Face IQ

OFF

ON

Face IQ

OFF

ON

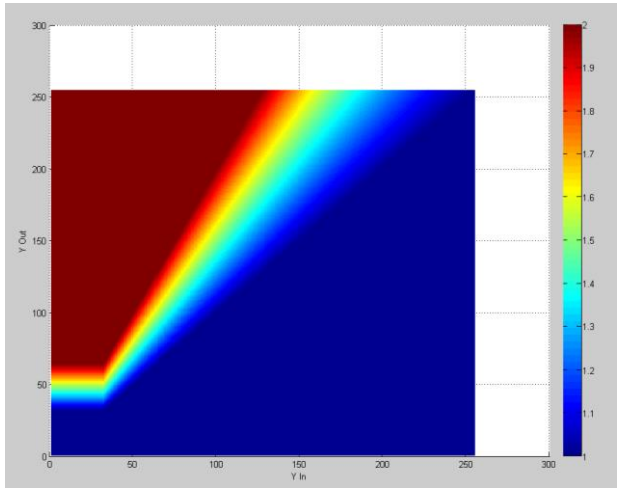
EE Improvement:
Preserve Smooth Gradation

EE Input P23 P40

EE Improvement:
Preserve Saturation on Color Edge

P23

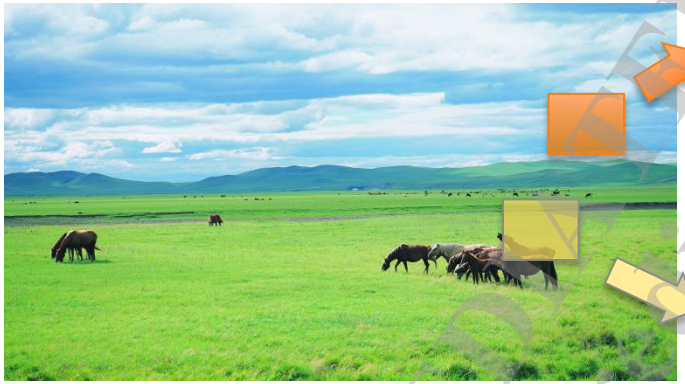
EE Improvement:
Preserve Saturation on Color Edge

