

Results from Laboratory 3: Basic statistical recognizer of handwritten vowels with the use of moments of Hu

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Vowels values in Hu Moments			
	A	E	I
1	3.79393369e-03	2.46397614e-03	8.78079029e-03
2	2.97379659e-08	4.97091842e-07	7.53056093e-05
3	2.68146224e-09	1.67750408e-09	9.84160880e-08
4	2.49598574e-10	9.57608619e-10	1.04152405e-07
5	-1.52754729e-19	1.06750504e-18	1.05447547e-14
6	4.20017488e-14	6.37119753e-13	9.03714190e-10
7	-1.35507703e-19	5.77509919e-19	1.63766687e-17

Vowels values in Hu Moments		
	O	U
1	5.20396310e-03	4.23624291e-03
2	9.19235193e-07	3.94466800e-06
3	9.91031852e-10	2.70161763e-09
4	1.11186091e-09	3.98263776e-09
5	-1.01549261e-18	1.24977948e-17
6	1.05398421e-12	6.22500452e-12
7	5.75298946e-19	-3.80354029e-18

Abstract—The next paper is going to explain the implementation about a statistical recognizer of handwritten words using the moments of Hu and it's variants.

I. INTRODUCTION

This document is going to be shown the results from testing the vowels into different variants to demonstrate that the variation is really small. Showing that these features could be important to identify vowels.

II. VOWELS AND THEIR RESULTS

A. VOWELS AND THEIR ORIGINAL HU MOMENTS

Here are the different hu moments calculated for each vowel.

B. THE VARIANTS

For each vowel it's going to be 3 variants in rotation, 4 in translation and 4 in scaling.

- Rotation: for this section we did the rotation of the image, filling the rest of parts with warpAffine from OpenCV. After the rotation, then is calculated again the Hu moments of the new image. Then with the Hu moments from the original image, we compare if there is difference and can be shown that is just really small.
 - With 90 degrees.
 - With 180 degrees.
 - With 270 degrees.
- Scaling: for this section we did the scaling of the image with the help of OpenCV. After scaling, it was calculated the Hu moments with the new image, and

compared to check if they changed. There was only small differences.

- 2 times bigger.
- 4 times bigger.
- 8 times bigger.
- 16 times bigger.
- Translation: for this section we did the translations of the image, filling the rest of parts with warpAffine from OpenCV. After the translation, then is calculated again the Hu moments of the new image. Then with the Hu moments from the original image, we compare if there is difference and can be shown that is just really small.
 - To point (2,10)
 - To point (4,10)
 - To point (8,10)
 - To point (16,10)

C. VOWELS VALUES IN VARIANTS

The results for each transformation are going to be displayed in the next tables. The intention in this lab was to demonstrate that hu moments gives us similar numbers no matter the transformation (in rotation, scaling, and translation). At the end we concluded that the different moments with the transformations aren't equal at all, but pretty similar, which is understandable because to get some meaningful answers we have to take a log transformation.

The fact they are not identical is to be expected, in openCV for some images, the original and transformed images are a bit different.

Vowel A values in Hu Moments in Rotation			
	Rotation 90	Rotation 180	Rotation 270
1	0.0037939336881427	0.00379393368814272	0.0037939336881427
2	2.973796587233e-08	2.9737965872331e-08	2.97379658723e-08
3	2.6814622362767e-09	2.681462236276e-09	2.681462236276e-09
4	2.495985742001e-10	2.495985742001e-10	2.4959857420016e-10
5	-1.527547290630e-19	-1.5275472906304e-19	-1.5275472906304e-19
6	4.2001748825620e-14	4.200174882561e-14	4.200174882561e-14
7	-1.3550770298288e-19	-1.355077029828e-19	-1.3550770298284e-19

Vowel A values in Hu Moments in Scaling		
	Scaling to 2	Scaling to 4
1	0.003802489503888946	0.003802318686687756
2	9.477592198333114e-08	9.429480814631931e-08
3	2.8234642686246607e-09	2.8219181945435155e-09
4	2.555396305092324e-10	2.504149569280882e-10
5	-2.1673173465859755e-19	-2.1028919030930806e-19
6	-3.036698856037262e-14	-2.8759549547536485e-14
7	-1.1921664293550279e-20	-9.531556964273454e-21

