

# Defocus-based Direct Visual Servoing - Addendum Guillaume Caron

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# Defocus-based Direct Visual Servoing - Addendum

#### Guillaume Caron

#### I. ADDENDUM

This document is meant to serve as an addendum to [1]. The main purpose of this addendum is to provide supplementary results, namely a statistical study of the convergence domain of the Defocus-based Direct Visual Servoing [1] (DDVS). It is conducted by starting the visual servoing for a various set of initial poses, which values of the six degrees of freedom (DoF) are randomly drawn (Sec. II), to a single desired pose. Section III reports DDVS results and Section IV reports the results of Photometric Gaussian Mixture-based Visual Servoing [2] (PGM VS) from the same initial poses. A comparison of these results concludes the addendum.

#### II. EXPERIMENTAL PROTOCOL

Following a similar methodology than other direct visual servoing [3], [4], [2], a set of initial poses is computed with respect to a desired pose. DDVS is then run with the camera at the end-effector of a robot arm (Universal Robot 10) from each of these initial poses to check if it converges, or not, to the desired pose.

In this addendum, the initial poses are defined on 3 concentric spheres centered at the desired pose. Their radii are: 20 cm, 40 cm, 60 cm. These values were chosen so that they encompass the previous largest reported convergence domains of DVS methods [5], [2], [6], [7], *i.e.* 30 cm, as well as the new capabilities claimed by DDVS [1], *i.e.* up to 90 cm. As the latter large distance is only possible within a very small part of the robot workspace, the largest considered sphere radius is 60 cm. Even limiting to 60 cm, only a subpart of the robot workspace is available, although of a much larger volume than the sphere of 90 cm radius.

Then, for each sphere, 23 initial positions are randomly generated with uniform probability density (ViSP library [8] implementation of [9]). On each of these 69 positions, the rotation of the camera around its horizontal and vertical axes is computed to ensure that the content of images acquired at initial poses overlaps the one of the desired image (Fig. 4). Then, the rotation around the optical axis is randomly generated in the interval [-15 degrees, 15 degrees].

The 69 obtained poses are reported in Table I where images are captured and shown in Figures 1, 2 and 3. Depending on the robot arm configuration, the scene illumination is not constant (*e.g.* shadowed as in Fig. 1f or 1j).

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### III. DDVS CONVERGENCE DOMAIN

In detail, from the 23 initial poses distant of 20 cm to the desired pose, the convergence rate of DDVS is 91% (21 successes, 2 failures in local minima). The convergence rate decreases as the sphere radius of initial poses increases: 60% for the radius 40 cm, 56% for the radius 60 cm. Interestingly, there is only one more failure from initial poses on the sphere of radius 60 cm than on the one of 40 cm: 10 failures for the former versus 9 failures for the latter.

Figure 6 shows the evolution of the cost [1, Eq. (15)] with respect to time for initial poses on the sphere of radius 20 cm. Figures 7 and 8 do the same for initial poses on spheres of radii 40 cm, resp. 60 cm.

As a summary, DDVS converges from 49 initial poses to the desired pose: a total convergence rate of 48/69 = 70%.

The penultimate column of Table I highlights for which initial poses DDVS succeeds or fails.

#### IV. PGM VS CONVERGENCE DOMAIN

In order to show the contribution of DDVS over the state-of-the-art, PGM VS is run from the same 69 initial poses.

In detail, from the 23 initial poses distant of 20 cm to the desired pose, the convergence rate of PGM VS is 87% (20 successes, 3 failures in local minima). As DDVS, the convergence rate of PGM VS decreases as the sphere radius of initial poses increases, but more drastically: 35% for the radius 40 cm and even 0% for the radius 60 cm. In most of the cases, the camera diverges until reaching the limits of the robot workspace (Fig. 5d).

To sum up, PGM VS converges from 28 initial poses to the desired pose. The total convergence rate is 28/69 = 40%.

The right column of Table I highlights for which initial poses PGM VS succeeds or fails.

#### V. COMPARISON OF CONVERGENCE DOMAINS

To conclude, DDVS and PGM VS show almost identical convergence rates when the distance between the initial and the desired poses is 20 cm. However, when the latter distance increases to 40 cm and 60 cm, DDVS convergence rate is more than three times the one of PGM VS.

