m60213

[V-DMC][New][EE 4.1 related]
1D displacements coding for the displaced subdivision surface

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Overview

- In the CfP response from Apple, mesh data is reconstructed by subdividing a base mesh with the additional displacements for the subdivision surface, where displacements are coded by a 3D vector.
- It is proposed that the 1D displacement coding for the displaced subdivision surface in the V-DMC.
- The proposed method can reduce the displacement bits and improve the coding performance.

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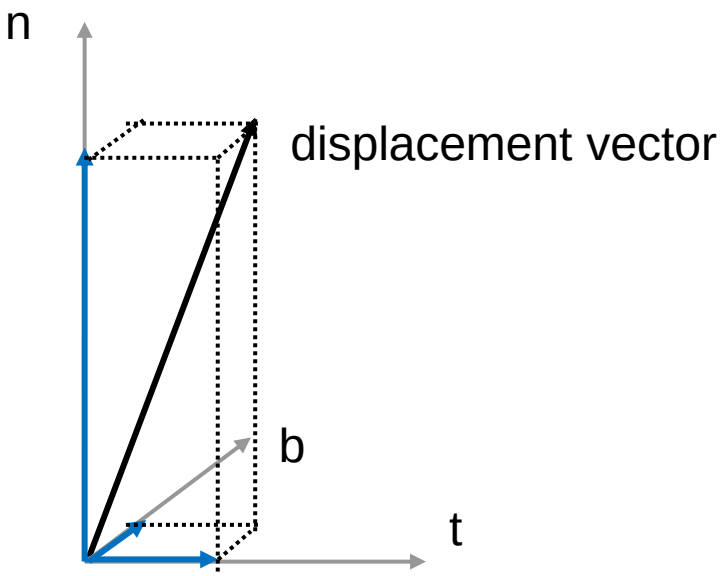
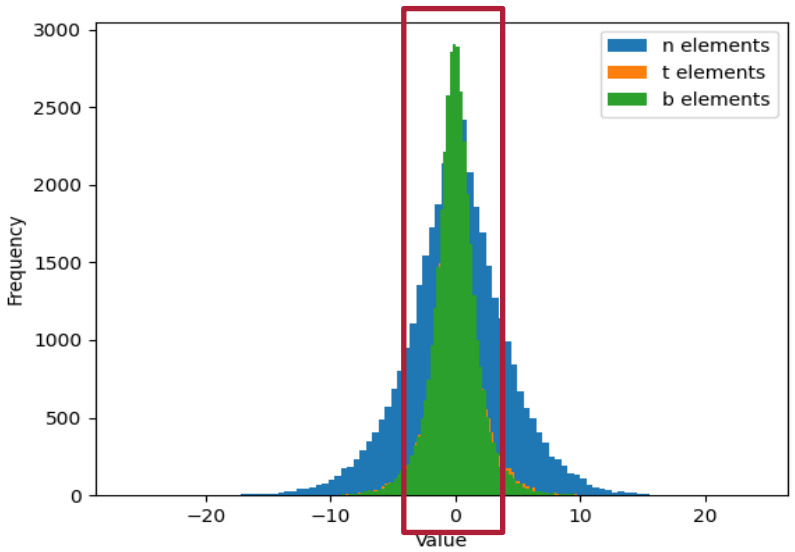
Problem statements

- **The software provided by Apple implements the local coordinate system, which defines the normal direction as the n-axis, and t-axis and b-axis as orthogonal to the n-axis.**
- **Most of the t-axis and b-axis values distributes in a neighborhood of zero. Therefore, the coding efficiency will be improved when such values are not coded.**



Local coordinate system



Distribution of each element of the displacements.

