The KTH-INDECS Database

Andrzej Pronobis, Barbara Caputo
Computational Vision and Active Perception Laboratory (CVAP)
Department of Numerical Analysis and Computer Science (NADA)
KTH, SE-100 44 Stockholm, Sweden
{pronobis, caputo}@nada.kth.se

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1   Introduction

The following document contains a detailed description of the KTH-INDECS database. The name INDECS is an acronym which stands for Indoor Environment under Changing conditionS. The database consists of several sets of pictures taken in five rooms of different functionality under various conditions.

The motivation for creating the database was the need for a flexible testing environment, which could be used to estimate the performance of an indoor place recognition system. Robustness is a key property for a recognition system aiming to work in realistic settings, thus in building the database special emphasis was placed on capturing the variability of the environment and its intrinsic properties. For this purpose, pictures were taken under various illumination and weather conditions at different periods of time. Each room (scene) was observed from many viewpoints and angles (the need for multi-viewpoint representation during human passive learning was explained in [1]). All this ensures that the response of the scene to the change of conditions was captured. Moreover, the normal activity in the rooms was recorded: people appear in the rooms, pieces of furniture are moved over time.

The database was acquired in a way that allows it to be used in experiments not only with indoor place recognition, but also with object recognition. The database may then be considered as a source of images containing objects in a cluttered scene. Thus, it is of potential interest not only for benchmarking of scene recognition systems, but also for context-based object recognition methods ([2, 3]) and visual attention algorithms.

The next sections provide information about the indoor environment in which the pictures were taken (Section 2), describe the acquisition procedure (Section 3), and present interesting examples illustrating several attributes of the database (Sections 4, 5, and 6). As a conclusion of this document, possible future extensions to the database are discussed (Section 7). Detailed maps of the environment and description of the file naming convention can be found in appendices.

The database is freely available on the Internet [4], however due to the amount of required space, the pictures are resampled to the resolution 512x384. Full-size images can be provided on request.
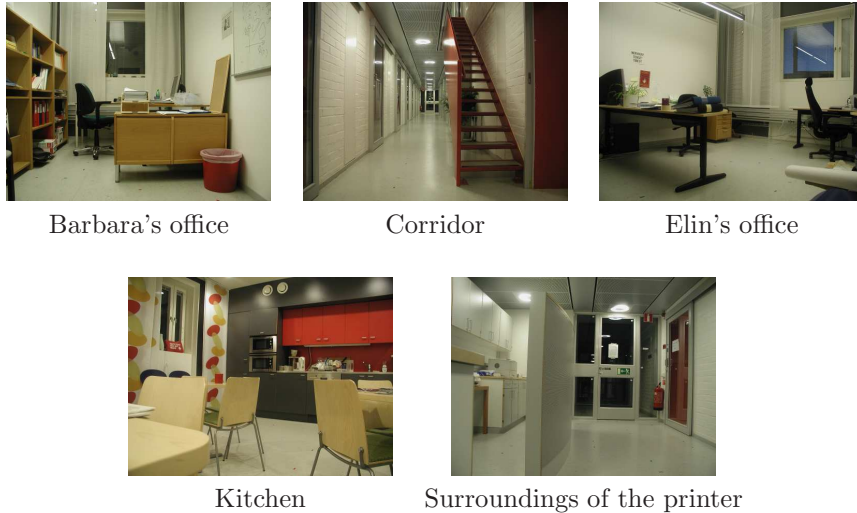
Barbara's office   Corridor   Elin's office

Kitchen   Surroundings of the printer

Figure 1: Pictures presenting the interior of each room.

2 Description of the Environment

The pictures included in the database were taken in the interior of The Computational Vision and Active Perception Laboratory. The environment consists of five rooms located on the same floor, performing various functions: *the kitchen*, *the corridor*, *the surroundings of the printer* (in fact a part of the corridor), and two offices (*Barbara's office* and *Elin's office*). Exemplary pictures of the rooms are shown in Figure 1.

A general map of the environment is presented in Figure 2. Boundaries between the rooms that were used in building the database are marked with dashed lines. Dotted lines were used to draw an outline of furniture. The map also contains positions of the points in which the pictures were taken. Several points were marked out and provided with arrows indicating the point and angle used to obtain the pictures in Figure 1. Detailed maps of the environment and coordinates of the points can be found in Appendix B.

As it was stated before, the rooms fulfill different functions that determine the activity that is likely to occur. Places like *the corridor* or *the kitchen* can be regarded as public, which implies that various people may be present and the furniture (e.g. chairs) is moved more often. On the other hand offices were photographed usually empty or with their owners at work.