#### REFERENCES

- [1] G. Caron, "Defocus-based Direct Visual Servoing," *IEEE Robotics and Automation Letters*, 2021.
- [2] N. Crombez, E. Mouaddib, G. Caron, and F. Chaumette, "Visual servoing with photometric gaussian mixtures as dense features," *IEEE T. on Rob.*, vol. 35, no. 1, pp. 49–63, 2019.
- [3] C. Teulière and E. Marchand, "A Dense and Direct Approach to Visual Servoing Using Depth Maps," *IEEE Trans. on Robotics*, vol. 30, no. 5, pp. 1242–1249, 2014.

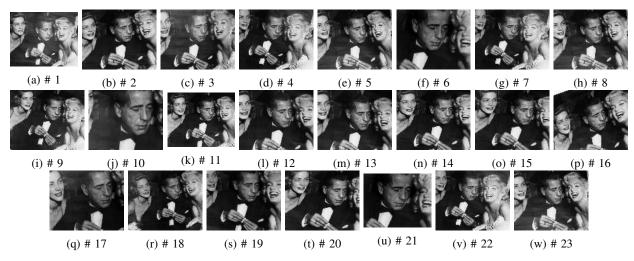


Fig. 1: Images captured at each of the 23 initial poses on the sphere of radius 20 cm. IDs are referring to those of Tab. I.

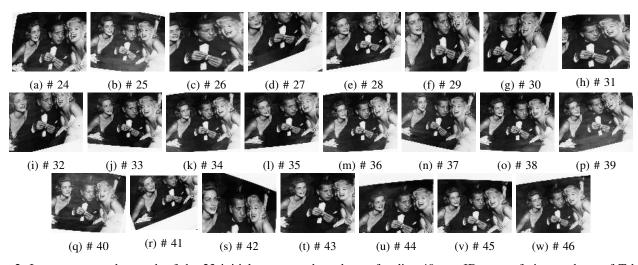


Fig. 2: Images captured at each of the 23 initial poses on the sphere of radius 40 cm. IDs are refering to those of Tab. I.



Fig. 3: Images captured at each of the 23 initial poses on the sphere of radius 60 cm. IDs are refering to those of Tab. I.

TABLE I: Initial camera poses relatively to the desired. Translations  $t_X \in \mathbb{R}$ ,  $t_Y \in \mathbb{R}$  and  $t_Z \in \mathbb{R}$  are in cm. Rotations are represented as angle  $\theta \in \mathbb{R}$  in degrees and unit axis  $\mathbf{w} = [w_X, w_Y, w_Z] \in \mathbb{R}^3 : ||\mathbf{w}|| = 1$ . The last two columns show the success (o) or failure (x) of DDVS (D) and PGM VS (G) from each initial pose.