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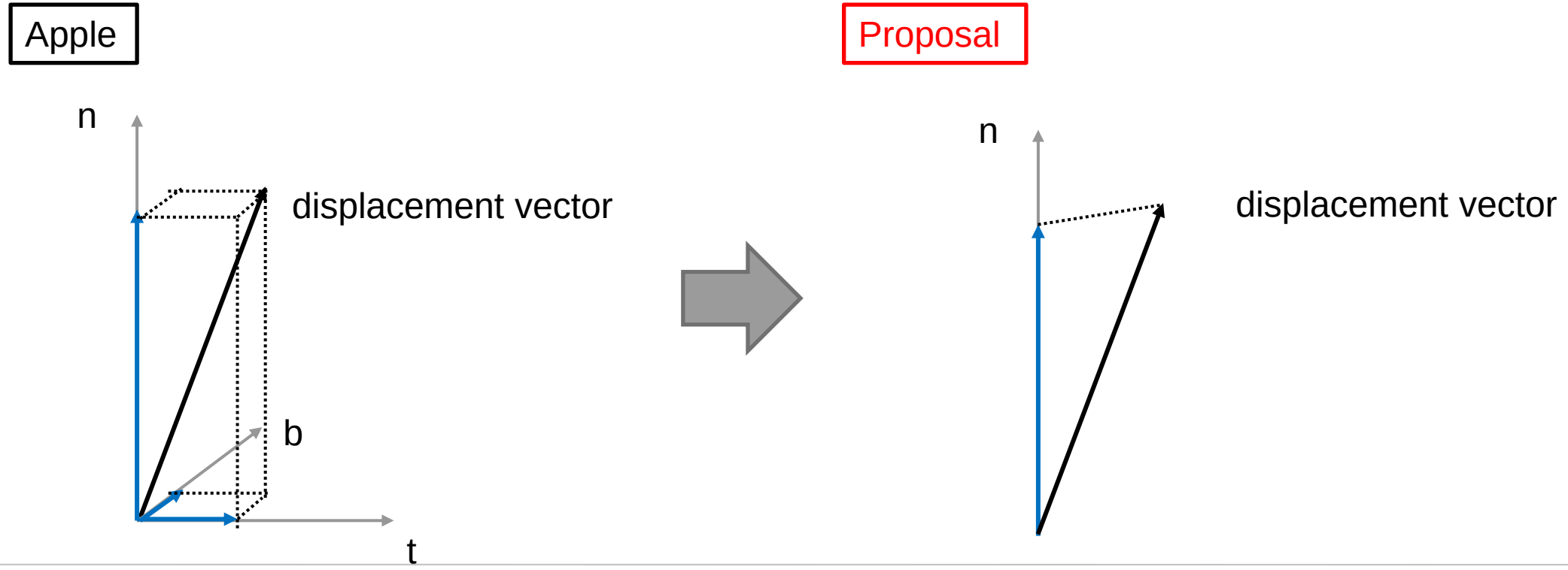
Proposed method

- **We propose a one-dimensional displacement coding instead of three dimensional one. In the detail of the decoding process, the inverse wavelet transform is applied for one component**
- **A normal vector of each vertex is derived and used for the signalled norm (n-axis value) in reconstructing the displacement vector.**



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Simulation results

- **Using the same experimental configuration in the CfP response from Apple, we implement the proposal on top of the provided software.**
- **It is confirmed that BD-rates are improved by the proposed 1D displacement coding.**
- **The proposed method can reduce by 12% at most in geometry coding.**

C1_ai	lossy geometry, lossy attributes [all intra]						
	Pointcloud-based BD-TotalRate [%]					Image-based BD-TotalRate [%]	
	D1	D2	Luma	Chroma Cb	Chroma Cr	Geom	Luma
Cat1-A average	0.0%	0.0%	-2.4%	-3.0%	-3.8%	-0.1%	0.0%
Cat1-B average	1.7%	1.9%	-1.9%	-2.2%	-2.4%	1.2%	0.0%
Cat1-C average	0.1%	0.1%	-0.2%	-0.4%	-0.5%	0.0%	-0.1%
Overall average	0.5%	0.6%	-1.0%	-1.3%	-1.5%	0.3%	-0.1%

Averaged BD-rate against the CfP Response for C1-AI condition (other than Longdress datasets)

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Conclusion

- In the CfP response from Apple in the April 2022 meeting, mesh data is reconstructed by subdividing a base mesh with the additional displacements for the subdivision surface, where displacements are coded by a 3D vector.
- It is proposed that the 1D displacement coding for the displaced subdivision surface in the V-DMC.
- The proposed method can reduce the displacement bits and improve the coding performance.
- It is recommended to consider this approach in future exploration or core experiments.

