

HSI-Drive Release Notes

1. Version 1.1

Corrected Ground-truth images

In the process of analyzing the spectral characteristics of some HS images in the v1.0 dataset, we detected that a few ground-true image files that did not correspond to the raw images and HSI cubes with the same image identifiers. We have fixed this bug in the v1.1 release:

nf4122_189.png
nf4122_190.png
nf4122_191.png
nf4122_192.png
nf4122_193.png

In the same process, we detected some ground-truth images with defective or dubious labelling in some areas. We have improved the labelling in the following files:

nf4121_039.png
nf4121_042.png
nf3131_243.png
nf4132_055.png
nf3432_072.png
nf3221_082.png
nf3232_100.png
nf3313_135.png
nf3312_209.png
nf4311_239.png
nf3131_243.png
nf3431_244.png
nf4222_278.png
nf4223_282.png
nf4223_283.png
nf4312_300.png

There was a duplicated image: images **nf3313_135** and **nf_4313_230** were the same one. We have selected a new scene for **nf_4313_230** and created its corresponding cube and ground-truth images.

nf_4313_230.png

New binary encoding

We have added cube files with 32-bit single precision floating point encoding for enhanced accuracy of reflectance values.

Denormalizing coefficients

The processing pipeline to generate HS cubes from raw images in the HSI-Drive v1.0 database includes a final band normalization stage. Band normalization was performed by per-image band reflectance values. This procedure may affect ML training processes due to non-constant normalization coefficients. We have added the normalization coefficients of every image in the dataset so users can denormalize cubes and retrieve original reflectance values before the normalization stage.

We provide a new Matlab function **denormalize.m** for cube denormalization using the **mapminmax** function.

Proposed image dataset splitting for ML training

Train set	Validation set	Test set
nf3112_105.png	nf3112_104.png	nf3112_108.png
nf3112_106.png	nf3121_139.png	nf3121_228.png
nf3112_107.png	nf3121_225.png	nf3121_229.png
nf3121_140.png	nf3122_144.png	nf3122_148.png
nf3121_141.png	nf3123_149.png	nf3123_153.png
nf3121_142.png	nf3131_240.png	nf3131_263.png
nf3121_143.png	nf3132_109.png	nf3132_113.png
nf3121_226.png	nf3211_251.png	nf3211_255.png
nf3121_227.png	nf3212_092.png	nf3212_096.png
nf3122_145.png	nf3221_082.png	nf3221_223.png
nf3122_146.png	nf3221_220.png	nf3221_224.png
nf3122_147.png	nf3222_077.png	nf3222_081.png
nf3123_150.png	nf3223_334.png	nf3223_337.png
nf3123_151.png	nf3231_103.png	nf3231_262.png
nf3123_152.png	nf3232_099.png	nf3232_101.png
nf3131_241.png	nf3232_100.png	nf3232_250.png
nf3131_242.png	nf3233_330.png	nf3233_332.png
nf3131_243.png	nf3311_125.png	nf3311_128.png
nf3132_110.png	nf3312_130.png	nf3312_208.png
nf3132_111.png	nf3312_131.png	nf3312_209.png
nf3132_112.png	nf3313_134.png	nf3313_138.png
nf3211_252.png	nf3313_137.png	nf3313_342.png
nf3211_253.png	nf3431_244.png	nf3431_257.png
nf3211_254.png	nf3432_075.png	nf3432_258.png
nf3212_093.png	nf3432_248.png	nf3432_259.png