##									
1	#	$t_X$	$t_Y$	$t_Z$	$\theta w_X$	$\theta w_Y$	$\theta w_Z$	D	G
2	1		5.8					0	0
3         17.3         10.0         -14.5         -11.7         19.6         -2.7         0         0           5         -10.9         1.0         -14.5         17.1         -13.3         14.8         0         0           6         1.0         4.5         -19.5         -8.4         1.9         -4.0         0         0           7         -3.0         -14.9         13.0         13.3         -2.7         -0.6         0         x           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           9         -2.2         -7.8         18.3         6.5         -1.9         -14.7         0         0           10         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         11.2         15.2         0.5         -5.4         0         0           12         7.0         18.1         -4.7         21.8         8.8         -4.5         0         0           13         10.4         -16.6         11.1         11.6         -5.7         0									
4         -8.4         -10.9         -14.5         17.1         -13.3         14.8         0         0           5         -10.9         1.0         16.8         -0.9         -9.3         14.0         0         0           6         1.0         4.5         -19.5         -8.4         1.9         -4.0         0         0           7         -3.0         -14.9         13.0         13.3         -2.7         -0.6         0         0           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           10         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         11.2         15.2         0.5         -5.4         0         0           12         7.0         -18.1         -4.7         21.8         8.8         -4.5         0         0           13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.0         -20.0         -0.0         21.8         -1.7         -11.5									
5         -10.9         1.0         16.8         -0.9         -9.3         14.0         0         0           7         -3.0         -14.9         19.5         -8.4         1.9         -4.0         0         0           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           9         -2.2         -7.8         18.3         6.5         -1.9         -14.7         0         0           10         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         11.2         15.2         0.5         -5.4         0         0           12         7.0         -18.1         -4.7         0.13.0         -7.6         0         0           14         -0.6         -2.0         0.4         21.6         -0.6         -7.7         0         0           15         -1.0         20.0         0.0         21.8         -1.2         -11.5         0         0           16         -15.1         -13.1         -13.7         -13.1         -18.1         3.3         0								0	
6         1.0         4.5         -19.5         -8.4         1.9         -4.0         0         0           7         -3.0         -14.9         13.0         13.3         2.2.7         -0.6         0         0           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           9         -2.2         -7.8         18.3         6.5         -1.9         -14.7         0         0           10         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         -16.4         -4.8         19.9         13.0         -7.6         0         0           13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.1         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.1         -13.1         -18.1         -3.5         -5.7         0         0         15.5         -1.0         0         0         15.9         0         0         11.3	4	-8.4	-10.9	-14.5	17.1	-13.3	14.8	0	0
6         1.0         4.5         -19.5         -8.4         1.9         -4.0         0         0           7         -3.0         -14.9         13.0         13.3         2.2.7         -0.6         0         0           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           9         -2.2         -7.8         18.3         6.5         -1.9         -14.7         0         0           10         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         -16.4         -4.8         19.9         13.0         -7.6         0         0           13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.1         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.1         -13.1         -18.1         -3.5         -5.7         0         0         15.5         -1.0         0         0         15.9         0         0         11.3	5	-10.9	1.0	16.8	-0.9	-9.3	14.0	0	0
7         -3.0         -14.9         13.0         13.3         -2.7         -0.6         0           8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0           9         -2.2         -7.8         11.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         11.2         15.2         0.5         -5.4         0         0           12         7.0         -18.1         -4.7         21.8         8.8         -4.5         0         0           13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           15         -1.0         -20.0         -0.0         21.8         -1.2         -11.5         0           16         -15.1         -13.1         -0.8         14.9         -17.0         13.0         0           17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0           18         -6.4         13.1         13.7         -11.8         13.5         0         0           21         -									
8         14.8         -2.4         -13.3         3.8         21.9         -13.0         0         x           9         -2.2         -7.8         -1.0         -18.4         1.9         -13.9         -4.6         0         0           11         0.6         -16.6         11.2         15.2         0.5         -5.4         0         0           12         7.0         -18.1         -4.7         21.8         8.8         -4.5         0         0           13         10.4         -16.6         -4.7         21.8         8.8         -4.5         0         0           14         -0.6         -20.0         0.4         21.6         -0.6         -7.7         0         0           15         -1.0         -20.0         -0.0         21.8         -1.2         -11.5         0           16         -15.1         -13.1         -0.8         14.9         -17.0         13.0         0           17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>									