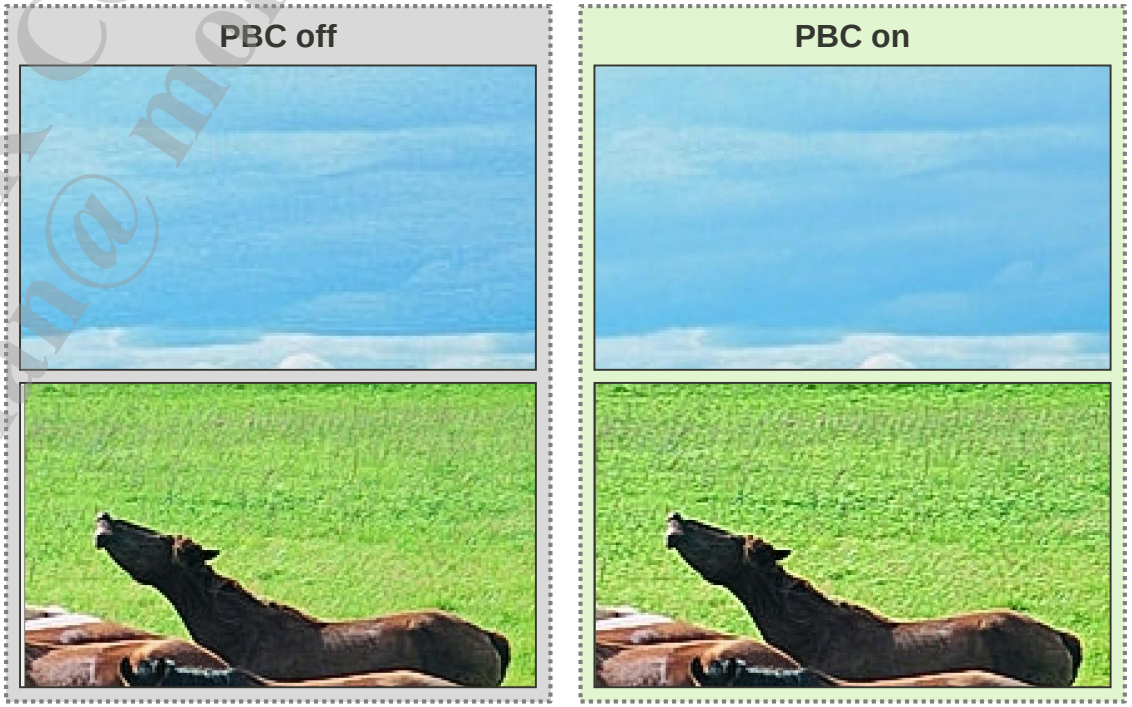


P40

EE Improvement: PBC (Peaking By Color)

- Color dependent sharpness/blurring
  - Apply different settings for different colors, e.g.,
    - Stronger sharpness for the grass and trees
    - Less sharpness for the skin and sky
    - Blur the details on the sky





