# Subjective Image Fusion Evaluation Data

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This document provides a brief description of the data collected during a series of subjective image fusion evaluation trials in the perion 1999-2002 as a part of the University of Manchester image fusion research programme. Trials reported on in this document were passive, informal, preference tests designed to compare performances of two "fusion for display" algorithms at a time. Test procedure involved a display of two multisensor input images of the same scene and two different fused images obtained by merging the inputs using a particular fusion algorithm. The subjects were then asked to decide which if either of the fused images represented the input pair better, based on their perceptual preference. More details on the test procedure and set-up can be found in [1].

Tests were run on representative sets of input images fused using a variety of different image fusion algorithms. Table 1 summarises fusion algorithms used to produce the images evaluated in the trials, where not specified the simple select max input coefficient fusion rule was used.

**Table 1:** Fusion schemes used in reported trials

| Test No. | Fusion Scheme 1 | Fusion Scheme 2 |
|---|---|---|
| 1 | DWT multires. | Image Averaging |
| 2 | DWT multires. 5×5 area selection | DWT multires. cross-band selection |
| 3 | Gradient multires. fusion | RoLP pyramid multires. |
| 4 | DWT multires. 5×5 area selection | RoLP pyramid multires. |
| 5 | Gradient multires. fusion | DWT multires. 5×5 area selection |
| 6 | Block bi-scale | DWT multires. 5×5 area selection |
| 7 | Laplace pyramid multires. | DWT multires. |
| 8 | DWT multiscale | DWT multires. |

In all 8 different trials were performed. Table 2 below summarises the number of subjects that took part in each of the tests and the number of input image pair used.

**Table 2:** Operational parameters of the perceptual tests

| Test No. | Image Groups | No. Subjects | Audience Expertise |
|---|---|---|---|
| 1 | 23 | 13 | mixed |
| 2 | 10 | 11 | mixed |
| 3 | 15 | 28 | expert |
| 4 | 15 | 19 | mixed |
| 5 | 15 | 19 | mixed |
| 6 | 12 | 9 | inexperienced |
| 7 | 15 | 15 | mixed |
| 8 | 15 | 15 | mixed |

The first, Test 1, was performed in September 1998 at the University of Manchester as over 23 different input scenes by 13 subjects closely associated with the field of image processing and display with some also experienced in the field of multisensor image processing and visualisation (audience of mixed expertese). Test 2 was performed in December 1998 at the same location in the University of Manchester and involved 11 subjects with a similar composition as Test 1 (some subjects took part in both tests). Tests 3-5 were performed during 1999 at two different locations and evaluated 3 different fusion schemes (each vs. each) on an equivalent input image set. Audiences for all three were mixed with some very experienced viewers and some inexperienced viewers involved in all three. The largest sample of 28 subjects perfromed Test 3 and 19 subjects (that also took part in Test 3) took part in Tests 4 and 5. Test 6 was held in September of 1999 at the premises of Orasys in Belgrade and involved 9 subjects inexperienced in the fields of multisensor image processing. The subjects, like for all other tests, nonethelss satisfy the recommended visual display evaluation audience standards stipulated by the ITU [4]). Tests 7 and 8 were performed in 2001 and 2002 at Orasys and Military Technical Academy in Belgrade, Serbia respectively. They were performed by different audiences of mixed experience.

**Test data**

Image data used in the trials is a series of multisensor input image pairs and fused images produced by fusing the input pair with a given fusion scheme. The images can be found at www.isbe.man.ac.uk\research\image_fusion.html. Input image data used in the trials was obtained from a number of sources and covers a wide variety of scenes and fusion scenarios. Most of the images were recorded under the USA Airborne Multisensor Pod System (AMPS) program [2] and include a large number of industrial, urban and natural scenes from a number of geographical locations captured by two hyper-spectral airborne scanners. Another significant source is a dataset of hyper-spectral images of natural scenes collected by Bristol University for DRA UK [3] and a small number of multi-focus and extreme exposure image pairs [4]. In all 120 input image pairs were used and a detailed list of the sensor source as well as actual source of the images is given in Appendix A. Note that some input pairs featured in more than one trial (e.g. Tests 3-5 were intentionally run on an equivalent set of 15 input images pairs). A number of thumbnail examples of the data are also shown in Figure 1 below.