9 -2.2 -7.8 18.3 6.5 -1.9 -14.7 0 0 11 0.6 -16.6 11.2 15.2 0.5 -5.4 0 0 12 7.0 -18.1 -4.7 21.8 8.8 -4.5 0 0 13 10.4 -16.4 -4.8 19.9 13.0 -7.6 0 0 14 -0.6 -20.0 0.4 21.6 -0.6 -7.7 0 0 15 -1.0 -20.0 -0.0 21.8 -1.2 -11.5 0 0 16 -15.1 -13.1 -0.8 14.9 -17.0 13.0 0 0 17 -11.9 8.5 -13.7 -13.1 -18.1 3.5 0 0 18 -6.4 13.1 13.7 -11.6 -5.7 5.2 0 0 19 -6.4 17.5 -7.3 -22.3 -8.5 -6.0 0 x 20 -5.1 -19.1 -2.8 22.1 -6.2 -12.9 0 0 21 0.6 9.7 -17.5 -16.6 1.1 -13.4 x x 22 2.6 18.1 8.0 -17.3 22.6 -11.9 x 0 23 16.1 -11.8 1.7 12.8 17.3 0.4 0 0 24 -34.7 -16.9 10.6 15.6 -29.8 -0.8 0 0 25 16.6 -6.9 35.7 4.6 11.0 -6.7 x 0 26 1.1 -39.5 -6.2 42.0 1.4 4.0 0 0 27 26.4 29.7 -4.2 33.0 30.0 10.0 x x 28 14.9 34.6 13.4 -28.7 13.2 7.6 x x 30 33.1 22.4 -2.3 -25.1 34.7 -8.0 x x 30 33.1 22.4 -2.3 -25.1 34.7 -8.0 x x 31 2.3 -39.8 -3.5 40.5 2.9 8.4 0 x x 33 3-9.6 30.6 23.8 -25.5 -7.4 0.7 x x x 34 -7.3 -12.4 37.3 8.1 -4.8 5.4 0 x x 37 -18.1 2.8 35.6 -1.9 -12.0 -7.7 0 x x 36 -7.3 -12.4 37.3 8.1 -4.8 5.4 0 x x 37 -18.1 2.8 35.6 -1.9 -12.0 -7.7 0 x x 38 1.2 -21.2 33.9 14.2 0.8 -1.0 0 0 39 20.7 -8.3 33.2 5.7 14.0 12.3 0 0 44 -15.9 -33.5 14.9 30.2 -13.8 1.2 0 x 40 19.1 15.0 31.8 -10.4 13.1 -6.8 0 x 41 18.2 28.8 21.0 -22.1 14.4 15.0 0 x 42 38.9 -7.6 -5.5 9.7 41.1 9.8 x 0 43 -3.7 -35.0 19.0 26.9 -3.1 -3.9 0 0 44 -15.9 -33.5 14.9 30.2 -13.8 1.2 0 x 45 7.4 -25.7 29.7 20.7 5.3 -0.4 0 0 x 47 -11.8 24.3 53.6 -10.3 -6.5 -13.0 0 x 48 -22.8 21.5 51.2 14.8 -12.7 -6.0 0 x 55 31.1 -12.5 49.8 10.0 17.3 13.4 x x 55 52.0 -10.4 53.6 8.6 13.6 4.0 0 x 55 36.0 10.0 -10.1 1.6 50.8 7.9 x x 56 -48.8 7.3 34.2 -2.1 30.1 -6.8 0 x 57 16.9 30.0 49.1 -14.0 9.7 2.6 0 x 58 28.3 27.2 45.3 -10.3 16.5 31.0 x x 59 -26.8 -40.1 35.6 28.0 -17.4 13.3 0 x 56 -52.0 -25.4 15.9 23.9 -38.3 -6.7 x x 56 -48.8 7.3 34.2 -2.1 30.1 -6.8 0 x 57 16.9 30.0 49.1 -14.0 9.7 2.6 0 x 58 28.3 27.2 45.3 -10.0 16.5 50.8 7.9 x x 56 -48.8 7.3 34.2 -2.1 30.1 -6.8 0 x 57 16.9 30.0 49.1 -14.0 9.7 2.6 0 x 58 28.3 27.2 45.3 -13.1 16.5 31.1 0 x 59 -26.8 -40.1 35.6 28.0 -17.4 13.3 0 x 60 -59.2 -6.3 -7.3 11.2 -54.2 -5.1 x x 60 -5						-2.7		0	0
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10	Q	-22	-7.8				-147		
11						12.0			
12									
13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           14         -0.6         -20.0         0.4         21.6         -0.6         -7.7         0         0           15         -1.0         -20.0         -0.0         21.8         -1.2         -11.5         0         0           16         -15.1         -13.1         -0.8         14.9         -17.0         13.0         0         0           17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           18         -6.4         13.1         13.7         -11.6         -5.7         5.2         0         0           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4	11		-16.6	11.2		0.5	-5.4	o	0
13         10.4         -16.4         -4.8         19.9         13.0         -7.6         0         0           14         -0.6         -20.0         0.4         21.6         -0.6         -7.7         0         0           15         -1.0         -20.0         -0.0         21.8         -1.2         -11.5         0         0           16         -15.1         -13.1         -0.8         14.9         -17.0         13.0         0         0           17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           18         -6.4         13.1         13.7         -11.6         -5.7         5.2         0         0           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4	12	7.0	-18.1	-4.7	21.8	8.8	-4.5	0	0
14						13.0			
15									
16         -15.1         -13.1         -0.8         14.9         -17.0         13.0         0         0           17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           18         -6.4         13.1         13.7         -11.6         -5.7         5.2         0         0           19         -6.4         17.5         -7.3         -22.3         -8.5         -6.0         0         x           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4         0         0           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         0         0           25         16.6         -6.9         35.7         4.6         11.0         -6.7								0	
17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           18         -6.4         117.5         -7.3         -11.6         -5.7         5.2         0         0           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4         0         0           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         0         0           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         0           26         1.1         -39.5         -6.2         42.0         1.4         4.0         0         0           27         26.4         29.7         -4.2         -33.0         30.0         10.0 <td>15</td> <td>-1.0</td> <td>-20.0</td> <td>-0.0</td> <td></td> <td>-1.2</td> <td>-11.5</td> <td>o</td> <td>0</td>	15	-1.0	-20.0	-0.0		-1.2	-11.5	o	0
17         -11.9         8.5         -13.7         -13.1         -18.1         3.5         0         0           18         -6.4         117.5         -7.3         -11.6         -5.7         5.2         0         0           20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4         0         0           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         0         0           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         0           26         1.1         -39.5         -6.2         42.0         1.4         4.0         0         0           27         26.4         29.7         -4.2         -33.0         30.0         10.0 <td>16</td> <td>-15.1</td> <td>-13.1</td> <td>-0.8</td> <td>14.9</td> <td>-17.0</td> <td>13.0</td> <td>0</td> <td>0</td>	16	-15.1	-13.1	-0.8	14.9	-17.0	13.0	0	0
18         -6.4         13.1         13.7         -11.6         -5.7         5.2         0         0           19         -6.4         17.5         -7.3         -22.3         -8.5         -6.0         0         x           20         -51         -19.1         -2.8         22.1         -6.2         -12.9         0         x           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         o           23         16.1         -11.8         1.7         12.8         17.3         0.4         o         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0									
19									