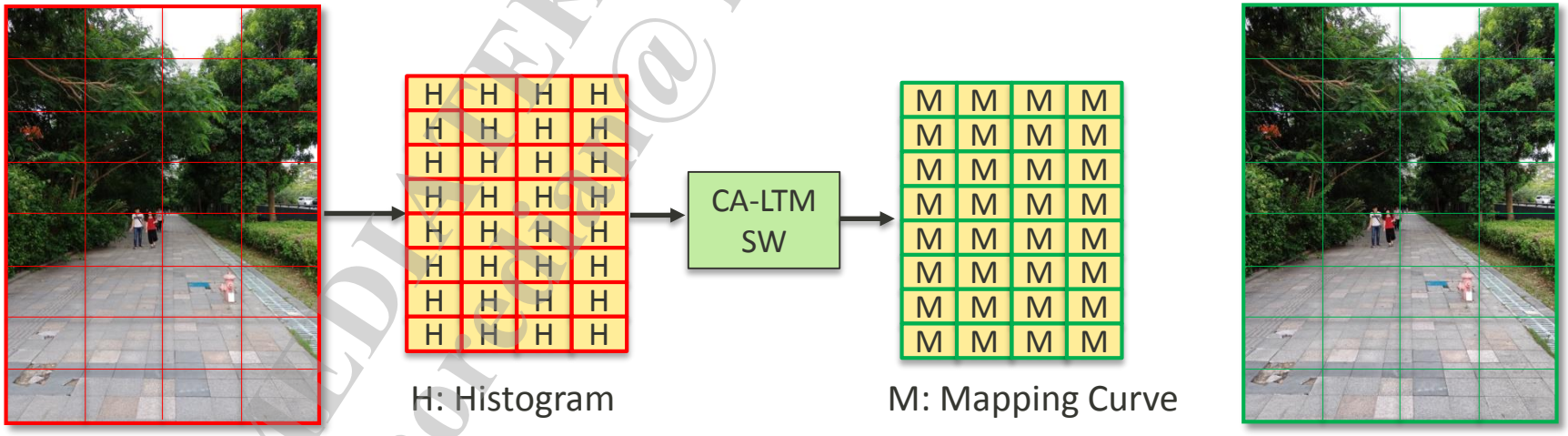
NBC2-ABF Improvement

- Real-time processing

Input HWABF output

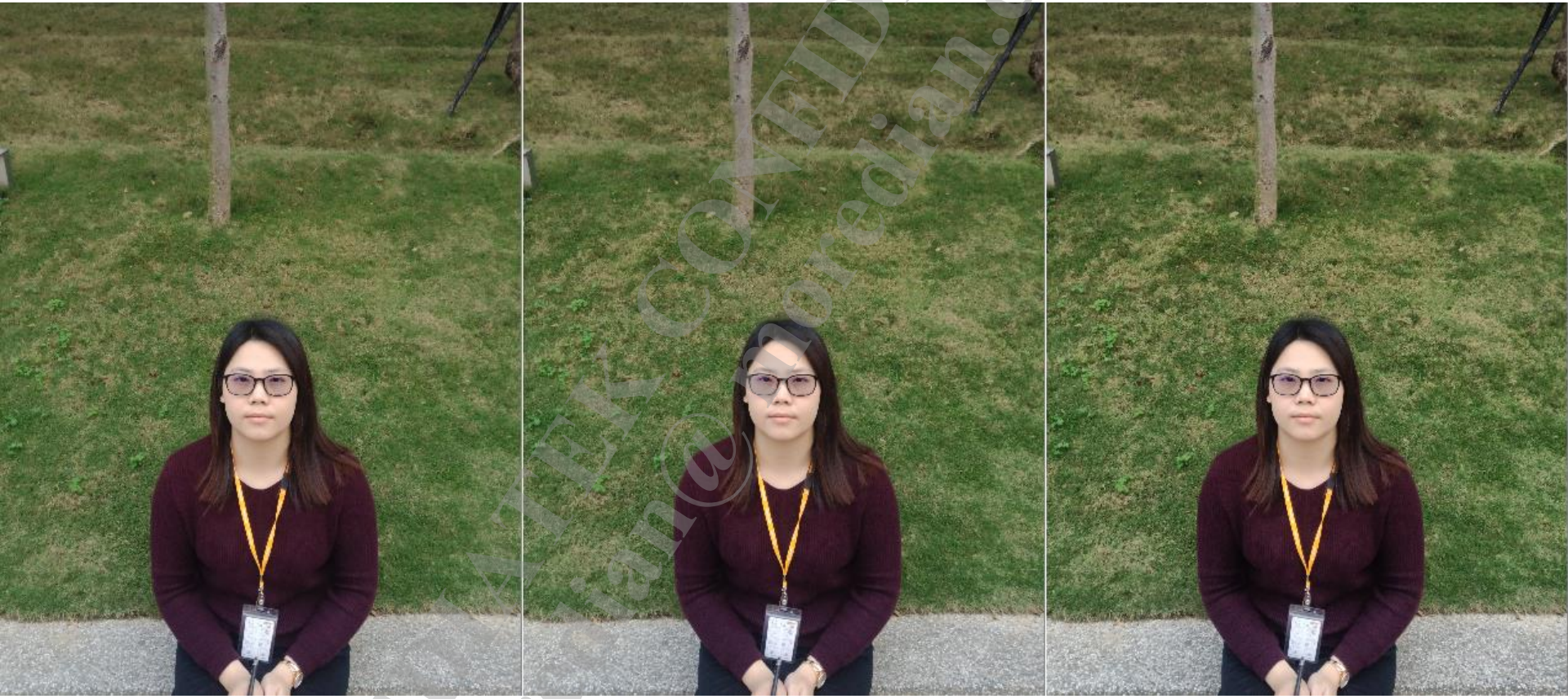
CA-LTM: Content-Aware Local Tone Mapping

- Key features
  - Keep overall luma average
  - Local contrast/detail enhancement
  - Skin/flat region protection
  - No noise boost

