ISP-CSC(color space convert)

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01 转换过程

RGB2YCrCb 2YUV

$$E'_Y = 0.299\,E'_R + 0.587\,E'_G + 0.114\,E'_B$$

则：

$$(E'_R - E'_Y) = E'_R - 0.299\,E'_R - 0.587\,E'_G - 0.114\,E'_B = 0.701\,E'_R - 0.587\,E'_G - 0.114\,E'_B$$

以及

$$(E'_B - E'_Y) = E'_B - 0.299\,E'_R - 0.587\,E'_G - 0.114\,E'_B = -0.299\,E'_R - 0.587\,E'_G + 0.886\,E'_B$$

$$E'_{C_R} = \frac{E'_R - E'_Y}{1.402} = \frac{0.701E'_R - 0.587E'_G - 0.114E'_B}{1.402}$$

以及

$$E'_{C_B} = \frac{E'_B - E'_Y}{1.772} = \frac{-0.299E'_R - 0.587E'_G + 0.886E'_B}{1.772}$$

假如亮度信号只占用了220（8位）或877（10位）级，以提供工作范围，并假设黑色位于16.00$_d$级，那么量化的亮度信号的十进制值Y为：

$$Y = \text{int}\{(219E'_Y + 16) \times D\} / D$$

其中，D在1或4中任选一个值，分别与8位和10位的量化相对应。操作符int( )为0到0.4999范围中的小数部分返回值0…，并为0.5到0.999范围中的小数部分返回值+1…，即它近似大于0.5的小数。

同样，假如色差信号只占用225（8位）或897（10位）级，并假设零级为128.00$_d$级，那么量化的色差信号的十进制值C_R和C_B为：

$$C_R = \text{int}\{(224E'_{C_R} + 128) \times D\} / D$$

以及

$$C_B = \text{int}\{(224E'_{C_B} + 128) \times D\} / D$$

BT 709

项	参数	系统值
3.1	基色信号概念性非线性预纠错	$\gamma = 0.45$（见第1.2项）
3.2	亮度信号 E'_Y 的推导	$E'_Y = 0.2126\,E'_R + 0.7152\,E'_G + 0.0722\,E'_B$
3.3	色差信号的推导（模拟编码）	$E'_{CB} = \frac{E'_B - E'_Y}{1.8556} = \frac{-0.2126\,E'_R - 0.7152\,E'_G + 0.9278\,E'_B}{1.8556}$ $E'_{CR} = \frac{E'_R - E'_Y}{1.5748} = \frac{0.7874\,E'_R - 0.7152\,E'_G - 0.0722\,E'_B}{1.5748}$
3.4	RGB、亮度和色差信号的量化 (1), (2)	$D'_R = \text{INT}[(219E'_R + 16) \cdot 2^{n-8}]$ $D'_G = \text{INT}[(219E'_G + 16) \cdot 2^{n-8}]$ $D'_B = \text{INT}[(219E'_B + 16) \cdot 2^{n-8}]$ $D'_Y = \text{INT}[(219E'_Y + 16) \cdot 2^{n-8}]$ $D'_{CB} = \text{INT}[(224E'_{CB} + 128) \cdot 2^{n-8}]$ $D'_{CR} = \text{INT}[(224E'_{CR} + 128) \cdot 2^{n-8}]$
3.5	通过RGB信号的量化推导亮度和色差信号	$D'_Y = \text{INT}[0.2126D'_R + 0.7152D'_G + 0.0722D'_B]$ $D'_{CB} = \text{INT}\left[\left(-\frac{0.2126}{1.8556}D'_R - \frac{0.7152}{1.8556}D'_G + \frac{0.9278}{1.8556}D'_B\right) \cdot \frac{224}{219} + 2^{n-1}\right]$ $D'_{CR} = \text{INT}\left[\left(\frac{0.7874}{1.5748}D'_R - \frac{0.7152}{1.5748}D'_G - \frac{0.0722}{1.5748}D'_B\right) \cdot \frac{224}{219} + 2^{n-1}\right]$