20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -23.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3				13.7				0	0
20         -5.1         -19.1         -2.8         22.1         -6.2         -12.9         0         0           21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -23.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3	19	-6.4	17.5	-7.3	-22.3	-8.5	-6.0	0	X
21         0.6         9.7         -17.5         -16.6         1.1         -13.4         x         x           22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         o           23         16.1         -11.8         1.7         12.8         17.3         0.4         o         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4									
22         2.6         18.1         8.0         -17.3         2.6         -11.9         x         0           23         16.1         -11.8         1.7         12.8         17.3         0.4         o         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         23.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
23         16.1         -11.8         1.7         12.8         17.3         0.4         o         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7									
23         16.1         -11.8         1.7         12.8         17.3         0.4         o         o           24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         o         o           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7	22	2.6	18.1	8.0	-17.3	2.6	-11.9	X	0
24         -34.7         -16.9         10.6         15.6         -29.8         -0.8         0           25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         0           26         1.1         -39.5         -6.2         42.0         1.4         4.0         0         0           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o			-11.8						
25         16.6         -6.9         35.7         4.6         11.0         -6.7         x         o           26         1.1         -39.5         -6.2         42.0         1.4         4.0         o         o           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         23.3         -36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0					15.6				
26         1.1         -39.5         -6.2         42.0         1.4         4.0         0         0           27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0 <t< td=""><td></td><td></td><td></td><td>10.6</td><td>15.6</td><td></td><td></td><td></td><td></td></t<>				10.6	15.6				
27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         23.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4								X	0
27         26.4         29.7         -4.2         -33.0         30.0         10.0         x         x           28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         23.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4	26	1.1	-39.5	-6.2	42.0	1.4	4.0	0	0
28         14.9         34.6         13.4         -28.7         13.2         7.6         x         x           29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         <				-12					
29         40.0         0.7         -0.7         -0.8         39.0         6.8         x         x           30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         0         0           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         <									
30         33.1         22.4         -2.3         -25.1         34.7         -8.0         x         x           31         2.3         -39.8         -3.5         40.5         2.9         8.4         o         o           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         x           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0								X	X
31         2.3         -39.8         -3.5         40.5         2.9         8.4         0         0           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0	29	40.0	0.7	-0.7	-0.8	39.0	6.8	X	X
31         2.3         -39.8         -3.5         40.5         2.9         8.4         0         0           32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0	30	33.1	22.4	-2.3	-25.1	34.7	-8.0	X	x
32         36.6         15.0         5.8         -15.0         33.3         4.2         x         x           33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0									
33         -9.6         30.6         23.8         -22.5         -7.4         0.7         x         x           34         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         o         x           41         18.2         28.8         21.0         -22.1         14.1         -9.8									
34         -7.3         -12.4         37.3         8.1         -4.8         5.4         0         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         o         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9								X	X
34         -7.3         -12.4         37.3         8.1         -4.8         5.4         0         x           35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         o         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9	33	-9.6	30.6	23.8	-22.5	-7.4	0.7	X	X
35         5.2         36.3         16.1         -28.8         4.5         7.0         x         x           36         -7.3         -12.4         37.3         8.1         -4.8         5.4         o         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         o         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         o         o           39         20.7         -8.3         33.2         5.7         14.0         12.3         o         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         o         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         o         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         o         o           44         -15.9         -33.5         14.9         30.2         -13.8         1.2	34	-73	-12 4				5 4	0	
36         -7.3         -12.4         37.3         8.1         -4.8         5.4         0         x           37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         0         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         0         0           39         20.7         -8.3         33.2         5.7         14.0         12.3         0         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4					20.1				