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Reference materials

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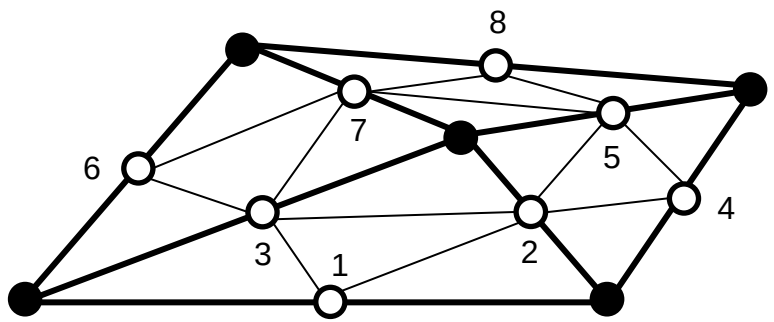
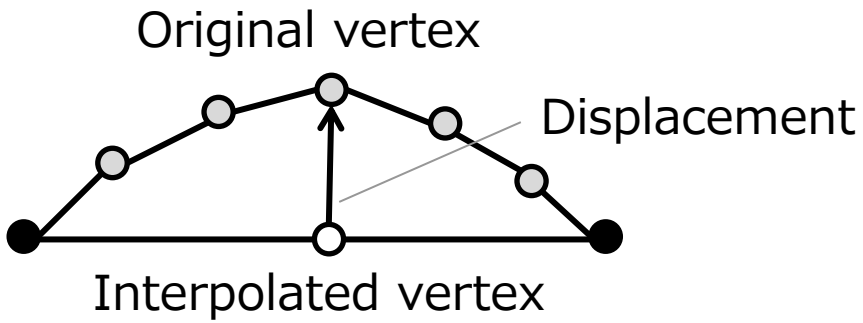
Subdivision with displacement

- **Displacement coding in local coordination instead of the global one.**
  - **A normal vector is derived for each interpolated vertex from adjacent faces.**
  - **A norm of the normal vector represents dominant energy.**
  - **The remaining component is truncated to zero.**
- **A bit amount of coded displacements are 16% reduced in maximum.**
  - **Geometry loss is 0.0% ~ 1.7%. Encoder optimization is future work.**



● Coded vertex
○ Interpolated vertex by subdivision



● Original vertex before decimation

Subdivision with displacement

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Averaged BD-rate against the CfP Response

C1_ai	lossy geometry, lossy attributes [all intra]						
	Pointcloud-based BD-TotalRate [%]					Image-based BD-TotalRate [%]	
	D1	D2	Luma	Chroma Cb	Chroma Cr	Geom	Luma
Cat1-A average	0.0%	0.0%	-2.4%	-3.0%	-3.8%	-0.1%	0.0%
Cat1-B average	1.7%	1.9%	-1.9%	-2.2%	-2.4%	1.2%	0.0%
Cat1-C average	0.1%	0.1%	-0.2%	-0.4%	-0.5%	0.0%	-0.1%
Overall average	0.5%	0.6%	-1.0%	-1.3%	-1.5%	0.3%	-0.1%
Avg. Enc Time [%]				90%			
Avg. Dec Time [%]				82%			

Averaged BD-rate against the CfP Response for C1-AI condition (other than Longdress datasets)