The rooms are physically separated by a sliding glass door. However, *the surroundings of the printer*, which is a continuation of *the corridor*, is an exception to that rule, and was treated as a separate room due to its different functionality. In conclusion the exact border between *the corridor* and *the surroundings of the printer* can be regarded as arbitrary.

The laboratory contains additional rooms which were not taken into consideration while creating the database. However, because of the glass door some of them can be visible in the pictures from *the corridor*.
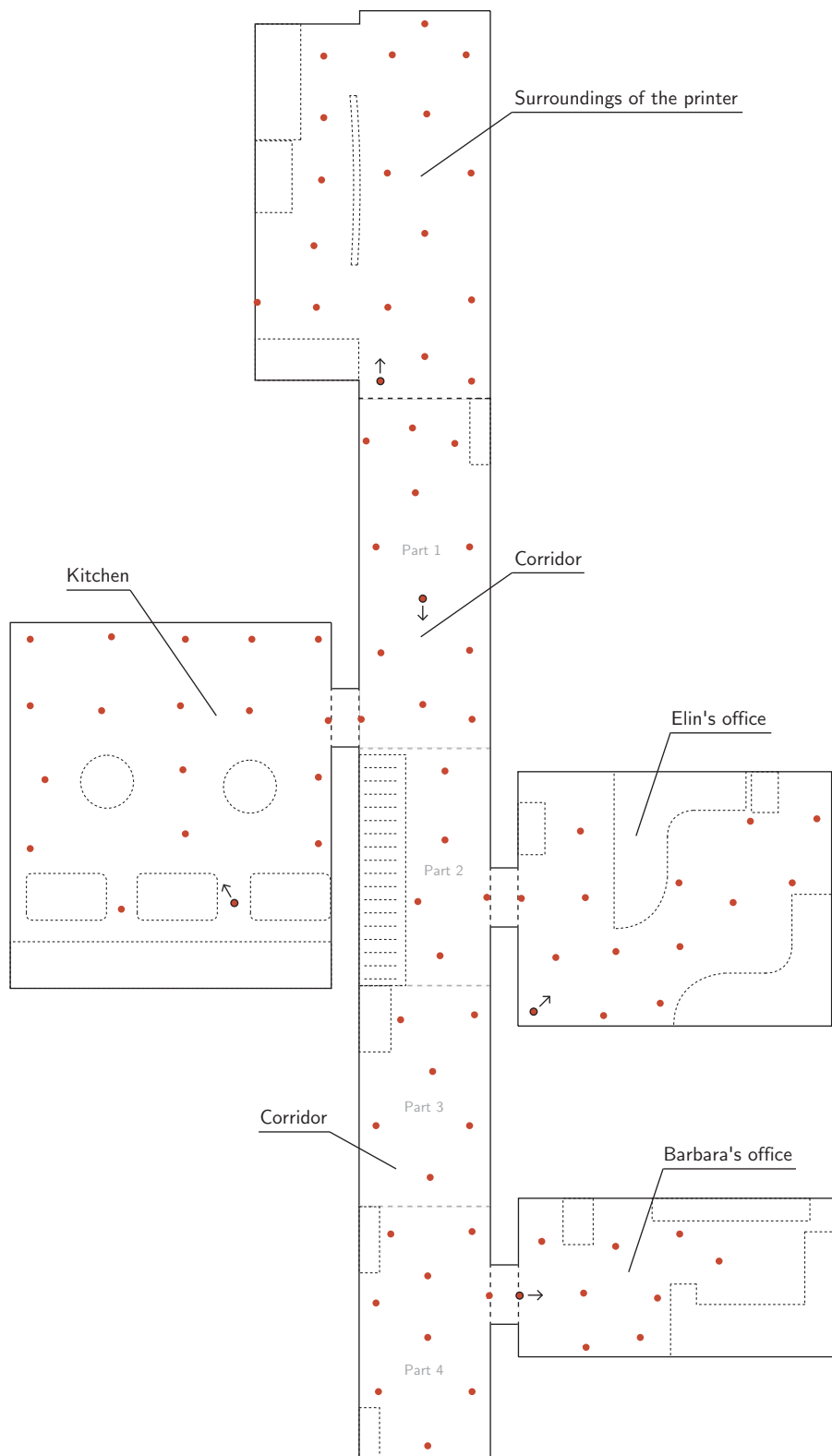
Figure 2: A general map of the environment.