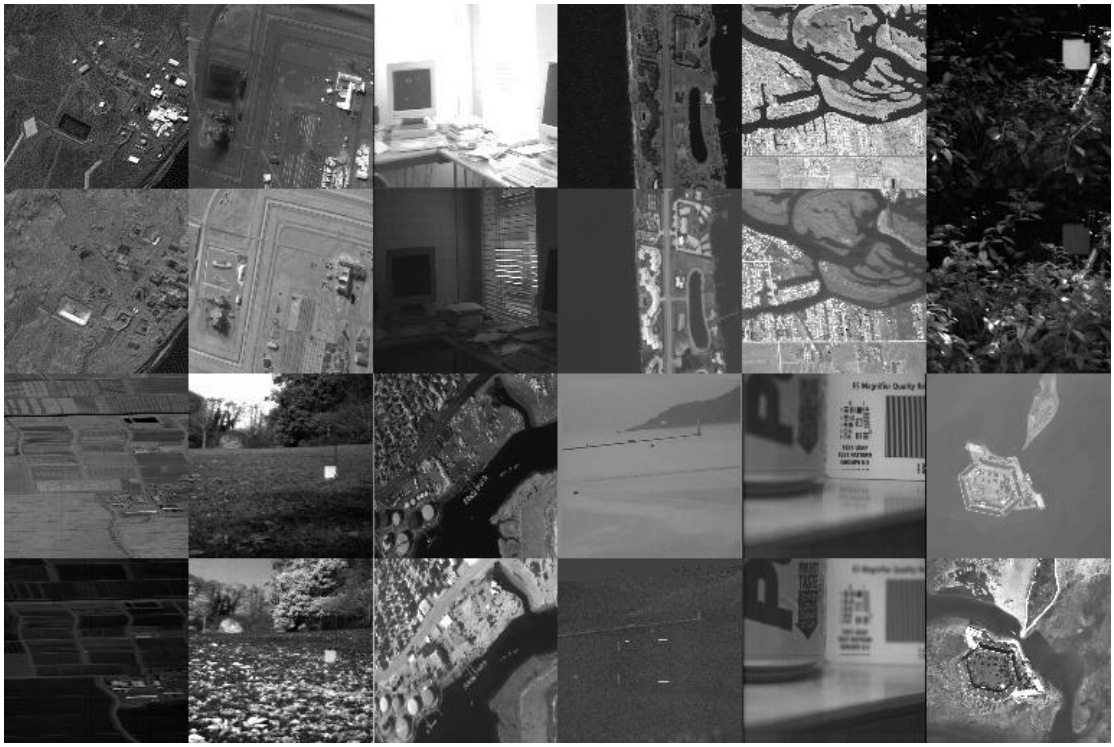

**Figure 1:** Examples of multisensor image pairs used in the subjective tests

## Test Results

Results of the subjective trials described in this document have been gathered in the form of subjects' responses, preferences for one or neither of the fused images of a particular input image pairs. Details on the methods and procedures for processing and summarising the results of such tests into discrete subjective fusion performance measures as well as a summary of the results of the tests can be found in [1]. Actual subject responses are listed with other implementations details in Appendix B.

