

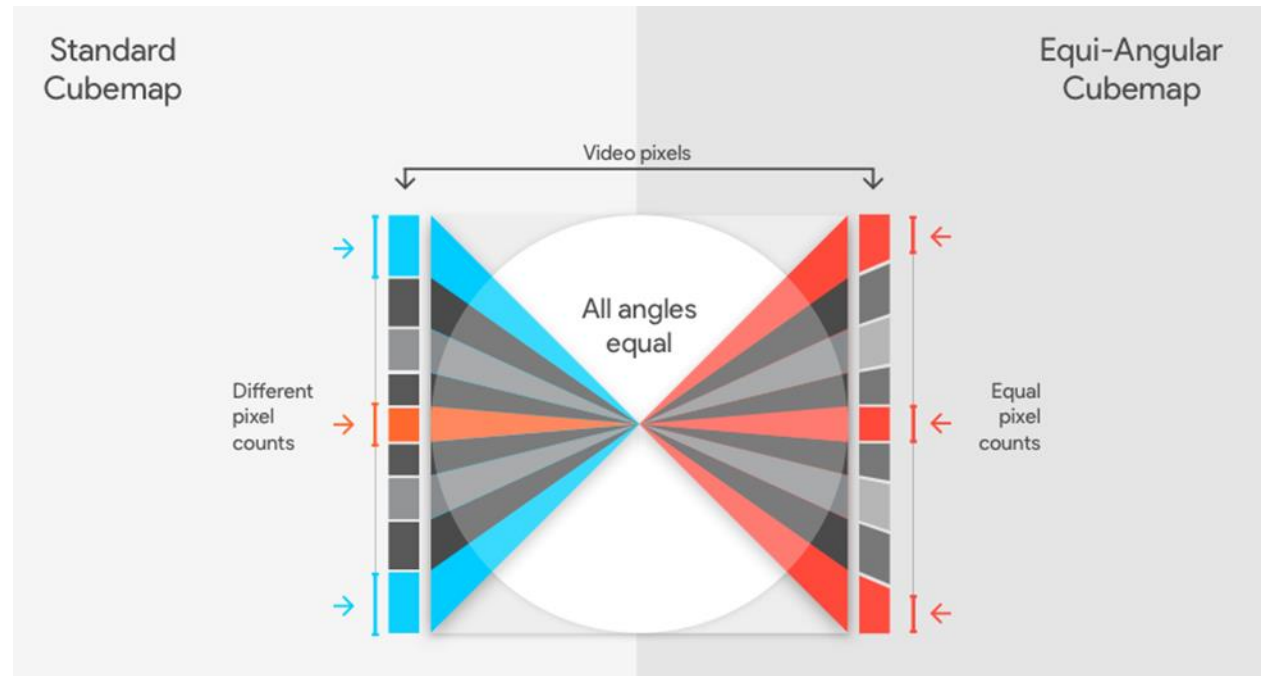
**JVET-G0056**

# **AHG8: A study on Equi-Angular Cubemap projection (EAC)**

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# Equi-Angular Cubemap (EAC) Projection

- Being used by YouTube 360 video
- Equi-Angular Cubemap Projection (EAC) <https://blog.google/products/google-vr/bringing-pixels-front-and-center-vr-video/>
- Design philosophy similar to ACP



# 3D to 2D Mapping – EAC vs. ACP

- Step 1: Determine cube face ID  $f$  and  $(u', v')$  from  $(X, Y, Z)$

Condition		$f$	$u'$	$v'$
$ X  \geq  Y $ and $ X  \geq  Z $ and $X > 0$		0	$-Z/ X $	$-Y/ X $
$ X  \geq  Y $ and $ X  \geq  Z $ and $X < 0$		1	$Z/ X $	$-Y/ X $
$ Y  \geq  X $ and $ Y  \geq  Z $ and $Y > 0$		2	$X/ Y $	$Z/ Y $
$ Y  \geq  X $ and $ Y  \geq  Z $ and $Y < 0$		3	$X/ Y $	$-Z/ Y $
$ Z  \geq  X $ and $ Z  \geq  Y $ and $Z > 0$		4	$X/ Z $	$-Y/ Z $
$ Z  \geq  X $ and $ Z  \geq  Y $ and $Z < 0$		5	$-X/ Z $	$-Y/ Z $

- Step 2: Mapping  $(u', v')$  to  $(u, v)$

– EAC

$$\begin{cases} u = \frac{4}{\pi} \tan^{-1} u' \\ v = \frac{4}{\pi} \tan^{-1} v' \end{cases}$$

– ACP

$$\begin{cases} u = \text{sgn}(u')(-0.36u'^2 + 1.36|u'|) \\ v = \text{sgn}(v')(-0.36v'^2 + 1.36|v'|) \end{cases}$$

- Step 3: Determine  $(m, n)$  on face  $f$  by solving the following equations

$$\begin{cases} u = (m + 0.5) * 2 / A - 1, & 0 \leq m < A \\ v = (n + 0.5) * 2 / A - 1, & 0 \leq n < A \end{cases}$$