Room	Number of markers	Total no. of pictures
Barbara's office	9	324
Corridor	32	1140
Elin's office	14	492
Kitchen	18	648
Surr. of the printer	18	648

Table 1: The number of markers and taken pictures for each room.

3 Image Acquisition

The pictures were taken using an Olympus C-3030ZOOM digital camera mounted on a tripod. The height of the tripod was constant and equal to 76 cm (in order to imitate the perspective of a robot). All the images were acquired using the following camera settings:

- The resolution was set to 1024x768 pixels.

- No image compression was used.

- The flash was disabled.

- The zoom was set to the wide-angle mode.

- The auto-focus mode was enabled.

The tripod was always placed exactly over the markers on the floor, which were prepared in the beginning and kept in the same position during the whole acquisition process (the markers may be visible on the pictures as a small red and green dots on the floor). The markers were positioned approximately one meter from each other in areas accessible to people or a robot. The rough position of all markers is shown on the general map in Figure 2. Coordinates and detailed maps can be found in Appendix B.

After the camera was placed above the marker, twelve pictures from twelve angles (every 30°) were taken. The camera was always turned clockwise, starting from the same direction. The angle 0° is indicated on the detailed maps by an arrow located near every marker. Each marker was assigned a unique number within the room. Table 1 contains the number of markers in each room, together with the total number of pictures of the room stored in the database.

The light used to illuminate the environment was not fixed or specially adjusted before the acquisition process, which means that the light suitable for the users of the room was used. All the rooms have windows, however artificial light was sometimes used even during the day, especially in cloudy weather.

4 Observing Environment from Multiple Viewpoints and Angles

Due to the arrangement of the points where the camera was placed (markers), and the fact that twelve pictures from different angles were taken in each point, most parts of the environment were observed from multiple viewpoints. This ensures that the image of the scene was captured under illumination from various directions, and three-dimensional objects were viewed from several sides. Two exemplary sets of pictures are shown in Figures 3 and 4.

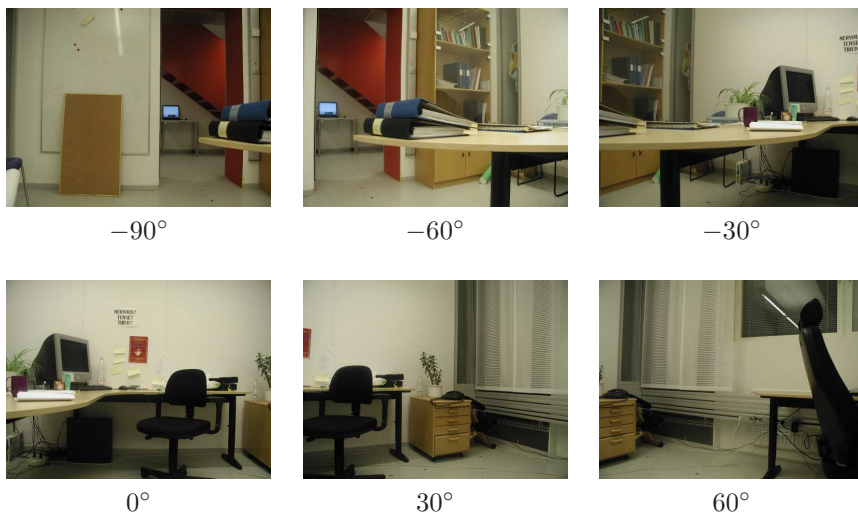Figure 3: One part of the environment observed from various viewpoints and angles.

Figure 4: Pictures taken from the same viewpoint and several angles.

5   Capturing Variability of the Environment

The database comprises pictures taken over a span of two months, under three different outdoor illumination and weather conditions: in *cloudy* weather, in *sunny* weather, and at *night*. As a result, the database always contains three pictures obtained from exactly the same viewpoint[1]. The following variations may be noticed in the pictures:

- The illumination conditions change because of variation in the outdoor and artificial light.

- Objects are moved and new objects appear.

- Furniture is moved.

- People appear in the rooms.

The most significant changes are caused by the illumination, as it can be observed especially in the pictures taken in front of a window on sunny days. The camera is equipped with an automatic exposure system, which, in this case, causes the pictures to darken.

Examples of scenes photographed under different weather and illumination conditions are presented in Figure 5.

