Data for the Pattern Recognition paper, including a comparison with state-of-the-art methods and images used for medical analysis.

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1 Appendix B. Comparison of state-of-the-art methods with our method.

This document presents Tables 1, 2, and 3, which compare state-of-the-art methods with our approach for the 66 voxelized objects used in Experiment 3. The results demonstrate identical values for shape descriptors, simplexes, and tetravoxels. Only 12 objects from the sample are shown to verify the accuracy of these formulas, but the complete dataset can be requested via email at Cesareduardomucha@hotmail.com.

Additionally, Tables 4, 5, 6, 7, and 8 provide a comparison with Experiment 4, which focused on medical images from the BraTS 2020 dataset. In this case, the results also show that our method achieved 100% accuracy across all cases.

In Figure 1, some of the images of specimens from the BraTS 2020 dataset are displayed, featuring six tumor samples.

Table 1: Comparison between the state-of-the-art approach and the formulas discovered for each model. Part 1

		Results	
Test images	**Descriptors and Simplexes**	**Traditional methods**	**All formulas found**
Axolotl	Euler	-1	-1
	ES	248648	248648
	CS	9461726	9461726
	Volume	3195350	3195350
	Points	3321260	3321260
	Edges	9836285	9836285
	Faces	9710374	9710374
	Tetravoxels	0	0
Babydragon	Euler	-8	-8
	ES	61306	61306
	CS	768799	768799
	Volume	266484	266484
	Points	298021	298021
	Edges	861650	861650
	Faces	830105	830105
	Tetravoxels	739038	739038
Bird	Euler	-1	-1
	ES	21880	21880
	CS	301003	301003
	Volume	103981	103981
	Points	115438	115438
	Edges	334341	334341
	Faces	322883	322883
	Tetravoxels	290581	290581
Cheese	Euler	-2	-2
	ES	81148	81148
	CS	2143672	2143672
	Volume	728082	728082
	Points	769004	769004
	Edges	2265744	2265744
	Faces	2224820	2224820
	Tetravoxels	2103448	2103448

Table 2: Comparison between the state-of-the-art approach and the formulas discovered for each model. Part 2

		Results	
Test images	**Descriptors and Simplexes**	**Traditional methods**	**All formulas found**
Cup	Euler	0	0
	ES	5788	5788
	CS	12520	12520
	Volume	5138	5138
	Points	8120	8120
	Edges	21290	21290
	Faces	18308	18308
	Tetravoxels	9714	9714
Torus	Euler	0	0
	ES	6538	6538
	CS	26137	26137
	Volume	9802	9802
	Points	13294	13294
	Edges	36167	36167
	Faces	32675	32675
	Tetravoxels	23091	23091
Torush	Euler	-1	-1
	ES	6712	6712
	CS	25687	25687
	Volume	9681	9681
	Points	13255	13255
	Edges	35974	35974
	Faces	32399	32399
	Tetravoxels	22550	22550
Vase	Euler	0	0
	ES	20440	20440
	CS	34672	34672
	Volume	14964	14964
	Points	25226	25226
	Edges	65374	65374
	Faces	55112	55112
	Tetravoxels	24494	24494

Table 3: Comparison between the state-of-the-art approach and the formulas discovered for each model. Part 3

		Results	
Test images	**Descriptors and Simplexes**	**Traditional methods**	**All formulas found**
Bird	Euler	-1	-1
	ES	21880	21880
	CS	301003	301003
	Volume	103981	103981
	Points	115438	115438
	Edges	334341	334341
	Faces	322883	322883
	Tetravoxels	290581	290581
Elephant	Euler	1	1
	ES	40248	40248
	CS	646761	646761
	Volume	222295	222295
	Points	242931	242931
	Edges	707644	707644
	Faces	687009	687009
	Tetravoxels	627148	627148
Gun	Euler	-7	-7
	ES	23422	23422
	CS	215719	215719
	Volume	75810	75810
	Points	87922	87922
	Edges	251260	251260
	Faces	239141	239141
	Tetravoxels	204416	204416
Moon	Euler	1	1
	ES	77350	77350
	CS	3199273	3199273
	Volume	1079316	1079316
	Points	1118377	1118377
	Edges	3315683	3315683
	Faces	3276623	3276623
	Tetravoxels	3160983	3160983

Table 4: Comparison of four images from the BRATS dataset and demonstration of the most effective formulas using the OMP model, achieving a perfect accuracy of 100%. Samples 1 through 4 are presented.