nf3212_094.png	nf4111_187.png	nf4111_188.png
nf3212_095.png	nf4112_189.png	nf4112_217.png
nf3221_083.png	nf4112_200.png	nf4112_218.png
nf3221_084.png	nf4112_215.png	nf4112_219.png
nf3221_085.png	nf4121_031.png	nf4121_043.png
nf3221_086.png	nf4121_037.png	nf4121_044.png
nf3221_221.png	nf4121_042.png	nf4121_045.png
nf3221_222.png	nf4122_029.png	nf4122_030.png
nf3222_078.png	nf4123_016.png	nf4123_024.png
nf3222_079.png	nf4123_023.png	nf4123_025.png
nf3222_080.png	nf4131_285.png	nf4131_286.png
nf3223_333.png	nf4132_046.png	nf4132_089.png
nf3223_335.png	nf4132_056.png	nf4132_090.png
nf3223_336.png	nf4132_088.png	nf4132_091.png
nf3231_102.png	nf4212_267.png	nf4212_268.png
nf3231_260.png	nf4221_272.png	nf4221_273.png
nf3231_261.png	nf4222_277.png	nf4222_278.png
nf3232_097.png	nf4223_282.png	nf4223_283.png
nf3232_098.png	nf4231_290.png	nf4231_291.png
nf3233_328.png	nf4232_295.png	nf4232_296.png
nf3233_329.png	nf4311_238.png	nf4311_239.png
nf3233_331.png	nf4312_300.png	nf4312_301.png
nf3311_124.png	nf4313_231.png	nf4313_233.png
nf3311_126.png	nf4313_232.png	nf4313_234.png
nf3311_127.png	nf4321_157.png	nf4321_158.png
nf3312_129.png	nf4322_159.png	nf4322_213.png
nf3312_132.png	nf4322_212.png	nf4322_214.png
nf3312_133.png	nf4331_172.png	nf4331_173.png
nf3312_205.png	nf4332_164.png	nf4332_197.png
nf3312_206.png	nf4332_196.png	nf4332_198.png
nf3312_207.png	nf4412_182.png	nf4412_183.png
nf3313_135.png	nf4413_177.png	nf4413_178.png
nf3313_136.png		
nf3313_338.png		
nf3313_339.png		
nf3313_340.png		
nf3313_341.png		
nf3431_245.png		
nf3431_246.png		
nf3431_256.png		
nf3432_072.png		
nf3432_073.png		
nf3432_074.png		
nf3432_076.png		
nf3432_247.png		
nf3432_249.png		
nf4111_184.png		
nf4111_185.png		
nf4111_186.png		
nf4112_190.png		
nf4112_191.png		
nf4112_192.png		

nf4112_193.png		
nf4112_199.png		
nf4112_201.png		
nf4112_202.png		
nf4112_203.png		
nf4112_216.png		
nf4121_032.png		
nf4121_033.png		
nf4121_034.png		
nf4121_035.png		
nf4121_036.png		
nf4121_038.png		
nf4121_039.png		
nf4121_040.png		
nf4121_041.png		
nf4122_026.png		
nf4122_027.png		
nf4122_028.png		
nf4123_017.png		
nf4123_018.png		
nf4123_019.png		
nf4123_020.png		
nf4123_021.png		
nf4123_022.png		
nf4131_284.png		
nf4132_047.png		
nf4132_048.png		
nf4132_049.png		
nf4132_050.png		
nf4132_051.png		
nf4132_052.png		
nf4132_053.png		
nf4132_054.png		
nf4132_055.png		
nf4132_087.png		
nf4212_264.png		
nf4212_265.png		
nf4212_266.png		
nf4221_269.png		
nf4221_270.png		
nf4221_271.png		
nf4222_274.png		
nf4222_275.png		
nf4222_276.png		
nf4223_279.png		
nf4223_280.png		

nf4223_281.png		
nf4231_287.png		
nf4231_288.png		
nf4231_289.png		
nf4232_292.png		
nf4232_293.png		
nf4232_294.png		
nf4311_235.png		
nf4311_236.png		
nf4311_237.png		
nf4312_297.png		
nf4312_298.png		
nf4312_299.png		
nf4313_204.png		
nf4313_230.png		
nf4321_154.png		
nf4321_155.png		
nf4321_156.png		
nf4322_160.png		
nf4322_161.png		
nf4322_162.png		
nf4322_163.png		
nf4322_210.png		
nf4322_211.png		
nf4331_169.png		
nf4331_170.png		
nf4331_171.png		
nf4332_165.png		
nf4332_166.png		
nf4332_167.png		
nf4332_168.png		
nf4332_194.png		
nf4332_195.png		
nf4412_179.png		
nf4412_180.png		
nf4412_181.png		
nf4413_174.png		
nf4413_175.png		
nf4413_176.png		

2. Version 2.0

Version 2.0 of the HSI-Drive dataset contains 476 new labeled images to make a total of 752 images. We have performed new recordings in both autumn and winter to cover the four seasons of the year. The labeled image count according to season is currently as follows:

Winter	206 images
Fall	201 images
Spring	166 images
Summer	179 images

Improved preprocessing

As in versions 1.0 and 1.1, applied raw image processing pipeline, which transforms 2D raw images containing radiance data into 3D hyperspectral cubes containing reflectance data, contained the following steps¹:

- 1- Image crop & framing.
- 2- Reflectance correction (bias removal and white balance).
- 3- Band extraction.
- 4- Median filtering (per band).
- 5- Translation to center (partial demosaicing by bilinear interpolation).
- 6- Band normalization (optional).

(1) No spectral correction was applied since scenes were recorded without rejection filters.