Vowel A values in Hu Moments in Scaling		
	Scaling to 8	Scaling to 16
1	0.003802928062063834	0.0038027753497668453
2	9.461010836197473e-08	9.455606654329895e-08
3	2.8263383847175287e-09	2.8255733239331554e-09
4	2.5122448416587015e-10	2.51257258118108e-10
5	-2.115166856394493e-19	-2.115337364078665e-19
6	-2.880417331956189e-14	-2.878611057716438e-14
7	-8.620537157135969e-21	-8.515046045947124e-21

Vowel E values in Hu Moments in Translation		
	To point (8,10)	To point (16,10)
1	0.0024639761351316807	0.002454041671529576
2	4.970918419076068e-07	4.74230700815302e-07
3	1.6775040776722247e-09	1.660584702084221e-09
4	9.576086187805253e-10	9.418782233659015e-10
5	1.067505038963147e-18	1.0270646507939085e-18
6	6.371197527827716e-13	6.099621369981037e-13
7	5.775099189723737e-19	5.767820455429694e-19

Vowel A values in Hu Moments in Translation		
	To point (2,10)	To point (4,10)
1	0.00379393368814272	0.00379393368814272
2	2.973796587233241e-08	2.973796587233241e-08
3	2.6814622362763352e-09	2.681462236276325e-09
4	2.4959857420016847e-10	2.495985742001638e-10
5	-1.5275472906303483e-19	-1.5275472906302987e-19
6	4.20017488256181e-14	4.200174882561734e-14
7	-1.3550770298285052e-19	-1.3550770298284684e-19

Vowel I values in Hu Moments in Rotation			
	Rotation 90	Rotation 180	Rotation 270
1	0.002467041119401	0.00878079028685	0.0024670411194017
2	5.202730940377e-06	7.530560925398e-05	5.20273094037e-06
3	6.587554563727e-11	9.84160880165e-08	6.5875545637e-11
4	8.73210792343e-11	1.041524054693e-07	8.73210792343e-11
5	6.3797746019301e-21	1.0544754725600e-14	6.3797746019146e-21
6	1.5210660267775e-13	9.037141901280e-10	1.521066026779e-13
7	-1.777576167759e-21	1.637666871513e-17	-1.777576167782e-21

Vowel A values in Hu Moments in Translation		
	To point (8,10)	To point (16,10)
1	0.00379393368814272	0.003788546142674309
2	2.973796587233241e-08	1.6648409175417462e-08
3	2.681462236276323e-09	2.3209769162392783e-09
4	2.4959857420017943e-10	2.7106873393150617e-10
5	-1.527547290630412e-19	-1.7090882430931013e-19
6	4.200174882561984e-14	3.497548600940721e-14
7	-1.3550770298286282e-19	-1.3045535402578455e-19

Vowel I values in Hu Moments in Scaling		
	Scaling to 2	Scaling to 4
1	0.0018499888405264107	0.0018451965066905872
2	1.4471307374796173e-06	1.4416006278132214e-06
3	5.418380163219132e-11	5.30869842203878e-11
4	8.138141938817186e-10	7.979290016397239e-10
5	1.4832686731749483e-19	1.383922214248974e-19
6	9.529905605828299e-13	9.328184404444132e-13
7	8.487247107597083e-20	8.841710405202907e-20

Vowel E values in Hu Moments in Rotation			
	Rotation 90	Rotation 180	Rotation 270
1	0.002463976135131	0.0024639761351316	0.002463976135131
2	4.970918419076e-07	4.970918419076e-07	4.97091841907e-07
3	1.677504077672e-09	1.677504077672e-09	1.67750407767e-09
4	9.576086187805e-10	9.57608618780e-10	9.5760861878e-10
5	1.067505038963e-18	1.0675050389630e-18	1.067505038963e-18
6	6.37119752782e-13	6.371197527827e-13	6.37119752782e-13
7	5.77509918972e-19	5.775099189724e-19	5.77509918972e-19