37         -18.1         2.8         35.6         -1.9         -12.0         -7.7         0         x           38         1.2         -21.2         33.9         14.2         0.8         -1.0         0         0           39         20.7         -8.3         33.2         5.7         14.0         12.3         0         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0									
38         1.2         -21.2         33.9         14.2         0.8         -1.0         0         0           39         20.7         -8.3         33.2         5.7         14.0         12.3         0         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0         x           45         7.4         -25.7         29.7         20.7         5.3				37.3				0	
38         1.2         -21.2         33.9         14.2         0.8         -1.0         0         0           39         20.7         -8.3         33.2         5.7         14.0         12.3         0         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0         x           45         7.4         -25.7         29.7         20.7         5.3	37	-18.1	2.8	35.6	-1.9	-12.0	-7.7	0	X
39         20.7         -8.3         33.2         5.7         14.0         12.3         0         x           40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0         x           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7									
40         19.1         15.0         31.8         -10.4         13.1         -6.8         0         x           41         18.2         28.8         21.0         -22.1         14.4         15.0         0         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         0           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6									
41         18.2         28.8         21.0         -22.1         14.4         15.0         o         x           42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         o         o           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         o         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         o         o         x           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         o         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         o         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.			-8.3						
42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         o         o           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         o         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         o         o         d           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         o         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         o         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9<			15.0			13.1		o	X
42         38.9         -7.6         -5.5         9.7         41.1         -9.8         x         o           43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         o         o           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         o         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         o         o         d           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         o         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         o         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9<	41	18.2	28.8	21.0	-22.1	14.4	15.0	0	X
43         -3.7         -35.0         19.0         26.9         -3.1         -3.9         0         0           44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4									
44         -15.9         -33.5         14.9         30.2         -13.8         1.2         0         x           45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         0         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         0         x           53         60.0         1.0         -1.0         1.6         50.8         7.9 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         0         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         0         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0 <td></td> <td></td> <td></td> <td>19.0</td> <td></td> <td></td> <td></td> <td>o</td> <td>0</td>				19.0				o	0
45         7.4         -25.7         29.7         20.7         5.3         -0.4         0         0           46         -4.2         -3.5         39.6         5.1         -2.7         8.0         0         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         0         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         0         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0 <td>44</td> <td>-15.9</td> <td>-33.5</td> <td>14.9</td> <td>30.2</td> <td>-13.8</td> <td>1.2</td> <td>0</td> <td>X</td>	44	-15.9	-33.5	14.9	30.2	-13.8	1.2	0	X
46         -4.2         -3.5         39.6         5.1         -2.7         8.0         o         x           47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         o         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4<	45		-25.7		20.7		-0.4	0	
47         -11.8         24.3         53.6         -10.3         -6.5         -13.0         0         x           48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         0         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         0         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         0         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         0         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6									
48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6 </td <td></td> <td></td> <td></td> <td></td> <td>3.1</td> <td></td> <td></td> <td></td> <td></td>					3.1				
48         -22.8         -21.5         51.2         14.8         -12.7         -6.0         o         x           49         3.0         27.9         53.0         -12.3         1.7         -4.5         o         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6 </td <td></td> <td></td> <td></td> <td></td> <td>-10.3</td> <td></td> <td></td> <td>0</td> <td>X</td>					-10.3			0	X
49         3.0         27.9         53.0         -12.3         1.7         -4.5         0         x           50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1	48	-22.8	-21.5	51.2	14.8	-12.7	-6.0	0	X
50         -52.0         -25.4         15.9         23.9         -38.3         -6.7         x         x           51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3<	49						-4.5	_	
51         -19.1         39.4         41.0         -20.5         -11.9         -6.0         o         x           52         25.0         -10.4         53.6         8.6         13.6         4.0         o         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