6   Difficult Examples

The database was created according to the assumption that pictures should be taken in the marked points from every of the twelve angles, irrespective of the contents of the picture. In result, several pictures can be regarded as non-informative, since they contain very little clues about the place where they were taken (e.g. pictures of blank walls). Figure 6 gives examples of non-informative pictures in the database.

Another difficulty that a place recognition system may encounter is caused by relatively narrow angle of view of the digital camera. The problem is observable especially near the edge of the room, because some pictures contain information coming only form the adjoining room. An example can be found in Figure 7, which contains pictures taken near the edge of *the corridor*.

7   Future Extensions to the Database

Several extensions to the database are planned. Currently, the database contains pictures taken on one floor of the laboratory under three weather and illumination conditions. However, it would be of interest to extend the database to other floors (which are similar) and acquire more data in the points used so far.

As it was mentioned before in Section 6, the pictures are of different significance in respect of the amount of the position information they contain. The database may therefore be filtered to exclude the non-informative pictures. To avoid using any prior knowledge, the number of corners detected in the image may be used as a measure of significance. Future work will also concentrate on recreating the database using a camera mounted on a robot.

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[1] The pictures taken at point M8 in *Elin's office* in the sunny weather and at point M32 in *the corridor* in the cloudy weather are missing.

Barbara's office

Cloudy　　　　　　　　Night　　　　　　　　Sunny

Corridor

Cloudy　　　　　　　　Night　　　　　　　　Sunny

Elin's office

Cloudy　　　　　　　　Night　　　　　　　　Sunny

Kitchen

Cloudy　　　　　　　　Night　　　　　　　　Sunny

Surroundings of the printer

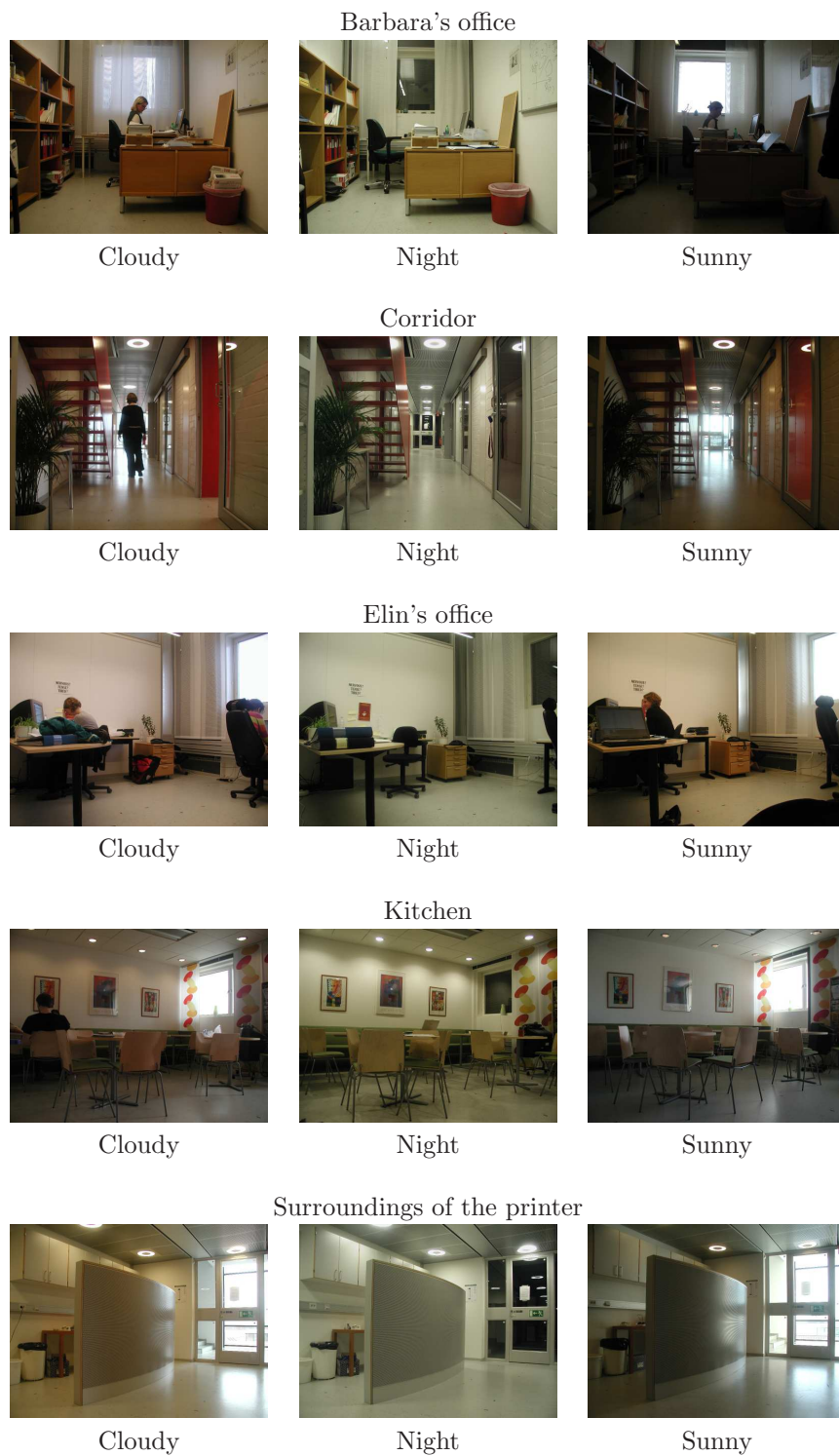
Cloudy　　　　　　　　Night　　　　　　　　Sunny

Figure 5: Examples of pictures taken under three different illumination and weather conditions for each of the five rooms.

Figure 6: Examples of non-informative pictures.

Figure 7: Examples of pictures taken near the edge of *the corridor*.

References

[1] C. Christou and H. H. Bülthoff. View-direction specificity in scene recognition after active and passive learning. Technical Report 53, Max Planck Institut, October 1997.