Y'_C和Y'的衍生物	$Y'_C = (0.2627R + 0.6780G + 0.0593B)'$	$Y' = 0.2627R' + 0.6780G' + 0.0593B'$
色差信号的衍生物	$C'_{BC} = \begin{cases} \frac{B'-Y'_C}{-2N_B}, & N_B \le B'-Y'_C \le 0 \\ \frac{B'-Y'_C}{2P_B}, & 0 < B'-Y'_C \le P_B \end{cases}$ $C'_{RC} = \begin{cases} \frac{R'-Y'_C}{-2N_R}, & N_R \le R'-Y'_C \le 0 \\ \frac{R'-Y'_C}{2P_R}, & 0 < R'-Y'_C \le P_R \end{cases}$ 其中 $P_B = \alpha(1-0.0593^{0.45}) = 0.7909854\ldots$ $N_B = \alpha(1-0.9407^{0.45}) - 1 = -0.9701716\ldots$ $P_R = \alpha(1-0.2627^{0.45}) = 0.4969147\ldots$ $N_R = \alpha(1-0.7373^{0.45}) - 1 = -0.8591209\ldots$ 在实际中，可采用以下数值： $P_B = 0.7910,\ N_B = -0.9702$ $P_R = 0.4969,\ N_R = -0.8591$	$C'_B = \frac{B'-Y'}{1.8814}$ $C'_R = \frac{R'-Y'}{1.4746}$