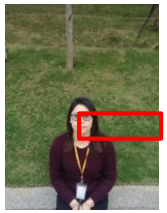


不影響整體平均亮度

- 即使強度不同，整體平均亮度皆一致

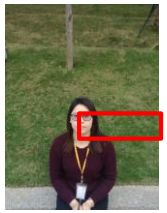


OFF　　DEFAULT　　STRONG



局部對比/細節強化

CA-LTM OFF

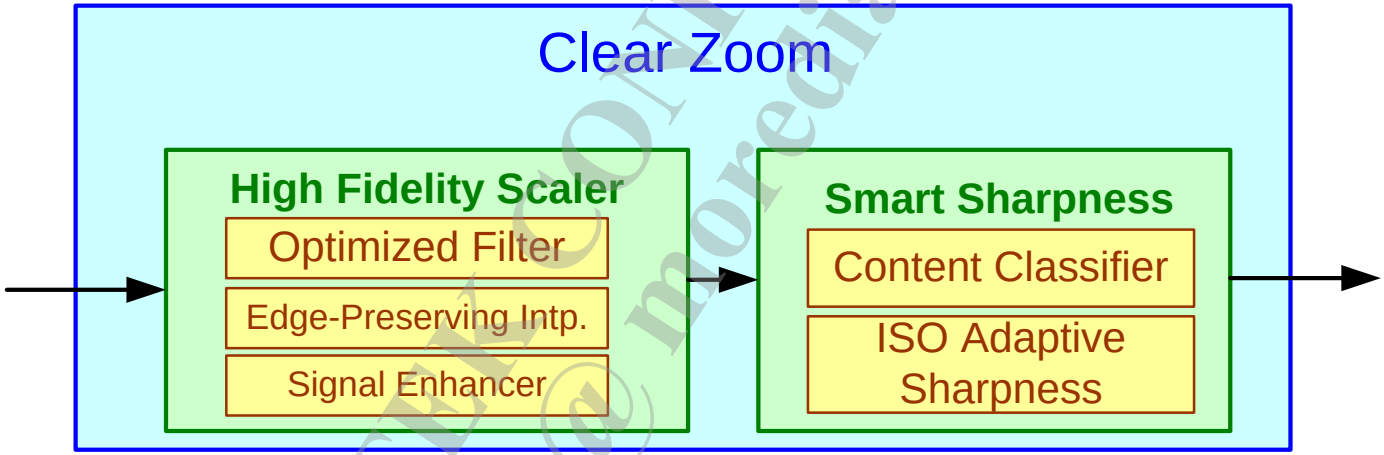


局部對比/細節強化

CA-LTM ON

ClearZoom

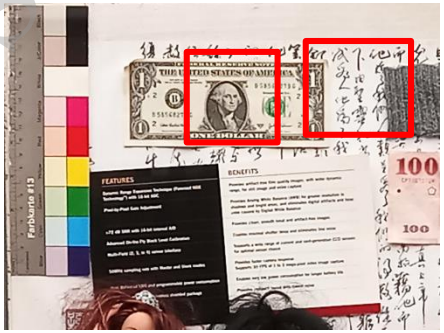
- Combination of **High Fidelity Scaler** and **Smart Sharpness** to achieve best digital zoom IQ