Vowel I values in Hu Moments in Scaling		
	Scaling to 8	Scaling to 16
1	0.0018462579506951645	0.0018458785734437404
2	1.443845892511941e-06	1.4430479340309337e-06
3	5.425262647773648e-11	5.425733582974505e-11
4	7.977763881623868e-10	7.980821256856959e-10
5	1.4046057770639244e-19	1.406631033807532e-19
6	9.337413760392335e-13	9.339384631307227e-13
7	8.841488249549811e-20	8.828552021585128e-20

Vowel E values in Hu Moments in Scaling		
	Scaling to 2	Scaling to 4
1	0.002515393693651906	0.002518996291853039
2	7.292382625390147e-07	7.3422037152565e-07
3	1.917976121119358e-09	1.9142697406189262e-09
4	1.034527506934605e-09	1.0276147279958025e-09
5	1.2994489952895326e-18	1.2884233543342867e-18
6	7.235712400417082e-13	7.226291478521252e-13
7	6.595572130108076e-19	6.459417456786854e-19

Vowel I values in Hu Moments in Translation		
	To point (2,10)	To point (4,10)
1	0.008780790286859644	0.008780790286859644
2	7.53056092539812e-05	7.53056092539812e-05
3	9.84160880165812e-08	9.841608801658121e-08
4	1.0415240546938278e-07	1.041524054693828e-07
5	1.0544754725600184e-14	1.0544754725600186e-14
6	9.037141901280978e-10	9.037141901280977e-10
7	1.6376668715129528e-17	1.6376668715130637e-17

Vowel E values in Hu Moments in Scaling		
	Scaling to 8	Scaling to 16
1	0.002518344232335031	0.0025180887940970597
2	7.311185057290218e-07	7.309252022181438e-07
3	1.9124877804469752e-09	1.912066003346983e-09
4	1.0277935878068591e-09	1.0279194501813458e-09
5	1.2877553747222896e-18	1.2879050138570655e-18
6	7.2154781518266e-13	7.214780454443e-13
7	6.466155918822229e-19	6.465532672113634e-19

Vowel I values in Hu Moments in Translation		
	To point (8,10)	To point (16,10)
1	0.008780790286859642	0.008720556228467997
2	7.530560925398123e-05	7.456034036169486e-05
3	9.841608801658205e-08	1.609614505994098e-07
4	1.041524054693825e-07	1.6557127164468313e-07
5	1.0544754725600186e-14	2.702945340281637e-14
6	9.037141901280957e-10	1.4289794406597195e-09
7	1.637666871506292e-17	6.225085803515793e-17

Vowel E values in Hu Moments in Translation		
	To point (2,10)	To point (4,10)
1	0.002463976135131677	0.0024639761351316807
2	4.970918419076081e-07	4.970918419076068e-07
3	1.677504077672179e-09	1.677504077672251e-09
4	9.576086187805455e-10	9.576086187805304e-10
5	1.0675050389631622e-18	1.0675050389631578e-18
6	6.371197527827819e-13	6.371197527827739e-13
7	5.775099189723914e-19	5.775099189723945e-19

Vowel O values in Hu Moments in Rotation			
	Rotation 90	Rotation 180	Rotation 270
1	0.0052039630963162	0.0052039630963162	0.0052039630963162
2	9.192351928361e-07	9.192351928361e-07	9.192351928361e-07
3	9.910318520849e-10	9.91031852084e-10	9.910318520849e-10
4	1.1118609126308e-09	1.1118609126308e-09	1.11186091263e-09
5	-1.01549261148e-18	-1.0154926114825e-18	-1.0154926114824e-18
6	1.0539842080016e-12	1.0539842080016e-12	1.053984208001e-12
7	5.75298946372e-19	5.752989463720e-19	5.752989463720e-19

Vowel O values in Hu Moments in Scaling

	Scaling to 2	Scaling to 4
1	0.005165293228556456	0.00516543518024773
2	5.976922558357582e-07	5.986614578674331e-07
3	1.1139367880773046e-09	1.1234965214326678e-09
4	1.0621676907820345e-09	1.020339348978795e-09
5	-1.042223457007498e-18	-9.835889674622992e-19
6	7.426857875060023e-13	7.192809356916227e-13
7	-4.986409839632608e-19	-4.754015314823707e-19