		Results	
Brain tumor Images	**Descriptors and Simplexes**	**Traditional methods**	**Best Formulas Found**
Specimen 1	Euler	-12	-12
	ES	55120	55120
	CS	608377	608377
	Volume	211979	211979
	Points	240094	240094
	Edges	691624	691624
	Faces	663497	663497
	Tetravoxels	581384	581384
Specimen 2	Euler	-16	-16
	ES	25402	25402
	CS	188323	188323
	Volume	67008	67008
	Points	80316	80316
	Edges	227049	227049
	Faces	213725	213725
	Tetravoxels	176245	176245
Specimen 3	Euler	10	10
	ES	16468	16468
	CS	81187	81187
	Volume	29807	29807
	Points	38466	38466
	Edges	106304	106304
	Faces	97655	97655
	Tetravoxels	73368	73368
Specimen 4	Euler	10	10
	ES	27556	27556
	CS	296710	296710
	Volume	103496	103496
	Points	117567	117567
	Edges	338327	338327
	Faces	324266	324266
	Tetravoxels	283215	283215

Table 5: Comparison of four images from the BRATS dataset and demonstration of the most effective formulas using the OMP model, achieving a perfect accuracy of 100%. Samples 5 through 8 are presented.

		Results	
Brain tumor Images	**Descriptors and Simplexes**	**Traditional methods**	**Best Formulas Found**
Specimen 5	Euler	5	5
	ES	10430	10430
	CS	60674	60674
	Volume	21963	21963
	Points	27460	27460
	Edges	76596	76596
	Faces	71104	71104
	Tetravoxels	55736	55736
Specimen 6	Euler	-5	-5
	ES	42586	42586
	CS	396397	396397
	Volume	139230	139230
	Points	161332	161332
	Edges	461090	461090
	Faces	438983	438983
	Tetravoxels	375918	375918
Specimen 7	Euler	10	10
	ES	17536	17536
	CS	110548	110548
	Volume	39772	39772
	Points	49054	49054
	Edges	137356	137356
	Faces	128084	128084
	Tetravoxels	102284	102284
Specimen 8	Euler	-23	-23
	ES	21736	21736
	CS	89470	89470
	Volume	33446	33446
	Points	44560	44560
	Edges	122343	122343
	Faces	111206	111206
	Tetravoxels	78871	78871

Table 6: Comparison of four images from the BRATS dataset and demonstration of the most effective formulas using the OMP model, achieving a perfect accuracy of 100%. . Samples 9 through 12 are presented.

		Results	
Brain tumor Images	**Descriptors and Simplexes**	**Traditional methods**	**Best Formulas Found**
Specimen 9	Euler	-30	-30
	ES	62614	62614
	CS	517975	517975
	Volume	183094	183094
	Points	215244	215244
	Edges	612769	612769
	Faces	580589	580589
	Tetravoxels	487541	487541
Specimen 10	Euler	-26	-26
	ES	28744	28744
	CS	119374	119374
	Volume	44582	44582
	Points	60014	60014
	Edges	163576	163576
	Faces	148118	148118
	Tetravoxels	106088	106088
Specimen 11	Euler	-4	-4
	ES	19214	19214
	CS	155783	155783
	Volume	55130	55130
	Points	65250	65250
	Edges	185121	185121
	Faces	174997	174997
	Tetravoxels	146693	146693
Specimen 12	Euler	-38	-38
	ES	17624	17624
	CS	87341	87341
	Volume	32051	32051
	Points	41632	41632
	Edges	114584	114584
	Faces	104965	104965
	Tetravoxels	79336	79336

Table 7: Comparison of four images from the BRATS dataset and demonstration of the most effective formulas using the OMP model, achieving a perfect accuracy of 100%. . Samples 13 through 16 are presented.

		Results	
Brain tumor Images	**Descriptors and Simplexes**	**Traditional methods**	**Best Formulas Found**
Specimen 13	Euler	-44	-44
	ES	21922	21922
	CS	128056	128056
	Volume	46339	46339
	Points	57960	57960
	Edges	161643	161643
	Faces	149978	149978
	Tetravoxels	117799	117799
Specimen 14	Euler	41	41
	ES	30630	30630
	CS	225873	225873
	Volume	80396	80396
	Points	95889	95889
	Edges	271955	271955
	Faces	256503	256503
	Tetravoxels	210695	210695
Specimen 15	Euler	48	48
	ES	36146	36146
	CS	357788	357788
	Volume	125287	125287
	Points	143807	143807
	Edges	412406	412406
	Faces	393934	393934
	Tetravoxels	340114	340114
Specimen 16	Euler	14	14
	ES	46408	46408
	CS	358363	358363
	Volume	127189	127189
	Points	150931	150931
	Edges	428499	428499
	Faces	404771	404771
	Tetravoxels	335683	335683

Table 8: Comparison of four images from the BRATS dataset and demonstration of the most effective formulas using the OMP model, achieving a perfect accuracy of 100%. . Samples 17 through 20 are presented.