## Bibliography


[1] Petrović V, "Subjective Tests for Image Fusion Evaluation and Objective Performance Metric Validation", submitted to *Int. Journal Information Fusion*, Elsevier, 2004

[2] AMPS Programme, http://info.amps.gov:2080, September 1998

[3] G Brelstaff, C Parraga, T Troscianko, D Carr, "Hyperspectral camera system: acquisition and analysis", *Proceedings SPIE*, Vol 2587 pp 150-159, 1995

[4] The Online Resource for Research in Image Fusion, *on* *www.imagefusion.org*, July 2004

# Appendix A: Input data

**Table A1:** Input image pair details for all subjective tests

| Im. No. | Test No. | Sensor 1 | Sensor 2 | Source | Pair Ref. |
|---|---|---|---|---|---|
| 1 | **1** | Daedalus | Daedalus | AMPS | p007 |
| 2 | | Daedalus | Daedalus | AMPS | p029 |
| 3 | | Daedalus | Daedalus | AMPS | p019 |
| 4 | | Daedalus | Daedalus | AMPS | p003 |
| 5 | | Daedalus | Daedalus | AMPS | p035 |
| 6 | | Visual | Infrared | | p010 |
| 7 | | Daedalus | Daedalus | AMPS | p022 |
| 8 | | Daedalus | Daedalus | AMPS | p004 |
| 9 | | Daedalus | Daedalus | AMPS | p033 |
| 10 | | Daedalus | Daedalus | AMPS | p013 |
| 11 | | Daedalus | Daedalus | AMPS | p033 |
| 12 | | Daedalus | Daedalus | AMPS | p006 |
| 13 | | Daedalus | Daedalus | AMPS | p030 |
| 14 | | CASI | CASI | AMPS | p009 |
| 15 | | Daedalus | Daedalus | AMPS | p024 |
| 16 | | Daedalus | Daedalus | AMPS | p008 |
| 17 | | Daedalus | Daedalus | AMPS | p028 |
| 18 | | Daedalus | Daedalus | AMPS | p002 |
| 19 | | Daedalus | Daedalus | AMPS | p018 |
| 20 | | Daedalus | Daedalus | AMPS | p034 |
| 21 | | Daedalus | Daedalus | AMPS | p020 |
| 22 | | Daedalus | Daedalus | AMPS | p021 |
| 23 | | Daedalus | Daedalus | AMPS | p031 |
| 24 | **2** | Daedalus | Daedalus | AMPS | p019 |
| 25 | | Daedalus | Daedalus | AMPS | p002 |
| 26 | | Daedalus | Daedalus | AMPS | p035 |
| 27 | | Daedalus | Daedalus | AMPS | p029 |
| 28 | | Daedalus | Daedalus | AMPS | p004 |
| 29 | | Daedalus | Daedalus | AMPS | p013 |
| 30 | | CASI | CASI | AMPS | p009 |
| 31 | | Daedalus | Daedalus | AMPS | p037 |
| 32 | | Daedalus | Daedalus | AMPS | p024 |
| 33 | | Daedalus | Daedalus | AMPS | p036 |
| 34 | **3** | Daedalus | Daedalus | AMPS | p146 |
| 35 | | Daedalus | Daedalus | AMPS | p018 |
| 36 | | Visual | Visual | Imagefusion.org | p150 |
| 37 | | Daedalus | Daedalus | AMPS | p091 |
| 38 | | Daedalus | Daedalus | AMPS | p047 |
| 39 | | Daedalus | Daedalus | AMPS | p080 |
| 40 | | Daedalus | Daedalus | AMPS | p151 |
| 41 | | Daedalus | Daedalus | AMPS | p066 |
| 42 | | Daedalus | Daedalus | AMPS | p084 |

