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Robot's Actions and Automatic Generation of Distance Functions for Sequences of Images

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Abstract

We consider a testbed for investigations of robot's actions. We consider examples of simple robot's actions that allow automatic generation of distance functions for sequences of images.

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The ability to anticipate consequences of robot's actions and changes of the environment is very important for robot self-awareness (see e.g. [1] – [6]). If the robot uses a visual navigation, the robot should analyze sequence of images to anticipate consequences of their actions and changes of the environment We can use different distance functions for sequences of images (see e.g. [7] – [10]). Such functions can be used to extract regularities. In this paper, we consider examples of simple robot's actions that allow automatic generation of distance functions for sequences of images. We use autonomous mobile robots Kuzma-I and Kuzma-II as main testbed (see e.g. [4]) for our experiments.

Note that a correspondence between sequences of images, actions of the robot and changes of the environment may contain several identical dependencies which, however, represented by sequences of images that reflect different phases of the same sequence of events (see e.g. Figure 1). In case of

Figure 1 a proper alignment of sequences $\mathrm{Im}_1[1]\mathrm{Im}_1[2]\mathrm{Im}_1[3]\mathrm{Im}_1[4]\mathrm{Im}_1[5]$ and $\mathrm{Im}_2[1]\mathrm{Im}_2[2]\mathrm{Im}_2[3]\mathrm{Im}_2[4]\mathrm{Im}_2[5]$ is as follows:

$$\begin{aligned} A \;= \{ \;& \mathrm{Im}_1[1] \;\; \Delta \;\; \mathrm{Im}_1[2]\mathrm{Im}_1[3]\mathrm{Im}_1[4]\mathrm{Im}_1[5], \\ & \mathrm{Im}_2[1]\mathrm{Im}_2[2]\mathrm{Im}_2[3]\mathrm{Im}_2[4] \;\; \Delta \;\; \mathrm{Im}_2[5]\}. \end{aligned}$$

It is easy to see that distances between pairs $(\mathrm{Im}_1[1], \mathrm{Im}_2[1])$; $(\mathrm{Im}_1[2], \mathrm{Im}_2[3])$; $(\mathrm{Im}_1[5], \mathrm{Im}_2[5])$ are relatively small. However, since in $\mathrm{Im}_1[3]$ all four skittles are clearly distinguishable, but in $\mathrm{Im}_2[4]$ only three skittles are clearly distinguishable, the pair $(\mathrm{Im}_1[3], \mathrm{Im}_2[4])$ should be heavily penalized. Therefore, usage of a weighted edit distance for localization and extraction of regularities in a correspondence between sequences of images, actions of the robot and changes of the environment is essential.

In some simple cases sufficiently accurate values of the distance function can be calculated relatively easily using genetic algorithms. For example, it can be done during the investigation on a testbed of collisions of the robot and skittles (see e.g. Figure 1) and results of these collisions (see e.g. Figure 2). Also this can be done during the investigation of the anticipation of appearance and disappearance of a robot (see e.g. Figure 3) or during the investigation of the anticipation of displacements of different objects (see e.g. Figure 4). Accumulation of data on such events can be implemented at testbeds in the automatic mode. Therefore, for such events there is an unlimited amount of data that allow us to train high-quality analyzers.