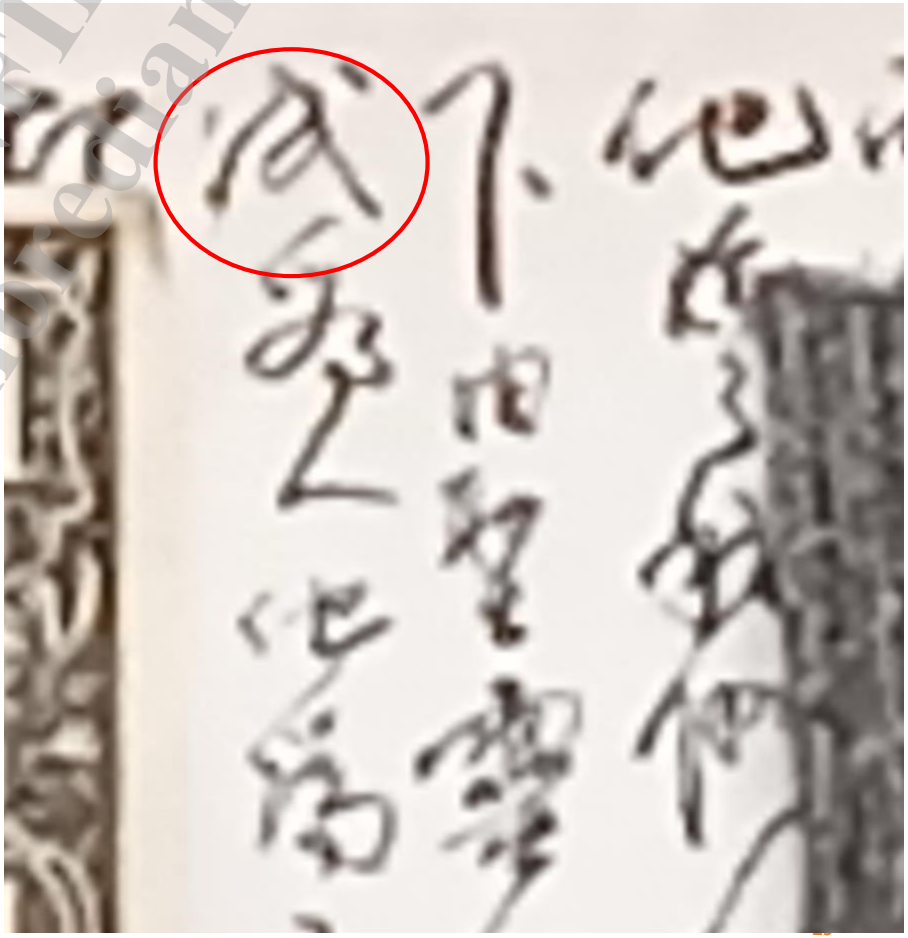


- Usage
  - Zoom for capture/preview/video
  - 4 cell sensor support

8X Digital Zoom (w/o ClearZoom)