| | | | | | |
|---|---|---|---|---|---|
| 43 | | Daedalus | Daedalus | AMPS | p118 |
| 44 | | Hyp. 30 | Hyp. 30 | DRA | p005 |
| 45 | | Hyp. 30 | Hyp. 30 | DRA | p149 |
| 46 | | Daedalus | Daedalus | AMPS | p135 |
| 47 | | Daedalus | Daedalus | AMPS | P082 |
| 48 | | Visual | Infrared | | p010 |
| 49 | | Hyp. 30 | Hyp. 30 | DRA | p005 |
| 50 | | Daedalus | Daedalus | AMPS | p151 |
| 51 | | Hyp. 30 | Hyp. 30 | DRA | p149 |
| 52 | | Daedalus | Daedalus | AMPS | p084 |
| 53 | | Daedalus | Daedalus | AMPS | p135 |
| 54 | | Daedalus | Daedalus | AMPS | p082 |
| 55 | | Visual | Infrared | | p010 |
| 56 | **4** | Daedalus | Daedalus | AMPS | p146 |
| 57 | | Visual | Visual | Imagefusion.org | p150 |
| 58 | | Daedalus | Daedalus | AMPS | p018 |
| 59 | | Daedalus | Daedalus | AMPS | p080 |
| 60 | | Daedalus | Daedalus | AMPS | p066 |
| 61 | | Daedalus | Daedalus | AMPS | p047 |
| 62 | | Daedalus | Daedalus | AMPS | p091 |
| 63 | | Daedalus | Daedalus | AMPS | p118 |
| 64 | | Daedalus | Daedalus | AMPS | p047 |
| 65 | | Daedalus | Daedalus | AMPS | p118 |
| 66 | | Daedalus | Daedalus | AMPS | p066 |
| 67 | | Daedalus | Daedalus | AMPS | p080 |
| 68 | | Visual | Visual | Imagefusion.org | p150 |
| 69 | | Daedalus | Daedalus | AMPS | p084 |
| 70 | | Daedalus | Daedalus | AMPS | p091 |
| 71 | **5** | Daedalus | Daedalus | AMPS | p082 |
| 72 | | Daedalus | Daedalus | AMPS | p135 |
| 73 | | Hyp. 30 | Hyp. 30 | DRA | p149 |
| 74 | | Visual | Infrared | | p010 |
| 75 | | Daedalus | Daedalus | AMPS | p151 |
| 76 | | Daedalus | Daedalus | AMPS | p146 |
| 77 | | Hyp. 30 | Hyp. 30 | DRA | p005 |
| 78 | | Daedalus | Daedalus | AMPS | p018 |
| 79 | | Daedalus | Daedalus | AMPS | P146 |
| 80 | | Daedalus | Daedalus | AMPS | p047 |
| 81 | | Daedalus | Daedalus | AMPS | p070 |
| 82 | | Daedalus | Daedalus | AMPS | p024 |
| 83 | | Visual | Visual | Imagefusion.org | p038 |
| 84 | **6** | Visual | Infrared | | p010 |
| 85 | | Daedalus | Daedalus | AMPS | p035 |
| 86 | | Daedalus | Daedalus | AMPS | p113 |
| 87 | | Daedalus | Daedalus | AMPS | p082 |
| 88 | | Daedalus | Daedalus | AMPS | p013 |
| 89 | | Daedalus | Daedalus | AMPS | p019 |
| 90 | | Daedalus | Daedalus | AMPS | p091 |