Vowel O values in Hu Moments in Scaling

	Scaling to 8	Scaling to 16
1	0.005165154371547926	0.005165780005082492
2	5.985109121803681e-07	5.986809115047842e-07
3	1.12569136139222e-09	1.1257358730137861e-09
4	1.0206680446634482e-09	1.022204135827989e-09
5	-9.899493473366021e-19	-9.916571906286105e-19
6	7.169615060368363e-13	7.183396484577647e-13
7	-4.657699923210785e-19	-4.679927700468136e-19

Vowel O values in Hu Moments in Translation

	To point (2,10)	To point (4,10)
1	0.005203673502368843	0.005203673502368843
2	9.175715009447537e-07	9.175715009447537e-07
3	9.831475085400268e-10	9.831475085401155e-10
4	1.1122160821102238e-09	1.1122160821102211e-09
5	-1.0154629604430104e-18	-1.015462960443062e-18
6	1.0534178848707735e-12	1.0534178848707714e-12
7	5.669985321270504e-19	5.669985321270573e-19

Vowel O values in Hu Moments in Translation

	To point (8,10)	To point (16,10)
1	0.00520367350236884	0.005240657757993058
2	9.175715009447574e-07	9.917736350974263e-07
3	9.831475085400915e-10	7.96414837683538e-10
4	1.1122160821102031e-09	1.311547411417154e-09
5	-1.0154629604430206e-18	-1.1913792203453999e-18
6	1.0534178848707502e-12	1.2489964734360571e-12
7	5.669985321270448e-19	6.143132335248249e-19

Vowel U values in Hu Moments in Rotation

	Rotation 90	Rotation 180	Rotation 270
1	0.0042362429111768	0.0042362429111768	0.00423624291117685
2	3.9446679969182e-06	3.9446679969182e-06	3.944667996918e-06
3	2.7016176262747e-09	2.7016176262747e-09	2.7016176262748e-09
4	3.982637763754e-09	3.982637763754e-09	3.982637763753e-09
5	1.249779476563e-17	1.2497794765635e-17	1.2497794765634e-17
6	6.2250045179752e-12	6.225004517975e-12	6.22500451797e-12
7	-3.803540292090e-18	-3.8035402920911e-18	-3.8035402920921e-18

Vowel U values in Hu Moments in Scaling

	Scaling to 2	Scaling to 4
1	0.004079690526771587	0.004082115493793461
2	2.611355922848855e-06	2.6273973534406973e-06
3	2.144746606779828e-09	2.131609827361746e-09
4	3.5752006591055157e-09	3.5611902590379187e-09
5	9.371420422358933e-18	9.273365651662185e-18
6	4.6205604761744686e-12	4.612594562111951e-12
7	-3.1918691432334554e-18	-3.2054942200983735e-18

Vowel U values in Hu Moments in Scaling

	Scaling to 8	Scaling to 16
1	0.004082940536073877	0.004082653530430875
2	2.62607114935009e-06	2.6257340215840154e-06
3	2.1317018035754966e-09	2.131928660431885e-09
4	3.574522638789863e-09	3.5711415158459704e-09
5	9.326679991066832e-18	9.312987589616749e-18
6	4.630734512102683e-12	4.6245860979344876e-12
7	-3.2207219768030503e-18	-3.2190973601088195e-18

Vowel U values in Hu Moments in Translation

	To point (2,10)	To point (4,10)
1	0.0042362429111768496	0.0042362429111768496
2	3.944667996918224e-06	3.944667996918224e-06
3	2.701617626274804e-09	2.7016176262748037e-09
4	3.982637763753935e-09	3.982637763753931e-09
5	1.249779476563448e-17	1.2497794765634447e-17
6	6.225004517974935e-12	6.225004517974926e-12
7	-3.80354029209141e-18	-3.803540292091444e-18

Vowel U values in Hu Moments in Translation

	To point (8,10)	To point (16,10)
1	0.004236242911176847	0.004220916491763073
2	3.944667996918215e-06	3.8398767205527785e-06
3	2.701617626274692e-09	3.152227968313242e-09
4	3.982637763753778e-09	4.1929329880549206e-09
5	1.2497794765633464e-17	1.473511895072553e-17
6	6.225004517974618e-12	6.151931019333913e-12
7	-3.803540292091171e-18	-3.904052734161198e-18