C2_ra	lossy geometry, lossy attributes [inter, random access]						
	Pointcloud-based BD-Rate [%]					Image-based BD-Rate [%]	
	D1	D2	Luma	Chroma Cb	Chroma Cr	Geom	Luma
Cat1-A average	1.3%	1.2%	-3.0%	-8.9%	-9.1%	0.5%	2.4%
Cat1-B average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Cat1-C average	-2.0%	-2.0%	-0.6%	-2.0%	-0.3%	-2.0%	-0.6%
Overall average	-1.2%	-1.2%	-1.2%	-3.7%	-2.5%	-1.4%	0.1%
Avg. Enc Time [%]				100%			
Avg. Dec Time [%]				99%			

Averaged BD-rate against the CfP Response for C1-RA condition (other than 4 datasets)

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		Anchor										proposal									
			Bitstream [bits]				Geometry Sub-bitstreams [bits]						Bitstream [bits]				Geometry Sub-bitstreams [bits]				
Sequence	Variant	No. output faces	Total	Geometry	Texture	Atlas	Base Mesh	Displacements	Motion	User Encoder runtime [s]	User Decoder runtime [s]	No. output faces	Total	Geometry	Texture	Atlas	Base Mesh	Displacements	Motion	User Encoder runtime [s]	User Decoder runtime [s]
longdress_voxelised	r01	22,565,248	49,653,280	18,057,752	31,589,288	6,240	9,045,456	9,012,296	0	5,893	89	22,565,248	48,437,640	16,849,992	31,581,408	6,240	9,045,456	7,804,536	0	5,900	90
longdress_voxelised	r02																				
longdress_voxelised	r03	4,306,254	119,432,576	53,702,712	65,723,624	6,240	50,467,592	3,235,120	0	5,825	100	4,306,254	119,432,576	53,702,712	65,723,624	6,240	50,467,592	3,235,120	0	5,834	101
longdress_voxelised	r04	5,745,427	148,114,824	72,000,464	76,108,120	6,240	64,217,744	7,782,720	0	5,864	104	5,745,427	146,904,056	70,794,616	76,103,200	6,240	64,217,744	6,576,872	0	5,855	104
longdress_voxelised	r05	11,991,502	214,393,400	112,260,128	102,127,032	6,240	112,170,368	89,760	0	6,052	125	11,991,502	214,393,400	112,260,128	102,127,032	6,240	112,170,368	89,760	0	6,058	125
soldier_voxelised	r01	22,502,208	49,631,776	21,030,944	28,594,592	6,240	9,559,768	11,471,176	0	9,607	177	22,502,208	48,082,912	19,462,760	28,613,912	6,240	9,559,768	9,902,992	0	6,018	90
soldier_voxelised	r02	45,357,312	87,671,536	45,177,824	42,487,472	6,240	14,823,432	30,354,392	0	9,943	188	45,357,312	82,804,088	40,307,584	42,490,264	6,240	14,823,432	25,484,152	0	6,240	96
soldier_voxelised	r03	45,357,312	115,844,288	45,177,824	70,660,224	6,240	14,823,432	30,354,392	0	10,134	192	45,357,312	110,929,424	40,307,584	70,615,600	6,240	14,823,432	25,484,152	0	6,397	98
soldier_voxelised	r04	5,743,426	147,610,960	74,311,648	73,293,072	6,240	67,554,784	6,756,864	0	9,821	201	5,743,426	147,126,000	73,812,784	73,306,976	6,240	67,554,784	6,258,000	0	5,801	102
soldier_voxelised	r05	11,991,306	219,711,152	118,303,120	101,401,792	6,240	118,213,360	89,760	0	9,805	233	11,991,306	219,711,152	118,303,120	101,401,792	6,240	118,213,360	89,760	0	6,152	130