| | | | | | |
|---|---|---|---|---|---|
| 91 | | Daedalus | Daedalus | AMPS | p080 |
| 92 | | Daedalus | Daedalus | AMPS | p046 |
| 93 | | Visual | Infrared | | p010 |
| 94 | | Daedalus | Daedalus | AMPS | p100 |
| 95 | | Daedalus | Daedalus | AMPS | p146 |
| 96 | | Daedalus | Daedalus | AMPS | p018 |
| 97 | | Hyp. 30 | Hyp. 30 | DRA | p011 |
| 98 | **7** | Daedalus | Daedalus | AMPS | p035 |
| 99 | | Daedalus | Daedalus | AMPS | p077 |
| 100 | | Daedalus | Daedalus | AMPS | p002 |
| 101 | | Daedalus | Daedalus | AMPS | p113 |
| 102 | | Daedalus | Daedalus | AMPS | p067 |
| 103 | | Daedalus | Daedalus | AMPS | p091 |
| 104 | | Daedalus | Daedalus | AMPS | p150 |
| 105 | | Daedalus | Daedalus | AMPS | p084 |
| 106 | | Visual | Infrared | | p010 |
| 107 | | Daedalus | Daedalus | AMPS | p002 |
| 108 | | Daedalus | Daedalus | AMPS | p124 |
| 109 | | Daedalus | Daedalus | AMPS | p085 |
| 110 | | Daedalus | Daedalus | AMPS | p035 |
| 111 | | Daedalus | Daedalus | AMPS | p053 |
| 112 | | Daedalus | Daedalus | AMPS | p022 |
| 113 | **8** | Daedalus | Daedalus | AMPS | p150 |
| 114 | | Hyp. 30 | Hyp. 30 | DRA | p011 |
| 115 | | Daedalus | Daedalus | AMPS | p089 |
| 116 | | Daedalus | Daedalus | AMPS | p097 |
| 117 | | Daedalus | Daedalus | AMPS | p036 |
| 118 | | Daedalus | Daedalus | AMPS | p066 |
| 119 | | Daedalus | Daedalus | AMPS | p058 |
| 120 | | Daedalus | Daedalus | AMPS | p084 |

Scanner abbreviations:

Daed - Daedalus scanner
(e.g. see www.geoinsight.com/Knowledgebase/RemoteSensing/Daedalus.cfm)
CASI - CASI hyperspectral scanner
(e.g. see www.csc.noaa.gov/products/maine/html/casi.htm)
Hyp. 30- 30 Channel DRA Hyperspectral scanner
Vis - Visual light camera
IR - Infra-red thermal camera

## Appendix B: Test Results

Subjects' responses to all the images included in the presented subjective tests are summarised in the Table B1 below. Image location indicates whether the image of this scheme appeared on the left (Image_1) or right (Image_2). For each subjective test, fusion scheme numbering is defined in Table 1.