BT 2020

2YUV

BT 601

CSC

CSM

RGB[]→YUV

HSV

RGB2YUV

CSC

RGB2HSV

CSM gamma

HSV

02 转换的作用

转换的作用

RGB -> YUV

YUV的作用

- 最早是为了适配彩色电视和黑白电视的兼容问题
- 将Y和UV分量分开，利用人眼对各自灵敏度的不同单独处理
- 为后续的数据压缩做准备

30fps

RGB => YUV

H264 H265

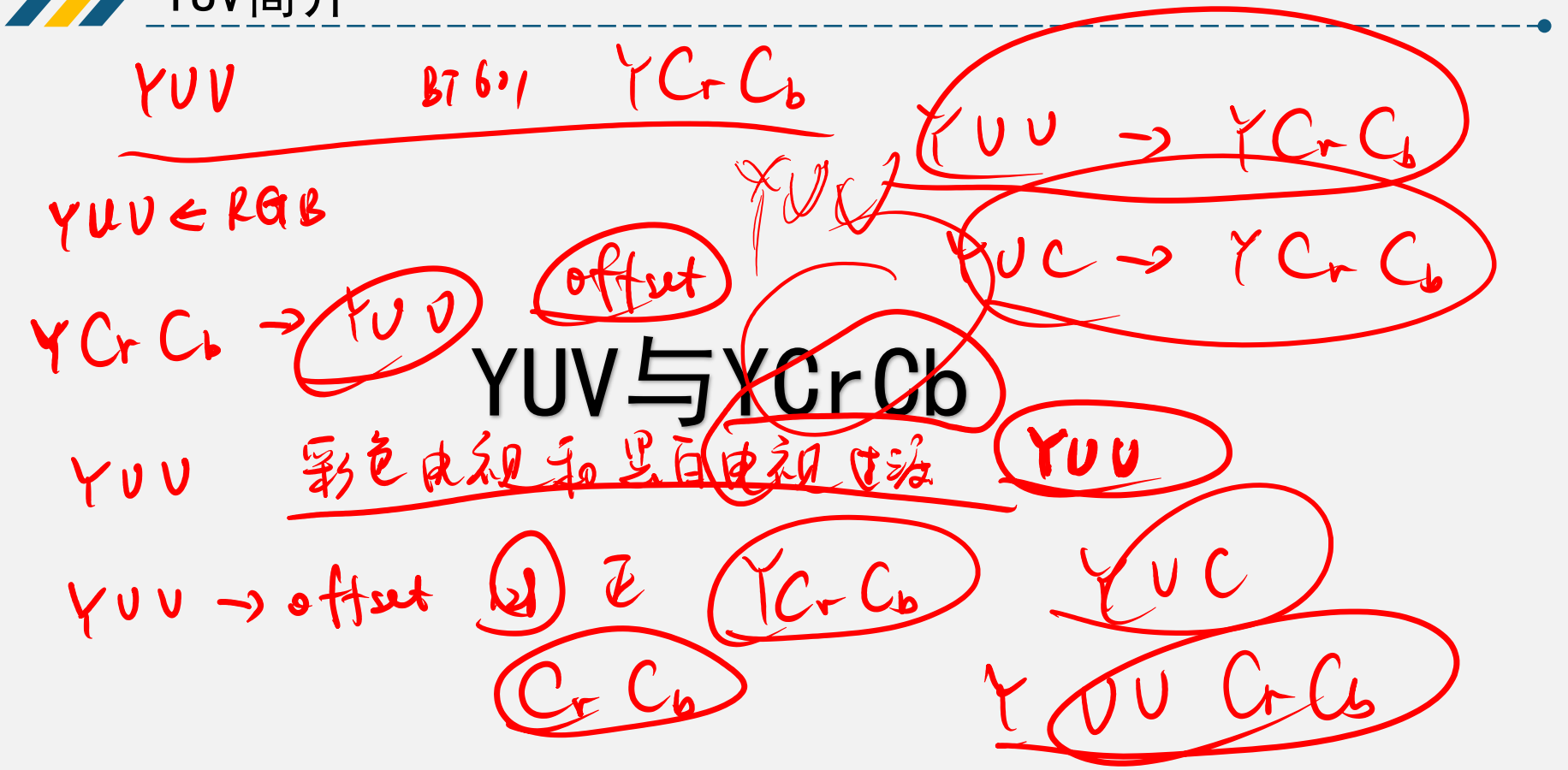
mjpg YUV H264 H265

4K YUV 30fps

4K mjpg 30fps

03 YUV简介

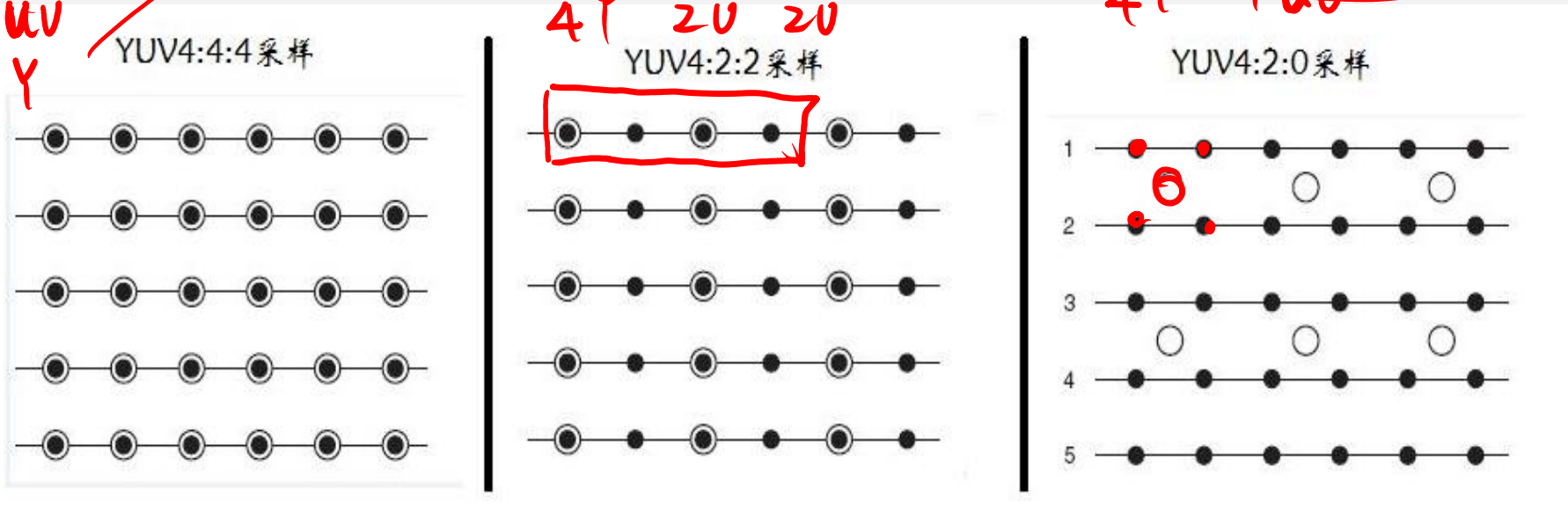
YUV简介


YUV
BT601
YCrCb
YUV ∈ RGB
YCrCb → YUV
offset
YUV → YCrCb
YUV → YCrCb
YUV与YCrCb
YUV
彩色电视和黑白电视信号
YUV
YUV → offset
Y
CrCb
YCrCb
YUV
Y
UV CrCb

YUV简介

常见的YUV格式

YUV444　　YUV422　　YUV420



YUV简介

IPC

UVC

amcap

window API

WMMEDIASUBTYPE_I420	YUV video stored in planar 4:2:0 format, with the U plane appearing first, followed by the V plane.
WMMEDIASUBTYPE_IYUV	Identical to I420.
WMMEDIASUBTYPE_YV12	YUV video stored in planar 4:2:0 format, with the V plane appearing first, followed by the U plane. YV12 is identical to I420 except that the U and V planes are switched.
WMMEDIASUBTYPE_YUY2	YUV video stored in packed 4:2:2 format.
WMMEDIASUBTYPE_UYVY	YUV video stored in packed 4:2:2 format. Similar to YUY2 but with different ordering of data.
WMMEDIASUBTYPE_YVYU	YUV video stored in packed 4:2:2 format. Similar to YUY2 but with different ordering of data.
WMMEDIASUBTYPE_P422	YUV video stored using a planar 4:2:2 format.
WMMEDIASUBTYPE_YVU9	YUV video stored in planar 16:1:1 format.

YUY2 → YUYV

422

YUYV YUYV

NV12 YUV420

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See You!