basketball_player_voxelised	r01	22,706,176	29,704,960	9,325,880	20,372,840	6,240	8,200,440	1,125,440	0	7,368	96	22,706,176	29,695,736	9,324,336	20,365,160	6,240	8,200,440	1,123,896	0	7,589	99
basketball_player_voxelised	r02	22,706,176	48,740,496	20,630,984	28,103,272	6,240	8,200,440	12,430,544	0	7,366	98	22,706,176	46,794,592	18,818,288	27,970,064	6,240	8,200,440	10,617,848	0	7,607	98
basketball_player_voxelised	r03	45,428,736	98,616,944	30,948,904	67,661,800	6,240	13,538,920	17,409,984	0	7,545	102	45,428,736	96,682,376	29,209,040	67,467,096	6,240	13,538,920	15,670,120	0	7,710	101
basketball_player_voxelised	r04	4,260,068	137,007,296	59,985,552	77,015,504	6,240	59,792,400	193,152	0	6,768	101	4,260,068	137,007,296	59,985,552	77,015,504	6,240	59,792,400	193,152	0	6,870	101
basketball_player_voxelised	r05	5,680,239	200,344,248	76,843,936	123,494,072	6,240	76,748,048	95,888	0	6,623	107	5,680,239	200,344,248	76,843,936	123,494,072	6,240	76,748,048	95,888	0	6,733	107
dancer_voxelised	r01	22,661,952	29,882,736	9,188,448	20,688,048	6,240	8,006,576	1,181,872	0	7,438	105	22,661,952	29,885,232	9,187,112	20,691,880	6,240	8,006,576	1,180,536	0	7,461	103
dancer_voxelised	r02	22,661,952	50,099,120	21,140,352	28,952,528	6,240	8,006,576	13,133,776	0	7,455	107	22,661,952	47,990,920	19,143,632	28,841,048	6,240	8,006,576	11,137,056	0	7,436	104
dancer_voxelised	r03	45,333,248	97,630,512	29,469,928	68,154,344	6,240	13,258,000	16,211,928	0	7,658	106	45,333,248	96,127,288	28,115,440	68,005,608	6,240	13,258,000	14,857,440	0	7,638	106
dancer_voxelised	r04	4,250,865	136,616,520	58,685,240	77,925,040	6,240	58,494,960	190,280	0	6,868	103	4,250,865	136,616,520	58,685,240	77,925,040	6,240	58,494,960	190,280	0	6,809	102
dancer_voxelised	r05	5,667,892	195,877,968	75,154,792	120,716,936	6,240	74,957,920	196,872	0	7,025	107	5,667,892	195,877,968	75,154,792	120,716,936	6,240	74,957,920	196,872	0	6,982	107
football_voxelised	r01	22,993,536	39,090,912	9,074,360	30,010,312	6,240	7,957,872	1,116,488	0	7,073	106	22,993,536	39,087,128	9,072,184	30,008,704	6,240	7,957,872	1,114,312	0	7,068	106
football_voxelised	r02	46,038,912	77,888,080	15,910,720	61,971,120	6,240	13,293,088	2,617,632	0	7,405	101	46,038,912	77,876,728	15,903,992	61,966,496	6,240	13,293,088	2,610,904	0	7,390	100
football_voxelised	r03	23,030,656	118,199,752	33,158,880	85,034,632	6,240	22,029,320	11,129,560	0	26,179	379	23,030,656	115,458,816	30,781,152	84,671,424	6,240	22,029,320	8,751,832	0	25,760	374
football_voxelised	r04	5,759,699	161,405,256	74,745,496	86,653,520	6,240	74,648,608	96,888	0	26,541	349	5,759,699	161,405,256	74,745,496	86,653,520	6,240	74,648,608	96,888	0	26,089	349
football_voxelised	r05	8,639,701	247,644,232	104,561,512	143,076,480	6,240	104,143,344	418,168	0	26,556	364	8,639,701	247,644,232	104,561,512	143,076,480	6,240	104,143,344	418,168	0	26,104	362