52         25.0         -10.4         53.6         8.6         13.6         4.0         0         x           53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0</td> <td>X</td>								0	X
53         60.0         1.0         -1.0         1.6         50.8         7.9         x         x           54         -10.9         -18.5         56.0         12.8         -5.9         7.0         o         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9 <td>52</td> <td>25.0</td> <td>-10.4</td> <td>53.6</td> <td>8.6</td> <td>13.6</td> <td>4.0</td> <td>0</td> <td>X</td>	52	25.0	-10.4	53.6	8.6	13.6	4.0	0	X
54         -10.9         -18.5         56.0         12.8         -5.9         7.0         0         x           55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9 <t>x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.</t>			1.0						
55         31.1         -12.5         49.8         10.0         17.3         13.4         x         x           56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         o         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1									
56         -48.8         7.3         34.2         -2.1         -30.1         -6.8         0         x           57         16.9         30.0         49.1         -14.0         9.7         2.6         0         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         0         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         0         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         0         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         0         x           65         -48.1         19.5         30.1         -10.8         -31.0									
57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6								X	X
57         16.9         30.0         49.1         -14.0         9.7         2.6         o         x           58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6	56	-48.8	7.3	34.2	-2.1	-30.1	-6.8	0	x
58         28.3         27.2         45.3         -13.1         16.5         3.1         o         x           59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6         6.4         x         x           67         -9.4         34.4         48.2         -16.4         -5.5 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>									
59         -26.8         -40.1         35.6         28.0         -17.4         13.3         o         x           60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6         6.4         x         x           67         -9.4         34.4         48.2         -16.4         -5.5         9.4         x         x           68         44.1         -30.9         26.5         22.0         30.0 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>									
60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6         6.4         x         x           67         -9.4         34.4         48.2         -16.4         -5.5         9.4         x         x           68         44.1         -30.9         26.5         22.0         30.0         -11.9         o         x									
60         -59.2         -6.3         -7.3         11.2         -54.2         -5.1         x         x           61         55.7         -11.4         -19.2         17.5         58.2         -1.7         x         x           62         54.7         -4.2         24.3         6.1         36.3         10.9         x         x           63         -25.2         -30.0         45.4         20.3         -14.8         1.9         o         x           64         -13.6         -43.2         39.4         28.6         -8.6         1.6         o         x           65         -48.1         19.5         30.1         -10.8         -31.0         10.5         x         x           66         36.5         29.1         37.7         -15.5         22.6         6.4         x         x           67         -9.4         34.4         48.2         -16.4         -5.5         9.4         x         x           68         44.1         -30.9         26.5         22.0         30.0         -11.9         o         x	59		-40.1					0	X
61       55.7       -11.4       -19.2       17.5       58.2       -1.7       x       x         62       54.7       -4.2       24.3       6.1       36.3       10.9       x       x         63       -25.2       -30.0       45.4       20.3       -14.8       1.9       o       x         64       -13.6       -43.2       39.4       28.6       -8.6       1.6       o       x         65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x	60	-59.2	-6.3	-7.3	11.2	-54.2	-5.1	X	X
62       54.7       -4.2       24.3       6.1       36.3       10.9       x       x         63       -25.2       -30.0       45.4       20.3       -14.8       1.9       o       x         64       -13.6       -43.2       39.4       28.6       -8.6       1.6       o       x         65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x									
63       -25.2       -30.0       45.4       20.3       -14.8       1.9       0       x         64       -13.6       -43.2       39.4       28.6       -8.6       1.6       0       x         65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x									
64       -13.6       -43.2       39.4       28.6       -8.6       1.6       0       x         65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x									
64       -13.6       -43.2       39.4       28.6       -8.6       1.6       0       x         65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x	63	-25.2	-30.0	45.4	20.3	-14.8	1.9	0	X
65       -48.1       19.5       30.1       -10.8       -31.0       10.5       x       x         66       36.5       29.1       37.7       -15.5       22.6       6.4       x       x         67       -9.4       34.4       48.2       -16.4       -5.5       9.4       x       x         68       44.1       -30.9       26.5       22.0       30.0       -11.9       o       x	64	-13.6	-43.2	39.4	28.6	-8.6		0	
66 36.5 29.1 37.7 -15.5 22.6 6.4 x x x 67 -9.4 34.4 48.2 -16.4 -5.5 9.4 x x 68 44.1 -30.9 26.5 22.0 30.0 -11.9 <b>o</b> x									
67 -9.4 34.4 48.2 -16.4 -5.5 9.4 x x 68 44.1 -30.9 26.5 22.0 30.0 -11.9 <b>o</b> x									
68 44.1 -30.9 26.5 22.0 30.0 -11.9 <b>o</b> x								X	X
68 44.1 -30.9 26.5 22.0 30.0 -11.9 <b>o</b> x	67	-9.4	34.4	48.2	-16.4	-5.5	9.4	X	X
09 -30.0 -4.2 19.3 0.3 -39.2 -14.2 X X									
	09	-30.0	-4.2	19.5	0.3	-39.2	-14.2	Х	X