[2] A. Torralba, K. P. Murphy, W. T. Freeman, and M. A. Rubin. Context-based vision system for place and object recognition. In *Proceedings of the IEEE International Conference on Computer Vision (ICCV),* 2003.

[3] K. Murphy, A. Torralba, and W. T. Freeman. Using the forest to see the trees: a graphical model relating features, objects, and scenes. In *Proceedings of the Neural Information Processing Systems Conference (NIPS),* 2003.

[4] A. Pronobis, B. Caputo. The KTH-INDECS database. Available at http://cogvis.nada.kth.se/INDECS.

A   File Naming Conventions

Complete information about each picture is encoded in its filename. The naming convention used to generate the filenames, written in the BNF[2] notation, is presented below:

r⟨*room*⟩_m⟨*marker*⟩_a⟨*angle*⟩_d⟨*date*⟩_t⟨*time*⟩_w⟨*conditions*⟩.⟨*extension*⟩

⟨*room*⟩	- Code of the room where the picture was taken.
::= BO	- Barbara's office
| CR	- Corridor
| EO	- Elin's office
| KT	- Kitchen
| PR	- Surroundings of the printer

⟨*marker*⟩ — - The marker number.

⟨*angle*⟩ — - A number representing the angle.

⟨*date*⟩ — - Date when the picture was taken.
    ::= ⟨*year*⟩-⟨*month*⟩-⟨*day*⟩

⟨*time*⟩ — - Time when the picture was taken.
    ::= ⟨*hour*⟩-⟨*minute*⟩

⟨*conditions*⟩	- Describes the weather/illumination conditions.
::= C	- Cloudy
| N	- Night
| S	- Sunny

⟨*extension*⟩ — - File extension. Depends on the image format.

The number indicating the angle from which the picture was taken is relative to the starting direction marked on detailed maps. Successive numbers, starting from one, denote angles increasing clockwise every 30°.

B   Detailed Maps and Positions of the Markers

The following section contains detailed maps of the environment used in the database (Figures 8 to 15). The maps include accurate positions of the markers and outlines of furniture and doors. Each room is presented on a separate map. The map of *the corridor*, because of its length, was divided into four figures.

Tables 2 to 9 contain coordinates of the markers, with respect to the axes of the map on which the markers are presented.

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[2]The BNF acronym stands for Backus Naur Form.
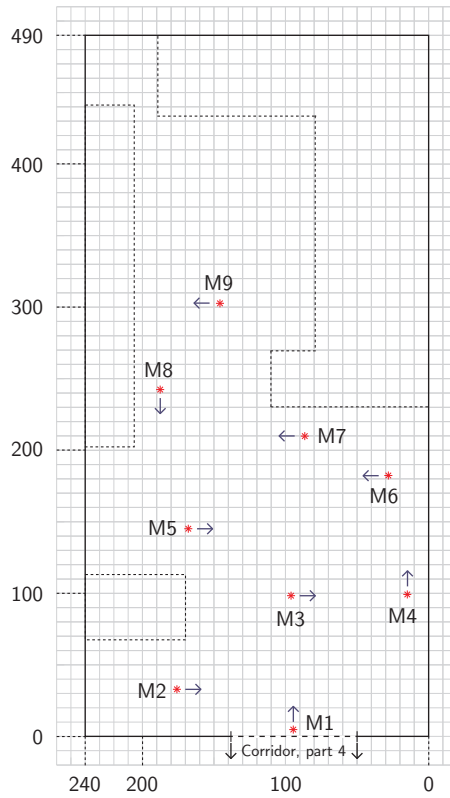
Figure 8: A detailed map of *Barbara's office*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
1	94.6	4.8
2	176.0	32.9
3	96.1	98.4
4	14.9	99.2
5	168.0	145.1
6	28.2	182.3
7	86.5	209.9
8	187.6	242.4
9	145.9	302.7