Translation to center: We noticed that the programmed translation to center (TC) function applied in versions 1.0 and 1.1 did not perform correctly at the edges of the images. Produced deviations were small, but anyway we have corrected this bug in version 2.0.

Median filtering: Median filtering (MF) can be beneficial in the training of spectral classifiers for image segmentation (per-pixel spectral classification), but do not necessarily improve the performance of spectral-spatial models (e.g. convolutional networks). Since per-band median filtering is a time-consuming process that introduces an additional delay in the inference stage of ML models, in version 2.0 we provide two cube sets: cubes generated with MF and cubes generated without MF.

Band normalization: In versions 1.0 and 1.1 we provided cubes containing normalized data at each spectral band together with the normalization coefficients of each image for an eventual denormalization process. Since there are many approaches to data normalization for ML algorithms and, we have removed the normalization stage from the preprocessing pipeline. In consequence, the user will find that the data ranges can vary from image to

image. This variety of ranges is a consequence of different setups in the camera configuration in order to adapt the image recording to different weather and lighting conditions. Since we have constrained the maximum exposure time of the camera to 20ms to avoid excessive image blurring in fast moving objects, in some situations it was necessary to use a wider lens aperture and even to apply the analog gain (AG) function of the camera to increase object visibility. The following table shows the resulting data ranges according to the different camera setups²:

Camera setup	f8/10ms AGx1	f8/10ms AGx2	f8/20ms AGx1	f8/20ms AGx2	f4/10ms/ AGx1	f4/10ms/ AGx2	f4/20ms AGx1	f4/20ms AGx2
Range	[0,4]	[0,2]	[0,2]	[0,1]	[0,2]	[0,2]	[0,1]	[0,1]

(2) Recording images with an f8 aperture implies that the sensor receives approximately half of the radiance compared to recording with an f4 aperture under the same lighting conditions (we have measured a reduction of 1/1.8 in the average sensor response). The reflectance correction algorithm applied in the processing pipeline of the raw images does not compensate for this variation.

The attached file *image_numbering.pdf* contains information about used camera setups for each image in the dataset.

Data normalization is applied at the end of the raw image-processing pipeline, so it can be regarded as the first stage of a classifier model. Thus, the user is free to apply whichever normalization procedure it considers most suitable for a particular algorithmic development. We provide a Matlab function named *perbandnorm.m* to perform per-image band normalization as it was applied to the cubes in versions v1.0 and v1.1.

Proposed image dataset splitting for ML training

Train set	Validation set	Test set
nf1111_571.png	nf1111_576.png	nf1111_577.png
nf1111_572.png	nf1111_578.png	nf1112_569.png
nf1111_573.png	nf1112_570.png	nf1113_557.png
nf1111_574.png	nf1113_561.png	nf1113_563.png
nf1111_575.png	nf1121_642.png	nf1121_641.png
nf1112_564.png	nf1122_650.png	nf1121_643.png
nf1112_565.png	nf1123_655.png	nf1122_649.png
nf1112_566.png	nf1123_659.png	nf1122_651.png
nf1112_567.png	nf1131_373.png	nf1123_657.png
nf1112_568.png	nf1131_375.png	nf1131_374.png
nf1113_556.png	nf1132_068.png	nf1132_070.png
nf1113_558.png	nf1132_391.png	nf1132_393.png
nf1113_559.png	nf1132_397.png	nf1132_399.png
nf1113_560.png	nf1132_401.png	nf1133_364.png
nf1113_562.png	nf1133_366.png	nf1211_624.png
nf1121_636.png	nf1211_625.png	nf1211_626.png