		Results	
Brain tumor Images	**Descriptors and Simplexes**	**Traditional methods**	**Best Formulas Found**
Specimen 17	Euler	1	1
	ES	35146	35146
	CS	284701	284701
	Volume	100758	100758
	Points	118848	118848
	Edges	337936	337936
	Faces	319847	319847
	Tetravoxels	267644	267644
Specimen 18	Euler	-7	-7
	ES	28772	28772
	CS	120968	120968
	Volume	45118	45118
	Points	60233	60233
	Edges	164862	164862
	Faces	149740	149740
	Tetravoxels	107318	107318
Specimen 19	Euler	-55	-55
	ES	18638	18638
	CS	122072	122072
	Volume	43797	43797
	Points	53825	53825
	Edges	150793	150793
	Faces	140710	140710
	Tetravoxels	113517	113517
Specimen 20	Euler	18	18
	ES	47606	47606
	CS	503222	503222
	Volume	175675	175675
	Points	200110	200110
	Edges	575245	575245
	Faces	550828	550828
	Tetravoxels	480033	480033

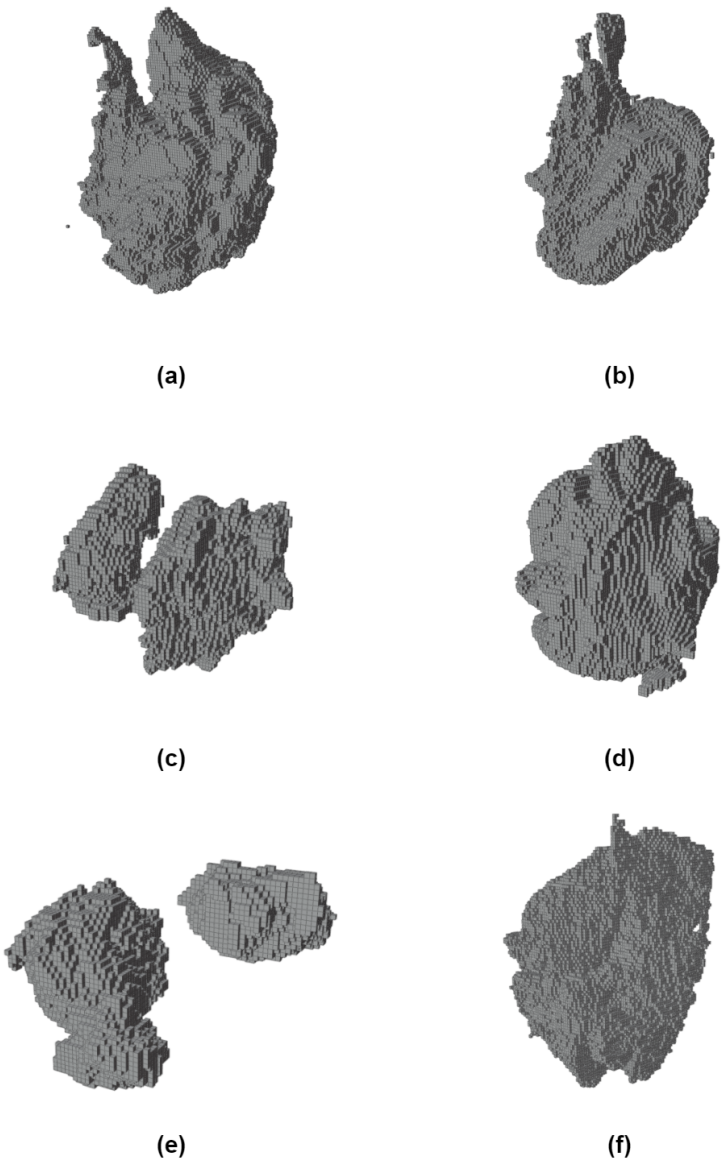

Figure 1: The images featured in the study by Menze et al. [1] illustrate brain tumors from the BRATS dataset. Specimen 1 is shown in image (a), Specimen 2 in image (b), Specimen 3 in image (c), Specimen 4 in image (d), Specimen 5 in image (e), and Specimen 6 in image (f). We extracted descriptors from all images in the dataset, with six representative images displayed here.

References

[1] B. H. Menze et al., 'The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS)', IEEE Transactions on Medical Imaging, vol. 34, no. 10, pp. 1993–2024, 2015.