Table 2: Positions of the markers in *Barbara's office*.
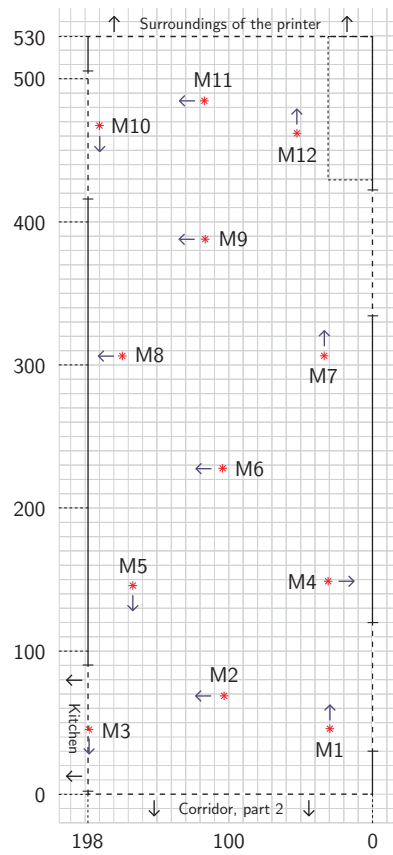
Figure 9: A detailed map of the *first* part of *the corridor*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
1	29.7	45.7
2	103.3	68.7
3	197.3	45.2
4	30.9	148.8
5	166.8	145.8
6	104.3	227.7
7	33.6	306.4
8	174.1	306.3
9	116.4	387.9
10	190.0	467.4
11	117.0	484.6
12	52.6	461.9

Table 3: Positions of the markers in the *first* part of *the corridor*.
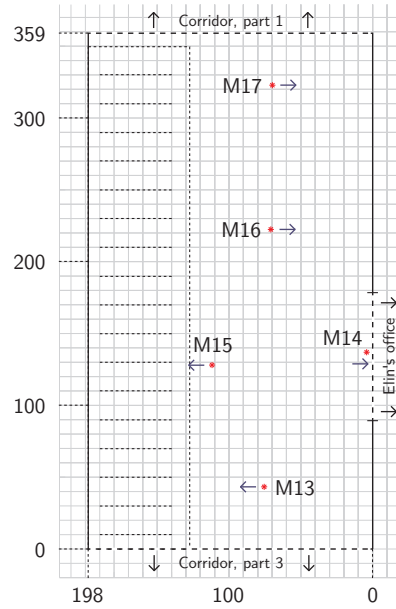
Figure 10: A detailed map of the *second* part of *the corridor*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
13	75.5	43.3
14	4.2	137.0
15	111.8	128.1
16	70.9	222.5
17	69.8	322.8

Table 4: Positions of the markers in the *second* part of *the corridor*.
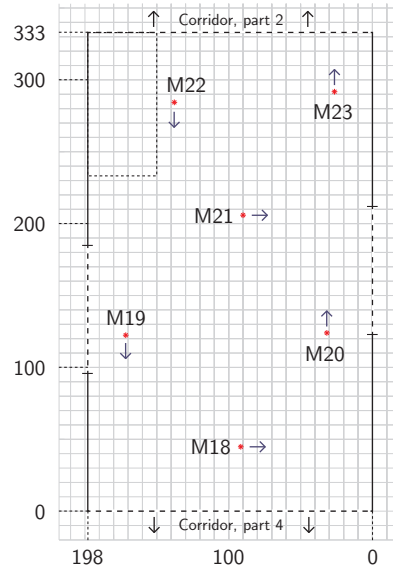
Figure 11: A detailed map of the *third* part of *the corridor*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
18	91.6	44.8
19	171.6	122.4
20	31.7	124.0
21	90.0	205.9
22	137.8	284.4
23	26.4	291.8