nf1121_637.png	nf1212_616.png	nf1212_617.png
nf1121_638.png	nf1212_618.png	nf1213_608.png
nf1121_639.png	nf1213_604.png	nf1221_316.png
nf1121_640.png	nf1213_610.png	nf1222_303.png
nf1122_644.png	nf1221_315.png	nf1223_308.png
nf1122_645.png	nf1221_317.png	nf1231_701.png
nf1122_646.png	nf1222_305.png	nf1231_703.png
nf1122_647.png	nf1223_310.png	nf1232_661.png
nf1122_648.png	nf1231_702.png	nf1232_665.png
nf1123_652.png	nf1232_663.png	nf1233_693.png
nf1123_653.png	nf1233_695.png	nf1233_697.png
nf1123_654.png	nf1311_706.png	nf1311_705.png
nf1123_656.png	nf1312_382.png	nf1312_384.png
nf1123_658.png	nf1312_386.png	nf1312_388.png
nf1131_368.png	nf1313_377.png	nf1313_379.png
nf1131_369.png	nf1321_063.png	nf1321_065.png
nf1131_370.png	nf1321_119.png	nf1321_121.png
nf1131_371.png	nf1321_354.png	nf1321_356.png
nf1131_372.png	nf1321_358.png	nf1321_360.png
nf1132_067.png	nf1322_058.png	nf1322_060.png
nf1132_069.png	nf1322_114.png	nf1322_116.png
nf1132_071.png	nf1322_344.png	nf1322_346.png
nf1132_392.png	nf1322_348.png	nf1322_350.png
nf1132_394.png	nf1323_319.png	nf1323_321.png
nf1132_395.png	nf1323_325.png	nf1323_327.png
nf1132_396.png	nf2111_521.png	nf2111_523.png
nf1132_398.png	nf2111_522.png	nf2112_507.png
nf1132_400.png	nf2112_506.png	nf2113_500.png
nf1132_402.png	nf2113_499.png	nf2121_417.png
nf1133_363.png	nf2121_416.png	nf2121_418.png
nf1133_365.png	nf2122_408.png	nf2122_409.png
nf1133_367.png	nf2131_553.png	nf2122_410.png
nf1211_619.png	nf2131_554.png	nf2131_555.png
nf1211_620.png	nf2132_432.png	nf2132_434.png
nf1211_621.png	nf2132_433.png	nf2133_426.png
nf1211_622.png	nf2133_424.png	nf2211_513.png
nf1211_623.png	nf2133_425.png	nf2211_514.png
nf1212_611.png	nf2211_509.png	nf2211_515.png
nf1212_612.png	nf2211_510.png	nf2212_494.png
nf1212_613.png	nf2211_511.png	nf2212_495.png
nf1212_614.png	nf2211_512.png	nf2212_496.png
nf1212_615.png	nf2212_491.png	nf2212_497.png
nf1213_603.png	nf2212_492.png	nf2213_489.png
nf1213_605.png	nf2212_493.png	nf2221_014.png
nf1213_606.png	nf2213_488.png	nf2222_633.png
nf1213_607.png	nf2221_015.png	nf2222_634.png
nf1213_609.png	nf2221_635.png	nf2223_629.png
nf1221_312.png	nf2222_632.png	nf2223_630.png
nf1221_313.png	nf2223_628.png	nf2311_457.png
nf1221_314.png	nf2311_456.png	nf2311_458.png
nf1222_302.png	nf2312_448.png	nf2312_449.png
nf1222_304.png	nf2313_440.png	nf2312_450.png
nf1222_306.png	nf2313_441.png	nf2313_442.png
nf1223_307.png	nf2321_545.png	nf2321_547.png
nf1223_309.png	nf2321_546.png	nf2322_539.png
nf1223_311.png	nf2322_537.png	nf2323_529.png