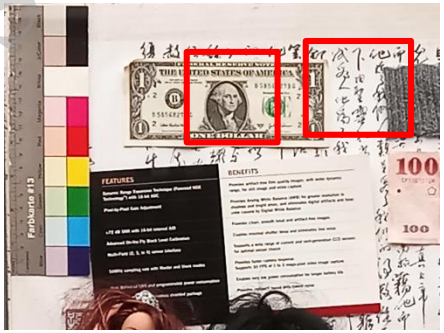
- 100%

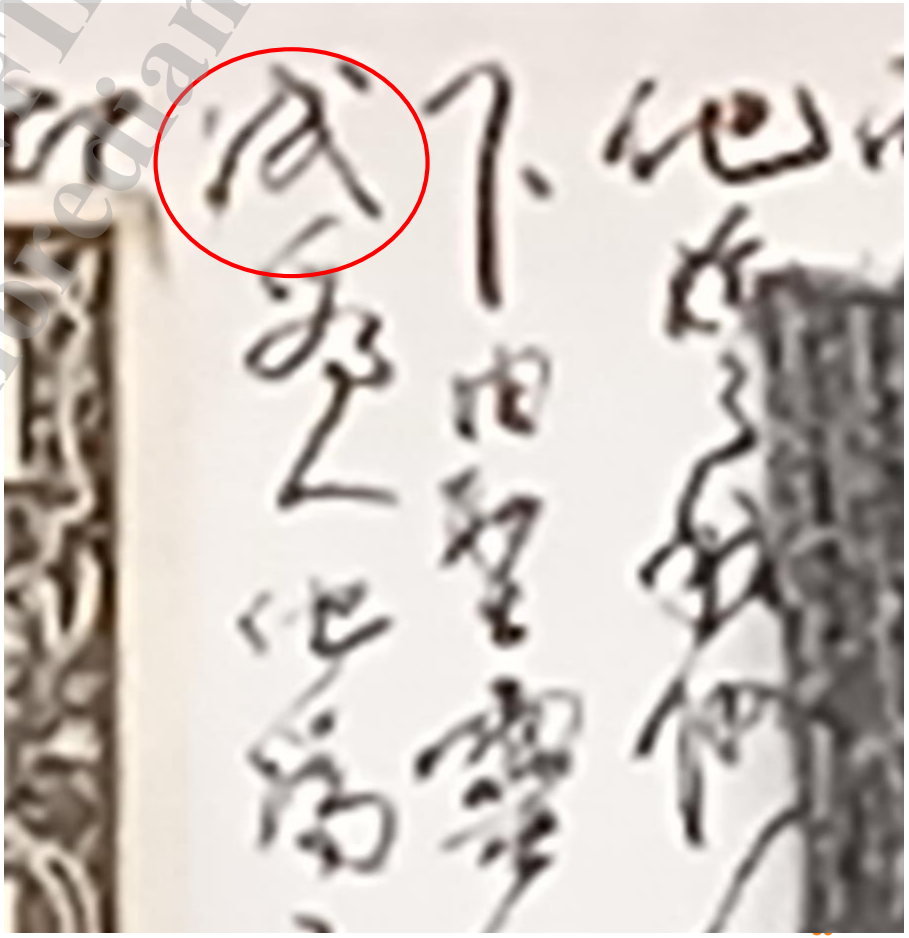




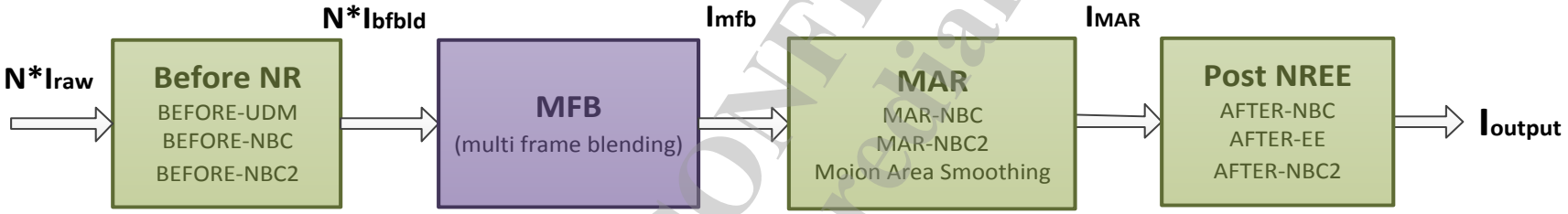
8X Digital Zoom (w/ ClearZoom)

- 100%



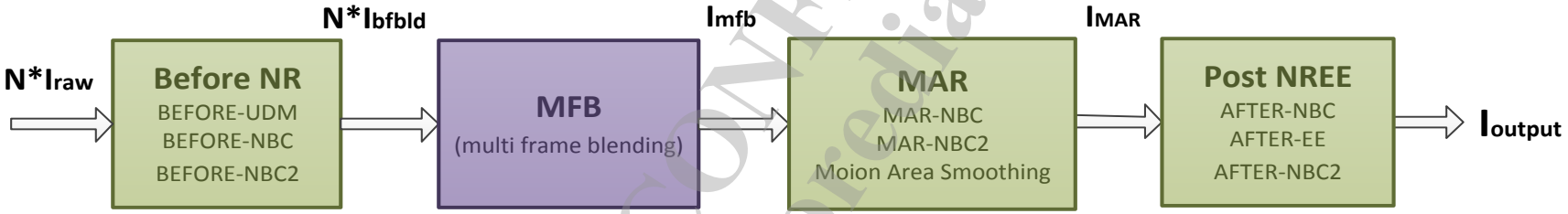


MFNR Flow



N*Iraw	Input RAW files. In P40, N=2~6
N*Ibfbld	Images prepared to do multi-frame blending
Imfb	Single blended Image
IMAR	Image after motion area refinement
Ioutput	Image after post-NR/EE processing

Module Control of Each Stage



Before Stage	Similar as single capture (no EE/ABF/CCR/HFG/COLOR)
MFB	MFB only
MAR	Only NR1/NR2 (no EE/HFG)
Post Stage	NR1/EE/NR2/ABF/CCR/EE/HFG/COLOR

everyday genius