Table 5: Positions of the markers in the *third* part of *the corridor*.
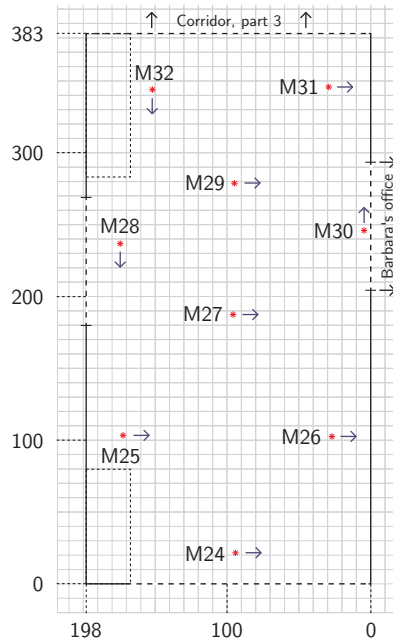
Figure 12: A detailed map of the *fourth* part of *the corridor*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
24	94.1	21.6
25	172.4	103.3
26	27.0	102.6
27	95.8	187.4
28	174.3	236.7
29	94.8	278.8
30	4.6	246.0
31	29.2	345.8
32	151.9	344.0

Table 6: Positions of the markers in the *fourth* part of *the corridor*.
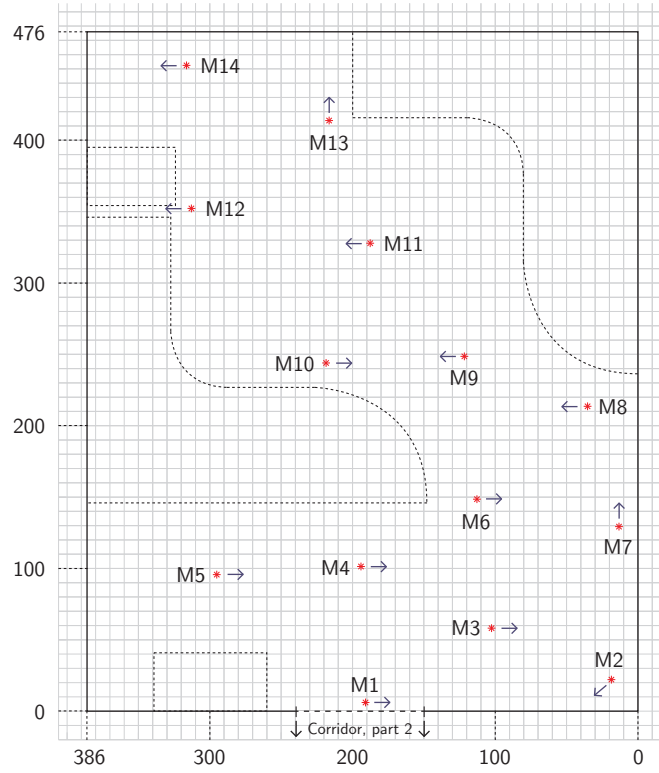
Figure 13: A detailed map of *Elin's office*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
1	190.9	6.1
2	18.6	22.1
3	102.6	58.2
4	194.1	101.4
5	295.1	95.7
6	112.8	148.5
7	13.3	129.3
8	35.3	213.6
9	121.6	248.6
10	218.5	244.0
11	187.6	327.8
12	312.9	352.3
13	216.4	413.8
14	316.3	452.5

Table 7: Positions of the markers in *Elin's office*.