# Experimental Results – With Compression

- Software HM16.15 + 360Lib-3.0, JVET 360 CTC

EAC vs. ERP	FW	FH	SPSNR-NN (End to End)			SPSNR-I (End to End)			CPP-PSNR (End to End)			WS-PSNR (End to End)		
			Y	U	V	Y	U	V	Y	U	V	Y	U	V
Trolley	1184	1184	-7.7%	2.8%	-1.9%	-7.8%	2.6%	-2.1%	-7.8%	2.6%	-2.1%	-7.7%	2.7%	-2.1%
GasLamp	1184	1184	-4.3%	2.2%	7.2%	-4.3%	2.0%	7.1%	-4.3%	2.0%	7.0%	-4.2%	2.1%	7.2%
Skateboarding_in_lot	1184	1184	-16.1%	-16.0%	-16.5%	-16.3%	-16.2%	-16.6%	-16.1%	-16.2%	-16.6%	-16.0%	-16.0%	-16.4%
Chairlift	1184	1184	-25.3%	-18.5%	-19.1%	-25.3%	-18.6%	-19.1%	-25.3%	-18.5%	-19.2%	-25.3%	-18.5%	-19.1%
KiteFlite	1184	1184	-10.1%	-3.5%	-4.8%	-10.2%	-3.6%	-4.9%	-10.1%	-3.5%	-4.8%	-10.0%	-3.4%	-4.7%
Harbor	1184	1184	-8.9%	-3.2%	-2.1%	-9.2%	-3.4%	-2.2%	-9.4%	-3.4%	-2.3%	-9.2%	-3.3%	-2.2%
PoleVault	960	960	-9.6%	-11.2%	-11.2%	-8.9%	-11.1%	-11.2%	-8.9%	-11.1%	-11.3%	-9.5%	-11.1%	-11.1%
AerialCity	960	960	-2.1%	-0.7%	-0.1%	-2.2%	-1.1%	-0.6%	-2.1%	-1.1%	-0.6%	-2.0%	-0.6%	-0.2%
DrivingInCity	960	960	-4.8%	5.6%	5.2%	-4.0%	4.9%	4.5%	-3.9%	4.9%	4.6%	-4.7%	5.6%	5.3%
DrivingInCountry	960	960	-21.8%	-17.0%	-17.4%	-20.9%	-17.4%	-17.7%	-20.9%	-17.4%	-17.6%	-21.8%	-17.0%	-17.3%
Overall (EAC)			-11.1%	-6.0%	-6.1%	-10.9%	-6.2%	-6.3%	-10.9%	-6.2%	-6.3%	-11.0%	-6.0%	-6.1%
Overall (ACP)			-11.1%	-6.2%	-6.3%	-11.0%	-6.3%	-6.4%	-11.0%	-6.3%	-6.5%	-11.0%	-6.1%	-6.3%

# Experimental Results – Conversion Only

- Software HM16.15 + 360Lib-3.0 (T&Q bypass mode), JVET 360 CTC

EAC	FW	FH	E2ESPSN R-NN Y	E2ESPSN R-NN U	E2ESPSN R-NN V	E2ESPSN R-I Y	E2ESPSN R-I U	E2ESPSN R-I V	E2ECPP- PSNR Y	E2ECPP- PSNR U	E2ECPP- PSNR V	E2EWS- PSNR Y	E2EWS- PSNR U	E2EWS- PSNR V
Trolley	1184	1184	45.3331	57.9678	57.8545	45.8094	59.3702	59.2776	45.7452	59.4081	59.3254	45.2936	57.9663	57.8606
GasLamp	1184	1184	50.2028	58.7924	57.649	50.6968	60.2271	59.0406	50.6626	60.2566	59.0843	50.1451	58.7901	57.6505
Skateboarding_in_lot	1184	1184	49.6859	61.3754	61.0462	50.0872	62.1938	61.8824	50.0974	62.2225	61.9005	49.6775	61.4181	61.0709
Chairlift	1184	1184	50.0006	59.5187	59.5881	50.3483	60.3169	60.4665	50.3435	60.3473	60.4944	49.9835	59.5274	59.6056
KiteFlite	1184	1184	46.4411	57.6711	57.6637	46.8944	59.0523	59.0361	46.8738	59.0941	59.0784	46.4212	57.685	57.6762
Harbor	1184	1184	48.9421	59.0934	58.08	49.4112	60.5285	59.4766	49.3728	60.575	59.5174	48.9166	59.1112	58.0879
PoleVault	960	960	51.0057	51.8535	53.715	52.5897	53.6275	55.5609	52.5749	53.8206	55.772	51.0086	51.8742	53.7288
AerialCity	960	960	48.1705	56.169	55.4435	49.736	58.0037	57.325	49.7059	58.2295	57.5442	48.1479	56.1585	55.4337
DrivingInCity	960	960	52.5878	59.7649	59.2955	53.9742	61.2634	60.7844	53.9836	61.4388	60.9353	52.5863	59.7706	59.2711
DrivingInCountry	960	960	49.0837	60.717	60.7136	50.65	62.2241	62.2024	50.6605	62.383	62.3591	49.091	60.6896	60.6899
Overall (EAC)			<b>49.14533</b>	<b>58.29232</b>	<b>58.10491</b>	<b>50.01972</b>	<b>59.68075</b>	<b>59.50525</b>	<b>50.00202</b>	<b>59.77755</b>	<b>59.6011</b>	<b>49.12713</b>	<b>58.2991</b>	<b>58.10752</b>
Overall (ACP)			<b>48.58446</b>	<b>57.60202</b>	<b>57.39933</b>	<b>49.52955</b>	<b>59.08333</b>	<b>58.89526</b>	<b>49.49713</b>	<b>59.14924</b>	<b>58.95878</b>	<b>48.55732</b>	<b>57.61221</b>	<b>57.41121</b>

# Recommendation

- EAC will likely be an important projection format thanks to YouTube
- Suggest to include it in 360Lib for further study