nf1231_698.png	nf2322_538.png	nf2323_531.png
nf1231_699.png	nf2323_530.png	nf2331_601.png
nf1231_700.png	nf2331_600.png	nf2331_602.png
nf1232_660.png	nf2332_592.png	nf2332_593.png
nf1232_662.png	nf2333_584.png	nf2332_594.png
nf1232_664.png	nf2333_586.png	nf2333_585.png
nf1232_666.png	nf2412_473.png	nf2412_475.png
nf1232_667.png	nf2412_474.png	nf2412_476.png
nf1233_692.png	nf3111_718.png	nf3111_720.png
nf1233_694.png	nf3111_719.png	nf3112_108.png
nf1233_696.png	nf3112_104.png	nf3113_712.png
nf1311_704.png	nf3113_711.png	nf3121_228.png
nf1311_707.png	nf3121_139.png	nf3121_229.png
nf1312_381.png	nf3121_225.png	nf3122_148.png
nf1312_383.png	nf3122_144.png	nf3123_153.png
nf1312_385.png	nf3123_149.png	nf3131_263.png
nf1312_387.png	nf3131_240.png	nf3132_113.png
nf1312_389.png	nf3132_109.png	nf3133_728.png
nf1312_390.png	nf3133_726.png	nf3211_255.png
nf1313_376.png	nf3133_727.png	nf3212_096.png
nf1313_378.png	nf3211_251.png	nf3221_223.png
nf1313_380.png	nf3212_092.png	nf3221_224.png
nf1321_062.png	nf3221_082.png	nf3222_081.png
nf1321_064.png	nf3221_220.png	nf3223_337.png
nf1321_066.png	nf3222_077.png	nf3231_262.png
nf1321_120.png	nf3223_334.png	nf3232_101.png
nf1321_122.png	nf3231_103.png	nf3232_250.png
nf1321_123.png	nf3232_100.png	nf3233_332.png
nf1321_353.png	nf3233_330.png	nf3311_128.png
nf1321_355.png	nf3311_125.png	nf3312_208.png
nf1321_357.png	nf3312_130.png	nf3312_209.png
nf1321_359.png	nf3312_131.png	nf3313_138.png
nf1321_361.png	nf3313_134.png	nf3313_342.png
nf1321_362.png	nf3313_137.png	nf3321_691.png
nf1322_057.png	nf3321_689.png	nf3322_682.png
nf1322_059.png	nf3321_690.png	nf3322_683.png
nf1322_061.png	nf3322_681.png	nf3323_674.png
nf1322_115.png	nf3323_673.png	nf3323_675.png
nf1322_117.png	nf3431_244.png	nf3431_257.png
nf1322_118.png	nf3432_075.png	nf3432_258.png
nf1322_343.png	nf3432_248.png	nf3432_259.png
nf1322_345.png	nf4111_187.png	nf4111_188.png
nf1322_347.png	nf4112_189.png	nf4112_217.png
nf1322_349.png	nf4112_200.png	nf4112_218.png
nf1322_351.png	nf4112_215.png	nf4112_219.png
nf1322_352.png	nf4121_031.png	nf4121_043.png
nf1323_318.png	nf4121_037.png	nf4121_044.png
nf1323_320.png	nf4121_042.png	nf4121_045.png
nf1323_322.png	nf4122_029.png	nf4122_030.png
nf1323_323.png	nf4123_016.png	nf4123_024.png
nf1323_324.png	nf4123_023.png	nf4123_025.png
nf1323_326.png	nf4132_046.png	nf4131_286.png
nf2111_516.png	nf4132_056.png	nf4132_050.png
nf2111_517.png	nf4132_088.png	nf4132_089.png
nf2111_518.png	nf4211_742.png	nf4132_090.png
nf2111_519.png	nf4211_743.png	nf4132_091.png

nf2111_520.png	nf4212_267.png	nf4211_744.png
nf2112_501.png	nf4213_734.png	nf4212_268.png
nf2112_502.png	nf4213_735.png	nf4213_736.png
nf2112_503.png	nf4221_272.png	nf4221_273.png
nf2112_504.png	nf4222_277.png	nf4222_278.png
nf2112_505.png	nf4223_282.png	nf4223_283.png
nf2113_498.png	nf4231_290.png	nf4231_291.png
nf2121_411.png	nf4232_295.png	nf4232_296.png
nf2121_412.png	nf4311_238.png	nf4311_239.png
nf2121_413.png	nf4312_300.png	nf4312_301.png
nf2121_414.png	nf4313_232.png	nf4313_233.png
nf2121_415.png	nf4321_157.png	nf4313_234.png
nf2122_403.png	nf4322_159.png	nf4321_158.png
nf2122_404.png	nf4322_212.png	nf4322_213.png
nf2122_405.png	nf4331_172.png	nf4322_214.png
nf2122_406.png	nf4332_164.png	nf4331_173.png
nf2122_407.png	nf4332_196.png	nf4332_197.png
nf2131_548.png	nf4333_750.png	nf4332_198.png
nf2131_549.png	nf4333_751.png	nf4333_752.png
nf2131_550.png	nf4412_182.png	nf4412_183.png
nf2131_551.png	nf4413_177.png	nf4413_178.png
nf2131_552.png		
nf2132_427.png		
nf2132_428.png		
nf2132_429.png		
nf2132_430.png		
nf2132_431.png		
nf2133_419.png		
nf2133_420.png		
nf2133_421.png		
nf2133_422.png		
nf2133_423.png		
nf2211_477.png		
nf2211_478.png		
nf2211_479.png		
nf2211_480.png		
nf2211_481.png		
nf2211_482.png		
nf2211_483.png		
nf2211_484.png		
nf2211_508.png		
nf2212_459.png		
nf2212_460.png		
nf2212_461.png		
nf2212_462.png		
nf2212_463.png		
nf2212_464.png		
nf2212_465.png		
nf2212_466.png		
nf2212_490.png		
nf2213_485.png		
nf2213_486.png		
nf2213_487.png		
nf2221_009.png		
nf2221_010.png		
nf2221_011.png		

nf2221_012.png		
nf2221_013.png		
nf2222_005.png		
nf2222_006.png		
nf2222_007.png		
nf2222_008.png		
nf2222_631.png		
nf2223_001.png		
nf2223_002.png		
nf2223_003.png		
nf2223_004.png		
nf2223_627.png		
nf2311_451.png		
nf2311_452.png		
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