levi_voxelised	r01	11,259,904	19,398,728	5,290,880	14,104,728	3,120	4,434,312	856,568	0	2,344	30	11,259,904	19,387,640	5,283,256	14,101,264	3,120	4,433,968	849,288	0	3,507	49
levi_voxelised	r02	11,450,016	38,641,688	13,082,272	25,556,296	3,120	11,639,456	1,442,816	0	7,930	111	11,450,016	38,619,704	13,062,992	25,553,592	3,120	11,641,168	1,421,824	0	13,435	165
levi_voxelised	r03	11,450,016	58,980,216	14,523,856	44,453,240	3,120	11,639,456	2,884,400	0	8,426	98	11,450,016	58,716,424	14,301,928	44,411,376	3,120	11,641,168	2,660,760	0	13,837	172
levi_voxelised	r04	1,435,274	83,867,408	21,693,320	62,170,968	3,120	21,663,928	29,392	0	8,025	101	1,435,274	83,821,288	21,692,104	62,126,064	3,120	21,662,712	29,392	0	12,988	176
levi_voxelised	r05	2,874,792	117,637,992	37,775,536	79,859,336	3,120	37,656,184	119,352	0	7,988	100	2,874,792	117,579,296	37,768,112	79,808,064	3,120	37,648,760	119,352	0	13,587	179
mitch_voxelised	r01	17,189,312	38,941,904	15,707,168	23,228,496	6,240	6,740,632	8,966,536	0	6,130	91	17,189,312	37,654,216	14,460,544	23,187,432	6,240	6,740,632	7,719,912	0	6,135	90
mitch_voxelised	r02	34,432,704	58,696,424	20,672,992	38,017,192	6,240	11,124,200	9,548,792	0	6,280	94	34,432,704	58,218,336	20,217,792	37,994,304	6,240	11,124,200	9,093,592	0	6,285	94
mitch_voxelised	r03	4,308,727	103,658,544	62,893,784	40,758,520	6,240	62,834,016	59,768	0	23,420	336	4,308,727	103,658,544	62,893,784	40,758,520	6,240	62,834,016	59,768	0	23,278	335
mitch_voxelised	r04	6,463,167	156,277,240	88,203,912	68,067,088	6,240	88,109,256	94,656	0	23,854	345	6,463,167	156,277,240	88,203,912	68,067,088	6,240	88,109,256	94,656	0	23,642	349
mitch_voxelised	r05	6,463,167	238,837,176	88,203,912	150,627,024	6,240	88,109,256	94,656	0	24,404	360	6,463,167	238,837,176	88,203,912	150,627,024	6,240	88,109,256	94,656	0	24,274	361
thomas_voxelised	r01	34,506,944	37,998,384	17,646,808	20,345,336	6,240	10,761,360	6,885,448	0	9,236	179	34,506,944	37,847,312	17,496,544	20,344,528	6,240	10,761,360	6,735,184	0	5,991	90
thomas_voxelised	r02	34,506,944	58,231,272	20,594,680	37,630,352	6,240	10,761,360	9,833,320	0	9,442	181	34,506,944	57,647,032	20,031,080	37,609,712	6,240	10,761,360	9,269,720	0	6,098	93
thomas_voxelised	r03	4,315,502	108,437,496	61,537,632	46,893,624	6,240	61,381,808	155,824	0	35,135	642	4,315,502	108,437,496	61,537,632	46,893,624	6,240	61,381,808	155,824	0	21,428	335
thomas_voxelised	r04	5,394,392	153,240,080	74,081,800	79,152,040	6,240	73,904,288	177,512	0	35,504	665	5,394,392	153,240,080	74,081,800	79,152,040	6,240	73,904,288	177,512	0	21,754	345
thomas_voxelised	r05	5,394,392	225,300,864	74,081,800	151,212,824	6,240	73,904,288	177,512	0	35,905	672	5,394,392	225,300,864	74,081,800	151,212,824	6,240	73,904,288	177,512	0	22,111	355

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