Fig. 4: The desired image acquired at the desired pose (center of spheres of initial poses). Same as [1, Fig. 8a].

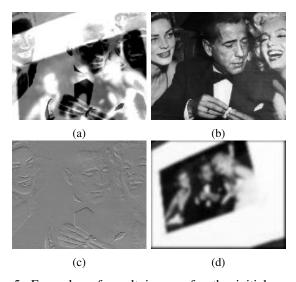


Fig. 5: Examples of result images for the initial pose # 59 (see Tab I). (a) Difference between the initial image (Fig. 3m) and the desired one (Fig. 4). (b) Last image of DDVS. (c) Difference between the last image of DDVS and the desired one. (d) Last PGM of PGM VS (the camera is on the border of the robot workspace).

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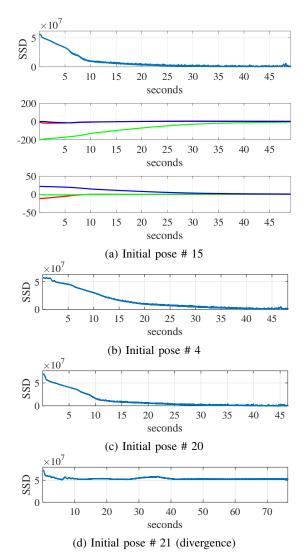


Fig. 6: Evolution of the Sum-of-Squared-Differences cost (SSD) between images brightness during the Defocus-based DVS from several initial poses on the sphere of radius 20 cm. (a) also shows the evolution of translational DoF (red:  $t_X$ , green:  $t_Y$ , blue:  $t_Z$ , unit: mm) on its second row and rotational DoF (red:  $\theta w_Z$ , green:  $\theta w_Y$ , blue:  $\theta w_X$ , unit: degrees) to highlight there smoothness.

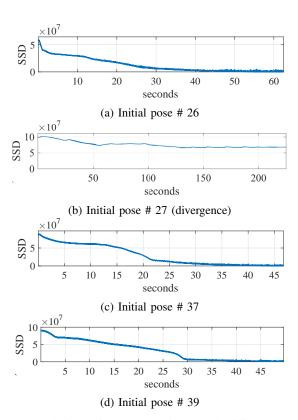


Fig. 7: Evolution of the Sum-of-Squared-Differences cost (SSD) between images brightness during the Defocus-based DVS from several initial poses on the sphere of radius 40 cm.

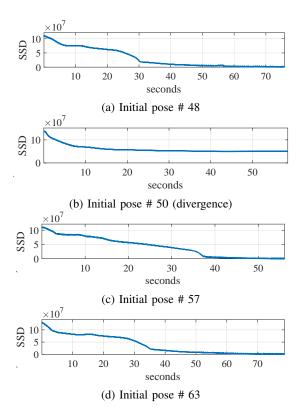


Fig. 8: Evolution of the Sum-of-Squared-Differences cost (SSD) between images brightness during the Defocus-based DVS from several initial poses on the sphere of radius 60 cm.