**Table B1:** Subject preferences

| | | Image Location | | Subject Responses | | |
|---|---|---|---|---|---|---|
| Image No. | Test No. | Scheme 1 | Scheme 2 | Prefered Image_1 | Prefered Image_2 | Equal Preference |
| 1 | **1** | Image_1 | Image_2 | 9 | 3 | 1 |
| 2 | | Image_1 | Image_2 | 4 | 8 | 1 |
| 3 | | Image_2 | Image_1 | 1 | 12 | 0 |
| 4 | | Image_1 | Image_2 | 2 | 11 | 0 |
| 5 | | Image_2 | Image_1 | 8 | 4 | 1 |
| 6 | | Image_2 | Image_1 | 1 | 11 | 1 |
| 7 | | Image_1 | Image_2 | 8 | 5 | 0 |
| 8 | | Image_2 | Image_1 | 4 | 8 | 1 |
| 9 | | Image_1 | Image_2 | 7 | 6 | 0 |
| 10 | | Image_1 | Image_2 | 10 | 3 | 0 |
| 11 | | Image_2 | Image_1 | 5 | 8 | 0 |
| 12 | | Image_2 | Image_1 | 9 | 2 | 2 |
| 13 | | Image_1 | Image_2 | 6 | 6 | 1 |
| 14 | | Image_2 | Image_1 | 2 | 11 | 0 |
| 15 | | Image_2 | Image_1 | 5 | 8 | 0 |
| 16 | | Image_2 | Image_2 | 12 | 1 | 0 |
| 17 | | Image_2 | Image_1 | 3 | 9 | 1 |
| 18 | | Image_1 | Image_2 | 12 | 1 | 0 |
| 19 | | Image_1 | Image_2 | 6 | 6 | 1 |
| 20 | | Image_1 | Image_2 | 12 | 1 | 0 |
| 21 | | Image_2 | Image_1 | 9 | 4 | 0 |
| 22 | | Image_2 | Image_1 | 4 | 9 | 0 |
| 23 | | Image_1 | Image_2 | 1 | 10 | 2 |
| 24 | **2** | Image_2 | Image_1 | 9 | 2 | 0 |
| 25 | | Image_1 | Image_2 | 1 | 10 | 0 |
| 26 | | Image_1 | Image_2 | 2 | 9 | 0 |
| 27 | | Image_2 | Image_1 | 8 | 1 | 2 |
| 28 | | Image_1 | Image_2 | 3 | 7 | 1 |
| 29 | | Image_2 | Image_1 | 8 | 1 | 2 |
| 30 | | Image_2 | Image_1 | 7 | 3 | 1 |
| 31 | | Image_1 | Image_2 | 3 | 4 | 4 |
| 32 | | Image_1 | Image_2 | 3 | 7 | 1 |
| 33 | | Image_2 | Image_1 | 11 | 0 | 0 |
| 34 | **3** | Image_2 | Image_1 | 13 | 15 | 0 |
| 35 | | Image_2 | Image_1 | 9 | 13 | 6 |
| 36 | | Image_2 | Image_1 | 11 | 14 | 3 |
| 37 | | Image_1 | Image_2 | 18 | 5 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 38 | | Image_2 | Image_1 | 20 | 6 | 2 |
| 39 | | Image_2 | Image_1 | 11 | 13 | 4 |
| 40 | | Image_1 | Image_2 | 18 | 9 | 0 |
| 41 | | Image_1 | Image_2 | 4 | 16 | 8 |
| 42 | | Image_2 | Image_1 | 12 | 12 | 4 |
| 43 | | Image_1 | Image_2 | 10 | 7 | 11 |
| 44 | | Image_1 | Image_2 | 10 | 8 | 10 |
| 45 | | Image_1 | Image_2 | 8 | 12 | 7 |
| 46 | | Image_2 | Image_1 | 19 | 6 | 3 |
| 47 | | Image_1 | Image_2 | 12 | 13 | 3 |
| 48 | | Image_2 | Image_1 | 1 | 27 | 0 |
| 49 | | Image_1 | Image_2 | 10 | 6 | 3 |
| 50 | | Image_1 | Image_2 | 15 | 1 | 3 |
| 51 | | Image_1 | Image_2 | 7 | 8 | 4 |
| 52 | | Image_2 | Image_1 | 17 | 0 | 2 |
| 53 | | Image_2 | Image_1 | 15 | 2 | 2 |
| 54 | | Image_1 | Image_2 | 1 | 17 | 1 |
| 55 | | Image_2 | Image_1 | 0 | 18 | 1 |
| 56 | **4** | Image_1 | Image_2 | 7 | 12 | 0 |
| 57 | | Image_2 | Image_1 | 13 | 4 | 2 |
| 58 | | Image_1 | Image_2 | 6 | 10 | 3 |