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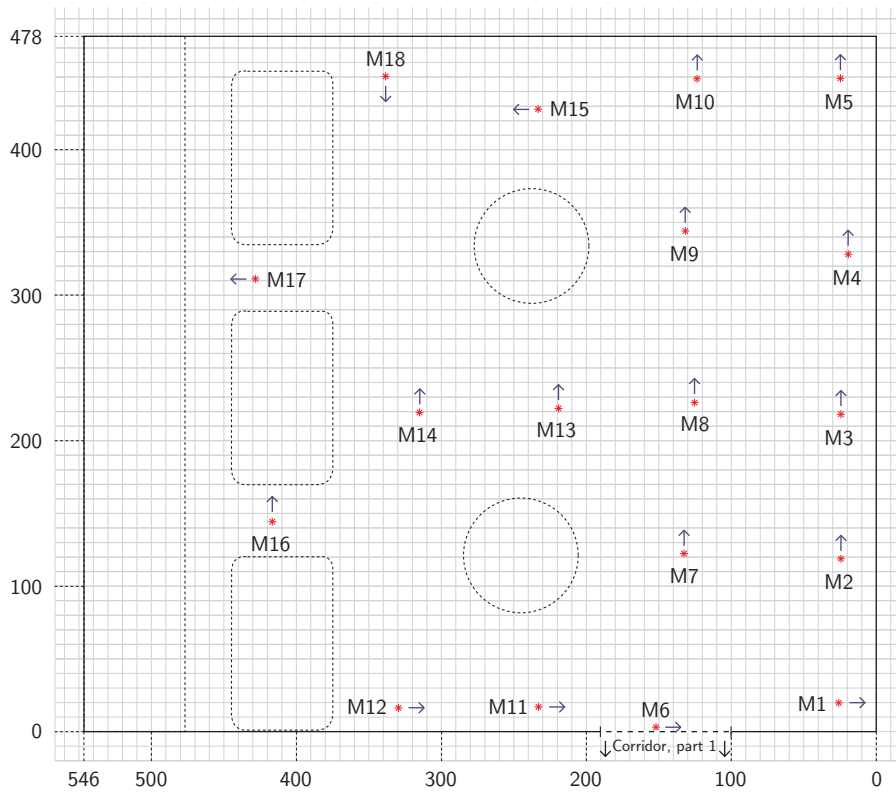
Figure 14: A detailed map of *the kitchen*.

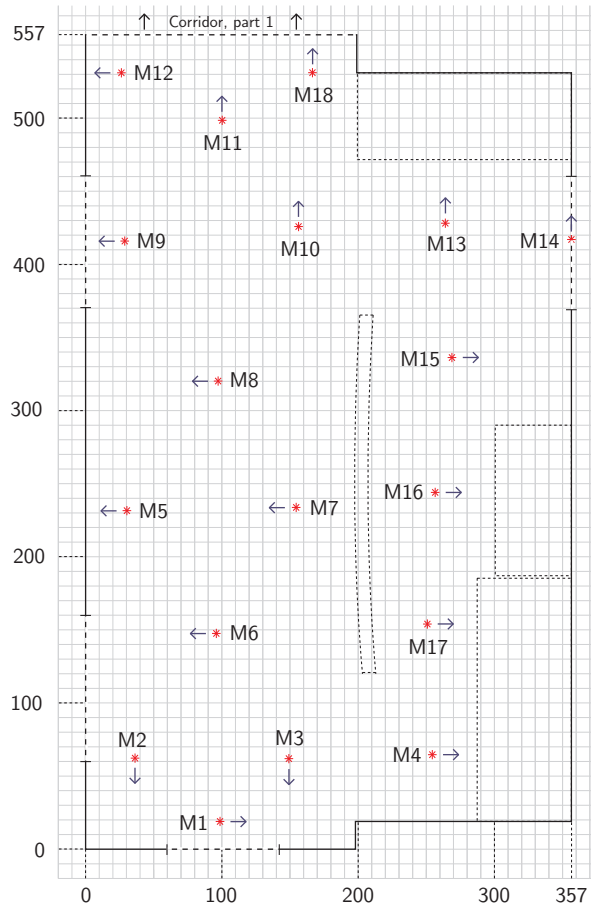| Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
1	25.8	19.7
2	24.4	118.8
3	24.4	218.1
4	19.3	328.2
5	24.7	449.1
6	151.9	3.0
7	132.6	122.4
8	125.3	226.1
9	131.7	344.1
10	123.6	448.8
11	232.9	17.0
12	329.6	16.3
13	219.1	222.2
14	315.0	219.5
15	233.2	427.9
16	416.6	144.3
17	428.3	311.2
18	338.4	450.5

Table 8: Positions of the markers in *the kitchen*.

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Figure 15: A detailed map of *the surroundings of the printer*.

Marker	Horizontal coordinate [cm]	Vertical coordinate [cm]
1	98.7	19.0
2	36.3	62.2
3	149.2	61.9
4	254.4	64.6
5	30.3	231.6
6	95.9	147.6
7	154.6	233.8
8	97.3	320.2
9	28.7	416.0
10	156.3	425.8
11	100.2	498.5
12	26.3	531.0
13	264.0	428.2
14	356.5	417.0
15	268.8	336.3
16	256.5	244.0
17	250.8	153.9
18	166.5	531.1

Table 9: Positions of the markers in *the surroundings of the printer*.