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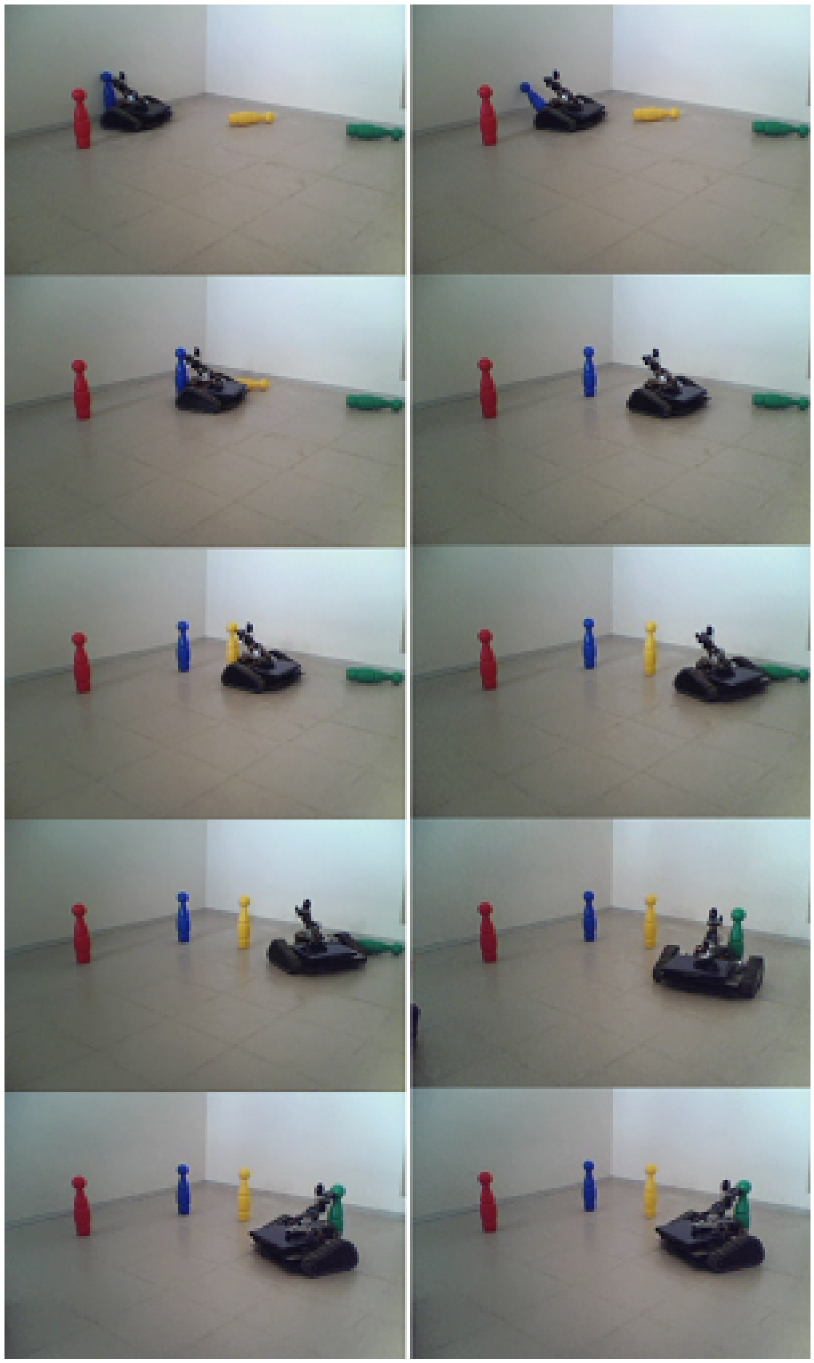

Figure 1: Two sequences of five images, left $\mathrm{Im}_1[1], \mathrm{Im}_1[2], \mathrm{Im}_1[3], \mathrm{Im}_1[4], \mathrm{Im}_1[5]$ (from bottom to top), right $\mathrm{Im}_2[1], \mathrm{Im}_2[2], \mathrm{Im}_2[3], \mathrm{Im}_2[4], \mathrm{Im}_2[5]$ (from bottom to top), that reflect different sequences of phases of the same sequence of actions of the robot Kuzma-II.2.

Figure 2: The same actions of a robot can lead to significantly different consequences. In particular, it is almost impossible to make two identical falls of skittles in a result of a collision with the robot.

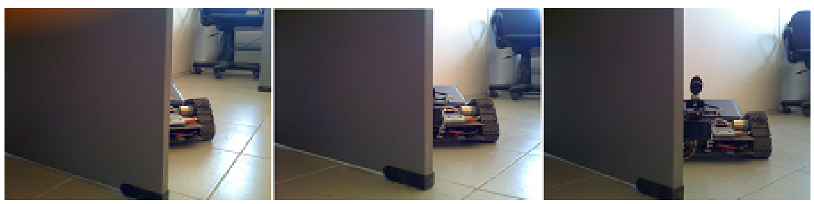

Figure 3: If some obstacle is located between robots, then the robot must not only calculate the trajectory of possible movement of another robot but also anticipate the possibility of collision of another robot with obstacle as well as anticipate the result of such collision.

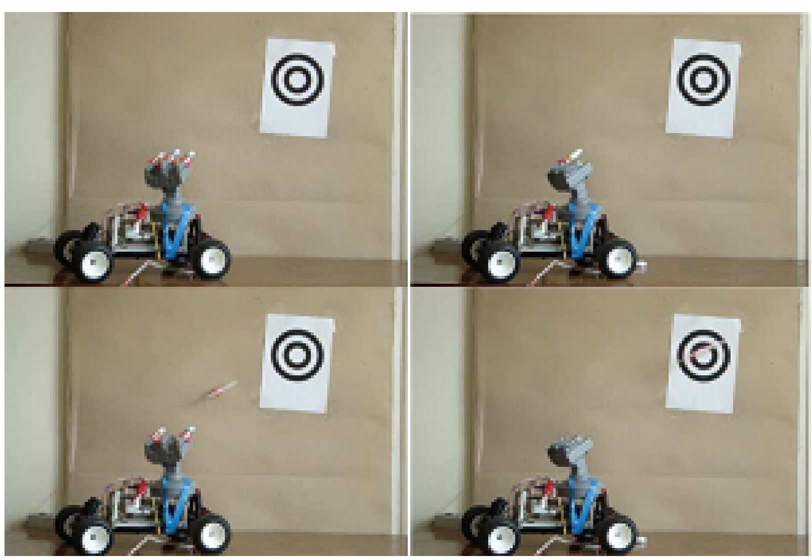

Figure 4: Rate of displacement of some objects is so high that the robot can not monitor their motion. In these cases, the anticipation is especially important ability of the robot Kuzma-I.2.

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