| 59 | | Image_2 | Image_1 | 13 | 3 | 3 |
| 60 | | Image_2 | Image_1 | 5 | 10 | 4 |
| 61 | | Image_2 | Image_1 | 17 | 2 | 0 |
| 62 | | Image_2 | Image_1 | 13 | 4 | 2 |
| 63 | | Image_1 | Image_2 | 2 | 14 | 3 |
| 64 | | Image_1 | Image_2 | 15 | 4 | 0 |
| 65 | | Image_1 | Image_2 | 11 | 1 | 7 |
| 66 | | Image_1 | Image_2 | 2 | 15 | 2 |
| 67 | | Image_1 | Image_2 | 18 | 0 | 1 |
| 68 | | Image_1 | Image_2 | 7 | 5 | 7 |
| 69 | | Image_2 | Image_1 | 1 | 14 | 4 |
| 70 | | Image_1 | Image_2 | 10 | 1 | 8 |
| 71 | **5** | Image_2 | Image_1 | 5 | 12 | 2 |
| 72 | | Image_2 | Image_1 | 2 | 9 | 8 |
| 73 | | Image_2 | Image_1 | 6 | 8 | 5 |
| 74 | | Image_2 | Image_1 | 2 | 12 | 5 |
| 75 | | Image_2 | Image_1 | 13 | 4 | 2 |
| 76 | | Image_1 | Image_2 | 12 | 6 | 1 |
| 77 | | Image_1 | Image_2 | 11 | 7 | 1 |
| 78 | | Image_2 | Image_1 | 3 | 10 | 6 |
| 79 | **6** | Image_1 | Image_2 | 9 | 0 | 0 |
| 80 | | Image_2 | Image_1 | 3 | 6 | 0 |
| 81 | | Image_2 | Image_1 | 5 | 3 | 1 |
| 82 | | Image_1 | Image_2 | 7 | 2 | 0 |
| 83 | | Image_2 | Image_1 | 9 | 0 | 0 |
| 84 | | Image_2 | Image_1 | 3 | 5 | 1 |
| 85 | | Image_1 | Image_2 | 8 | 1 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 86 | | Image_1 | Image_2 | 1 | 8 | 0 |
| 87 | | Image_2 | Image_1 | 0 | 5 | 4 |
| 88 | | Image_1 | Image_2 | 2 | 7 | 0 |
| 89 | | Image_2 | Image_1 | 1 | 7 | 1 |
| 90 | | Image_1 | Image_2 | 4 | 4 | 1 |
| 91 | **7** | Image_1 | Image_2 | 12 | 3 | 0 |
| 92 | | Image_1 | Image_2 | 9 | 6 | 0 |
| 93 | | Image_2 | Image_1 | 3 | 11 | 1 |
| 94 | | Image_2 | Image_1 | 3 | 8 | 4 |
| 95 | | Image_1 | Image_2 | 8 | 7 | 0 |
| 96 | | Image_2 | Image_1 | 7 | 5 | 3 |
| 97 | | Image_2 | Image_1 | 5 | 10 | 0 |
| 98 | | Image_1 | Image_2 | 10 | 4 | 1 |
| 99 | | Image_2 | Image_1 | 5 | 9 | 1 |
| 100 | | Image_1 | Image_2 | 4 | 9 | 2 |
| 101 | | Image_1 | Image_2 | 9 | 4 | 2 |
| 102 | | Image_2 | Image_1 | 6 | 8 | 1 |
| 103 | | Image_2 | Image_1 | 5 | 6 | 4 |
| 104 | | Image_1 | Image_2 | 12 | 0 | 3 |
| 105 | | Image_2 | Image_1 | 6 | 7 | 2 |
| 106 | **8** | Image_2 | Image_1 | 0 | 15 | 0 |
| 107 | | Image_1 | Image_2 | 8 | 4 | 3 |
| 108 | | Image_1 | Image_2 | 11 | 2 | 2 |
| 109 | | Image_2 | Image_1 | 1 | 13 | 1 |
| 110 | | Image_1 | Image_2 | 13 | 1 | 1 |
| 111 | | Image_2 | Image_1 | 2 | 12 | 1 |
| 112 | | Image_1 | Image_2 | 13 | 2 | 0 |
| 113 | | Image_2 | Image_1 | 6 | 4 | 5 |
| 114 | | Image_2 | Image_1 | 4 | 10 | 1 |
| 115 | | Image_1 | Image_2 | 10 | 2 | 3 |
| 116 | | Image_1 | Image_2 | 12 | 2 | 1 |
| 117 | | Image_2 | Image_1 | 4 | 11 | 0 |
| 118 | | Image_1 | Image_2 | 10 | 2 | 3 |
| 119 | | Image_2 | Image_1 | 1 | 11 | 3 |
| 120 | | Image_1 | Image_2 | 3 | 12 | 0 |